On technological and spatial patterns of lithic objects

Evidence from the Middle Paleolithic at Grotte de la Verpillière II, Germolles, France

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(exceptions to this are this sentence and the page number)

Table of contents

Chapter I: Introduction

„Wenn eine Idee am Anfang nicht absurd klingt, dann gibt es keine Hoffnung für sie.“ (If at first the idea is not absurd, then there is no hope for it, Albert Einstein)

or:

„Das Werk der Kunst hat für den Künstler zu sprechen, der es schuf; die Arbeit des betrachteten Forschers, welcher hinter ihr zurücktrat, erlaubt ihm zu fragen, was ihn trieb, sich zu äußern.“ (The work of art has to speak for the artist, who made it; the work of the considered researcher, who takes place behind his work, allows to ask what forced him to express themself, Mackay 1891: VI)

I.1 Acknowledgment

In writing an acknowledgment, there is always the difficulty to say thank you to all people that are related or connected to this work and not to overwhelm it. Likewise, one could think, why I am just mentioned with such a short meaningless phrase and the other person gets such a great one? I circumvent this fact in listing `em all in alphabetical order using the first name (multiple first names are mentioned only ones) and send a great thank you to all people that contributed with words and deeds to bring this work to a satisfying end:

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- and in the unimaginable case there is someone still missing in this list I apologize profoundly and deeply, and repeat the THANK YOU to this person, too!
- The evaluation committee of the disputation consited of Prof. Dr. Michael Bolus (Head of the committee), Prof. Dr. Halad Floss (second examiner), Prof. Nicholas John Conard, PhD (third examiner) and Jun.-Prof. Dr. Christopher Miller (fourth examiner). Many thanks to all of them!

I.2 Summaries

I.2.1 Short summary

Sites in Saône-et-Loire were object of early observations about the legacy of stone age people. As early as in the 1860s, first excavations were conducted at Solutré (1866), as well as at Grotte de la Verpillière (1868, that was renamed to Grotte de la Verpillière I in 2006, because of the discovery of another site about 50 m southwards on the same local sub-district Verpillière). Precisely this recently discovered site is object of research in this thesis.

This study focusses on lithic objects of three stratified Late Middle Paleolithic layers at Grotte de la Verpillière II in Germolles (municipality of Mellecey, Saône-et-Loire, France) that is a collapsed rock shelter with a corresponding cave tunnel. The analysed assemblages derive from layers sandwiched between the collapsed rock shelter roof and a former collapse of blocks from the ceiling, situated on the transition from the cave tunnel to the rock shelter. All three assemblages are attributed to the Late Middle Paleolithic and preliminary dated by radiometric methods into the early OIS 3.

This thesis is a technological and spatial study that deals with these recently excavated lithic assemblages from a site that luckily did not suffer from ancient excavations. The materials studied were recovered during the 2009 to 2014 field season conducted under the auspice of Prof. Harald Floss (University of Tübingen). It includes analyses about lithic raw material, blank production, reduction concepts, metrics and spatial distribution of lithic objects. The results are compared with observed patterns of the surrounding Middle Paleolithic record and place them in the wider geographical context.

The aim of this thesis is to find reliable evidence for classifying the lithic assemblage of GH 3, 4x and 4, and to find patterns that can be compared with other observations on other sites.

It is demonstrated that the assemblage of the uppermost Middle Paleolithic layer (GH 3) is clearly associated with assemblages from central Europe because of the presence of Keilmesser and other elements that are common in a *Keilmessergruppen* context. Levallois reduction is the main concept for obtaining blanks. The assemblages of GH 4 and 4x are quite small but yield evidence for the same association.

In the beginning of the study the presence of *Keilmesser* was foremost known from studies of Desbrosse and others in the 1970s about collections from Grotte de la Verpillière I (Méray excavation in 1868)

The study at hand discusses the unifacial and bifacial industries and does not exclude coarse-grained materials such as quartzite to get a good overview of all

stratified Late Middle Paleolithic lithic assemblages at the site. Lithic objects of mixed colluvial sediments (that are situated on top of the stratified) are only a minor part of this discussion. It further forms a corpus of observations that are as well present in many other Middle Paleolithic assemblages of the surrounding area (Côte chalonnaise).
This study clearly deals with the problem of classification systems for the Middle Paleolithic lithic record and tries to find bridges between french and german systems to build chronological and spatial entities in the context of assemblages associated with Neanderthals.

I.2.2 Kurze Zusammenfassung

Fundstellen in Saône-et-Loire waren Gegenstand früher Beobachtungen über die Hinterlassenschaften steinzeitlicher Menschen. Bereits in den 1860er Jahren fanden erste Ausgrabungen in Solutré (1866), sowie der Grotte de la Verpillière statt (1868, die im Jahre 2006 zu Grotte de la Verpillière I umbenannt wurde, weil 50 m südlich eine neue Fundstelle auf derselben Gemarkung entdeckt wurde). Eben diese kürzlich entdeckte Fundstelle ist Gegenstand dieser Dissertation.
Diese Arbeit legt den Fokus auf lithische Objekte aus drei stratifizierten Spät-Mittelpaläolithischen Schichten der Grotte de la Verpillière II in Germolles (Gemeinde Mellecey, Saône-et-Loire, Frankreich), welche aus einem kollabierten Felsüberhang und einem daran angeschlossenen Höhlentunnel besteht. Die analysierten Inventare stammen aus unterhalb des kollabierten Felsdaches befindlichen und auf kollabierten Deckenblöcken abgelagerten Schichten, die am Übergang zwischen dem kollabierten Felsüberhang und dem Höhlentunnel ausgegraben wurden. Alle drei Inventare werden dem späten Mittelpaläolithikum zugerechnet und konnten vorläufig durch radiometrische Methoden in das OIS 3 datiert werden.
Diese Dissertation ist eine technologische und räumliche Studie die sich mit kürzlich ausgegrabenen Steininventaren beschäftigt, welche an einer Fundstelle ausgegraben wurden, die glücklicherweise nicht durch Altgrabungen in Mitleidenschaft gezogen wurde. Das studierte Material wurde während der Kampagnen 2009 bis 2014 unter der Leitung von Prof. Harald Floss (Universität Tübingen) geborgen. Sie schließt Analysen zu lithischem Rohmaterial, Grundformproduktion, Abbaukonzepte, Metrik und räumliche Verteilung von Steinartefakten mit ein. Die Ergebnisse werden mit beobachteten Mustern von umgebenen mittelpaläolithischen Fundstellen verglichen und in den weiteren geographischen Kontext gesetzt.
Das Ziel dieser Dissertation ist es, glaubhafte Indizien für die Klassifizierungen der Steinartefaktinventare des GH 3, 4x und 4 zu finden, sowie Muster aufzu-

spüren, die verwendet werden können, um diese Beobachtungen mit solchen anderer Fundstellen vergleichen zu können.

Es konnte gezeigt werden, dass das Inventar der obersten mittelpaläolithischen Schicht (GH 3) aufgrund der Präsenz von Keilmessern und anderen Keilmesser-gruppen-Elementen klar mit Inventaren aus Mitteleuropa assoziiert ist. Levallois ist das vorwiegend angewandte Konzept zu Bereitstellung von Grundformen. Die Inventare des GH 4 und 4x sind recht klein aber zeigen ebenfalls Indizien für dieselbe Assoziation. Zu Beginn der Studien war das Vorhandensein von Keilmessern vorwiegend durch die Arbeiten von Desbrosse und anderen im Laufe der 1970er Jahre an Sammlungen der Grotte de la Verpillière I (Méray-Ausgrabung 1868) bekannt.

Die vorliegende Studie diskutiert unifazielle und bifazielle Industrien und schließt grobkörnige Materialien wie Quarzit nicht aus, um einen guten Überblick über die spät-mittelpaläolithischen Inventare der Fundstelle zu erhalten. Steinartefakte aus durchmischten Schichten (diese befinden sich oberhalb der stratifizierten) werden nur am Rande behandelt. Des Weiteren beschreibt diese Arbeit einen Korpus an Beobachtungen, welche sich auch in umliegenden Fundstellen der Côte chalonnaise finden lassen.

Diese Studie behandelt deutlich Probleme von Klassifikationssystemen der mittelpaläolithischen Hinterlassenschaften und versucht eine Brücke zwischen französischen und deutschen Systemen zu finden, um chronologische und räumliche Einheiten im Kontext von Inventaren zu schaffen, welche mit Neanderthalern assoziiert sind.

I.2.3 Court résumé

Plusieurs sites préhistoriques du département de Saône-et-Loire furent parmi les premiers à permettre des observations sur la vie des hommes du Paléolithique. Dès les années 1860 des fouilles eurent lieu à Solutré (1866), ainsi qu'à la Grotte de la Verpillière (1868). Le nom de cette dernière a été récemment changé en « Grotte de la Verpillière I », en raison de la découverte d'une deuxième grotte en 2006, à 50 m de distance au sud de la première. Cette nouvelle grotte, dite « de la Verpillière II », est précisément l'objet de la présente thèse de doctorat.

L'étude repose sur les vestiges lithiques attribuables à un Paléolithique moyen tardif, provenant de trois unités stratigraphiques de la Grotte de la Verpillière II à Germolles (commune de Mellecey, Saône-et-Loire, France). Le site se compose d'un abri sous roche effondré, suivi d'un couloir de grotte largement comblé. Les assemblages analysés proviennent des couches situées entre les blocs d'effondrement du plafond de la grotte, en partie haute, et une phase d'effondrement plus ancienne à la base, à la jonction entre l'ancien abri et son prolongement en grotte.

Les trois assemblages sont attribués à un Paléolithique moyen tardif, que les premières datations radiométriques rapportent à l'OIS 3.
Cette thèse présente l'étude technologique et spatiale d'ensembles lithiques récemment fouillés, provenant d'un site complètement épargné par les fouilles anciennes. Les ensembles étudiés ont été recueillis entre 2009 et 2014, lors de fouilles programmées dirigées par le Prof. Harald Floss (Université de Tübingen). La thèse contient des analyses sur les matières premières, le débitage, les concepts de production, la métrique et la distribution spatiale des vestiges lithiques. Les résultats obtenus sont ensuite comparés à des observations similaires issues de sites du Paléolithique moyen régional, puis replacés dans un contexte géographiquement plus élargi.
Le but de cette thèse est de relever des indices crédibles, permettant la classification typo-chronologique des ensembles lithiques des unités stratigraphiques GH 3, 4x et 4, mais aussi d'identifier des modèles aptes à comparer ces observations avec d'autres sites contemporains.
Il est ainsi démontré que l'assemblage lithique de la couche supérieure du Paléolithique moyen (GH 3) peut être clairement associé aux assemblages de l'Europe centrale, en raison de la présence de Keilmesser et d'autres éléments communs dans le contexte des Keilmessergruppen. Le concept dominant de débitage est le concept Levallois. Si les ensembles issus des unités des GH 4x et 4 sont quantitativement plus restreints, ils montrent des indices probants d'une même association. Au début de l'étude, la présence des Keilmesser était surtout connues par les travaux de R. Desbrosse et de quelques autres, au cours des années 1970, à partir des collections anciennes de la Grotte de la Verpillière I (fouille Méray, 1868).
La présente étude débat des industries unifaciales et bifaciales, sans exclure l'utilisation de matières premières plus grenues comme le quartzite, afin d'obtenir une vue globale des industries du Paléolithique moyen tardif présentes sur ce site. Des vestiges lithiques provenant des dépôts perturbés (situés à la partie supérieure de la stratigraphie) ne jouent qu'un rôle mineur dans cette analyse. Cette étude fournit ainsi un corpus détaillé d'observations, qui sont également attestées pour d'autres sites paléolithiques de la Côte chalonnaise.
Plus globalement, cette thèse traite des problèmes liés aux systèmes de classification des industries lithiques du Paléolithique moyen et tente de trouver des ponts entre les systèmes français et allemands. Il s'agit d'établir des unités chronologiques et spatiales bien contextualisées, pour les ensembles lithiques attribués aux néandertaliens.

(translated and corrected by K. Herkert and Y. Pautrat)

I.3 Motivation

With its stratified layers and homogeneous assemblages, the archeological site of the Grotte de la Verpillière II is in its highest degree suitable to be the subject of a dissertation.

Up to now, the Grotte de la Verpillière II (VP II) is — in addition to Grotte de la Verpillière I (VP I) — the only newly excavated and stratified archeological site in the Côte chalonnaise (wider area around Chalon-sur-Saône) yielding a high-resolution record of the Middle Paleolithic.

In the course of the excavation at the Grottes de la Verpillière I & II , the so called Tübingen excavation system, which was developed and established by Joachim Hahn (e.c. Hahn 1988), was redeveloped, modified and updated to modern electronic possibilities (Frick & Hoyer 2009, 2011, 2012; Frick et al. 2013; Frick et al. 2014). One aim of the work group of Prof. Floss is and was to establish systematics for excavation and analysis in the work area of southern Burgundy. This dissertation also contributes to this aim. It will show possibilities how lithic assemblages can reveal information about the human behavior and is a piece in the puzzle of Neanderthal's Paleohistory.

Eastern France suffers in only modest research activities in the field of paleolithic research (in contradiction to southwestern France or the Paris basin). Therefore only a small amount of well stratified and recently excavated Paleolithic sites are available to establish a reliable chronology of Pleistocene times. This work — embedded into diverse university projects — wish to give an impulse to fill in this gap.

After long consideration, the author decided to write the present work in English. The motives to this decision are numerous. On the one hand, the English language has been established as the major language of prehistoric research. On the other hand, this dissertation discuss an archeological site in France. Thereby researchers from France should also have the possibility to participate on the results.

To write such a long work in a non mother-tongued language is definitely a challenge and we do not want to hide the fact that for sure certain circumstances might be better illustrated and refined in the native language. Nevertheless, to write such a long text in another language is not to be sneezed at and only skill comes with practice!

If someone is wondering, in reading this thesis, that here normally all siliceous lithic raw materials are studied in a similar way, the following sentences can explain these fact: In the beginning of the study of the lithic material from Grotte de la Verpillière II it was visible on the one hand that some objects from quartzite show removal negatives as well and in the course of studying we found a nodule from the commonly used raw material (flint of the *argiles à silex*) that shows impact features in that sense that it was probably used as hammerstone. So it was our goal to be forearmed if more of these features will occur and that is why we decided to find a solution for data collection that all siliceous raw materials can be analyzed in a very similar manner.

This thesis is written in the attempt to avoid racial prejudices against Neanderthals as it can be read frequently (review of older literature in Trinkaus & Shipman 1993). But still today, the term Neanderthals is often used as synonym for unteachable, stubborn, or stupid persons (Bernstein & Rozen 1993).

An example of this can be found in derogatory synonyms in dictionaries (as example a short list from www.merriam-webster.com, requested 2015-07-10, see tab. 1):

Example sentence	Her boyfriend's Neanderthal tastes and manners were often embarrassing
Synonyms	Barbarian, barbaric, barbarous, heathen, heathenish, natural, rude, uncivil, uncivilized, uncultivated, wild
Related words	Coarse, crude, primitive, rough, uncouth, uncultured
Near antonyms	Cultured, enlightened, humane, sophisticated, genteel, polished, polite, refined, urbane, well-bred, semicivilized
Antonym	Civilized

Tab. 1 - Synonyms and antonyms of the term Neanderthal as found in www.merriam-webster.com (requested 2015-07-10)

Our noble aim cannot be to establish an equality between Homo sapiens and Homo neanderthalensis, but the try to find an objective perspective of consideration. The severity is to find possibilities to consider the life and tasks of another taxon without judging. In my belief direct comparison of us (living people) and an extinct taxon (yes, some genes continue in us) is a very complicated and mostly vainer attempt. As I see, in the last 20 years, new branches and approaches of Paleolithic research were established and I hope we all will find and establish better objective criteria to study Paleolithic people without biases.

The deeper I delve into the field (Neanderthals with its stones, and what they did with them), the more I have to say succinct: „*I do not understand them!*". Quite often I asked myself, why they continued to reduce on this core and why they didn't finish the other one. Of course we can argue with raw material quality, edge angles, bad surfaces, expertise, environmental conditions or special purpose. But there could be also a task behind, we would never think about from our perspective (as Modern Humans).

An important factor for me is that knapping stones is a handcraft. By continuous exercise one can learn the necessary actions and operations, if one has a bit of practical know-how. I come from this area of handcraft (with training from my grandfather and my apprenticeship as tool-mechanic) and trying to learn to knapp for now around ten years. So I converge the field of lithic objects of the Paleolithic from the side of a craftsman with tool-production knowledge. I expect that this way of thinking is manifested in my writing.

Or in combined words of my Professors: „*We have to sit into the Paleolithic people's lap to learn from them with the aim to write their Paleohistory*" (this sentence may combines ideas of Prof. Floss and Prof. Conard about Paleolithic research quite well).
It could be that in some parts the thesis persuade to have the ultimate „recipe" how to study the Middle Paleolithic. This is wrong, of course! It is (like many other approaches) a try to incorporate different traditions of research into an expedient construct of Paleolithic research.

I.4 Structure of the thesis

This work is subdivided into 17 chapters. Each of these tries to be self-contained and examine an aspect of this work. Every section got its chapter, integrated are also the introduction as well as the bibliography.
Chapter I gives the introduction, containing the acknowledgments and short summaries, also the motivation to this dissertation and its general structure. Chapter II discusses parameters that are necessary to understand the formation, modification and use of lithic assemblages in the context of Neanderthals and the Middle Paleolithic record. Chapter III gives an overview to classification systems of the Paleolithic record in regard to facies, techno-complexes and space-time unites in the Middle Paleolithic in a deductive way. Chapter IV introduces the archeological site mostly discussed in this context (Grotte de la Verpillière II). Chapter V explains the methodology used to describe, analyze and display the lithic objects of the assemblages.
Chapter VI discusses the lithic raw materials used to produce the analyzed artifacts. Chapter VII instead presents the litho-technological analyses of GH 3. Chapter VIII presents the analysis of the GH 4x assemblage and chapter IX the analysis of GH 4. Chapter X describes idiosyncrasies and preferences of the studied assemblages. Chapter XI compares the analysed assemblages of VP II with assemblages from VP I. Chapter XII demonstrates the presence of similarities and dissimilarities of assemblages in the contextual area (circulating area, the Côte chalonnaise). Chapter XIII contextualizes VP II in Europe. Chapter XIV summarizes and conclude the dissertation. Chapter XV contains lists of tables and figures, as well as abbreviations. Chapter XVI yields an extended table of contents and chapter XVII finishes this contribution with the cited literature (bibliography). Every citation was integrated with the help of Endnote X7 (university license). The selected output style of the in-text citation and the bibliography is a slightly modified version of ***SpringerBasisAuthorDate*** normally used for in-text cited books.

I.5 Annotations

I.5.1 Introduction

This section shows terms used in this work as well as explanations and meanings of these terms. Here, these terms are not defined, only so called simplified spellings are explained.

Very often terms are used in a *pars pro toto* way (e.g., flake for blank). But also, the other way round is not uncommon (*Totum pro parte*), like the use of the term Neanderthals for classical Neanderthals or the use of the word artifacts if only anthropogenic used or modified lithic objects are meant.

I.5.2 Target or wanted blank

We are using the terms target blank (German *Zielabschlag*, see also Uthmeier 2004) and wanted blank as synonyms. Another possibility would be to use the term preferential blank, but mostly this is used for the one and only blank that results from a preferential core reduction (like from the preferential Levallois method, see also Boëda 1994). But as we will see later (chapter VII to X) other blanks can also be seen as objects wanted for further use. With other words the terms target blank and wanted blanks are used for blanks that cannot be seen simply as waste.

I.5.3 Concept

There are many ways to express that in lithic reduction (if a knapper wants to have specific blanks), one has to follow specific rules and criteria (within physical laws, with specific gestures and techniques) in a specific order (operational chain or *chaîne opératoire*) to get what is wanted. This idea behind a lithic reduction sequence is often called concept (Boëda 1986, 1994). Such concepts are necessary in the performance of a craft and are the logic behind a technical action (Boëda 2013; Frick & Herkert 2014). In our particular case, the combination of stone (Greek *λίθος*, *lithos*) and the reduction technology can be expressed in different ways. Some commonly used terms are listed below:

- Lithic technological concept
- Litho-technological concept
- Stone technological concept
- Technological concept
- Lithic concept
- Lithic reduction concept
- Reduction concept
- Knapping concept

I.5.4 Neanderthals

When we are talking about Neanderthals we are talking about the taxon that was assigned as *Homo neanderthalensis* KING 1864 (see the original description in King 1864). Whether we classify them as own species or as subspecies of *Homo sapiens* LINNAEUS 1758 (see for example in Linnaeus 1894) and therefore as *Homo sapiens neanderthalensis*, there is evidence for anatomical (Harvati 2007, 2010; Harvati-Papatheodorou 2013) and behavioral (Mellars 1996) differences to Modern Humans (as we are, too) visible. Some of these differences are described in chapter II.

To go not to deep into paleoanthropological questions we therefore just speak from the taxon Homo neanderthalensis or the Neanderthals. We definitely prefer now (on the contrary to 2009 when writing the Magister's thesis) the spelling with a ***th***, mostly because in the 19th century, the German word *Tal* (valley) was written *Thal* and the biological taxonomical term also use the ***th*** (emphasis of the origin).

As a rule (and because of our research subject and the dating suggestions), we refer to so called classical Neanderthals (Neanderthals that lived in OIS 5 to 3, around 125 to 40 ka BP). If not, it is explicitly written (like the addition of pre or early).

I.5.5 Chronology

In this work the expression ka BP is used for lat. *kilo annum* (thousand years) and before present (normally the year 1950 of our era) to shorten terms. An alternative expression (b2k) for the term *before the year 2000* was not used in this context, but is common in climate research (e.g., http://www.iceandclimate.nbi.ku.dk/research/strat_dating/annual_layer_count/gicc05_time_scale/).

An example for the use of ka BP can demonstrate this well: instead of using 40.000 years before now, 40 ka BP is used. In the chapter about radiometric dating (chapter IV.5), we are adding the dating technique (in brackets) to the chronological expression, such as 40 ka BP (IRSL) or 40±5 ka BP (IRSL), if a particular chronological result is used.

For clarification the following radiometric dating techniques are mentioned in the text (normally only the abbreviations are used, see tab. 2):

Radiometric dating technique	Abbreviation	Description
Infrared stimulated luminescence on potassium-feldspar	IRSL	Optic stimulated luminescence technique for feldspar
Radiocarbon	AMS ^{14}C	Accelerated mass spectroscopy of radiogenic carbon using ABA, ABOx, Ultrafiltration,…
Electron-spin-resonance coupled with Uranium-series	ESR/U-Th	Dating by grid errors and radiogene isotopes

Tab. 2 - Radiometric dating techniques used at VP II

Calibrated ^{14}C dates are expressed for example as 40±5 ka BP (cal. AMS ^{14}C).

I.5.6 Used computer programs and licences

A vast range of computer programs were used to create this work. Just to mention a few of them, illustrations (figures) are created using *Adobe Creative Suite* (CS6). Trilinear diagrams were produced using free *TriPlot 4.1.2* from Todd Thompson Software (Indiana University, www.mypage.iu.edu/~tthomps/programs/html/tnttriplot.htm, page visited at 2015-10-07). Boxplots (a.k.a. box-and-whisker plots) were created using a free *Excel template* from www.sixsigmablackbelt.de/box-plot/ (page visited at 2015-10-07). Three-dimensional plots were created using *Voxler 3.3* from Golden Software. The data management was done using Microsoft *Access 2013*. All programs that are not free available were run under a licence owned by the University of Tübingen.

I.5.7 Display of lithic objects

In this thesis four varieties of displaying lithic objects are used. On the one hand traditional drawings are used following the rules of Hahn (1992). Additionally, a modified scheme of Dauvois‘ (1976) arrows showing blow directions and directions of negative are used. Drawings and photographs are the background for displaying production sequences of lithic objects. On drawings surfaces are shaded in gray scale, whereas on photographs the same gray scale is used, but the opacity is lowered to 70% to see the structure of the lithic object (see also chapter VII to X). In some figures additional lines, colors, terms or arrows illustrate particular aspects.

I.5.8 Other annotations

There are different terms in the literature to express the typological analysis method established by F. Bordes in the late 1940s and whole 1950s. Following expressions could be found: *Bordian method* (e.g., Debénath & Dibble 1994a), *Bordesian method* (Monnier 2006), *Bordes' method* (Pettitt 2009), *Bordes's method* (Hovers 2009) or *Bordes method* (Kolpakov & Vishnyatsky 1989). We simply prefer using the term *Bordesian method*.

Chapter II: Intrinsic and extrinsic parameters

„The Guide is definitive. Reality is frequently inaccurate.“ (Adams 2009b: 22)

II.1 Introduction

The idea behind this chapter is that the common sense suggests that by analyzing, reflecting and interpreting aspects of the human history the producers and their environment should be taken into account to draw a paleohistorical picture. In this way, a fully detached reflection of lithic objects without thinking about the producers is not possible. For this reason, we are reflecting aspects or better fixed constants (*Grundkonstanten*) that influence the formation, morphology and modification of lithic industry as well as the human use of it.

Papers on the field of paleoanthropology, paleogenetics as well as the prehistory and other disciplines of the last 15 years increasingly show that only interdisciplinary research (the fusion of different approaches to one subject) can reach the aim to formulate a Paleohistory of non-literate human groups. A remarkable example of this coherence is the paleogenetic contribution to the dispersal of Modern Humans (e.c. Bräuer 2008; Sankararaman et al. 2012; Stewart & Stringer 2012; Wang et al. 2013).

In the course of research history of the last 160 years many physical and cognitive features of paleolithic men were detected. It is therefore possible to make an attempt to interweave these features within the interpretation of the archeological record to get a more comprehensive and meaningful picture. The aim altogether should be to contribute a piece in the puzzle to the picture of Paleolithic human history (the human Paleohistory). The term Paleohistory reflects the discussion if the very old non-literate history of humans should be called Prehistory (before the written history) or Paleohistory (the oldest human history). For that, see also the discussion in Eggert (2012) about the German terms *Urgeschichte und Vorgeschichte*. Sometimes it is used in Paleolithic research, e.g., Conard (2010b) or Audouze & Valentin (2010), for pointing out historical aspects.

II.1.1.Assemblages and their producers

The initial point of every reflection of stone artifact assemblages should be (in my opinion) the species which was thought to be the producer, because it combines an element of premisses — as good as physical constants — which should slip into the analyses in a decisive manner. But frequently, however there are ideas formulated to separate paleoanthropological and archeological aspects (e.g., Zilhão 2006a). Nevertheless, the research of more than 150 years suggests that Neanderthals produced what we call classic Middle Paleolithic assemblages. The distribution of Neanderthals in space and time is discussed in chapter III.4 and is not part of this section. In cases of western European assemblages denominated as Middle Paleolithic, we can preliminarily assume Neanderthals (*Homo neanderthalensis*) as there producers (Serangeli & Bolus 2008) and therefore we have to take them and their behavior into account by studying Middle Paleolithic assemblages.

Name of the Individual	Site	Excavator and year of field work	Datation	Archeological entities from the literature	Lithic finds	Paleoanthropological finds	Hominin species	Literature
	Vergisson I (Grotte des Tasnières) in Vergisson, Saône-et-Loire	Razet & Berthaud (1840), Henry de Ferry (1850 or 1865), André Leroi-Gourhan (1946), Marcel Jeannet (1965-1972)	46.970 and 44.830 ka cal BP	*Moustérien de type Quina*	yes	5 teeth of 2 adults and one enfant	Homo neanderthalensis?	Combier 1976, Condemi 2014, Steigerwald 2014, Jeannet 1970
	Vergisson II (Grotte de Ronzevau or Grotte de Maréchaux or Grotte de la Maréchaude) in Vergisson, Saône-et-Loire	André Jeannet (1952), Jean Combier (1954-1961)	> 43.500 BP, 46.430-44.6, 60 cal BP	*Moustérien*	yes	19 teeth, two cranium fragments and three phalanges	Homo neanderthalensis	Combier 1976, 2001, Condemi 2014, Steigerwald 2014,
	Vergisson IV (Grotte ?) in Vergisson, Saône-et-Loire	Jean Combier (1957-1962)	44.600-42.9 70 cal BP	*Moustérien de type Quina*, *Aurignacien*	yes	one tooth and a fragment of a parietal bone, both from an enfant of 6-7 years	Homo neanderthalensis	Condemi 2014, Steigerwald 2014, Combier 1976
	Grotte d'Hyène in Arcy-sur-Cure, Yonne	Alexandre Parat (1889s to 1905), André Leroi-Gourhan (1947, 1949-1958)	Würm I (level 20), Würm I/II (level 15)	*Moustérien*	yes	mandible, maxilla and metacarpus from level 20; 20 teeth, skull fragments, long bones and an parietal bone from level 10; Three teeth from level 15	Homo neanderthalensis) level 20)	Petit-Maire et al. 1971, Baffier & Girard 1998, Steigerwald 2014
	Galerie Schoepflin Arcy-sur-Cure, Yonne	Leroi-Gourhan (1954),	Würm I (correlates with level XVI of Grotte du Renne), 39,5 ± 1,8 ka (for Level IV-2)	*Moustérien*	yes	three teeth	?	Petit-Maire et al. 1971, Steigerwald 2014
	Grotte du Loup Arcy-sur-Cure, Yonne	Alexandre Parat (1890s to 1905), André Leroi-Gourhan (1946-1950)	Würm I/II for level III	*Moustérien*		One tooth from level III; three teeth and skull fragments from level IV	?	Petit-Maire et al. 1971, Tillier et al. 2012, Baffier & Girard 1996, Leroi-Gourhan 1950, Steigerwald 2014

	Grotte du Renne Arcy-sur-Cure, Yonne	Alexandre Parat (1890s to 1905), André Leroi-Gourhan (1946-1961), Francine David (1998)	29,93 to 34,81 ka for the Aurignacien; 35,38 to 37,71 for the late Châtelperronian, 35,5 to 40,97 for the early Châtelperronian and 40,9 to 43,23 for the Mousterian (Hublin et al. 2012)	Châtelperronien (level VIII-X), Aurignacien (level VII)	yes	temporal bone from level X; around 60 isolated teeth from the levels VIII-X; Two teeth from level VII	Homo neanderthalensis (level VIII-X), Homo sapiens (level VII)	Petit-Maire et al. 1971, Delibrias & Fontugne 1990, Hublin et al. 1996, Steigerwald 2014
	Grotte du Bison Arcy-sur-Cure, Yonne	P. Polain (1958),André Leroi-Gourhan & F. Hours (1961-1963), Francine Davide M. Hardy (1995-today)	35,25 ± 0,85 ka, 38,0 ± 1,3 ka (unknown levels); 34,05 ± 0,75 ka and 33,67 ± 0,45 ka (level D); 38,4 ± 1,6 ka (level E); 40,2 ± 1,5 ka (level F), 51,519-44,120 cal BP and 47,951-42,658 cal BP (level I)	*Moustérien*	yes	5 teeth from level J, maxilla and 6 teeth from level I	Homo neanderthalensis?	Tillier et al. 2012, Steigerwald 2014
	Grotte de Fées Arcy-sur-Cure, Yonne	Robineau-Desvoidy (1853), Marquis Paul de Vibraye (1858), Alexandre Parat (1890s to 1905), André Leroi-Gourhan (1947-1965)	Würm	Middle Paleolithic	yes	mandible, phalange? atlas, axis	?	Baffier & Girard 1998, Petit-Maire et al. 1971, Hublin1989, Steigerwald 2014
Genay 1 (skull), Genay 2 and 3 (isolated teeth)	Brèche de Genay or Montagne de Girault in Genay, Côte-d'Or	J. Joly & J.-J. Puisségur (1953-1960)	82 +20/-16 ka (Th230/U234); 75 ± 6 ka (Pa231/U235), all datation at associated animal bones	*Moustérien*	yes	65 skull fragments of an adult (around 40 years old), 25 isolated teeth and a molar of an infant	Homo neanderthalensis	Petit-Maire et al. 1971, Yokoyama 1987, Joly 1955, Pautrat & Verjux 1985, Pautrat & Gommery 2005, Garralda et al. 2008, de Lumley 1987, Steigerwald 2014
Créancey 1 (tooth)	Grotte Boccard à Bas-de-Morant in Créancy, Côte-d'Or	Boccard (1960-1973), Djindjian (1974-1980)	no	*Moustérien* with Levallois (level 65)	yes	upper left I2 (tooth)	Homo neanderthalensis	Djindjian 2005, Maureille, et al., 2008, Steigerwald 2014
Créancey 2 (tooth)	Grotte Boccard à Bas-de-Morant in Créancy, Côte-d'Or	Boccard (1960-1973), Djindjian (1974-1980)	no	*Moustérien* with Levallois (level 65)	yes	upper right P2 (tooth)	Homo neanderthalensis	Djindjian 2005, Maureille, et al., 2008, Steigerwald 2014
Créancey 3 (tooth)	Grotte Boccard à Bas-de-Morant in Créancy, Côte-d'Or	Boccard (1960-1973), Djindjian (1974-1980)	no	*Moustérien* with Levallois (level 65)	yes	lower right M2 (tooth)	Homo neanderthalensis	Djindjian 2005, Maureille, et al., 2008, Steigerwald 2014

Tab. 3 - Table summarizing paleoanthropological remains of Neanderthals in the region Burgundy

In Burgundy n=10 archeological sites yielded paleoanthropological remains of Neanderthals. To give an overview, the tab. 3 (above) lists these finds (see also Steigerwald 2014). The mentioned sites yielding Neanderthal remains are plotted in the following map (see fig. 1):

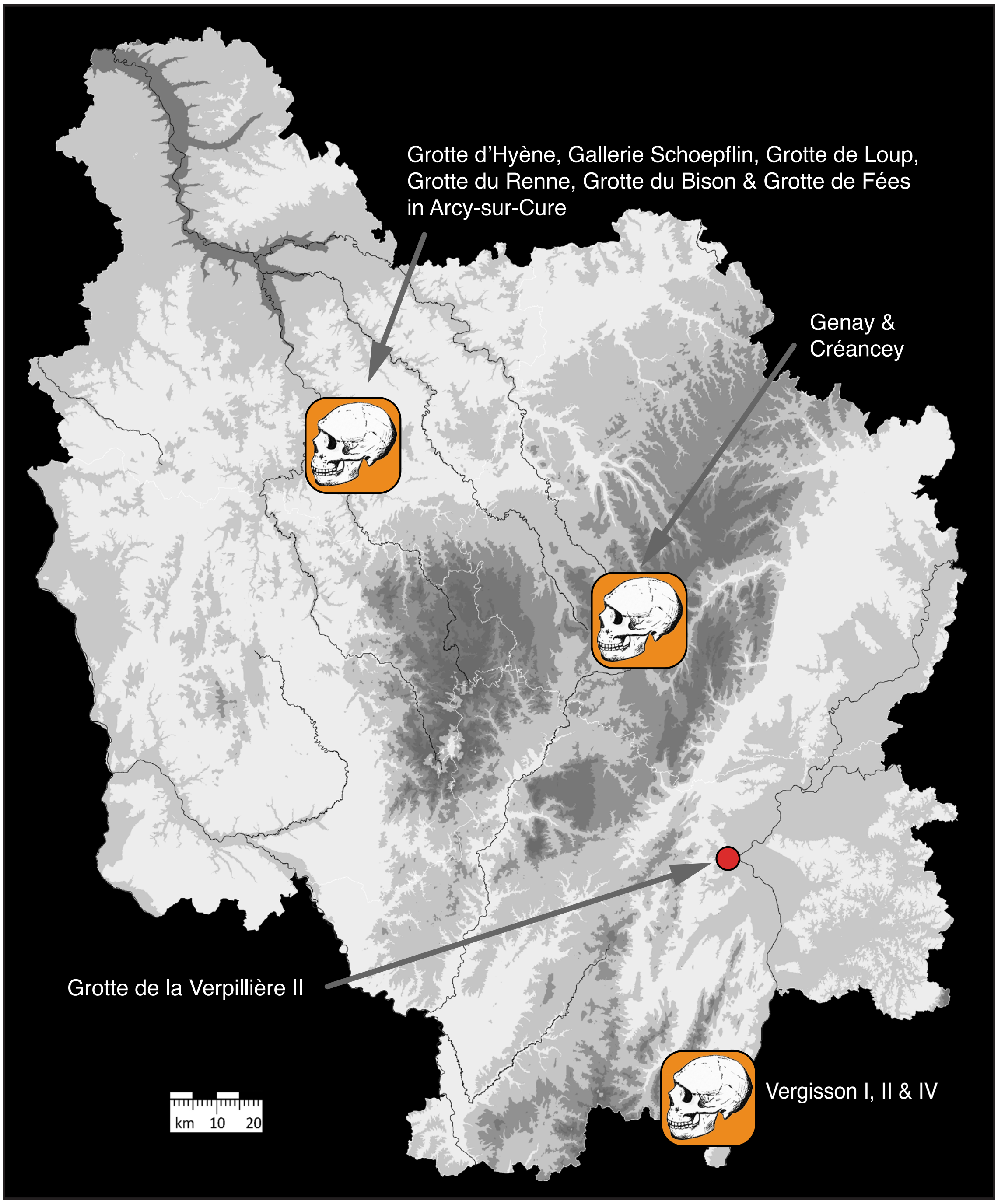

Fig. 1 - Sites yielding Neanderthal remains in the region of Burgundy. 1. Sites in Arcy-sur-Cure (Grotte de Hyène, Gallerie Schoepflin, Grotte de Loup, Grotte du Renne, Grotte du Bison and Grotte de Fées); 2. Grotte de Brocard in Bas-de-Morant, Créancey and 3. Sites in Vergisson (Grotte des Tasnières or Vergisson I, Grotte de la Maréchaude or Vergisson II and Vergisson IV)

At the end of Neanderthal's time span, the connection between paleoanthropological and archeological remains get highly complicated. For some archeological space-time units (we use the term space-time unit here, because they are distributed in a quite specific time and space) around 40 ka BP such as the Châtelperronian or the Uluzzian there is an ongoing discussion about their relation to paleoanthropological remains (see e.g., Bar-Yosef & Bordes 2010; Benazzi et al. 2014; Benazzi et al. 2011; Douka 2014; Floss 2003; Hublin 2012, 2013; Jöris & Street 2008; Jöris et al. 2011a; Lévêque et al. 1993; Moroni et al. 2013; Pelegrin & Soressi 2007; Soressi & Roussel 2014; Zilhão 2006; Zilhão et al. 2015). As we do not deal with such assemblages, we do not need to discuss this subject in more detail.

II.1.2 Division between extrinsic and intrinsic parameters

The *chaîne opératoire* approach uses natural and human parameters to define relationships and influences to conceptual and operational schemes in e.g. lithic reduction (see Soressi & Geneste 2011). The approach here is to have another perspective by dividing such parameters in such that influence from outside (extrinsic) and from inside (intrinsic).

Extrinsic parameters (parameter with an external locus of control) are such that influence something from outside and vis versa for intrinsic (internal locus of control) parameters. The term parameter is used because in experimental archeology it is possible to vary some of these variables (or parameters) to get an idea about their impact on the field of study.

We are using the surface of a lithic object as parting plane. Our decision to define the surface of a lithic object as isosurface dividing extrinsic and intrinsic parameters is based on practical knapping experiences. Or, in other words, this division separates material-immanent factors from factors that influence from the exterior. These extrinsic factors are the human intention (including the human body and mind, as well as population, group and individual or innovation and tradition), the environmental condition and functionality.

Material-immanent factors that influence the knapping process are leaded by physical parameters concluded in breakage mechanics. These are discussed later in chapter II.6. Extrinsic parameters are discussed in the following section. These are physiological and psychological aspects of Neanderthals and their environment, as well.

After the discussion of these somatic and environmental aspects (extrinsic) and material-immanent factors (intrinsic) we compare these with population, intention and functional aspects and try to find definitions for a holistic view on Neanderthals and their lithic assemblages.

II.2 Physiological and psychological consequences on subsistence and settlement behavior

II.2.1 Introduction

To describe physiological and psychological aspects of an extinct taxon is a challenging issue. Nevertheless, Wynn & Coolidge (2012, 2013) point out cognitive and behavioral aspects of Neanderthals assumed from studying the archeological and paleoanthropological record. Their research helps to refine the picture of habits and abilities of Neanderthals (mostly in respect of „classical" Upper Pleistocene Neanderthals), and they show that some Neanderthal features derives from their genetic record and others from lifestyle.

Some remarkable key points for the understanding of Neanderthals habits and abilities are listed in the following tab. 4 (some of them are also discussed in the following chapters, as well). If the null hypothesis for all reflection here is that Neanderthals do not distinguish from Modern Humans (similarity in anatomy and genes), differences can be revealed (Wynn & Coolidge 2013: 9).

Key points	Explanation and literature
Energy requirements	There seems to be a difference of around 10% in energetics between Neanderthals and Modern Humans (Verpoorte 2006) „Comparative data suggest that four important factors contribute to high energy requirements in Neandertals: 1) large body mass and high levels of muscularity; 2) exposure to severe cold stress; 3) consumption of high meat, high protein diets; and, 4) high levels of physical activity." Snodgrass & Leonard (2009)
Labor division	Mostly non to very little division of labor visible in the record (Wynn & Coolidge 2012, 2013; Kuhn & Stiner 2006) Sexual labor division must exist because of the small number of group members (Hayden 2012)
Temperature adaptation	Neanderthals seem to be not as adaptive for low temperatures as Modern Humans, as visible in the archeological record (northern parts of ice age Europe and high altitudes sparsely occupied, e.g. Hublin & Roebroeks 2009)
Thermoregulation and clothing	Insulation against cold using muscularity and not fat (Churchill 2014) Neanderthals must had clothing (Wales 2012)
Body size and mass	Neanderthals were not as tall as Modern Humans but heavier (Churchill 2014)
Muscularity	Neanderthals had much more muscle mass as Modern Humans, as visible in muscle marks and skeletal robustness (Churchill 2014)
Endurance and activity	Neanderthals were highly active (large mammal hunting), but for their energetic requirements not as persistent (Wynn & Coolidge 2012, 2013, Churchill 2014)
Exploitation of the landscape	By reflecting the consistent remains (stones and bones), it seems that the degree of exploitation of the landscape was very low, because of band size and duration of stay (Snodgrass & Leonard 2009, Churchill 2014)
Size of territory	Mostly, the territorial size can be seen as in a daily walking range (Floss 1994, Féblot-Augustins 1997)

Duration of stay	Neanderthal camps were mostly short-term occupied (Verpoorte 2006, Hayden 2012, Pettitt 2000)
Diet	Consumption of high meat and high protein diets (Snodgrass & Leonard 2009) Consumption depends highly on location (fish on the coast, e.g. Finlayson 2004; mid to large mammals in the hinterlands, e.g. Soulier 2013, Rendu et al. 2012)
Enduring running	The ankle of Neanderthals suggest that they could not run as enduring as Modern Humans (Raichlen et al. 2011)
Agility of hand and arm	There seem to be no difference in the agility of finger and hands between Neanderthals and Modern Humans (Niewoehner et al. 2003)
Physical growth rates, lifespan	Skeletal remains of Neanderthals children and teenagers show a fast growth rate (Ramirez Rozzi & Bermudez de Castro 2004), which is not as clearly visible in dental studies (Guatelli-Steinberg 2009) Short lifespan (Churchill 2014)
Experience and learning from grownups	The shorter lifespan of Neanderthals implies a shorter time of learning inalienable tasks and operations, which could result in repeating and consolidate the learned, but without a high rate of innovations (Wynn & Coolidge 2012, 2013)

Tab. 4 - Key points of Neanderthal habits and abilities

II.2.2 Neanderthals versus Modern Humans

Very often Neanderthals are compared with Modern Humans. The reason is simple, because we are Modern Humans and we have a much better idea of our own being then of any another taxon. By doing so, often lists of behavioral aspects are presented to illustrate similarities and differences between Neanderthals and Modern Humans (e.g., Conard 2007; D'Errico 2003; Zilhão 2007). These lists normally contain similarities and differences of the archeological record that is associated with the particular human taxon. As example, the following shows such a behavioral modernity list (tab. 5), as presented by McBrearty & Brooks (2000):

Topic	Listings
Ecology	Range extension to previously unoccupied regions (tropical lowland forest, islands, the far north in Europe and Asia) Increased diet breadth
Technology	New lithic technologies: blades, microblades, backing Standardization within formal tool categories Hafting and composite tools Tools in novel materials, e.g., bone, antler Special purpose tools, e.g., projectiles, geometrics Increased numbers of tool categories Geographic variation in formal categories Temporal variation in formal categories Greater control of fire

Economy and social organization	Long-distance procurement and exchange of raw materials Curation of exotic raw materials Specialized hunting of large, dangerous animals Scheduling and seasonality in resource exploitation Site re-occupation Intensification of resource extraction, especially aquatic and vegetable resources Long-distance exchange networks Group and individual self-identification through artefact style Structured use of domestic space Symbolic behavior Regional artefact styles Self adornment, e.g., beads and ornaments Use of pigment Notched and incised objects (bone, egg shell, ocher, stone) Image and representation Burials with grave goods, ocher, ritual objects

Tab. 5 - List of aspects for behavioral modernity, adopted from McBrearty & Brooks (2000)

As criticised by Shea (2011a, b) such lists mostly represent the knowledge about the younger record such as the Early Upper Paleolithic record and are used to find out if such „*modern*" treats are visible in the earlier record as well. He campaigns the term „*behavioral variability*" (Shea 2011b) for detecting similarities and differences between different entities in terms of their behavior, taxon or the chronological appearance.

Our aim here is not to compare Neanderthals with Modern Humans in their behavior. Rather the object is to find fixed constants (*Grundkonstanten*) using the archeological and paleoanthropological record to define the general behavioral and cognitive range of Late Neanderthals (post-Eemian). This frame of biological, physiological, psychological, behavioral and environmental aspects could help to understand the Neanderthal's legacy with the idea to find evidence for clustering the archeological record.

II.2.3 Temperature adaptation

According to Davies & Gollop (2003) or Stewart et al. (2003) Neanderthals preferred milder climates. Their tolerance to cold was not as high as that of Modern Humans (e.g., Churchill 2014). But as many researchers pointed out, Neanderthals are to a certain degree cold adapted (e.g., Churchill 2014) but not totally to very harsh and extreme glacial climate conditions. This is visible in the post-cranial skeleton, for examples in having large hands (e.g., Churchill 2014).

Another evidence of this preference can be seen in their spatiotemporal range. Hublin & Roebroeks (2009) reckon that Neanderthal movement and occupation resulted in a so called ebb-and-flow movement pattern. With the meaning that Neanderthals did not moved in long distances and stayed in their ancestral area, even if the climate got too harsh. In consequence that populations of areas with too harsh climate died out. These areas were re-occupied piecemeal if the climate got milder. But on the other hand, there is also new evidence for a sparsely but constant inhabitation (between OIS 8 and 3) of areas with harsh climates such as Northern France (see Locht et al. in press).

Researchers working in the south of Europe describe Neanderthals as „peoples of mild climates“ (e.g., Finlayson 2004: ix). But this is challenged by research in Northern Russia in Byzovaya, where Slimak et al. (2011) state a late Middle Paleolithic occupation around 31 to 34 ka BP (a retreat area of Neanderthals). In an area that is believed to be exclusively occupied by Modern Humans in the Upper Paleolithic.

Additionally, some cranial parts of their body were described as being not cold adapted, e.g., the complete face (Rae et al. 2011) and especially the wide nasal aperture (Holton & Franciscus 2008).

Following the research of Churchill (2014), who summarize our knowledge about Neanderthal's temperature adaptation, we can assume that Neanderthals were able to deal with glacial conditions to a certain degree (maybe not as good as Modern Humans) and could also live in warm conditions, for examples during the Eemian interglacial or in the Mediterranean region (from Spain to the East Mediterranean Levant).

II.2.4 Thermoregulation and clothing

In the paragraph before, we referred that Neanderthals were to a certain degree better cold adapted. Nevertheless, we have to keep in mind that the survival in harsh (cold and windy) conditions is only possible in clothes (e.g., from fur and leather) for thermoregulation (Wales 2012).

The conductivity of fur is 20.833 times lower than of the naked skin (Vogel 2005) as Churchill (2014) points out (tab. 6):

Protection	Conductivity
Naked skin	0.5 W/mK
Thick layer of fur	0.024 W/mK

Tab. 6 - Protection and conductivity of skin and a layer of fur, adapted from Churchill (2014)

For Modern Humans, the normal human body temperature (normothermia or euthermia) is 36.8 ± 0.4°C if measured under the tongue (Longo et al. 2012). If the body core temperature is under 35°C (so called hypothermia) symptoms from shivering, mental confusion, muscle mis-coordination, blue extremities to lethal heart stopping can be seen (e.g., Brown et al. 2012). When we suppose that the somatic functions of Neanderthals are similar to them of Modern Humans, we must assume that they must have external body temperature regulation mechanism (clothes, shoes, tents, air traps, hearths, and so on) to survive in glacial times in Eurasia.

Wales (2012) demonstrates with the aid of mapping predictive models (combining ethnographical and climate data) where and when in Europe (during OIS 5 to 3) Humans needed how much body cover to survive. In his modelling using ethnographical data about clothing from Binford (2001) and climate data from the Stage 3 project (Van Andel & Davies 2003), he showed the percentage of body cover that must be assumed.

Oxygen Isotope Stage (OIS)	Name	Climate	Phase	Begin in ka BP	End in ka BP	Duration in ka
2	Second (or last) glacial maximum	very cold	glacial phase	27	16	11
3	Interpleniglacial	cold	early cold phase	37	27	10
3	Interpleniglacial	warm	transitional phase	44	37	7
3	Interpleniglacial	warm	stable warm phase	59	44	15
4	First glacial maximum	cold	glacial phase	66	59	7
4	Late early glacial	warm	transitional phase	74	66	8
5a	Late early glacial	warm	early glacial	85	74	11
5b	Early glacial	cold	early glacial	95	85	10
5c	Early glacial	warm	early glacial	105	95	10
5d	Early glacial	cold	early glacial	117	105	12
5e	Last interglacial	slightly warmer than today	warm phase	130	117	13

Tab. 7 - Position and length of climatic phases of the Upper Pleistocene (Jöris 2002; Van Andel & Davies 2003; Wales 2012)

The tab. 7 above shows length and position in time of the climatic phases of the Upper Pleistocene (with my additions found in Jöris 2002) as used by Wales (2012) and taken from Van Andel & Davies (2003). For getting an idea about the necessity of clothing, in the following model maps the region of southern Burgundy is indicated by a red circle (fig. 2 to 5):

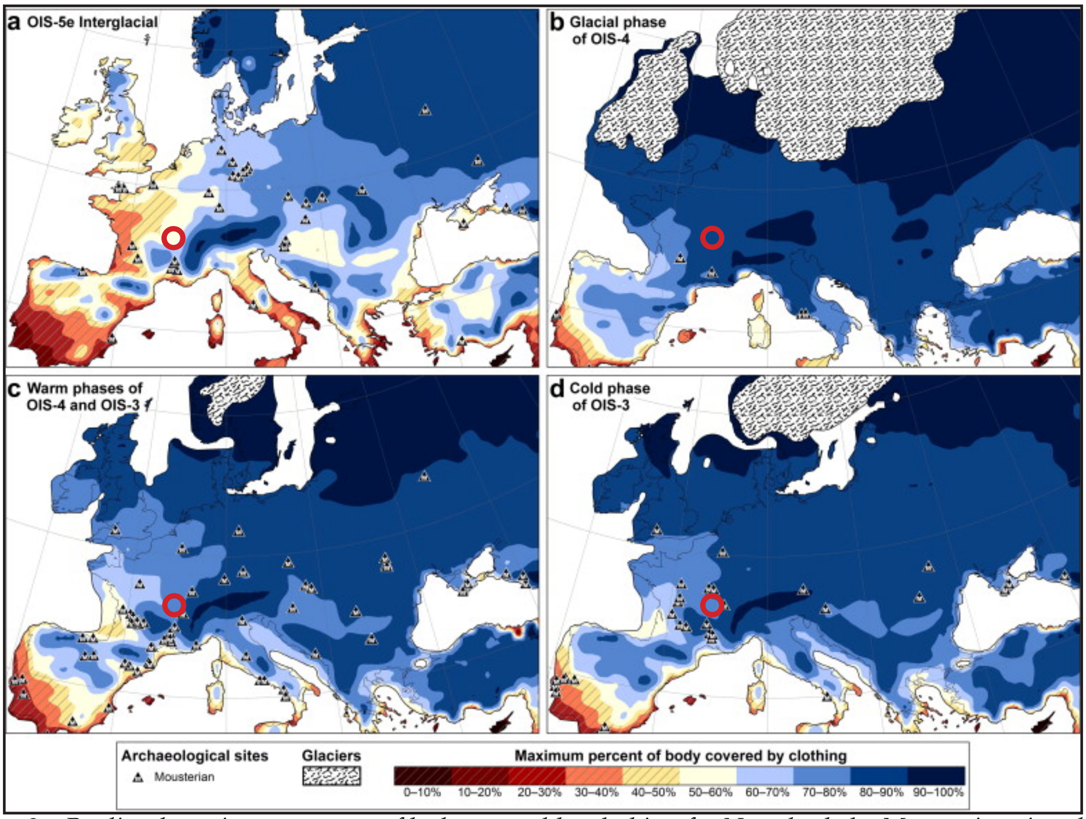

Fig. 2 - Predicted maximum amount of body covered by clothing for Neanderthals. Mousterian sites displayed according to climatic regime: a) OIS-5e Interglacial [130-117 ka BP] (modern climate model), b) Glacial phase of OIS-4 [66-59 ka BP] (Last Glacial Maximum climate model), c) Warm phases of OIS-4 [74-66 ka BP] and OIS-3 [59-37 ka BP], and d) cold phase of OIS-3 [37-27 ka BP], after Wales (2012, fig. 3)

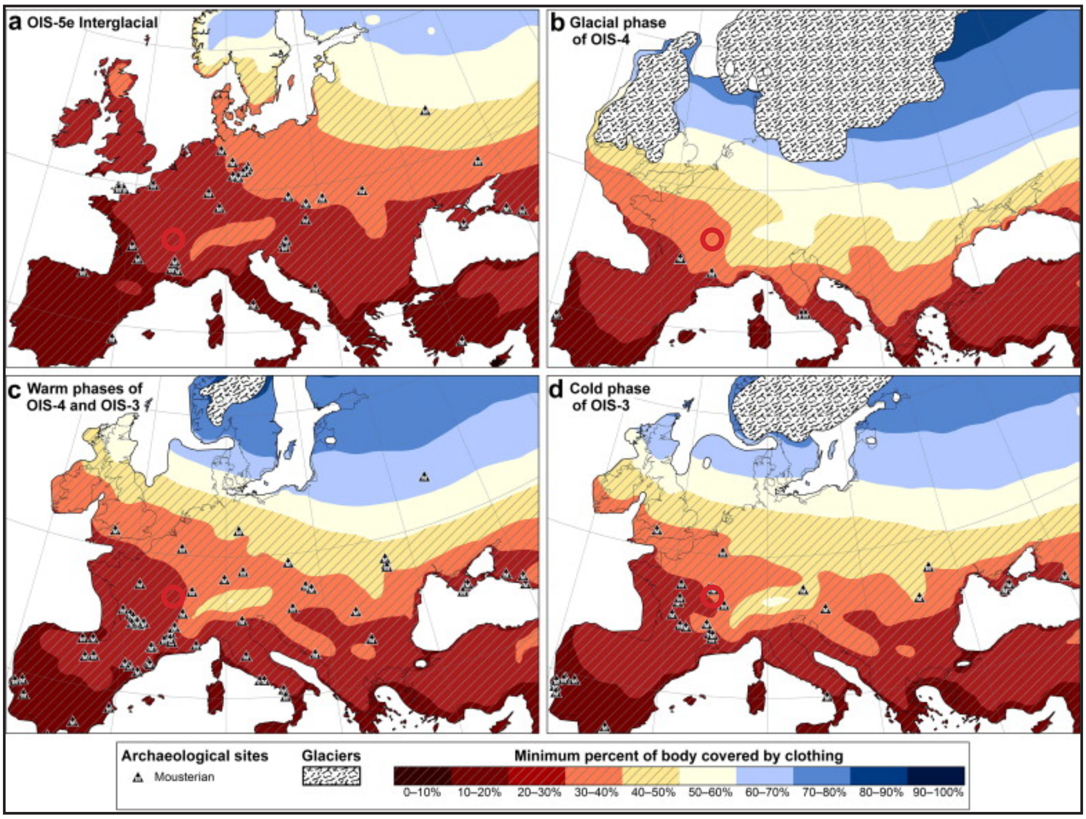

Fig. 3 - Predicted minimum amount of body covered by clothing for Neanderthals, after Wales (2012, fig. 5)

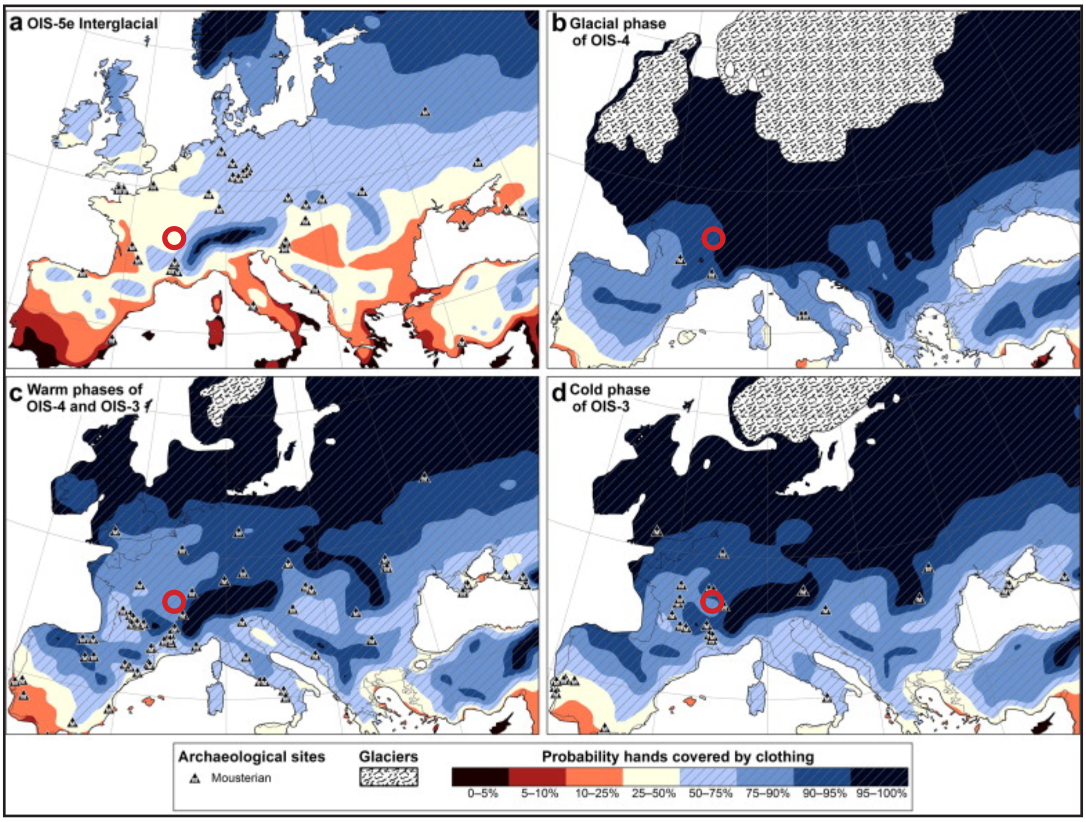

Fig. 4 - Probability that Neanderthals covered their hands with clothing, after Wales (2012, fig. 8)

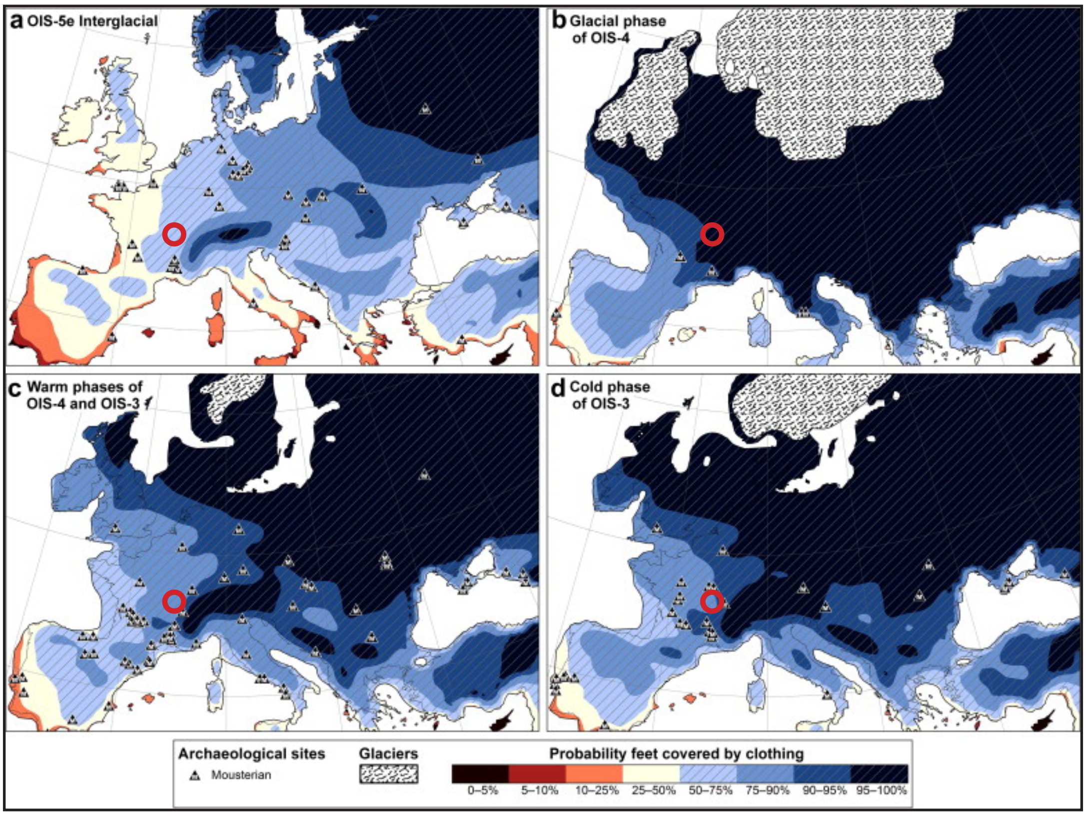

Fig. 5 - Probability that Neanderthals covered their feet with clothing, after Wales (2012, fig. 8)

We collected the data provided on these maps for the area of southern Burgundy, which is shown in tab. 8:

Phase	Predicted maximum amount of body cover	Predicted minimum amount of body cover	Probability that Neanderthals covered their hands with clothing	Probability that Neanderthals covered their feet with clothing
Cold phase of OIS 3	70-80%	30-40%	50-75%	50-75%
Warm phase of OIS 4 & 3	70-80%	20-30%	50-75%	50-75%
Glacial conditions at OIS 4	80-90%	30-40%	90-95%	95-100%
Interglacial cond. of OIS 5e	50-60%	20-30%	25-50%	50-75%

Tab. 8 - Prediction of necessary body cover for the region of southern Burgundy, extracted from Wales (2012)

As we know from preliminary radiometric dating of Grotte de la Verpillière II (Richard et al. 2016; Zöller & Schmidt 2016), the timespan of interest for us is OIS 3 to 4. It shows that Neanderthals could have the need to cover at minimum 20 or 30% or their body and the probability of covered hands and feet is above 50%. Now, a following step would be to refine the used climate data (and body cover) and combine them with the distribution of Middle Paleolithic techno-complexes to see if distinctive pattern exists (but this is not part of this work). This would contribute to discussions about old questions, such as if there is a correlation between assemblage entities and climate as it was proposed by Rolland (e.g., 1977, 1981, 1996). In his view the Bordesian facies of the *Moustérien à denticulés* are related to warm climates and the *Moustérien type Quina*, as well as the *Moustérien type Ferrassie* to cold climates.

II.2.5 Body size, robustness and energy supply

Body size seems to be the most important factor of the biology of an organism. It has major influence on physiological processes and the relationship to the environment. It also governs energy through-flow, storage and is important for thermoregulation, as well (Churchill 2014). Churchill (2014: 73-74) collected data for the body mass and stature estimation in Neanderthals from Ruff et al. (2005; 1997). An abbreviated list of his tab. 4.1 is shown in the following (tab. 9):

Neanderthal (mean)	Mass	Stature	Mass-to- statue-ratio
Male	77.9 kg	166.1 cm	0.47 kg/cm
standard deviation	4.7	4.9	0.03
number	17	16	16
Female	65.6 kg	156.6 cm	0.42 kg/cm
standard deviation	4.6	5.6	0.01
number	11	8	7

Tab. 9 - Mass and stature estimations of Neanderthals, based on long bones measurements, after Churchill (2014, tab. 4.1)

If these mass data is now compared to data (n=121) for Modern Humans collected by Armstrong et al. (1990) it is visible (at best in the mass-stature-ratio) that Neanderthals were quite massive Humans (Churchill 2014: 74), see tab. 10:

Human (mean)	Mass ± SD	Stature ± SD	Mass-to-stature-ratio
Neanderthal male	77.9 ± 4.7 kg	166.1 ± 4.9 cm	0.47 kg/cm
Neanderthal female	65.6 ± 4.6 kg	156.6 ± 5.6 cm	0.42 kg/cm
Modern Human male	76.8 ± 11.3 kg	175.1 ± 6.9 cm	0,44 kg/cm
Modern Human female	59.9 ± 8.0 kg	162.4 ± 6.4 cm	0.37 kg/cm

Tab. 10 - Comparison of mass and stature of Neanderthals and Modern Humans, after Churchill (2014)

Furthermore, Churchill (2014: 78) compares Neanderthals from glacial (OIS 6 and 4) and cold-temperate (OIS 5d to 5a and OIS 3) conditions and concludes that Neanderthals from glacial conditions were slightly smaller and lighter. The post-cranial skeleton of Neanderthals suggest from the size of muscle attachment positions that they had a much higher degree of muscularity than Modern Humans (Churchill 2014: 80).

This robust body (in comparison to Modern Humans) and also their brain size suggest that the metabolism of Neanderthals needed a slightly higher energy supply. To matrix this statement, Churchill (2014: 83-85) calculates the basal metabolic rate (BMR) of Neanderthals with different methods and conclude that for an average-sized adult male Neanderthal 1800 to 2300 kcal/d and for female 1400 to 1950 kcal/d is needed.

If we compare this with the mean of the above described modern male (76.8 kg, 30 years old, extremely active) and female (59.9 kg, 30 years old, extremely active) it is quite visible (tab. 11) that Neanderthals needed more energy for basal body functions just because of their higher weight (BMR for Modern Human counted on www.globalrph.com/schofield_equation_bmr.htm, visited April, 28, 2015 and counts for Neanderthals from Churchill 2014):

Human (mean)	Mass ± SD	Estimated age	Activity level	BMR
Neanderthal male	77.9 ± 4.7 kg	30 years old	Extremely active	1824 ± 78 kcal/d
Neanderthal female	65.6 ± 4.6 kg	30 years old	Extremely active	1417 ± 47 kcal/d
Modern Human male	76.8 ± 11.3 kg	30 years old	Extremely active	1754 ± 167 kcal/d
Modern Human female	59.9 ± 8.0 kg	30 years old	Extremely active	1332 ± 111 kcal/d

Tab. 11 - BMR comparison for Neanderthals and Modern Humans (data from Churchill 2014 and www.globalrph.com)

To get the real food supply of a Neanderthal per day, we also have to find out the daily energy expenditure (DEE). There are several studies that provided different DEE. As we cannot deal to proof its reliability, some are displayed in the following tab. 12:

Sex	Maximum daily energy expenditure (DEE) in kcal/d	Minimum daily energy expenditure (DEE) in kcal/d	Literature
Female	4200	3000	Sorensen & Leonard 2001
Female	2500	2200	Leonard & Robertson 1997
Female	4500	3500	Churchill 2008

Male	5500	3700	Sorensen & Leonard 2001
Male	2700	2500	Leonard & Robertson 1997
Male	5000	3800	Churchill 2008

Tab. 12 - Maximum and minimum daily energy expenditure of Neanderthals

As we can see, the daily energy expenditure is quite high in most of the studies. For comparison, the DEE is calculated using www.globalrph.com/schofield_equation_bmr.htm with the same values as above (tab. 13):

Human (mean)	Mass ± SD	Estimated age	DEE for an extrem activity level	DEE for a very low activity level
Neanderthal male	77.9 ± 4.7 kg	30 years old	4241 kcal/d	2297 kcal/d
Neanderthal female	65.6 ± 4.6 kg	30 years old	3034 kcal/d	1793 kcal/d
Modern Human male	76.8 ± 11.3 kg	30 years old	4210 kcal/d	2289 kcal/d
Modern Human female	59.9 ± 8.0 kg	30 years old	2930 kcal/d	1732 kcal/d

Tab. 13 - DEE comparisons for Neanderthals and Modern Humans

II.2.6 Metabolism and settlement patterns

A first aspect to discuss here is the connection between metabolism and settlement patterns and the implication for the Middle Paleolithic record. As Verpoorte (Macdonald et al. 2009; Roebroeks & Verpoorte 2009; Verpoorte 2006) points out, the indication that Neanderthals had higher energetic requirements for their body maintenance has strong influence on the interpretation of their spatial behavior. Up to now, it seems that Neanderthals needed around 10% more energy for their life than Modern Humans (Aiello & Wheeler 2003; Churchill 2008, 2014; Sorensen & Leonard 2001; Steegmann et al. 2002). For Verpoorte (2006), the difference in energetic needs is an important factor: „Neanderthals used the landscape in different ways from the Moderns" (Stringer & Gamble 1993).

But how can differences in energy intake influence the way people are settling? Some considerations to this aspect are summed up in the following tab. 14 (modified after Verpoorte 2006, tab. 1). It shows that a simple reduction in the effective foraging radius can change the whole movement of a group, if a simple central place model is taken into account (e.g., Kelly 1995):

Mobility parameter	Setting A	Setting B	Diff. (%)
Effective foraging radius (daily circulating radius)	4 km	3 km	75 %
Effective foraging area (daily circulating area)	50.265 km^2	28.274 km^2	56 %
Hypothetical staying time	16 days	9 day	56 %
Annual residential moves	22.8	40.6	178 %
Distance per residential move (= 2x effective foraging radius)	8 km	6 km	75 %
Annual distance of residential moves	182.4 km	243.6 km	134 %
Simplified daily foraging distance	8 km	6 km	75 %
Annual travel distance	2920	2190	75 %

Tab. 14 - Comparison of mobility parameter for a daily calculation radius of 3 and 4 km (Verpoorte 2006)

In result to this consideration, Verpoorte (2006) summarize that only such slightly differences in the effective foraging radius results in a difference in the staying time (how long a camp is occupied), the amount of annual residential moves and there distances and in the end in the annual travel distance, as well.
If we bear that in mind, we can assume that the difference in staying time and the number of residential moves should be visible in the archeological record. In the following we sum up the ideas of Verpoorte (2006) concerning site structure, raw material use, site as a central place and the range limits visible in the Middle Paleolithic legacy (tab. 15):

Feature of the Middle Paleolithic record	Explanation
Mostly lack of structural traces	If a group moves frequently from site to site less investment in site structure is done
Normally short-lived and substantial fireplaces	If a group moves frequently from site to site less investment in site structure is done
Little investment in location	If a group moves frequently from site to site less investment in site structure is done
Mostly short distance for raw material transportation	Less movement in the landscapes leads to shorter distances between raw material source and site
Low proportion of exogene raw materials	Less far distance movement
Expectation that the camp is often changed	A small effective foraging area is exhausted, therefore the camp has to move more often
Significant difference in range limits	Indication of an ebb-and-flow-pattern with climatic fluctuation, because in northern latitudes less biomass is available

Tab. 15 - Site structure, raw material use, site as a central place and the range limits visible in the Middle Paleolithic legacy (Verpoorte 2006)

In concluding this approach, Verpoorte (2006) writes, „*based on the archaeological signature of northwestern Europe, Roebroeks & Tuffreau (1999:128) characterised the spatial behaviour of Middle Palaeolithic hominids as 'short term, episodic and highly mobile'. The focus on Neanderthal energetics explains why this behaviour is preferred.*"

II.2.7 Diet and settlement patterns

A long time, it was assumed that Neanderthals were the top predators, hyper-carnivorous and occupied the most upper trophic level (e.g., Bocherens et al. 1991). The research of the last two decades could change this picture in different ways. New studies show that vegetal diets also played an important role in the subsistence of Neanderthals (e.g., Fiorenza et al. 2015). In addition to the study of faunal remains and their isotopic structure, new studies have found different lines of evidence for diet reconstruction by studying faecal remains of Neanderthals from El Salt, Spain (Sistiaga et al. 2014) or by studying calculus on Neanderthal teeth from Shanidar III, Iraq and Spy I & II, Belgium (Henry et al. 2011). In addition to that, sometimes there is evidence for small (fast) game processing, too (Cochard

et al. 2012; Hardy et al. 2013). New evidence about bird processing and using of feathers (Fumane cave, Italy or caves in Gibraltar, especially Gorham's cave, Vanguard and Ibex Caves) or claws as ornaments (Krapina, Croatia) are also very impressive (Finlayson et al. 2012; Peresani et al. 2011; Radovčić et al. 2015; Romandini et al. 2014) and shows, if Neanderthals had the possibility to stay longer in their camps, their record can yield artifacts that we would normally expect in Upper Paleolithic assemblages (this written, it is not our intention to review the broad range of literature about behavioral modernity or cultural diversity).
Paleolithic Humans were only able to exist in areas where the landscape could provide food, because of their hunter-and-gatherer being (Hublin 2009). If the climate was to harsh they had to move to other areas or they died out (Hublin & Roebroeks 2009). This would suggest that if the paleolithic environment of a landscape can be reconstructed, there should be possibilities to position Humans into this landscape. The human body is in general omnivorous and a vast range of plants and animals (as well as mushrooms) have the potential to serve as diet. In regard to hunting and faunal remains from Neanderthal diet, mono-species (mostly dominance of one species) and multi-species hunting strategies are visible. Salzgitter-Lebenstedt is an example for the dominance of reindeer hunting (Gaudzinski & Roebroeks 2000). Other monospecific faunal spectra are visible in Les Pradelles of reindeers or Mauran for bisons (Rendu et al. 2012). But the other case is also present.

II.2.8 Capability of movement and mind with regards to knapping

Introduction

Conducting precise knapping techniques require in addition to know-how or skill (e.g., Moore 2011; Nonaka et al. 2010; Roux & David 2005) and working memory (Wynn & Coolidge 2004), a particular capability of movement (see for example Hoshino et al. 2014). These motor skills depend (among others) from cognitive abilities (Haidle 2012), visual thinking (Wynn & Coolidge 2012), stereoscopic vision (Kaas 2004), hand-eye coordination, shoulder rotation (Maki 2013; Rhodes & Churchill 2009), arm movement and gesticulation, hand grip and / or hand sensors. Within this thesis, we just have here a short overview to demonstrate that all of the listed motor skills are of high importance for knapping processes. The practical ability or the level of craftsmanship can be seen as a function of all of this factors.

Planing and long-term working memory

In performing a knapping sequence, a knapper needs a step-by-step plan. It is necessary to know which step need to follow on which step to fulfill the requirements of a specific litho-technological reduction concept. The planning process needs to be learned and practiced, and it depends on the knowledge of the knapper, the available raw materials, the available time and the purpose of the knapping process. All these factors influence the bandwidth of the opportunities for action in every step of the knapping process. An knapping expert is controlling this bandwidth and will (mostly) pick out the one that will lead to the wanted result.

Wynn & Coolidge summarizes this as follows: „*Our hypothesis is that Neandertals relied on a form of expert cognition known as long-term working memory, that this ability was essentially modern in scope, and that it formed the centerpiece of Neandertal problem solving.*" (Wynn & Coolidge 2004: 467).

Agility of the hand, grip strength and force resistance

We might ask, if Neanderthals had other preconditions for hand movement, but paleoanthropological studies of wrist and digits movement and hand precision show that the agility of the hand can bee seen as very similar to Modern Humans (Niewoehner 2006; Niewoehner et al. 2003). Therefore, for this study, the agility of the hand cannot be used to find good explanations about differences of stone artifact production between Neanderthals and Modern Humans.

The differences that are visible are concerning the „*grip strength and the ability to resist forces incurred in certain grip positions.*" (Churchill 2001: 2953). And therefore Churchill (2001: 2954) concludes: „*Neandertals, in contrast, had hands well suited to forceful transverse power grips (as when gripping a hammerstone), as indicated by the greater leverage of their thumbs, enlarged crests for the muscles of finger flexion, broad finger tips, and lack of specializations in the midhand (carpometacarpal joints) to resist obliquely oriented reaction forces* […]." Further on, Churchill relates these differences with hafting and retouch technology, compares the archeological evidence from Kebara (related to Neanderthals) and Qafzeh (related to Modern Humans) and concludes that the differences in retouch frequency (Kebara around 20% and Qafzeh around 64%, see Shea 1989) indirectly indicates that „*Sharpening retouch is to be expected with hafted tools, because it's easier usually to resharpen an edge than to replace the lithic. However, retouch on the tools from Qafzeh seems to have been used more to shape the lithics than to resharpen them* […]." (Churchill 2001: 2954).

Maybe the ability of a slightly stronger power grip of Neanderthals can simply explain their preferences of using hard hammer techniques (this technique is part of Boëda's definition of Levallois).

Visual field

An evaluation of the literature about the visual filed of Neanderthals led to the result that no clear ideas exist about it. Therefore we cannot evaluate the influence of it in regard to knapping, but its importance is mentioned in Wynn & Coolidge (2013).

Shoulder rotation, throwing and knapping

Studies about shoulder rotation and humeral retroversion are mostly related to questions about hunting and spear throwing (e.g., Rhodes & Churchill 2009; Schmitt et al. 2003). The construction of the humerus, as well as the shoulder joint seems for them that thrusting lances (mostly the word spear is used) was preferred over throwing spears, depending of the rotation capacity of the shoulder joint. But, another study about Neanderthal humeri suggest that this bone „*may reflect adaptation to scraping tasks, but not for spear thrusting*" (Shaw et al. 2012: 1). The results shows that „*during spear thrusting tasks, patterns of activity among muscles that originate at the shoulder and chest and insert onto the humerus are significantly greater on the left side of the body compared to the right.*" (Shaw et al. 2012: 2). The left arm is seen as the holding arm, whereas the right as pushing arm (right handedness). The suggesting from this study is that the detected patterns speak for an adaptation to intensive scraping with the right hand.

Endurance, power and battues

It is said that a normal Neanderthal would win every discipline if one would be in decathlon with a highly trained Modern Human top athlete (e.g., Trinkaus & Shipman 1993). So here, in following Churchill (2014), we can assume that general endurance and power of Neanderthals was much higher than for Modern Humans. However, Raichlen et al. (2011) demonstrate that the calcaneal tuber length of Neanderthals is slightly bigger than of contemporaneous Modern Humans. They conclude in their study that Neanderthals needed a bit more energy for enduring running than Modern Humans. However, the capability of enduring running is the basis for chevy or battue. In the case Neanderthals needed more energy for enduring running, we can assume that they aligned hunting strategies in such a manner that long battues were not often necessary, because of the high energy loss. In opposite to long distance running and hunting, the so called thrusting hypothesis (Churchill 1993, 2014) was formulated which means that Neanderthals hunted in short distances using thrusting spears. This hypothesis was also supported by trauma analysis of Trinkaus who compared trauma patterns of Neanderthals with rodeo riders (Berger & Trinkaus 1995). Recently, he relativized this, because „*It is now evident that other factors, including interhuman violence and the greater susceptibility of the neurocranial vault to minor traumatic lesions, are involved in the anatomical distribution of traumatic lesions. Furthermore, assessment of Late Pleistocene modern human traumatic lesions indicates a similar pattern to that of the Neandertals. These considerations, therefore, indicate that explaining the trauma pattern solely as a result of Middle Paleolithic hunting weaponry, or conversely using the Neandertal trauma pattern to argue for ineffective Middle Paleolithic weaponry, should be abandoned.*" (Trinkaus 2012: 3693)

II.2.9 Genetic evidence

It is the current belief of the author that very few published studies about paleogenetics can be related to stone knapping. An exception is the detection of FOXP2 in Neanderthals (Krause et al. 2007). If Neanderthals were (now also genetical assumed) able to speak, as it was suggested by the detection of the hyoid from Kebara (Arensburg et al. 1989), this leads to questions about knowledge transfer by voice and questions about learning and teaching techniques by Neanderthals, as well (e.g., Uthmeier 2013). But future research will show if other genes can be used for relations to lithic studies (possibly studies related to muscles or cognition).

Most of the genetic studies are related to questions about the degree of relationship to Modern Humans (e.g., Prüfer et al. 2013). It is also suggested that Neanderthals had often bright skin and red hair (Lalueza-Fox et al. 2007), which was possibly genetical transferred to Modern Humans (Sankararaman et al. 2014). The paleogenetic research related to their demography is summarized by Sánchez-Quinto & Lalueza-Fox (2015: 1): *„An emerging picture is that Neanderthals had a long-term small population size, lived in small and isolated groups and probably practised inbreeding at times.“*

The genetic evidence that Neanderthals lived in small isolated groups can be of high interest for the interpretation of the archeological record, as it is very complicated to find reliable large-scale patterns for entities of the Middle Paleolithic record (see chapter III). The probability of interbreeding might be also reflected in the archeological record, for example that the transfer of knowledge was only possible inside the isolated group. This can lead to the transfer of enduring traditional patterns, instead of a patchwork knowledge in adapting traditions or knowledge from other groups.

II.3 Environment and their influence on Neanderthal behavior

II.3.1 Introduction

Since Neanderthals were hunter and gatherers we can assume that the environment has had a strong influence on their behavior, mostly in the sense of seasonality and long-term movements of whole populations. But said so, this chapter is not a statement for environmental determinism. However, we must assume that environmental factors (such as relief, latitude, sunshine duration, geology and climate and therefore wind direction, vegetation, water supply, raw material sources and seasonality) had (and have) major influence on Humans living in a particular environment.

An important factor is availability of resources (for daily life like food and water and raw material for implements of every kind). In that way, the major factor that can be influenced by the Neanderthals is position in landscape (location), because Humans can move and are not static as a tree. But these movements must always be connected to environmental factors (availability of subsistence resources) as the carrying capacity of Humans is limited. In more recent times this carrying capacity was intensively extended by pack animal and vehicles. A hunter-and-gatherer is limited to the weight she or he can carry or trail behind. Therefore environments that do not provide available subsistence sources can only be occupied as long as the provisions stretches.

II.3.2 Latitudinal movement

Because of this location factor, we have to compare large territories (in terms of environmental regimes) first. Hublin and Roebroeks (2009) provide a model of repeated local extinction of Neanderthals in northern latitudes in cold and harsh climatic phases, because of glacier extension or rapidly climatic harshness. They assume that Neanderthals did not move in long distances and therefore only minor population movement southward are visible. The remaining population of Neanderthals (in this harsh northern latitudes) died out (regional extinction). On the other hand, Neanderthals extended their territory northward if the climate conditions were more moderate. This so called 'ebb and flow' hypothesis provide a model that has to be proven in the archeological and paleoanthropological record. They use Northern France (and Northwestern Europe, i.e., with the addition of Doggerland and the British Islands) as model region to prove their hypothesis and say that this region was occupied throughout the Middle Paleolithic (with the exception of very harsh climates). To demonstrate migration flows they argue that blade technology (*lames à crêtes* and core tablets) was present throughout the MIS 5 in Northern France and with the harsh MIS 4 conditions this technology disappear completely, without any evidence in Southern regions. Another example is the presence of Neanderthals on the British Islands (e.g., White & Pettitt 2011). Research demonstrates that Neanderthals (respectively Middle Paleolithic industries) were present in the Early Middle Paleolithic (OIS 9-7, around 330 to 180 ka) and the Late Middle Paleolithic (OIS 3, 59 to 36 ka). Their presence is separated by a long hiatus of around 120 ka. The access to these islands were blocked from time to time by the North Sea (in the warm phases). The occupation of the so called Doggerland (the dried out North Sea) is for the Paleolithic hardly researched (but see White 2006; White & Pettitt 2011). Mechanical excavation work northwards of the Nederland (Zealand ridge) unearthed Neanderthal remains (Hublin et al. 2009). From the absence of a region wide chronological grid of the Middle Paleolithic in Burgundy (contrary to Southwestern France, see e.g., Jaubert 2011), the continuity or discontinuity of occupation cannot be proven (see fig. 29). The best evidence

of a frequent occupation (in the Late Pleistocene) in the region is La Baume de Gigny (Campy et al. 1989; Fabre 2010; Navarro et al. 2004), because of its long stratigraphy (more than 20 sedimentological units) and their (quite recent) chronological correlation (between OIS 5a and 3) using oxygen isotopes.
An important observation of latitudinal movement and/or occupation is that much more Middle Paleolithic sites are present in the south of the continent (e.g., Spain, France, Italy, Balkan, Greece, etc.). Many sites in the South show long chronological sequences of occupation and sedimentation (e.g., in the Dordogne or the Middle Rhône Valley).

II.3.3 Environmental parameters for positioning in a landscape

The stage three project discussed a vast range of environmental parameters for the OIS 3 in Europe (Van Andel & Davies 2003). The following lines lists important environmental factors (non exhaustive) for landscape occupation in Paleolithic times:

- Geology and availability of geological raw materials
- Relief of the landscape
- Latitude and altitude
- Accessibility for sunlight
- Climate and seasonality
- Wind direction
- Vegetation
- Accessibility of water
- Migration corridors of animals

As this thesis does not explore these environmental factors on human occupation, they are just listed.

II.4 Population estimation

The calculation of Bocquet-Appel & Degioanni (2013) for Neanderthal demographic estimates result in a contemporaneous population of 5,000 to 70,000 individuals. This large bandwidth is described as being the result of frequent bottleneck situations, maybe caused by highly fluctuating climatic conditions.
Richter's (2006b) demographic estimation bases on the antagonism of two cultural entities during the OIS 3 (MTA and MMO). The model uses maximum distances of raw material importation for calculating territorial size. For the MTA around 80 km is estimated (Féblot-Augustins 1997a, b) and for the MMO distances between 80 in the West and 200 km in the East (Féblot-Augustins 1997b; Floss 1994). His calculation results in territory diameters of 80 to 100 km (see tab. 16). He estimates 20 to 80 territories for the MTA and around 25 individuals per territory for the MMO.

Minimum territory diameter (km)	MTA or MMO size of territory (km2)	MTA social groups (bands) (n)	MTA population (n)	MMO social groups (bands) (n)	M.M.O. population (n)	MTA or M.M.O. population density (n/km2)
40	1256	119.4	2985.6	311.3	7782.6	0.0199
80	5024	29.8	746.4	77.8	1945.6	0.00498
100	7850	19.1	477.7	49.8	1245.2	0.00318
200	31400	4.7	119.4	12.4	311.3	0.0008

Tab. 16 - Richter's (2006) demographic estimation for MIS 3 Neanderthals land use. A band is estimated with 25 individuals, one band per territory (Richter 2006b: 63, tab. 1)

The estimations of Bocquet-Appel et al. (2005) for Upper Paleolithic populations are much lower than the estimates of Richter (2006) for the Middle Paleolithic. The average of the population density of both are compared in tab. 17:

Entity	Population density (n/km2)
MTA or M.M.O. (territory diameter of 40 km)	0,01990
MTA or M.M.O. (territory diameter of 80 km)	0,00498
MTA or M.M.O. (territory diameter of 100 km)	0,00318
MTA or M.M.O. (territory diameter of 200 km)	0,00080
Aurignacien	0,00168
Gravettian	0,00183
Glacial Maximum	0,00257
Late Glacial	0,00722

Tab. 17 - Comparison of population density (individuals per square kilometers) from Richter (2006) for the Middle Paleolithic and Bocquet-Appel et al. (2005) for the Upper Paleolithic

As the comparison of these both approaches show, different basic assumption results in very different results for population density. If we would simply compare the population density of these both studies, their would results in the large size spectrum as assumed by Bocquet-Appel & Degioanni (2013).

II.5 Organic technology

Up to now, there is only little evidence (compared to billions of lithic artifacts) that Neanderthals used hard tissues of perishable organic materials for intensive tool working. Nevertheless, there are site showing the use of bone, antler or ivory as implements for different tasks. But prevalently broken bones are to find and generally it is assumed that the breakage was done because of bone marrow (*Medulla ossium*) extraction (e.g., Gaudzinski-Windheuser & Niven 2009). Since this thesis is not dealing with tools from hard tissues of perishable organic materials, we will just give a short overview to such implements.

Bone, antler and ivory are stable materials that own features that are quite similar to stone and also features that are totally different from stone. They can also be used for a vast variety of tasks. However, what are bone tools? How are they defined? And also, what is their relationship to lithic artifact? Rosell et al. (2011)

define bone tools with these terms: „*From a technological point of view, bone tools include: 1) intentionally polished bones, 2) bones knapped by direct percussion (retouched edges or flaked), and 3) unmodified bones used for a particular purpose.*“ Definition for tools made from ivory or antler are often quite similar. Ivory can be used to produce utilitarian artifacts (as seen in the Upper Paleolithic) like projectile points, awls or beveled tools, also this material was used to create figurine, beads, pendants and musical instruments (e.g Conard 2009; Floss & Rouquerol 2007; Heckel 2015; Wolf 2015; Wolf et al. 2013). In addition to grinding and scraping, there is the possibility to knapp ivory, as well (Heckel & Wolf 2014). Nevertheless, it seems that in the Middle Paleolithic context, this material is not very commonly used (but see Villa & d'Errico 2001). If mallets are excluded, Costa (2010) groups the archeological evidence for bone use in three entities (tab. 18):

Modification	Example	chronology
Unintentional modification because of use	Digging bone tools from Swartkrans (member 1-3) and Drimolen	1.8 to 1.1 ma
Flaking	Bone hand-axe from Castel di Guido	OIS 9
Scraping and grinding	Bone tools from the MSA in Africa and Upper Paleolithic in Europe	OIS 5 to 2

Tab. 18 - Three temporal stages of bone use, adopted from Costa (2010)

II.5.1 Lissoirs

There are examples that bone was used for making smoothing tools (fr. lissoirs). Soressi et al. (2013) report four rib fragments from medium-sized ungulates, likely red deer (*Cervus elaphus*) or reindeer (*Rangifer tarandus*) from MTA layers in Pech-de-l'Azé I and Abri Peyrony (both in Dordogne, France, see also fig. 6). Normally, such lissoirs can be found in younger context like the Châtelperronian (d'Errico et al. 1998; Farizy & Combier 1990), the Protoaurignacian (Schmider 2002), the Early Aurignacian (Leroy-Prost 1975) or the Magdalenian (Deffarges et al. 1974).

II.5.2 Retouchers

Retouchers are the most common tool from hard tissues of perishable organic materials in Middle Paleolithic context. As the name suggests they are probably used to retouch lithic objects. Such retouchers can be made from bones, antlers or teeth (Patou-Mathis & Schwab 2002). They bear marks (pits and scores) that result from intentional and repeated knapping of lithic raw materials. Is seems that the most of the marks seen on these retouchers are perpendicular to the main axis (Mallye et al. 2012). Mostly herbivore bones are used (e.g., Armand & Delagnes 1998; David 2002; Patou-Mathis & Schwab 2002) and sometimes also carnivore bones (Abrams et al. 2014; see also fig. 7). There are even examples that Human bones were used, too (Verna & d'Errico 2011).

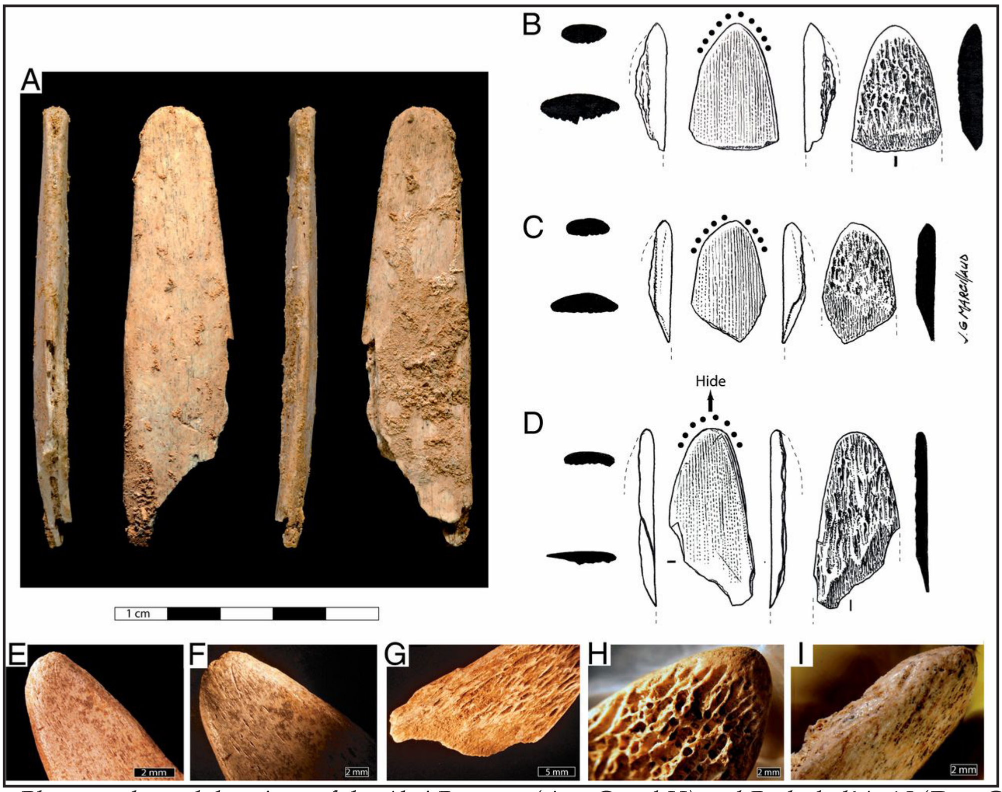

Fig. 6 - Photographs and drawings of the Abri Peyrony (A to C and H) and Pech-de-l'Azé I (D to G) bone tools, adopted from Soressi et al. (2013, fig. 2)

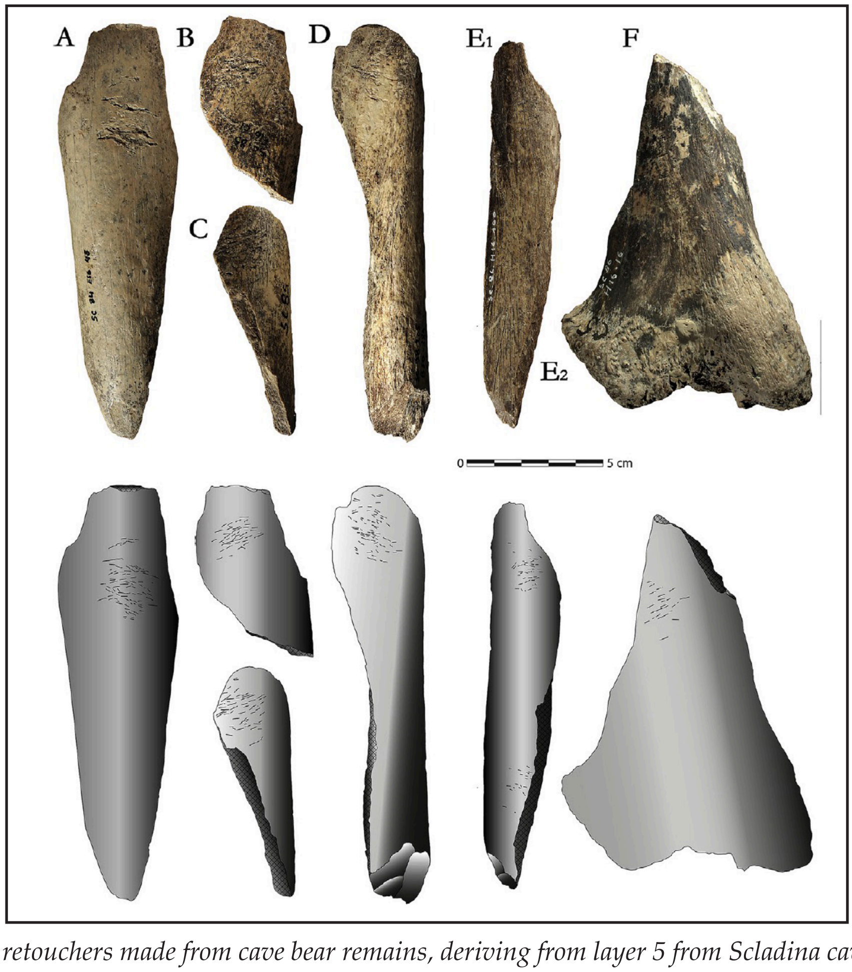

Fig. 7 - Bone retouchers made from cave bear remains, deriving from layer 5 from Scladina cave (Belgium), adopted from Abrams et al. (Abrams et al. 2014; fig. 2)

Examples for such retouchers from Lower and Early Middle Paleolithic context are (as listed in the following tab. 19) displayed here:

Site	Dating	Literature
Boxgrove	MIS 13	Smith 2013
Cauna de l'Arago	MIS 12	Moigne 1996
Gran Dolina TD10	MIS 10-9	Rosell et al. 2011
La Micoque E & H, Dordogne	OIS 9/10	Langlois 2004
Bolomor cave, Spain	OIS 9	Blasco et al. 2013
Qesem cave, Israel	OIS 9	Blasco et al. 2013
Orgnac 3, Ardèche, France	OIS 9	Moncel et al. 2012
Cagny-L'Epinette	MIS 9	Lamotte and Tuffreau 2001
Biache-Saint-Vaast	MIS 7	Auguste 2002
Le Lazaret	MIS 6	Valensi 1994

Tab. 19 - Examples for bone retouchers from Lower to Early Middle Paleolithic context in Europe and the East Mediterranean Levante (see also Daujeard et al. 2014)

For the Late Middle Paleolithic much, much more of these organic tools are reported (these are listed in a following section, see chapter II.5).

Experimental studies related to retouchers

Chase (1990) made some experimental series to find links between specific observed trances on bones and the cause of them. These trances differ from butchery trances. He described these traces as *„deep, short, subparallel, closely clustered grooves, V-shaped in cross section and often joined by small areas where the bone has been broken away […]“* (Chase 1990). In the following (see tab. 20), Vincent (1993) conducted experiments and describe different forms of trances that are attested to different kinds of contact to lithics (see also Mallye et al. 2012):

Marks on the retoucher	Description of the contact
Score mark (hatch marks)	Contact between retoucher and the lithic edge is linear and the scores are formed by violent action
Cup marks (hatch marks)	Contact between retoucher and the lithic edge is linear and the cup marks result from puctiform contact between the lithic edge and the retoucher

Tab. 20 - Marks visible on retouchers

Another experimental study by Armand and Delagnes (1998) show the strong relationship between these mentioned traces and the use of these bone objects as retoucher. Further experimental questions are related to the use of fresh or old bone. The most scholars attest fresh bone a higher efficiency because of its elasticity (e.g., Deaujeard 2008; Tartar 2002; Vincent 1993). But also the periosteum should be removed (e.g., Armand & Delagnes 1998; Deaujeard 2008; Vincent 1993).

How to use such a retoucher?

In the course of her dissertation, Élise Tartar analysed archeological and experimental material to answer questions about the use of retoucher found on Aurignacian sites (Tartar 2009, 2012). Florent Le Méne as an outstanding expert in knapping provided Aurignacian tools and helped with the experiments. She revealed that the horizontal and vertical marks (we would prefer to use the term transversal and longitudinal) on the retouchers derive from different handling and positioning in retouching lithic objects (see also fig. 8).

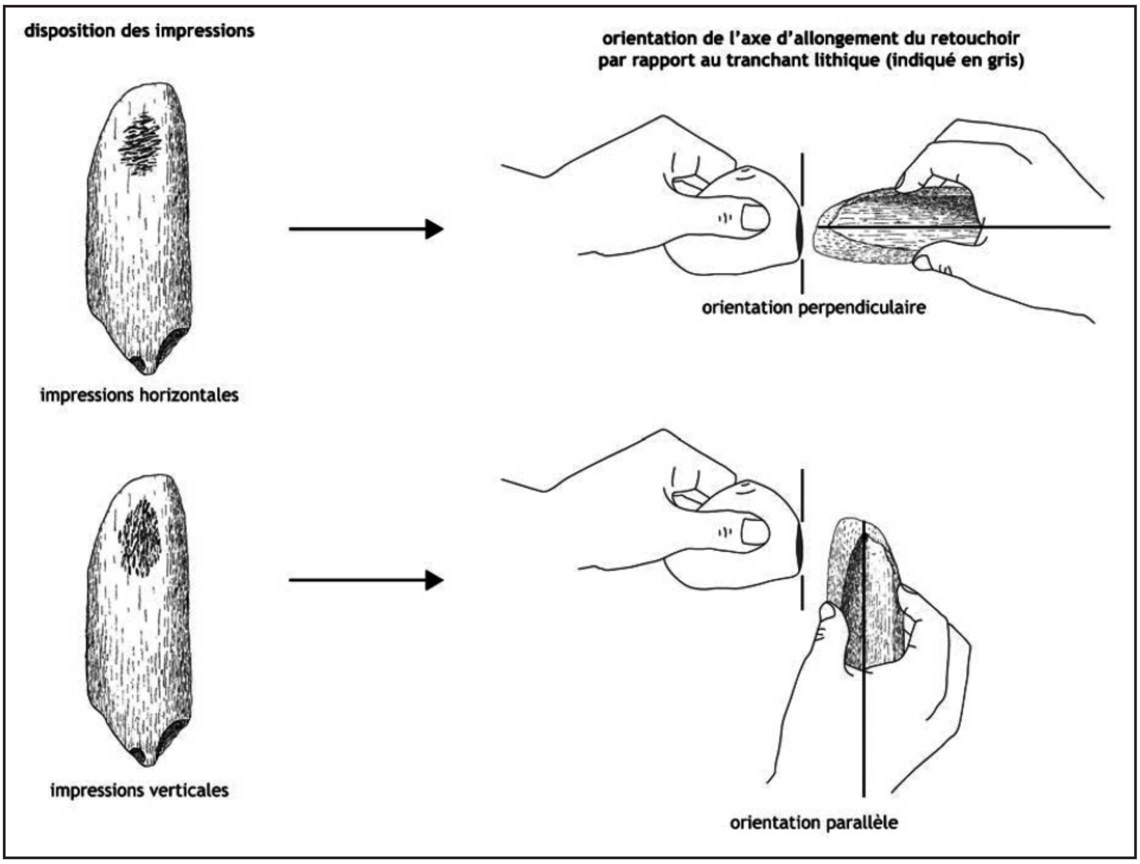

Fig. 8 - Orientation of marks on retouchers. Above: horizontally (transversally) oriented marks, below: vertically (longitudinally) oriented marks on retouchers (adopted from Tartar (2012, fig. 5)

The normal handling of an organic retoucher is quite similar to the use of a soft hammer billet organic hard tissue (see the next paragraph below). If they are used actively, they have to be moved in a tangential way to hit the edge of a lithic object. As it is demonstrated in that way that the position of the marks are never on the edge but a bit centered. As I am not so familiar with organic tools, I would also think that such retouchers might also be used in a passive way as anvil for retouch (compression of a lithic object on the retoucher, dt. *Abdrücken*). Without conducted precise experiments, I would suppose that the traces will be a bit different, because in the anvil technique much more often the lithic object will make scratches on the retoucher from a slip off.

II.5.3 Soft hammer billets from organic hard tissue

The question if soft-hammer percussion technique occurred in pre-Upper Paleolithic times is related to the questions if the observed lithic concepts needed them.

As we can see for simple flake production, physical constraints do not show an imperative necessity for the use of soft-hammer percussion techniques. The majority of lithic blanks production concepts like Levallois, Discoidal or Quina are defined and exclusively performed by using hard hammer techniques (Boëda 1994; Bourguignon 1997; Frick & Herkert 2014; Peresani 2003). Nevertheless, there are different knapping actions where soft-hammers seem to be necessary. This is due to energy spread in the core (velocity of the blow, surface and position of the impact, direction of blow, etc.) which has major influence of the shape of the produced blank.

Particularities concerning the shape of soft hammer flakes

Blanks produced with a soft hammer are normally thin and strongly follow the shape of the reduction surface (see for example Newcomer 1971) and the „imprint" (the negative of the bulb of percussion) is bland expressed. This lead to a particularly regular and plane surface of the detachment negative. If the surface of the reduction surface is quite plane, soft-hammer blanks tent to be trapezoidal (or cake slice shape) in top view.

Very small blanks (e.g., from retouch) are often lenticular in top view. At the very most, bigger blanks are bend in the same way as the flaking surface, which seems not the case for hard hammer techniques (e.g., the parallelism of the Levallois reduction it different to this explanation, see e.g. chapter VII.10.17, VII.15.4 or X.2.2). My personal knapping experience lead me to say that blanks from soft hammer flaking follow the shape of the flaking surface strictly and hard hammer flaking does not have to follow this surface strictly, they can also detach irregular pieces in a controlled way. This circumstance leads to the possibility to shape a surface in different ways (plane, plane-to-convex and convex) as Boëda (1995a, c) explained it for bifacial shaping from Kůlna cave (see fig. 9).

The possibility of detaching blanks that follow the morphology of the reduction surface in a parallel manner makes soft-hammers reduction necessary for uni- and bifacial surface rework, as well. It can be used for the thinning and finishing of bifacial elements. The following tab. 21 lists knapping actions, were soft hammer techniques are very useful:

Knapping action	Necessity	literature
Thinning of a bifacial	As blanks from soft hammer knapping follow the knapping surface, successive thinning by constant thickness of the blanks is ensured	Newcomer 1975 Callahan 1979
Finishing of bifacials	Soft hammer flaking can produce very regular edges	Callahan 1979
Production of normalized blades and bladelets	As the force of soft hammer percussion strongly follows the flaking surface, this can be taken to produce blades and bladelets that are very similar to each other	Pelegrin 2000
Retouching	Soft hammer flaking on edges can produce very regular edges with a constant angle (removing of blanks with a quite parallel surface, instead of blanks with a triangular cross section)	Boëda 1995a, c

Tab. 21 - List of knapping actions, where soft hammer techniques are useful

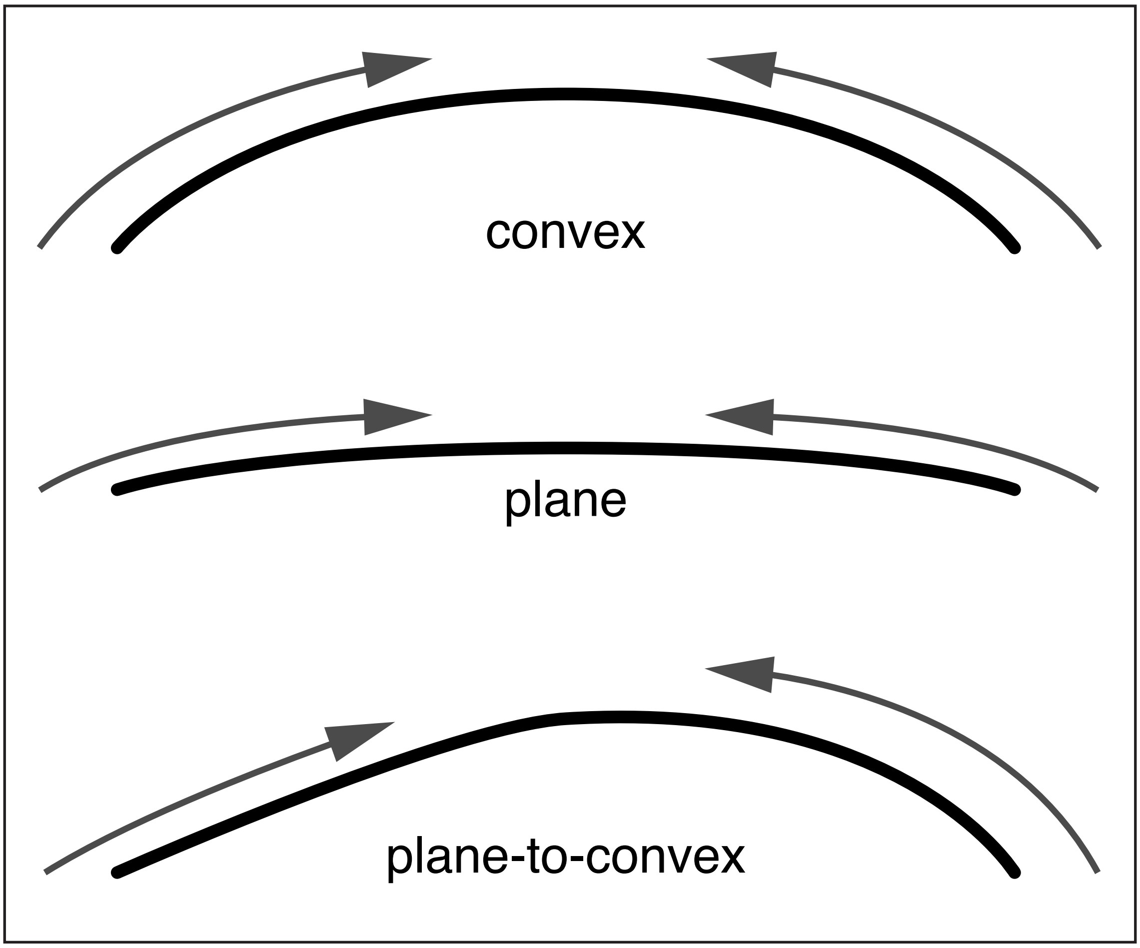

Fig. 9 - Plane and convex shaping possibilities for surfaces (after Boëda 1995c, Abb. 1)

Soft hammer types

According to Jöris (2001) bone, antler and soft-stone billets are thinkable as raw material for soft-hammers, but boxwood billets are also possible. The used material needs to be a bit flexible but hard enough to hold its shape (tab. 22):

Soft-hammer	Literature
Box wood billet	Bordes 1947; Newcomer 1975, pers. comm. F. Le Mené
Antler billets	Jöris 2001: 54
Bone billets	Jöris 2001: 54
Soft-stone billets	Jöris 2001: 55

Tab. 22 - Possible materials used for making a soft hammer

Evidence

There are different lines of evidence for the presences of soft-hammer techniques in the archeological and experimental record. Some possibilities are listed in the following:

- Oblong objects that show traces from direct impact (crushed zones, pits, scores and embedded flint chips, see Bello et al. 2013)
- Diagnostic features on artifacts removed from a core by knapping (keywords: shape of the ventral face, bulb, lip, point of percussion, shape of knapping platform, etc.)

- Diagnostic features on artifacts from that an object was removed (keywords: shape of the negative, shape of the exterior platform angle, bulb, etc.)

A major problem in finding evidence of soft-hammer percussion is that sometimes the use of organic retouchers are seen as indication for it (see e.g., Abrams et al. 2014). In the proper sense this is right because a soft object (the organic retoucher) is used to process a hard material (lithic object). Such an organic retoucher can be called soft-hammer billet. But normally this term is used for indicate bigger hammer like objects that serve as arm extension for the production of blanks for further purposes (débitage) or for the removal of blanks for surface shaping (façonnage). In reading literature about organic billets and organic retouchers, it comes to mind that in some cases both can be used to conduct similar tasks (depending on the size and weight balance of them).

Soft hammer percussion in the Pre-Upper Paleolithic record

To date, the earliest and clearly evident record for the use of soft hammer devices derives from the MIS 13 (533 to 478 ka BP, Lower Paleolithic) in Boxgrove (Bergman & Roberts 1988; Roberts & Parfitt 1999) showing evidence that derive from bone and antler billets (fig. 10), as well as diagnostic features on bifacials and particular by-products.

Fig. 10 - One of the organic soft hammers from Boxgrove, adopted from Stout et al. (2014; fig. 5)

Wenban-Smith (1999) undertook knapping experiments with different techniques for analytical comparisons with the archeological materials (hand axes, débitage, marked bones, cortical and rolled flint nodules) from Boxgrove and suggests that at least four different kinds of knapping implements were use (organic soft hammers from bone and antler, soft-stone hammers made from cortical flint nodules and hard-stone hammers made from rolled flint beach pebbles).

During the Middle Paleolithic many sites exists bearing evidence for the use of soft-hammer techniques for blank production and façonnage (billets), as well as retouching (billets and retouchers). The following table is therefore an abbreviated list, but gives an overview about this organic hard tissue objects for lithic knapping (tab. 23):

Site	Dating	Specimen and peculiarities	Literature
Amont de la Quina, Charente, France	OIS 4	Use of animal bone diaphyses and a human cranial fragment as retoucher, scraping of the object before its use as a percussion tool	Verna & d'Errico 2011, Malerba & Giacobini 2002, Valensi 2002
Artenac, Charente, France	OIS 5?	Bone retouchers in layer 6c, scraping of the object before its use as a percussion tool	Armand & Delagnes 1998, Delagnes et al. 1999
Biache-Saint-Vaast, Nord de la France, France	OIS 7	Use of antler red deer and giant deer, also brown bear bone used as retouchers	Auguste 1995, 2002, Dusseldorp 2009
Buran Kaya III, C, Crimea	OIS 3	Use of a horse metapodia as haft for a stone tool	d'Errico 2003, Burke & d'Errico 2008
Caverna delle Fate, Arma delle Manie, Liguria, Italy	OIS 4?	Use of cave bear bones for retouchers	Psathi 2003, Valensi & Psathi 2004
Chez Pinaud à Jonzac, France	OIS 3	Flakes from the biface production and bifaces, as well as bone retouchers, scraping of the object before its use as a percussion tool	Jaubert et al. 2008, Beauval 2004
Combe-Grenal, Dordogne, France	OIS 4-3	Use of animal bone diaphyses as retouchers	Vincent 1993, Backwell & d'Errico 2014, Faivre et al. 2014
Espagnac, France	39-46 ka BP (U-Th)	Use of animal bone diaphyses as retouchers, scraping of the object before its use as a percussion tool	Jaubert et al. 2001
Fumane, Verona, Italy	around 40 ka	Use of brown bear bones as retouchers, but also bones from red deer, giant deer, elk, bison, chamois and ibex (in layer A3 n=8, layer A4 n=5, layer A5-A5+A6 n=21 and layer A6 n=46, A3 and A4 belongs to the Uluzzian, A5-5+A6 to the final Mousterian)	Jéquier et al. 2012
Isturitz, Pyrénées-Atlantiques, France	OIS 3	Use of bones as retouchers	Schwab 2002
Kabazi V, Crimea	100-60 ka	205 bone retouchers from long bones	Tartar 2002, Veselsky 2008, Chabai et al. 2007

Kulna cave, Moravia, Czech Rep.	OIS 3	167 bone retouchers for the Micoquian layers	Neruda et al. 2011 Auguste 2002
La Micoque, France	OIS 7-9	Bone retouches made on horse bones	Langlois 2004
Noisetier cave, France	OIS 3	Use of bone diaphyses from red deer and ibex to retouch objects from flint and quartzite.	Mallye et al. 2012
Riparo Tagliente	OIS 3	Use of animal bone diaphyses as retouchers	Patou-Mathis 2002 Thun-Hohenstein 2006
Saint-Marcel cave, Ardèche, France	OIS 3	Bone retouchers made from cervid bones	Deaujeard 2004, Szmidt et al. 2010, Moncel et al. 2004
San Bernardino, Tagliente, Italy	OIS 3?	Use of animal bone diaphyses as retouchers	Malerba & Giacobini 1996, 2002
Scladina cave, unit 5, Belgium	MIS 5d to 5b	26 bone retouchers (6 from cave bear bones, Lithic splinter are still embedded in grooves as indications for their function as knapping tools	Abrams et al. 2014
Starosele, Crimea	OIS 5-3	Use of animal bone diaphyses as retouchers	Tartar 2002
Vaufrey cave, Dordogne, France	OIS 5-4	Use of animal bone diaphyses as retouchers	Vincent 1993
Vindija cave, Croatia	OIS 3	Use of animal bone diaphyses as retouchers	Ahern et al. 2004

Tab. 23 - Examples for the use of soft-hammer techniques using organic hard tissues of perishable materials like bone, antler and tooth (billets and retouchers) in Late Middle Paleolithic context for flaking and shaping of lithic objects (sites sorted in alphabetic order)

An interesting case is the fact of small lithic fragments embedded in distal articular surfaces of a red deer humerus from (again) Boxgrove. These indicate that this objects were used as retoucher (Smith 2013). Also cut marks on an antler base indicate their removal and the possibility to be used as billet (Smith 2010). Blasco et al. (2013) conclude that antler from red deer and joints from limb bone were used to knapp hand axes in Boxgrove.

II.5.4 Bifaces made of bone

It seems that the use of bone for manufacturing a bifacially knapped object was mostly performed in the Middle Pleistocene. The examples extracted from the literature (e.g., Costa 2010) are listed below (tab. 24):

Site	Material	Quantity	Dating	Literature
Olduvai Gorge FC Bed 2, Tanzania	Bone	1	1.7 to 1.2 ma	Leakey 1971
Fontana Ranucchio, Italy	Bone	around 4	458±4 ka	Bidditu et al. 1979, Bidditu & Celletti 2001, Segre & Ascenzi 1984
Bilzingsleben, Thuringia, Germany	Bone	1	400 to 280 ka	Mania 1990
Verteszöllös, Hungary	Bone	1	400 to 160 ka	Dobosi 2001

Malagrotta, Italy	Bone	1	around 300 ka	Cassoli et al. 1982
Castel di Guido, Italy	Bone	99	OIS 9	Ono 2006, Mallegni et al. 1983, Mallegni & Radmilli 1988, Radmilli & Boschian 1996
Chongquing, China	Hand axe was manufactured from the mandible of Stegodon orientalis	1	around 170 ka	Wei et al. in press
Rhede, Nordrhein-Westfalen, Germany	Made from a femur of a mammoth	1	120 to 40 ka	Tromnau 1983

Tab. 24 - Bifaces made of bone (Walker et al. 2012)

In addition to these bifaces made from bone examples exist where limestone was used, too. We refer here to the one from Cueva Negra del Estrecho del Río Quípar (Walker et al. 2001).

II.5.5 Connection between lithic and organic technology

In this paragraph we shortly reflect about the connections between lithic and organic technology in the time of Neanderthals. This connection is reflected via physically direct contact of both materials. Examples of this direct contact of both materials is listed (non exhaustive) in the following (tab. 25):

Kind of contact	Process	Examples
Short-time and fast contact of both materials	Organic object for shaping a lithic object	An organic billet or a retoucher is used to knapp stone
Long-time contact, fixation	Organic object for hafting a lithic object	A Levallois point is fixed with glue and binding on a wooden haft
Short-to-long-time contact	Lithic objects for shaping an organic object	Leather or hide is cut or scraped

Tab. 25 - Examples of direct contact between organic and lithic objects

As we saw, Neanderthals (sometimes) used organic materials (billets or retouchers) to knapp lithics. For the production of some stone artifacts the use of organic hammers is even compulsory. But on the other side the use of long-lasting organic materials (bone, antler and ivory) as matrix for tools is only occasionally evident. Unfortunately, the use of wood for all kind of tools is only marginally detectable. But examples from Schöningen (spears, Thieme 1997) or Payre (use-wear and residues for exploitation of starchy plants, birds and fish, Hardy & Moncel 2011) show that under particular preservation conditions organic material can survive and with the aid of elaborated methods they can be detected.

II.6 Physical parameters and lithic breakage mechanics

In addition to other extrinsic and intrinsic premisses for the morphology of an assemblage and a single lithic object, physical constants of breakage mechanics describe the frame inside that a targeted blow will initialize a break that splits an object in a wanted way. The desiderated aim of blank production is the manufacture of useful blanks, that can be used as they are or in a modified way. The morphology of a blank depends on specific premisses and is determined of physical parameters. A knapper has to control these mostly intuitively. Some parameters also depend on the used raw material, and as mostly seen in nature every raw piece has its own peculiarities like cracks, fissures, coarser inclusions or variations in cortex thickness. To initialize a break two variations are quite common: unipolar and bipolar force effects (see fig. 11).

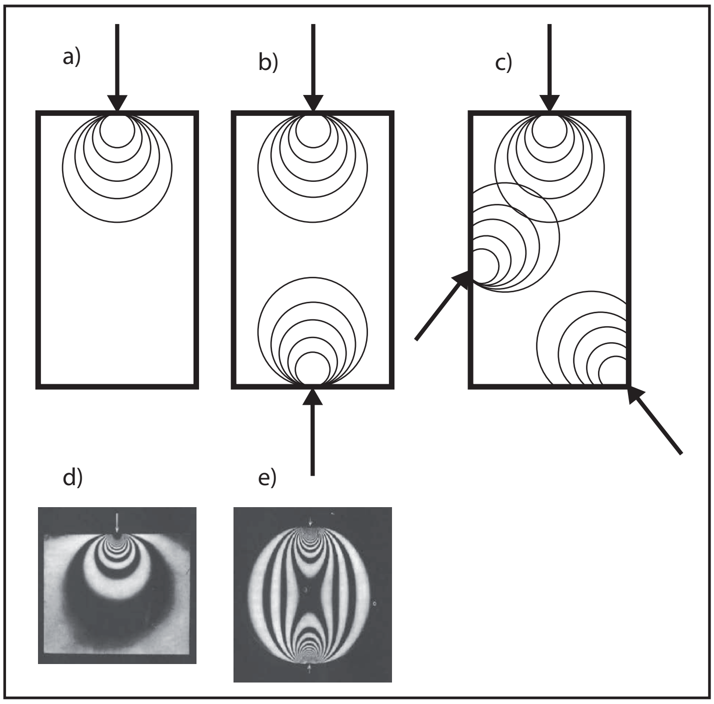

Fig. 11 - Variations of initial force direction (unipolar, bipolar and polypolar). a) spheric wave of a unipolar initial force direction; b) spheric waves of bipolar initial force directions; c) spheric waves of polypolar initial force directions; d) illustration of a unipolar spheric wave with polarized light on plastic cute (adopted from Bertouille 1989: 73, planche 1) and e) illustration of bipolar spheric waves with polarized light on plastic cute (adopted from Bertouille 1989: 73, planche 1)

One active direction of force seems to be the most common case in Paleolithic times, this is commonly called the unipolar technique of knapping.

Such a unipolar fore direction must be explained because the third axiom of Newton (Newton 1726) says that every interaction between two objects contemporaneously produce a counter reaction (*actio = reactio*) or as it is commonly said: For every action, there is an equal and opposite reaction. This implies that in every interaction of objects, a pair of forces acting. That also means that the size of the first forces equals the force of the second and also the direction of the forces are in opposite to each other.

In the case of knapping the active force (*actio*) is generated with the hammerstone or organic billet and the passiv force (*reactio*) is generated by the body that holds the lithic object and the lithic object for itself. In the other case — the bipolar variation — the active action is generated in the same way, the passive reaction is build with an anvil or matrix, the body (the human) just holds the object that it cannot fall. The main difference in these both ways is the passive grasping system (unipolar = soft; bipolar = hard) or the splitting of the reactive force and therefore the amount of absorbed and reflected energy. As it can be seen, the hardness and direction of the intruder, as well as the physical features of the raw material produce different features that are visible at the core and the blank. In that way we can differ between three main kinds of breakage:

- Unipolar Hertzian cone fracture at an edge, a way of sheer off
- Unipolar Bending fracture at an edge, a way of bend up
- Bipolar split fractures with sheer and compression forces

II.6.1 Hertzian cone fracture

In homogenous, quasi-isotropic materials (e.g., amorph silica, quartz varieties, fine grained sandstone, banked limestone, in a sort also ivory or bone) an introduced force (hit or pressure) can lead to a fracture. The introduced energy will spread more or less in a spheric wave and firstly compress the material (Fischer-Cripps 1997). If the energy is high enough, the stress will lead to a break tangentially to the compression wave front (see fig. 12). After a certain time and way the spherical stress wave change to a plane which is flat or S-shaped.

Van Peer (1992: 36) summarize the mechanical and mathematical principles that was brought together by Bertouille (1989). *„They are founded in theories of elasticity and vibration. A shock (compression force) applied to the surface of an elastic body, will traverse that body during a certain time and will form a compression wave [e.g. when a hammerstone hits the platform of a core]. That compression wave will cause a breakage along a plane which is tangential to the direction of the applied force. In the case of a semi-infinite body (a body which is only limited in one of its directions), the rupture plane will first be spheric (spheroid of equal tangential tension of Boussinesq) and, as it gets further away from the point of force impact, change to a curved surface (curved surface of Caquot). In the case of a finite body, the spheroid of equal tangential tension which is the bulb of percussion will always be in relief at the ventral surface of the flake. The lateral limits of that body guide the general direction of the rupture. The proceeding of the compression force through the body as a wave and the resulting alternating compression and extension of the mass, is the reason for a rupture plane in the form of a „S". As it was said above, the contour of the body will direct the general direction of the rupture. According to Bertouille (1989: 37), it has even a definite control over the shape of a flake: due to what* *he calls effets de bord, the flake shape will assume the shape of the core outline; it is completely independent of ridges present at the upper core surface. In other words, a round, oval, or triangular core will produce flakes with these respective shapes. This is the principle that is supposedly underlying Levallois shape-control. This principle of shape-control is in complete opposition with the one explained in the introduction. As a matter of fact, it offers an explanation of the old notion of core and flake shape parallelism. If we put physical and mathematical theory aside for a moment and take a simple empirical stand, it seems that observation contradicts the proposed model of shape control.“*

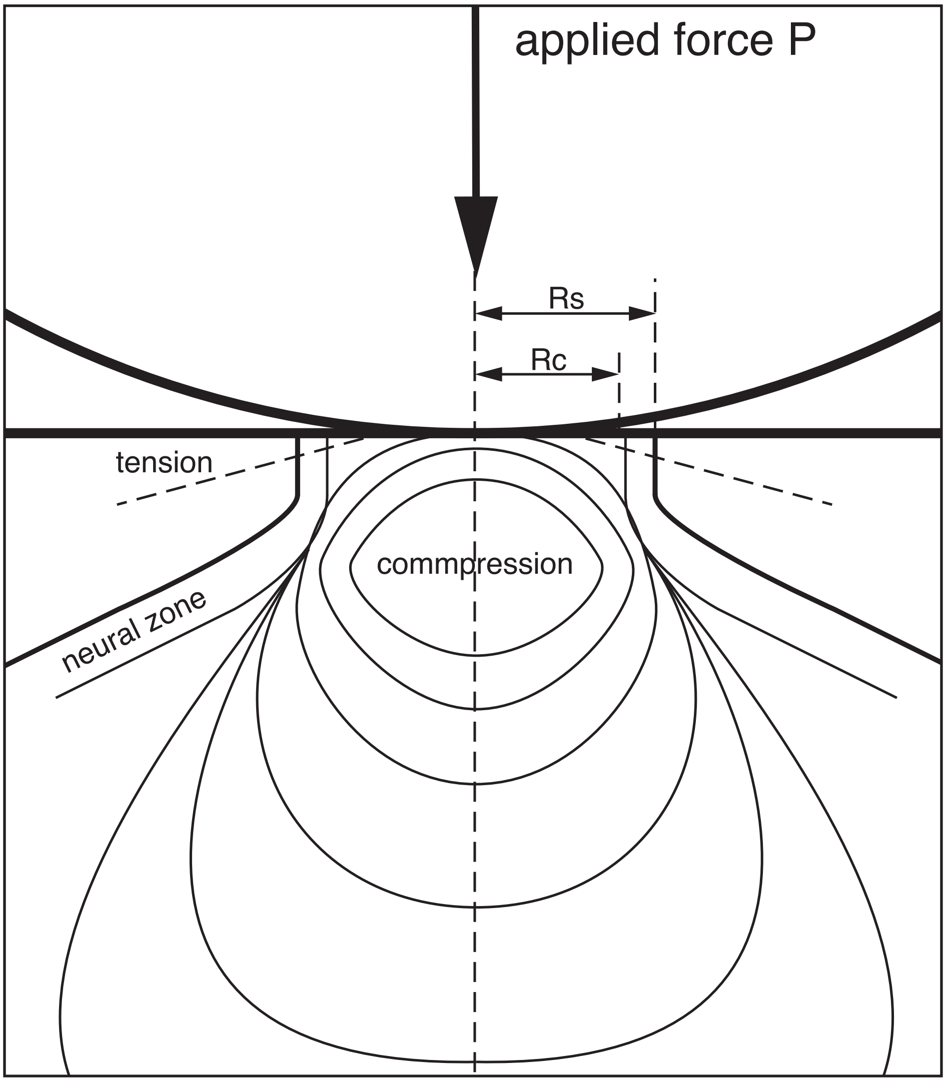

Fig. 12 - Illustration of theoretical aspects of a Hertzian cone crack, after Fischer-Cripps (1997: 1280, fig. 3)

As Van Peer's (1992) observation shows that the combination of the *effets de bord* and the effects of ridges are together of importance for blank shape. In further observations he concludes: „*Simplified, this could be rephrased as follows: when a force is applied close to the surface of a body, the propagation of the force through the mass of the body will be along those points which are situated within a same plane. At those points the body surface is intersected. The exact location of this plane in the body mass will depend on the position of the outer edges of the butt where the flake initially leaves the core, in other words, on the thickness of the butt.*“

The clearest realization of this phenomena is illustrated by a bullet that hit a glass plate orthogonally with high energy. Here, the differences in stress will generate a so called cone fracture, that is named after Heinrich Hertz (e.g., 1882; 1895; 1896). Normally, in quasi-isotropic, hard and brittle materials, this angle is around 136° (Kocer & Collins 1998). The size of the angle depends on different factors, foremost the stability (elasticity) of the homogenous material that is illustrated with the Poisson's ratio v (Greaves et al. 2011). The Poisson's ratio is defined as the negative relation between a thickness change (Δd/d) and a length change (Δl/l) when a force influence:

$$\boxed{v = -\frac{\left(\frac{\Delta d}{d}\right)}{\left(\frac{\Delta l}{l}\right)}}$$

Positive values of Δd/d or Δl/l are equal to an increase, negative values to a decrease. Glass (soda lime glass or sodium lime glass) has a Poisson's ratio of 0,21. This corresponds to a breakage angle between surface and break of 22±1° (Kocer & Collins 1998) and correlates with an Hertzian cone angle of around 136° for silica. Exterior of this angle the material gets tension and interior a compression. The break surface of the cone is the neutral zone without tension and compression. Experiments with glass showed that if the introduced force has an angle between 15° and 90° to the surface, it is highly probable that an Hertzian cone will occur (Chaudhri & Liangyi 1989).
Another aspect is that the contact radius of an intruder is not equal to the initial radius of the Hertzian cone (Fischer-Cripps 1997). It normally differs in some μm. The contact radius can be calculated (Frank & Lawn 1967):

$$\boxed{a = \left(\frac{4}{3} \cdot \frac{kPR}{\mathrm{E}}\right)^{\frac{1}{3}}}$$

In this case k is the material constant of the medium that introduce the energy (Intruder), P is the introduced fore, R is the radius of the intruder and E is the Young's modulus. The break cone starts some 5μm above the surface. Before that , the force will spread orthogonally to the surface (Kocer & Collins 1998).
For lithic analysis it is important to detect the coherencies between knapping angle and Hertzian cone. Experiments on glass illustrate the break progress of an Hertzian cone for different angles of incidence (Chaudhri & Liangyi 1989). In this case high speed photographing was use to detect the progress in big glass plates. Interestingly, the Hertzian cone is not orientated in the same direction as the introduced force (see also fig. 13). In this case, we have to bear in mind that they used clamped glass blocks, tungsten carbide spheres (WC sphere) and they hit the glass block in the center. So the experimental setup it quite different to the requirements of a reduction of a blank with the help to the direct-hard blow. In the most experiments of fracture mechanics and glass industries test are done under ideal requirements to have the results repeatable.

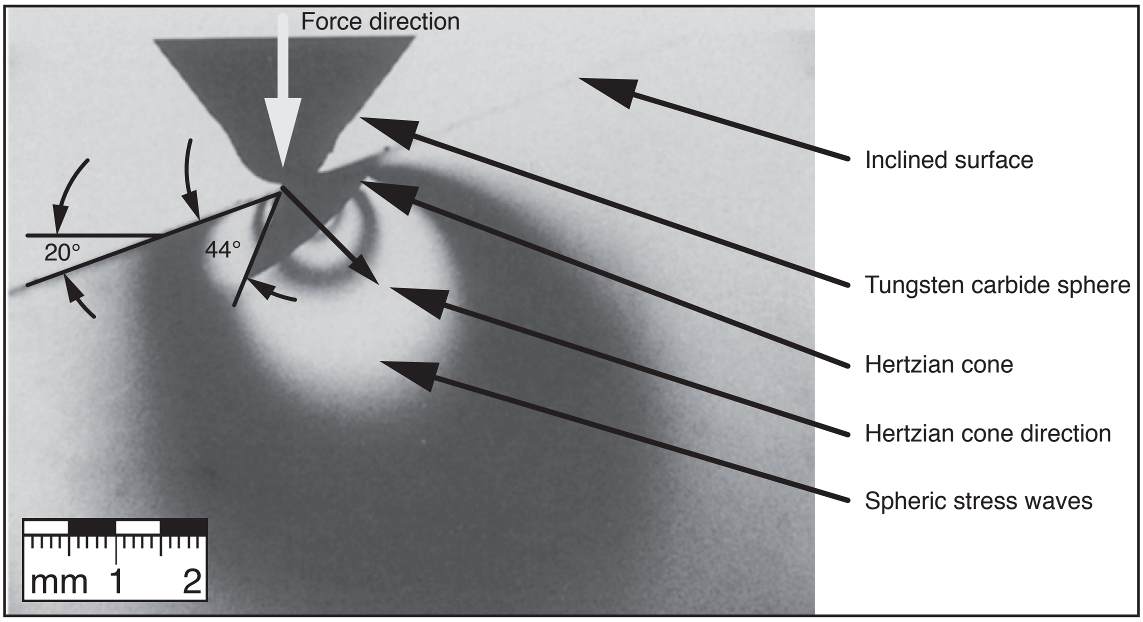

Fig. 13 - Differences in the orientation of the Hertzian cone on an inclined surface, after Chaudhri & Liangyi (1989: 3448, fig. 10)

As we saw a Hertzian cone is not always oriented in the direction of the applied force (Chaudhri & Liangyi 1989). This needs explanation, because in the archeological literature (e.g., Inizan et al. 1995; Inizan et al. 1999; Pelegrin 2005) is written that a Hertzian cone will be orientated symmetrical to its force axis. At this moment in time we would belief in the results of material science first but cannot proof it (possibly this needs to be done later). We would expect that the reflection of force on the surface of the core has an influence to this aspect (Bertouille 1989; Van Peer 1992; Weißmüller 1991).

II.6.2 Bending fracture

The bending fracture differs from a fracture with a Hertzian cone. Here the force direction is not linear but circular/tangential (Cotterell & Kamminga 1987; Inizan et al. 1995; Inizan et al. 1999). A first thought might be that a bending fracture occurs when the knapping direction to the surface is smaller than 15°. Normally, this is done with a long intruder (a billet) as arm extension of organic material like wood or antler, but a stone would be also plausible (Byrne et al. 2006; Newcomer 1971; Pelegrin 2000; Stodiek 1990; Swanson 1975; Tinnes 1995). A bending fracture can also occur if the exterior platform angle is large. The fracture initialization for hammerstones can sometimes be similar to a bending fracture (Cotterell & Kamminga 1987).

By using a billet in a tangential (circular) direction of force material is bend of the core. The material is clinched first and then press apart. Because of the elasticity of the organic billet the contact surface is bigger as for hard hammerstones. In general, there is agreement that the features of a direct-hard-linear blows (hammerstone) differs from direct-soft-tangential blows (organic billet) visibly (Floss & Weber 2012; Pelcin 1997b; Pelegrin 2000).

II.6.3 Bipolar split fracture

A split fracture can divide a lithic object into two or more pieces (Pelegrin 2005). This kind is also called bipolar technique (Clacton technique) or anvil technique (sur enclume) (Breuil 1932b; Eren et al. 2012; Honea 1965; Kobayashi 1975; Kuijt et al. 1996; Mourre 2004; Mourre & Jarry 2010; Mourre et al. 2010; Ohel 1977; Ohel et al. 1979; Shott 1989; Sollberger & Patterson 1976; Vergès & Ollé 2011). The force progression can be seen if plastic blocks and polarizes light is used (Bertouille 1989: 73) as illustrated in fig. 11, above.

A nice modern expression of this split progress can be seen in paving stones, e.g., in Freiburg im Breisgau, where pebbles are split to build handcrafted mosaics on the paving-stone streets. A bipolar spit break can be classified via position of matrix point, knapping point and knapping axis. We can differ a linear (see fig. 14a-c) and an oblique (see fig. 14d-e) split fracture as well.

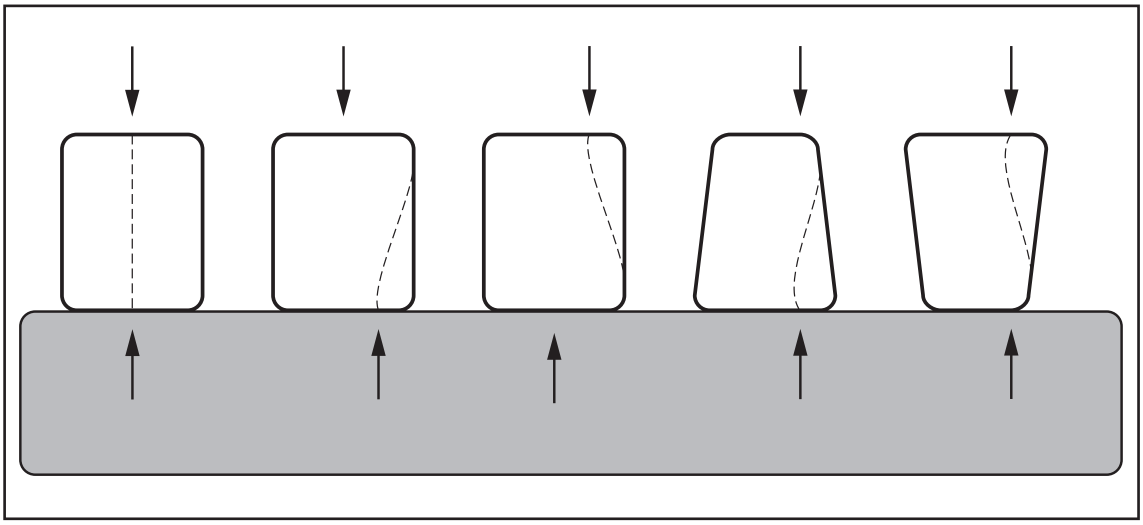

Fig. 14 - Possibilities of bipolar split fracture

In a linear bipolar splitting the matrix point is exactly vis-à-vis to the knapping point and in the knapping axis. The interference of the mutual P and S waves cause an extension of the object. Here, it is necessary that the knapping point is centered. This variation is e.g. used to split a very round cobble into two very similar pieces where no usable angle are provides (Pelegrin 2005). For Boëda (2013) this is a very specific concept of knapping (called F3). In an oblique (or sometimes parallel) bipolar splitting the knapping axis is not congruent to the axis between knapping and matrix point. Mourre & Jarry (2010) called this technique „*Entre le marteau et l'enclume*". Vergès & Ollé (2011) provide models to illustrate this aspect. For a better understanding this models are redrawn (see fig. 14, above).

II.6.4 General breakage mechanics

The force of the hammerstone or billet (that has a speed and weight, F=m * a) is transmitted to the contact area. So it can be seen as mechanical pressure. Inside the knapped object, the pressure on the contact area transforms into spheroidal shockwaves (shear waves or transversal waves, S-waves) and induce the break. Shear waves have a speed of around 3000 m/s (Jaeger et al. 2009) and part the blank from the core. For the initialization of the break the induced force must be higher than the break resistance.

For modern window glass the break resistance is around 100 to 150 N/mm2. For float glass the bending break resistance is around 45 N/mm^2 (DIN 1249-10). For so called bald eagle jasper from Pennsylvania/USA the break resistance is quoted with 60 N/mm^2 and can be lowered to 30 N/mm^2 by heat treatment at 300-400 °C (Schindler et al. 1982). Mono crystallin α-quartz (quartz beneath 573 °C) the break resistance is around 40 N/mm^2 (Hartley & Wilshaw 1973).

As said before, for the initialization of the break the induced force must be higher than the break resistance. However, if the force is to high and the morphology of the reduction surface allows it there is the possibility that a plunging can happen (overshot, *outré-passé*, *Kernfuß*) (Hahn 1993) as it can be seen in fig. 15.

Fig. 15 - Plunged flaking of Mahogany Obsidian (intentionally experimental plunging done by the Author in April 2013)

The common scientific consensus says that this happens because the spread force is not lowered by a break but reflected on the core surface — it might say — „around the corner" and the blank will have a foot-like shape (therefore *Kernfuß* in German).

In conclusion, the following parameters are of importance for a wanted break (tab. 26):

Physical features	Explanation
Intrinsic features of the knapped piece	Break resistance
	Hardness
	Break features (fissility, conchoidal fracture)
	Fissures, irregularities, isotropy, change of granularity
	Angle conditions (shape, roughness, resistance, breaks)
	Platform conditions (shape, roughness)
	Reduction surface conditions (shape)
Extrinsic features of the intruder (hammerstone or billet)	Hardness, toughness, bending strength
	Shape of handle
	Shape of hammerhead
	Weight
	Weight balance, weight distribution
Extrinsic features of the used technique	Blow direction (straight, tangential)
	Blow condition (drawn through, rebound, stopped, pulled, pushed)
	Blow angle
	Blow force
	Fixation (hand, vice-like, thigh, bare-hand, hand-protection)
	Position and dimension of the impact point

Tab. 26 - Physical features to know for detaching a blank.

A good knowledge of physical parameters can exert influence on blank morphology. If the physical features (the behavior) of the used raw material are known, the choice of the force direction or the position of the impact point can have major influence to the thickness of the blank (Cotterell & Kamminga 1977; Cotterell & Kamminga 1986, 1987, 1992; Cotterell et al. 1985; Dibble & Pelcin 1995; Pelcin 1996, 1997a, b, c). The morphology of the knapping surface (as well as the induced force) has influence to length, width and the shape of the blank (Boëda 1994; Floss 2012b; Hahn 1993). The shape of a blank is also influenced with the choice of the intruder and the used technique. Thick and massive blanks can be produced by using the direct-hard-linear technique with a hammerstone (Bourguignon 1997; Hiscock et al. 2009; Pelegrin 1990, 2000, 2001, 2005; Pelegrin & Texier 2004). Very thin but wide blanks can be produced by using direct-soft-tangential technique with an organic billet (Crabtree 1970; Crabtree & Davis 1968; Stodiek 1990).

The direction and kind of force that lead to break can be described with the aid of wave mechanics (Speth 1972). Like in seismicity, primary (longitudinal, p waves) and secondary (transversal, s waves) waves are spread from a center in a spheroid way. They lead to strain and stress zones (see fig. 12). The impulse is generated through the impact of the intruder. The material of the knapped piece is brittle and also elastic and oscillates. At density differences (like at fissures, the core surface to the air or the grasping hand) the spheroidal spread force will be reflected (angle of incidence equals angle of reflection). This cause interference

patters. At positions they are amplified the material gets strained. This can explain the characteristic shape of the break surface between core and blank (Bertouille 1989; Cotterell & Kamminga 1977; Cotterell & Kamminga 1987; Dauvois 1976; Kerkhof & Müller-Beck 1969). We would expect that there are the same forces in using the different techniques of knapping. But the differences are the length of the contact between intruder and core, the elasticity of the intruder and the angle of the induced force.
One characteristic of different knapping techniques is the shape of the contact zone between intruder and core. By using a hard hammerstone (e.g., from quartzite) we would expect a small, round contact zone, sometimes with a ring crack. If an organic billet is used, we would expect a larger, sometimes linear contact zone, because the billet is deformed and much more elastic. The knapping features will be more diffus.

II.6.5 Intrinsic and extrinsic parameters (knapping techniques and raw materials)

There are numerous parameters involved in the production of blanks. Some of them can vary and can be combined. We can divide them into intrinsic parameters (of the core or raw piece) and extrinsic parameters (varied by the knapping person).

Intrinsic parameters of the knapped object

There are material immanent and morphological parameters. Normally, raw material immanent parameters cannot be influenced by the knapper (but remember, one possibility to change raw material features is heat treatment or water soaking). These parameters are physical features like hardness or elasticity and existing fissures or inclusions. Whereas morphological features can be varied by the knapper, such as the roughness of surfaces that influence the crack initiation (Langitan & Lawn 1969) and wave reflexion or the surface shape that also influence reflexion. Also angles can be varied. Material immanent parameters depend on the used raw material, such as the break resistance or the preference direction of break. In general in can be said the more fine-grained and homogeneous a material is the more isotropic it is. If the material is inhomogeneous and coarse-grained the more uncontrolled the breakage is.
The only chance for a knapper to avoid uncontrolled breakage (in regard to raw material immanent parameters) is timely to detect this circumstance and use another object for knapping, remove the awkward part or find another knapping technique to deal with it.

Extrinsic parameters

Extrinsic parameters influence the knapped object from outside and can be varied by the knapper and are related to the knapping technique. On the one hand this is related to the fixation of the knapped object in the hand, on the leg or in a mechanical fixation (keyword vise). On the other hand, the intruder and its used techniques influence the result. Parameters to control here are the kind of the intruder (e.g., inorganic or organic hammer), knapping direction and force effect (e.g., straight, tangential, drawn through, rebounded, drawn away, see fig. 16), knapping angle, force and many more (e.g., Baena Preysler & Carrión Santafé 2003; Bourguignon 2001; Pelegrin 2005).

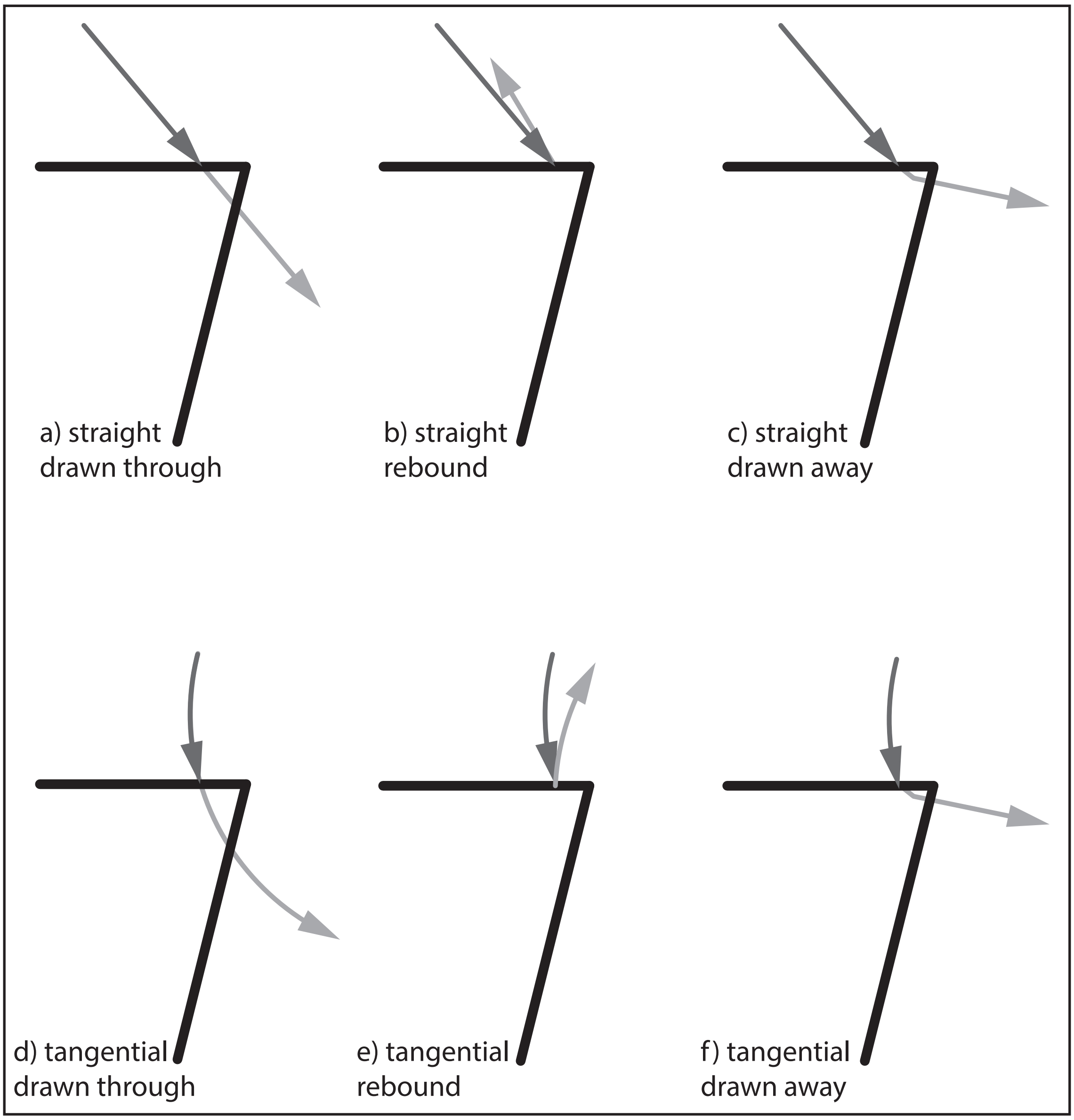

Fig. 16 - Illustration of knapping direction and force effect. a) Straight drawn through; b) Straight rebound; c) Straight drawn away; d) Tangential drawn through; e) Tangential rebound and f) Tangential drawn away

Interaction of intrinsic and extrinsic parameters

Only if all of these parameters interact well, it is possible to produce a blank. A simple example can explain this: If the raw material is too soft (e.g., foam material) there is no possibility to produce a blank of it. Is it hard enough (and brittle) it is possible (like homogenous limestone or silex). Normally, the harder a material is, the more brittle it is. Depending on the parameters the blank will have another shape, as well.

II.6.6 Experiments on morphological criteria in blank production

There are many mechanical studies existing how a blank can be produced with hard hammer techniques (Cotterell & Kamminga 1977; Cotterell & Kamminga 1987; Cotterell et al. 1985; Speth 1972; Speth 1981). It seems that the shape of the core was only casually considered until the 1990s and therefore Weißmüller (1991: 175) write: *„Bei den referierten Untersuchungen über die Bruchmechanik ist die Form des Probekörpers nicht eigentlicher, sondern höchstens beiläufiger Beobachtungsgegenstand; tatsächlich ist sie aber die wichtigste Voraussetzung für das Gelingen des Grundformabbaus mit Hilfe präparierter Kerne.*"

An early study to get an idea of the influence of the core surface for blanks production used six variables that were counted with a computer (Weißmüller 1991):

- Shape of the core
- Position of the contact point
- Direction of the force
- Spread of this force inside the core
- Total reflexion on the core surface
- Time length of the force spreading The variables 1 to 3 and 6 were varied to study there effects. This study is a two dimensional model how a blank is produced. The future will show if it is possible to generate such a model in three dimensions

Since the 1980s H. Dibble and many others study breakage mechanical feature (e.g., Clarkson & Hiscock 2011; Davis & Shea 1998; Dibble & Pelcin 1995; Dibble & Razek 2009; Dibble & Whittaker 1981; Pelcin 1996, 1997a, b, c, 1998; Rezek et al. 2011; Shott et al. 2000; Shott & Trail 2011). Mostly, these studies tried to rebuild the „archeological reality" to find measurable relations. To compare results normalized conditions are necessary. Therefore, some studies used glass cores and wolfram carbide spheres. In this idealized experiments (with knapping machines) for example the morphology of knapping surfaces are tested to see which kind of blanks are produced (Rezek et al. 2011). Or if there is a correlation between size of the butt and the mass of a blank (Clarkson & Hiscock 2011), if exterior angle and butt size vary the length of a blank (Dibble 1997; Dibble & Razek 2009; Rezek et al. 2011; Shott et al. 2000) or if the intruder vary the size of a blank (Pelcin 1997b). The ideas and results of knapping experiments from the 1980s and 1990s can be seen as visualized in the program *vdFlaker* by Dibble et al. (2003). The following fig. 17 displays some screenshots of this program.

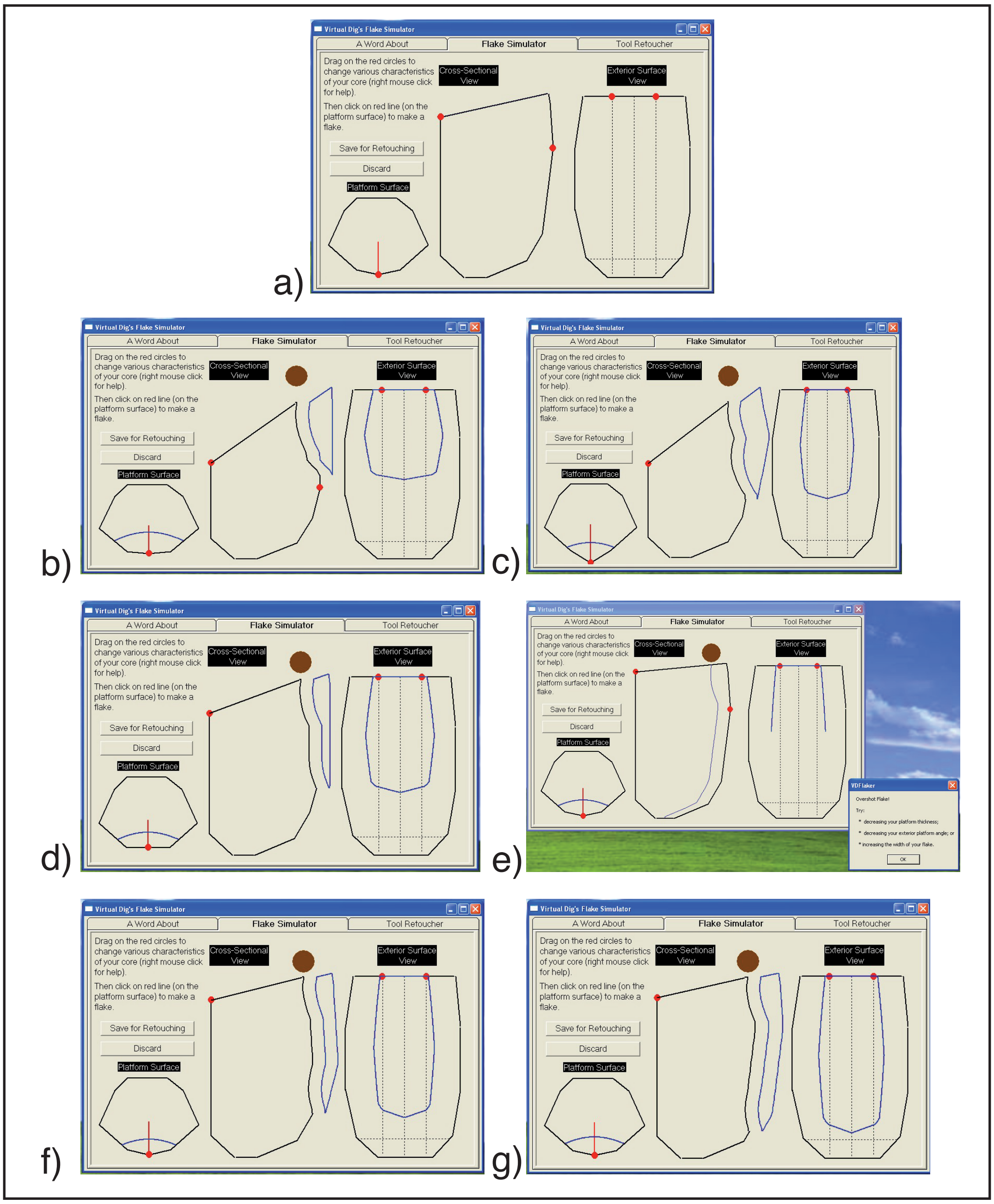

Fig. 17 - Screenshots of Dibble et al. (2003). a) before the detachment; b) flake with hinge because of a to small platform angle; c) flake with hinge because of a to small platform angle; d) short but feathered flake; e) overshot; f) almost ideal flake and g) almost ideal flake

Another kind of experiments are such made by knapping experts. For example the comparison of knapping features if different intruders (hard and soft hammerstones or organic billets) are used (Pelegrin 2000). Also the differences between novices and professional knappers and different raw material are studied (Bril et al. 2010; Eren et al. 2011; Geribàs et al. 2010; Pelegrin 2007).

II.7 Creativity, innovation, tradition and functionality

II.7.1 Introduction

This chapter is exploring nexuses between creativity, innovation, tradition and functionality in regard to stone artifacts. For a long part of the research history, the Middle Paleolithic was seen as a time where minimal innovation happened. New research of the last 20 years struggle this picture. Researchers found evidence that show that new ideas and devices which spread rapidly in the Upper Paleolithic were actually invented earlier. So the proclaimed revolution of the Upper Paleolithic (rapid change of the archeological record) might not be existing. It seems to be real that the focus on long and narrow blanks (i.e., blades and bladelets) as well as organic tool is much stronger in the Upper Paleolithic (Adams & Blades 2009; Tartar 2009). On the other hand laminar technologies were also wide spread in the Middle Paleolithic. For example in the OIS 5 in Northern France, Belgium and Western Germany (Conard 1990; Otte et al. 1990; Poltowicz 2009) or in the Early Middle Paleolithic in the so called Hummalian in the East Mediterranean Levant (Boëda 2013; Hauck 2010; Wojtczak 2014) at a much longer timespan as the Upper Paleolithic. On the other hand formal organic tools are visible only sporadically (Soressi et al. 2013).

The following chapters define and discuss the terms of creativity, innovation, tradition and functionality. After that the interaction of these is discussed in regard to the Middle Paleolithic record.

II.7.2 Creativity and innovation

Innovation is the process of introducing a new idea, or device or method (www.merriam-webster.com/dictionary/innovation). In regard to stone artifacts, innovation can comprise the development of a new shape, a new handling, a new usage, a new fixation or the use of a new raw material for production. And creativity is the play with and selection of original ideas or imagination (*Gedankenexperiment*) out of a range of possibilities. Innovation is dependent of creativity. We would think that an innovation is mostly rather a little modification than a complete new invention.

Hafting

According to Wynn and Coolidge (2012) the only real innovation of Neanderthals is hafting. But as we see, hafting was also used for spear points by earlier hominids, as hafting-trace evidence from Kathu Pan 1, South Africa (Wilkins 2013) around 500 ka BP or Gademotta Formation, Ethiopia >279 ka BP (Sahle et al. 2013) suggest. Another indirect evidence is known from Boxgrove (around 500 ka) by a semicircular perforation on a horse scapula, (Roberts & Parfitt 1999) or shape and use-wear analysis of points from the Middle Paleolithic (around 250 ka) in Biache-Saint-Vaast (Rots 2013). Wilkins et al. (2014: 2) summarized this with the following words: „*Hafting a stone tip to a wooden shaft was a significant innovation for Middle Pleistocene hominins and may represent the origin of new cognitive and social capacities within the human lineage.*"

Research of the last years show clearly more and more microscopical evidence for hafting in Middle Paleolithic context (e.g., Rots 2009; Rots 2011; Rots 2013). But how can we assess if something is an innovation? Still, the only possibility is to search similarities in the earlier record and maybe detect development processes.

Specific and purposive devises

A remarkable aspect of Middle Paleolithic lithic objects is that some of them seem to had a very specific function (in our case the *Keilmesser* with tranchet blow(s)). However the way to produce them was completely different to production ways seen in the Upper Paleolithic record of Europe, where the production focused on series of blanks (very often blades and bladelets) that have the potential to serve as matrix for a vast range of tools (e.g., end-scraper, lateral retouch, retouched point or burin). The other extremum can be seen in the production of *Keilmesser* with tranchet blow(s). Here, in the complete production procedure the focus is on the final product, which means that the final product must be „seen" from the beginning in the big variety of potentially used matrices. Richter (1997) contrasted in this context two concepts of tool production: the assortment and the serial production (see also chapter III.3.2). The following fig. 18 attempts to illustrate these differences contrasting *Keilmesser* with tranchet blow and tools-on-blades.

The focussing of serial production is also visible in Middle Paleolithic cases. An impressive example is the standardization and specialization of blade production in the OIS 5 in Northern France, Belgium and Western Germany (e.g., Révillion & Tuffreau 1994) or MTA-Biface production of the early OIS 3 in southwestern France (e.g., Soressi 2002), which looks often as these bifaces would derive out of a swage.

Maintenance

Another aspect can also be stressed as innovation. The maintenance of objects for further use. It can be seen as re-confection after production and use of a tool. Maintenance can be separated into four categories, as listened below in tab. 27. The term reuse is used for immediate re-confection after utilization of a lithic object. If a time hiatus is visible between production and use, and the re-confection (mostly via two degrees of patination) this can be called recycling (see e.g., Romagnoli 2015; Vaquero 2011; Vaquero et al. 2015).

Denomination	Time constrains	Modification	Differences in patination
Reuse	Immediate after use	Remoulding	No
Reuse	Immediate after use	Reshaping	No

Recycling	After a hiatus in time	Remoulding	Yes
Recycling	After a hiatus in time	Reshaping	Yes

Tab. 27 - Remoulding and reshaping with and without a hiatus in time

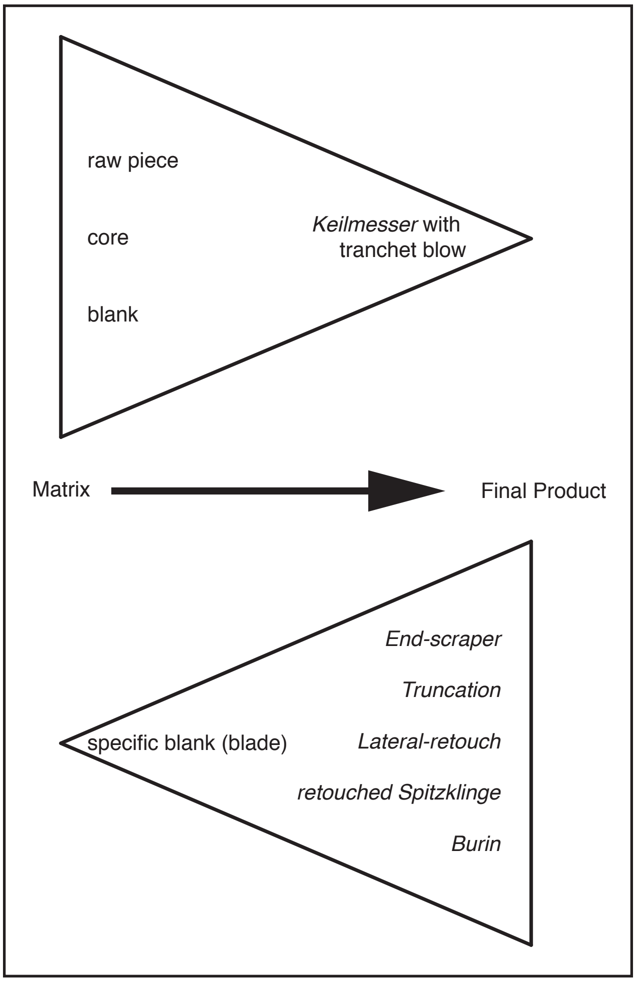

Fig. 18 - Contrary perspectives of the focus in producing lithic objects on the examples of Keilmesser with tranchet blow and Upper Paleolithic serial production

The differences between reshaping and remoulding are illustrated in fig. 19, but may need some explanation. The difference is if the general morphology of an object will be changed or not.

This separation into reuse and recycling as well as reshaping and remoulding is different to the concept used by Romagnoli (2015). For her (Romagnoli 2015: 203) the significant factor of recycling is: „*Evidence of a tool's discard before finalising re-manufacturing for a new use event was assumed to indicate recycling.*" She lists the following features for a discard phase between two use events:

- Tools manufactured on patinated blanks
- Core transformed into tool
- Flake (which could be retouched) transformed into core
- A new retouched cutting edge on a broken tool made of shell

We advocate the addition of blanks that were heavily retouched within multiple phases.

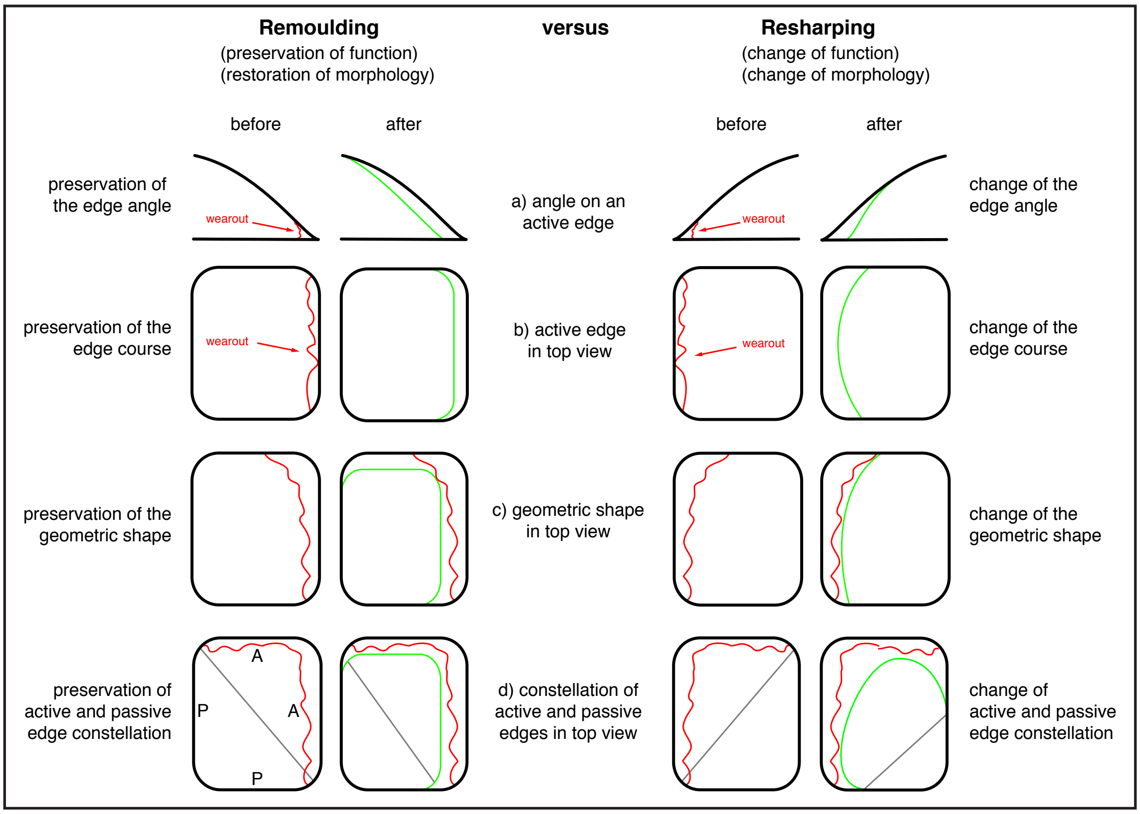

Fig. 19 - Reshaping and remoulding illustrated on hypothetical examples of lithic objects. a) resharpening on an edge, view on cross section. Left - retouch does not change the edge angle; right - retouch modifies the edge angle. b) resharpening on an edge in top view. Left - retouch does not change the edge course; right - retouch modifies the edge course. c) resharpening on one or two edges. Left - retouch does not change the geometric morphology of the top view; right - retouch modifies the geometric morphology of the top view. d) resharpening on two edges. Left - retouch does not change the geometric morphology and the active as well as passive edges stay in the same constellation; right - retouch modifies the geometric morphology and therefore change the constellation of active and passive edges.

II.7.3 Tradition?

Tradition in regard to stone artifacts can be defined as the transfer of knowledge (the know-how) from person to person, or from generation to generation (e.g. Tostevin 2007). This includes the knowledge about raw material qualities, utility and sources, the knowledge about the bandwidth (or a part of) of knapping techniques, as well as the knowledge about production sequences. In addition to this knowledge, tradition can be seen as the use of familiar patterns of stone artifact production.

In a coarse view on the Middle Paleolithic, long lasting traditions of stone artifact production seem to exist, but on a closer look many (regional) patterns of lithic tool use and productions appear, as Koehler (2009) evaluated for France (see fig. 20) and Conard & Fischer (2000) for the Middle Paleolithic record of Germany (fig. 21). Jöris (2003) proposed a chrono-stratigraphical model of the *Keilmessergruppen* assemblages (see fig. 22).

For Chevrier & Koehler (2013) these clusters in space and time depend on the scale of analysis. The finer the analysis the more individual an assemblage is.
As seen in the studies described above, there are clusters (depending on the scale of analysis) for the Middle Paleolithic record. Unlike the Upper Paleolithic record, these clusters seems to be much more individual, which might be explained by smaller areas of distribution and exchange of materials (predominantly use of local raw materials).

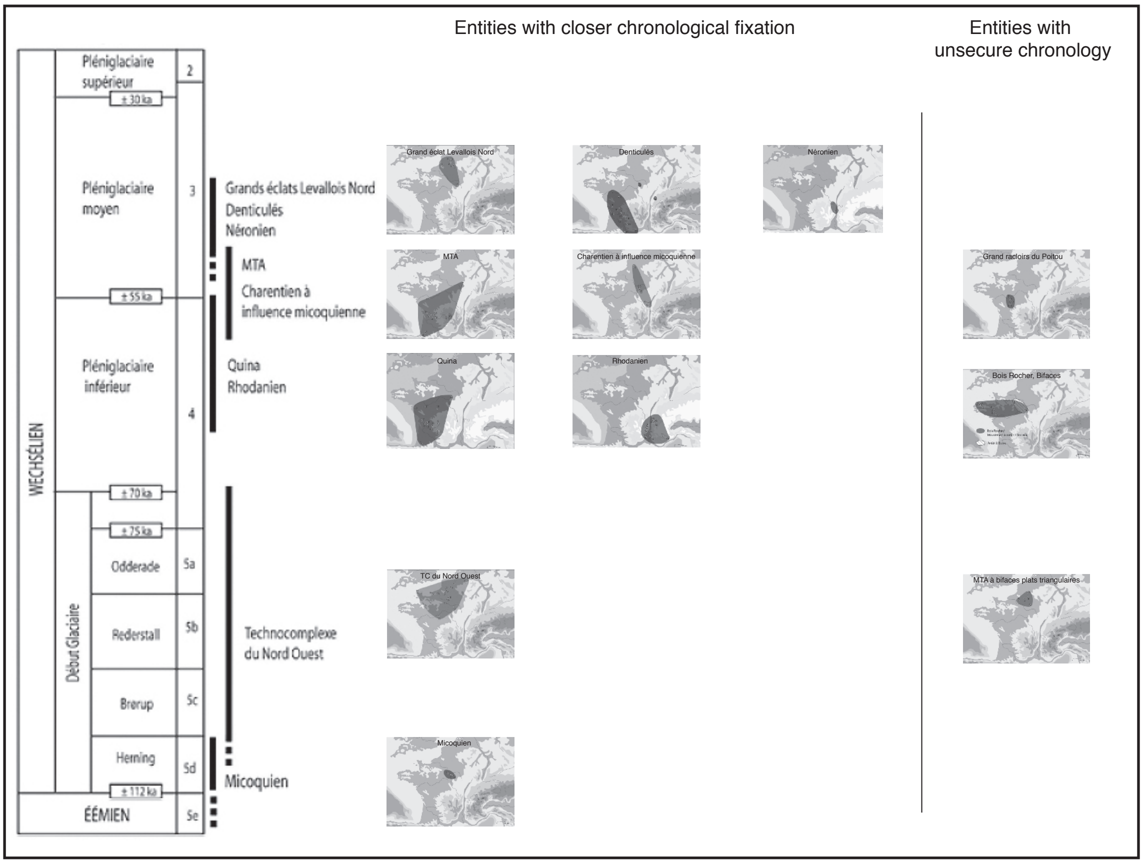

Fig. 20 - Summary of Late Middle Paleolithic entities as researches by Koehler (2009), picture collage of fig. 2 to 14 in Koehler (2009).

II.7.4 Functionality?

Functionality can be defined as the quality of an object to serve a purpose as wanted. It implies the question for what purpose an object is made. The functionality of lithic objects can be evaluated using approaches of use-wear, hafting and residual analysis, experiments and the approach of techno-functional units (Unité techno-fonctionelles, UTFs) on lithic objects.
The important question in regard to functionality is, if similar shapes of lithic objects imply a similar function, or not. The functionality of lithic objects can depend on many factors (some are listed in the following):

- Worked material (stone, bone, ivory, antler, wood, hide, leather, etc.)
- Stability of the used raw material (hardness, brittleness, flexibility, abrasion, etc.)

- geometry of the cutting edge (angle, shape in top view, position, see fig. 23)
- Proportion of UTFs
- Handling of lithic objects (handheld, hafted)
- direction of use (longitudinal, transversal)
- are multiple functions thinkable?
- distance between hand and the active edge (length of the transmitting part)

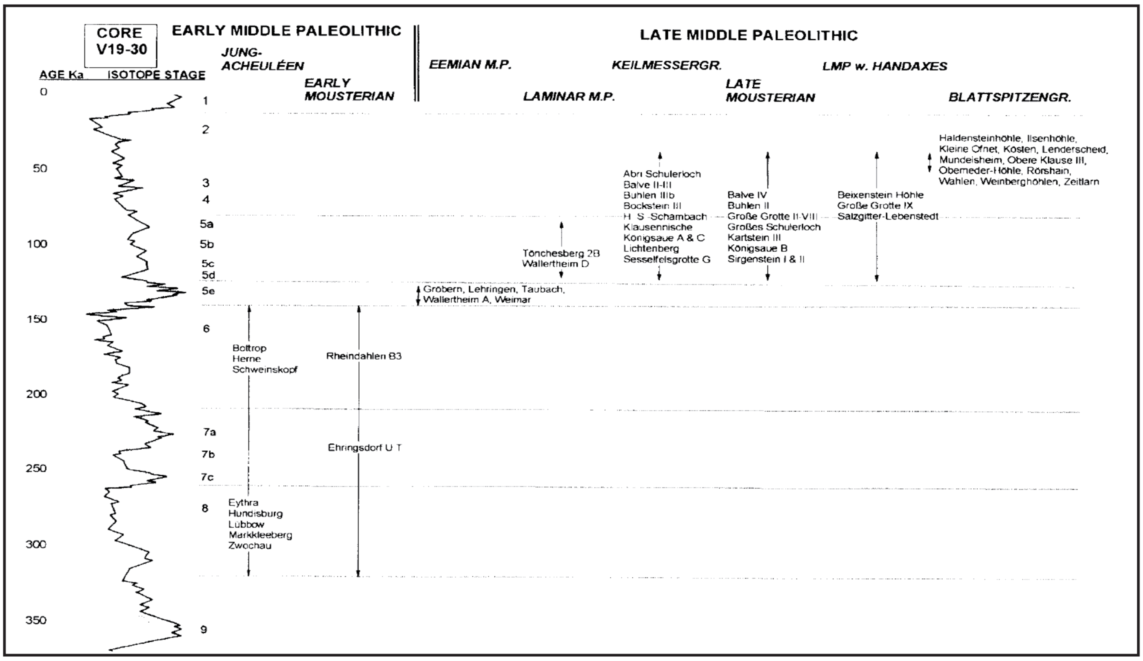

Fig. 21 - Proposed system for classifying the German Middle Palaeolithic, adopted from Conard & Fischer (2000: 15, fig. 2)

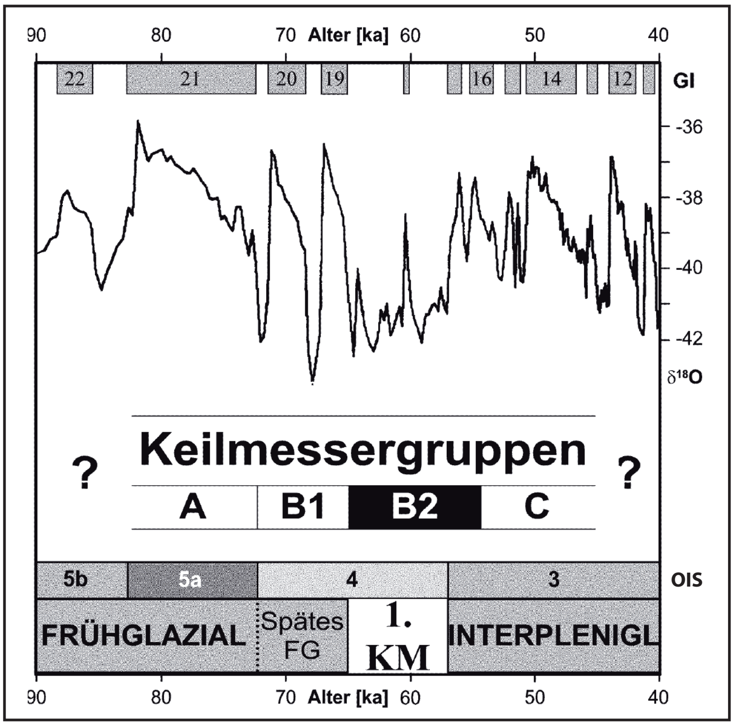

Fig. 22 - Summary of datings of assemblages belonging to the Keilmessergruppen between 85 and 40 ka, adopted from Jöris (2002: 22, fig. 16)

In using a lithic object for the transformation of other materials, the object is interconnected between the hand and the object which is worked. The contact of the hand and worked material is indirect. The distance of both depends on the length of the transmitting part (part that transmit energy or power from the used to the transformed material).

A stone artifact for it self can be griped with the bare hand (direct) or with an interconnection (like a piece of leather or a shaft). It is in the nature of things that a fixation with glue, binding or pressure left more traces (of hafting) than the bare hand.

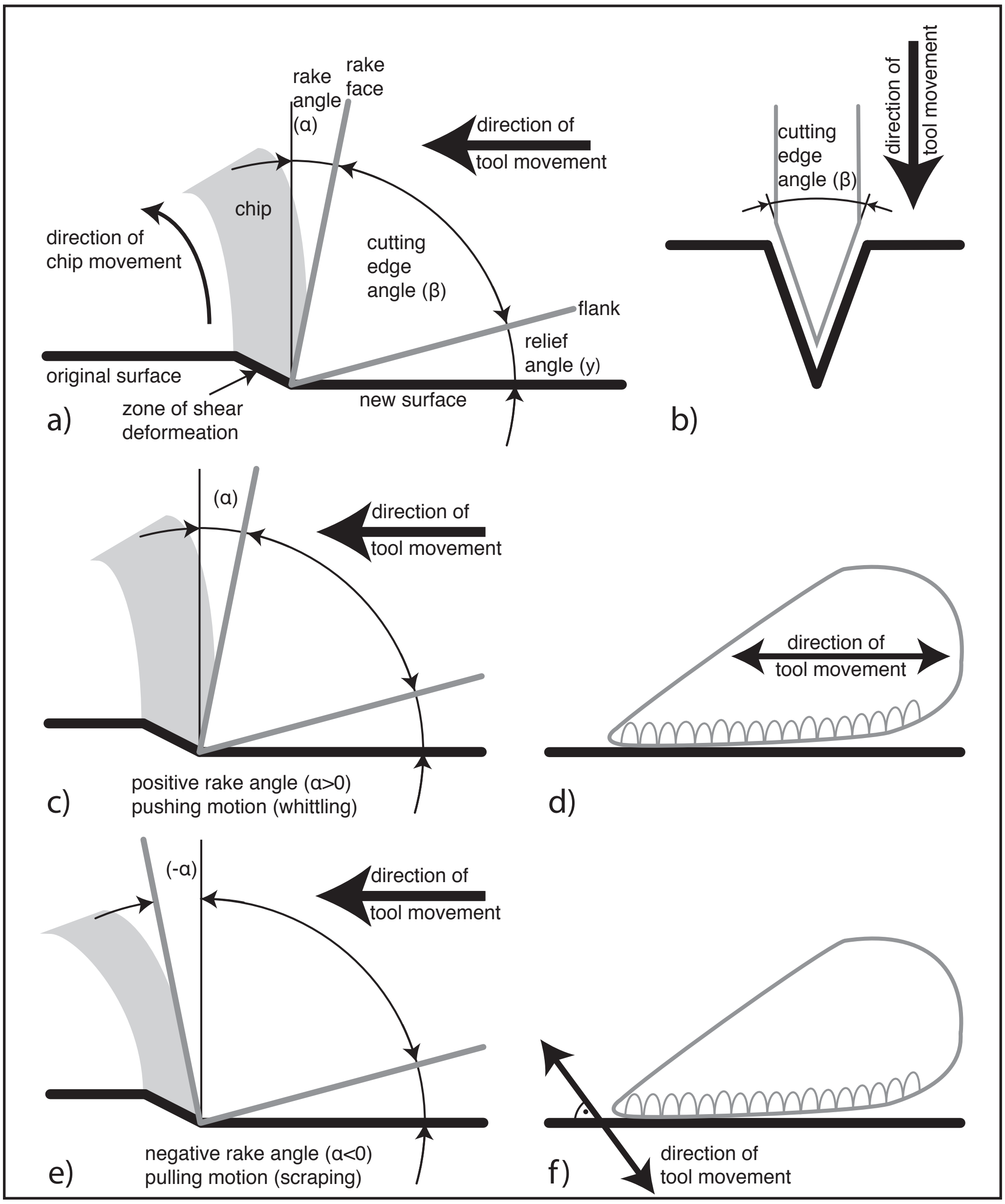

Fig. 23 - Cutting-edge geometry. a) Terminology adopted from modern industrial machining for cutting-off (see e.g., Oberg et al. 2012); b) Illustration of cutting-in (see also Soressi 2002, fig. III 8); c) Cutting-off with positive rake angle (whittling after Takase 2010); d) Illustration of cutting-in with longitudinal tool movement (usa as knife, consider that also a force to the surface is necessary); e) Cutting-off with negative rake angle (scraping after Takase 2010) and f) Illustration of cut-off with longitudinal tool movement (use as scraper or whittler, consider that also a force to the surface is necessary).

II.7.5 Interaction and regard to stone artifacts

It is not an easy task to evaluate the interaction between these aspects outlined above. In a simple sketch every aspect can depend on every other (see fig. 24). Questions in regard to the interaction might be to evaluate if evolutive processes can be detected or if tendencies are existing.

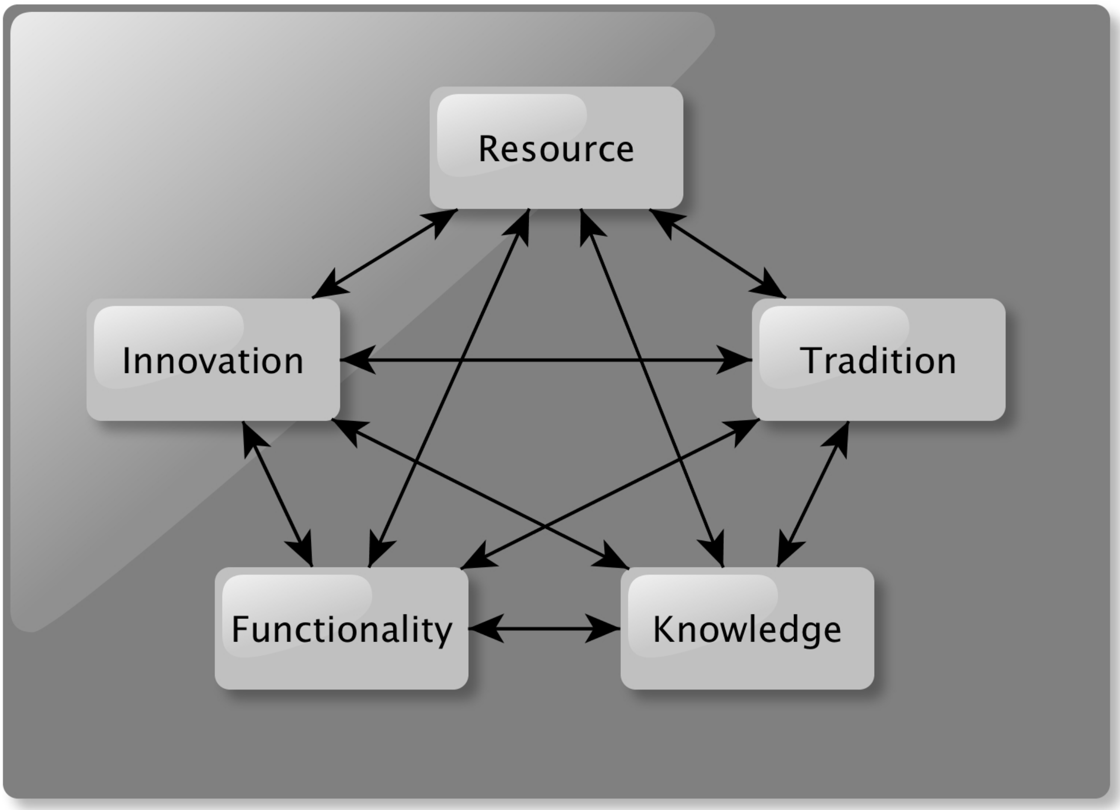

Fig. 24 - Interplay and relations between resources, innovation, tradition, functionality and knowledge to explain the embodiment of an assemblage

II.8 Summary of intrinsic and extrinsic parameters

VP II yielded (up to now) no Human fossile remains. Therefore the association between human taxon and assemblages is based on analogical observation. From preliminary dating attempts we know that GH 3, 4x and 4 are assumed to be deposited in the early OIS 3. The lithic industry present in these GHs are determined as being part of the Middle Paleolithic spectrum. As we know no other Human taxon as Homo neanderthalensis associated with such assemblages in western European context we can assume that here at VP II there is also a strong connection between both. Reflections about physiological and psychological aspects, as well their consequences for subsistent strategies and settlement patterns prove that Neanderthals are acted similar but somewhat different to Homo sapiens (chapter II.2.6). If the assumptions about metabolism and the resulting settlement pattern are right, we must think about somewhat smaller territories. But also that the residence time on a site, as well as site structures are slightly different to outlined features of settlement patterns (Binford 1980), as illustrated by Uthmeier & Chabai (2010: 215, fig. 9). Recently, higher energetics of Neanderthals are questioned in regard to uncertainty of body mass estimation and „the differences in predicted energy expenditures [seem to be] not statistically significant.“ (Heyes & MacDonald 2015: 196).

Smaller territories of Neanderthals are obviously illustrated in the prevalent use of close-by raw-material sources (Floss 1994), but this is also visible in the Upper Paleolithic context of the Côte chalonnaise. Mid-to-high quality material is always available in nearby sources and is used prevalently. A smaller degree in diversification of site-internal settlement structures maybe base on the accumulation of many short-term residence on a site. On the other hand, the opposite is also known (example Abric Romaní) in highly structured occupation floors.

In regard to knapping, the ability of hand movement and hand-eye coordination seem to be very similar to observations on Modern Humans (chapter II.2.8). As we see in the Middle Paleolithic lithic record the ability of handling different lithic raw material (from the fines obsidian to the coarsest quartzite) is very high. But specific concepts of lithic reductions are mostly predominant in assemblages and most likely preferred. Following Wynn & Coolidge (e.g., 2004) this could be related to the pronounced long-term working memory that enabled Neanderthals to follow very specific working steps even if the conditions (raw material quality et al.) are far from good. This is similar to handcraft experts (and enthusiasts, German: *Bastler*) that are able to find solutions inside the rules of a specific working step framework to fulfill the needs (e.g., to build a devise or to prepare something).

The lithic record of Neanderthals show that (if focussed on the Late Middle Paleolithic) they were able to fulfill nearly every thinkable reduction strategy using direct hard and soft hammer techniques to produce predicted morphologies of flakes, blades or bladelets (e.g., chapter VII.11).

The presence of organic technology (chapter II.5, as well as art) is maybe related to larger population density and long-term occupations of landscapes (as well as sites). In the Middle Paleolithic (and for Europe the Neanderthal's) record, the presence of devices of hard animal tissue is in opposite to the Upper Paleolithic (and Modern Human's) record is minimal. If we think about awls or smoother there, it could be the case that Neanderthal had completely different methods for manufacturing thinks (e.g., clothes or tents) that are not present in the current resolution of the archeological record. A good hint for the cleverness of Neanderthals is the manufacturing of birch-bark pitch (Palmer 2007) for clueing or the use of pyrolusite for lowering the combustion point (Heyes et al. 2016).

Chapter III: Classification approaches and systems of the Middle Paleolithic record

„The classification of facts, the recognition of their sequence and relative significance is the function of science, and the habit of forming a judgment upon these facts unbiassed by personal feeling is characteristic of what may be termed the scientific frame of mind.“ (Pearson 1900: 6)

III.1 Introduction

This chapter discusses schemes to classify the Middle Paleolithic record. It is a journey through out the research history, and a trial to compare these classification schemes. It gives an overview to Middle Paleolithic classification systems and shows classifications of the paleolithic record in our research area. Here, the continuous question is always: how to cluster the Middle Paleolithic archeological record? Most of classification systems proposed during the research history used lithic objects for clustering. Sometimes organic objects were also integrated. We will have a look how these entities were separated and if possible discuss there meaning.

This chapter combines two aspects: first, it discusses classification systems and entities proposed for the Middle Paleolithic record. Second, it gives a deductive overview of the Middle Paleolithic record as it can be seen in the light of recent research.

III.2 Approaches for classification systems

This section will give a short overview of approaches to classify the lithic record as used in the paleolithic research history. Early systems of artifact classification descending from museological sorting systems (e.g., Thomsen 1836, 1848) separated artifacts into coarse raw material groups like stone, bronze and iron. The seminal work of Bouches de Perthes (1847, 1857, 1864) proved the contemporaneity of extinct species and handcrafting man by means of hand axes associated with extinct megafauna. In the following de Mortillet (1883; 1881) began to distinguish different epochs inside the paleolithic record (e.g., Acheulian, Mousterian or the Magdalenian) and allot specific tools to these epochs. This systematization was challenged and essentially modified in the first half of the 20th century by integrating the Aurignacian (e.g., Breuil 1905, 1907, 1909) between the Mousterian and Solutrean or defining the position of the Pre-Solutrean (now called *Blattspitzenkomplex* or leaf point complex) as one of the latest phenomenon of the Middle Paleolithic in southern Germany and the Czech Republic (Freund 1952). Breuil's later phase of the Aurignacian (with Gravette character) was later renamed into Gravettian (Garrod 1938). All of these early approaches to classify the paleolithic record into time units based on so called index fossils (French: *fossiles directeurs*, German: *Leitfossilien*). For an overview, in the following, a table provides the discussed classification approaches (see tab. 28):

Approach	Quantity	Examples & notes	Literature
Fossile directeur*, index fossil, *Leitfossil	A single piece is enough to demonstrate the presence of artifacts from a certain time period	A Châtelperronian point demonstrate the presence of Châtelperronian A split-base point points in the direction of early Aurignacian A Micoquian biface represent the Micoquian Bifacial, flakes and points are the representatives for the Mousterian	Breuil (1907, 1909), Peyrony (1920, 1930a,b, 1934), Hauser (1907, 1908, 1916), de Mortillet (1881)
Bordesian typology, Bordesian method	Better more then 100 diagnostic pieces (formal tools and Levallois pieces)	A high percentage of Levallois blanks indicates the Moustérien type Ferrassie Assemblages can be compared Prevalently retouched pieces are compared	Bordes 1961
Typology of Sonneville-Bordes and Perrot	Better more then 100 diagnostic pieces (Upper Paleolithic tools)	An assemblage of specific types of artifact reflects a specific Upper Paleolithic entity (Early Aurignacian, Middle Gravettian, Late Magdalenian)	de Sonneville-Bordes & Perrot (1954, 1955, 1956a,b), de Sonneville-Bordes (1971)
***Leitformen* of Bosinski**	A small assemblages of diagnostic pices are representatives for a type of assemblage	Separation of four distinct groups (Bockstein, Schambach, Rörshein and Klausennische) inside the „Micoquian“ in Western Germany	Bosinski 1967
Morphological Analysis	The complete assemblage	Description of débitage (flaking) and façonnage (shaping) processes and formed tools of an assemblage	Hahn 1988, Texier et al. (1980), Inizan et al. (1995, 1999)
Dynamic technological analysis	The complete assemblage	Analysis of dynamic changes of lithic objects	Krukowski (1939), Schild (1980), Burdukiewicz 2008
Multivariate and discriminant analysis	Complete assemblages	Statistical comparison of artifact features	Weber (1995, 2006), Schäfer (1981, 1990, 1993, 1997)
Technological approaches	Technological diagnostic pieces and a good overview of the assemblages	Reconstruction of reduction sequences	Boëda et al. (1990), Delagnes & Ropars (1996), Swanson (1975)

Tab. 28 - Classification approaches for the paleolithic record by means of lithic artifacts

III.2.1 *Fossile directeur* approaches

These are artifacts that were seen as so important for one time period that the single being of one proves that this time period is existing (e.g., in a stratigraphy or a museum collection). A recent example for such a *fossile directeur* is the split-base point from the Aurignacian (Albrecht et al. 1972), but recently an article about datings of bone from Trou de la Mère Clochette started the discussion again, if such a split-base point is only to find in the early Aurignacian, because the associated lithic industry can be attributed to the Protoaurignacian (Szmidt et al. 2010). There are many other artifacts that can still function as *fossile directeur* or are highly characteristic for a specific time period (for simplification here are some well known examples from the European Stone Age record):

- Very flat and large leaf points (bifacial objects) are only to be found in the Solutrean in the context of the European Upper Paleolithic (e.g., Aubry et al. 2003)
- *Livre de beurre* (huge blade cores) from Grand-Pressigny flint from the Neolithic (Kelterborn 1981; Pelegrin 2002; Sestier 2006)
- Very large hand axes from the Acheulian (Bello et al. 2009; Goren-Inbar & Sharon 2006)

III.2.2 Typological approaches

Research after WW II provided many approaches to classify the Paleolithic record. A very long lasting approach was the typological approach of Lower and Middle Paleolithic assemblages from F. Bordes (Bordes 1961, 1988), what was called Bordesian method (*méthode Bordes*, see e.g., Escalon de Fonton & de Lumley 1955). He defined lithic artifact types (e.g., Bordes 1953b, c; Bordes 1954) and his assemblage comparison method (Bordes 1950a; Bordes 1950b; Bordes & Bourgon 1951) in many papers in the 1950s. The complete method was published in the beginning of the 1960s (Bordes 1961). The aim was to have a comparison tool on the level of assemblages and to overcome the index fossil approach. The comparison of assemblages in the 1950s lead to different facies, which where successively enriched by new ones (Bordes 1981).

The following list shows the succession of analytical steps for this approach:

- Sorting artifacts from a Lower or Middle Paleolithic assemblage into types (n=63)
- Drawing cumulative diagrams (in the x axis the types and in the y axis the cumulated amount of these types; real list with 63 types, essential list without types 1-3 and 45-50 and the new list without types 1-3, 5, 38 and 45-50)
- Comparison of diagrams with ones from other assemblages
- Attribute this assemblage to a specific facies (for Middle Paleolithic assemblages)

„*The Bordian Method, as it is called, was originally intended to provide statistical and graphical means to comparing assemblages on the basis of their entire lithic composition. It thus was intended to eliminate the „index fossil" approach used by earlier prehistorians, where one or two diagnostic types were all that were required for the classification of assemblages (see Sackett 1982). It also served as the basic for the definition of Bordes' various assemblage groups (or facies) of the Mousterian (see Bordes 1950b; Bordes & Bourgon 1951a).*" (Debénath & Dibble 1994). As the forgoing explains, it intended to eliminate the index fossil approaches. Because at least 100 pieces were necessary to use this approach, as Bordes (1961) points out.

In addition to this Bordesian typological approach, many others were developed, e.g., the analytical typology of Laplace (1957), the typology of Clark and Kleindienst (1974) or Leakey (1971) for the Oldowan. Bordes' methodological approach was updated and completed by Débenath and Dibble (1994), by adding some previously non-described types to Bordes' typology. De Sonneville-Bordes & Perrot (1954, 1955, 1956a, b) developed a very similar typological approach for classifying Upper Paleolithic assemblages from France. To do so, they adapted statistical methods to describe them (de Sonneville-Bordes & Perrot 1953) from Bordes & Bourgon (1951a).

Also, morphological description of artifacts were developed, for example that of Leroi-Gourhan et al. (1966). Brézillon (1971) collected accessible information about knapped lithic objects (*objets de pierre taillée*) and combined typological and morphological (descriptive) approaches of stone artifacts. He also provides an early description of the *chaîne opératoire* (Brézillon 1971: 78)

III.2.3 Reduction sequence approaches in the 1970s by US researchers

As impressively illustrated in Swanson (1975) US-American lithic analysts developed approaches to reconstruct reduction sequences of knapped lithic materials in the 1970s, including a glossary about lithic reduction (Bradley 1975).

The experimental work that led to these technological reduction approaches were mostly done by D. Crabtree and F. Bordes (Bordes & Crabtree 1969; Crabtree 1967, 1970, 1972; Johnson et al. 1978). But also by Bradley (1977), who did his Ph.D. about lithic experiments and the reconstruction of reduction sequences (mainly Levallois reduction) from the Middle Paleolithic. There are many examples showing the use of lithic reduction sequence approaches for the materials of North American sites in the 1970s, such as Patterson (1977) for the stone artifacts from North Fork Reservoir Area in Texas.

The first reconstruction of a reduction sequence seems to be done in the end of the 19th century by Holmes (1894), who studied the „*Natural History of Flaked Stone Implements*".

In a retrospective at the beginning of the 21th century, Shott (2003; 2007) pointed out, that neither the idea of reduction sequences nor the adaptation of *chaînes opératoires* to lithic objects were invented by french researches, as it is often to read.

III.2.4 *Chaîne opératoire* approaches from the 1980s by French researchers

In the early 1980s many french researches adopted the idea of operational chains (or that specific steps in lithic reduction have to follow each other) for there lithic research, like Boëda, Geneste or Pelegrin, who used this approach for there lithic studies. Geneste (1985) described Mousterian assemblages from the Périgord, France with respect to raw material issues and demonstrated that used raw

material from further distances are heavier reduced than short distance material. Boëda (1986) defined the Levallois reduction concept in a technological way and defined within this concept preferential and recurrent methods for lithic reduction by using material from three Middle Paleolithic sites from northern France. Pelegrin (1986) described and defined lithic reduction sequences from the *Périgordien ancien* (Châtelperronian) from sites in southwestern France.
But in French tradition the *chaîne opératoire* approach is more than just an order of specific steps in lithic reduction. It is an anthropological approach to study prehistoric societies through their techniques (Soressi & Geneste 2011). Leroi-Gourhan (1943) proposed the concept of technology as the science of human activities from en ethnologic perspective. He was followed by Haudricourt (1964), Balfet (1975) or Lemonnier (1976). From the late 1970s on J. Tixier and others started to establish these ethnological approaches of *chaîne opératoire* to stone artifact studies (Tixier 1978, 1979; Tixier et al. 1980). These technological approaches were heavily enlarged and enriched from the 1980s till now by many researchers. The methodological foundation of the *chaîne opératoire* approach is the incorporation of stone artifact studies into the context of the studied archeological society (or better group). „*Consequently, the context in which the stone tool was produced was recognized as being as important as the process of manufacture and use itself.*“ Soressi & Geneste (2011: 337). In that sense, a lithic object is a product of the technical system of a group (see also chapter V.3.1). From the perspective of a knapper there are natural and human parameters that influence the conceptual and operational scheme, as described by Pigeot (1991), see also Soressi & Geneste (2011: 337). In chapter II we are also using such parameters to discuss factors that influence the knapping process, but from a slightly other perspective.
Leroi-Gourhan, as well as Haudricourt were students of Mauss, who wrote about technology in ethnological context (Mauss 1926, 1947). But it took until the late 1970s that these ideas of operational chains were adapted to the archeological research (Lemonnier 1976).

III.2.5 Morphological approaches from the 1980-90s by German researchers

An important thing in German prehistory (as I learned it to know and as I found it in the literature) is that normally there aren't restricted „schools“ how to think and analyse lithic objects. This is an advantage and disadvantage at the same time, because in thinking and analysing traditions (as I know it from France, for example) there are strict rules how to do it, in an open environment one is faced with finding its way much more alone. The advantage is, that many researchers had combined and are combining approaches from different research fields and different thinking traditions to get there work done. Sometimes such new appro-

aches can lead to research traditions (for example the transformation analysis of Weißmüller 1995, which is described in chapter V.5.6) or are in such a way that new technical innovations can prove if such (formerly analog) approaches are now practicable and usable (like the description of edges from Rieder 1992). An early example for the combination of reduction sequences and morphological descriptions of lithic objects can be seen in the work of Hahn (1988, 1993). As an example, he combined refitting, technological sequence description and spatial analysis for the Aurignacian and Gravettian of the Geißenklösterle (Hahn & Owen 1984, 1985). Hahn (1988) also started to sort lithic artifacts into raw material units, as Roebroeks (1988) published it in the same year.
Löhr (1979) started the discussion about the primary and basic equipment (the first imported tool-kit) „*Erst- und Grundausstattung*" of a group arriving the first time on a site, using the definition of Leroi-Gourhan & Brézillon (1966) for *équipment des base* (a contingent of lithic material that was brought on a site during the first arrival) for the Magdalenian. Floss (1994: 345-349) lists paleolithic sites in Europe where artifacts were found with a blank production off-site (what he is calling basic equipment, *Grundausstattung*).
Another approach derives from Weber and Schäfer, who measured and described lithic objects from pre-Upper Paleolithic context. Their approach is to find significant values to compare assemblages for finding similarities (attribute analysis with large numbers of metrical and non metrical data that can be compared). Weber's opinion is that „[…] *indices of length, breadth, and thickness are better than absolute measurements, the latter being a product of raw-material size, which has only a small influence on technological characteristics* […]." (Weber 1981: 706). Examples of these ratios, indices and measurements are listed in the following:

- Length-Breadth ratio
- Relative thickness index
- Flaking angle

The aim of these statistical analysis is to find patterns that allow to cluster pre-Upper Paleolithic. This attempt was done for sites in Middle Germany (e.g.; Schäfer 1997) and was extended by Ertmer (2012).

III.2.6 Dynamic technological approaches by Polish researchers

In the 1930s, Krukowski (1939-1948: 55-56) demonstrated that bifacially backed knifes that he called Prądnik (mainly from Ciemna cave) underlay a specific reduction process. He interpreted the smaller ones as resharpened bigger ones and called such a reduced one *Prądnickich* (small *Prądnik*). This very early example of the detection of resharpening, reuse and reduction processes was later picked up and clearly confirmed by Migal & Urbanowski (2006) or Jöris (2001).

The work of Krukowski (1939-1948) can be seen as the initial ignition of the dynamic technological analysis (DTA). This dynamic approach to lithic studies was re-established by Schild (1980) and is nowadays wide spread (e.g., Burdukiewicz 2008 for analysis of lower Paleolithic cores).

Schild (1980: 57) describes a dynamic technological analysis with the following words: „*The idea behind dynamic analytical approach is very simple and reflects an obvious fact that prehistoric chipped stone objects are the result of core and tool preparation, exploitation, use, repairing and remodelling. Some of these objects passed through their life unchanged from the moment of their separation from the block of stone, such as a nodule, core, blank or tool; others, on the other hand, underwent considerable changes at various stages of their life, e.g., during preparation, use, remodelling and discard. Reconstructing morphological curriculums of chipped objects, as they changed, and finding their place in the continuum of production, use and discard processes permits, it is believed, a much better insight into the functioning of various technologies, individual and group strategies, etc. The number of questions that may be answered by proper application of the Dynamic Technological Classification and statistical processing of the obtained raw data is quite impressive, especially when accompanied by other supplementary analyses.*“

A recent example of such a DTA can be seen in the work of Burdukiewicz on late Lower Paleolithic assemblages (e.g., Burdukiewicz 2008). He adds the following to Schild's description: „*In opposition to the „type fossils“ approach, lithic assemblages are treated as a result of human activity limited in time and space. According to Krukowski and Schild, all artifacts should be ordered by technological sequences combined with morphological classification. A basic unit, which is a lithic concentration, includes all artifacts left by an isolated human group living for a short time on limited space, usually no more than just a few square meters occupied as a single camp or workshop. Krukowski further used technological analysis to distinguish domestic and workshop facies. All lithic elements found in such concentrations should be analyzed in terms of the processing sequence: from raw material procurement, preparation and early stages of core exploitation through advanced core exploitation to the final stage and retouched tools along with waste from their production. The first step is a comprehensive study of all cores, flakes, blades, tools and waste. Next is spatial analysis, refittings of artifacts and reconstruction of technological modus operandi, including analysis of flaking directions on both flake sides, kinds of dorsal side, butts, flaking angles, general shape, as well as transversal and longitudinal sections, etc.*“

The main aspects, as described by Schild (1980) and Burdukiewicz (2006, 2008) are listed in the following tab. 29:

Aspect	Description
Work stages of artifact production, technological sequences	„[…] *chipped stone objects are the result of core and tool preparation, exploitation, use, repairing and remodelling.“ (Schild 1980: 57)* *„All lithic elements found in such concentrations should be analyzed in terms of the processing sequence: from raw material procurement, preparation and early stages of core exploitation through advanced core exploitation to the final stage and retouched tools along with waste from their production.*“ (Burdukiewicz 2008: 263)
Unchanged	*„Some of these objects passed through their life unchanged from the moment of their separation from the block of stone, such as a nodule, core, blank or tool* […].“ (Schild 1980: 57)
Change	„[…] *underwent considerable changes at various stages of their life, e.g., during preparation, use, remodelling and discard.*“ (Schild 1980: 57)
Object biography	*„Reconstructing morphological curriculums of chipped objects, as they changed, and finding their place in the continuum of production, use and discard processes permits, it is believed, a much better insight into the functioning of various technologies, individual and group strategies, etc.*“ (Schild 1980: 57)
Working steps of analysis	*„The first step is a comprehensive study of all cores, flakes, blades, tools and waste. Next is spatial analysis, refittings of artifacts and reconstruction of technological modus operandi, including analysis of flaking directions on both flake sides, kinds of dorsal side, butts, flaking angles, general shape, as well as transversal and longitudinal sections, etc.*“ (Burdukiewicz 2008: 263) Sequence 1: Raw material procurement; sequence 2: Preparation and early core exploitation; sequence 3: Advanced core exploitation; sequence 4: Final core exploitation; sequence 5: Tool Production and comparative analysis (Burdukiewicz 2008)

Tab. 29 - Main aspects of the Dynamic Technological Analysis, as described by Schild (1980)

As tab. 29 shows, a dynamic technological analysis is quite similar to a *chaîne opératoire* approach, but understand all processes in a dynamic way and integrates (therefore the term) processes like core reorientation, resharpening, or reuse for other purposes.

III.2.7 How to combine and apply these classification approaches?

By bearing these described approaches in mind, the question is open to combine this classification and description approaches into a suitable and contemporary approach for lithic analysis. To recall the described approaches, one is confronted that these different approaches can explain different aspects of the research topic. A Bordesian typological approach assume that the defined lithic types are invariant and a person in Paleolithic times would also recognize them in the same way (Wargo 2009), which corresponds to an emic view on artifacts. Such types can be seen as the platonian idea of things (Burdukiewicz 2006). But different individuals view artifacts differently in regard of the general shape as described in typologies. „[…], *bias is introduced when one claims that an artifact is a particular type, when someone else could assign that same artifact to another type category.*“ Dybowski (2008: 7)

Since the 1970s, researches have made efforts to overcome such approaches in focusing on morphological and technological criteria for artifact classification. The aim should always be to find criteria that can withstand a strong test about its emic and etic characteristic.
A technological reduction-sequence approach assumes that the reconstructed lithic reduction sequence are in that way as a Paleolithic individual did it. If we can proof these reduction sequences with physical refittings we are producing hard facts and it can be assumed that the assumptions are more or less reliable.
Shott (2003; 2007) compares reduction sequence and *chaîne opératoire* approaches and comes to the conclusion that *„refitting and what North Americans now call „individual flake analysis" are more common among chaîne opératoire in French"* or *„reduction opératoires advocates, mass analysis and the like more common among those of us who call the same thing „reduction sequence." That is a difference in detail, not kind."* (Shott 2007)
If our aim is to reconstruct the Paleo-historiography (Frick & Herkert 2014) of a specific time and a specific place we have to find ways to look on the discarded legacy of Paleolithic people in that way they would have looked on this material and also a way of comparing different assemblages and site in space and time. We have to find approaches that are emic and etic in the same way. This is definitely easier said than done. The approach here is therefore to summarize (in our case lithic) analysis methods and display what they can tell us about the past (tab. 30):

Lithic analysis method	Approach behind his method	Proposition	Example	Literature
Classification of retouched lithic objects into highly distinctive units	Index fossil	If such an object can be found in a site it is proven that a specific epoch is present	If bifaces, points and side scrapers are to be find on a site, the present of the Mousterian is proven	de Mortillet 1883
Classification of retouched lithic objects (and Levallois blanks) into highly distinctive units, assemblage should be bigger than 100 pieces	Typology	If specific objects are present together, a specific facies of a paleolithic epoch is present	High percentage of scrapers with Quina retouch proves that this assemblage belongs to the Quina facies	Bordes & Bourgon 1951, Bourgon & Bordes 1957

Experimentation of lithic reduction	Experimental technology	If specific experiments show that there is only one way to produce a specific object, it is highly possible that this was the way Paleolithic people did that, too	Lithic reduction experiments by Boëda to prove the reduction of so called Levallois cores Pressure flaking experiments by Pelegrin with the aid of a lever to show how very normalized blades can be produced	Boëda 1986 Chabot & Pelegrin 2012
Experimental replica production	Experimental technology	Experimental replication of lithic artifacts can show ways to produce objects found in the paleolithic record	Experimental replication of Solutrean laurel leafs to find ways how these large but very thin objects can be produced or the replication of Levallois reduction	Bradley 1977, 2013
Experimental use of lithic objects	Experimental technology	Use experiments can demonstrate how objects could be used and what use-wear looks like	By carving animal carcasses it can be studied what kind of traces stands for what action	Rots 2010
Refitting of detached lithic objects	Reduction	Refitting of blanks and cores can demonstrate how a core was reduced and if there was a concept, etc. behind this action	Refitting of blanks to cores shows different ways of reduction	Hahn & Owen 1985 Delagnes & Ropars 1996
Spatial analysis of refitted objects	Spatiality	Mapping the spatial distribution of objects that could be refit can show how objects were moved (anthropogenic or taphonomic)	Spatial analysis of the connection between different fire places could demonstrate the contemporaneous use of these	Jöris et al. 2011
Categorizing lithic objects into clusters of consecutive reduction steps	*Chaîne opératoire*, reduction sequence	Assignment of lithic objects to experimentally realized steps inside a reduction sequence	Determination and sorting of lithic objects can lead to realize specific ways of reduction like Levallois	Boëda 1986, 1994
Sorting of lithic objects into raw material units (single objects, work pieces)	Transformation	The sorting and grouping of lithic objects that belongs to one raw piece can demonstrate import and export issues	Demonstration in which condition lithic objects were transported to a camp and which steps of the operational chain were done on- and off-site	Weißmüller 1995

Analysis of distances from raw material source and discard place	Raw material transportation	It is assumed that in mapping distances between raw material source and discard place the territorial range of a camp can be shown	Raw material mapping in the Rheinland could show how the territorial range between paleolithic epochs change	Floss 1994
Intra-site spatial analysis	Occupation organization	It is assumed that by mapping and comparing different artifact categories and features, the internal structure of a site can be realized	Spatial organization around a fire place by separating them into drop and toss zones interpretation about empty places in find distribution of a site	Binford 1978 Jöris & Terberger (2001) Gaudzinski (2015) Julien & Karlin (2015)
Analysis about the dynamic character of artifacts	Alterability of artifacts in their use life	An artifact can be modified and used in the same and different ways as before	Remodeling of broken *Keilmesser*	Krukowski (1939-48) Jöris (2001)
Continuous reduction changes the typological denomination	Alterability of artifacts in their use life	Re-sharpening processes change the characteristic of an artifact	Scraper reduction	Dibble (1987)
Core and reduction classification	Defining specific ways of reduction sequences	Physical and human criteria for the classification of specific reduction sequences	Separating Levallois from Discoidal reduction different reduction schemes for different shapes of blanks	Chabai & Sitlivy (1993) Boëda (2009, 2013) Frick & Herkert (2014) Koehler (2009)

Tab. 30 - Methods of lithic analysis and what they can tell us about the past

In my point of view, the dynamic character of artifacts, the alteration and modification in their use life (their archeological object biography) is one of the major aspects that was integrated in the discussion in the last decades (see Schild 1980 for early descriptions). This approach is similar to discussions about recycling (e.g., Amick 2014, 2015; Romagnoli 2015) or reduction of blanks (Eren et al. 2005; Eren & Sampson 2009). My approach in this discussion was (Frick 2010) and is to divide modification processes (resharpening, re-confection) in processes that will change the morphology to fulfill other functions (reshaping or remodeling) or to sharpen it (in the same way) to fulfill the same function (remoulding).

Ramification is another aspect to mention (e.g., Bourguignon et al. 2004; Rios-Garaizar et al. 2015), which is the serving of products from one reduction sequence to be the matrix for another reduction sequence (see chapter V.5.6 or X.2, classification as primary, secondary,… concepts of lithic reduction). The function of a lithic objects can also be analysed using use-wear and residual analysis (e.g., Hardy et al. 2013; Lemorini et al. 2016), as well as approaches about hafting (Rots 2010) and techno-functionality (Boëda 2013).

III.3 Classification of assemblage entities

III.3.1 Hypothesis about assemblage formation

The approach behind this whole chapter is to find definitions for clustering assemblage entities, because the archeological literature provides an abundance of approaches how assemblages can be grouped. For the Middle Paleolithic record the most prominent clustering approach is the division into Mousterian facies (Bordes 1981, 1992; Bordes & Bourgon 1951a) by using the Bordesian typology (Bordes 1961), which is shortly described in chapter III.2.

Since the 1980s the idea of so called techno-complexes expand. The term „*techno-complex*“ was first used by Clarke (1968), but was not discussed in Renfrew and Bahn's (2005) key concepts of archeology and still lack a clear definition (Monnier & Missal 2014).

Here, it is not our aim to discuss the big and legendary Bordes-Binford debate about the meaning of the Bordesian facies, for this we refer to Wargo (2009). But we want to repeat these approaches (hypotheses) that were summed up in Frick (2010). To show in which way specific assemblage can be interpreted, see tab. 31 (non-exhaustive):

Hypothesis	Meaning	Literature
Cultural	The facies of the Mousterian represent different cultural entities and therefore different human groups	Bordes 1961, Bordes & Sonneville-Bordes 1970, Delagnes & Meignen 2006
Functional	The facies reflect different functional entities. The assemblage base from other functions	Binford & Binford 1966, Binford 1973, Delagnes & Rendu 2011
Chronological	The facies are clustered in a specific chronological order and represent a specific moment in time	Mellars 1996
Evolutional	Archeological cultures (or facies) can follow each other in a developing sense	Breuil & Kosłowski 1931, Roland 1995
Environmental	The facies reflect different adaptations to specific environmental settings	Roland 1977, Roland & Dibble 1990, Dibble & Roland 1992
Mobility	Different types of assemblages reflect different mobility patterns	Delagnes & Meignen 2006
Site	Different assemblages represent different types of sites, like base camps or special task camps	Jaubert & Delagnes 2007
Novice	Different assemblages could also reflect different grades of professionality	Loecker 2006, Stapert 2007, Shea 2006

Tab. 31 - Hypothesis about archeological assemblages

Sometimes scholars switch between these hypotheses, in explaining assemblage formation. An interesting contrast can be seen in the switch between the cultural hypothesis (Bordes) and functional hypothesis (Binford), which is recognizable in papers from Delagnes (tab. 32):

Hypothesis	Literature
Entities are explained as cultural groups (after Bordes)	Delagnes & Meignen 2006
Entities are explained as functional groups (after Binford)	Delagnes & Rendu 2011

Tab. 32 - Use of different explanation hypothesis for entities

As often in discussions, more than just one explanation hypothesis might be real. We would suggest that all (and maybe more) of these explanation patterns are necessary and should be tested on the record to study (if this is the attempt). We would suggest that different cultural groups may have different functional approaches for their tools and all are framed by in the chronology that may reflect evolutionary patterns and are the result of environmental and mobility patterns of young and old individuals, groups and populations that use or make different camps.

III.3.1. What is a techno-complex?

The original definition of Clarke (1968: 328-329) for a technocomplexes is as follows: „*These grosser entities involve* ***groups of cultures*** *which are* ***not related*** *or collateral cultures but which do* ***share polythetic complexes of type families*** *on the basis of common factors in* ***environment****,* ***economy*** *and* ***technology****. Since it is extremely difficult to discuss an entity without a name let us tentatively call these gross groupings* ***technocomplexes****. […] The Acheulean and Chopper-chopping tool complexes surly reflect huge and loos alignments of this gross rank, rather than those small, higher rank entities that we have discussed […]. The technocomplex represents the partly independent arrival of diverse developing culture systems at the same general equilibrium pattern based on a similar economic strategy, in similar environments with a similar technology and a similar trajectory.*" (emphasis added by the author).

In using this original definition, a very coarse definition of a techno-complex is:

- **Assemblages that share the same economic strategy, in similar environments with a similar technology and a similar trajectory.**

This would mean that whenever such a combination shows up we have to name this entity as technocomplex. This definition has therefore a no clear temporal connotation. The definitions and groupings of these similarities varied vastly over time. For example, Delagnes et al. define techno-complexes as assemblages shared by human groups showing the same knowledge and approach, using the same *chaînes opératoire*: „*C'est l'ensemble des savoirs et pratiques s'appliquant aux chaînes opératoires de production lithique et partages par un ensemble de groupes humains, qui sert à definer pour le préhistorien différents «technocomplexes».*" (Delagnes et al. 2007). But recently, Monnier & Missal (2014) pointed out, the term techno-complex still lacks a clear and precise definition. The „*lack of clear and widely accepted interpretation*" of „*´facies' and ´technocomplexes' or ´groups'* " is also discussed by Koehler (2011: 17). As we see (with this examples) for more than 40 years now, the term technocomplex is used, but still misses a useful clear and precise definition and Monnier & Missal (2014: 61) recognize : „*In practice, the term 'technocomplex' now appears to be used as a new type of 'facies' definition, albeit one that is based upon both typological and* *technological factors.*“

If we think about the first clear definition using similarities in economic strategies, environments, technologies and trajectories, and we focus on lithic reduction, we are faced with the problem of assessment. This is best described using examples:

- A lithic assemblage consists of 90% Levallois reduction products and the rest are products of initialization (the classification is simple, it is an exclusively and clearly Levallois dominated industry)
- Another assemblages shows 20% Levallois reduction, 23% Discoid, 21% Quina and 19% bifaces (here, no clear domination is visible)

These two are extreme examples but show the problem of classification and the difficulties in the assignment of assemblages to a specific taxon (namely technocomplex, assemblage group, taxon, etc.).

Delagnes & Meignen (2006) respectively Delagnes & Rendu (2011) use dominance of ‘*concept(s) and method(s) of reduction*’ and ‘*production systems*’ as criteria for assemblage assignment, to illustrate distribution of these entities (note they use a separation in dominant/secondary resp. primary/secondary concepts or systems, the terms primary and secondary are used differently in this thesis, see chapter V.4.1). But without clear determination what this dominance or primary mean (dominance as highest percentage inside the study group, of the complete assemblage or of recognized pieces? etc.), but for the main faunal taxa, NISP (number of identifiable specimen), as well as percentage is used to show this issue (Delagnes & Rendu 2011).

Another example is the assignment of a Middle Paleolithic archeo-sequence for South-West France (Jaubert 2011, 2014). Here (in fig. 4 resp. fig. 2) the diversity of lithic assemblages and their assignment to technocomplex (the new ‚*facies*‘ for Jaubert) is visible. Correctly, Monnier & Missal (2014: 63) criticise that these displayed entities are 'not explicitly defined' and „*In sum, while the CO approach can reveal important information about flaking technology, the archaeological entities that have been defined on the basis of this approach — whether they are called lithic production systems or the more encompassing ‘technocomplexes’ — remain problematic because neither their definitions, nor their meaning, are agreed upon.*“

A first step to overcome this critique is to display counts and percentage for the display of lithic entities. Or in other words, if faunal remains are counted, lithics can also be counted (NISP in defined groups, percentage, etc., without facts no proof).

Monnier & Missal (2014: 65) recommend a change in Paleolithic systematics: „*Therefore, what we need to do now, is to change Paleolithic systematics in the following ways: first, facies, TCLs, production systems, and the like, must be defined with an a priori purpose, according to the typological principles laid out by Adams and Adams (1991).*

In other words, TCLs should be defined to answer specific chronological, functional, or cultural questions.We should not define them on the basis of an intuitive understanding of archaeological patterning, then seek what this patterning means, because our intuitive understanding is subjective and biased in many ways. Second, we need a systematic way of describing lithic industries that 1) captures the behavioral information we need to answer key Paleolithic questions, and 2) facilitates quantitative comparisons between assemblages."

III.3.2 Diversity in homogeneity?

Until the beginning of the 20th century, the Middle Paleolithic was seen as a quite homogenous entity of flake-based industries (e.g., Breuil 1909). In the following years, some researches demonstrated a degree of diversity in the Mousterian industries of Europe (examples are listed in the following tab. 33).

Researcher	Contribution	Generic literature
Hugo Obermaier	Outline of the french earlier Paleolithic	Obermaier 1908
Henri Breuil	Specification of definitions for the early Upper Paleolithic (what is the Aurignacian?), Levalloisien	Breuil 1909, 1911, 1930, 1932
Robert Rudolph Schmidt	Correlation of South-german paleolithic sites and their industries with sites in western and eastern Europe	Schmidt 1912
Otto Hauser	Excavation of many sites in the Dordogne, defining the Micoquian, chronological relations of industries and sites, comparison of industries in Western and Central Europe, transition from the Middle to the Upper Paleolithic	Hauser 1916, 1917, 1920, 1921, Geer 1971, Drösele 1988
Denis Peyrony	Excavation of many sites in the Dordogne, defining facies in the Mousterian (*Moustérien typique*, *Moustérien de tradition acheuléenne*) and facies of the early Upper Paleolithic for the Dordogne	Peyrony 1920, 1930a,b, 1934

Tab. 33 - Examples of contribution for the diversity of earlier Paleolithic times in the beginning of the 20th century

In the 1950s, research about the Middle Paleolithic observed a much greater diversity. On the one hand, the typological approach of Bordes (e.g., Bordes 1953a; Bordes & Bourgon 1951b) detected many facies of the „*Paléolithique moyen*" in France. In Germany, as well, specific entities in the Middle Paleolithic were detected, for example the leaf point complex in southern Germany (Freund 1952) or a structuring of the upper Early Paleolithic in southern Germany (Müller-Beck 1956). Wide influence had the evaluation of the Middle Paleolithic record by Bosinski (1967) for his Micoquian, that was later renamed to *Keilmessergruppen* (Mania 1990:144-148).

The diversity of the Middle Paleolithic can also be detected in focusing of used raw material (fine grained varieties such as flint or chert, coarse grained materials such as quartzite or mono-crystallin quartz), location of sites (caves, rock shelters and open-air sites, in the mountains, on river systems or the coast), produced blanks (oval and rectilinear flakes and blades, and sometimes bladelets), independent reduction concepts (e.g., Levallois, uni- or bifacially Discoidal, Quina, SSDS, crested configuration of blade cores, bifacial objects and so on) or the vast variety of modification on a vast variety of blanks.

An example for clustering this diversity by focusing on different observation levels is displayed in the work of Koehler (Chevrier & Koehler 2013; Koehler 2009b) using technological analysis and techno-types. Another approach is attribute analysis for detecting diversity and homogeneity in the Middle Paleolithic record (Monnier & Missal 2014; Perreault et al. 2013). However, the formation of entities of the Middle Paleolithic record seems to be catchier as for the Upper Paleolithic. An explanation for this circumstance was described by Richter (1997b: 253-254). For him two different concepts face each other (that are sketched in the following tab. 34):

Criteria	Assortment concept	Serial concept
Chronological entity	Lower Paleolithic, Middle Paleolithic, Aurignacian	Gravettian and younger entities
Production of lithic objects	Production of the entire range of matrices (flakes, blades, oval, rectangular, triangular,…)	Serial production of similar products in high quantities (blades and bladelets)
From blank to tool	The variety of matrices can be modified to a vast variety of tools	Mostly all tools can be produced by using the same matrix (the blade or bladelet)
Blank shape and tool shape	Different matrices can be modified to the same tool	The same matrix is modified to a variety of tools
Planning constraints	High, because not every tool can be produced from every matrix	Ssmall, most every tool can be produced from the matrix
	Planning necessary what kind of tools are necessary when and how much are needed	If the matrix is available, every needed tool can be produced
Possibilities for minimizing the planning constraints	Knowledge about re-confection, remoulding or reshaping of tool can lower planning constraints	Knowledge about re-confection, remoulding or reshaping of tool can lower planning constraints
	Knowledge about multifunction tools (often the same active edge is used for different tasks)	Knowledge about combination tools (different active edges on the same object)

Tab. 34 - Differences between assortment and serial concept, as envisaged by Richter (1997: 253-254)

As sketched by Richter (1997: 253-254), this assortment concept makes the detection of entities highly challenging, because much more factors are variable in difference to the serial concept.

For Weißmüller (2003: 180-181), the lack of a willful standardization of Neanderthal tools is of importance. For him, Neanderthals had a real view of the needful and saw no occasion to do something beyond the purpose, therefore they had complete design freedom. In comparison to this, modern people seem to be exposed to the compulsion to parallelize their work on that of the group, which might lead to loose individual creativity: „*Noch viel wichtiger erscheint mir jedoch das Fehlen einer absichtlichen Standardisierung der Werkzeuge der Neandertaler und dies gerade im Hinblick auf die Werkzeuge der Nachfolger, der modernen Sapienten. Den Unterschied möchte ich wie folgt formulieren: Die Neandertaler, ausgestattet mit einem realen Blick für das Nötige, sahen nirgends die Veranlassung, etwas über den Zweck hinaus zu tun, und waren so im Besitz vollständiger Gestaltungsfreiheit. Im Vergleich dazu scheinen die modernen Sapienten dem Zwang ausgesetzt, ihr Schaffen an dem des Kollektivs zu kontrollieren - bis hin zur Aufgabe der individuellen Kreativität […].*“

The question of diversity in homogeneity is also related to discussions about curated and expedient toolkits (see e.g., Binford 1979) and other processes that can alter components of an assemblage, such as transportation, reparation, recycling or reuse. „*The introduction of the terms "curated" and "expedient" to describe components of the same technological system with markedly different use-lives (Binford 1973, 1979) had a profund effect on lithic analysis in archaeology. Since the introduction of these terms, archaeologists have become increasingly aware of the role that transport, repair, recycling, lateral cycling and other behavioural factors played in shaping the technological and typological characteristics of lithic assemblages (Shott, 1996).*“ (Davis & Shea 1998: 603).

A collection of definitions to describe curated and expedient assemblage(s) (components) is listed in the following tab. 35 using Binford (1973, 1979), Bamforth (1986), Floss (1994), Shott (1996) and Davis & Shea (1998).

Term	Curation	Expediency	Criticism
Production of tools	Individual production of a specific tool	Fast production of an objects that can serve for an immediate need	Expediency is therefore related to a low degree of confection after production
Function and purpose	Individual tool made for specific purposes	Made for different purposes	Question about multifunctional tools (tools with different functional parts)
Efficiency	Tool is very efficient for a specific purpose	Tool is able to fulfill the need	For Shott (1996) efficiency is not part of curation
Time length of the production	Assumed to be longer	Fast production of an objects that can serve for an immediate need	Question is related to the position of confection (during production or after production of an objects) as retouch
Time distance between production and use	A span of time between production and use is thinkable	Tool is made for direct and immediate use	The time span is only visible in transport distances, differences in patination or a change in morphology for serving other purposes
Duration of the use-life	Long use-life of the objects	Short use-life	For Shott (1996) use-life is not part of curation
Recycling	Recycling and reuse processes often visible	Maybe immediate resharpening	For Shott (1996) recycling is not part of curation

Transportation	Transportation evident in highly modified objects of „exotic“ raw materials	Objects are made, immediate used and discarded	For Shott (1996) transportation is not part of curation
Technological sophistication	Highly sophisticated	Lowly sophisticated	Fast made tools could be also linked to high sophisticated technology because it the process of planning could have been happen way before the immediate production
Formal separation of tools	Very good possible	Differentiation is more complicate	Reflexion about the shape of the entire object or of specific parts
Degree of modification	High degree of modification visible	Low degree of modification	This modification needs to be related to maintenance
Distance between raw material source and site	Long distances are possible	Immediate use of raw material for immediate needs	If a tool is in use for a long time and over a long distance, it is assumed that the longer the distance between source and site is the more intensive the objects could be modified and reduced
Organisation of the group	Organized in base camps and special task camps	Organized in movements from small camps to the next	Fast made and fast used tools could be just related to special tasks and therefore are more related to the base-special task model

Tab. 35 - Juxtaposition of curation and expediency

Shott (1996: 267) summarizes what for him curation is in the following sentence: *„Curation is the degree of use or utility extracted, expressed as a relationship between how much utility a tool starts with — its maximum utility — and how much of that utility is realized before discard (Shott 1989: 24, 1995).“* The detection of diversity in homogeneity is strongly related to the observed intrinsic and extrinsic parameters for the formation of assemblages. It seems that the raw material, the environment, as well as physiological and psychological aspects are all related to find explanations about observed diversity in an homogeneous mass of lithic objects.

III.4. Maximum territory of the entire Neanderthal population

Neanderthals reached their maximum territorial distribution in the Late Pleistocene (OIS 5 to 3). As illustrated by Serangeli & Bolus (2008), skeletal remains of hominins described as Homo neanderthalensis are found in sites in Europe and Asia (Eurasia). Mostly, they are separated into three chronological (and morphological) groups (tab. 36):

Chronological (and morphological) groups	Timeframe	Oxygen Isotope stages (OIS)	Maximum range
Pre-Neanderthals	> 200 ka	> 7	Western (south and north), central Europe and south-eastern Europe
Early Neanderthals	200 to 115 ka	7 and 6	Western (south and north), central Europe and south-eastern Europe
Classical Neanderthals	< 115 ka	5e to 3	Western (except the British isles), central and eastern Europe, Near East, southern Siberia

Tab. 36 - Chronological entities of Neanderthal remains as used by Serangeli & Bolus (2008)

Since 2008, additional skeletal remains of Neanderthals were detected and add our picture about this hominin taxon. New sites (extracted from the literature) are listed in the following tab. 37:

Site	Region	Dating	Note	Literature
Chagyrskaya cave	Gordy Altai, Russia	100 to 44 ka	Many cranial and post-cranial specimen of Neanderthals (around n=67)	Buzhilova 2013, Derevianko et al. 2013, Mednikova 2013
Cova del Gegant	Sitges, Barcelona, Spain	52.3±2.3 ka BP (U-series)	Mandible without teeth, mandible with teeth, fragment of a humerus, isolated teeth	Daura et al. 2010, 2015, Rodriguez et al. 2011, Quam et al. 2015
Kalamakia	Mani peninsula, Greece	between 109+14-13 ka BP (U-series) and >39 ka BP (AMS 14C)	Isolated teeth, occipital fragment, vertebrae, fibula fragment, navicular	Harvati et al. 2013
Okladnikov	Altai, Russia	45 to 40 ka BP (U-series and 14C)	Isolated deciduous and permanent teeth, humeri	Dobrovolskaya & Tiunov 2013, Dobrovolskaya 2014
Stajnia	North of the Carpathian Mountains, Poland	OIS 5c or 5a, >49 ka BP (AMS 14C), 52.9 ka BP (U-Th)	Permanent molars	Urbanowski et al. 2010, Dabrowski et al. 2013
Zeeland ridge	Nederlands	Late Pleistocene	Frontal bone fragments	Hublin et al. 2009

Tab. 37 - Six additional sites with Neanderthal remains published after 2008

The following fig. 25 displays all these sites with Neanderthals remains from the Late Pleistocene on a map with a lowered sea level of around 120 m, as it can be expected for colder parts of the Late Pleistocene (e.g., OIS 4 and 2). The majority of sites with Neanderthals remains are found in the southern part of glacial Europe. Other sites are spread around the Black sea and in the East Mediterranean Levant. Sites from central Asia are clearly isolated from the area of the main distribution:

III.4.1 Mousterian at the arctic circle?

But we need to bear in mind that this map (fig. 25) illustrates only sites with skeletal remains and they may do not reflect the entire area of Neanderthal occupation. The site of Byzovaya in the far North of Russia is such an example. The site is situated near the arctic circle and yielded archeological remains (Slimak et al. 2011). The site is clearly way far outside of the range of the skeletal distribution, but attributed to a Middle Paleolithic. But there is also critic about the Middle Paleolithic attribution of this site (Zwyns et al. 2012), because it might also be that this very isolated site is in the spectrum of the early Upper Paleolithic. Up to now this site bears no human remains, so a clear association remains an open question.

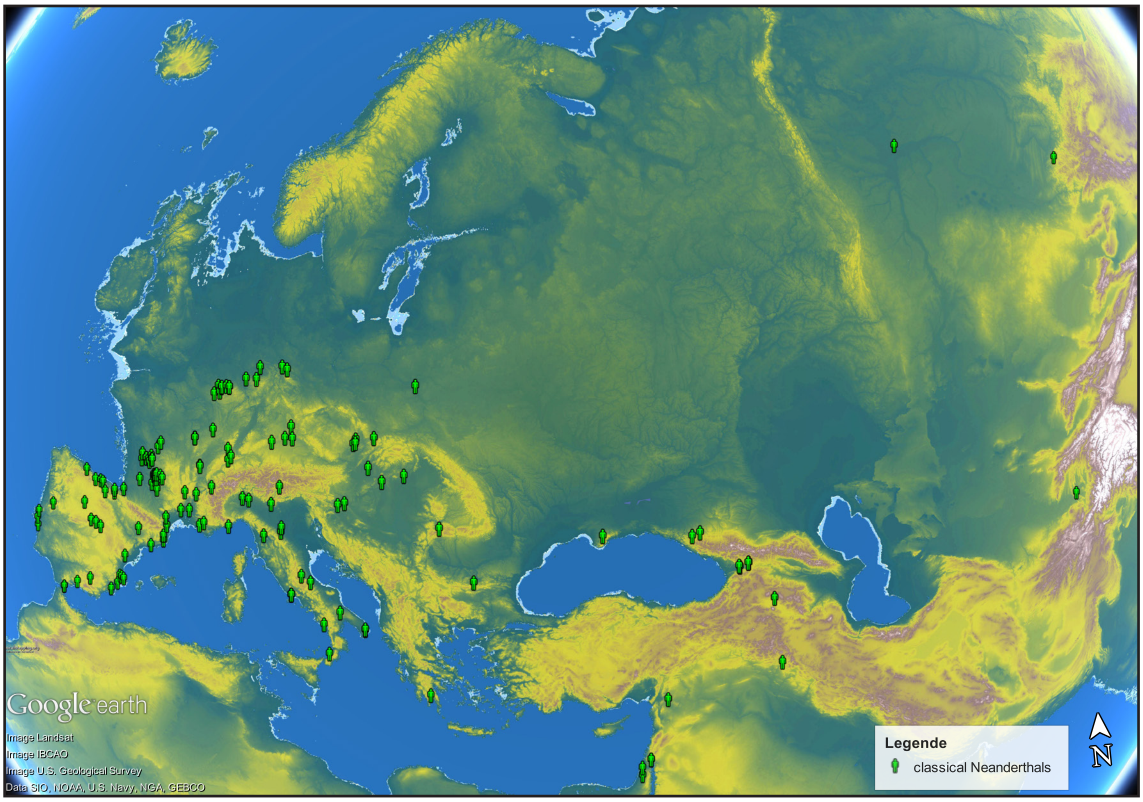

Fig. 25 - Distribution of skeletal remains attributed to Late Pleistocene Homo neanderthalensis. Sites from Serangeli & Bolus (2008) with the addition of publications after 2008 and unmentioned remains. Base map from Google Earth Pro, Paleochron map layer of sea level 120 m b.s.l. from www.temporalmapping.org (April 25, 2015).

III.4.2 Middle Paleolithic in East Mediterranean Levant

Another point of application can be seen in sites in the Near East, where we know that Neanderthals and Modern Humans shared the same territory, but maybe not at the same time (Akazawa et al. 1998). „*Ten Levantine MP sites have yielded human fossils, but only about half of them preserve remains complete enough for their morphological affinities to be identified either with Neandertals (Homo neanderthalensis) or early modern humans (Homo sapiens) […]. Both Neandertals and early modern humans are associated with superficially similar sets of faunal remains and lithic assemblages (Bar-Yosef, 2000; Kaufman, 1999; Lieberman and Shea, 1994; Shea, 2001). No single level of any Levantine MP site contains the remains of both hominids.*“ (Shea 2003b)

In the following tab. 38, we display skeletal finds from the East Mediterranean Levant (Shea 2003a; b: 327, tab. 1):

Site and layer with hominin skeletal remains	year of disco-very	Natur of skeletal remains	Taxonomic attribution	Literature
Shukbah D	1928	Neanderthal tooth, cranial fragments, two distal femo-rae, and astragalus	Neanderthal	Keith 1931:204-208

El Wad G	1929-33	Adult molar tooth, affinity intermediate	Intermediate	McCown and Keith 1939
Tabun B	1929-34	Numerous dental remains of all Neanderthal	Neanderthal	McCown and Keith 1939
Tabun B/C	1929-34	adult female Neanderthal (C1) buried with neonate (not recovered)	Neanderthal	McCown and Keith 1939; Bar-Yosef and Callendar 1999
Tabun C	1929-34	Level C—adult mandible (C2), numerous other isolated postcranial remains of Neanderthal (?) affinities	Neanderthal?	McCown and Keith 1939; Stefan and Trinkaus 1998
Skhul B	1931-32	Seven adults, three juveniles, all early Modern Humans	Modern Human	McCown and Keith 1939
Qafzeh L	1933-35	Four adults (3, 5–7), two juveniles (4, 4a), all early Modern Humans	Modern Human	Vandermeersch 1981; Tillier 1999
Kebara, Level F	1964	One fragmentary juvenile skeleton (KH1)	?	Smith and Arensburg 1977
Ras el-Kelb	1959	Two teeth, affinity indeterminate	Intermediate	Bourke 1998
Amud, Level B	1961-64	Two adults, two juveniles, all Neanderthal	Neanderthal	Bourke 1998
Shovakh "lower cave earth"	1962	Two adults, two juveniles, all Neanderthal	Neanderthal	Trinkaus 1987
Hayonim, Level E	1965-79	Cranial, dental, and postcranial remains of uncertain affinity	?	Arensburg et al. 1990
Qafzeh XV-XXII	1965-77	Two adults, five juveniles, several isolated teeth, all early Modern Humans	Modern Human	Arensburg et al. 1990
Geulah A, Level B2	1967	Two adults, five juveniles, several isolated teeth, all early Modern Humans	Modern Human	Wreschner 1967
Kebara VII-XII	1984-91	One partly-complete adult skeleton (KH2) in Level XII, numerous isolated bones and teeth throughout Levels VII–XII, all Neanderthal	Neanderthal	Bar-Yosef and Vandermeersch (1991)
Amud B	1992-96	Two juveniles, both Neanderthal, numerous fragmentary remains	Neanderthal	Hovers et al. (1995)
Dederiyeh Levels 11	1993-98	Two juvenile Neanderthals (#1 D 10 months, #2 D 19 months)	Neanderthal	Akazawa et al. (2003)
Umm el Tlel	1995	Occipital fragment	Neanderthal	Couture 1998

Tab. 38 - Hominin remains from the East Mediterranean Levant, as displayed in Shea (2003, tab. 1).

Most scholars consider that they cannot see any significant differences of the Middle Paleolithic record attributed to skeleton remains, neither attributed to Neanderthals nor Modern Humans. Or in the words of Shea (2003a: 175): „*Some* *flintknapping techniques and tool types are more commonly associated with Levantine Neandertals than they are with early modern humans and vice versa. Yet neither particular tool types nor particular techniques are exclusively associated with one or the other set of hominid fossil contexts. In fact, the overwhelming majority of most Late Levantine Mousterian assemblages are comprised of the same simple flake tools found in most European Middle Paleolithic and African Middle Stone Age assemblages.“*

III.4.3 Mousterian industries in India

As illustrated for the Near East region it seems not possible to define an exact Neanderthal territorial range with the aid of lithic industries. Finally, examples from India also demonstrate that typical Middle Paleolithic industries — in European context for the most part associated with Neanderthals - can be found far apart of the spatial distribution of Neanderthal skeleton remains (e.g., Biagi & Starnini 2014).

III.4.4 Levallois in Australia

This is also displayed in the occurrence of Levallois-like industries in Australia (Cochrane 2014; Dortch & Bordes 1977) which is (up to now) associated with Modern Humans. As we can assume from the burial of a Modern Human at Lake Mungo (Bowler et al. 1970; Durband & Westaway 2013) with an age estimation of 40±2 ka BP (Bowler et al. 2003) and the estimation of human presence at Lake Mungo around 50 to 46 ka BP (Olley et al. 2006). As we see (fig. 26) the Levallois concept for lithic object production is much more spread (here: spatial) than the distribution of skeletal remains from Neanderthals (see fig. 25).

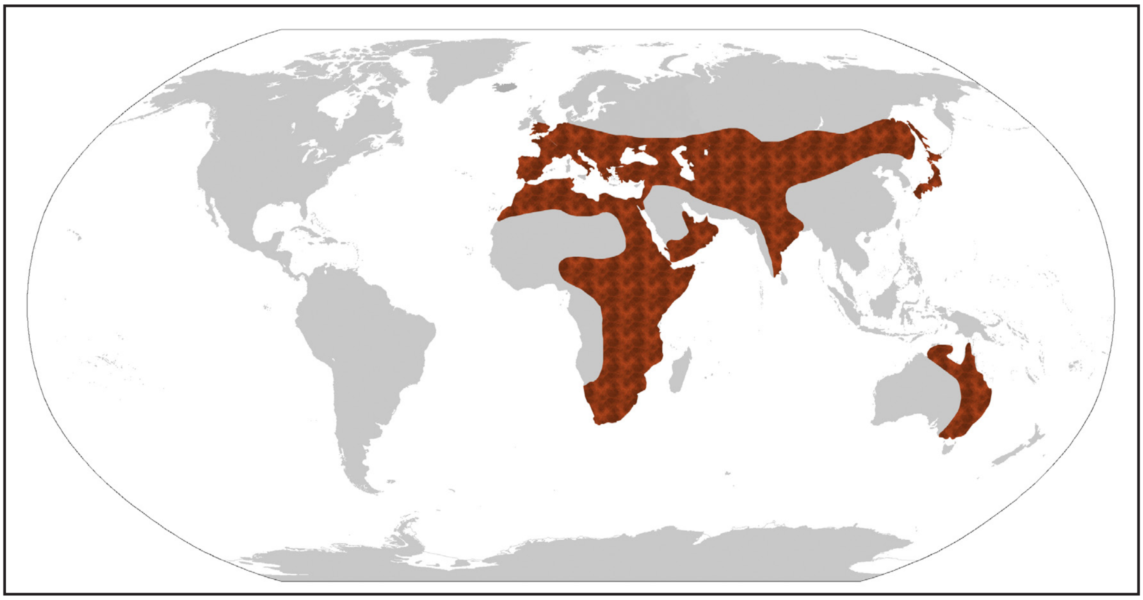

Fig. 26 - Global distribution of Levallois, after Brantingham & Kuhn (2001), Sato et al. (1995), Dortch & Bordes (1977), Bordes (1980), Otte & Derevianko (2000), Crassard (2008) and Lycett (2007, 2009), see also Frick (2010, fig. 30)

III.4.5 Contact to Denisovans in central Asia?

Recent paleogenetic research in Denisova cave, Altai demonstrates that another hominin showed up around 40 ka BP (Krause et al. 2010) and it is suggested that there are genetic relations to Modern Humans and Neanderthals (Marchi et al. 2013). Different lines of evidence show that Denisova cave was alternated occupied by all of these three Humans (Stewart & Stringer 2012). That leads to new distribution maps as shown in fig. 27. Newly published results of DNA analyses from Denisovans (Sawyer et al. 2015) suggest a close relationship between Neanderthals and Denisovans.

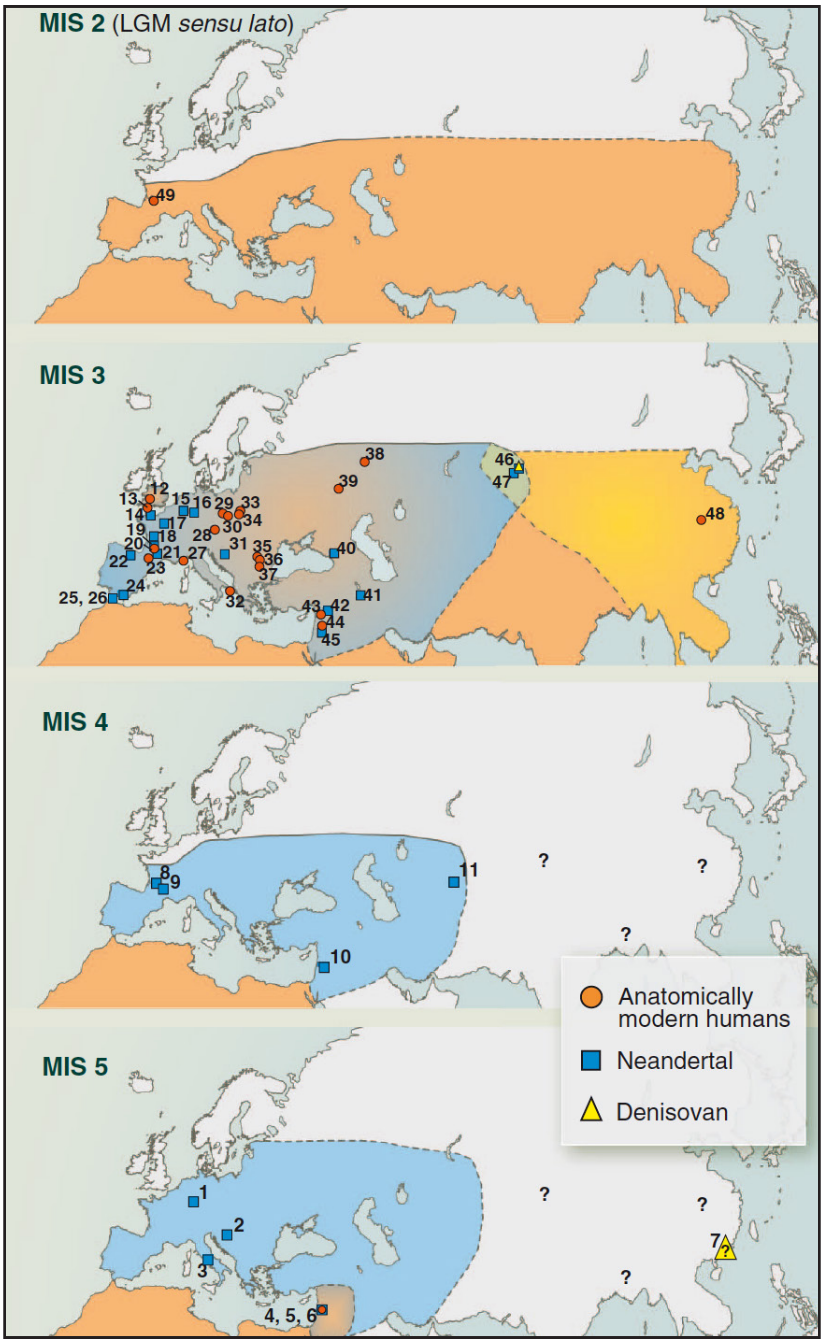

Fig. 27 - Territorial range of Neanderthals, Denisovan and Modern Humans around OIS 3 (Stewart & Stringer 2012, fig. 1)

III.4.6 Neanderthals in Northern Africa?

Another question (but more related to the research history) is if Neanderthals were also distributed in Africa. In the 1940s, this question seems to be solved, because of Hrdlička's collection of human skeletal remains (Hrdlicka 1929; Hrdlička 1930) and the discovery of the Tangier man by C. S. Coon in May, 1939 (Şenyürek 1940a, b). In the 1960s there was still the belief that Neanderthals were personally present in Northern Africa (Ennouchi 1963, 1969) and therefore Bordes (1968: 125) wrote the following in his overview of the Paleolithic (here the German translation): *„In Marokko kennt man als sichere Fundstätte nur die von Dschebel Irhoud, die erst in jüngster Zeit entdeckt wurde; dies scheint - vorbehaltlich eines genauen Verzeichnisses - typisches Moustérien zu sein. Man hat in dieser Fundstelle Überreste des Neandertalers gefunden.“* (In Morocco the only secure site is Jebel Irhoud…with remains of Neanderthals). From the late 1970s on, more and more examinations were conducted about human skeletons thats were associated to Neanderthals (e.g., Briggs 1968; Santa Luca 1978) and rejected. In 2012 a summary of known hominid remains of northern Africa showed clearly that no skeleton remains of Neanderthals are present there (Hublin & McPherron 2012), but genetic analysis demonstrates that *North African Populations Carry the Signature of Admixture with Neandertals* (Sánchez-Quinto et al. 2012).

Lithic industries in northern Africa (between 300 and 40 ka) are similar to the European Middle Paleolithic (see for example Linstädter et al. 2012; Van Peer 1992). This is the reason that both were attributed to be Moustérien (Bordes 1968, 1981). But the originator seems to be different (Hublin & McPherron 2012). A distinct lithic entity there is the Aterian (Scerri 2013). A specific reduction systems seems to be non-existing in European context, the Nubian Levallois reductions (mainly in OIS 5) for the production of points and oval flakes, which is almost exclusively distributed in Africa (Van Peer 1986; Will et al. 2015) and Arabia (Crassard & Hilbert 2013).

It seems that Neanderthals never crossed the strait of Gibraltar heading to the South nor did Modern Humans northwards in Middle Paleolithic times (Straus 2001; Zilhão 2011).

III.4.7 Neanderthals on islands?

While it seems that Neanderthals never crossed the strait of Gibraltar (see above), there is evidence that Neanderthals crossed water bodies to reach islands in the Mediterranean sea (e.g., Bednarik 2003). Even way before the presence of Neanderthals water were crossed, illustrated by artifacts on Flores that were found in sediments dating back between 960 and 700 ka BP (Brumm et al. 2010). In the whole Pleistocene, this island was always surrounded by water and lays east of the Wallace line. We display two prominent examples that Neanderthals (respectively Middle Paleolithic artifacts) also crossed water bodies and reached land that were islands in the time of occupation in the mediterranean sea (see tab. 39):

Island	Evidence	Time of occupation	Literature
Southern ionian islands (Corfu, Lefkada, Kefallinia,	Middle Paleolithic sites on these islands, geological evidence for islands also at very low sea levels	110-35 ka	Ferentinos et al. 2012
Crete	Middle Paleolithic sites in the south of Crete, Crete was an island in the entire Pleistocene period	>130 ka	Runnels 2014, Strasser et al. 2010

Tab. 39 - Examples of water crossing of Neanderthals

III.5 Middle Paleolithic in Europe

Neanderthals are the only hominin species whose skeletal remains were found in Middle Paleolithic context in Europe (for Asia, respectively Near East and central Asia this is different, as it was partly displayed above). To date, for central and western Europe it can be said with high certainty that Neanderthals were the originators of industries defined as early, middle and late Middle Paleolithic. For so called transitional industries it is way more complicated to determine their originators. The following section will give an overview of industries that are defined as Middle Paleolithic. To do so, first a timeframe for the Middle Paleolithic is given and some definitions what a Middle Paleolithic industry is (or can be). Secondly, an overview to early, middle, late and final Middle Paleolithic industries is given.

III.5.1 Timeframe for the European Middle Paleolithic

Most scholars agree that the European Middle Paleolithic is the time of Neanderthals (see for e.g., Jöris 2005; Mellars 1996). If we are suspicious about this correlation of hominins and a specific Paleolithic industry we would have a look into the paleoanthropological record to define when and where Neanderthals occurred in space and time and in its extremest sense we would only call archeological layers that bear Neanderthals remains Middle Paleolithic. Another possibility would be to use analogies to define the Middle Paleolithic. When we use the definition that the European Middle Paleolithic is the time of Neanderthals we can also add layers that bear no Neanderthals remains but yield the same industry. For Western and central Europe it seems that this definition is working well (for the discussion about the Uluzzian, Bohunician and other industries see below in section final Middle Paleolithic). As we pointed out earlier, in the eastern mediterranean Levant Homo sapiens and Homo neanderthalensis remains are associated with nearly the same Middle Paleolithic industries (Shea 2003b). For this area the analogical definition of association does not work.

The only hominin skeletal remains that are associated with the archeological record in the timespan between 300 and 50 ka BP in Europe are from Homo neanderthalensis (Serangeli & Bolus 2008). This association last now since the beginning of the 19th century were skeletons were excavated that were associated with Middle Paleolithic finds. Examples here are skeletons found by Denis Peyrony like in Pech de l'Azé (Capitan & Peyrony 1909) or La Ferrassie (Capitan & Peyrony 1909, 1921; Peyrony 1934) or the skeleton (Homo mousteriensis hauseri) found by Otto Hauser in Le Moustier (Hauser 1909). For the later, Hauser showed the direct connection between this skeleton and lithic artifacts (Hauser 1909).

III.5.2 Definitions for the European Middle Paleolithic

If we accept the assumption that Neanderthals were the originators of the Middle Paleolithic in Europe, the beginning of the Middle Paleolithic should correlate with the first occurrence of the species Homo neanderthalensis. But in many definitions the beginning of the Middle Paleolithic is set on this point in time, when specific lithic reduction concepts get dominant in the archeological record. Richter's (2011) definition for the Middle Paleolithic is the following: „*Nowadays, we understand the Middle Paleolithic as the time when lithic assemblages came into use which were characterized by the predominance of tools made on flakes from standardized flake production such as the Levallois concept, the discoid concept or the Quina concept of flake production. Occasionally, Middle Paleolithic lithic industries may also display bifacial tools (Bosinski 1967; Richter 1997) and blades (Conard 1992), sometimes as a dominating component.*"

Mostly Levallois reduction is used to define the beginning of the Middle Paleolithic (e.g., Bosinski 1967, 1982; Mellars 1996; Tuffreau 1995). Because it got the dominant flaking strategy. Normally, this point is set to something around 300 ka BP (Richter 2011). Richter (2011) discuss also the possibilities if Discoidal or Quina reduction could be used as domain of definition, but explains that they also occurred much earlier (Delagnes & Meignen 2006). This is the case when Discoidal technology is defined sensu lato (Leakey 1971; Potts 1991; Terradas 2003) and their occurrence during Oldowan is also integrated.

For defining the end of the Middle Paleolithic different approaches are used. To give an idea how the end in time of an archeologically defined group in space and time can be defined, the reader is referred to the following table (tab. 40):

Denomination	Criteria	Example	Literature
Last occurrence of a specific artifact	people of later periods didn't use this specific artifact	Levallois reduction is referred to occur only in Middle Paleolithic context (in Europe)	Bosinski 1967, 1982
Occurrence of a new artifact, formerly unknown	people of earlier periods didn't invent or use this specific artifact	Upper Paleolithic blades	Peyrony 1920, 1934
Change of geological (ecological) setting	the geological (ecological) change can be seen in the record	Defining the Eem as Middle Middle Paleolithic Defining the Mesolithic as industries of hunter and gatherers in the early Holocene	Bosinski 1982, Mellars 1981
End of dominance of a specific artifact	people of later periods didn't use this specific artifact often	Levallois reduction is referred to have its dominance in Middle Paleolithic context (in Europe)	Bosinski 1967, 1982
Disappearance of a hominin species that were associated with a specific set to artifacts	good association of skeleton remains and artifacts must be given	disappearance of Neanderthals around 40 ka BP can be seen as the end of the Middle Paleolithic	Jöris & Street 2008, Jöris et al. 2011

Tab. 40 - Examples of occurrence and disappearance as indices for defining an archeological entity

Definitely, there are much more possibilities to define the chronological beginning (or the end) of an archeological entity in space and time. A definition of such a group can stay and fall with its chronological fixation.

As we saw there are different options how the ending of an archeological occurrence can be defined. The paragon for such a situation in the archeological record is the transition from the Middle to the Upper Paleolithic, because this moment (or time span) can be defined very differently.

Mainly there are two different approaches to define the End of the Middle Paleolithic. The one is to say that Levallois defines the Middle Paleolithic and when this lithic concept stops to be the dominant lithic reduction concept the end is reached (Bosinski 1982). Also when a new artifact occurs (e.g., the Châtelperronian point) the archeological occurrence before this moment stops (De Sonneville-Bordes 1960). Another perspective would be to claim that the Châtelperronian shows some Middle Paleolithic features, i.e. affinities to the *Moustérien de tradition acheuléenne* (e.g., d'Errico et al. 1998; Guilbaud 1993; Leroi-Gourhan 1968; Pelegrin & Soressi 2007; Ruebens et al. 2015; Zilhão & d'Errico 1999), or that some sites in southwestern France show a clear gab between the *Moustérien de tradition acheuléenne* and the Châtelperronian (Jaubert et al. 2011a).

Another definition would integrate the originators of an industry as Jöris does (Jöris & Street 2008; Jöris et al. 2011a). In his idea, so called transitional industries that can be associated with high certainty to a specific hominid (in this case the Neanderthals) are seen as final Middle Paleolithic, as the last expression of

Neanderthals. In such a scenario the Uluzzian changed its position, because it was formerly associated with Neanderthals. Recently hominin teeth from Grotta Cavallo were analysed and now attributed to *Homo sapiens* (Benazzi et al. 2011). Therefore, now, the Uluzzian can be associated with Modern Humans and can therefore defined as an early Upper Paleolithic expression of Modern Humans (Banks et al. 2013; but see also Ronchitelli et al. 2014).

In the following we are using the following statements to define the chronological beginning and end of the Middle Paleolithic:

- The European context suggest a clear correlation between Middle Paleolithic industries and the hominin species of *Homo neanderthalensis*
- No other hominin form than *Homo neanderthalensis* was found in Europe between 300 and 50 ka BP (Serangeli & Bolus 2008)
- The late Middle Paleolithic, namely the *Moustérien de tradition acheuléenne* (Soressi 2002), the *Keilmessergruppen* (Jöris 2003) or the East European Micoquian (Chabai 2003; Chabai et al. 2007, 2008; Sinitsyn 2003) only contain Neanderthal skeletal remains (Jöris et al. 2011a)
- We are using Clark's (1961) definition of Mode 3 (prepared cores) and add the dominance of these reduction (all prepared, or better configured cores like Discoidal, Quina and Levallois cores)
- Around 300 ka, a shift to new ideas for the systematic production of flakes and blades can be seen in Europe, as well as the shift to flake tool concepts, like knives, scrapers and points, because of much higher frequencies in lithic assemblages in Europe (Jöris 2015)
- The beginning of the Middle Paleolithic was defined as the beginning of the appearance of prepared cores, namely Levallois (Bosinski 1967, 1982; Grahmann 1952; Richter 2011)
- If so called transitional complexes are proven to be made by Neanderthals we entitle them as final Middle Paleolithic, as this was done by Jöris et al. (2011a).
- Preliminary, the Uluzzian is defined as Early Upper Paleolithic, because it was probably made by *Homo sapiens* (Benazzi et al. 2011)
- For entities without a proven originator (e.g., the Bohunician) but with a clear tendency (Middle Paleolithic, e.g., Škrdla 2013) they are preliminary defined as Final Middle Paleolithic

Finally, we would go into advance to separate the Middle Paleolithic into the following (mostly chronological) entities (tab. 41), as it was proposed by others (Bosinski 1982; Jöris 2015):

Denomination	Chronological frame	Chronological position in regard to the last interglacial	Oxygen isotope stages (OIS)	Literature for the chronological frame
Early Middle Paleolithic	300 to 125 ka BP	ante-Eem	9c to 6	Richter 2011
Middle Middle Paleolithic	125 to 112 ka BP	inter-Eem	5e	Gaudzinski et al. 2013
Late Middle Paleolithic	112 to 45 ka BP	post-Eem	5d to 3	Jöris 2015
Final Middle Paleolithic	45 to 40 ka BP	post-Eem	3	Jöris et al. 2011

Tab. 41 - Chronological separation of the Middle Paleolithic.

It would be hardly possible to explain the Middle Paleolithic in following chapters in detail, therefore we refer to other extensive works (e.g., Jaubert 1999, 2014; Jöris 2015; Zilhão 2014). A short overview is given for the timespan of the Late and Final Middle Paleolithic of the surrounding, because the preliminary radiometric datings of Grotte de la Verpillière II indicate an age inside OIS 3 (see chapter IV.5).

III.5.3 Late and final Middle Paleolithic as timespan

The Late Middle Paleolithic as the timespan after the Eemian interglacial (OIS 5c) is traditionally seen as the Middle Paleolithic. In Bordes' (1984) definition of the Middle Paleolithic (which is definitely outdated) the Middle Paleolithic (*le Paléolithique moyen*) was the time between the Eemian interglacial and the beginning of the Upper Paleolithic. The so called Micoquian was for him an entity that belongs to the Acheulean (the time before the Eemian interglacial). Advances in dating (mostly radiometric) and material analysis showed clearly that the time gab between the Acheulian and the post-Eemian can be appointed to more than 150 ka.

Facies and Formengruppen as entities

In regard to Middle and Western Europe, a vast bandwidth of entities defined using a diversity of lithic analysing approaches were proclaimed. From the 1950s to the 1980s the approaches of Bordes (Bordes 1953a; Bordes & Bourgon 1951) and Bosinski (1963, 1967, 1972, 1982, 2000) were mainly used to defined cultural entities that belongs to the Middle Paleolithic, but these approaches are hard to compare with each other. A similarity between both approaches is that they avoid to use the word culture for their entities (Bordes: *facies*, Bosinski: *Formengruppen*), but both approaches state that these entities „*document the existence of groups of hominids that transferred their stone knapping practices via learned behavior from one generation to the next and recognized themselves as belonging to a social group (Bosinski 1967: 84)*" (Conard & Fischer 2000: 8) and „*There existed, during the Lower Palaeolithic (Acheulian, Clactonian), the Middle Palaeolithic (diverse Mousterian facies) and the Upper Palaeolithic (Perigordian, Aurignacian) different cultures, with different traditions of tool making, which coexisted on the same territory and influenced each other very little.*" (Bordes & de Sonneville-Bordes 1970: 65).

New approaches to define entities

As we saw in other chapters (e.g., chapter III.2), from the 1980s on new analytical methods, using technological (including dynamic and transformation) approaches showed other clusters and entities. One West European approach is to classify assemblages into entities using dominantly specific unifacial lithic reduction concepts (Delagnes et al. 2007; Delagnes & Meignen 2006; Delagnes & Rendu 2011; Locht et al. in press). In other cases the presence of specific bifacial objects define the affiliation, such as the MTA (Soressi 2002) and many other entities containing bifacial elements (Cliquet 2001). In Middle European research the use of unifacial and bifacials objects for defining entities are also used, with its prominent example, the *Keilmessergruppen*. Many approaches for the formation of entities are used and still no consensus is reached. Namely that Mousterian and Micoquian (Mousterian with Micoque option, MMO) are part of the same entities, just a longer time of site occupation will lead to bifacial objects (simplified, after Richter 1997b). An approach which is strictly denied by Jöris (2003), in arguing that „*Die sich aus den ‚Gerätebiographien' ergebende lange Nutzungsdauer von Keilmessern und anderen bifazialen Geräten impliziert, daß in KMG-Inventaren solche — d. h. bifaziale — und nicht etwa andere Werkzeuge als Initialgeräte […] in Form einer ‚Grundausstattung' an den jeweiligen Platz gebracht und im Laufe der Belegung umgeformt wurden. Daß diese Formen aber erst bei – nach Richter – längerer Belegung eines Platzes hergestellt worden sein sollen […], steht zu dem Konzept der Geräteumarbeitungen in krassem Gegensatz.*" (Jöris 2003: 90). Richter (2016: 118-119) set the record straight in explaining: „*At the beginning of the land-use cycles (not at the beginning of single occupations, as it was often misunderstood: f.e. Jöris, 2003) bifacial tools tend to reflect their initial status* […]: *at the end they tend to be more reduced.*"

We could add many more examples of approaches or sites that will at first prove the one or the other possibility of classification of assemblages to entities. At the moment it seems that only the combination of lithic studies (lithic study that can show proportions of specific lithic approaches), site use, organic remains, landscape analysis and chronological fixation can help to advance our knowledge about group entities.

The future (because of the possibility using 'big data') will maybe provide possibilities to cluster the known Middle Paleolithic record using statistical similarities and dissimilarities (a good example for using a supercomputer). Because just the correlation of some factors for hundreds of sites will produce too much data to handle personally. Examples of such factors are listed in the following table 42:

Factor	Specification
Time	Chronological position
Environment	Position in the landscape Altitude Distance to resources (water body, food, raw material) Shelter from wind and weather (wind direction, exposition to the sun,…)

Lithic	Statistical dominant lithic production Percentage of a specific tool type Composition of the whole assemblage (import, on-site, export Composition of the production (what is produced for usage?) Raw material composition
Fauna	Statistically dominant species Statistically dominant body parts What was done with the animal remains?
Kind of site	In the cave, in the cave entrance, under a rock-shelter, openair-site,…
Type of site	Base camp, game observation stand, hunting camp, kill site, butchery site, raw-material source, workshop,…

Tab. 42 - Selected examples for factors that might aid to find statistical relevance in site comparisons

Mid-to-high resolution data in the surrounding for comparisons

In the proximity of Grotte de la Verpillière II, only a few sites can provide mid-to-high-resolution data regarding chronological fixation, litho-technological and faunal approaches , etc., for the Middle Paleolithic. These sites are listed in tab. 43, the geographical position is displayed in fig. 28 and fig. 29 shows a comparison in regard to dating.

Site	Dating	Specification	Levels and associated affiliation	Dating method	Literature
Les Hauts Massous à Vinneuf, Yonne	Mostly between 85 and 110 ka BP (OIS 5a to 5c)	Openair-site, short-term occupation in hunting camp	Level N0, N1 and N2 - Micoquian	Stratigraphical and sedimentological correlations	Deloze et al. 1994
Le Fond de la Tournerie à Lallly, Yonne	Mostly between 85 and 110 ka BP (OIS 5a to 5c)	Openair-site,short-term occupation in hunting camp	Level NA and NB - Mousterian	Stratigraphical and sedimentological correlations	Deloze et al. 1994
Le Domains de Beauregard à Lailly, Yonne	Between 40 and 50 (OIS 3), between 70 and 80 (OIS 5a), between 90 and 110 (OIS 5c and 5d)	Openair-site,short-term occupation in hunting camp	Level NA, NB, NC - Mousterian	Stratigraphical and sedimentological correlations	Deloze et al. 1994
Le Grand Chanteloup à Molinons, Yonne	Between 70 and 80 ka BP (OIS 4)	Openair-site, short-term occupation in hunting camp	Level NA - Mousterian	Stratigraphical and sedimentological correlations	Deloze et al. 1994
La Prieurée à Villeneuve l'Archevêque, Yonne	Between 40 and 50 (OIS 3), between 70 and 80 (OIS 5a), between 90 and 110 (OIS 5c and 5d)	Openair-site, short-term occupation in hunting camp	Level NA and NB - Mousterian, level NC - Micoquian	Stratigraphical and sedimentological correlations	Deloze et al. 1994
Le Dessous de Bailly à Champlost, Yonne	Between 45 and 60 ka BP (OIS 3 to 4)	Openair-site, short-term occupation in hunting camp	Level I, J and K - Micoquian	ESR	Gouédo 1999

Grotte du Renne à Arcy-sur-Cure, Yonne	Between 45 and 110 (OIS 3 to 5d)	Cave site, base camp?	level XII, XIII, XIV and XV - Mousterian	AMS 14C	Higham et al. 2010, Zilhão et al. 2012
Grotte du Bison à Arcy-sur-Cure, Yonne	Between 60 and 70 ka BP (OIS 4)	Cave site, base camp?	level E, F, G, H, I and J - Mousterian	AMS 14C	David et al. 2005, 2009
Grotte de l'Hyène à Arcy-sur-Cure, Yonne	Unknown	Cave site, base camp?	level 12 to 30? - Mousterian	Non	Leroi-Gourhan 1961, Girard 1978
Bissy-sur-Fley, Saône-et-Loire	Unknown	Openair-site, surface collection	Mousterian	Non	Parriat 1956, Desbrosse and Texier 1973
Rue Cateaux à Chenôves, Saône-et-Loire	Unknown	Openair-site, surface collection	Mousterian	Non	Guillard 1960
Beaux-Regards à Chenôves, Saône-et-Loire	Unknown	Openair-site, surface collection	Mousterian	Non	Guillard 1960
Grotte de Teux Blancs à Saint-Denis-de-Vaux, Saône-et-Loire	Unknown	Cave site, base camp? Fast and uncontrolled excavation	Mousterian	Non	Mayet et al. 1920, Lènez 1935, Combier 1956
Grotte de la Mère Grande à Rully, Saône-et-Loire	Unknown	Cave site, base camp?- Fast and uncontrolled excavation	Mousterian	Non	Combier 1959, Combier 1957, Desbrosse and Parriat 1975, Fabre 2009
Grottes de la Verpillière I à Mellecey Saône-et-Loire	GH 15 (mix of MP and UP material) - between 40 and 50 ka BP (OIS 3) GH 16 (intact) - unknown	Rock shelter, base camp? Early fast and uncontrolled excavations, recent excavations showed intricate stratigraphy, occupation in front and under the rock shelter	Mousterian Levallois, blade production, bifacial elements, tranchet-blows	ESR/U-Th AMS 14C	Desbrosse et al. 1976, Floss 2006-2011, Floss et al. 2013, 2014, 2015, 2016, Hoyer et al. 2016, Frick and Floss in press, Richard et al. 2016

Grottes de la Verpillière II à Mellecey, Saône-et-Loire	GH 3 - 45±4 ka BP (IRSL), 33±2 ka BP (ESR/U-Th EU), 36±3 ka BP (ESR/U-Th RU), 38 ±4 ka BP (ESR/U-Th) GH 4 - 47±5 ka BP (IRSL), 38±3 ka BP (ESR/U-Th) 41±3 ka BP (ESR/U-Th)	Rock shelter, base camp?	Recent excavation, clear stratigraphy, occupation unter the rock shelter and in the beginning of a cave tunnel. GH 3 - Levallois, opportunistic reduction and bifacial elements. GH 4 - Levallois and opportunistic reduction	Dating with IRSL, ESR/U-Th and 14C AMS	Frick and Floss 2015, Zöller 2016, Richard et al. 2016, Frick and Floss in press, Frick 2016, Frick reviewed
Le Bois des Ranches à Blanzy, Saône-et-Loire	Unknown	Openair-site, short-term occupation in hunting-camp	Surface collection	Non	Desbrosse 1979, Desbrosse and Tavoso 1970
La Roche à Saint-Martin-sous-Montaigu, Saône-et-Loire	Unknown	Openair-site, short-term occupation in hunting-camp	Surface collection	Non	Lènez 1926, Pouliquen 1982a,b, 1983, Gros and Gros 2005
Grotte de Folatière à Culles-les-Roches, Saône-et-Loire	Unknown	Cave site, base camp?	Fast and uncontrolled excavation	Non	Bourdier 1947, Lafond 1947, 1957, Guillard 1959
Les vignes du Colombier à Sennecé-lès-Mâcon, Saône-et-Loire	Unknown	Openair-site, short-term occupation in hunting-camp	Rescue excavation	Stratigraphical and sedimentological correlations	Connet et al. 2004

La Baume de la Gigny à Gigny-sur-Suran, Jura	14C of 28 to 30 ka BP. Oxygen Isotope correlation of OIS 5a to 3 (Navarro et al. 2004), level VIII - 30 to 40 ka BP, OIS 3, between H3 and H4; level XV - around 55 ka BP, OIS 3, level XVI - around 60 ka BP, OIS 4, level XIX - between 70 and 80 ka BP, OIS 4 to 5, level XX - around 80 ka BP, MIS 5a, XXIa' - > Eem?	Excavation of the entrance of a long tunnel cave 14C old dating, unreliable OIS correlation seems to be a bit to young, especially for the upper levels	Level VII - Mousterian with many scrapers, level XV - typical Mousterian, level XVI - Denticulated Mousterian, level XIX - typical Mousterian, level XX - Mousterian with many scrapers and few denticulates level XXIa' - Acheulian	dating with 14C, OIS-correlation and dating of a speleothem, typological description of the lithic industry, recent analysis of faunal remains	Campy et al. 1989, Navarro et al. 2004, Coudenneau 2005, Fabre 2010
Champ Grand à Saint-Maurice-sur-Loire	MIS 3 to 4	open air-site, long-term occupation?	level B and D - Mousterian	stratigraphical and sedimentological correlations	Slimak 2008, Nicoud 2010, Combier 1957

Tab. 43 - Sites with the potential to provide mid-to-high resolution data for making comparisons and clustering attempts of the Middle Paleolithic record of southern Burgundy

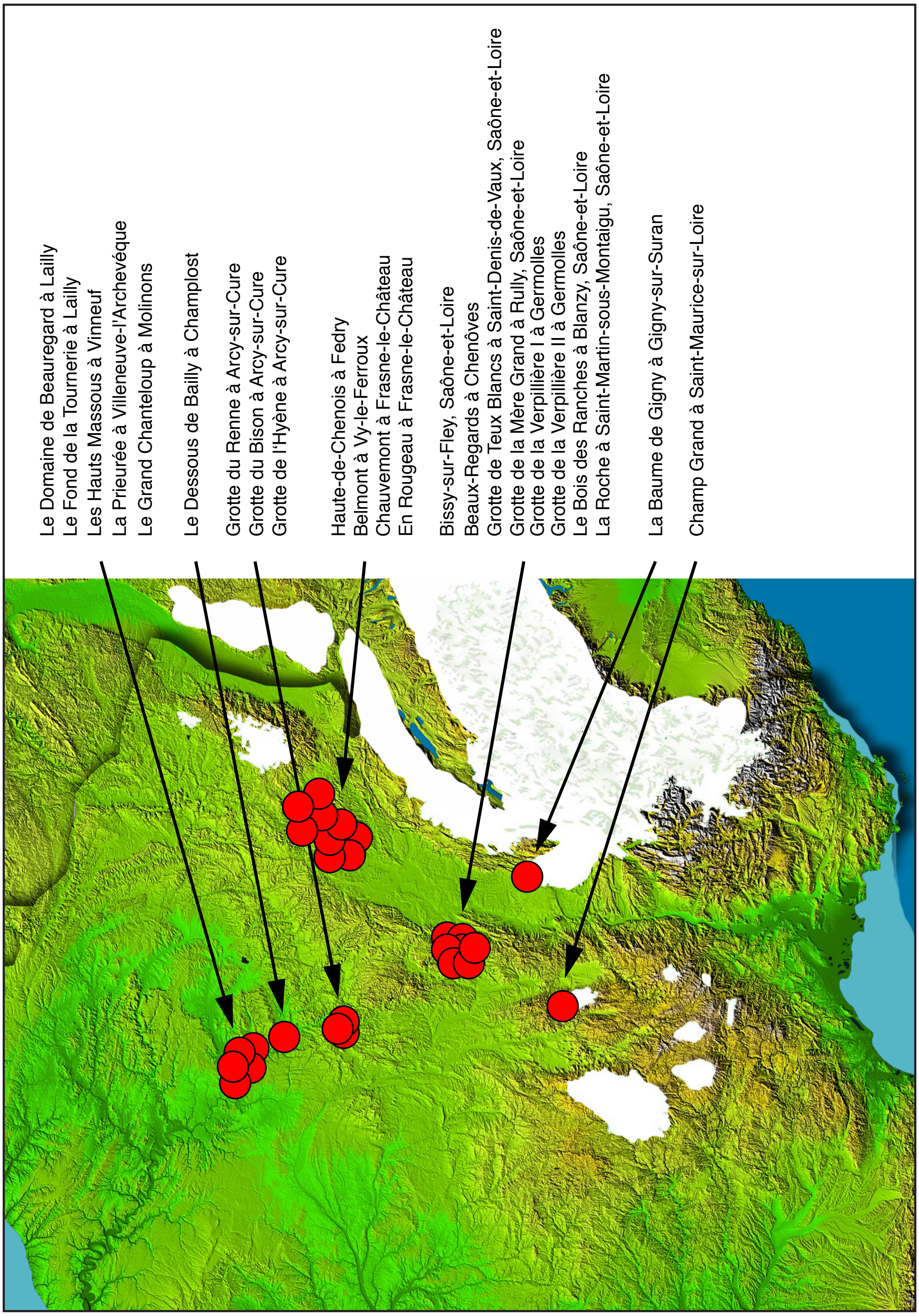

Fig. 28 - Geographical position of Middle Paleolithic sites used for comparison purposes

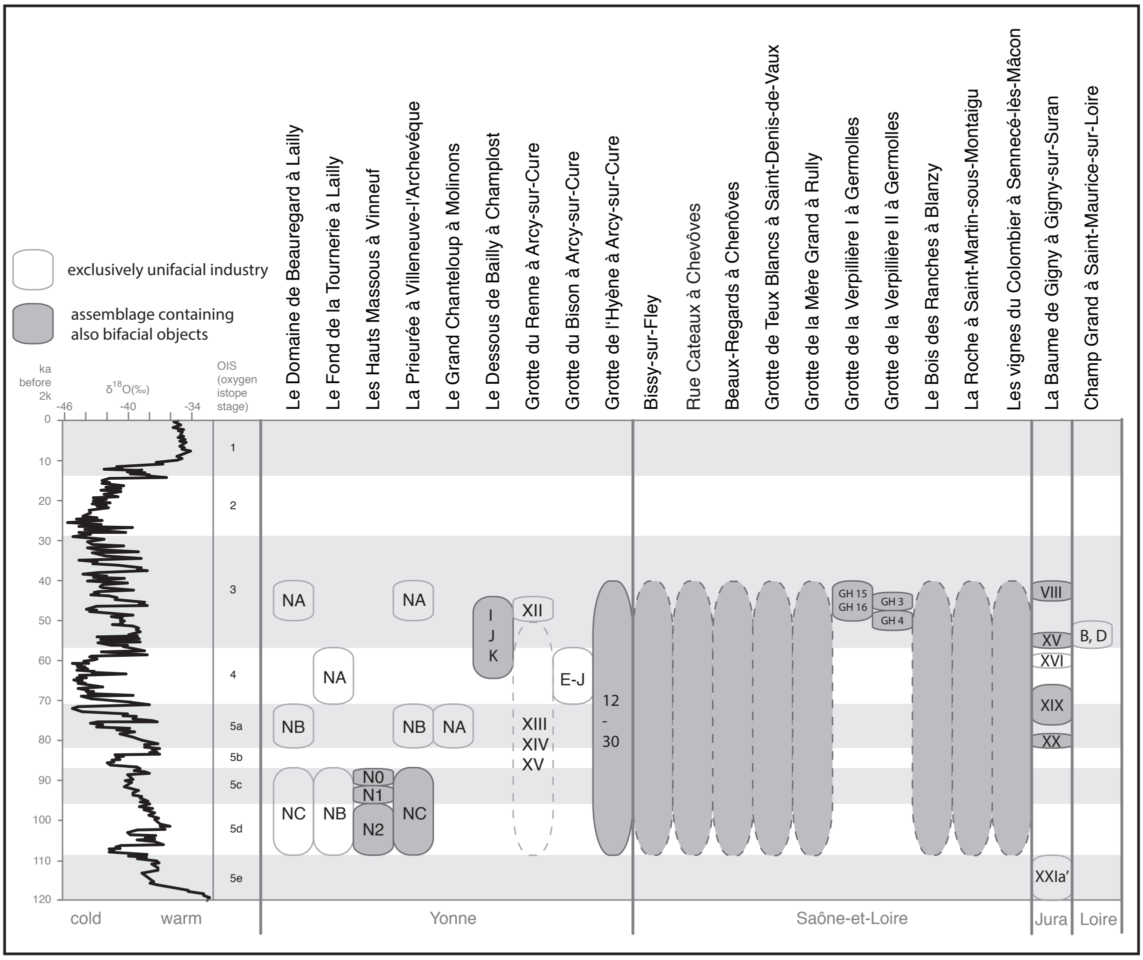

Fig. 29 - Dating of comparable sites, displayed agains δO-curve and oxygen isotope stages

Chapter IV: Grotte de la Verpillière II

“The cave you fear to enter holds the treasure you seek.” (Joseph Campbell)

IV.1 Introduction

The aim of this chapter is to give a broad overview of the archeological site of Grotte de la Verpillière II. Most of the aspects concerning the site can be explained best in the succession of knowledge acquisition. Embedded into the site history, geological, geographical and excavation methodical matters are discussed, as well.

IV.2 Research history of the site

Here, we summarize the research history of the site, beginning with its discovery in 2006, via the discovery of stratified sediments complexes belonging to the Middle Paleolithic time period in 2009, the following excavation of these sediments and the included studies. In addition to the excavation reports for the cultural heritage (*Service Régional d'Archéologie Bourgogne, SRA*) a preliminary insight into the site is given in the Festschrift for Jiří A. Svoboda's 60th birthday (see Frick & Floss 2015), which summarize the work done between 2006 and 2013. The following chapters are summaries of the detailed reports about the excavation (Floss 2006, 2007, 2008, 2009, 2010, 2011; Floss et al. 2013a, b, 2014a; Floss et al. 2014b, 2016).

Officially, the start of work related to Grottes de la Verpillière can be seen in the geographical measurement of the interior of Grotte de la Verpillière (I) at August, 2 to 3, 2003, as well as first publications for the evaluation the site's potential (Floss 2003, 2005). The entire excavation and all related research are under the auspice of Prof. Floss (University of Tübingen and Université de Bourgogne).

IV.2.1 Discovery in 2006

In the course of excavations at Grotte de la Verpillière (or Grotte de Germolles) at test pit of two square meters were conducted (on the cliff face around 50 m to the South) in 2006. The note of the potential site was given by an archeological amateur (J.-N. Blanchot) who found scratched out archeological artifacts at the cliff face on an animal den. It was proposed that an archeological site could be found there, because the sediment moved by animal were fresh and some artifacts adhered sintered sediment that should derive from the ground and not from landslide processes from the plateau above (see fig. 30).

The real discovery of the site can be dated to September, 25, 2006, at around 3 p.m. (Floss 2006), when it was possible to get a glimpse into a filled cave tunnel (around 30 to 50 cm under the surface of the animal den, see fig. 31). In this time M. Schumacher and Ch. Wißing excavated there. In the second week of the first campaign (two weeks, from September, 17 to 30, 2006) only two square meters (228-061 and 228-062, see fig. 32), directly at the cliff face were excavated.

Fig. 30 - Surface of the animal den without vegetation in 2006 (picture: Ch. Th. Hoyer)

Fig. 31 - First look into the cave tunnel of Verpillière II in 2006 (picture: Ch. Th. Hoyer)

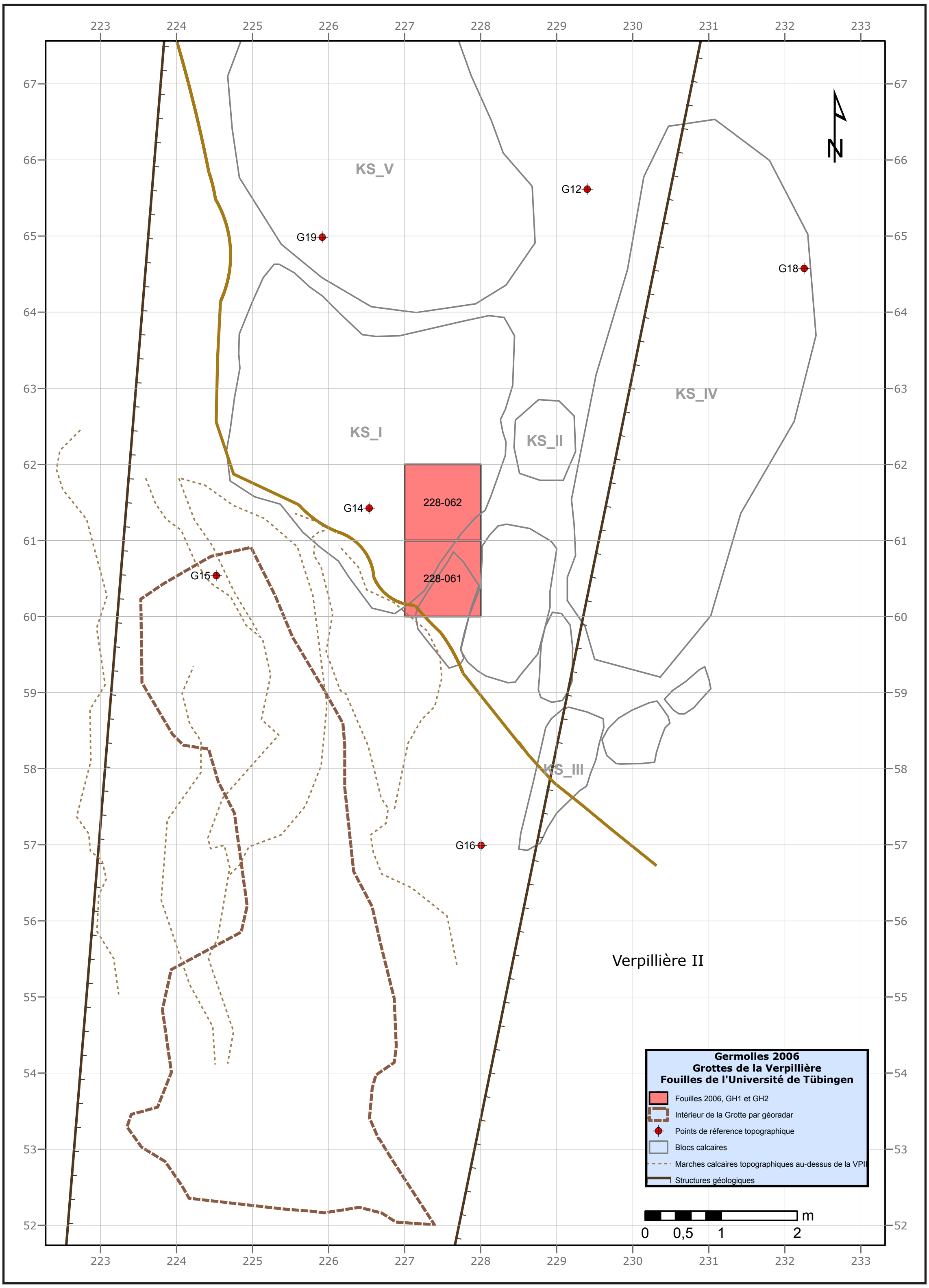

Fig. 32 - Excavated square meters in 2006 (GIS map: Ch. Th. Hoyer)

The visible tunnel had a diameter of 30 to 50 cm in southeastern direction and showed that there is a filled cavity. It was assumed that the visible tunnel is around 10 m long. PD Floss (at that time *Privatdozent*) decided after discussions at around 8 p.m. at this day that this new site should named Grotte de la Verpillière II, to associate it to the communal subdistrict. This denomination is also the reason that the former Grotte de la Verpillière is now Grotte de la Verpillière I. During the two week of excavation only collective finds were recovered, followed by sorting and extraction of the artifacts. Two sediment units could be distinguished, GH 1 and GH 2 (GH=geological horizon; all sediment units will be described later). The surfaces of these units were measured. The artifact spectrum contents lithic and faunal objects, as well as some modern pieces (plastic). It was clear that these sediment units are mixed layers and show mostly animal activities and the like. In addition to lithic objects that can be associated to the Middle Paleolithic (fig. 33), also Upper Paleolithic objects were found (fig. 34), as well as faunal remains from bison, horse and hyena. The combination of lithic objects of Middle and Upper Paleolithic affinity led to considerations, if here the transitions from Middle to Upper Paleolithic can be detected and studied (as we will discuss later up to now this seems not to be the case).

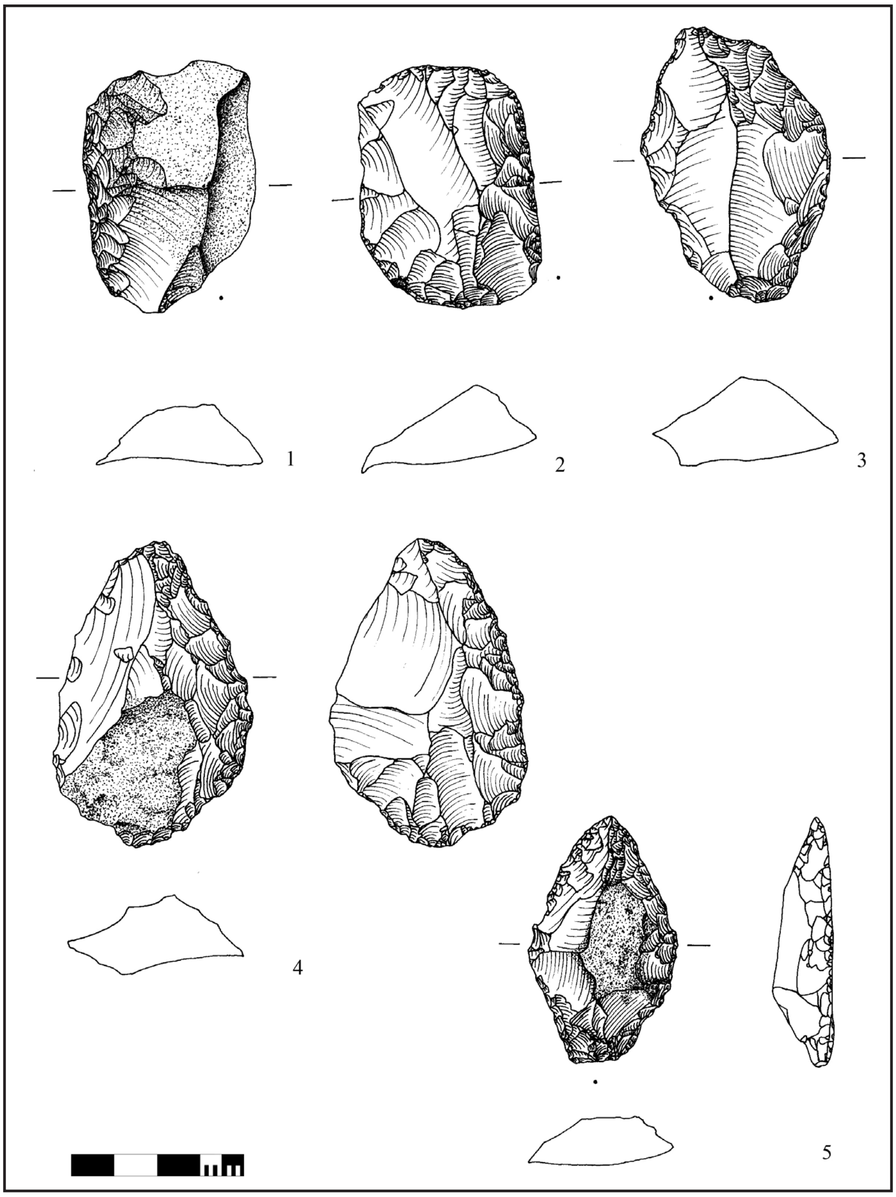

Fig. 33 - Middle Paleolithic artifacts from the 2006 campaign (see Floss 2006, fig. 11)

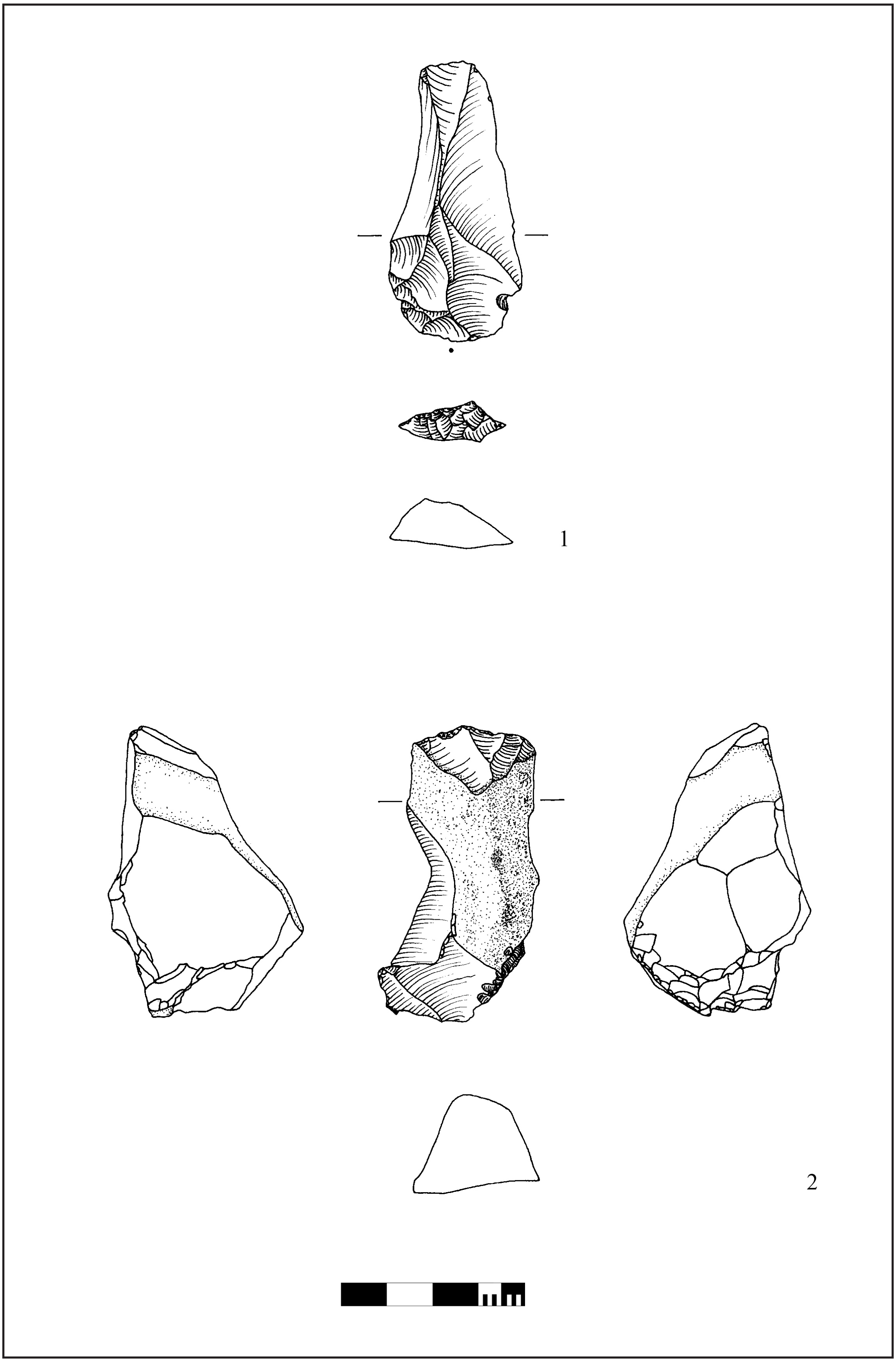

Fig. 34 - Upper Paleolithic artifacts from the 2006 campaign (see Floss 2006, fig. 12)

The following fig. 35 gives an overview of the discovery of this archeological site (Floss et al. 2013a, fig. 1):

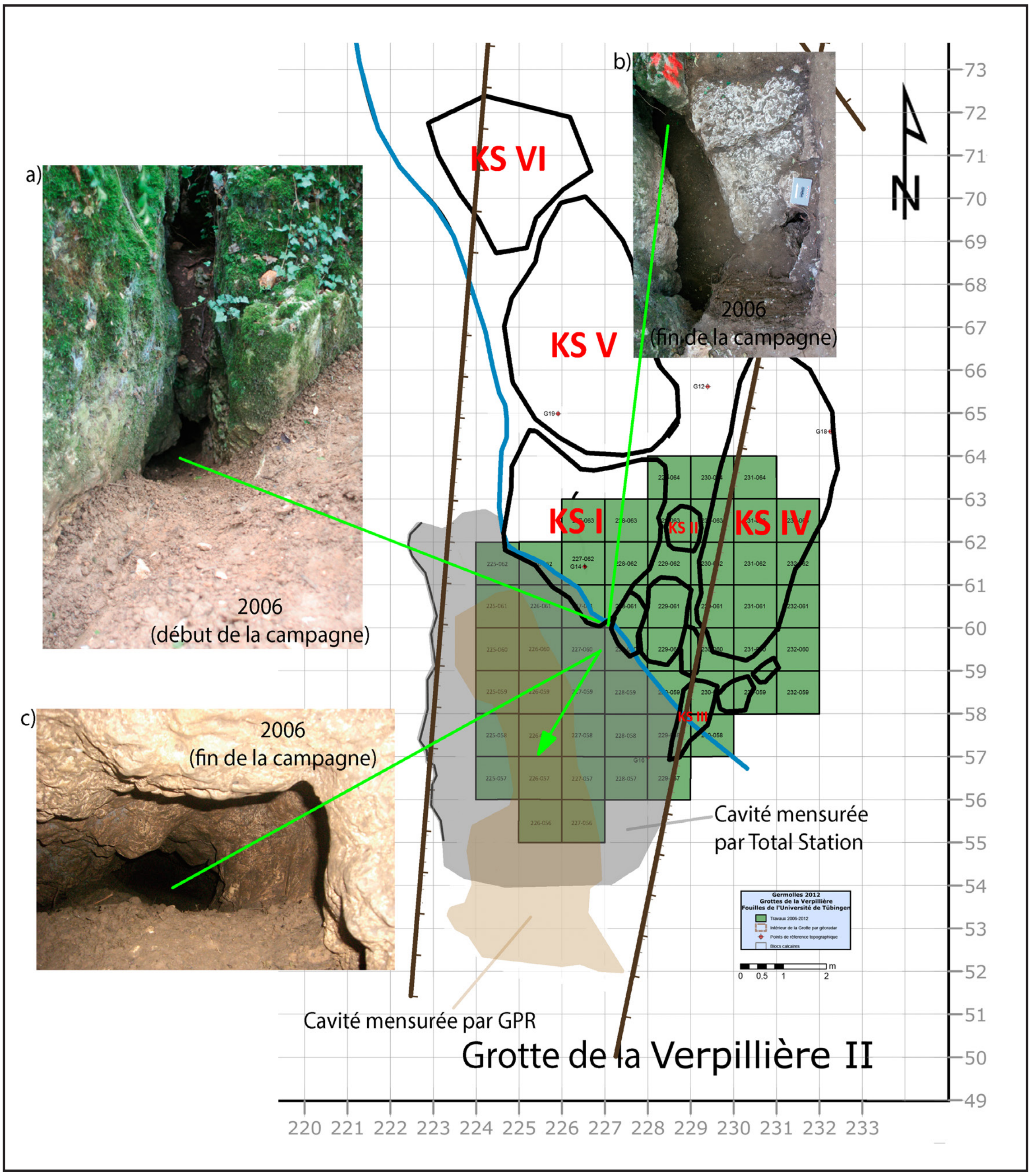

Fig. 35 - The discovery of the Grotte de la Verpillière II in 2006

IV.2.2 Excavations in 2007

In 2007, four weeks of excavations were conducted and a huge sediment volume of the animal den (still GH 1 and 2) in front of the cliff face and large limestone blocks were removed (Floss 2007). To do so, 13 square meters were under excavation (square meters 228-058 to 228-060, 229-058 to 229-062 and 229-058 to 230-062, see fig. 36 and 37).

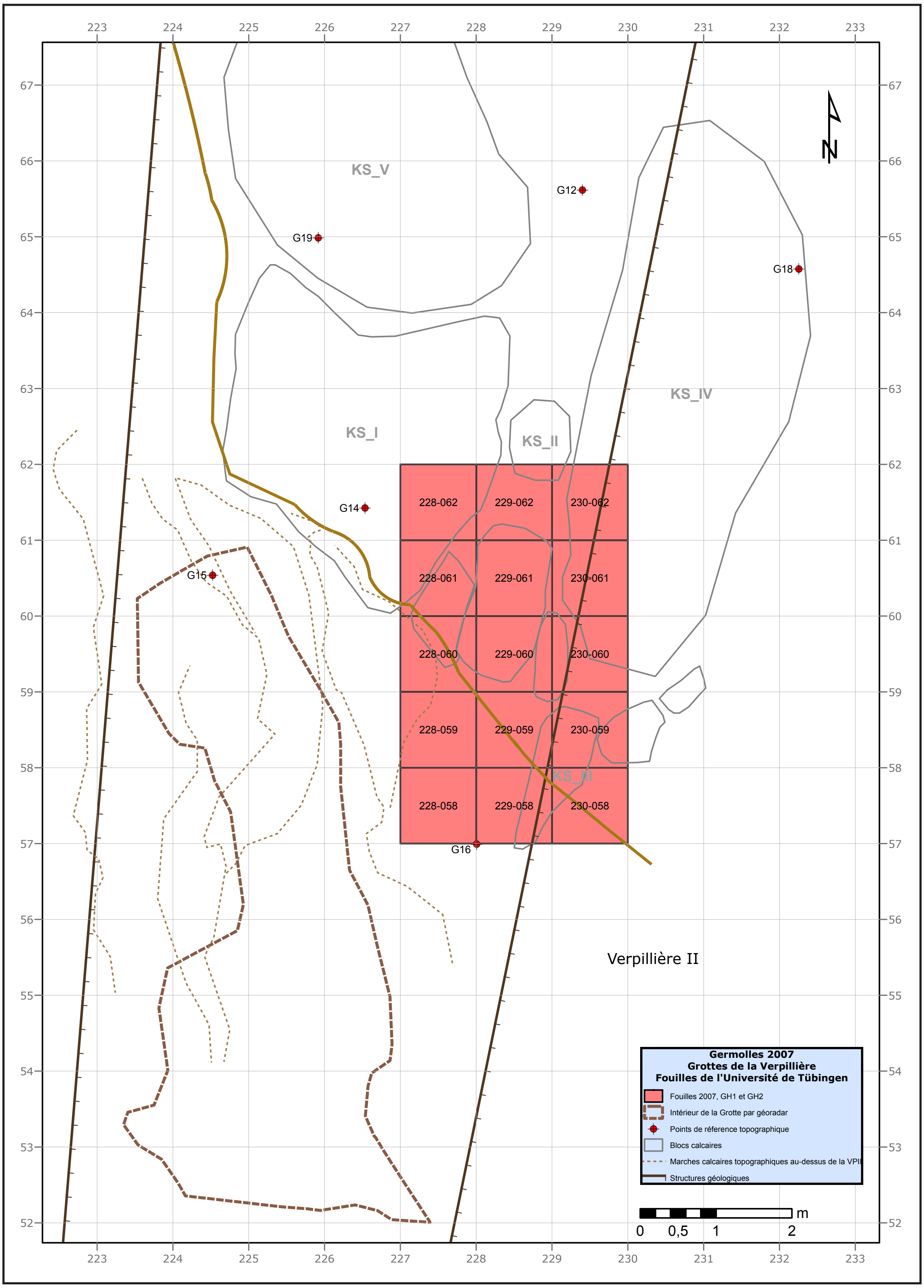

Fig. 36 - Excavated square meters in 2007 (GIS map: Ch. Th. Hoyer)

Fig. 37 - Large limestone blocs that blocked the entrance to the detected cave. The entrance of the cave tunnel is indicated by red arrows (see also Floss 2007, fig. 22 & 23)

In addition to lithic artifacts and faunal remains, quite modern objects were recovered. Among others, a roman belt buckle and further post-Paleolithic finds could be detected in around 1 m depth (see fig. 38).

Fig. 38 - Roman belt buckle from the campaign 2007 (see Floss 2007, fig. 36)

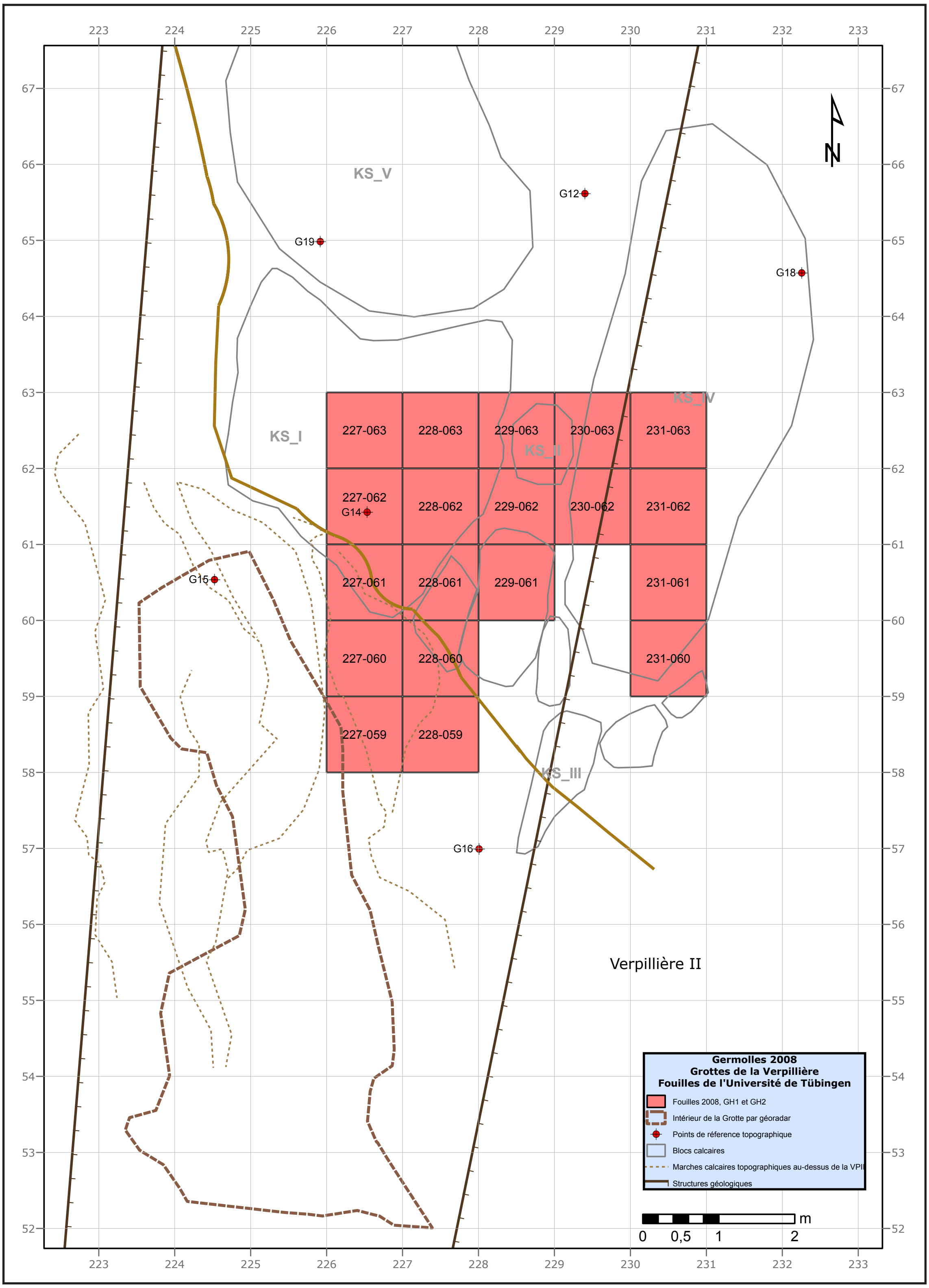

Fig. 39 - Excavated square meters in 2008 (GIS map: Ch. Th. Hoyer)

In this time of excavation in disturbed sediments, the idea came into mind that part of the sediments derived from areas in the visible cave tunnel and others are from the plateau.

IV.2.3 Excavations in 2008

In 2008, the excavation was conducted for another 4 weeks. In that time, further square meters were under excavation. In complete the square meters 227-059 to 227-063, 228-059 to 228-063, 229-061 to 229-063, 230-062 to 230-063 and 231-060 to 231-063 are now in work for removing GH 1 and 2 sediments (see fig. 39).

In addition to the removal of sediments and big limestone block, micromorphological samples were taken to get a better idea about the GH 2. Also first trials to scann the large limestone blocks were done (grazing light scanner from David™).

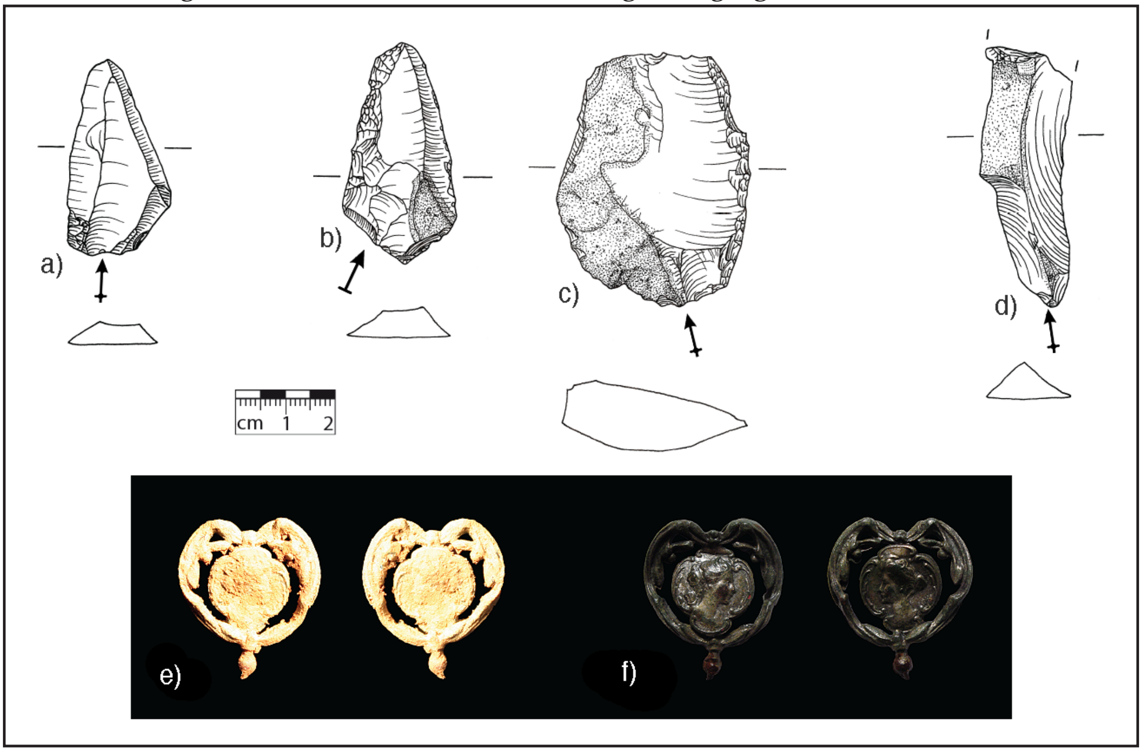

Fig. 40 - Overview of finds from 2008 (see Floss 2008: 39, fig. 20, modified)

These are documented in Binczik (2011). By removing a large pile of sediments and lime stone block is was now clear that the excavation has to deal with a partly collapsed rock shelter. As in the years before a mixture of Middle and Upper Paleolithic objects as well as Medieval artifacts were found (fig. 40).

IV.2.4 Excavations and discoveries in 2009

For the ongoing excavations at Grotte de la Verpillière II, the campaign 2009 was of high importance, because intact sediments were found. It was the first campaign that took 8 weeks and 29 m² were influenced by work (see fig. 41).

In the first 4 weeks many different operations took part. The second half was used to excavate a test pit of 4 m² in the potentially stratified sediments. The following list gives an overview (tab. 44). To illustrate the different aspects of the campaign 2009, a picture collage from the excavation report (Floss 2009) is presented (fig. 42).

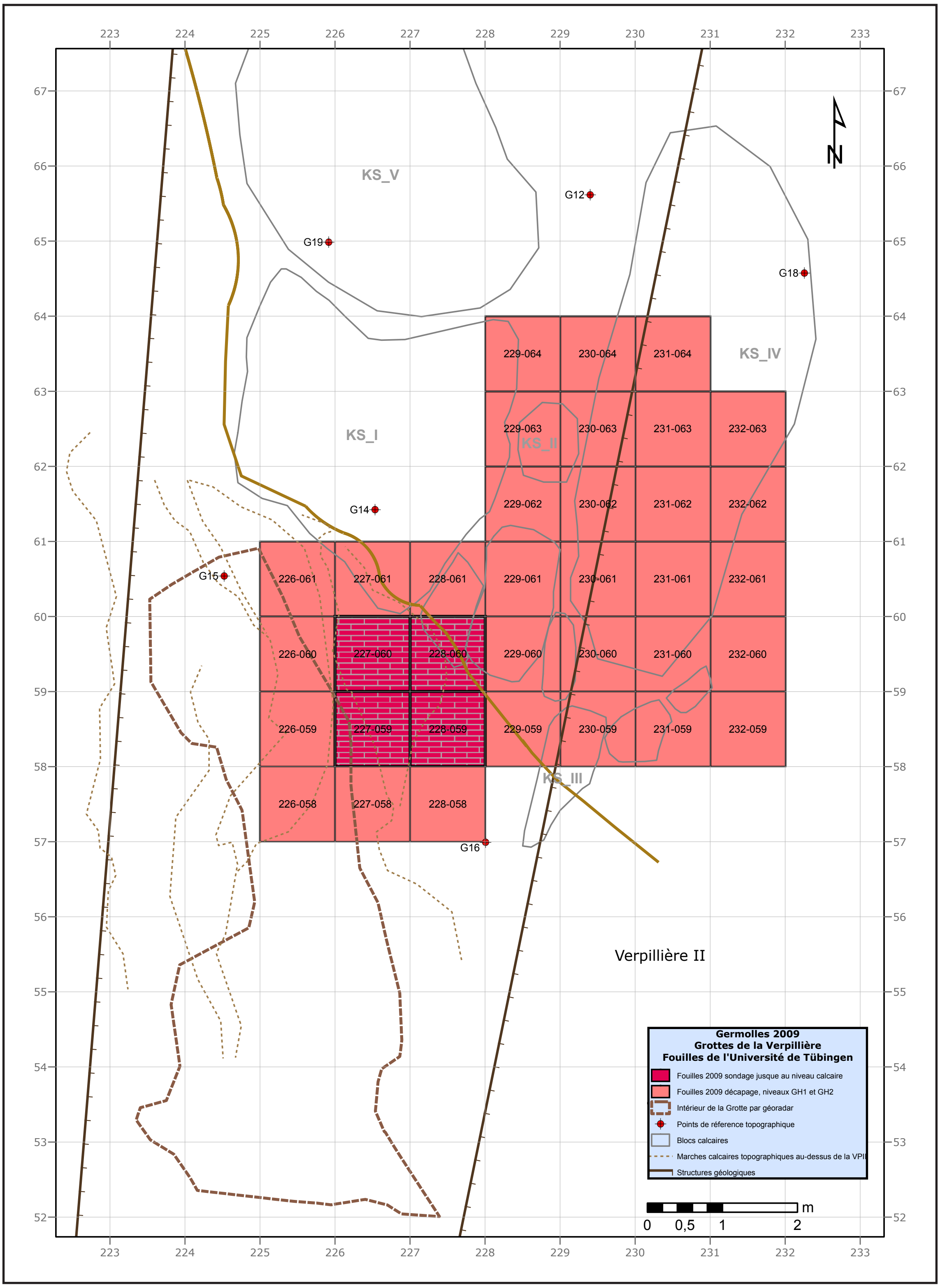

Fig. 41 - Square meters in 2009 that were affected by work (GIS map: Ch. Th. Hoyer)

Work	Duration of this work (days)	Reason	Persons involved	Literature
Removal of disturbed sediments from GH 1 and 2	30	Uncovering of collapsed limestone blocks	excavation team	Floss 2009
Removal of collapsed limestone blocks	30	To get access to the visible entrance of the cave tunnel	excavation team	Floss 2009
Scanning of the cliff face and of limestone blocks	10	Possibility to integrate these scans into a 3D model of the site	Wieland Binczik and Jens A. Frick	Floss 2009
Rescue of samples for micromorphological questions	2	Integrity of sediment units	Christoph Wißing and Jens A. Frick	Floss 2009
Geomorphological surveys and sampling	5	How was the site formed? What kind of limestone is visible?	Paul Bons and Christoph Wißing	Bons & Wißing 2009
Ground penetrating radar (GPR) surveys	3	How big is the cave tunnel? Are there layered sediments to find?	Peter Leach and Christopher Miller with help of Jean-Marie Geiling	Leach & Miller 2009
Survey of the cave tunnel with the aid of video and camera	1	Is there just a pile of sediment in the entrance and after that (in the cave tunnel) a bigger cavity or is the cavity mostly filled with sediment?	Klaus Herkert	Floss 2009
Core sampling under the cliff face	1	How are the sediments structures? how deep are the sediments visible?	Christopher Wißing and Jens A. Frick	Floss 2009
Excavation of 4 m² of intact sediments	4	How is the sediment structures? are there archeological finds in the sediment? is there bedrock under?	Christopher Wißing and Jens A. Frick	Floss 2009

Tab. 44 - Work in the 2009 campaign

Fig. 42 - Picture collage of works done in campaign 2009. 1) GPR on the plateau (Floss 2009: 85, fig. 54); 2) GPR inside the accessible cave tunnel (Floss 2009: 85, fig. 55); 3) Video exploration of the accessible cave tunnel (Floss 2009: 86, fig. 56.1); 4) Drill core exploration of GH 3 and 4 (Floss 2009: 87, fig. 57.1); 5) Artifact with sintered cave sediments from the accessible cave tunnel (Floss 2009: 88, fig. 58.1); 6) View on the sediments of GH 1 and 2 on the terrace, visible are also collapsed limestone blocks (Floss 2009: 89, fig. 60) and 7) Top edge of GH 3 in the entrance of the cave tunnel (Floss 2009: 91, fig. 63)

The excavation of a test pit of 4 m² took part in the square meters 227-059, 227-060, 228-059 and 228-060 (see fig. 42.7, see above).

Only very important finds were single measured during this test excavation. All sediments were (two buckets per measurement and find number) were sorted on big tarps to collect the items (all what isn't sediment or limestone). It was possible to entrench a stratigraphical succession of the GHs 1 to 10 (these stratigraphical units will be discussed in chapter IV.7, the stratigraphy and as well as the results from GPR, Micromorphology, core sampling and geomorphological analysis will be discussed in different sections later in chapter IV.4). The following list summarizes the results from the test pit excavation and their analyses (tab. 45):

Results	**How these results influenced later work**
GH 3 is very homogenous and contains many finds	The most finds are from GH 3
In all the sediments from GH 3 to GH 10, no post-Middle Paleolithic material was detected	The GHs 3 to 10 are Middle Paleolithic or older and seems not heavily disturbed
The sediments from GH 3 and 4 didn't show any signs of animal disturbance	The sediments of GH 2 and the reworked material from the upper parts of GH 3 (animal hole fillings counted to GH2) is good to differentiate from GH 3 and so on
GH 3 and 4 are yielding finds and can be attributed to a Moustérien de type Ferrassie or to a Typical Mousterian	All intact sediment units with finds show Middle Paleolithic industries that contain a high portion of Levallois items
GH 5 and 6 are steril and bear no finds	GH 5 and GH 6 were removed faster
In GH 4, a cluster of artifacts and faunal material was detected and was named finding 1 (Befund 1)	Later work in GH 4 showed that this cluster of artifacts are surrounded by other artifacts and do not reflect an occupation surface
Documentation of 4 profiles	Every further excavations around these square meters had now the possibility to get an idea at which depth a new GH should start
In the intact GH 3 and also in the mixed GH 2, animal dens were detected	The sediments from quite recent animal activities is good distinguishable from intact sediments. This animal mixed sediments are much darker, quite loose, bearing leafs and cherry pits, sometimes plastic or metal objects
Most of the animal dens are located at the border of GH 2 and 3	It was highly visible that these animal activities removed and mixed parts of the upper part of the GH 3 So there is still the assumption that much of the items from the Middle Paleolithic of the GH 2 derives from GH 3
In parts were no animal activities could be detected the surface of the GH 3 was very flat	Is was the idea while excavating that GH 3 is a highly cryoturbated sediment unit, micromorphological analysis and further detections found evidence for a much lower degree of distortion by cryoturbation
GH 7 is a highly weathered flowstone	This suggest that between the first rock collapse (GH 8) and the sedimentation of above this there was a time gap where these rock collapse was exposed to air
In a deep test pit in a quarter square meter inside GH 7 and 8 it could be confirmed that GH 8 is not the bed rock	We could detect two bigger rock collapses, one before the occupation and one after the Middle Paleolithic occupation

Tab. 45 - Results of the test pit from 2009

IV.2.5 Excavations in 2010

In 2010, the excavations were conducted for eight week. In addition to the excavation in intact horizons (GH 3 and 4) also GH 2 were removed (see fig. 43).

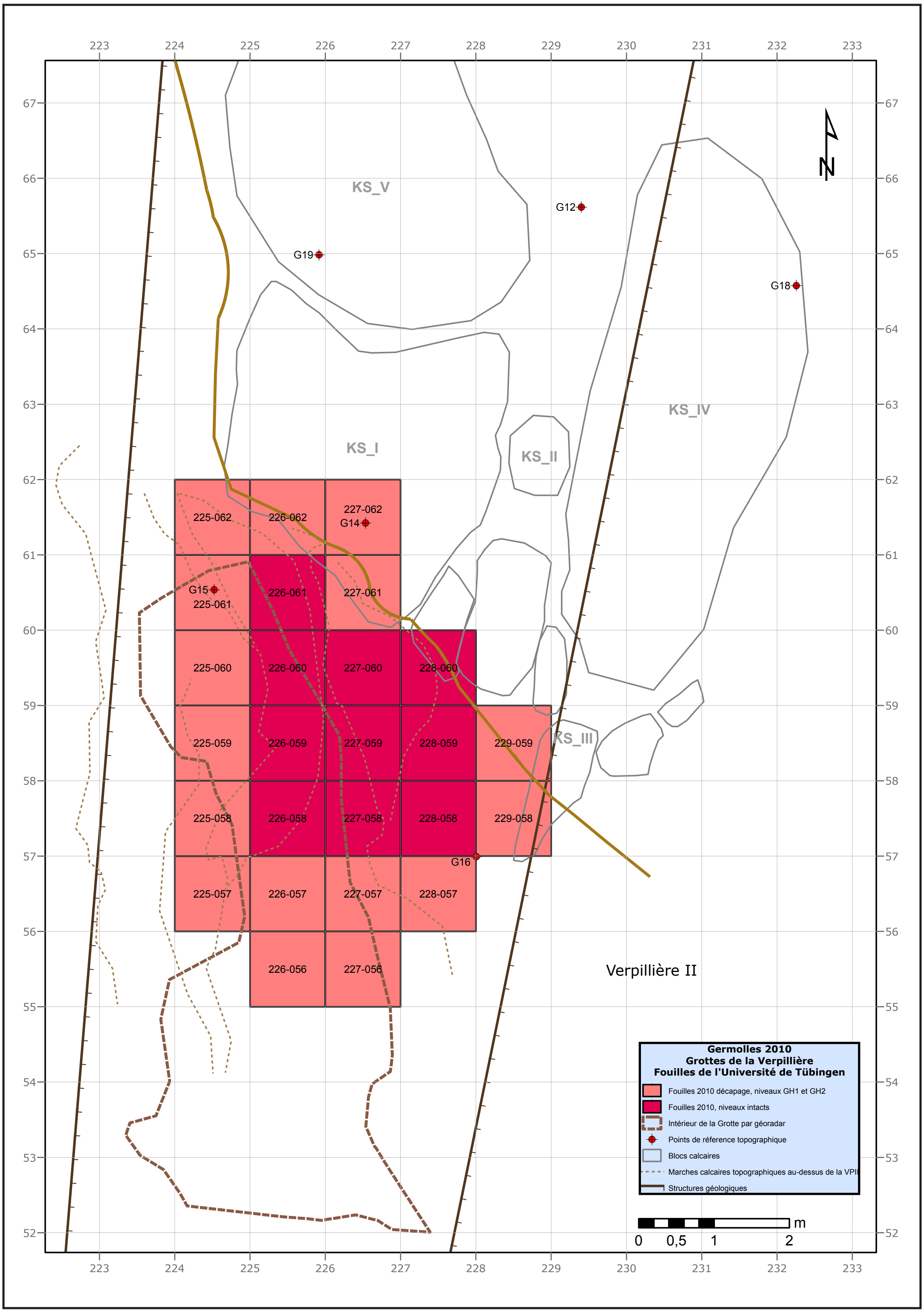

Fig. 43 - GIS map of the excavated square meters in 2010 (GIS map: Ch. Th. Hoyer)

Mostly sediments from GH 3 and 4 in six square meters were excavated (square meters 226-058, 226-059, 226-060, 226-061, 227-058 and 228-058). In addition to this GH 2 was removed in the square meters around these (square meters 225-057 to 225-062, 226-057 to 226-058, 226-062, 227-057 to 227-058, 227-062 and 229-058 to 229-059). As in the year before, big nearly complete bones were extracted from GH 4. Surprisingly, in the western part of the excavation (squares 225-057 to 225-062) an absence of GH 4 was detected. Here GH 3 follows directly GH 6 (yellow weathered sediments). The distinction between GH 3 and 4 is clearly visible. Single object measurements were performed in all the intact sediments. At the end of the campaign all new profiles were documented. Concerning artifacts, the high proportion of Levallois in GH 3 and 4 is clearly recognizable. In GH 3, mostly fragmented bones and teeth are found, in contrary, GH 4 yield nearly complete bones. Also in GH 3 some charcoal were detected, however GH 4 yield none.

IV.2.6 Excavations in 2011

In 2011, only two week of excavation were performed. This campaign was denoted by the detection of vandalism at the beginning of the campaign. The wooden closing construction was violently removed. Luckily, inside the cave tunnel and the excavation area, only slightly damage were found. In the time of excavation only GH 2 and a bit of GH 3 were excavated (squares meters 225-057 to 225-060, 226-057 and 227-057, see fig. 44). The spectrum of artifacts was in the range of the years before. From this year on, the pace of the excavation was slowed down to have the potential to measure the position even of tiny finds.

In the western part of the excavation (row Y=225) a huge amount of fragmented bones were detected. The most impressive find of this campaign was a nearly complete atlas of an adult mammoth in square meter 225-057. Unfortunately, it was found in the mixed GH 2, but only some centimeters above the intact material of GH 3. Its position suggests that it belonged to it, but the sediment around was excavated and disturbed by animal activity (see fig. 45).

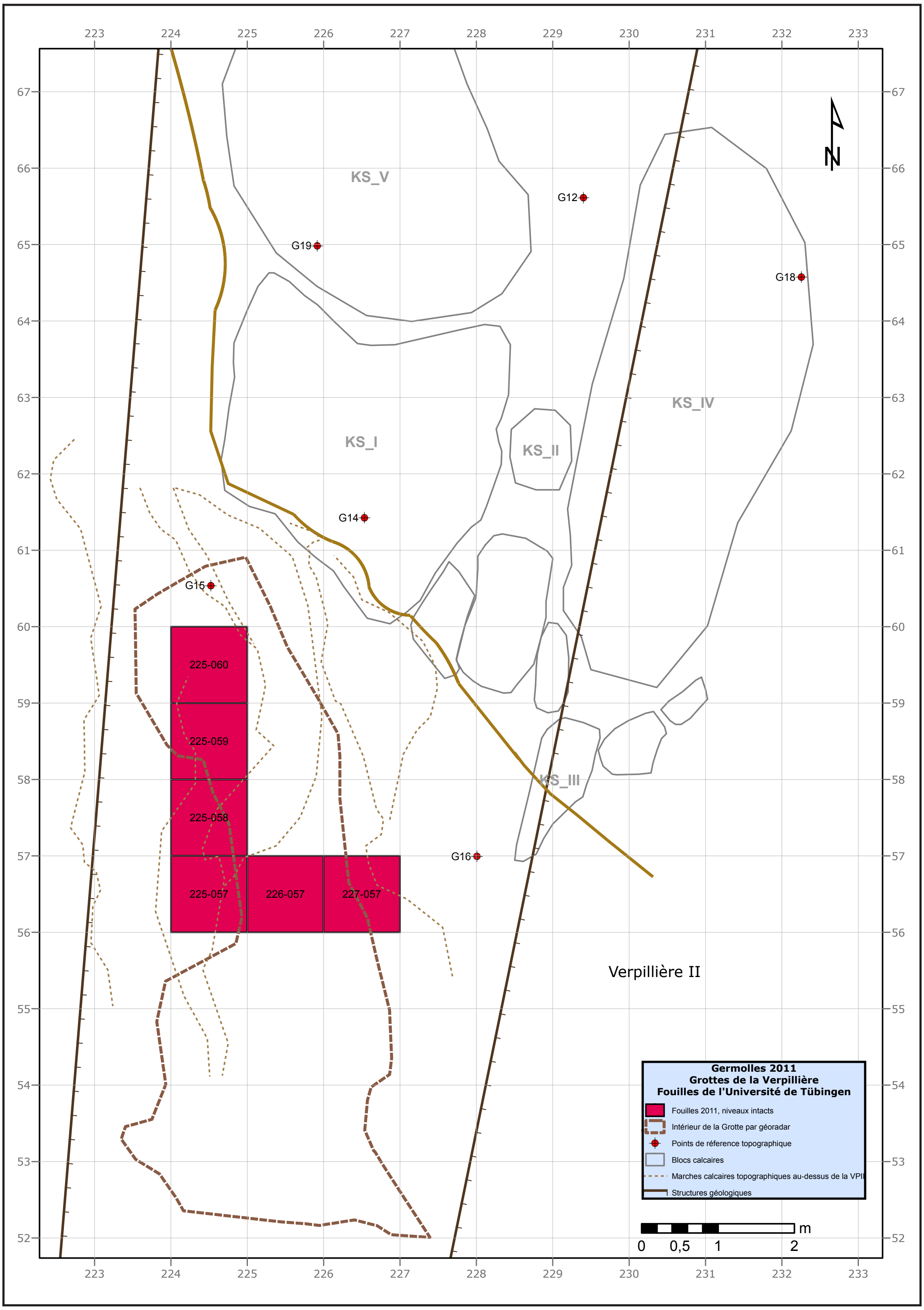

Fig. 44 - GIS map of the excavated square meters in 2011 (GIS map: Ch. Th. Hoyer)

Fig. 45 - Atlas of an old, adult mammoth from GH 2 in find position, square meter 225-057 (picture: J. A. Frick)

IV.2.7 Excavations in 2012

The excavation champaign 2012 yielded very interesting activities, finds and insights. First there are listed in the following and after that, they are discussed:

- Detection of hundreds of small charcoal fragments inside of GH 3
- Detection of the first *Keilmesser* with tranchet blow from GH 3
- Removal of cubic meters of mixed sediments and limestone blocks from the terrace with the help of a mechanical mini-excavator
- Further detection of hundreds of small bone and teeth fragments in the west of the excavation area (square meters 225-058 and 225-059)
- Massive promotion of topographical measurements to build a three dimensional model of the site

The excavations were conducted for eight weeks. In the first four weeks the focus were on square meters in the West (225-058 and 225-059) and south (226-057 and 227-057) of the excavation area. In the second half, the excavation were conducted in the South (226-057 and 227-057) and the East (229-058 and 229-059, see fig. 46). Only sediments of GH 2 and 3 were removed.

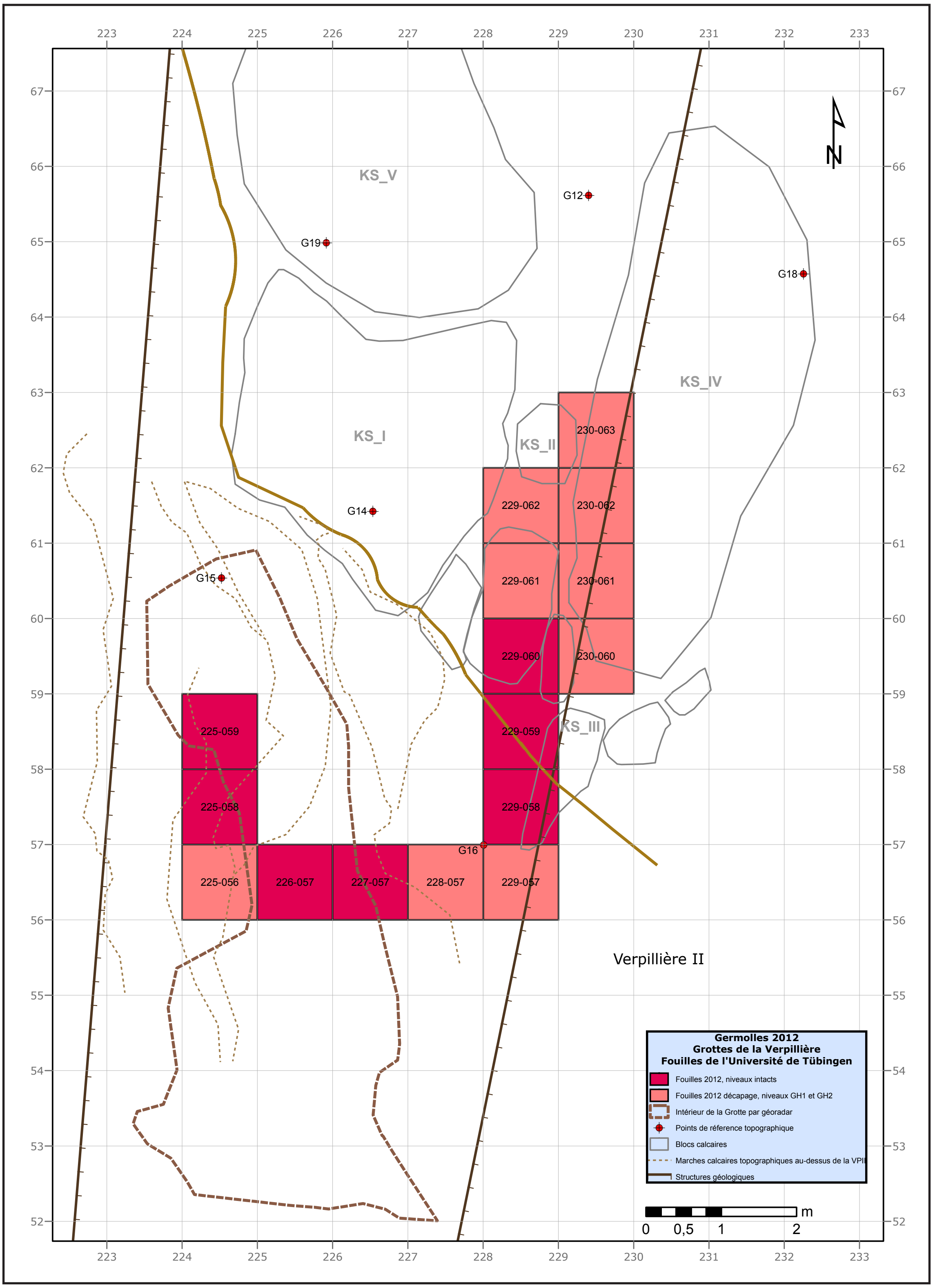

Fig. 46 - GIS map of the excavated square meters in 2012 (GIS map: Ch. Th. Hoyer)

In the second week of the campaign, a mechanical mini-digger removed sediments and limestone blocks from the terrace. After one day of mechanical digging, the terrace was lowered of around 1 m (see fig. 47). This offered the possibility to evaluate the positions and constellation of the limestone blocks.

Fig. 47 - Lowering of the terrace of around one meter by the help of a mechanical mini-digger

After the removal of material from the terrace, there were two interpretations about the site setting. The first saw the limestone blocks of the terrace as part of a former cave wall. In this case, the entrance of the cave would be in the North (see fig. 48). In this case, the site would be long cave of 15 to 20 m.

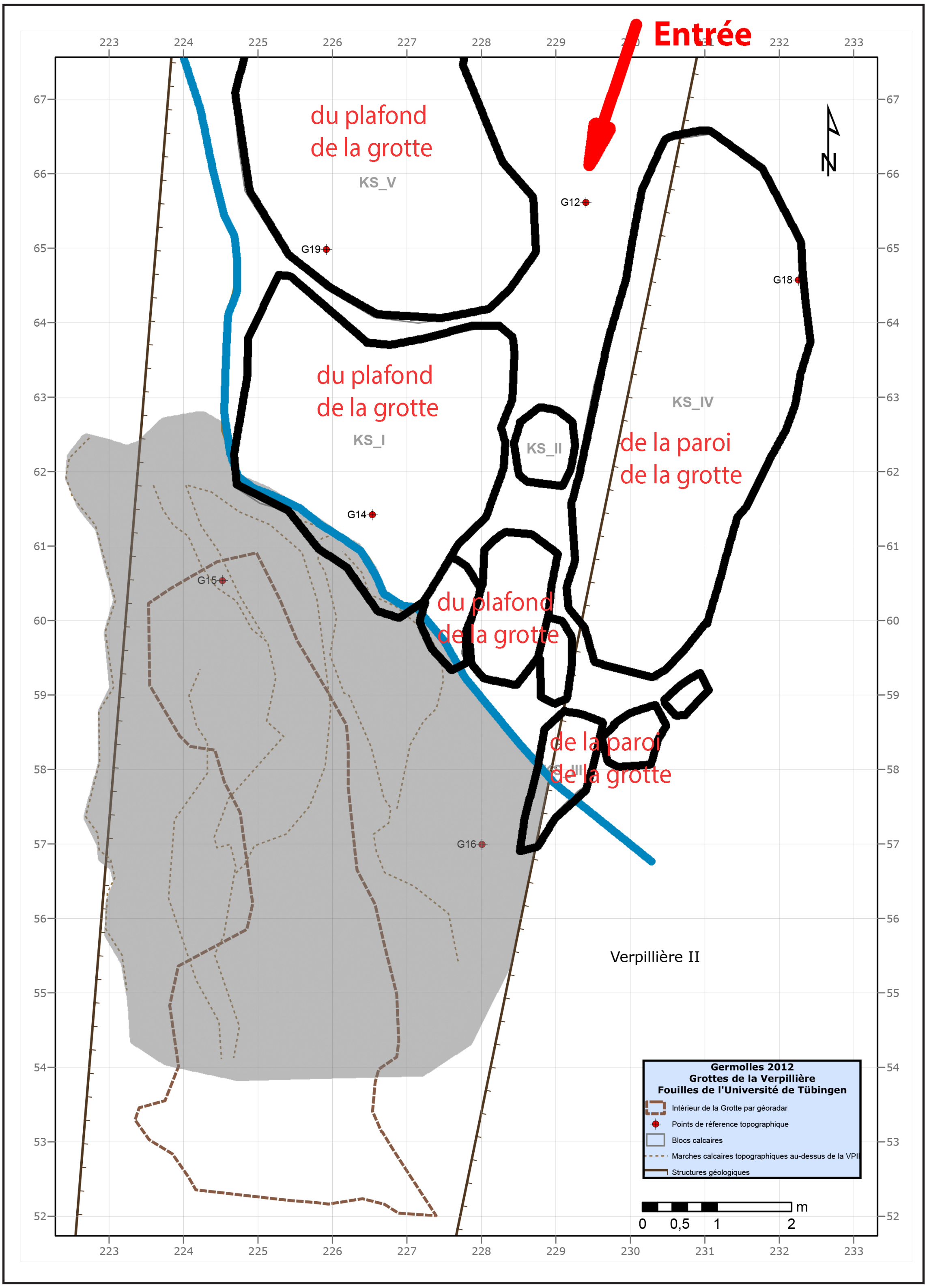

Fig. 48 - Consideration about the site setting. Here: position of the entrance of a cave, if the big block of the terrace would be part of the cave wall

The second interpretation possibility consider that all the block visible on-site are from a roof collapse of a rock shelter (as we will see later this was the right idea). In this case we are dealing with the presence of a quite huge rock shelter (see fig. 49), opening to northeast.

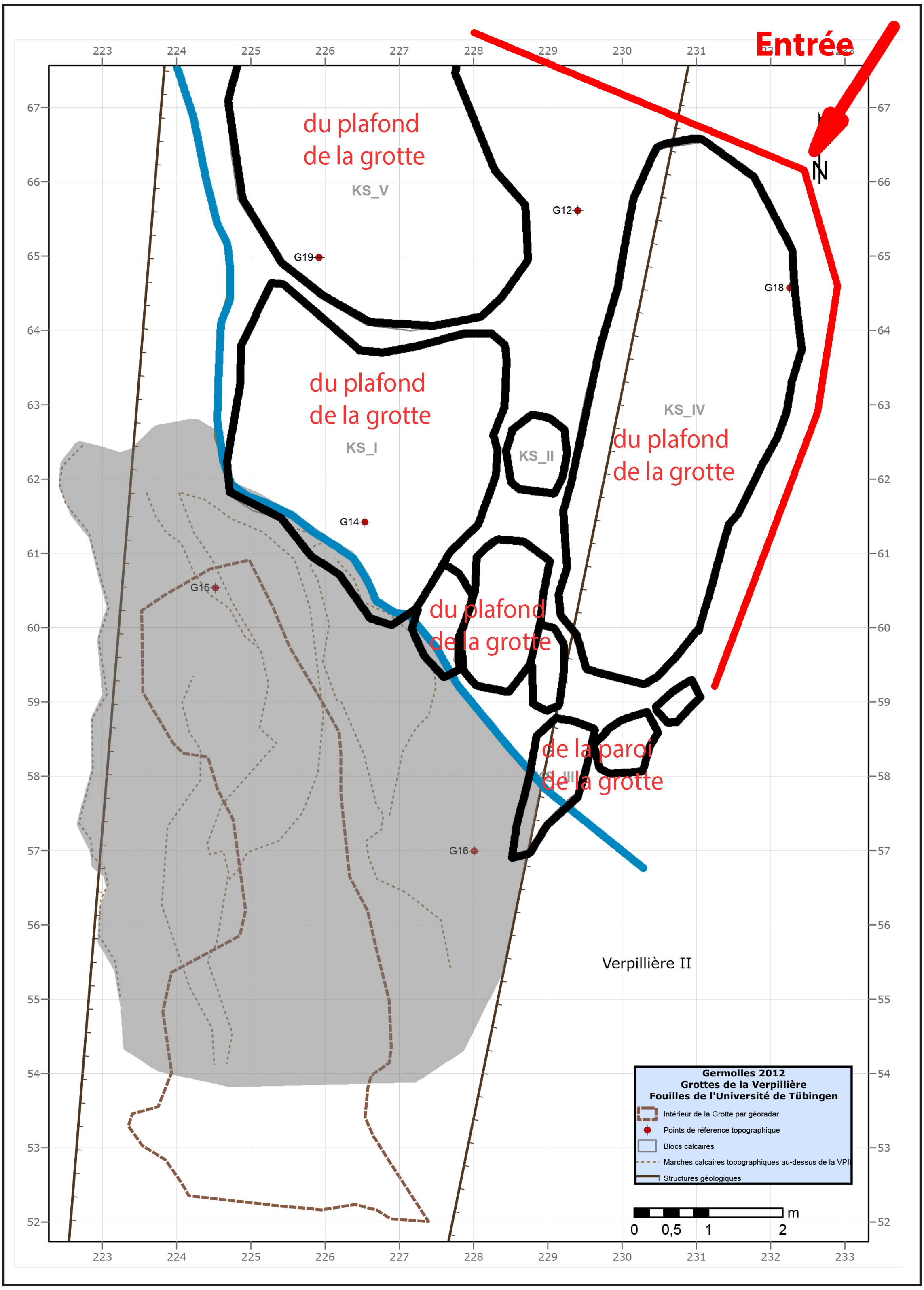

Fig. 49 - Consideration about the site setting. Here: position of the opening of a big rock shelter, if the big block of the terrace are part of the roof collapse

In all excavation directions (west, south and east) in the area of the intact sediments, artifacts were found. With this knowledge and the information from the terrace activities new considerations about the distribution of artifact and intact sediments were undertaken. At the end of the 2012 campaign we assumed a range of around 100 square meters of potential intact sediment (the existing cave and the area that is covered by the collapsed blocks, regardless of wether they belong to a collapsed roof or are part of a former cave wall).

IV.2.8 Excavations in 2013

In the campaign 2013, which was conducted for eight weeks, mostly areas in the South (226-057, 227-057 and 228-057) and West (225-058 und 225-059) were excavated (see. fig. 50).

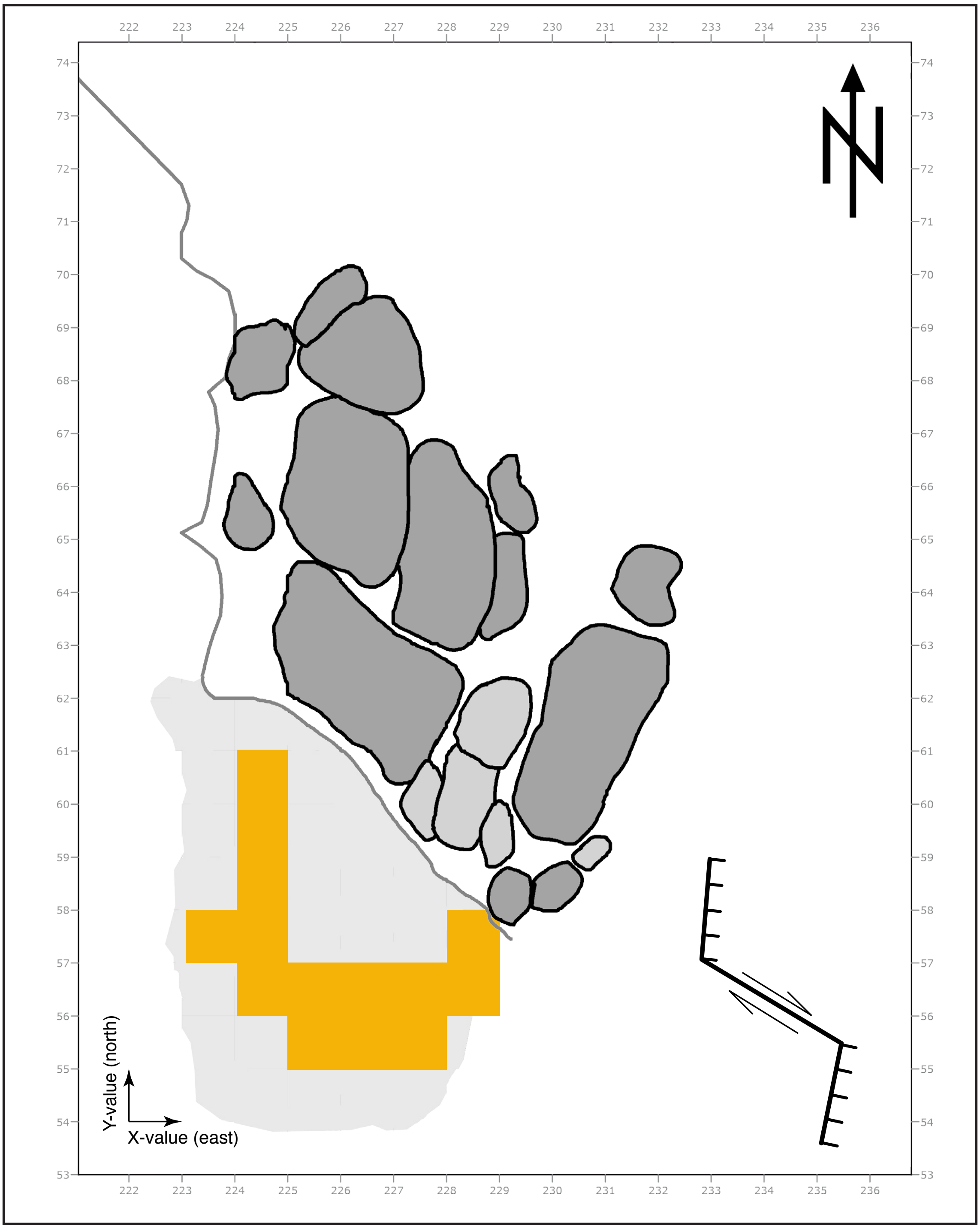

Fig. 50 - GIS map of the excavated square meters in 2013.

In addition to normal excavation activities, dosimeter were installed (D. Richter) and OSL sediment samples were taken (L. Zöller). Therefore, some square meters (225-057, 229-058 to 229-060) were not under excavation. This campaign could manifest the potential of the site's archeology by unearthing many artifacts. In addition to excavation and dating sampling more topographical measurements were performed. The cave tunnel (ceiling and walls) were measured, also the actual state of the terrace, parts of the cliff face in the North-west of the site and many of the collapsed blocks in the North, as well.

In the West of the excavation area (square meter 225-058 und 225-059), all remained sediments of GH 3, 4x and 6 were removed. Here in this two square meters in is now visible that more to West, only collapsed rocks (GH 8) are visible, as well as there weathered remains (GH 6 and 7).

In the South (square meters 226-057, 227-057 and 228-057) more sediments of GH 3 were removed and showed that the surface of GH 8 (with the partially weathered remains, GH 6 and 7) submerge slightly to the South (in to the deeper parts of the cave tunnel). From the situation in this area, it is possible that in one meter (approximately) to the South the underlaying rock collapse could end, but from the amount of sediments to be removed in the direction of the cave tunnel interior this question will remain open till new excavations will be conducted.

IV.2.9 Excavations in 2014

In March 2014, P. Leach conducted new ground penetrating radar (GPR) observations (Leach 2014) and in the summer campaign eight weeks of diverse excavation activities were undertaken (see fig. 51).

GPR observations in 2014

The aim of the GPR survey was to answer (or give hints) to the following questions:

- Clarification if there are sediments left on the plateau above the site (regarding the question of the origin of the Aurignacian and Châtelperronian artifacts in GH 1 and 2)
- To find out if KS IV (a huge limestone block on the today's terrace) was part of the cave wall or another collapsed rock
- And to get evidence if northwards of the clearly collapsed rocks are stratified sediments left (concerning the extension of the potential occupation area).

The GPR survey and analysis verified that the sediment cover above the sites is quite thin, but it seems that there is another cavity in the underground (which could or could not be connected to the cavities we know, i.e., the cave tunnel). Regarding the Aurignacian and Châtelperronian finds in the mixed layers of GH

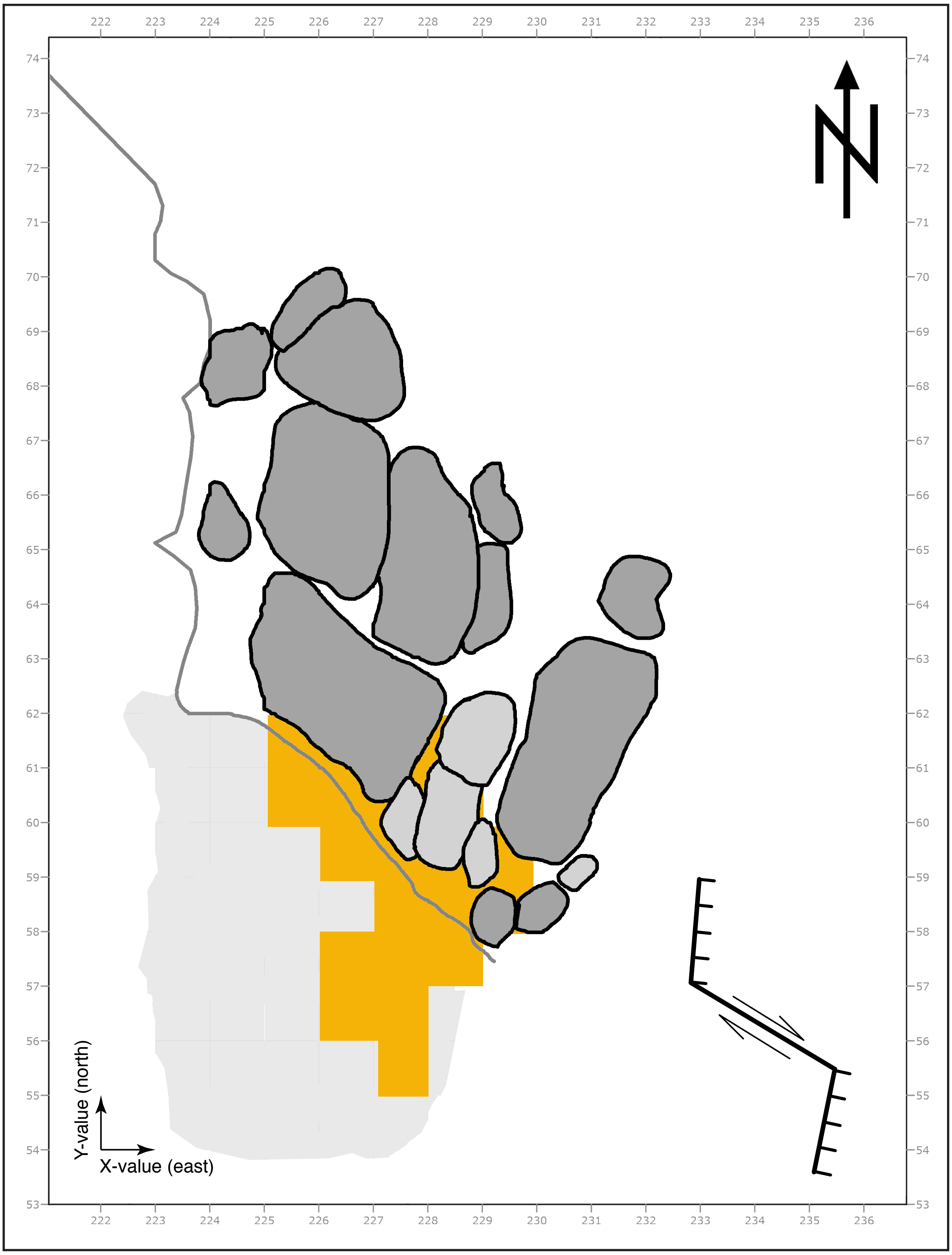

Fig. 51 - GIS map of the excavated square meters in 2014.

1 and 2 it is now highly suggested that their origin was either on top of the collapsed rocks or a landslide after an occupation above the site transported them (this question will be addressed in future and shall not further be part of this thesis). For the massive limestone block KS IV the GPR survey made clear that it has to be part of the rock collapse. This leads to questions about the chronological order of sedimentation and different rock collapse events, because this block lays deeper than the collapsed rocks in the West (see fig. 52).

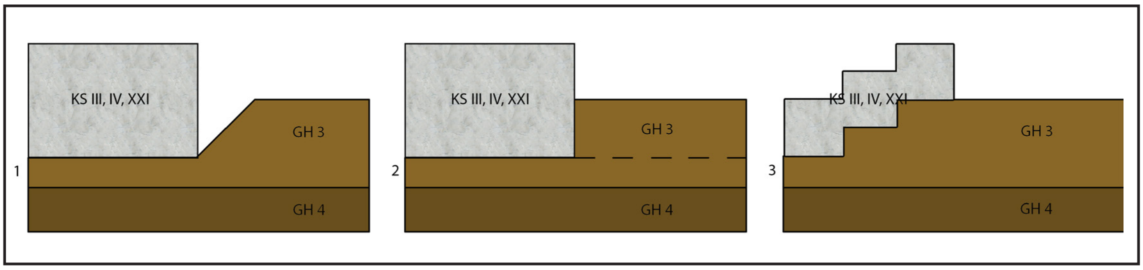

Fig. 52 - Different scenarios of the relation between KS III and GH 3 and 4. View to the South

Concerning the third GPR observation, it is quite possible that the stratified sediment package gets successively thinner to the North. The area of excavated stratified sediments and the potential extension are drawn in fig. 53.

Summer campaign 2014

In the course of eight excavation weeks, square meters 227-057, 228-057, 229-058, 229-059 and 229-060 were further excavated in GH 3 and 4. Furthermore, two test pits (square meter 225-071 and 234-067) were constructed to verify the potential northern and eastern end of the collapsed rocks (see fig. 54) and many different topographical measurement were taken to create a three-dimensional model (first results directly after the summer campaign see on fig. 53). The aim of these three-dimensional measurements are to create data for virtually shifting the collapsed blocks back to their original position and therefore to reconstruct the shape and size of the original rock shelter.

Concerning the two test pits, there is now a better understanding about the deposition of the collapsed rocks of the rock-shelter, and how far the stratified sediments might reach to the North. The excavation in GH 3 and 4 run smoothly. Many new charcoal fragments were measured (more than 5000), finds were rescued and all visible findings were measured as well.

IV.2.10 Excavations in 2015

The 2015 campaign involved regular excavation in the stratified sediments of GH 3 and GH 4 in the Northwest (square meter 225-061), in the North (227-061), in the East (229-058, 229-059, 229-060) and in the Southeast (228-057). In three square meters GH 4 could be excavated (because GH 3 was completely removed; square meters 228-057, 229-058 and 229-059). In all the other square meters the excavated took place inside GH 3 sediments. There are no exceptional highlights for this campaigns work, but an extension of the established knowledge of the side. Another *Keilmesser* was added to the collection of bifacial objects and many charcoal fragments were measured as well.

In addition to these regular excavations, three test pits were conducted in greater extension than in 2014 (see fig. 55). Two test pits were dug with the aid of a mechanical excavator. An extension of the test pits north of the collapsed rocks (*Nordsondage*) and a small test pit in the east of KS VII (*Sondage östlich des KS VII*).

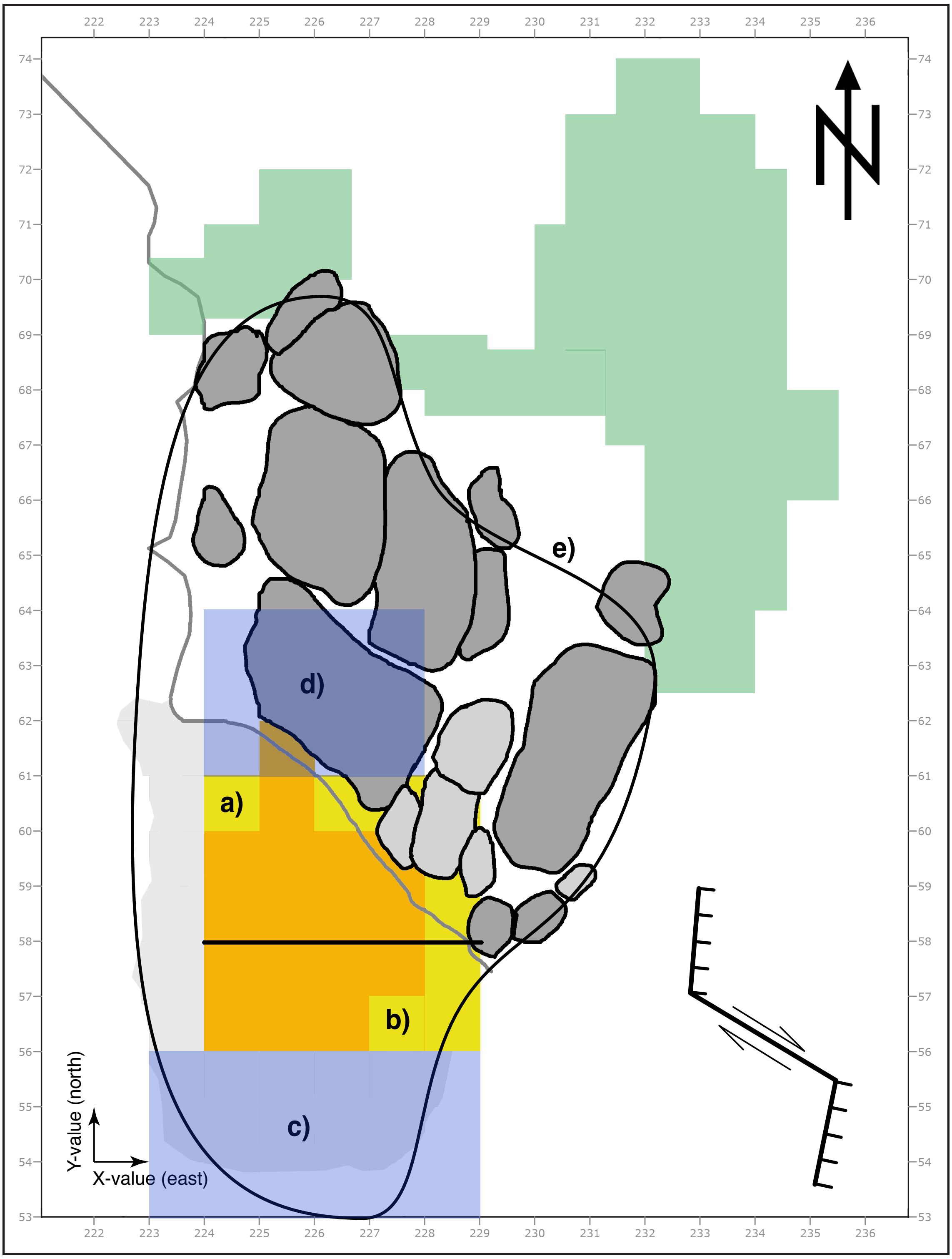

Fig. 53 - Area of excavated stratified sediments and the potential extension, evidenced by geomorphological and GPR surveys as estimated after the 2014 campaign

The third test pit was excavated manually, because of the hill slope (*östliche Sondage*) and removed cubic meters of sediment to uncover limestone formations. This test pit exposed a north-to-south separation of these limestone blocks. In the South they should derive from the rock collapse and in the northern part it seems thats they are part of the bedrock. At the moment these are tendencies and need more evidence (by removing more sediment cover).

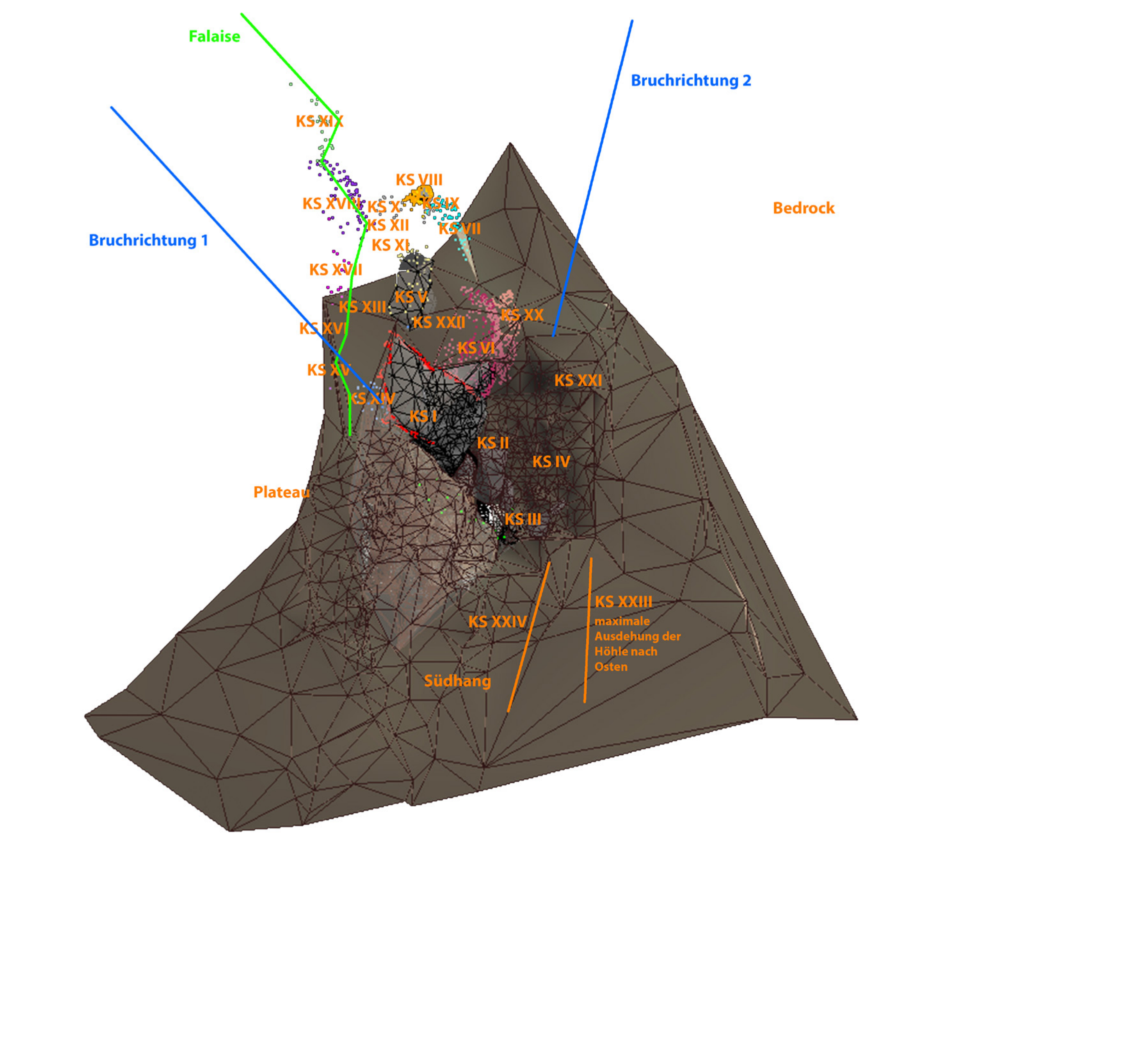

Fig. 54 - First results of topographical measurement for creating a three-dimensional model of the site (data in major from campaign 2013, processing: Ch. Th. Hoyer)

IV.2.11 Summary of excavation activities

The site of Grotte de la Verpillière II was discovered in 2006 in the course of excavations at Grotte de la Verpillière (now I). Since then the site was successively excavated using current standard methods. The removal of mixed sediments unearthed a collapsed rock shelter with a corresponding cave tunnel. In the following the outcomes of the excavations at VP II between 2006 and 2015 are summarized.

In the early years (2006 to 2008) mixed sediments were removed to get access to assumed, stratified sediments. Some tens of square meters showing collapsed rocks from the cliff face were unearthed. In 2009, enough blocked were removed to get entrance to the cave whose ceiling was discovered in 2006. It was now visible that the site is much bigger than thought. In addition to the removal of mixed sediments and the beginning of excavations of assumed (and later verified) stratified sediments, other observation methods were used to get information about the site's morphology. GPR (ground penetrating radar) provided evidence about the size of the cave (Leach & Miller 2009b). Geomorphological studies supplied evidence about the formation of the limestone massif, main fissure directions and cave formation (Bons & Wißing 2009). Micromorphological observations provided evidence for the condition of sediments and could demonstrate the major difference between GH 1 and 2, on the one hand and GH 3 following, on the other hand (Floss 2009; Wißing 2012). The following campaigns (2010 to 2015) focused on the excavation of these stratified sediments in the entrance of the cave.

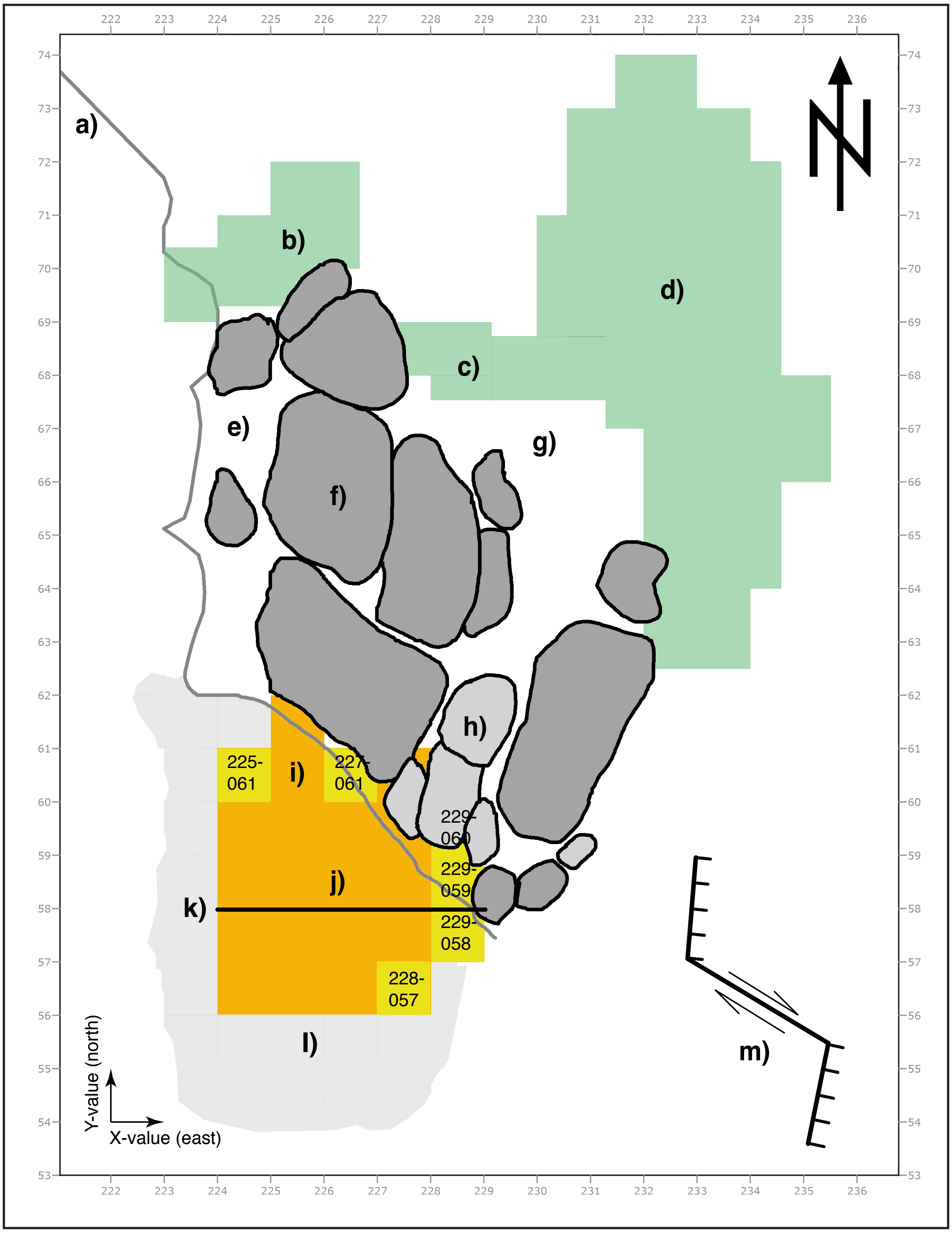

Fig. 55 - GIS map of the excavated square meters in 2015.

The research at VP II could evaluate that at least two rock collapses occurred (one before and one after the Middle Paleolithic occupation) and that the most of the younger finds derive from landslide from the plateau. The entire extension of the site is now almost clear, covering around 100 square meters. The rock shelter covered at least 30 square meters of the site. Another 20 square meters are situated in the cave tunnel.

Different geological layers (or sediment units) could be observed (grouped in the following tab. 46):

Group of units	Geological layer	Formation processes
Landslide and animal activities	GH 1 and 2	It is highly possible that the most of the material on top of the second rock collapse derives from landslide processes that transported younger material from the plateau down These sediments are highly reworked by animals (keyword badger)
Second rock collapse	Limestone blocks in GH 1 and 2	Limestone block derive from a big rock collapse of a former rock shelter
Middle Paleolithic occupation	GH 3, 4x & 4	During mostly homogenous climate conditions (with minimal fluvial, but mostly aeolian processes), Middle Paleolithic humans occupied the area under the rock shelter and the beginning of the cave tunnel
Soil formation	GH 5	A thin cover of sediment was altered during soil formation processes (found in the beginning of the cave tunnel)
First rock collapse	GH 6, 7 & 8	A first rock collapse occurred deriving from cracked rocks of the ceiling of the rock shelter and cave tunnel
Another occupation?	GH 9	Only a small test pit of a quarter square meter indicates that under the first rock collapse are further sediments
Rock shelter and cave formation	GH 10, walls and roof	Formation of the rock shelter and cave tunnel via washing processes of the limestone massif

Tab. 46 - Geological units and their meaning at Grotte de la Verpillière II

IV.2.12 Other recently conducted excavations at sites in Saône-et-Loire

The site offers the possibility at least to contribute to the research of the Paleolithic of the region. An evaluation of the Middle Paleolithic of Burgundy for the years 1994 and 2005 lists the following research activities for the Saône-et-Loire Department (Soriano 2015) and shows clearly that a lack of recent and well documented sites exists (tab. 47):

Site	Activity	Literature
Grotte de la Verpillière I à Germolles	Evaluation for excavations	Farizy 1995, Floss 2003, 2005
La Clôsure à Bissy-sur-Fley	Discussion about the lithic industry and faunal remains of the 1950s surface collection, incorporation of the site into the *industries de Charentien à influence micoquiennes*	Farizy 1995
Ozenay, Mancey, Boyer, Pontot	Surface collections of the G.R.A.T.	
Cave Denuziller	Small excavation in Solutré in the 1990s	Pautrat & Pugh 2001
Vergisson II	Discussion of the 1954 to 1961 excavation	Combier 2001
Les Vignes du Colombier à Sennecé-lès-Mâcon	INRAP excavation in 2006 of an open-air site of 400 m*2*, bifacial objects	Connet et al. 2006

Tab. 47 - Research activities between 1994 and 2005 concerning the Middle Paleolithic in Saône-et-Loire, after Soriano (2005)

IV.3 Excavation methodology

For standardization of excavation methods and for the possibility to compare the results of each year with each other we decided to create an excavation handbook, which was only slightly updated every year (Frick & Hoyer 2009, 2011, 2012; Frick et al. 2013; Frick et al. 2014). The following chapter is therefore only a short summary of these around 100 pages comprehensive excavation methodology.

IV.3.1 Excavation grid (square meters system)

The square meter system of the excavations at VP I and II is oriented to the magnetic north and it includes both sides (see fig. 56). X represents the direction to the East (east value), Y represents the direction to the North (north value) and Z represents the hight. From its orientation and it imaginary origin far-off at the plateau, it is possible to measure everything between the plateau and the Orbize Valley (including the cliff face between both sites, the archeological sites for itself, the slope, the street in the valley and also the route of the Orbize creek). From the far distance of the next ordinance survey point (*Landesvermessungspunkt*) it is not possible to mount the excavation grid (but the coarse mounting via UTM coordinates are given).

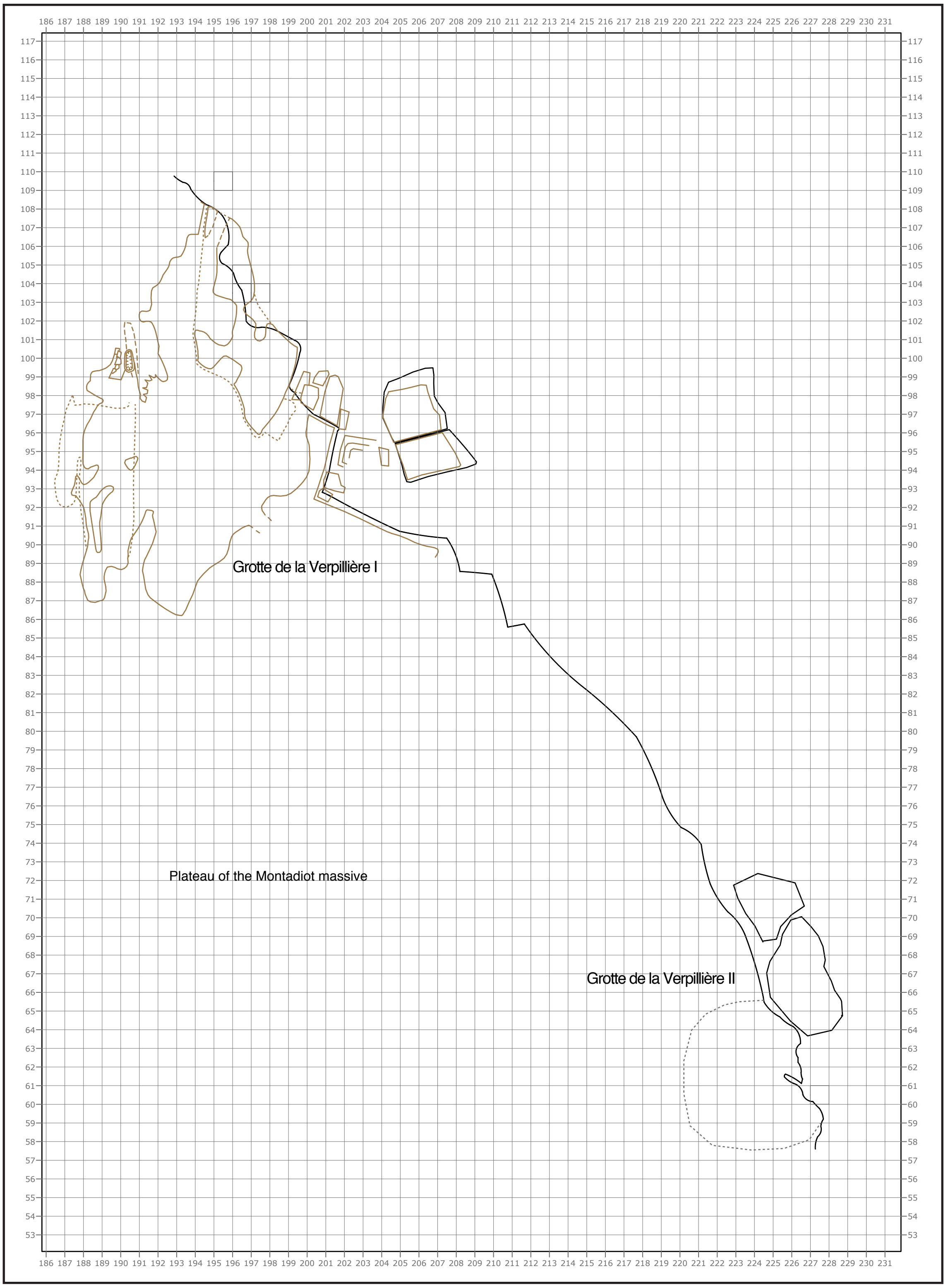

Fig. 56 - Excavation grid for both sites, as established in 2006 (GIS: Ch. Th. Hoyer)

All three coordinates are given in meters. This is why every position can be directly shown in a three-dimensional model. Also every measurement (of finds and findings) possess this coordinates. For example a find from square meter 225-059 posses the coordinates in its find number [excavation year.square meter.consecutive number], like GER09.225-059.234

In that way, e.g., the excavation team is also able to refer photographs directly to finds, because this find number can be used as file number of a digital photograph.
The square meters are numbered in that way that the maximum point in the northeastern corner give its name (see fig. 57).

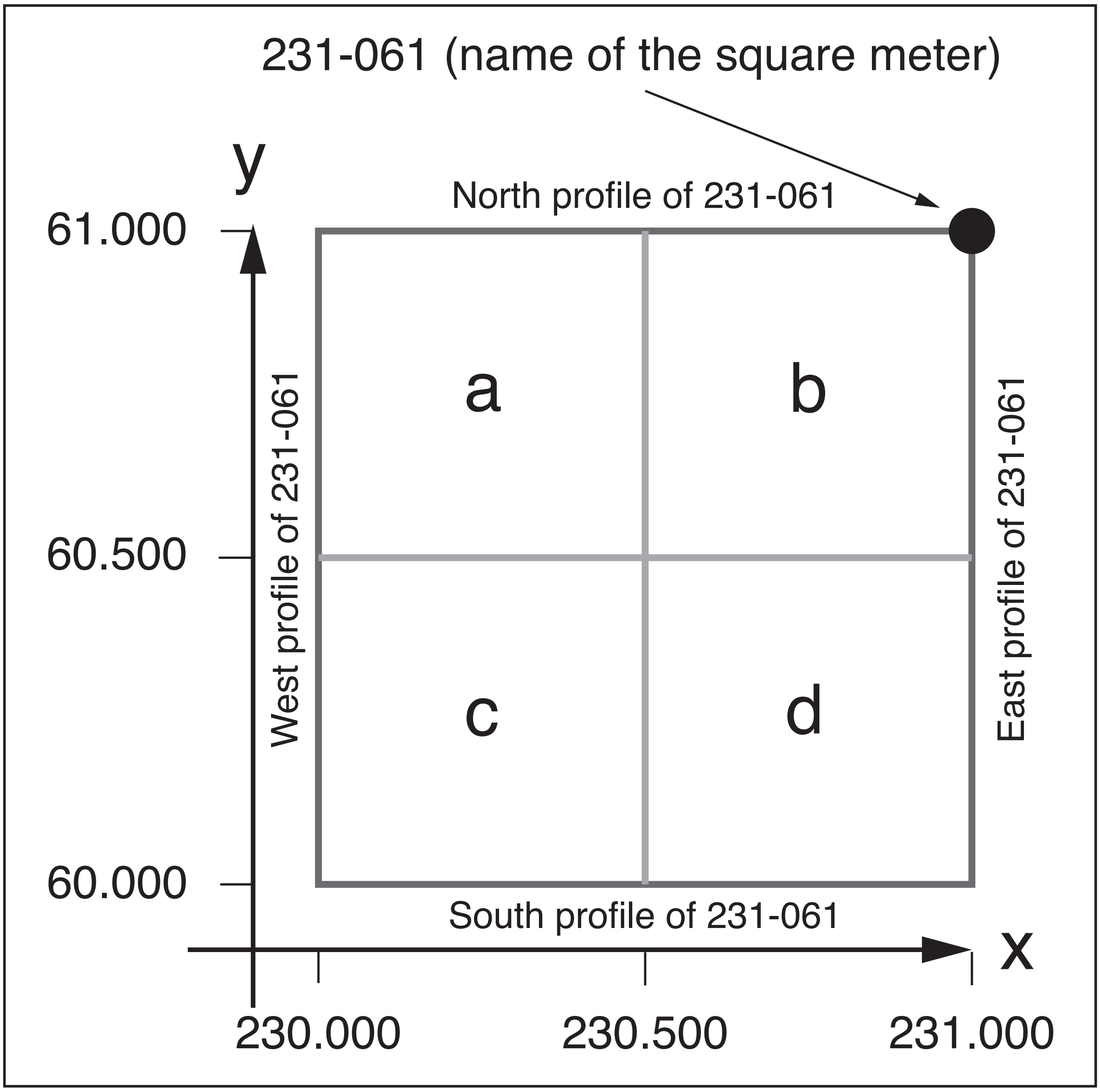

Fig. 57 - Denomination of square meters, see also Frick & Hoyer 2009

IV.3.2 Natural and artificial excavation layers

Paleolithic excavations are mostly conducted in that way that inside a geological (or archeological) unit the excavation is performed in horizontally artificial layers, but in the moment a new unit is visible this has to be uncovered following its natural surface (see fig. 58).

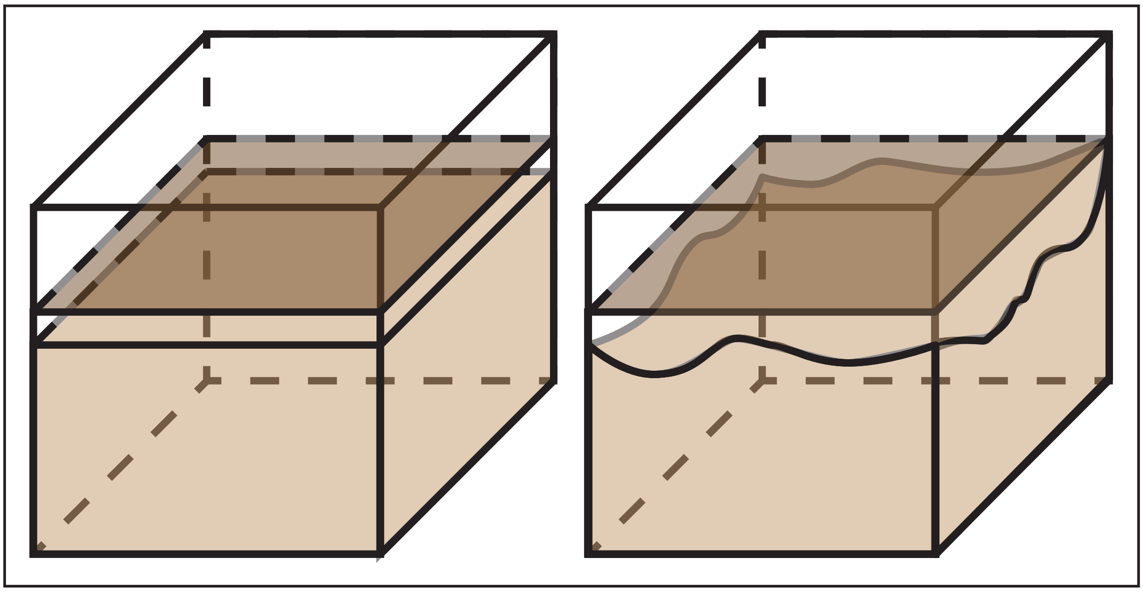

Fig. 58 - Natural and artificial excavation layers

To do so, it is possible to refer every find to a sediment unit and to the volume of the collective find (also for single finds).

IV.3.3 Distinction of sediment units

During excavation the excavator and the supervisor of a trench are forced to separate sedimentological units with techniques that can be performed immediately. Very often the personal experience and the feeling are crucial. Since 2011 the excavation is performed under day-light lamps to have constant light conditions. This helped a lot to find minimal color differences inside the sediment. Other means and techniques are geological magnifiers, diluted hydrochloric acid, color comparison with Munsell® color charts, grain size analysis by hand and sieves, and so on (the whole range of means and techniques can be seen in Frick & Hoyer 2012). The aim of all of these means and techniques is to find differences or similarities of sediments to allocate these to a sedimentological unit.
Other methods need to be performed in a laboratory (thin slice analysis for micromorphology, chemical sediment analysis, flotation of sediments, micro fraction analysis, etc.) and samples need to be taken.

IV.3.4 Single find and collective find measurements

The excavation is using a tachymeter (Leica™ or Sokkia™) with a connected laptop running a WinEDM (software written by H. Dibble and Sh. McPherron, see also http://www.oldstoneage.com/software/edm.shtml). With that aid it is possible to measure objects and features as well. It gives the XYZ coordinates (inside the grid system), a consecutive number, the square meter allocation and many other options to classify a shot point. In the system of work group Floss, there are three main categories of measurements (see tab. 50):

Measurement category	Examples
Single find	An archeological object like a lithic core
Sediment volume (collective find)	A bucket full of sediment from the excavation (normally around 10 liters)
Topographical measurements	Like the cave roof, the slope, excavation surfaces, surfaces of geological units, etc.

Tab. 50 - Main categories of measurements

In addition to these numbering system that creates find numbers, there is the possibility to assign sub-find numbers. There meaning differs inside the main categories (tab. 51):

Measurement category	Sub-find number	Example
Single find	Sub-find number belongs to this specific single find	For example if a lithic core is quite big and needs to be measured with different points or the orientation of a find has to be measured
Sediment volume	Sub-find number categorize a find inside this sediment volume	This are the numbers of finds inside the sediment volumes, like lithic objects, bones, etc. that are big enough to be separated
Topographical measurements	Sub-find numbers are specific measured points of this topographical measurement	E.g., by measuring a big limestone block, many points are shot to measure this block in that way that the volume and coarse surface structure can be reconstructed

Tab. 51 - Meaning of sub-find numbers

In general, the find-number is used to identify finds, files, data sets or pictures of finds. The system used there contains the site of excavation, the year of excavation, the square meter, as well as a consecutive number. This is exemplified in the following (fictive number):

- GER24.327-033.1235
- GER - Germolles as synonym for both Grottes de la Verpillière
- 24 - year of excavation
- 327-033 - Name of the square meter, here: X = 326.000 to 326.999 and Y = 32.000 to 32.999
- 1235 - consecutive number of measurements inside the square meter

All other information to the data set or find is collected in the data base. This labeling is also used for digital artifact photographs and drawings.

IV.3.5 Dokumentation

The excavation is daily documented with the aid of manually filled form sheets (from 2009 on) and digital photographs.

Form sheets

The years before only a diary for the whole trench was made (the trench is defined here as the whole excavation in each site, VP I and VP II, because both are running parallel). The full description of the form sheets can be seen in the handbook of the excavation (Frick & Hoyer 2012). Manually filled form sheets are existing for the following aspects (tab. 52) and are scanned for digital processing and storage:

Form sheet	Frequency	Content	Examples for the content
For the trench	Daily	Description of all activities of the whole trench per day	Staff, who works where and what, new realizings about coherences of the whole trench (new GH description, opening of new square meters, correlation of features)
For every square meter	Daily	Description of all activities and occurrences inside the square meter per day	Description of the daily work, sediment structure, finds, specifics (accumulations, gaps)
For profils	If necessary	Description of a profile (position, what is to see? layer description, photogrammetry, …)	Every new profile will be documented, but sometimes also old profiles can be documented again
For surfaces	If necessary	Description of a surface. This can be a surface inside a GH or a surface after the removal of an GH	This can be a surface inside one square meter or of many square meters, to describe its structure and to describe the transition from one layer to another
For samples	If necessary	Description of every sample that will be analysed under laboratory conditions	This can be big charcoal fragments, burnt lithic objects, limestone samples, etc.
For geological units	If necessary	Description of a geological units, if a new shows up or if something of high interest happen	Description of sedimentological content, color, texture, structure, etc.
For sketches	If necessary	A form sheet for sketches can be use for every feature that is necessary to be drawn	Sketches of accumulations, correlations, uneven surface, etc.

Tab. 52 - Description of the form sheets used at VP II

Digital photographs

The purpose of photographs are diverse. The technological development allows now to use digital photographs in high resolution, that can be processed in the computer in a fast way. At the one hand, everything during excavation can be easy documented by pictures. On the other hand, artifacts can be documented in high resolution, too (as described earlier the numbering of files corresponds with its documentation number). In addition to simple documentation and photogrammetry of profiles and surfaces, digital photographs can be used to document object three-dimensional, as well (key word SfM or three-dimensional photogrammetry). Pictures were made over the years with different digital cameras, with a resolution of higher than 5 megapixels (in 2014 and 2015 with resolution of 24 MP). In addition to the camera with different lenses, tripods, daylight lamps, gray cards and scales are used. The raw pictures of the camera were processed with Adobe Lightroom™ (white balance and so on) and used in a vast range of other programs after.

IV.4 Site formation

The following section describes the site formation in its totality from a geological point of view. Beginning with the graben system, the formation of the caves, their occupation and rock collapses.

IV.4.1 Rhine-Saône-Rhône (RSR) graben system

In the following, we are summarizing the part of the Western European Rift Zone (WERZ) that formed the area of interest as Rhine-Saône-Rhône graben system. It includes the northern part as the Rhine graben, the Burgundian transfer zone (north of the French and Swiss Jura), the Bresse graben (and parallel to this the Roanne/Forez and Limagne/Cher graben), the Saône graben and in the south the Rhône graben, down the Golf de Lyon (e.g., Anderson 1987), as it can bee seen (for the Saône and Rhône graben) in the following fig. 59.VP I & II are geologically located in the western shoulder region of the Bresse graben. As described by Bons & Wißing (2009), around and in the Grottes de la Verpillière small-scale faults are visible that correspond to the formation of this Bresse graben. These normal faults (*Abschiebung*) are clearly visible at the today's entrance of the cave tunnel at VP II and are in general orientated NNE/SSW.
This graben system formatted in the Eocene and Oligocene and is manifested in the Bresse and Limagne graben basins and resulted in a big lake in the Pliocene (Michon 2000).

IV.4.2 Cave formation in Upper Oxfordian limestone

Both sites are located in Upper Jurassic limestones, which was identified as limestone formation of the Upper Oxfordian (*Calcaires lithographiques puis oolithiques de Nantoux*) as described by Bons & Wißing (2009). The Oxfordian stage lasted between 163.5 ± 1 Ma and 157.3 ± 1 Ma and is the lower most stage of the Upper Jurassic series (Cohen et al. 2015)
Bons & Wißing (2009) identified three distinctive limestone layers (from bottom to top, I to III) on the cliff face at the subdistrict Verpillière (see fig. 60):

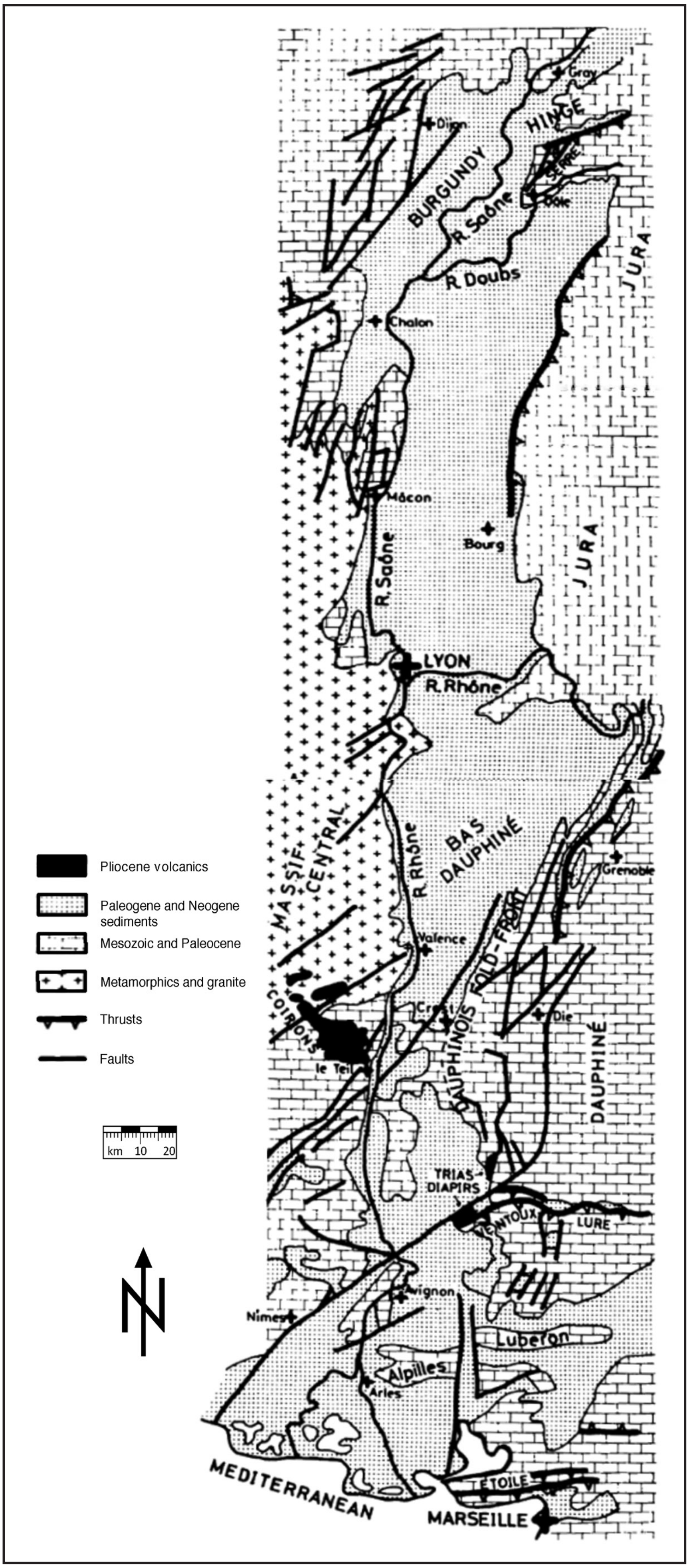

Fig. 59 - Structure of the Saône graben and Rhône corridor (Anderson 1987; fig. 8.1, after Debelmas & Demarq 1974)

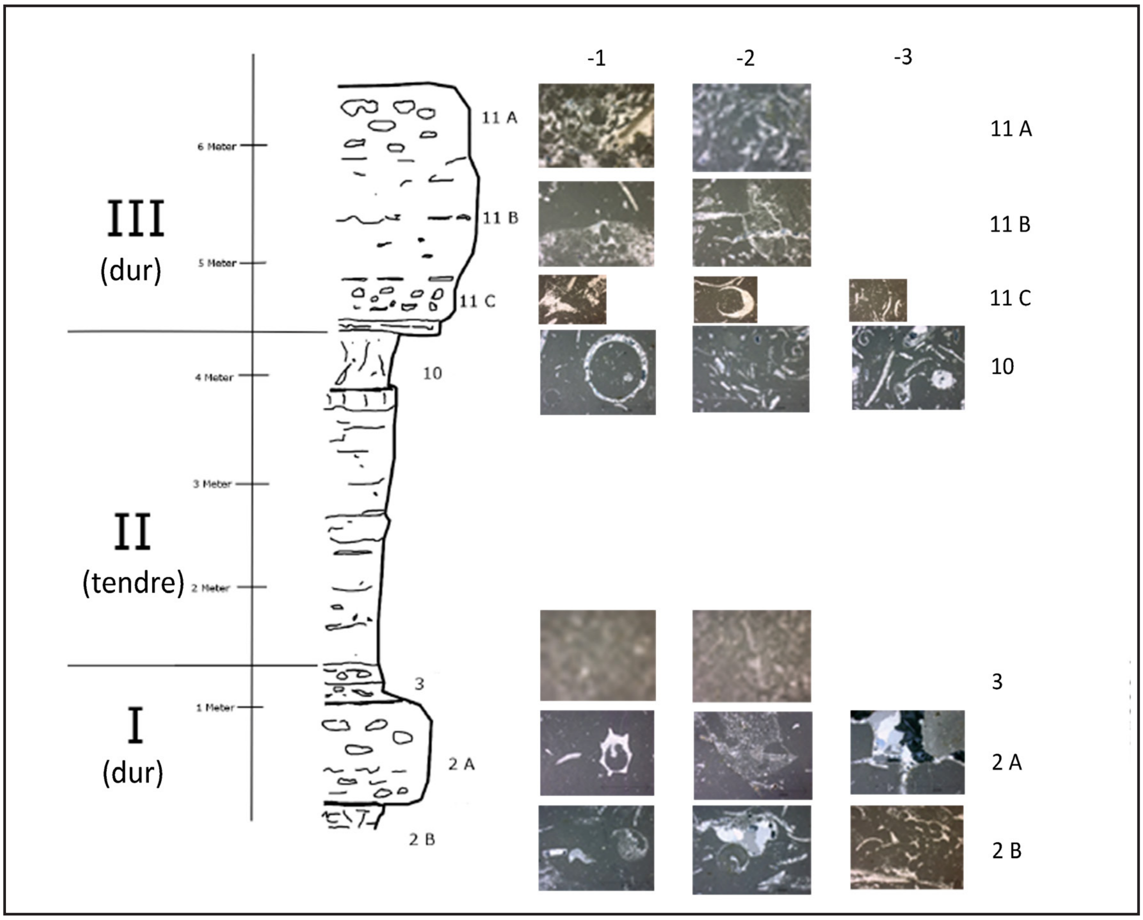

Fig. 60 - Summarized stratigraphy of the limestone formation of the sub-district Verpillière with corresponding thin slices (see also Bons & Wißing 2009; fig. 2; and Wißing 2012; fig. 22)

These three limestone layers were sampled for thin slice analysis and are described in the following tab. 53, from top to bottom:

Limestone layer	Observed thickness	Material	Cavities
III	2 m	Massive limestone, 1-10cm sized dissolution holes, very hard and forms the cliff face	Massive rock
III base	10-20 cm	Platy limestone	Position of the cavities
II	4 m	Marly limestone with beds (10 to 20 cm) of slightly more weathering-resistant limestone	Position of the cavities
I top	20 cm	Platy limestone	Massive rock
I	1 m	Weathering resistant limestone bed	Massive rock
Underground	unknown	Marly limestone of unknown thickness, in the underground	Massive rock

Tab. 53 - Distinguishable limestone layers at the cliff face at VP I & II.

Interestingly, all three layers „consists of very fine micritic to oolithic limestone with abundant small fossils and fragments (mostly <cm in size). Porosity and fractures are generally well cemented with sparry calcite. No significant difference could be detected petrographically between the different layers.“ (Bons & Wißing 2009: 3).

The cavities (that formed the cave tunnel and the rock shelter) are formed by the combination of normal faults (*Abschiebung*) and washout processes (see fig. 61). Due to the massive and stable top layer III, the cavities could be open as rock shelter and cave tunnel. It seems highly possible that the Orbize creek are responsible for the washing processes that helped to form the cavities at least in the Paleogene and Neogene (Wißing 2012)

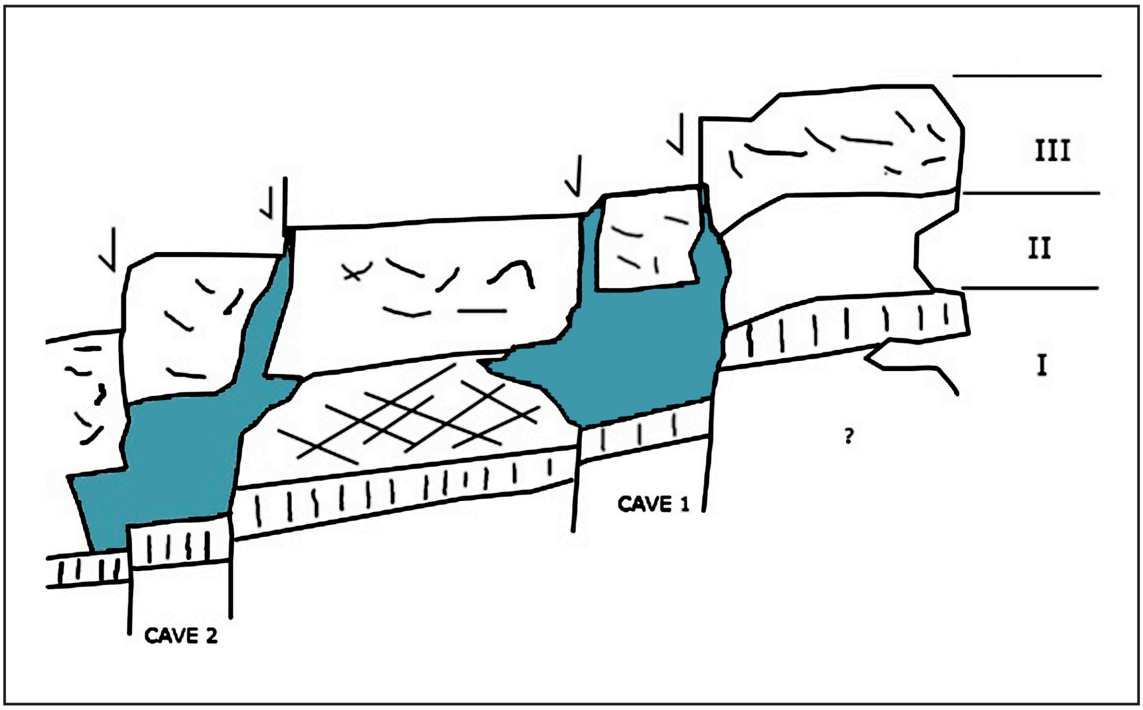

Fig. 61 - Scheme of the normal fault and washout processes at both sides (Bons & Wißing 2009; fig. 3)

IV.4.3 Sedimentation during the settlement of the cavities

The cave tunnel and rock shelter filling (as it can be seen in GH 3, 4, 4x and 5) during the Middle Paleolithic settlement can be coarsely described as sediments containing a small fluvial (from inside of the cavity) and large aeolian (from outside) component. The sediments of GH 3 and 4 are clayey sediments with a quartz fraction in silt size. They contain a small amount of calcite. Muscovite, as well as feldspar is also present. Zöller & Schmidt (2016) assume that these silicates have its origin in the granitic base of the Morvan Mountains.

In the zone under the recent drop line (today's entrance of the cave tunnel, micromorphological samples from square meter 227-059) also bioturbation in the form of small roots is present. In general, the sediments of GH 3 to 5 are described as non-cave sediments. It can be assumed that in areas not influenced by the drop zone in the today's entrance a stratification inside the sediments is possible (Wißing 2012).

More precise descriptions of the settlement events that are detectable in GH 3, 4x and 4 can be found in chapter X.

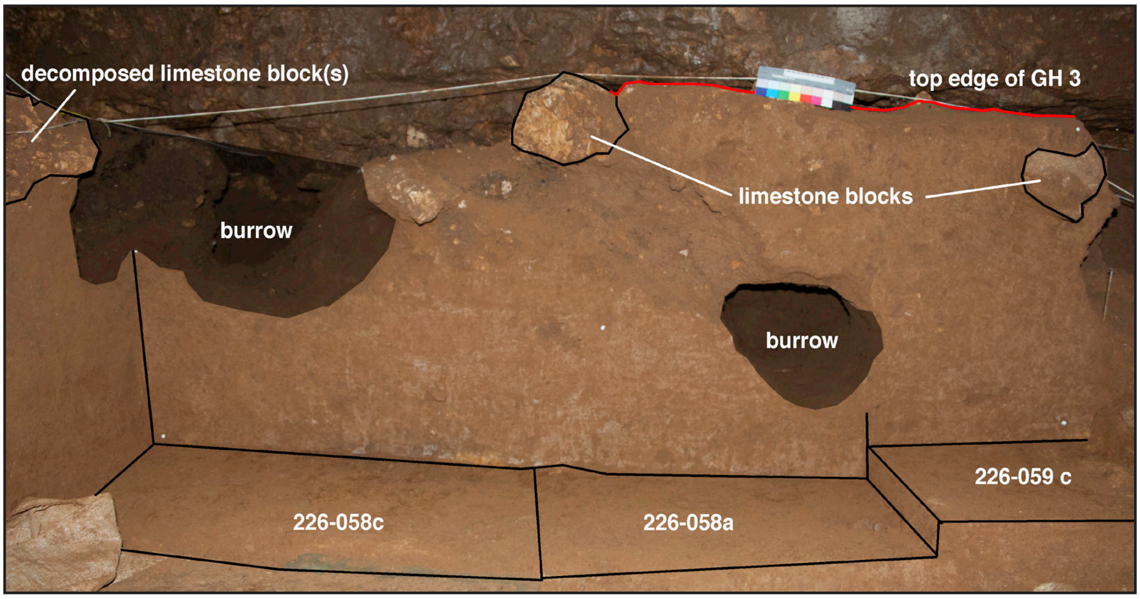

Fig. 62 - Examples of limestone blocks that were found in 2010 at the border of GH 2 and 3

IV.4.4 Collapse of the rock shelter

Introduction

In the time of excavation between 2009 and 2013, there was the assumption that the rock collapse that closed the entrance to the cave tunnel (second rock collapse) occurred after the sedimentation of GH 3. This assumption based on the fact that the excavation team could detect many limestone block of different sizes (mainly 20 to 50 cm in diameter) on top of this sediment unit. Some of them were buried exactly at the border between the GH 2 and 3 (as an example see fig. 62). In campaign 2014, it was possible to excavate a spot that clearly shows that this assumption was right. In square meter 227-061, the direct, physical contact between KS I (huge limestone block that can mentally refitted to the limestone above the cave tunnel entrance) and the surface of GH 3 was detected (see fig. 63).

This lucky situation leads to the consolidation of the assumption that the huge (second) rock collapse of the rock shelter occurred immediately after the sedimentation of GH 3 (this spot would also be excellent for dating the moment of the second rock collapse with highly sophisticated radiometric dating methods, by dating the time of the last sunlight exposure).

First rock collapse

Evidence for the (first) rock collapse before the known occupation are not as dense as for the rock collapse after it, but it is hardly possible to find other explanations of the phenomena visible on the site. In 2009 and 2010, under the sediments of the GH 3 and 4 complex and GH 5 and 6, large limestone blocs were detected. From the observations of P. Bons, who studied the structural geology at that time, this surface of limestone blocks cannot be assumed as bedrock of the cave.

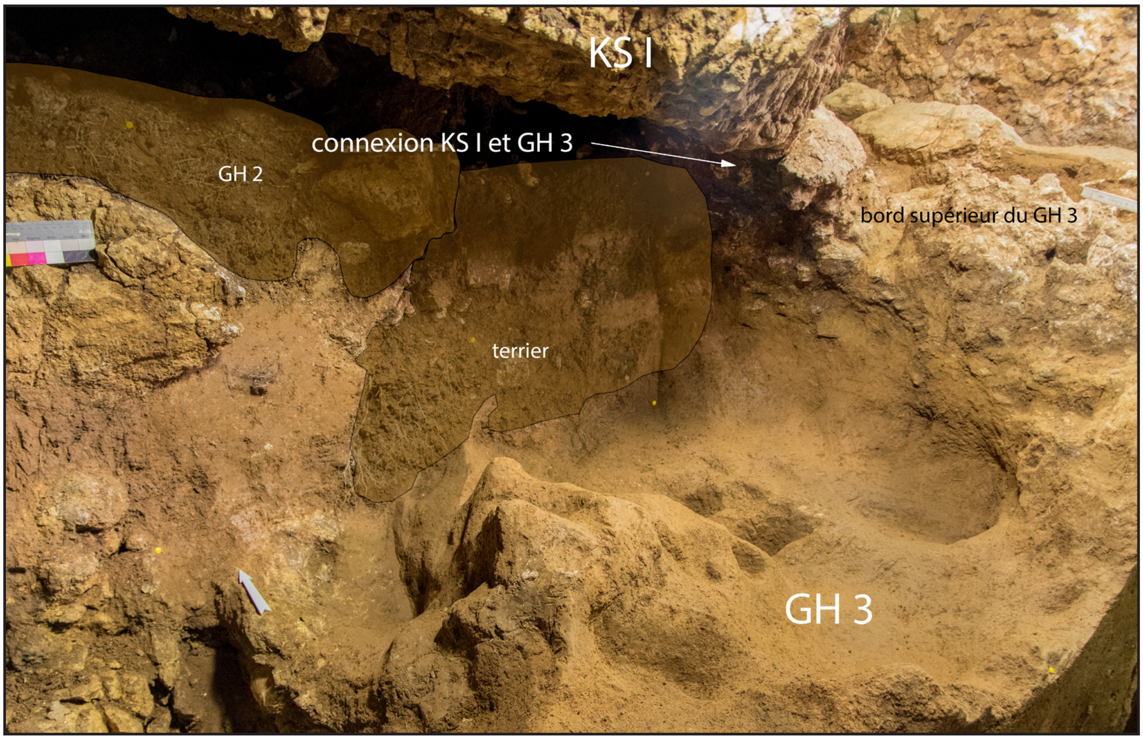

Fig. 63 - Direct, physical contact between KS I and GH 3 as it can be seen in square meter 227-061

As a result of this observation, a deep test pit in square meter 227-059 was started, to find the bedrock and other sediment layers. The test pit showed that the limestone is actually blocks in cubic meter size. The surface of this limestone-bloc complex increase in northwestern direction to the back wall of the former rock shelter (see fig. 64).

Fig. 64 - Blocs of the first rock collapse that increase in northwestern direction

If the test pit actually reached a layer under this first rock collapse, the collapse is in the eastern part (square meter 227-059, test pit of 2009) around 0.8 m thick and in the western part around 2.3 m (topographical measurement in square meter 225-060 from 2013), resulting in an altitude difference of 1.5 m. In some square meters, this altitude difference was removed by the excavation to have a horizontal platform for working (square meters 225-058, 226-058 to 226-061 and 227-058 to 227-060).

The limestone blocks of the first rock collapse are labeled as GH 8. On the surface of these blocks a flowstone was deposited, that was heavily altered. From the preliminary dating results for GH 3 and 4 (Heckel et al. 2016; Richard et al. 2016; Zöller & Schmidt 2016) we imagine that the rock collapse and flowstone formation can be associated to the end of OIS 4 or the beginning of the OIS 3 (around the Heinrich event 6?) were the permafrost slowly melted.

Second rock collapse

For the formation of the (second) rock collapse and the crush down of large parts of the rock shelter roof, there is good evidence on the site. The best evidence is visible in square meter 227-061, were the sediment of GH 3 is directly connected to a huge collapsed block (denominated as KS I, see fig. 63, above).

For the moment the time of the collapse can be coarse encircled by stratigraphical and archeological indices. We know that it happened after the Middle Paleolithic occupation and sealed it. In mixed sediments on top of the collapsed also Final Middle Paleolithic artifacts occur (Châtelperron-points). This gives a hint for the rock collapse of somewhat after 50 or 45 ka BP (maybe around the Heinrich event 5 ?). From the state of the excavation work, it is still not clear in which way exactly the second rock collapse and especially the crush down of the rock shelter roof happened. The constellation of the collapsed rocks of the rock shelter roof indicate that it happened in one big event. The collapsed rocks are not totally freed from sediments, therefore it is actually not possible to describe the rock collapse in total.

Determination of rock-collapse extension and rock-shelter size

Both, the extension of the rock collapse and the size of the rock shelter are not easily determinable. This is due to the fact that not all parts of the rock collapse are excavated. In the course of the excavation, all visible big limestone blocks were measured to be able to virtually refit them later together. The aim is here to get a good idea of the actual size and shape of the rock shelter during occupation and the extension of there collapsed rocks to know how it looked as processes accumulated the sediment on top of it.

In addition to geomorphological observations of cave and rock shelter formation, fracture directions and the position of the bedrock, GPR surveys helped a lot to refit a plausible picture of the position and affiliation of the massive limestone blocks. In 2009, GPR survey determined the approximate extension of the cave tunnel and that there are sediments between big blocks on the terrace. The GPR survey of spring 2014 leads to the certainty that on top of the plateau only a thin sediment cover is located. It was also found out that KS IV on the terrace (a block of a surface of 5 to 2 m) is part of the rock collapse, because there are sediments under it. A test pit during the summer campaign 2014 in the Northeast (direction to the street) verified this observation, too. In the 2015 campaign the area northeast of this huge block was excavated and showed stepped limestone

blocks and a big fissure (see fig. 65).

Fig. 65 - Panoramic view of limestone blocks and supposed bedrock in the northeastern part of the site (indicated are displaced limestone blocks, the supposed bedrock and the fissure between both parts)

IV.4.5 Animal den

At the least, during excavation of the upper parts of GH 3, it was highly visible that parts of it were disturbed by animal activities. This disturbance could also be detected during the excavation of GH 1 and 2, because inside these mixed layers, burrows and some badger (Meles meles) sculls were excavated. The first of these skulls occurred in 2006. This and the typical carnivorous smell led to the nick name Dachsbau (badger den) of VP II. In spring 2013, some badgers were captured in live catch traps and were relocated, because it was obvious that these animal were still active here and disturbed stratified sediments. During a one week campaign in march 2013 for the stabilization of a huge collapsed and wedged limestone block at VP I, we were able to see one badger at VP II. After that time, almost no animal activities at the position of the excavation were visible.

In the beginning, in 2006, the animal den were quite well visible. And now, after years of excavation in is quite obvious why these animal choose this place. Because between the collapsed rocks are hollows, the landslide sediments that covered the rock collapse is quite soft and the area (cliff face) seems to be only slightly anthropogenically affected (in modern times). On a photograph by J. Combier from April 24, 1963, that was made after clearing, the northern part of the rock collapse of VP II is visible and looks nearly the same as the excavation team found it in 2006 (see fig. 66).

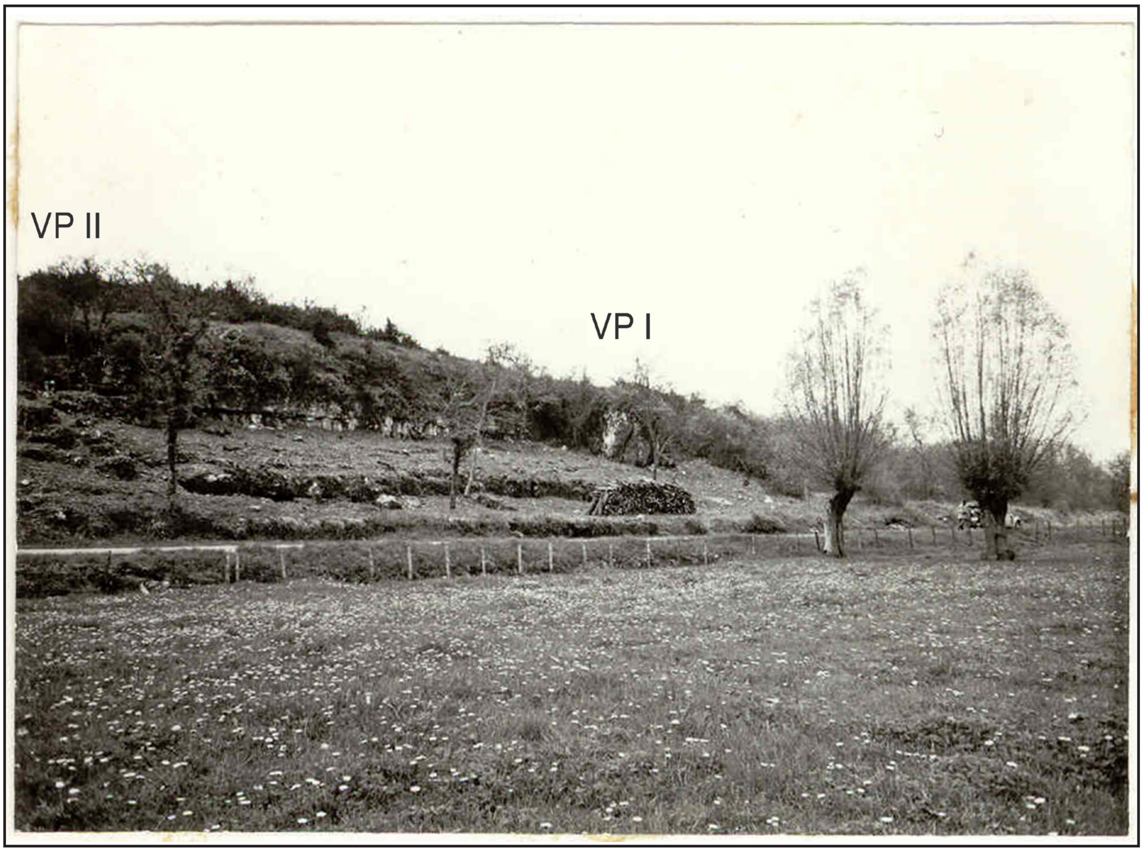

Fig. 66 - Photograph made by J. Combier (April 24, 1963) showing the cleared cliff face of the Montadiot and both Grottes de la Verpillière (VP I & II are added).

The area of the site is situated directly on the cliff face and the hill slope is quite plunge, so only heavy earth movement could clear this area in that way that it would be integrated into a modern improvement area. The next modern houses are situated around 70 m to the Southwest, away from the cliff face.

IV.4.6 Landslide detrital

In the beginning of the excavations in 2006, only the tips of the collapsed blocks were visible (see fig. 30, above). The most of the site was covered by mostly lose humus (GH 1 and 2), with a high degree of calcite. A GPR survey in 2014 revealed that on top of the site, on the plateau to the West (Montadiot massif) almost no sediments are present (Leach 2014). It is also very unlikely that occupations as indicated by artifacts from the Upper Paleolithic and Neolithic, as well as Roman and Medieval times happened directly on the collapsed rocks. Therefore the easiest interpretation is, that the most of the sediment that covered the site derives from the plateau. Artifacts from these mixed sediments, assumed as Upper Paleolithic, were studied by Götz (2013) in the course of his Bachelor's thesis. More research about the artifacts from the mixed layers (all time periods, spatiality, etc.) is planned as another Bachelor's thesis for 2016-2017. The artifacts from GH 1 and 2 are always distributed on top of the collapsed blocks, as well as in the mixed sediments in the cave tunnel.

IV.4.7 Summary of site formation

The formation of the site occurred by washing out of fissures at the cliff face of a limestone massif. The stratified sediments are associated with a Late Middle Paleolithic occupation and are wedged between to rock collapses. The occupation took place under a rock shelter and in an immediately connected cave tunnel. The rock shelter's roof crushed down after the Middle Paleolithic occupation. The excavation of stratified sediments between 2009 and 2015 removed some cubic meters of sediments in the entrance of the cave tunnel. The majority of stratified sediments is still un-excavated and are sealed under limestone blocks that weighing tons. It is assumed that the first rock collapse took place close before the occupation (maybe end of OIS 4) and builded the surface for the Middle Paleolithic occupation and aeolian-fluvial sedimentation. The Middle Paleolithic layers were sealed shortly after the occupation (before 40 ka BP?). Artifacts from younger periods are always on top of the rock collapse to be found.

IV.5 Radiometric dating and chronology

IV.5.1 Introduction

To get a chronological determination of the Middle Paleolithic occupation, different radiometric dating methods were used. In 2009 and 2010 it seemed that AMS ^{14}C, Thermoluminescence or Uranium series were quite promising. But after observation by dating experts it seemed that not enough collagen is in the bones (for Radiocarbon), the lithic material was not high enough heated (for Thermoluminescence) and the flowstone layer of GH 7 was to much weathered (for Uranium series).

In 2013, dating experts (L. Zöller and D. Richter, University of Bayreuth) were invited to visit the site for suggesting adequate dating methods. They showed up during the excavation campaign at August, 5 to 6, 2013, and sediment samples from GH 3 and 4 for OSL dating, and installed dosimeters for counting the background radiation inside the sediments. At the same campaign Ch. Falguères and M. Richard (IPH, Paris) visited the site and took teeth for ESR/U-Th dating. In the following year (March, 4) more teeth and sediments samples were sent to Paris. In late 2014, bone fragments were sent to Th. Higham for AMS ^{14}C dating. The preliminary results of these dating attempts are summarized in the 2015 report for the PCR (Heckel et al. 2016; Richard et al. 2016; Zöller & Schmidt 2016).

IV.5.2 AMS ^{14}C

For the evaluation if Radiocarbon dating is possible, collagen tests (N-test) on bone material were performed in 2009 (work group of H. Bocherens, University of Tübingen). These tests showed for material collected in the entrance of the cave tunnel that not enough collagen was preserved. A new attempt for Radiocarbon dating started in 2014 on bones from the interior of the cave tunnel. Bones were collected that had a characteristic collagen smell (pers. comm. C. E. Heckel). Three long bones from GH 3 were extracted and taken to Oxford to Th. Higham (see tab. 54):

Find number	Z-value	GH	Material	Sample weight	Description
GER11.225-059.282	7.27	3	Long bone fragment	590 mg	Fragment of long bone diaphysis with faint but identifiable discontinuous cut marks on exterior surface
GER10.228-058.132	6.99	3	Long bone fragment	600 mg	Unmodified fragment of large diaphysis
GER12.226-056.20	7.3	3	Long bone fragment	630 mg	Possibly modified long bone

Tab. 54 - Bone samples from GH 3 for Radiocarbon dating in Oxford

Only one of these bones yield enough collagen for the dating process (GER11.225-059.282) and gave a terminus ante quem date of > 48,200 ka BP (AMS ^{14}C, OxA-32230). The other two samples yield not enough collagen for dating. The preliminary radiocarbon result is discussed in Heckel et al. (2016).

IV.5.3 IRSL

The sediment samples taken with a core cutter by L. Zöller in 2013 showed that the Quartz fraction was saturated and therefore the OSL dating attempt failed. In another test feldspar was found be in good quality for being used with Infra-Red-Stimulated-Luminescence (IRSL). The preliminary calculated ages (Zöller & Schmidt 2016) are as follows (tab. 55):

Lab number	GH	Thorium [cph]	Thorium [error]	Uranium [cph]	Uranium [error]	Thorium [ppm]	Thorium [error]	Uranium [ppm]	Uranium [error]	Potassium [mg/g]	Calculated IRSL age
BT1202	3	16.19	1.45	31.90	1.51	8.96	0.80	5.15	0.24	16.80	45±4 ka BP
BT1203	4	14.47	1.58	47.71	1.65	8.01	0.87	7.71	0.27	13.70	47±5 ka BP

Tab. 55 - Calculated age of IRSL samples from VP II

These dating samples suggest a quite young age of the stratified Middle Paleolithic of VP II. But the uncorrected ages are stratigraphically consistent. As the discussion in Zöller and Schmidt (2016) suggests the uncorrected (calculated) ages of both samples laying close to the true ages. The assumption for the archeological occupation from this results will discussed later (see chapter X).

IV.5.4 TL

Unfortunately, as it could be evaluated by D. Richter there are not enough highly burnt lithic objects available from the stratified units to perform Thermoluminescence dating. The performance of heating experiments in 2012 demonstrated clearly that the local FAS has the same heat features as other flint material (Frick et al. 2012). From the conducted analysis of the entire material from VP II it seems that only n=335 (2006-2015, all GHs) lithic artifacts show influence of heat (for integrity they are shortly listed in tab. 56):

GH	Number of heat influenced lithic objects
1	12
2	50
2-5	1
3	255
4	17
Total	335

Tab. 56 - List of lithic objects showing heat influence

Unfortunately, most of these lithic objects showing minor influence of heat (lower temperatures, > 350°) indicated from their heating features. For TL, objects are necessary that are heated with temperatures of around 400 and more degrees (Richter 2006a, 2009).

IV.5.5 ESR/U-Th

In total, n=5 sampled teeth were used for the ESR/U-Th dating attempt in IPH in Paris (*Institute de Paléonlogie Humaine*). The processing and calculation of these samples and data was part of the dissertation work of M. Richard (see also Richard et al. 2016). All teeth are molars of large herbivores like bos/bison or horse, and are listed in tab. 57:

Fund number	GH	determination	notes	taxon	calculated age (early uptake)	calculated age (recent uptake)
GER12.229-058.108	3	upper left M3	could be dated	Bos/Bison	33±2 ka BP	36±3 ka BP
GER10.228-059.25.1	4	upper Molar	could be dated	Equus	41±3 ka BP	
GER10.228-058.541	4	upper Molar	could be dated	Equus	38±3 ka BP	
GER13.225-059.1015	3	Molar	could be dated	Artiodactyla (Even-toed ungulate)	38±4 ka BP	
GER13.225-058.1106	3	Molar	could be dated	Bos	43±5 ka BP	81±9 ka BP

Tab. 57 - Samples and results for ESR/U-Th dating from GH 3 and 4

The exact position of these teeth samples and the dosimeter can be seen in fig. 67:

IV.5.6 Radiometric dating results and chronological assumptions

All dating attempt together indicate (note the provisional nature) that GH 3 and 4 are deposited during the early OIS 3. The dating results are insofar consistent that GH3 is considered to be a bit younger than GH 4, as their stratigraphic position assumes. The ESR/U-Th results seem to be too young, if compared to the IRSL and Radiocarbon dates.

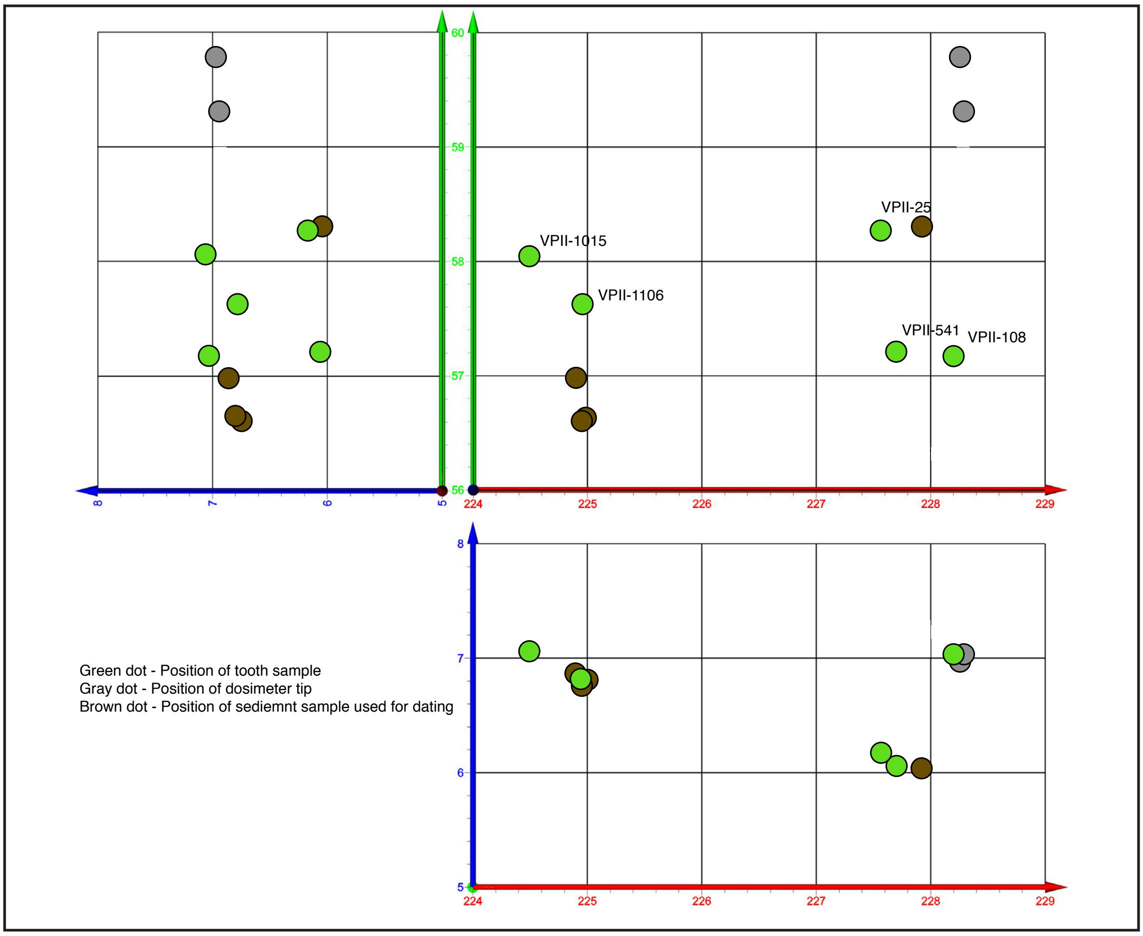

Fig. 67 - Position of ESR/U-Th teeth samples and dosimeter from VP II (above left view to west, above right top view and bottom right view to north)

Without to much knowledge about interpreting these dating results, we suggest simply an early OIS 3 dating for GH 3 and 4. Fig. 68 summarize the radiometric dating attempts for GH 3 and 4 of the site.

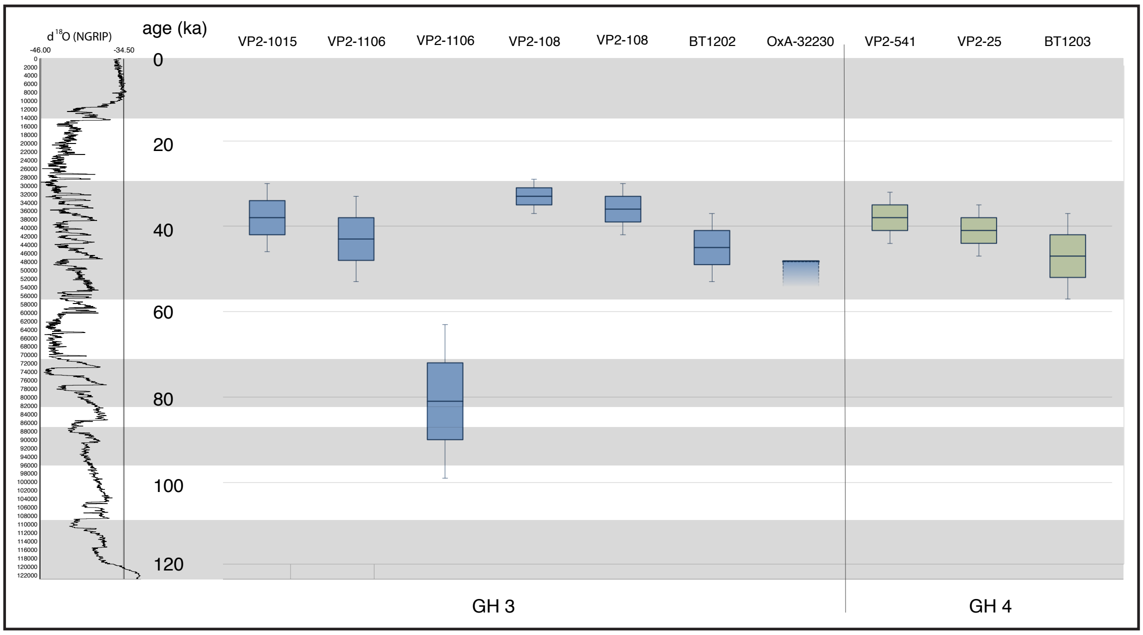

Fig. 68 - Collection of radiometric datings for GH 3 and 4 of VP II

IV.6 Topography of the site

IV.6.1 Introduction and topographical data collection

The topographical measurement with a total station (Leica or Sokkia tachymeter with connected laptop) running WinEDM from Dibble and McPherron (http://www.oldstoneage.com/software/default.shtml) tried to measure all geomorphological features. With the aim to have the possibility to display these in the way they occur today, but also in their constellation during the time of occupation. For the moment, we choose the computer program Voxler™ to display these measurements as scatter plots. Future work will try to display these features (e.g., a single collapsed rock) as three-dimensional volumes, with the possibility to move volumes by vectors. The idea behind this is to reconstruct the former rock shelter with its occupation under it.

WinEDM has the possibility to encode measure points with a find-number and a sub-find-number. This helps enormous to measure one feature (e.g., the mentioned collapsed rock) under one find-number, with individualized measurement point (the sub-find-numbers). The measurement of topographical features took place during excavation and non-scheduled campaigns.

In total, (in the campaigns 2006 to 2014) n=49,467 points were measured including n=11,793 that represent topographical features. These features are measured with the determination code KS for limestone (*Kalkstein*) and TOPO for Topography. In addition to this code, attributions like the GH, a note and description and many more were recorded.

IV.6.2 Topographical appearance of the site in past and present

Excavations and geomorphological observations indicate that Grotte de la Verpillière II was actually not a cave but a rock shelter with a corresponding cave tunnel during the time of occupation. Today the complete rock shelter is collapsed. It seems the reason that the cave tunnel is not collapsed is, that harder limestone that was stepped and sintered during the formation of the graben system (see above) forms parts of the wall (for the division of the limestone varieties of the cliff face, see chapter IV.4).

In the time of discovery (see chapter IV.2), the site appeared as sediment hill in front of minimal slid at the cliff face. It looked much more (after detecting the cave tunnel) in that way that the much later collapsed cliff face blocked the entrance of a cave entrance. After many excavation campaigns and the removal of vegetation and sediment it is clear that it was not a collapse of a lateral cliff face but the collapse of a quite huge rock shelter.

The sediment hill (with its features of an animal burrow) was that obvious that the internal name of the site was *Dachsbau* (badger den). Fortunately, the excavation could show that mostly the part on top of the second rock collapse was affected by animal activities and not so much of the stratified layers under the rock collapse. But also the upper parts of GH 3 showed clear signs of animal activities in some spots (which is the main reason that after the animal affection the surface of GH 3 appears wavy and artificially altered in its shape. To separate these reworked sediments it was measured as GH 2-TG (GH 2 sediments of an animal burrow).
After cleaning the collapsed rocks it was obvious that some of there sides can be refitted to each other. The size of these blocks up to some duzen of cubic meters makes it impossible to refit them physically. The only way of refitting is to use virtual simulations. After removing massive limestone blocks and tons of sediment from GH 1 and 2, the actual appearance of the site is much more obvious. It was apparent that there are possibilities to refit these block in a mental (or better virtual) way.

IV.6.3 Today's appearance of the site

Today, after many excavation campaigns the actual appearance during the Paleolithic occupation can be reconstructed. The area of collapsed rocks is quite large (larger as thought some years ago, because test pits and more geomorphological observations brought more details to light).

Rock shelter

From the position of the big limestone block that formed the roof of the rock shelter, it can be assumed that it was parallelogram shaped (see fig. 69). The former rock-shelter roof should cover an area of around 50 square meter, north of the corresponding cave tunnel, and the still underlaying sediments remain un-excavated. The reason for this assumption is that very often a Middle Paleolithic occupation took place under such a rock shelter or in the entrance area of a cave. It is very likely that the main occupation is still un-excavated.
As suggested from the entrance of the cave tunnel the actual hight (between the surface of GH 3 and the ceiling) was around 2 m. If the ceiling is inclined as it is suggested from an imaginary refit of the collapsed blocks, the hight at the norther entrance of the rock shelter should be something around 3 m.

Cave tunnel

In the beginning of the excavation, the actual cave tunnel was assumed as being the cave and yielding the main occupation. The removal of some of the collapsed block and the cleaning of them revealed that they belong to a collapsed rock shelter. The cave tunnel is directly connected to the rock shelter. If we would assume a further weathering of the limestone cliff, the cave tunnel would going to be a rock shelter as well. The observations made with the help of GPR in 2009 and speleological entering of the space between the ceiling and the sediment, it is suggested that the cave tunnel is in total around 8 to 10 m long (in North-South direction). In the interior of the tunnel around three to four meter of sediment is remaining (see fig. 69).

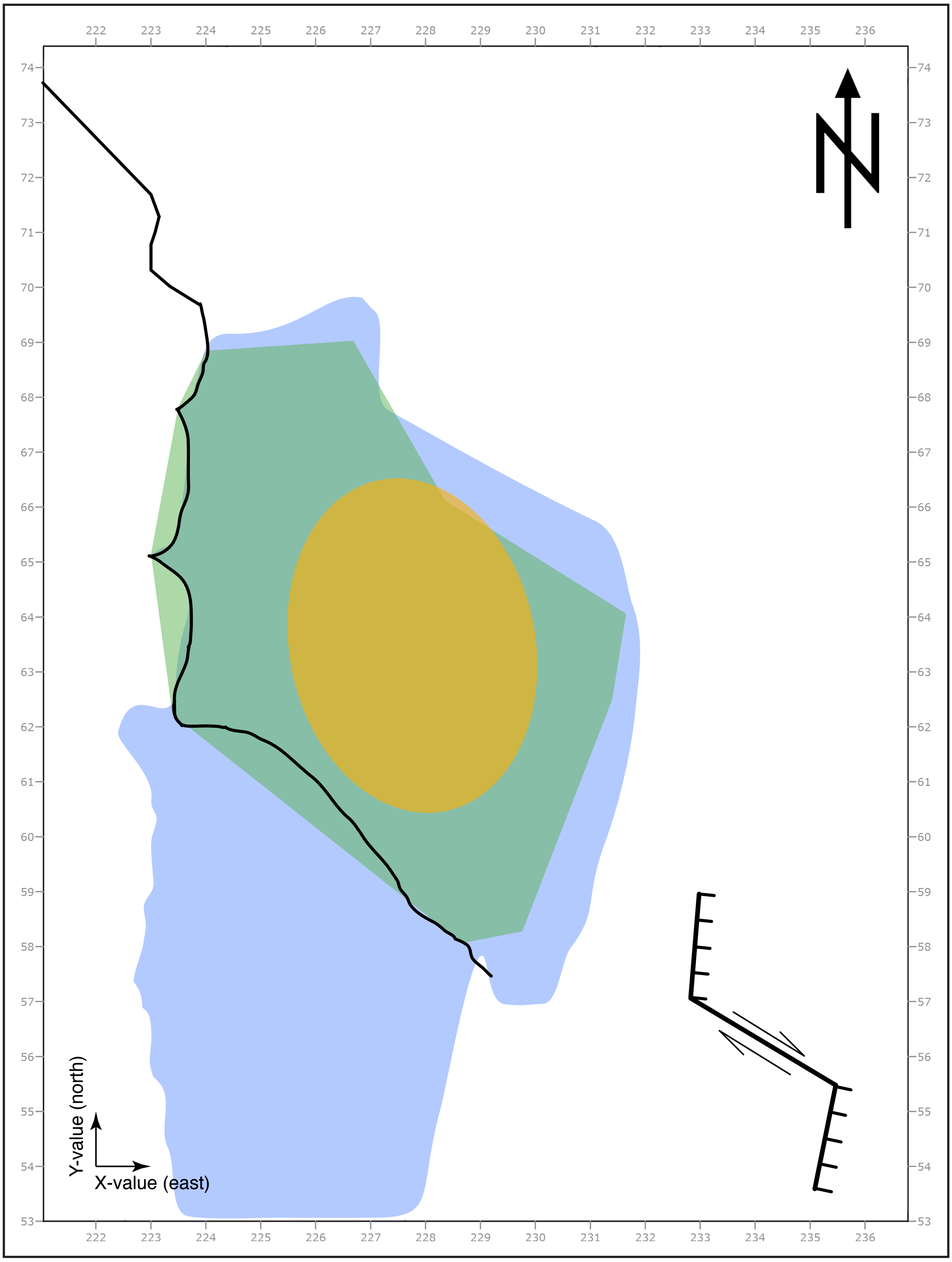

Fig. 69 - Map of VP II showing the potential area of the former rock shelter (shaded green), potential extension of the stratified sediments (shaded blue) and possible position of the main occupation (shaded orange)

Potential area of stratified sediments

It appears that around 50 or more square meters of stratified sediment were covered by the rock shelter. Also around 40 to 50 square meters of the area of the cave tunnel might be filled with stratified sediments (see fig. 69). As matter stands, we could estimate the potential area of intact sediments bearing Middle Paleolithic artifacts of something around 100 square meters in total. The main sources of this estimation are the GPR survey from 2009 and 2014 (Leach 2014; Leach & Miller 2009), geomorphological observations (e.g., fracture directions, position of the bedrock, steps in the limestone formation of the cliff face), the area covered by collapsed rocks and observations through test pits around this estimated area (in 2014 and 2015).

Appearance during Middle Paleolithic occupation

The actual appearance of the site during Middle Paleolithic occupation can just be estimated and must still stay a *Gedankenexperiment*. In the following an evaluation list presents visible facts and possible interpretations concerning the appearance of the site and implication for the occupation (tab. 58):

Visible fact	Interpretation of the site's appearance	Implication for the occupation
Area of the excavated sediment from GH 3 onwards is located under the recent entrance of the cave tunnel	In a mental refitting of the collapsed rock shelter, the excavation is situated in the interior periphery of the rock shelter (around 5 m from the entrance of the rock shelter)	A usual feature of Neanderthal occupation of caves and rock shelter is that the entrance is more intensively occupied than the interior
An area of over 60 square meters is covered by the rock collapse and the cave tunnel has an area of around 50 square meter	In a mental refitting of the collapsed rock shelter, the former size of the rock shelter is smaller, maybe around 50 square meters	The area covered by a roof (rock shelter and cave tunnel) might be around 100 square meter
Many charcoals in the sediment of GH 3 indicate a close distance transport of rests from heart pits	The actual wind direction in the small Orbize Valley favors the accumulation of material from under the rock shelter in the cave tunnel	If the charcoals in GH 3 are the result from close distance transport then there is the possibility that rests of occupation structure are still present under the collapsed rocks (in the mean of heavier objects)
The first rock collapse (before the occupation) formed an inclined surface of limestone blocks on the west wall of the cave tunnel	The area in front of the cave's west wall (and maybe the rock shelter) was not horizontally flat	During the sedimentation of GH 4 and 4x the area in front of the west wall was inclined and therefore an occupation is not as likely as on flat surfaces, maybe more an area of dumping Only the highest parts of GH 3 are higher than the first rock collapse at the West wall and accumulated many organic material on the West wall.

In front of VP I and at the cliff face to VP II the bedrock shows large flat steps	The occupation surface in front of the first rock collapse could have flat steps or could be a complete flat surface	Flat surfaces are ideal for an occupation and if the rock shelter and cave tunnel are aeolian sediment traps, durable material of the occupation under the rock shelter could still be in place In the steps are very short, a hill slide of the accumulated sediments is likely and less chance exist for good visible occupation structures under the rock shelter
The second rock collapse happened immediately after the MP occupation	The second rock collapse sealed the Middle Paleolithic of the site and therefore many unknown, untouched features, objects, etc. was found under the weighing several tons of limestone blocks	During the Late Middle Paleolithic occupation people had a shelter, in the Final Middle Paleolithic and Upper Paleolithic the site was blocked by the rock collapse
Evaluation of the potential area of stratified sediments	If the hill slope was similar to that we can excavate there, the actual size of the site (complete occupation area) might be as it was evaluated	North ofVP II, in front of the cliff face a quite flat bedrock situation is present, that could have been used by Paleolithic people, too (but everything could be eroded)
Length of the front of the rock collapse	The size of the rock shelter's opening could have been around 15 m wide	15 m wide is enough space to have shelter for a nice groups of people (including hearth, workshops, sleeping areas and so on)
Position of VP II in the Orbize Valley	The site has a perfect position on the cliff face to oversee the valley bottom in both directions and the hills nearby	Position implies a good control of the landscape, early visibility of herds of animal passing the valley, close distance for often used lithic raw material and water
Preliminary radiometric dating of VP I and II shows no contemporaneous occupation in the Middle Paleolithic of both sites but the assemblages share commonalities	This might be an evidence that the other site nearby was in a condition that an occupation was not possible	This might be an evidence that the other site nearby was in a condition that an occupation was not possible

Tab. 58 - Evaluation of the site's appearance and implications for the occupation

We are suggesting that the main occupation of the site happened under the rock shelter and the excavated area in the entrance of the cave tunnel is the periphery of the find scatter. The rock shelter was open in northern, northeastern and eastern direction. This gave the chance to have a good view into the Orbize Valley from VP II, the site of Germolles-Saint-Sulpice (another raw material source for FAS and a Middle Paleolithic site) can be seen. VP I is concealed by the cliff face.

IV.7 Stratigraphical sequence

In VP II, the stratigraphical sequence is numbered from top to bottom, with some small exceptions. GH 12 is now part of GH 2 and GH 4x was defined as a sediment unit between GH 3 and 4 (because it was found later). But first of all we need to define the term geological horizon (GH). After than the GHs of the sites are listed and explained.

IV.7.1 Definition

A geological horizon is a sediment unit that is defined to be different to others. These differences can be diverse. Or in other words, a sediment unit is in itself more similar than to others. The following tab. 59 shows features how sediment units can differ from each other (all these features are also listed in Frick & Hoyer 2009, 2011, 2012; Frick et al. 2013). These criteria are also used to describe features of surfaces and profiles:

Feature	Criteria	Technique of determination	Example
Estimation of surface distribution	Can we see clusters of material? Are these materials everywhere?	Estimation on surfaces or in volumes by means of pictures or plots	Accumulation of small stones or charcoal Differences in the distribution of finds
Borders of findings	Is the border exact to see? Is there a succession from one to another visible?	Cleaning, estimation of transition	Is the border sharp, washed? Is the transition highly visible?
Inclusions	How much coarser material is visible? Are they rounded?	Magnifier, granularity chart, sieving, finger test	Bigger grain sizes (sand and stones)
Color	Comparison of slightly wet sediment	Munsell color chart RGB values with defined light conditions	Only an approximate value is possible, depending on the magnification
Color distribution	Can wee see differences in sediment color?	Munsell color chart RGB values with defined light conditions	Only an approximate value is possible, depending on the magnification
Granularity	What kind of grain sizes are there?	Magnifier, granularity chart, sieving, finger test	Is the sediment clayey, silty or sandy?
consistence	Is the sediment hard, soft, water saturated? Plasticity, density,…	Finger test	binding of the sediment, water content
Sorting	Can we see different grain sizes?	Magnifier, granularity chart, sieving, finger test	Is the sediment homogenous?
pH value	Contains the sediment calcite?	Reactivity with diluted hydrochloric acid	Karstic or aeolian sediment content?

Tab. 59 - Some criteria to separate geological horizons

IV.7.2 GH 12

This sediment unit was defined in 2013 to distinguish a batch of sediment (later recognized to be a part of GH 2) containing manganese oxide crusts around loose sediment lumps. As it could be seen, between these lumps and included in some are some plastic fragments, but also some bone and teeth fragments. The volume of this distinctive spot is small (n=5 collective finds). Two samples were taken, to have the possibility to analyze them. The sediment is of middle to dark brown, if such a lump is crushed the sediment gets much darker, because of the high manganese oxide content. The sediment matrix is sandy and silty, bigger ingredients are some rounded quartz fragments and the mentioned bone and teeth fragments. Probably, this spot is part of burrow sediment in the already mixed sediments of GH 2 and was found only in square meter 226-056 at a Z-value between 7.44 and 7,62.

IV.7.3 GH 11

GH 11 is the smallest sediment spot so far. This material was excavated in 2010 on the ground of a very small test pit in square meter 228-058 at a Z-value of 5.19 and consist of one bucket of sediment and no finds were in the bucket of the dark loamy sediment. From the position the sediment might belong to GH 5. Further excavation in this spot can be done if the stratified layers around are removed.

IV.7.4 GH 10

The bedrock inside the cave tunnel is defined as GH 10. In the excavation the lowermost visible limestone unit (see Bons & Wißing 2009; Wißing 2012) that forms the cave and rock shelter floor was labeled as bedrock or limestone layer I (see chapter IV.4.2). For further information to it, the deep test pit from 2009 would be needed to be reopened and widened. For the moment the position of the bedrock in the cave tunnel is just an assumption.

IV.7.5 GH 9

GH 9 is a sediment unit that was found in the deep test pit (Tiefensondage) of square meter 227-059, too. It consists of n=4 sterile collective finds and contains clayey sediments with many calcite crusts (1 to 3 cm). It seems that this layer is around 10 cm thick, but was only tested in this quarter square meter wide test pit. The color of the sediment is between strong brown (MMC 7.5 YR 5/8), dark yellowish brown (MMC 10 YR 4/4) and very dark grey (MMC 10 YR 3/1). We found some un-diagnostic pieces of silex, but it is highly possible that they fell into the tiny test pit during excavation. For a better understanding of this GH, the test pit also needs to be widened.

IV.7.6 GH 8

GH 8 is defined at the first rock collapse. It consist of bigger limestone blocks that are secondarily connected by concretions. The number of these block is not easy

to evaluate because of the secondary connection. In some parts these block are red, yellow and black because of weathering, iron oxides and manganese oxide crusts. The limestone is very hard and contains a dolomitic part. It is highly possible that all of these limestone blocks were part of the ceiling and fallen down before the occupation. In non of the parts of the excavation sediments containing Middle Paleolithic artifacts are below this GH.
The exact thickness is hard to determine. The evaluation of spatial measurement suggests that this GH is in the eastern part around 0.8 m thick and on the west-wall around 2.5 m.

IV.7.7 GH 7

GH 7 is sterile and is defined as a highly weathered flowstone layer on top of GH 8. It contains much manganese oxide and is rusty. In some parts this GH can be up to 20 cm in thickness. It is supposed that warmer conditions are necessary to build such flowstone. This flowstone layer follows the surface of GH 8 in their almost entire extension (square meters 226-058 to 226-061, 227-058 to 227-060, 228-058 to 228-060).

IV.7.8 GH 6

This GH is a yellow clay weathering unit and sterile, too. It is to find in the interior area of the cave tunnel. It contains almost now limestone (no reaction with diluted muriatic acid) and is assumed as the product of limestone weathering.

IV.7.9 GH 5

GH 5 could only be detected in the front part of the cave tunnel (northeast). It is darkish brown, sterile and can be seen as a soil formation under open conditions. It is a silty-sandy sediment and only visible in places where GH 4 was found. In its maximum thickness GH 5 is around 10 cm thick.

IV.7.10 GH 4

GH 4 is brown-gray to dark-brown and is only visible in the eastern part (row 227, 228 and 229). It contains archeological finds that can be attributed to the Middle Paleolithic. It contains sintered parts. The matrix is a clayey-sandy sediment that contain bigger inclusions of quartz and feldspar, but also small limestone fragments. This GH is in the western part quite thin and gets thicker to the East. The color is around MMC 10YR 4/4 to 10 YR 6/8. At the beginning in 2009, it seemed that it is a cannel filling, but the excavation of 2013 and 2014 demonstrated that it continuous into eastern direction, as well. At the moment is seems to be filled into a basin of GH 5, 6 and 7, because these GHs slope down to the East. In 2009, as is was assumed, that the surface of this GH looked like a living floor, further excavations showed that the material of the entire GH is related to each other, because almost all part this GH contains bigger, almost complete bones (from rhino and mammoth), associated with some stone artifacts, as well. The density of artifacts is similar to GH3, but still the area where it is excavated is quite small. Therefore only very preliminary observations about the material can be made.

IV.7.11 GH 4x

This GH was separated from GH 4 in 2013. Sediment parts of 2010 that were attributed to GH 4 were integrated into GH 4x because in three-dimensional plots it was clearly visible that they are separated by a sterile, horizontal gap and a difference in its Z-value of around 10 cm. This GH is only visible in square meters 225-058 to 225-060, 226-058 to 226-061 and 227-058 (on the western wall of the cave tunnel). It contains not many archeological objects. The color is slightly darker than GH 4 and the matrix is a bit finer. It also contains small quartzite fragments. From its shape and position, it can be determined as a single, short event of occupation. GH 4x contains only n=108 measurements, included n=46 collective finds and n=61 single finds. From the profiles of square meter 225-057 it seems that this GH fade out here too (for the next time this square meter will stay as witness for further excavation).

IV.7.12 GH 3

GH 3 is the biggest and richest GH. It is of mid-brown to red-brown color and its matrix consist mainly of clayey-sandy sediment, with many tiny quartz and feldspar fragments, sometimes also small fragments of mica are visible. The limestones of this GH are mostly clustered on the walls in the western and in the eastern wall of the cave tunnel. Interestingly, this GH contains nearly ten thousand of tiny charcoal fragments (mostly in dimensions of 1 or 2 mm).

In many parts the surface is of this GH is irregular because of many burrows. The sediment of these burrows were attributed to GH 2 (with the note that it is from these burrows). In some parts there are sintered sediment particles to find. These spots are well visible and were noted in the diary (in the future these notes will be integrated into the three-dimensional model of the site, to get further information about its spatial distribution). Often, manganese oxide around smaller limestone fragments (around 2 to 5 cm) is visible, too.

In the upper part of this GH, small channels of roots are visible (diameter of 1 to 3 mm), but none of bigger channel fillings. Micromorphological observations suggest that the sediment of GH 3 was cryoturbated in a small amount, but not in that way that bigger objects like bones and silex were moved (pers. comm. Ch. Miller 2013). In all of the excavated parts of this GH no modern material showed up (in means of Upper Paleolithic artifact or plastic particles).

This GH is of different thickness. On the one hand, the upper surface was reworked by animal activities (which are very obviously visible and good to distinguish). On the other hand, the lower surface was irregular by means of the prior rock collapse. In the interior of the cave tunnel the GH is much thicker than in the excavated part at the recent entrance of the cave tunnel. The whole area under the collapsed rock shelter is un-excavated, but from field observations is seems that it will continue some meters to the North. So the thickness vary around 30 cm to 1 m, because of the explained observations. The former surface (before the modification by burrows) was quite even.
Its color varies slightly from the exterior to the interior (MMC 7.5 YR 4/6; 10 YR 5/8; 10 YR 4/6) but overall, this sediment unit is very homogenous. In some profiles the sediment appears that homogenous that only a brown wall is visible. After water screening, normally, less than a hand full of particles >1 mm is left. This water screening rest (Schlämmrest) contains mostly some small calcite and quartz fragments.
Artifacts in this GH are always horizontally bedded. In the entire excavation (2009 to 2015) only a dozen artifacts stood upright and these were oriented between limestone blocks. This observation suggests that the observed minor cryo- and bioturbation didn't affect the spatial distribution of the artifacts much.

IV.7.13 GH 2

GH 2 is a loose humous, brown sediment, containing material from Middle Paleolithic, Upper Paleolithic, Neolithic, Roman and medieval era, as well as modern material (plastic and metal objects) and covered the entire second rock collapse in the cave tunnel and on the terrace, too. The sediment is highly bioturbated and disturbed, often roots and other botanical material can be seen. The maximum thickness is around 3 m. In the cave tunnel the thickness varies between 5 cm and 1.5 m. On the terrace the mean thickness is around 1 m. Micromorphological observations of samples from 2009 showed that this GH is not stratified and not intact and highly bioturbated (Wißing 2012). As it is also visible in the scattered distribution of artifacts from different ages.

IV.7.14 GH 1

GH 1 is a huge bulk of loose humous, brown sediment, that also contains material from different time periods. In some parts it was obvious that parts derive from animal activities shoveling material out of burrows. It covers nearly the entire site and is highly bioturbated in all parts. It contains many roots, leaves, plastic, wooden logs, and so on. In the cave tunnel its thickness varies from 5 to 40 cm. In some part of the terrace the GH 1 is summarized around 2 meters thick (but that includes the limestones in it) without them (just the sediment) this layer is mostly around 10 cm thick. The differences between GH 1 and 2 are small. It can said that GH 2 contains more small limestone fragments and is often a bit darker. From the observations about the spatiality of the Upper Paleolithic artifacts by Götz (2013) both sediment units are almost completely reworked by animal activities.

IV.7.15 Summary of the stratigraphical sequence

Summarizing the stratigraphical sequence, it can be said that the second rock collapse sealed the Middle Paleolithic occupation and separated the stratigraphy in an upper part (GH 1 and GH 2, mixed sediments) and a lower part (GH 3 to 10) that appears as stratified layers, containing Middle Paleolithic artifacts (GH 3, GH 4x and GH 4) and sterile geological material (GH 5 to 10). A synopsis of the stratigraphy can be seen in tab. 60:

Geological layer (GH)	Status	Yield	Sediment	Thickness
1	Mixed	Modern material, items from the middle ages, upper and middle paleolithic artifacts	Cover soil with many limestones and less humus and throw-off of the badger den (maybe also from the top of the plateau)	Around 10 cm
2	Mixed	Modern material, items from the middle ages, upper and middle paleolithic artifacts	Soil with a big humus content, mostly bigger limestones, limestone blocks of the roof collapse, patches of cave sediments, badger den	20 cm to 3 m
3	Intact	Middle paleolithic artifacts	Mostly aerial soil with a small fluvial component, slightly altered through bio- and cryoturbation, very fine grained	40 to 1 m
4x	Intact	Middle paleolithic artifacts	Mostly aerial soil with a small fluvial component, almost no alteration visible, mid-fine grained	0,5 to 10 cm
4	Intact	Middle paleolithic artifacts	Mostly aerial soil with a small fluvial component, almost no alteration visible, mid-fine grained	10 to 40 cm
5	Intact	Sterile	Dark-brownish soil horizon under the contemporary entrance	5 to 10 cm
6	Intact	Sterile	Yellow weathering horizon of limestones inside the cave	5 to 50 cm
7	Intact	Sterile	Weathered flowstone	Around 10 cm
8	Intact	Sterile	Concreted limestone blocks	Around 70 cm
9	Intact	Possibly another find horizon	Crusts and blocky deposits of limestone (only in a small depth sondage)	Possibly 10 cm

Tab. 60 - Synthetical summary of the geological units and VP II (see also Frick & Floss 2015)

IV.7.16 Synthetical stratigraphy

To display a synthetical stratigraphy is not an easy issue, because of the areas excavated. As clear, the stratigraphical sequence inside the cave tunnel appears different to the excavated areas on the terrace (see fig 70 and 71).

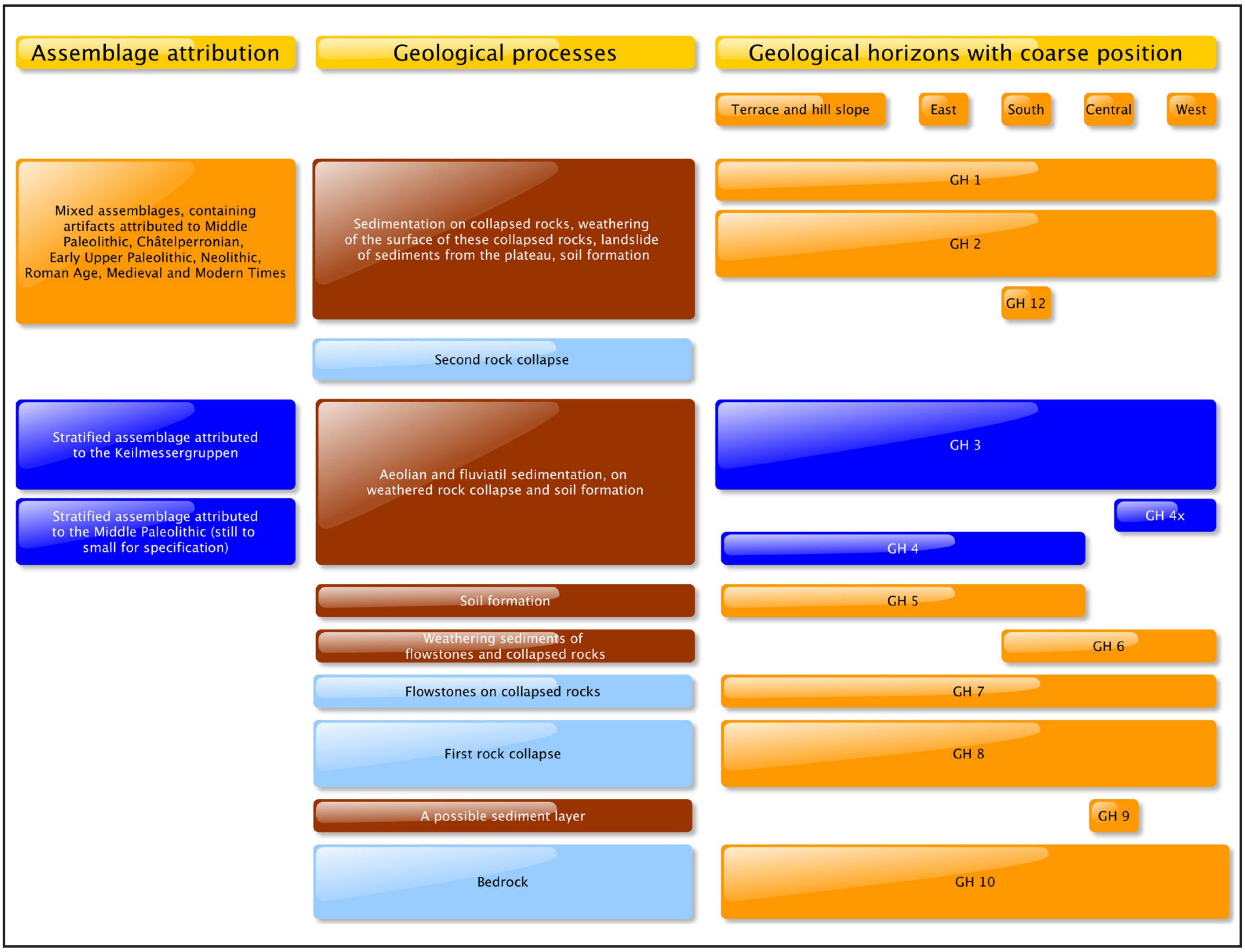

Fig. 70 - Synthetical stratigraphical sequence inside the excavated cave tunnel entrance. Left column - assemblage attribution of sediment units; mid column - short description of geological processes that from the section and right - denomination and coarse position of the geological horizons (displayed also in Frick in press, fig. 2)

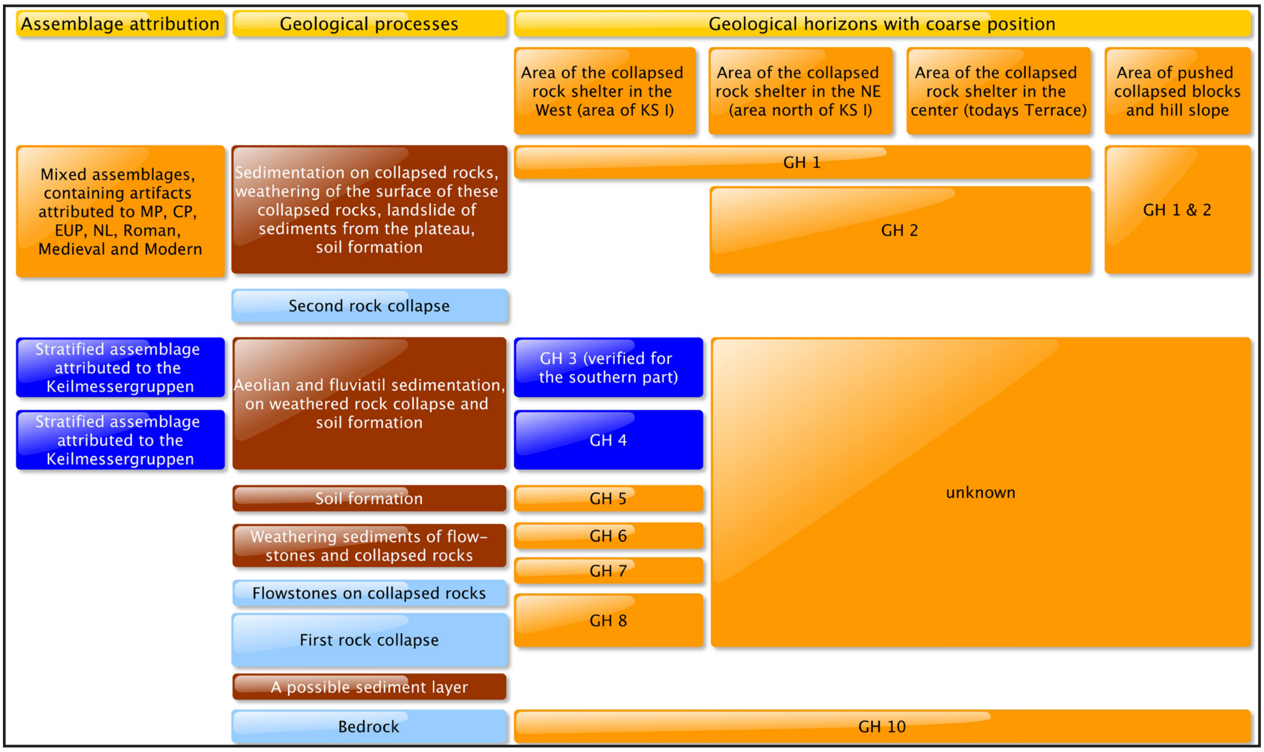

Fig. 71 - Synthetical stratigraphical sequence in the area of the collapsed rock shelter, on the terrace and on the hill slope

IV.8 Geological horizons and their finds, the separation into archeological horizons

This section will summarize the preliminary attempts to divide the archaeological material of (mainly) GH 3 into separate assemblages. Following the observation that a separation of the assemblage (separation into sub-units and maybe archeological horizons) on the base of differences in patination, banding or interior raw-material features is not possible, it was the attempt to see if spatial comparison of different materials show tendencies. The first attempts were presented in April 2015 in Siena on the congress of the CAA (Frick 2015) and are published in the proceedings of this congress (Frick 2016). It evaluates if by plotting two different types of artifact spatial patterns are visible. Obviously, the material of GH 3 seems not to be randomly scattered. Starting with the observation that faunal and lithic material is in its density spatially separated (see also fig. 433). The separation in density is also visible for charcoal fragments and limestone; they are almost mutual exclusive (see also in fig. 434). Burnt and unburned organic matter is separated, too (see fig. 432 for the distribution of all heated objects). Another observation is, that bifacial elements are mainly scattered in the upper part of GH 3 (see also fig. 273 and 281). The observation differs, if the focus is set on distribution inside a single artifact category. For example Levallois objects (here cores, flakes and blades) are quite randomly scattered.

Based on this observations, it can be speculated that there are possibilities for spatial differentiations of the material of GH 3. But yet no adequate method is explored. The evaluation of evidence for a intra-GH separation resulting from this thesis are discussed in chapter X.15

IV.9 Spatial distribution of and inside geological units

IV.9.1 Introduction

This chapter gives an overview to the entire distribution from the distribution of geological units to the distribution of finds inside these geological units. It will show where what find category was found. It will show the distribution of all finds, of different categories and the distribution of the material in its size, as well as descriptions of refittings. As in the section before GH 3 is the main source of information.

The find distribution is displayed with the aid of three-dimensional scatter plots, isosurfaces and volume renders (Voxler™) following the excavation database that contains all measurements, including single-finds, collective finds, findings and topographical measurements. The total distribution is represented in that way that each geological unit and the topographical components like cliff face, collapsed rocks can be distinguished by different symbols or colors (they are explained for each figure).

IV.9.2 Spatial distribution of GH 1 and 2

GH 1 is the topmost sediment unit. Its surface forms the sedimentation hill in front of the cliff face and covers the collapsed rocks of the second rock collapse. It is followed by GH 2, also mixed. The transition of GH 1 to 2 is not always obvious. From the mixed character of these sediment units, a separation of the finds into distinct patterns is not part of this dissertation and will presented elsewhere. Particular objects found in this GH are mostly quite modern material like roman and medieval metal items, neolithic ceramics, but also Upper and Middle Paleolithic artifacts. An example, the following fig. 72 will show the distribution of Upper Paleolithic artifacts of GH 1 and GH 2 above the stratified sediment units. The empty zones inside the distribution of finds from these two GHs represent the huge limestone blocks.

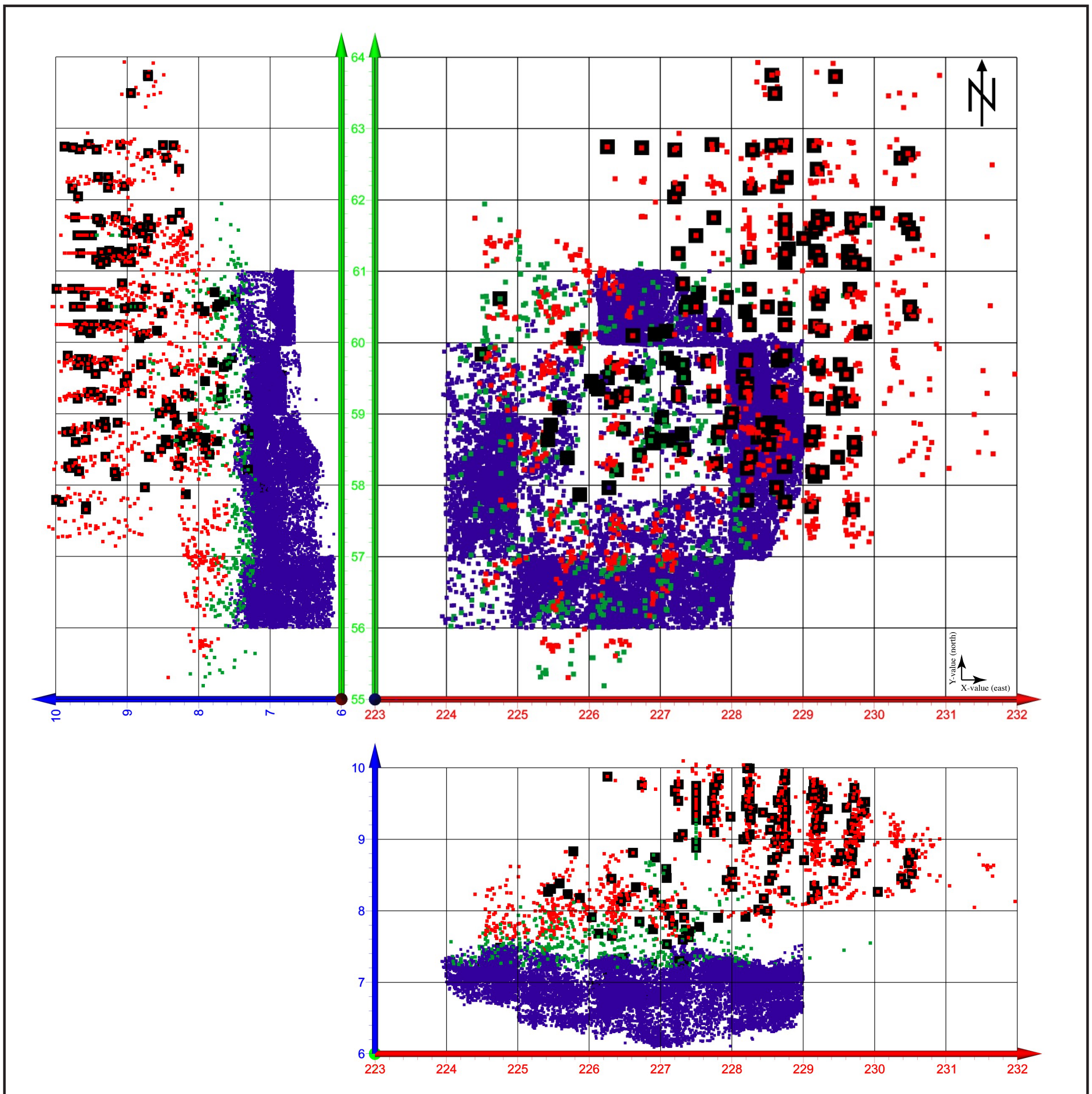

Fig. 72 - Spatial distribution of artifacts attributed to the Upper Paleolithic (between 2006 and 2011, black dots), measurements of GH 1 (red dots), GH 2 (green dots) and GH 3 (blue dots). Note that not all collective finds of GH 1 and 2 of all campaigns are analysed in detail

IV.9.2 Spatial distribution of GH 3

For GH 3 two distributions can be drawn. First the appearance of the GH in the excavated area and second the estimation of its total distribution.

Spatial distribution of GH 3 in the excavated area

Inside the excavated area GH 3 was detected in n=26 square meters (square meters 225-056 to 225-060, 226-056 to 226-061, 227-056 to 227-061, 228-056 to 228-061, 229-058 to 229-061 and 230-058 to 230-059, see also fig. 73). As it is obvious from the profiles, this GH will continue to the South (into the interior of the cave tunnel), to the North (unter the collapsed rock shelter blocks) and to the East (in direction of the hill slope). In the West, the end of the distribution is reached.

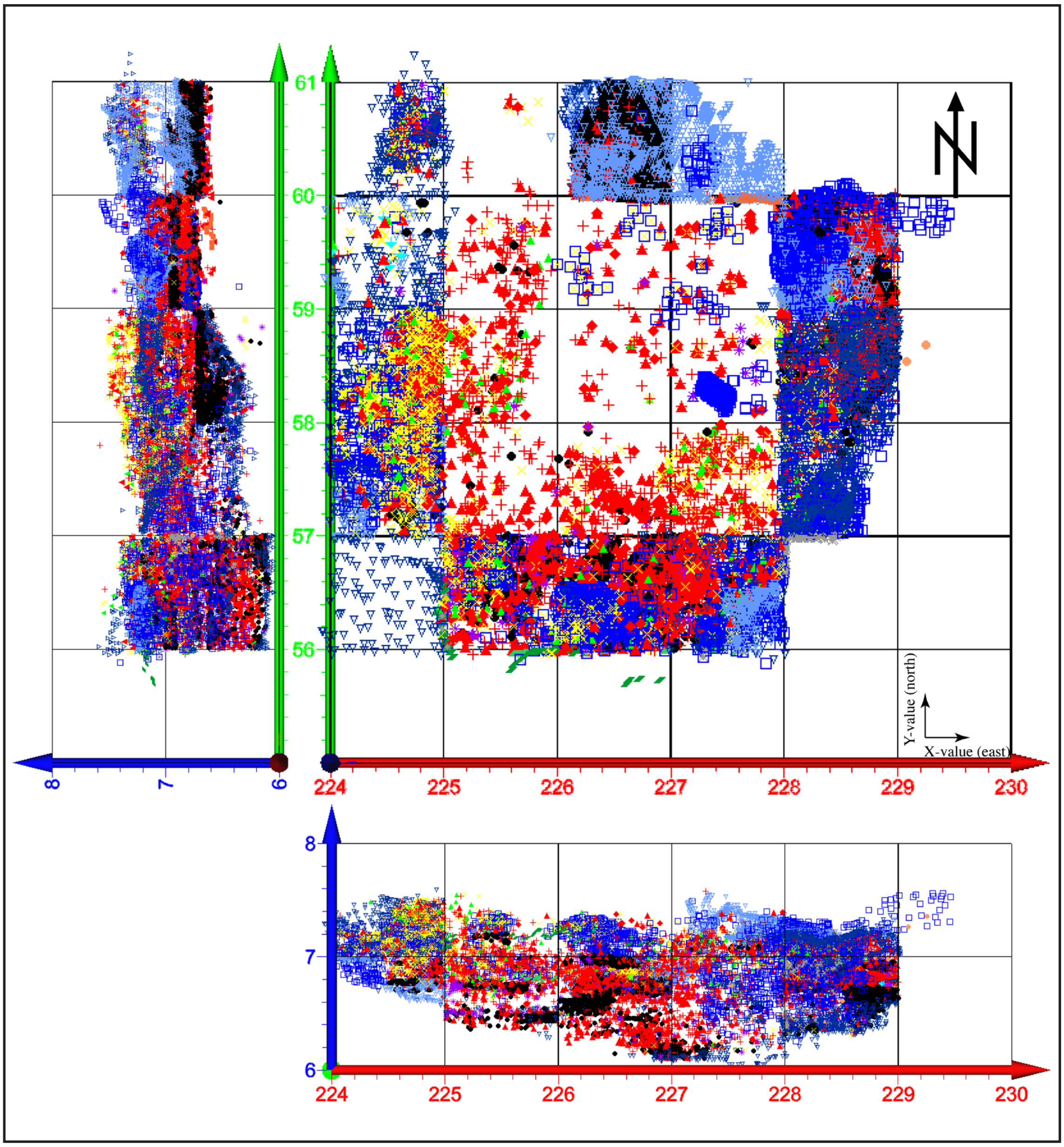

Fig. 73 - Spatial distribution of the excavated parts of GH 3 in top view (top right), view from East to West (top left) and view from South to North (bottom right). Plot displays all measurements attributed to GH 3 in the campaigns 2009 to 2015

Thickness of GH 3 in the excavated area

The thickness of this GH varies (fig. 74 and 75). In the western part of row 225 it is only 20 cm thick, because GH 3 is situated directly on the yellow limestone weathering horizon (GH 6) of the first rock collapse. In the eastern part, especially in row 228 this GH can reach a thickness of nearly 1.6 m.

In two square meters the sediment manipulation of burrows are especially visible. On the one hand, a large corridor was dug around a weathered limestone block in square meter 226-057. The sediment of the burrow and of GH 3 is very good dividable, because the sediment of the burrow is loose, soft, brighter, contains plastic and bright white and soft limestone fragments. Rests of this burrows are left (after the campaign 2015) in square meter 226-056 (the correspondence to the South). On the other hand, in square meter 227-061, in the north of the excavated zone, a big sleeping cave was dug. It affected nearly the complete square meter. Here the sediment of the burrow was much coarser and a mix of roots, bigger limestones, very humous sediments and modern materials. There are another two areas where the burrow affection was very clearly visible. This is the matter in square meter 229-059, where the original surface of GH 3 was affected by irregular channels. Another was visible in square meter 226-059 with a long wound tunnel of around 15 to 20 cm in diameter. For all of these areas the affection of burrows was very clearly visible and the sediment was separated for GH 3. Further research can affiliate the finds from the burrows to GH 3 material, e.g., by refits.

From the very clearly division of sediments of burrows and stratified sediments, this circumstance does not need to affect the discussion about indication of accumulation events inside GH 3 (as we discusses in chapter X.15).

If we exclude the influence of burrows on the thickness of this GH, there are still indications for differences in the thickness. The first is indicated by the first rock collapse that is visible in the western part of the excavation. This rock collapse built a kind of a slope. The predominantly aeolian sediments were quite horizontally accumulated there, from the lowest parts of the collapse to the top. In the same manner, as the surface of the rock collapse submerge into southern and south-eastern direction (interior), the GH 3 gets thicker. The original top edge of GH 3 was quite flat and horizontal. Nowadays, the influence of burrows is visible.

Expected spatial distribution of GH 3 in its totality

The evaluation of the spatial distribution of GH 3 base on different lines of evidence. They are shortly listed in the following and discusses after:

- Excavated volume of GH 3
- Profiles of the excavated area
- GPR surveys
- Test pits

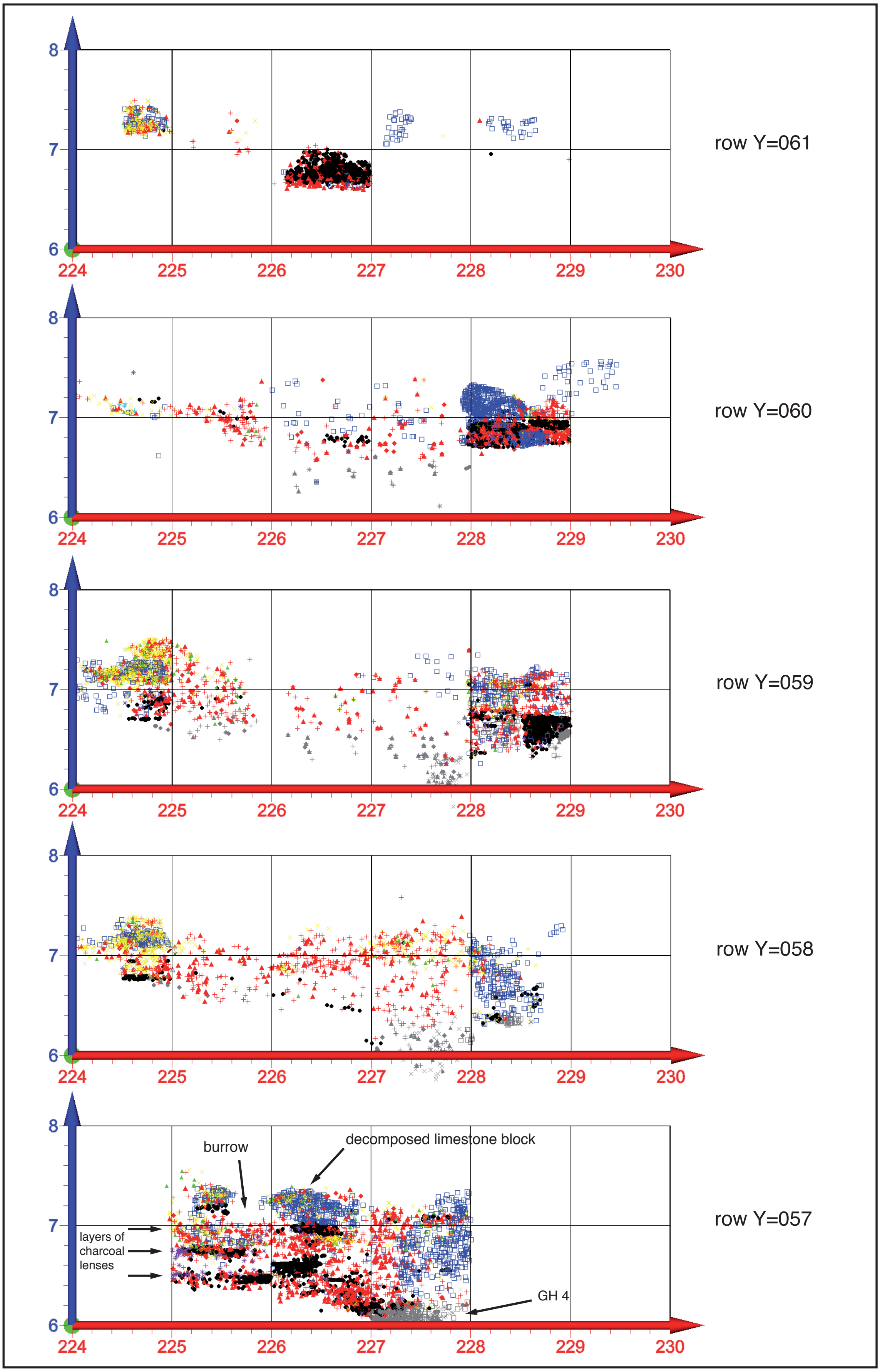

Fig. 74 - Compilation of measurements in square-meter rows Y=057 to Y=061 combining all finds from GH 3 from 2009 to 2015 and showing the differences in thickness (with indications of some reasons)

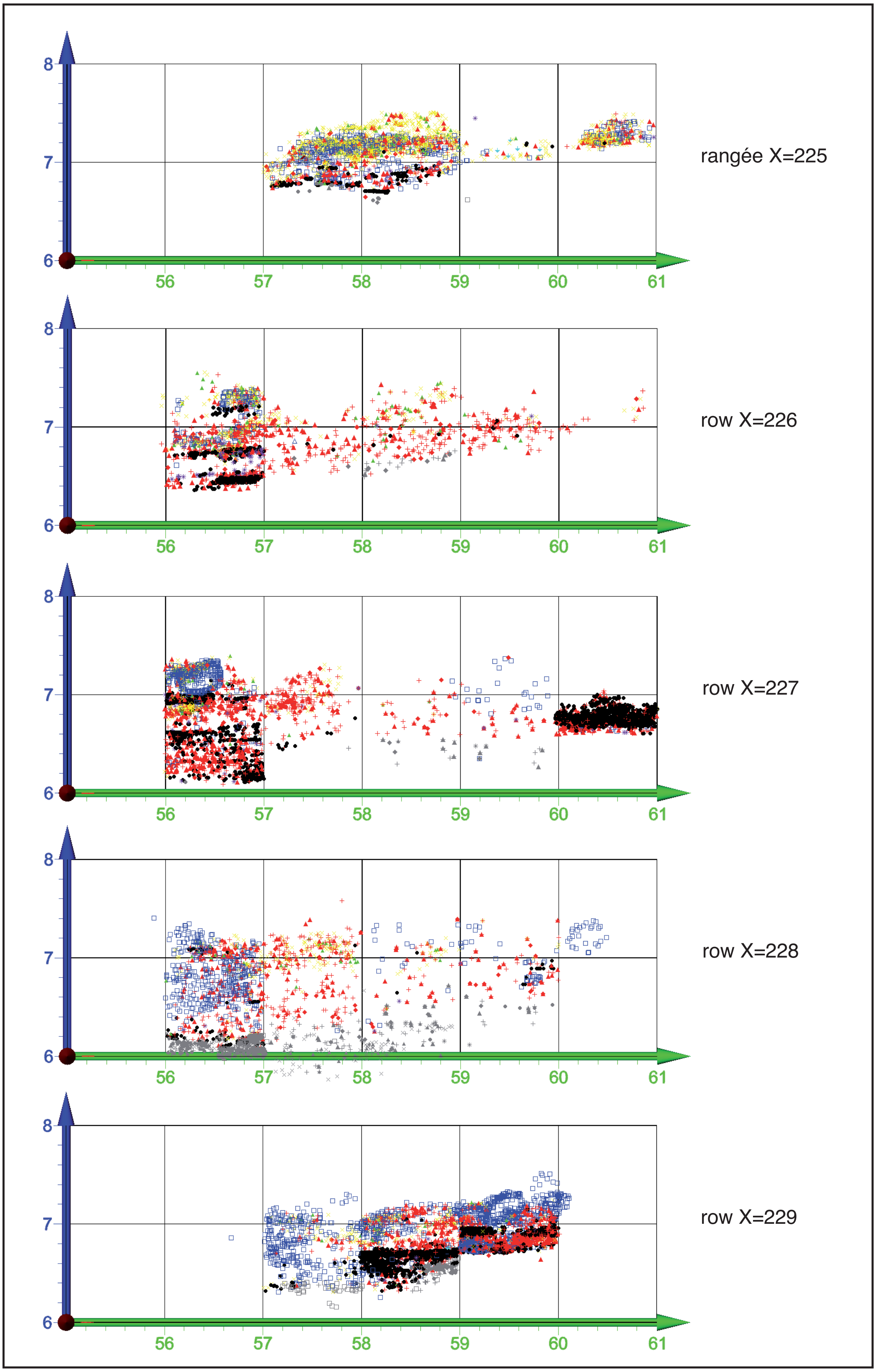

Fig. 75 - Compilation of measurements in square-meter rows X=225 to X=229 combining all finds from GH 3 from 2009 to 2015 and showing the differences in thickness (with indications of some reasons)

At first, the excavated area shows that GH 3 spread all over the area where stratified sediments were excavated (the area of the cave tunnel entrance). GH 3 is present n=26 square meters.
The second reposes on the profile view of the emptied volume of GH 3 and clearly shows that GH 3 continue into the South (into the interior of the cave tunnel), into the Northeast (in direction of the terrace and hill slope) and into northern direction (under the limestone blocks of the second rock collapse). In western direction the cave wall is nearly reached and blocked from the first rock collapse. In southeastern direction, the upright, vertical cave wall is reached.
The third evidence derives from GPR surveys in 2014 (Leach 2014), where GPR track on the plateau and in front of VP II (today's terrace) were taken. The tracks on the terrace indicate that the visible vast limestone blocks (mostly KS IV) bury stratified sediment under and it seems the stratified sediments get thinner in northern direction.
The fourth evidence derive from test pits dug in 2014 and 2015 (one north of the collapsed blocks, one big one along the hill slope and one small test pit to connect both. The test pit in the north of the collapsed blocks show that there the bedrock is not reached and further excavation is necessary (in mixed sediments, to find bedrock or continuing stratified sediments). In 2014 a conglomerate of old (very similarly) weathered bovid bones was found there (in the mixed sediments) and could be an indication for stratified sediments near by. The test pit in the East, on the hill slope demonstrates that the evaluation of the exact situation concerning bedrock and collapsed blocks is not an easy task. At the end of the 2015 campaign it seemed that there is evidence for a step situation in North-South direction, it that way that in the southern part sediments were accumulated in a trap and a limestone step hindered sediments in the northern parts to be accumulated. Only further research (including regular excavation, test pits and geomorphological study and GPR survey) will clear the current situation.
Distributional comparison of finds
The distribution of finds from GH 3 is subject of many chapters (e.g., chapter VII) of this thesis and first attempts are published in Frick (2016).

IV.9.3 Spatial distribution of GH 4x and 4

The spatiality of these both GHs is described in the respective chapter about the lithics of these GHs. GH 4x is a small lenticular spot of distinguishable sediments on the western wall of the cave tunnel (see fig. 76). Rests of this GHs are visible in the witness block in square meter 225-057. GH 4 is situated in the eastern part of the stratified excavation. It stood under excavation in six square meters and continues in northeastern direction (see fig. 77).

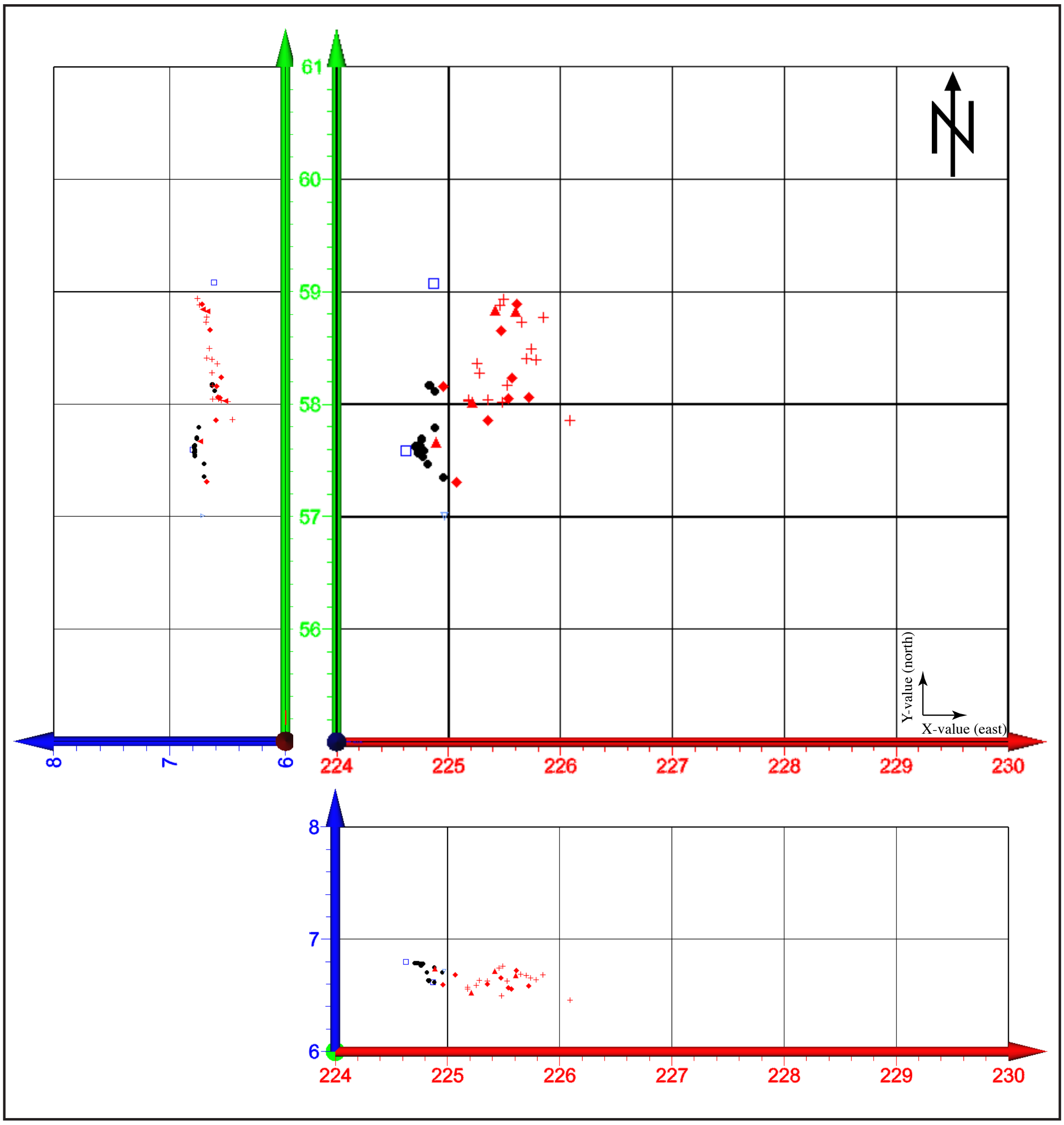

Fig. 76 - Spatial distribution of all measured finds from GH 4x

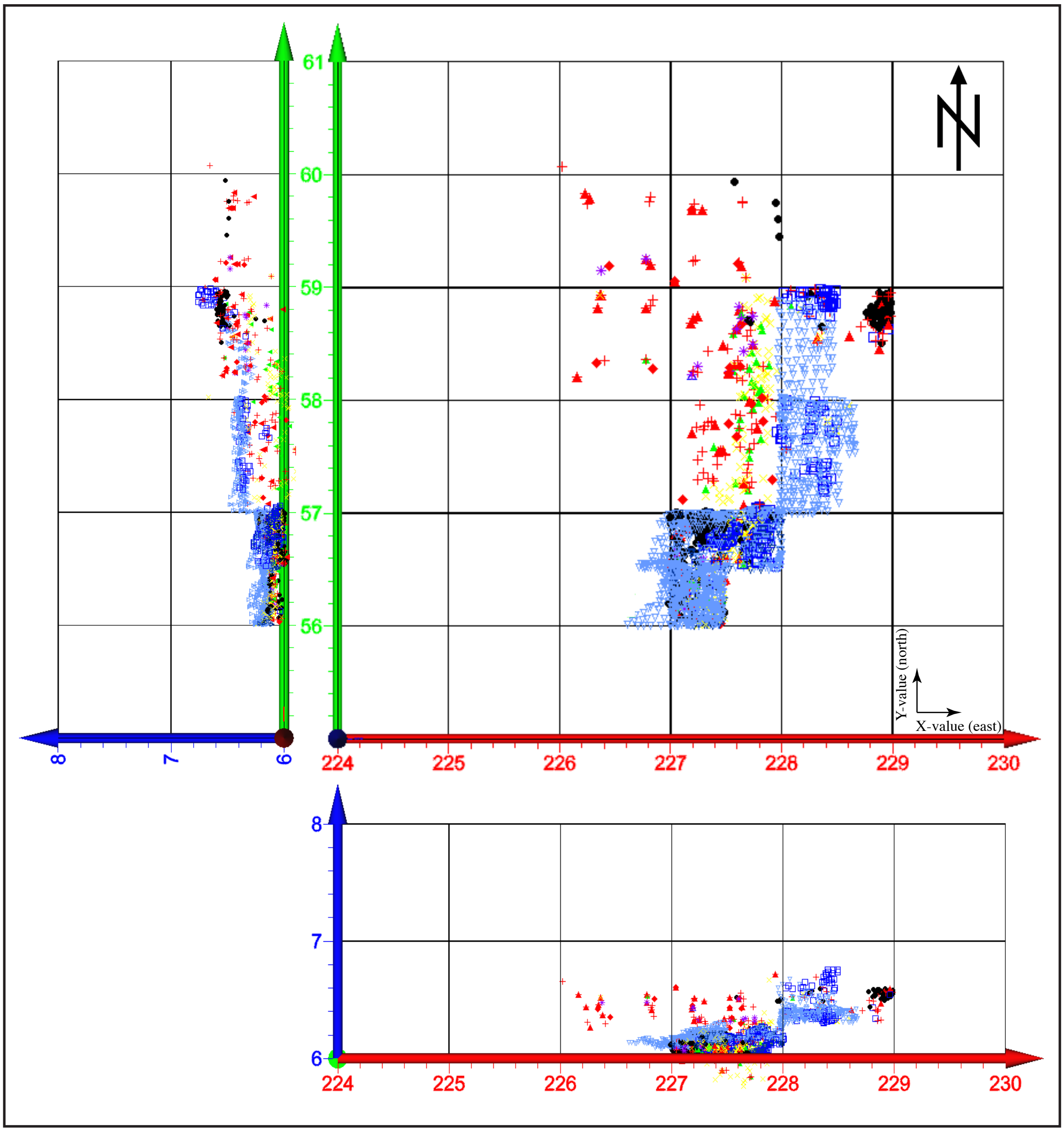

Fig. 77 - Spatial distribution of all measured finds from GH 4

Chapter V: Methodology of litho-technological analyses

„Being an intellectual creates a lot of questions and no answers.“ (Janis Joplin, in Whitney 2005)

V.1 Introduction of methodology

The following chapter illustrates the underlaying methodology of the lithic analysis described in this thesis.

V.1.1 Methodology of lithic data recording

The recording and determination of features of the lithic objects involves different procedures, like manual length measuring with a caliper, optical distinction of features (counting and determination) or virtual measuring inside a computer program (like manual measurement but on digital pictures). Manual and virtual procedures determine physical measurement parameters. Optical procedures including observation with the help of a magnifier (x10), binocular (x30), eScope™ (magnifying webcam) or the naked eye can classify features or quantifies. All collected data are combined in a Microsoft Access™ and pictures (digital photographs and drawings) are processed in an Adobe Lightroom™ data base.

V.1.2 Observation versus measurement

Manual and virtual procedures can be seen as quantitativ data collection because they compare measurements with given benchmarks (e.g., a distinct length of an object is compared through a caliper or a scale) and these measurements are repeatable. The used optical procedures compares characteristics of features within a continuum. They categorize and are seen as qualitative. The classification is not always adequately repeatable by researches. They have to be performed in such a way that they are of minimized subjectivity and are comprehensible by other researchers.

V.1.3 Direct and derived features

Most of the features can be directly recorded using a measurement device, e.g., the direct measurement of the maximum length of a blank. But for some measurements like data collection about angles, a kind of interpolation is necessary. This is the case, e.g., if surfaces are not flat (convex, concave or irregular) or the position to measure is not reachable, such as the original edge angle on a retouched blank. Here, the measurement is performed using length measurements and angle functions. Features that cannot be measured but classified have to be seen as derived features and are subjective (except they are countable) and include a sort of interpretation during data collecting.

V.1.4 Manual, optical and virtual recording of data

Manual recording

We combine the measurement of physical measurement parameters like length or mass as manual recording, because there is a device necessary (which is held in hand) to get the data. The following tab. 61 gives examples of such devices used in this study:

Device	Brand	Measuring error	Measurement	Example
Electronic caliper	DIGI-MET® HP 200mm	0,01 mm	Length in Millimeters	Maximum dimension of a stone tool
Manual goniometer	unknown	1°	Angle (a right angle has 90°)	Interior platform angle between the butt and ventral surface of a blank
Electronic scale	Sartorius® BL 3100	0,1g	Weight in Grams	Mass of a core

Tab. 61 - Devices used for manual data recording

Optical data recording

Optical data recording is not a measurement procedure, it categorize and qualify features. Therefore it needs to be good defined to be repeatable. Counting features (e.g., the negatives on a butt's surface) are repeatable. On the other hand, positioning of features in a continuum is much more vague (e.g., describing the simple geometrical shape of the top view of a lithic piece). A lot of categorization is unavoidable.

As example the fragmentation has bee chosen. If a lithic object is orthogonally broken into two pieces in the mid section and there is the piece left that contains the butt and the bulb it is easy to describe it as a basal fragment (e.g., of a blade, see fig. 78a). It is more difficult if just a tiny part of a tip at a terminal fragment is broken off. Some researcher would classify such a piece as terminal fragment with a small tip fracture, other would classify it as a medial fragment, because it is broken at its terminal and basal end (see fig. 78b). Such differences are mostly unavoidable and not clearly described in the literature.

As described above we use a microscopical (magnifier, and binocular) and macroscopical devices (the naked eye) to record the optical data. The following list gives some examples of optically recorded features:

- Features of the complete piece, like geometrical shape
- Raw material determination
- Fragmentation
- Thermic features
- Finials of blanks
- Number and kind of distinctive surfaces
- Features on surfaces
- Description of the top view and side view
- Number and direction of negatives
- Retouch

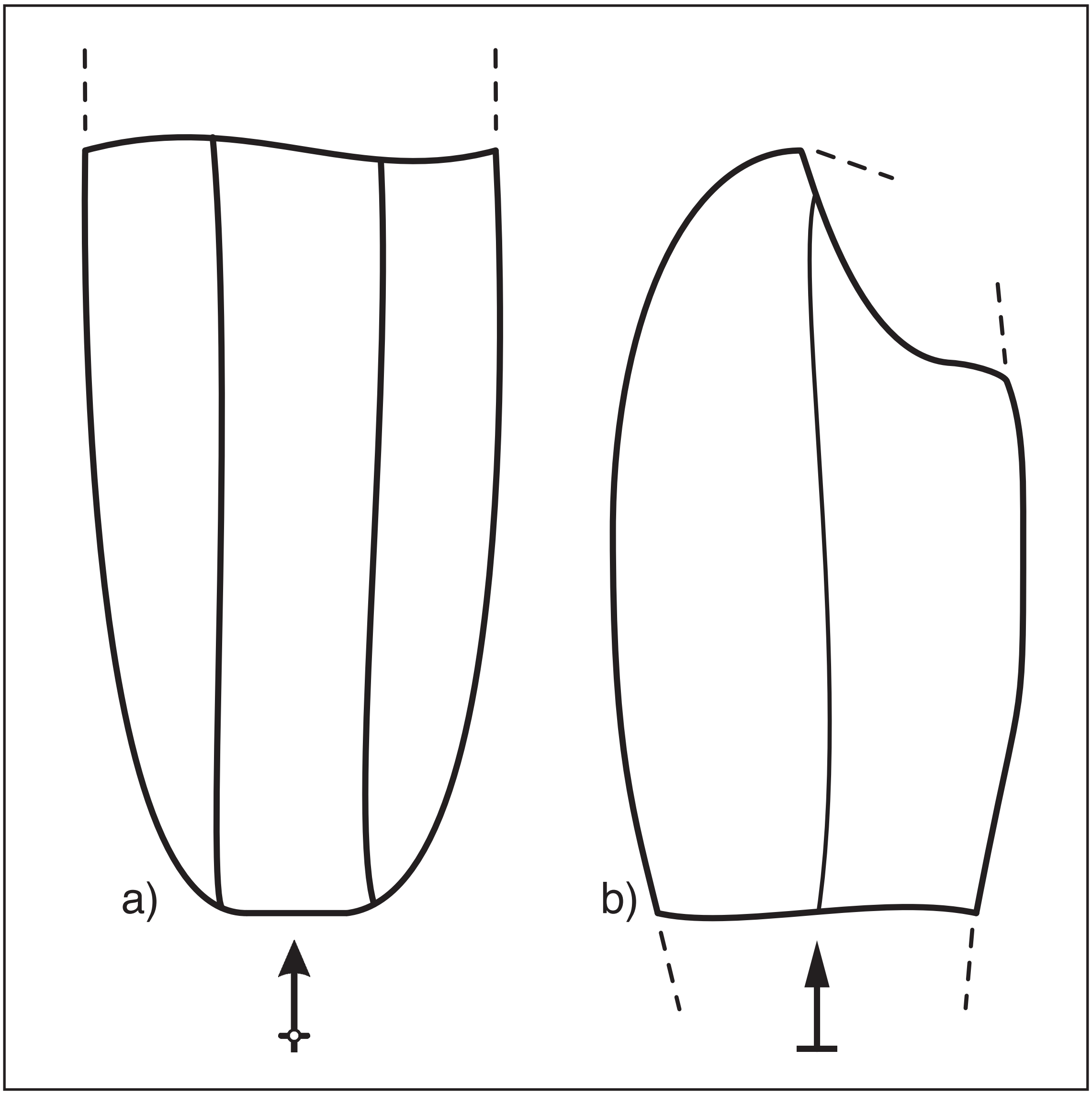

Fig. 78 - Special cases of fragmentation as example for difficulties in optical data recording. 1) Basal fragment of a blade and 2) Medial or terminal fragment (without basal part and tip fracture)

Virtual data recording

Virtual data recording combines image editing (two dimensional) and three-dimensional digital procedures of images and measurement points. Images made with digital cameras (Pentax K200D™, Pentax K-3™ and iPhone 4s™), three-dimensional position data from a Total Station (Leica™ or Sokkia™ Tachymeter with Laptop and WinEDM) and measurements by hand are the base. In the case of lithic objects, the images are processes in Adobe Lightroom™ for white balance and tagging, as well as Adobe PhotoShop ™ and Adobe Illustrator ™ (see also Frick 2010: 127f). Three-dimensional data and manual measurements are processed in a Microsoft Access™ database and displayed using Golden Software Voxler™.

Digital imaging of lithic objects
For an orthogonal image of a lithic object it is of importance that the Object is orientated exactly, particularly if the image is used for measurements. The reference plane is used to orientate the piece horizontally (the reference plane is described later, see chapter V.6.11). For stabilizing lithic objects for taking pictures the following materials were used: grey pillows filled with fine sand, rolled paper, a piece of ceramic (sic!) and a stone with different angles. The background has to provide a good contrast (color and structure) opposite to the piece, therefore gray and black backgrounds were used. Scale, grey card and tripod are of greatest importance and a must. In general, standard techniques of photographing are used to get good images, such as cropping of the picture, adequate lens, avoiding of shaping, control of aperture, time and ISO, as well as day light lamps for illumination. Normally the standard aperture is set to F 20, with ISO 100. Pictures are taken with the aid of an infrared remote control to avoid shaking. After the process of taking pictures they are integrated into Adobe Lightroom™ for white balancing, lens correction and tagging. All files of pictures of lithic object views are named after the find number, such as GER09.225-058.2345 for having the opportunity of rapid retrieval and control of the databases.

V.1.5 Orientation and main axis of lithic objects

In thumbing through the literature it is visible that there are different ways to orientate lithic objects in images. In the US-american literature, normally lithic artifacts are orientated in that way that the knapping direction is downwards. The butt of blanks is ahead, as well as the platform of cores (e.g., Andrefsky 2005). In french and german literature artifacts are normally orientated the other way round (Bordes 1988; Dauvois 1976; Floss 2012b, 2013; Hahn 1992). Blanks are normally oriented along their blow direction of production (platform below and terminal end above). But for some artifact the orientation is often more random, such as bifacial objects or heavily retouched pieces. Often they are oriented that the tip or functional end ist above (e.g., Hahn 1992).
In many works the orientation of artifacts is a mixture of technological and supposed functional orientation (e.g., Debénath & Dibble 1994; Mellars 1996; Roussel 2011). The differences of morphological and functional orientation as well as their interpretation was repeatedly shown and discussed (e.g., Slimak 2004: planche 45).
For comparability of lithic objects beyond traditional type borders it is advisable to orientate, determinate and measure all lithic objects with the help of the same categories. For that reason, the vertical orientation of the maximum dimension of a lithic piece is prevalently used as reference (see fig. 79).

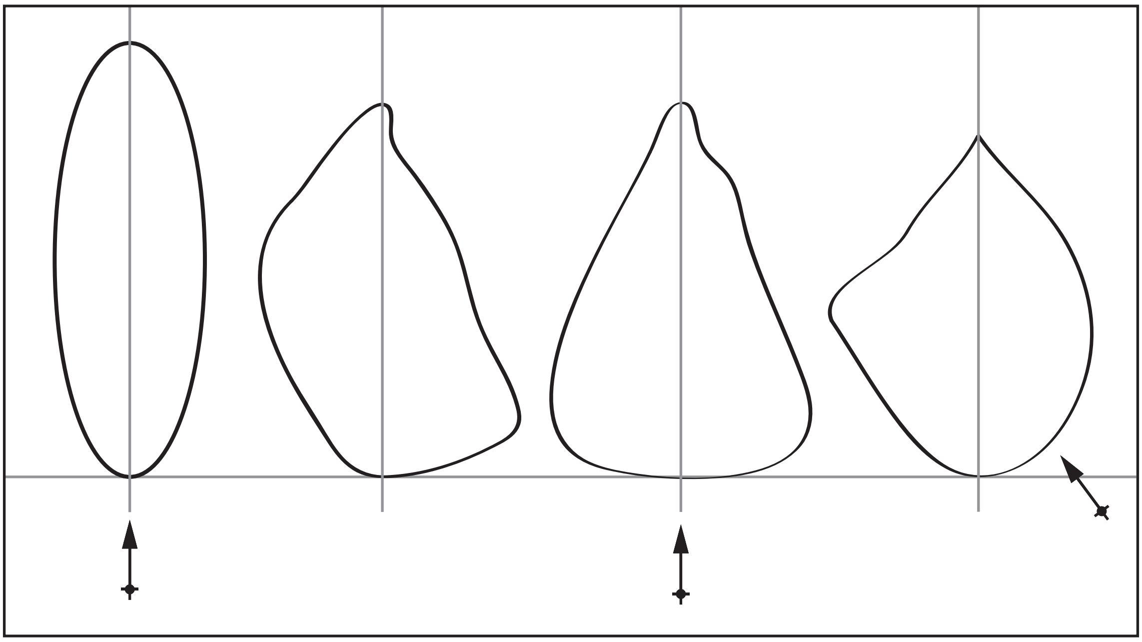

Fig. 79 - Vertical orientation of the maximum dimension as reference for the majority of lithic artifacts

The axis of the maximum dimension is seen as the main axis (of the analysis). We see the following advantage of this orientation:

- Possibility to compare symmetrical features of objects
- The thinner and pointier part of the objects is always ahead
- The thicker and rounder part is always below
- The virtual measurement is easier, faster and standardized
- The measuring of the maximum dimension is the most objective data of all length measurements of a lithic piece
- The greatest advantage of this view is an optimal level of comparison and reproducibility of the results

The orientation along the knapping direction yield the potential that the exact direction is not always angular accurate visible. This is the case, when Wallner lines (Wallner 1939) are badly visible (e.g., because of the raw material) or the Hertzian cone (Hertz 1895) or the bulb of percussion is asymmetrically shaped.

If we orientate blanks in its maximum dimension, there is still the question if core should be also orientated in this way, especially if they yield more than one flaking surface. The orientation (that can be found in the literature) is also very inconsistent. They can be orientated that the knapping platform is downwards, but often cores with a number of knapping platforms are orientated along their maximum dimension (Pastoors 2001; Richter 1997; Van Peer 1992; Weißmüller 1995). Another possibility is the orientation of the direction of the negative of the so called target blank, which can be done upwards or downwards (e.g., Boëda 1994).

For cores with centripetal flaking negatives it is much more difficult to orientate them in a consistent matter. The systematic of orientation is for example for discoidal cores very inconsistent (e.g., Mourre 2003; Peresani 2003; Terradas 2003). For blanks as well as core, we are endeavor to orientated them all along their maximum dimension vertically (see again fig. 79, above).

V.1.6 Metrics and measurement accuracy

Measurements are never absolutely exact and there are deviations for every measurement (Gaussian bell curve). The accuracy depends on the used measuring instrument, the handling of it and the environmental conditions. Systematical measuring errors (e.g., shifted scale) if recognized can be corrected. This is different for random measuring errors (e.g., different pressure on caliper). The only way to minimize such it to train measuring with the specific instrument and to find statistical solutions (e.g., mean or standard deviation).
All measurements in this thesis are done with the help of the International System of Units (SI, *Système international d'unités*). All length measurement are given in millimeter (accuracy of measurement is around 0.1 mm), the mass measurement is given in grams (accuracy of measurement is around 0.1 g) and the angle measurement in degrees (90° is a right angle, with an accuracy of 1°). For manual measurement the following measurement devices are used:

- Electronic caliper (accuracy of 0,01 mm)
- Ruler or scale (accuracy of 1 mm)
- Electronic balance (accuracy of 0,1 g)
- Manual goniometer (accuracy of 1°, arcdegree)

V.1.7 Conventions for drawings and coloration

Introduction

The following section shows the conventions used to illustrate stone artifacts. In addition to digital photography, drawings are of importance to illustrate a big range of aspects related to stone artifacts. The way that is used here, is a combination of different traditional and modern approaches for the display of stones. At the one hand, traditional drawings (Dauvois 1976; Floss 2013; Hahn 1992; Laurent 1985) are used to display the structure of an artifact. These drawings are often completed by diacritical signs using a slightly modified template as Dauvois (1976) introduced it (fig. 80). At the other hand, the succession of removals can be displayed using coloration of negatives and additional signs can display techno-functional units and functionality.

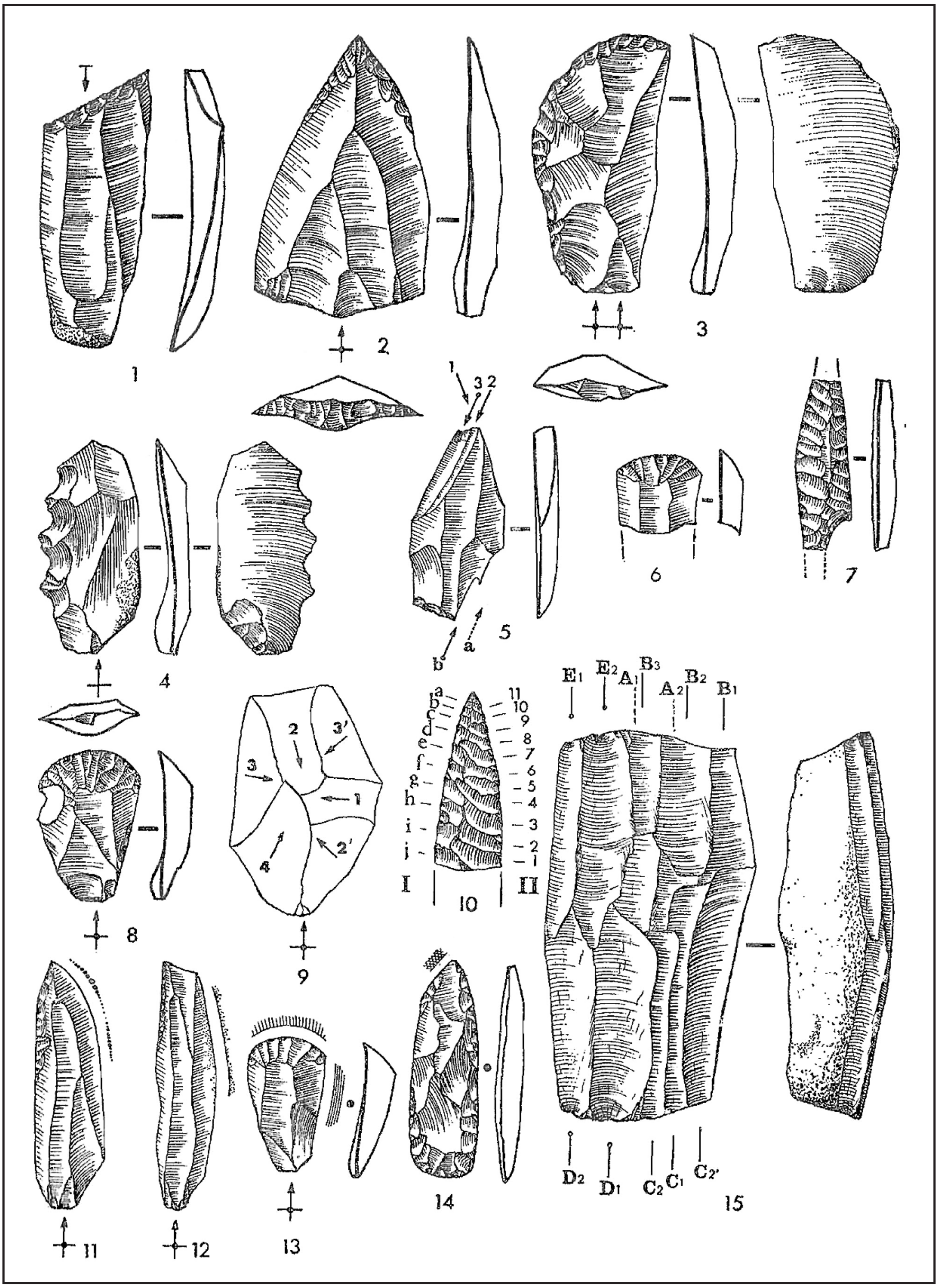

Fig. 80 - Diacritical signs as introduces by Dauvois (1976: 131, fig. 29). 1) Removed butt, direction of blow is known; 2) Butt, point of impact and direction of blow in known; 3) Two point of impact visible; 4) Butt is present but no impact point, the direction of blow is known; 5) Burin blow; 6) Old breaks; 7) Modern break on basal end and ancient break on terminal end; 8) Pseudo-retouch or modern break; 9) Diacritical scheme for negatives; 10) Numbered progression of negatives; 11) Blunted edge; 12) Gloss on edge; 13) Unidirectional abrasion; 14) Multidirectional abrasion and 15) Progression of reduction on a core

Diacritical signs for negatives and blow directions

The signs (arrows) are guided by Dauvois (1976) explanations. The following tab. 62 lists them. In fig. 81 some of them are displayed on a gray-shaded (sucession of working stages) artifact example.

Diacritical sign	Denomination	Explanation
	Simple arrow	Showing the direction of negatives when the basal part is removed or cut-off by other negatives, mostly used on flaking surfaces of cores or on dorsal faces on blanks
	Simple arrow with filled circle as end	Showing the direction of negatives when the basal part is complete, the arrow starts on the origin of the negative Filled circle represent hard hammer Mostly used on flaking surfaces of cores or on dorsal faces on blanks
	Simple arrow with unfilled circle as end	Showing the direction of negatives when the basal part is complete, the arrow starts on the origin of the negative Unfilled circle represent soft hammer Mostly used on flaking surfaces of cores or on dorsal faces on blanks
	Flagged arrow	Showing the direction of edge removals such as burin-blows or tranchet-blows, sometimes it is possible to evaluate the technique, therefore a filled or unfilled circle at the end is added
	Arrow with a crossed end	Showing the blow direction in blank production, the platform is present, but an impact point is not visible (e.g., for soft-hammer percussion)
	Arrow with crossed and filled circle as end	Showing the blow direction in blank production, the platform is present and an impact point is visible Hard-hammer percussion
	Arrow with crossed and unfilled circle as end	Showing the blow direction in Blank production, the platform is present and an impact point is visible Soft-hammer percussion
	Arrow with flat end	Showing the blow direction in blank production, the platform is removed and an impact point in not visible

Tab. 62 - Arrows as used in this work as diacritical signs for negatives and blow directions

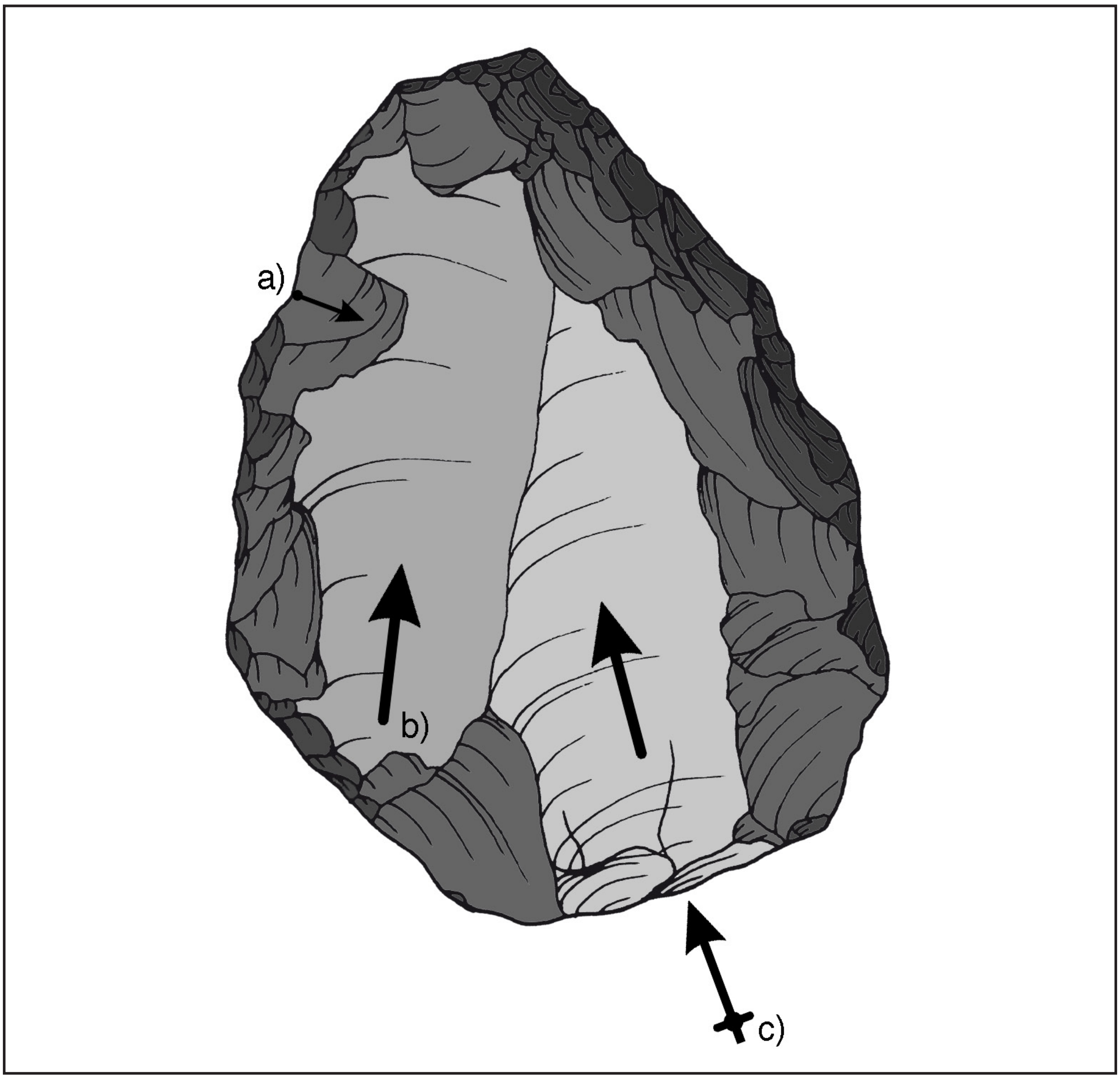

Fig. 81 - Example of the use of diacritical arrows for negatives and blow directions. a) Direction of a negative possessing its bulb negative, b) Direction of a negative that does not possess its bulb negative and c) Blow direction of the blank (possessing the platform and shows the point of percussion (exemplified on GER11.225-059.140 of GH 3)

Production sequence

Production sequences (e.g., on cores) or negative successions (e.g., on bifacial objects) can be displayed using traditional drawings with colorized negatives. We are using gray shades for the illustration. The younger a negative is the darker it is (except for modern damage). The following list displays the used gray shade succession (tab. 63) and fig. 81 displays an example:

Color in RGB-values	Explanation	Additional signature
256/256/256 (white)	Modern and recent damage	
220/220/220 (light gray)	Cortex or cleft	C for cortex and CL for cleft, fissure
200/200/200	First series of negatives	Numbering inside a series if necessary
170/170/170	Second series of negatives	Numbering inside a series if necessary
140/140/140	Third series of negatives	Numbering inside a series if necessary
100/100/100	Fourth series of negatives	Numbering inside a series if necessary
70/70/70	Fifth series of negatives	Numbering inside a series if necessary
50/50/50 (dark gray)	Sixth series of negatives	Numbering inside a series if necessary

Tab. 63 - Color code for production sequences and negative successions

In addition to this scheme, if photographs are used as base, the layer with the gray shaped is lowered to 70% to display the photograph of the artifact.

Signatures of techno-functional units and functionality

For the display of techno-functional units (see Lepot 1993), there are two different ways. At the one hand a separat outline displays the edge sections of these techno-functional units (see Frick & Floss under review-a). On the other hand the surface units can also be colored with a transparency in the drawing of the artifact. The following tab. 64 lists the used color shadings for surfaces (that correspond to the involved volumes):

Denomination	Color shading	Description
Surface of the active volume	Green	Surface of the volume that is confected in that way that it can transform other materials
Surface of the transmitting volume	Orange	Surface of the volume that is confected in that way that it can function as energy transmitter
Surface of the passive volume	White	Surface of the volume that is not suggested to be used and could be removed without changing of the object's functionality
Surface of the grip volume	Red	Surface of the volume that is confected in that way that it can function as a handle
Surface of the hafting volume	Violet	Surface of the volume that is confected in that way that it can function as hafting contact

Tab. 64 - Color shadings for techno-functional units of artifacts

Two examples illustrate these color shading for a production (or reduction) sequence (fig. 82a) and techno-functionality (fig. 82b).

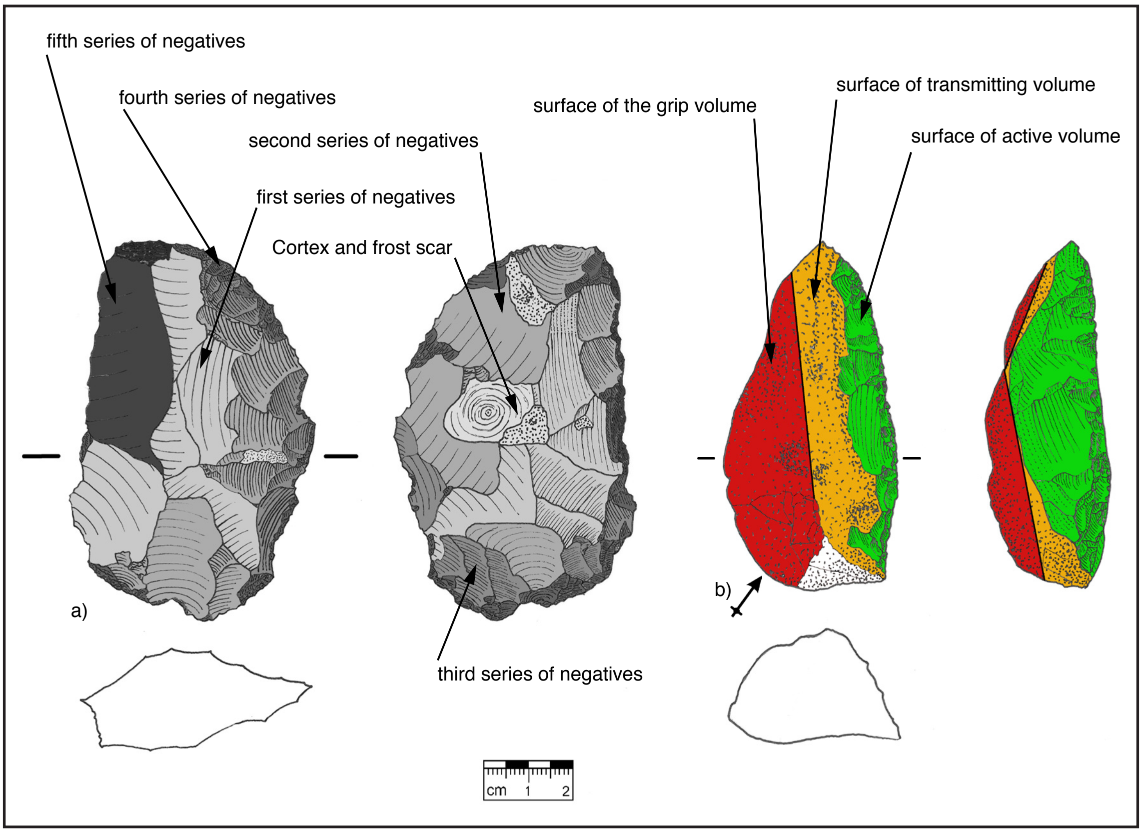

Fig. 82 - Two lithic objects with color shading on surfaces that reflects, a) The reduction sequence of a Keilmesser with tranchet blow (GER12.229-059.428) and b) Techno-functional units (volumes) of a raw-piece cap with side-scraper retouch (GER12.226-057.294)

V.2 Features of lithic objects

Every lithic object can show a range of distinct features, which can be measured or categorized and later compared. The features of a lithic object are separated into four entities:

- Features of the whole object
- Features of a surface of an object
- Features of edges
- Features of edge segments

The aim was to build such a data collection frame that every lithic object can be analyzed with the same criteria to compare them all.

V.2.1 Metrical features

The metrical data collection is done with the help of manual, optical and virtual techniques (see chapter V.1.4, above) and is substantial influenced by the orientation of the lithic object.

Maximum dimension of the whole lithic object (L_{max})

Maximum possible length of the object (see fig. 83). The direction of measurement is seen as the main axis. It is used, e.g., for comparing symmetries or for segmental separation. Normally for this measure a caliper is used, but it is also possible to collect data with specific software.

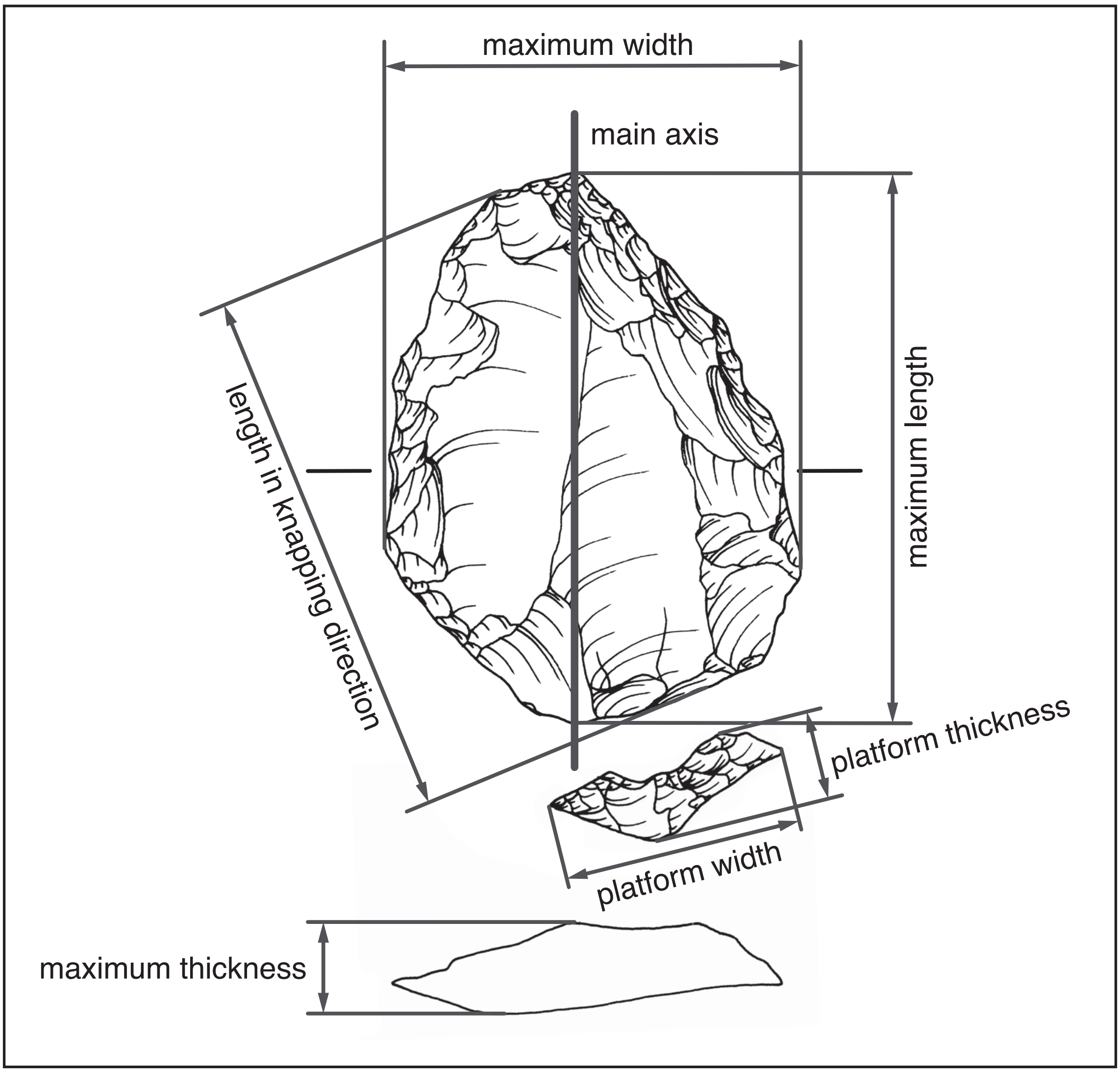

Fig. 83 - Examples of measurements on a lithic object (GER2011.225-059.140)

Width (W_{max}) and thickness (Th_{max}) of the whole lithic object

The maximum width (wmax) is measured orthogonal to the maximum dimension of the object. The width can be also measured at different length divisions (e.g., at 1/2). The thickness is also measured in an orthogonal way to the maximum dimension

Mass (m) of the whole piece

Masses are measured with the help of an electronic scale (Sartorius™ BL 3100), with an accuracy of 0.1 grams.

Width and thickness of butts (blanks) and knapping platforms (cores)

The width of a butt is measured parallel to the reference plane. This plane separates the ventral and dorsal surface of a lithic object (see fig. 83). The thickness is measured orthogonal to the former. For cores, the measurement of the dimensions of knapping platforms is not always easy, because of a high variability of shapes and mostly it is an estimation (the width and thickness measuring is shown in fig. 83).

Exterior and interior angle on butts and knapping platforms

They are measured orthogonal to the reference plane with the aid of a goniometer. The interior angle is measured directly at the Hertzian cone, or if not visible in the middle of the platform. The exterior angle is calipered opposite to the Hertzian cone or the middle of the butt. The exterior angle of a core (or of a specific negative of it) is measured at the position where the cone crack happened or in the middle of the specific negative.

The interior angle of a blank is close to the exterior angle of a core (but not always, because of small spall fractures around the point of impact and along the breakage plane. Reconstruction of the original volume of a lithic object before modification or damage.

Simple geometric calculation can be used to reconstruct the original volume of a lithic objects that was modified at its edges (e.c. via retouch). An early illustration of such calculations is shown in the Index of reduction (IR= [(D) sin (a)]/T) established by Kuhn (1990). He used the length of the retouch negative (D), multiplied that with the sinus of the edge angle (a) and divided by the thickness of the artifact. In the course of research this index was modified (Eren et al. 2005) and discussed (Eren & Prendergast 2008; Eren & Sampson 2009). In this thesis we are using a very similar approach, which are discussed in the following.

A mono phase modification (intentional) or a damage (non-intentional) removes a volume from an edge and can be approximately calculated in the following way:

- $[(\cot \alpha * d2/\ 2) - (\cot \beta * d2/\ 2)] * L_{mod} = V_{lost}$

In this case, $[\cot \alpha * d2/\ 2]$ is equal to the entire area A_{ent} and $[\cot \beta * d2/\ 2]$ is equal to the area A_2. After subtraction of A_2 from A_{ent}, the area A_1 ist left and express the area removed by modification or damage (see fig. 84 and 85). If we multiply this area A_1 with the length L_{part} of the edge segment, we will get the removed Volumen V_{lost} in an approximate sense. For the calculation, two angle measurements (α und β), the hight (d) and the length L_{part} are necessary to measure. For simplification the removed area is seen as a triangle.

If necessary it is possible to add all removed volumes of a lithic object to calculate the entire lost volume.

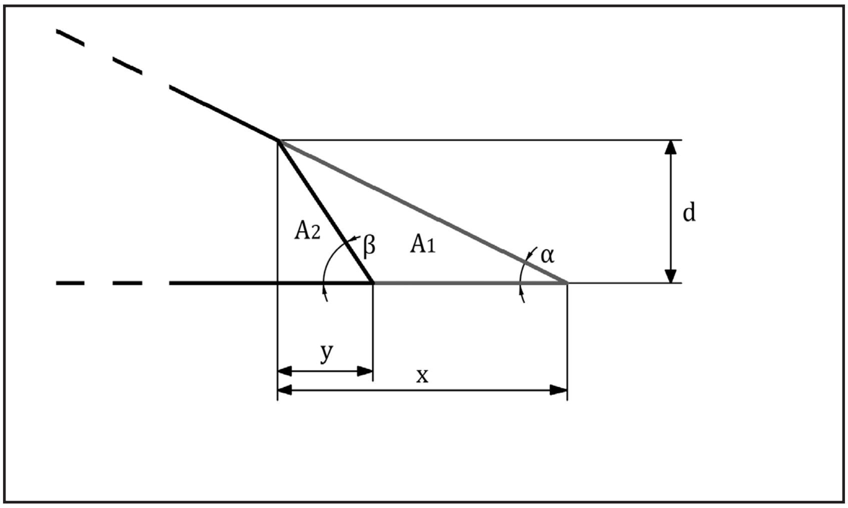

Fig. 84 - Necessary length and angle measurements for calculation the lost volume during modification or damage

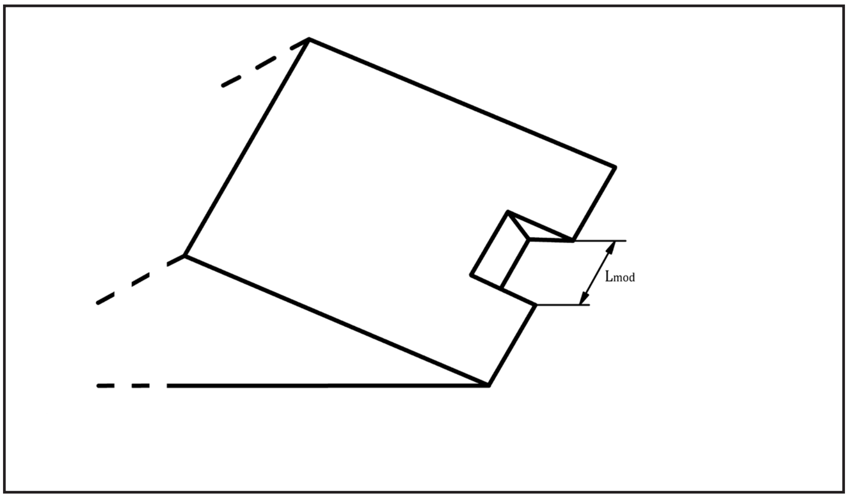

Fig. 85 - Length of a modification or damage

With this procedure it is also possible to calculate multiphase modification if every phase is separately calculated.

V.2.2 Non-metrical features

Non-metrical features are such, which are countable or be part of a continuum. If the data collection is done seriously, they can resample also facts. In case of lithic objects these are features such as raw material, fragmentation or specific morphological features.

Fragmentation

The fragmentation describes which part of a lithic object is present if it is broken. Every lithic object can be present as fragment. It can be fragmented before import, on-site or after the occupation. Numerous processes can fragmentize or damage a lithic object. The following table (non-exhaustive) congregate these (tab. 65):

Kind of fragmentation	Example	Literature
Intentional breakage	Production of segments for lateral glued projectile armatures	Inizan et al. 1995, Inizan et al. 1999, Pétillon et al. 2011, Jennings 2011
Non-intentional trampling	Human trampling inside a camp or trampling of animals on a pathway	McBrearty et al. 1998, Shea and Klenck 1993
Non-intentional rock fall	Collapse of a rock shelter	Nocilla, et al. 2009
Impact breakage	Impacted fracture of projectile armatures	Villa et al., 2009a, Villa and Lenoir 2009, Villa et al. 2009b
Axial breakage (Siret breakage)	Axial splitting of blanks (mostly during production)	Siret 1933, Tsirk, 2010
Micro cracks and fissures	Breakage during production along cracks or frost and heat splitting	Frick et al. 2012
Sedimentation fragmentation	Breakage because of sediment pressure, cryoturbation, solifluction or glacier movement	Thiébaut 2005
Expansion fragmentation	Fragmentation because of heat and frost	Frick et al. 2012, Sieveking & Clayton 2011

Tab. 65 - Kinds of fragmentation of lithic objects

Every educt, blank or product can be intentionally or non-intentionally fragmented. As we know, sometimes it is not easy to find out, if a piece is intentionally or non-intentionally fragmented. We avoid the use of purely anatomical terms like proximal and distal and prefer the terms basal (the base part) and terminal (the part most distant from the base which shows the finial of a blank). If we add left and right lateral to it, we can combine these terms to eight directions or parts of a lithic object in its top view (see for illustration also fig. 86):

- Basal (BAS)
- Terminal (TML)
- Left lateral (l LAT)
- Right lateral (r LAT)
- Left lateral basal (l LAT BAS)
- Left lateral terminal (l LAT TML)
- Right lateral basal (r LAT BAS)
- Right lateral terminal (r LAT TML)
- Medial (MED)
- Complete
- Unknown

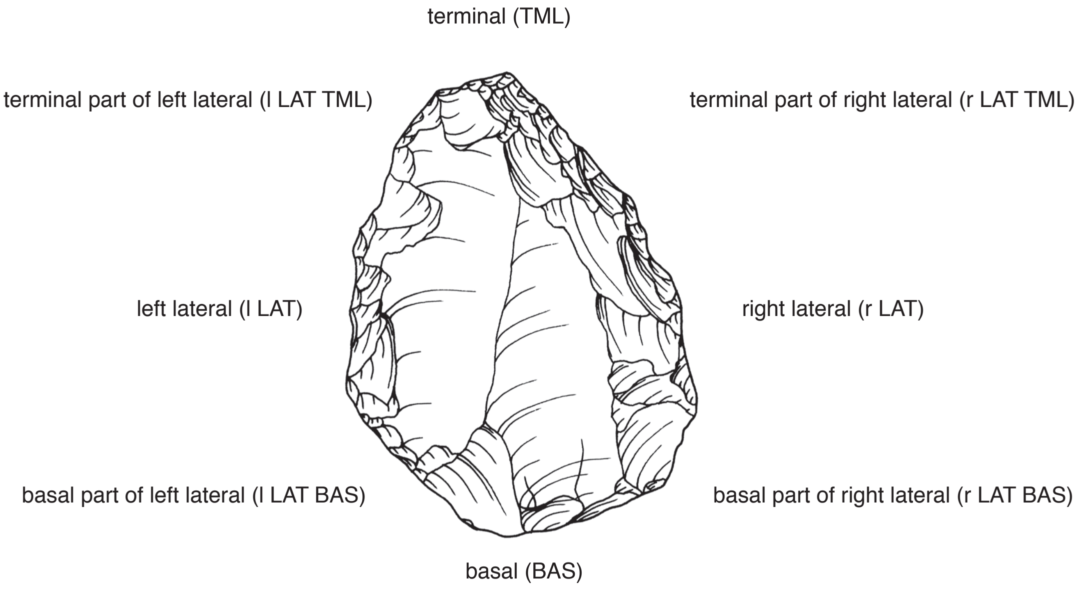

Fig. 86 - Position and direction terms for the top view of lithic objects, exemplified on GER11.225-059.140

If we recognize an intentional modification (on edges or surfaces) like retouch or façonnage we never use the term fragmentation for it.

A basal fragment of a blank has the features of the breakage initialization (like butt, bulb, knapping point, ring crack, bulb scars, etc.). A terminal fragment has the features of the breakage finalization (feathered, step, hinge, inflexed, reflexed or plunging end). Also Wallner lines and Lancet scars cam show such a part. A medial fragment don not show features of a basal or terminal fragment. An axial breakage splits an object into left and right lateral parts (compare with Andrefsky 2005; Floss 2012a; Hahn 1993; Inizan et al. 1995; Inizan et al. 1999).

Heat influence

The influence of high temperatures on lithic objects can leave different traces, mostly a combination of discoloration, fragmentation and gloss. For an overview of traces for heat influence we refer to Frick et al. (2012) were heat influence is shown on fresh lithic from flint from the *argiles à silex*.

Breakage finials of blanks

This category resamples features at the terminal end of a blank (modified or not). For educts this category is used to describe the finials of negatives shown on flaking surfaces. The following breakage finials are described in the literature (Cotterell & Kamminga 1986, 1987; Floss 2012b; Hahn 1993):

- Acute end (feathered)
- Step end
- Hinge end
- Inflexed finial
- Reflexed finial

- Plunging end
- Pseudo-bifurcation finial

The shape of the finial depends of the breakage features of the raw material, the kind of the force influence (technique), as well as the extent and direction of the influenced force.

Quantity and kind of distinctive surfaces

To describe features resembled on a surfer this surface must be defined. In case of lithic objects the following surfaces terms are used (see also Floss 2012b; Hahn 1993; Inizan et al. 1999; Inizan et al. 1995). For cores (made out of a raw piece, not of a blank) we distinct three surfaces:

- Striking platform (surface that receive the blow of detachment)
- Flaking surface (reduction surface, surface a blank is detached)
- Auxiliary surface (surface without direct function in detachment)

Here the term auxiliary surface is added, because this surface can be used to configure the striking platform or the flaking surface, it can differ the morphology of a core or stays untouched (fissure or cortical surface).

A complete blank possesses three surfaces: the **butt**, the **dorsal face** and the **ventral face**. If a blank is broken, it has also a **breakage surface**. For cores and bifacial objects the terms **top side** (the more convex surface on bifacial objects or the main reduction surface on cores) and **bottom side** (the more flat surface on bifacial objects or the opposing surface of the reduction surface of a core) is used.

Symmetries

For simplification we are using symmetrical features only for views not for volumes. By knapping a total reflection symmetry of lithic objects is hardly possible. A possibility to detect and measure symmetry could be to use image processing software, such as *Tomato Analyzer 3.0* (see Heckel 2015) to calculate symmetrical features of views (obovoid, ovoid, vertical symmetry, horizontal symmetry obovoid, horizontal symmetry ovoid, width widest position). For detailed description of the software see Gonzalo et al. (2009) and Rodríguez et al. (2010). The symmetrical features of blanks are collected via looking at the top view (view on the dorsal face), via looking at the side view (view on the right side) and the cross section (view onto the terminal part). For cores the top view is the view onto the flaking surface and the side as well as the cross section view is similar to blanks

But why are symmetrical features important to analyze? Symmetrical features of lithic objects are frequently focused. Often they are used to explain cognitive capabilities (Haidle 2004, 2010; Iovita & McPherron 2011; Machin et al. 2007; Nowell 2000; Saragusti et al. 2005; Wynn 1995). If only functional aspects are regarded, symmetry is e.g. for projectiles of high importance, because normally they stabilize ballistic features of missiles. Such is e.g. visible at the wooden spears of Schöningen (Thieme 1996, 1997, 2007), because they are except of the tip axisymmetric conceived. For composite missiles, we can register different symmetries. At first, nearly the complete missile must be axisymmetric. And second, for the tip of one piece (e.g., Levallois point, bone or antler point) or several pieces (laterally fixed backed lithic pieces) symmetrical features are of importance. Symmetry and surface investigation are used to demonstrate if a lithic object can be considered as part of a projectile. Likewise, impact traces have to slip into discussion of projectiles (Hutchings 2011; Yaroshevich et al. 2013).

Shape of views

With the help of optical extrapolation simple geometrical shapes of every lithic object are given. This was done for the top and side view (longitudinal section), as well as the cross section. For approximation following geometrical basic forms are used: triangle, square, rectangle, ellipse, circle, bow, lenticular, pentagon and hexagon (see fig. 87).

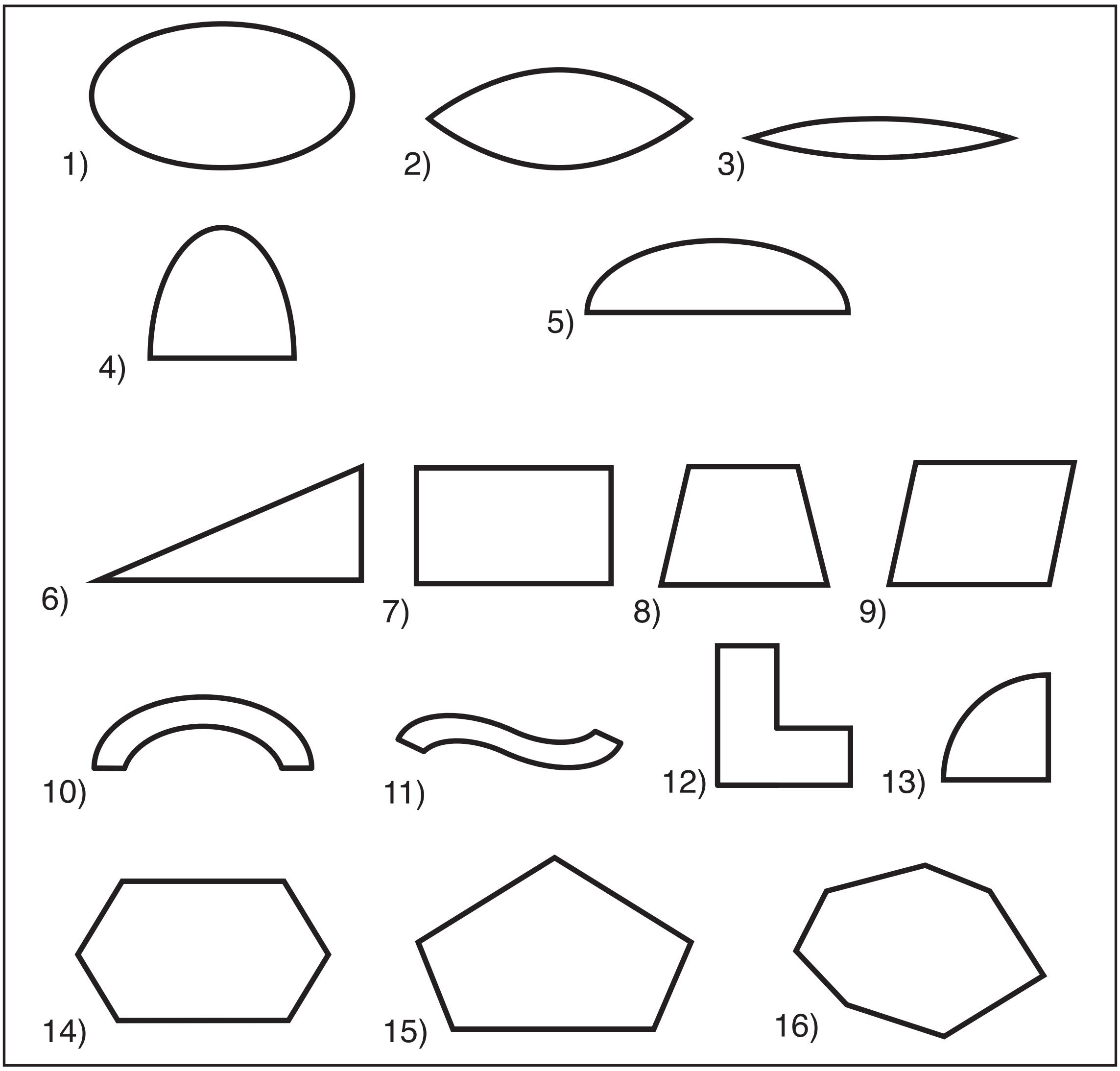

Fig. 87 - Geometrical basic forms used to describe the top and side view, as well as the cross section of lithic objects. 1) Oval; 2) Lenticular; 3) Thin lenticular; 4) Half oval; 5) Plano-convex; 6) Triangle; 7) Rectangular; 8) Trapezoid; 9) Parallelogram; 10) Arc; 11) S-shaped or chapeau de gendarme; 12) L-shaped; 13) quarter of a circle; 14) Hexagonal; 15) Pentagonal and 16) Polygonal

The posed approximation is used to compare morphological, symmetrical and technological features. It was also used to delimitate so called techno-types (Boëda 2013; Frick & Herkert 2014; Koehler 2009, 2011), which can be seen in chapter V.5.8.

Shape of longitudinal section

The determination of the shape of the longitudinal section is equal to the right lateral (or side) view of the main axis (see fig. 87). Here, the thicker end is left (of blanks the base). We use this view also for educts (raw pieces and cores). Products (i.e., mostly blanks) can be straight or bowed (sometimes also twisted) (see also Koehler 2009). Normally blanks are more or less triangular (because of the thicker butt and the feathered terminal end). Cores, however, can have very different geometrical shapes (rhombic, trapezoid, deltoid, conical, etc.). We can expect that paleolithic man integrated the longitudinal sections also in their view and used specific shapes for specific tasks. The following examples demonstrate this necessity:

- Suitability of a lithic object to be used as part of a projectile
- Suitability of a lithic objects to be used to scrape
- Suitability of a lithic object as core to remove specific blanks

If a lithic object is produced with the idea that it can be used as cutting projectile, we would expect that at minimum one edge yields an acute angle. Provided an object is attached terminal to a composite projectile we would expect that the terminal part yields this acute angle or is a tip. For unifacial lithic objects the cross section should be triangular (e.g., Levallois point), for bifacial lithic objects (e.g., leaf point) the cross section should be lenticular or rhomboid. But in the case a lithic object is attached laterally we would expect a very different shape (e.g., that one lateral is acute the other is backed). If a lithic object is thought to be used to scrape or scratch, we would expect that the edge angle of the active part is not very acute (otherwise it would break fast). In the case of using a lithic object as projectile or knife the angle of the active parts needs to be much more acute (Soressi 2002: 62). For transversally and longitudinally used cutting parts the edge angle is of high importance.

For cores the convexity of the flaking surface is of particular importance if blanks with specific shapes should be produced. A good example is a preferential Levallois core. The terminal convexity determine the length of the blank and the shape of the dorsal face (Boëda 1994), in interaction with the exterior angle and the thickness of the butt.

Shape and symmetry of the cross section

We can classify cross sections of lithic objects in their shape and symmetry. A cross section can be symmetrical, left asymmetrical or right symmetrical. For its simple approximation of the shape the same terms are use as for the side view.

Shape of the terminal end

We can also determine the shape of the terminal end from its top view and its side view (see Koehler 2009). We are using the terms pointed, convex, concave, sinusoidal, rectangular, denticulated, plan and nose shaped. This feature characterize the shape of the terminal end and do not describe how the lateral edges match together.

Point of impact

Lithic cleavage products yield normally a specific surface that impacted the energy of splitting and from there the splitting was initialized (knapping platform). A point of impact is only visible if the intruder (e.c. hammerstone or organic billet) is hard enough to print into the knapping platform or if the energy is high enough that the knapping platform shows an area of impression. Normally the impact zone is a ring or circle of cracks (these are the separation lines between compression and strain). Physically, there is no difference, if the intruder or the core is actively moved (Bordes 1988; Pelegrin 2005).

The observed features of impact points in the assemblages of VP II are listed in the following tab. 66:

Feature	Possibilities	Explanation
Position	Right, mid, left	The position of the impact point is approximated from the shape of the butt if no ring crack is visible
Is a ring crack visible?	Yes or no	A ring crack is the best indication for the knapping process (but mostly detectable for hard-hammer techniques)
Number of impact points	From one to four	Up to four impact points are visible (indicated by four ring cracks)

Tab. 66 - Spectrum of impact points as observed in the assemblages of Grotte de la Verpillière II

Shape of knapping platform and butt

Knapping platforms of cores and butts of blanks are described using as well simple geometric shape description. They can be lenticular, D-shaped, triangular, a circle, sinusoid, a bow, a parallelogram, rectangular, a square, with a nose (en éperon), trapezoid, a point or a line. In general, the same geometric figures are used as for the outline of objects (see fig. 87, above).

Number of negatives of knapping platforms and butts

During data collection, we recognized that classical descriptions (Inizan et al. 1995, 1999) of these surfaces are not suitable for the assemblages to study. A good example, here, is a dihedral shaped surface (two negatives are in contact in an angle). As Pelegrin in an interview pointed out (Callahan 1982), it is almost impossible to hit this angle exactly. The blow will always hit more or less onto one of these two surfaces. Actually, therefore only one of these surfaces is the knapping platform and parts will build the butt of the blank. Also it was visible that the so called faceting is not regular. At first sight, it looks like that these surfaces are only facetted if some uneven parts are there. We decided therefore to count the negative and if there is cortex or not.

Shape of the lateral edge in the top and side view

The shape of lateral edges are described in its top and side view (similar to Koehler 2009). The plan of the circumferential lateral edge is equal to the reference plane (Referenzebene, see Frick 2010). The concept of reference plane is extensively described in chapter V.6.11. It can be used for cores and blanks as well.

Viewed from the top a lateral edge can be straight, concave, convex or sinusoid. Also the terms straight-kinked (two straight parts), concave-kinked (two concave parts) and convex-kinked (two convex parts) as well as denticulated and notched are used. Also lateral edges can be described in their relation to each other (parallel, nearly parallel, konvergent, convergent-D-shaped, divergent and divergent-konvergent).

By a view from the side mostly the same terms are used (straight, concave, convex, sinusoid, straight-kinked, concave-kinked and convex-kinked). The interesting thing here, is the possibility to observe edge treatment. This fact is good to illustrate for bifacial elements. Typically, an Acheulian biface shows a sinusoid circumferential lateral edge, because after every removal from the surfaces the bifaces is turned around to remove the next correction blank (see Goren-Inbar & Sharon 2006). Another possibility is to finish the edges of a bifacial element by finishing first one surface and then the other. In this case, the edge will be very regular and straight, what we call „alternating unidirectional edge modification" (wechselseitig-gleichgerichtete Kantenbearbeitung, after Bosinski 1967). Weißmüller (1995: 201, fig. 37) showed this kind of edge treatment in an illustrative manner, which we extended and modified (see also fig. 88).

Cross section of edges

We use this term to describe the relation of surfaces meeting each other at edges. For blanks, e.g., this can be done for both lateral edges and the terminal part, too. The terms are dyadic. The first part describes the shape of the dorsal face (or the upper face), the second part describes the shape of the ventral face (or the lower face). Possibilities are as followed: straight-straight, convex-straight, concave-straight, convex-convex, concave-concave, convex-concave and concave-convex (see fig. 89).

Polarity, directionality and vergence

In many cases, the terms polar and directional are used synonymously. To beware confusion, we suggest a distinction of these terms. The term polar ist used to describe the number of force effect directions. For example bipolar knapping, the force is introduced in two points (the hammerstone and the anvil). Normal knapping can be seen as uni-polar, because the main force is introduced using one hammer (if we are correct the holding hand also reflects the energy and introduce force into the knapped object). The term directional is used for the direction of negatives on reduction surfaces. For example on a Levallois core, the direction of the negatives suggest a bidirectional reduction of the core. The third term, vergence describe the constellation of negatives on reduction surfaces. For example if they differ less than 90° the constellation is called convergent. The following list simply shows the use of the terms:

- Uni-polar, bi-polar, tri-polar, multi-polar
- Uni-directional, bi-directional, multi-directional
- Convergent, divergent, orthogonal, centripetal

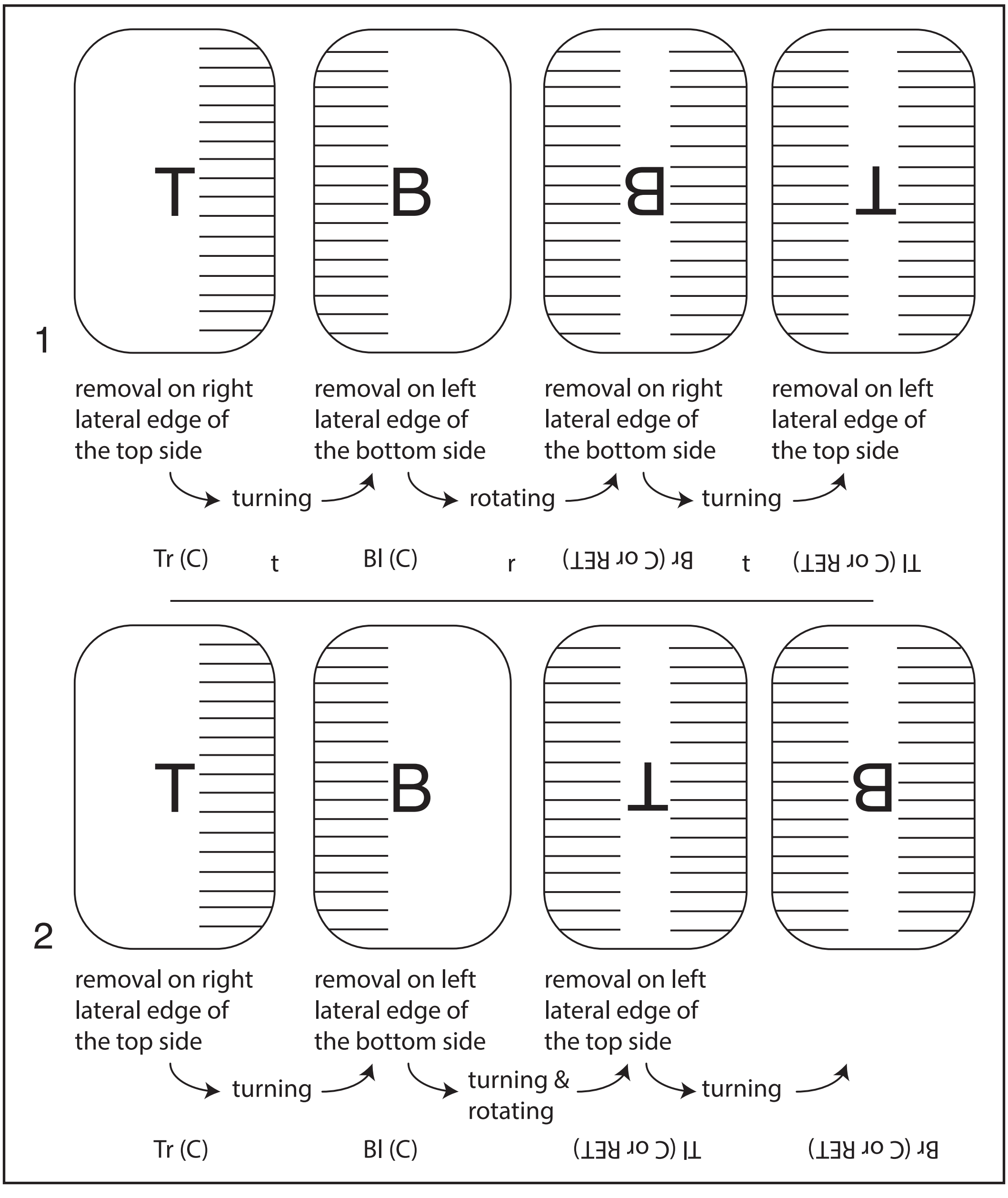

Fig. 88 - Production of a knife-like cutting edge on bifacial objects, adapted from Weißmüller (1995: 201, fig. 37), extended and modified

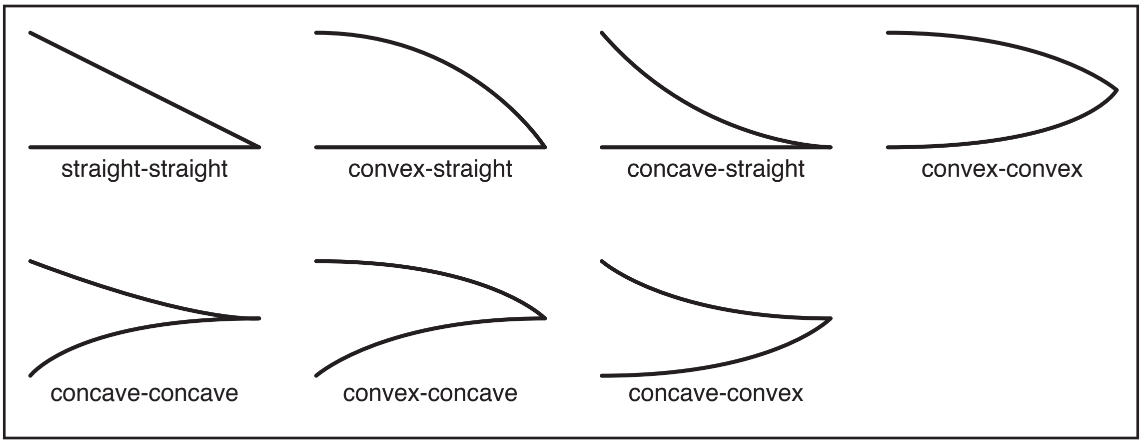

Fig. 89 - Shape possibilities for the cross section of edges

V.2.3 Modification and damage

Modification

In a general sense, we are using the term modification for all kind of alteration of educts (raw pieces and cores) as well as products (blanks, blank-cores,…). First, we differentiate two variations of modification:

- Modification 1 (modification of a surface)
- Modification 2 (modification of an edge)

In a coarse separation, a modification can be intentionally made by man (e.g., attaching a retouch) or can be natural (e.g., movement in sediment). But there are much more possibilities for alteration of a piece (these are described later).

Normally, an edge modification before a surface modification is invisible, because mostly a surface modification removes it, therefore the surface modification is entitled as modification 1.

Modification 1 or Shape refactoring

Shape refactoring combines all kinds of modification that influence a surface of a piece (normally the edge are also influenced). In a literature review the following terms are found:

- *Façonnage* (Boëda et al. 1990; Inizan et al. 1995, 1999)
- *Flächenbearbeitung* and *Verdünnung* (Pastoors 2001)
- *Formüberarbeitung* (Richter 1997)
- Bifacial thinning and shaping (Callahan 1979)

But if we are particular about the modification of a surface, we have to add actions like the removal of blanks from blanks (Frick 2013), the modification of a core's surface after removal of blanks and so on. The idea of shape overprinting is also used for the formation of bifacial pieces (Boëda et al. 1990). The following list shows how bifacial production can be structured (Nicoud 2013):

- *Piece bifacial-support d'outil* (biface used as a blank for a tool) - shaping of the whole bifacial element to produce a blank for further use or modification, normally in the Acheulian the shaping stopped here

- *Pièce bifacial-outil* (biface as tool) - subsequent modification of a bifacial object, normally applied in the Middle Paleolithic
- *Support à enlèvement bifacial* (pebble with bifacial removals) - shaping of a pebble with removals on both sides

The first two bifacial concepts can also be seen as following steps in a *chaîne opératoire*, because every bifacial objects need to be decorticated, shaped and finished (see Callahan 1979).

The concept of shape refactoring (*Formüberarbeitung*) can be used for bifacial, but also for unifacial refactored objects, which was proposed by Richter (1997). In this work, we are following this approach, because in this case every modification of a surface can be described. An illustrative example is the shaping of unifacially worked leaf points of the so called Lincombanian-Ranisian-Jerzmanowician (Flas 2002, 2008, 2011), or northern *Blattspitzen* complex (Bolus 2004). But also multiphase retouch of unifacial objects (change of the shape by intensive retouch) can be described. The modification 1 massively modifies cross section and overall shape of the whole lithic object.

To avoid confusion, terms for surface-shape denomination must be clear. Our approach is to have a good descriptive separation of cross-section shape for one surface and for both surfaces (of a biface, for example). We are using for example the term plano-convex for the structure of two surfaces to each other (one surface is plane and the other is convex) and plane-to-convex for the shape of one surface itself (as it is illustrated in fig. 90). These definitions are also used in Frick & Floss (in press).

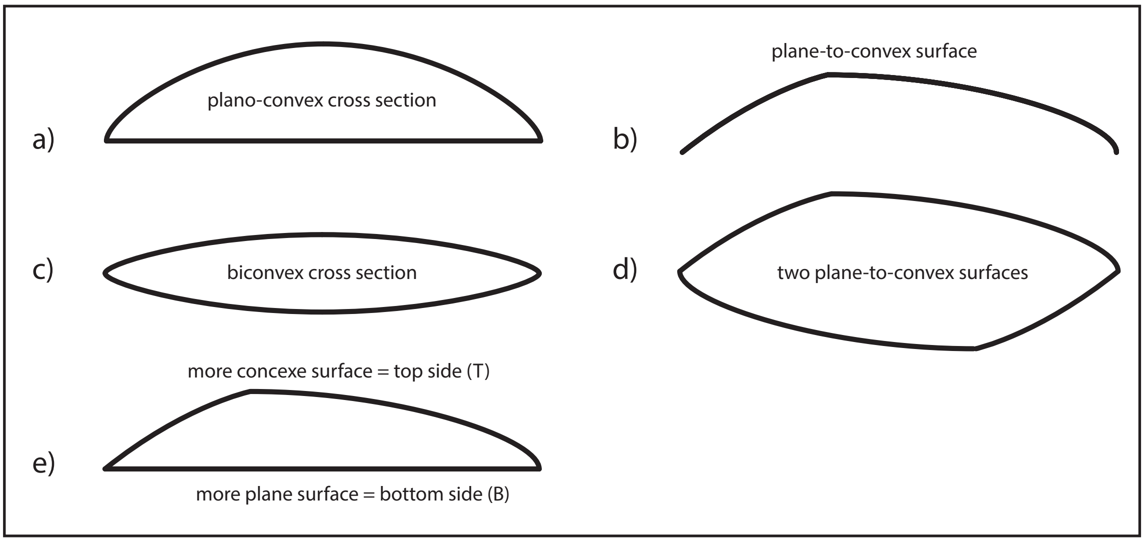

Fig. 90 - Plano-convex cross section and plane-to-convex surface on bifaces seen in their cross section. a) A plane and a convex surfaces building a plano-convex cross section; b) A plane-to-convex surface in cross section; c) Two convex surfaces building a biconvex cross section; d) Two plane-to-convex surfaces in cross section and e) The more convex surface is called top side (T) and the more plane surface is called bottom side (B)

Modification 2 or edge alteration

Every alteration of edges is called modification 2. An intentional modification of an edge could be a retouch (which is orthogonal to the edge) or it can be along the edge (e.g., a burin). Also unintentional but man-made modification like impact traces or natural traces (e.g., trampling, sediment movement) are integrated here. To give an overview of possibilities of edge alterations, please consult the following list (not exhaustive):

- Evenly, regularly running modifications (intentional retouch), which can also effect the surface (Bordes 1988; Brézillon 1971; Floss 2013b; Inizan et al. 1995, 1999)
- One or more negatives running along an edge and from specific edges (e.g., burin and para-burin blows) to produce active edges or are the leftover of blank removals (Frick 2013; Jöris 2006; Knecht 1988; Tomáŝková 2005)
- Regularly or irregularly, continuously or interrupted modification because of hafting (e.g., Rots 2008, 2009, 2010)
- Regularly or irregularly, continuously or interrupted modification caused by trampling (e.g., McBrearty et al. 1998; McPherron et al. 2014; Nielsen 1991; Pargeter 2011)
- Regularly or irregularly, continuously or interrupted modification caused by use (Cesaro & Lemorini 2011; Hardy 2009; Moncel et al. 2014; Pawlik 1995)
- Regularly or irregularly, continuously or interrupted modification caused by sediment movement (O'Brien 2006)
- Intentional abrasion (rounding and deburring, etc.) of an edge for stabilization and preparation of the exterior platform angle or as blunting of an edge (Sheets 1973; Tringham et al. 1974)
- Subsequent or rezent edge damage during and after the excavation, so called Grabungs- und Museumsretusche (see also Hahn 1993)

There are specific characteristics that can be collected (shape and position) and can aid the division of edge parts. The following list is collected from different publications (Bordes 1988; Floss 2012b; Frick 2010; Hahn 1993; Inizan et al. 1995; Inizan et al. 1999):

- Position of the edge modification (direct - dorsal or upper position; invers - ventral or lower position, alternated, alternating or bifacial)
- Impact of edge modification (e.g., re-shift of an edge with the same angle, re-shift of an edge with a different angle, regulation of an edge part, producing a notch or denticulate, steepening or reduction of an edge angle)
- Kind of edge modification (scaled, stepped, sub-parallel or parallel)
- Invasive direction - do the negative run orthogonal (retouch) or parallel to the edge (burin and para-burin)?

- Multiphase modification - how often was the edge part modified?

There is always a problem with negatives. It is not always clear, wether a negative is produced to modify an edge (retouch) or to remove a blank (core), which is used for other purposed. Classical cases are burins (Tomáŝková 2005) or para-burins (Jöris 2006). A burin spall can be seen as waste if only the burin tip was necessary as active edge and the spall was just removed to get a sharp edge. But these spalls can also be used as blanks with specific morphology. This may also be the case for blanks used as cores and there removals, e.g., for truncated-faceted pieces (Frick 2013)

Damages

Damages (mostly on edges) are at first part of the modification 2. In this case we would define them as processes during and after the discard of pieces. Often they occur during deposition and movement (e.g., cryoturbation, solifluction or rock fall) or during and after excavation (excavation or storage damage, Hahn 1993). With the help of confusion by analogy it is possible to divide use-wear from taphonomic damage.

V.2.4 Morphometrical analysis of the outline

Since the late 1970s geometric-morphometric analyses are highly spread in different disciplines. They are used to describe outlines of e.g. leaves (Jensen et al. 2002; Torres et al. 2009), teeth (Benazzi et al. 2012; Bernal 2007), bones (Senut 1981) or medical pictures (Bookstein 1997). But such methods are also used to describe the outlines of lithic objects (e.g., Buchanan & Collard 2010; Buchanan et al. 2012; Eren & Lycett 2012; Iovita 2011; Iovita & McPherron 2011; Lycett et al. 2010). Two approaches are used (sometimes also combined). At the one hand, a mathematical counted curve (e.g., elliptical Fourier analysis). At the other hand, defining specific positions with landmarks are used (e.g., geometric morphometric analysis). Lately, digital pictures of e.g. top views of artifacts can be used to count outlines and specific measurements. An outstanding way was described by Heckel (2015). By using the program Tomato Analyzer 3.0 (Gonzalo et al. 2009) Heckel was able to get a vast variety of dimensional data (lengths, angles, area, etc.) for personal ornaments of the early Upper Paleolithic.

In this work we are using another (quite simple) approach, because of the vast amount of analysed objects. In a similar way as Koehler (2009), we are using simplified morpho-geometric shapes to describe cores and blanks.

V.2.5 Working stage analysis (WSA)

The analysis of working stages are an established way to make production stages visible. The aim is to interpret clusters of interconnected negatives on artifacts as so called working stages (Pastoors 2000; Pastoors & Schäfer 1999; Pastoors et al. 2015; Richter 1997, 2001). Or in other words, a working stage represent a negative or a succession of negatives that are interpreted as being contemporaneous produced. The detected working stages are ordered chronological. To display these clusters and their chronology color and sign codes on pictures of artifacts or diagrams are used.

The chronological relationships can for example be displayed using a Harris-matrix (Harris 1975, 1979). The first attempt for using such a matrix for describing lithic reduction sequences seem to be done by Roebroeks (1988: 47, fig. 55) for the reconstruction of raw material units (RMU) of refitted artifacts.

Approaches to display working stages on individual artifacts can be used on all lithic objects that show negatives of detachment, i.e., cores, blanks or bifacial objects. WSA was developed for the study of lithic materials from Salzgitter-Lebenstedt (Pastoors 1996, 2001; Pastoors & Schäfer 1999) and Sesselfelsgrotte G (1997). The technological analysis of Jöris (2001) au fond describes the same issues.

In general, it is possible to use WSA on cores to describe visible reduction patterns, on blanks (describing reduction before and after the detachment), as well as on bifacial objects. WSA is used to describe all alterations of an artifact.

The method is lately summarized by Pastoors et al. (2015). The essential attributes for the chronological relation of neighboring negative are (see Pastoors et al. 2015: 67):

- The younger negative lies deeper and is more concave in the immediate area of the separating ridge than the previous negative.
- The younger negative has lateral lances; those of the older negative were cut off by the younger one.
- The lances of the younger negative are frequently accompanied by lance-shaped, often multistage microchips
- The contour of the younger negative follows the relief of the older one and cuts across it.
- In the terminal area of the younger negative Wallner lines are clearly recognizable.

The described attributes to detect the chronological relation, as well as the clustering of negative to one woking stage is illustrated in fig. 91 using figures and explanations of Pastoors et al. (2015) and Richter (2013: 7, fig. 7 and 2001: 234, fig. 13.1).

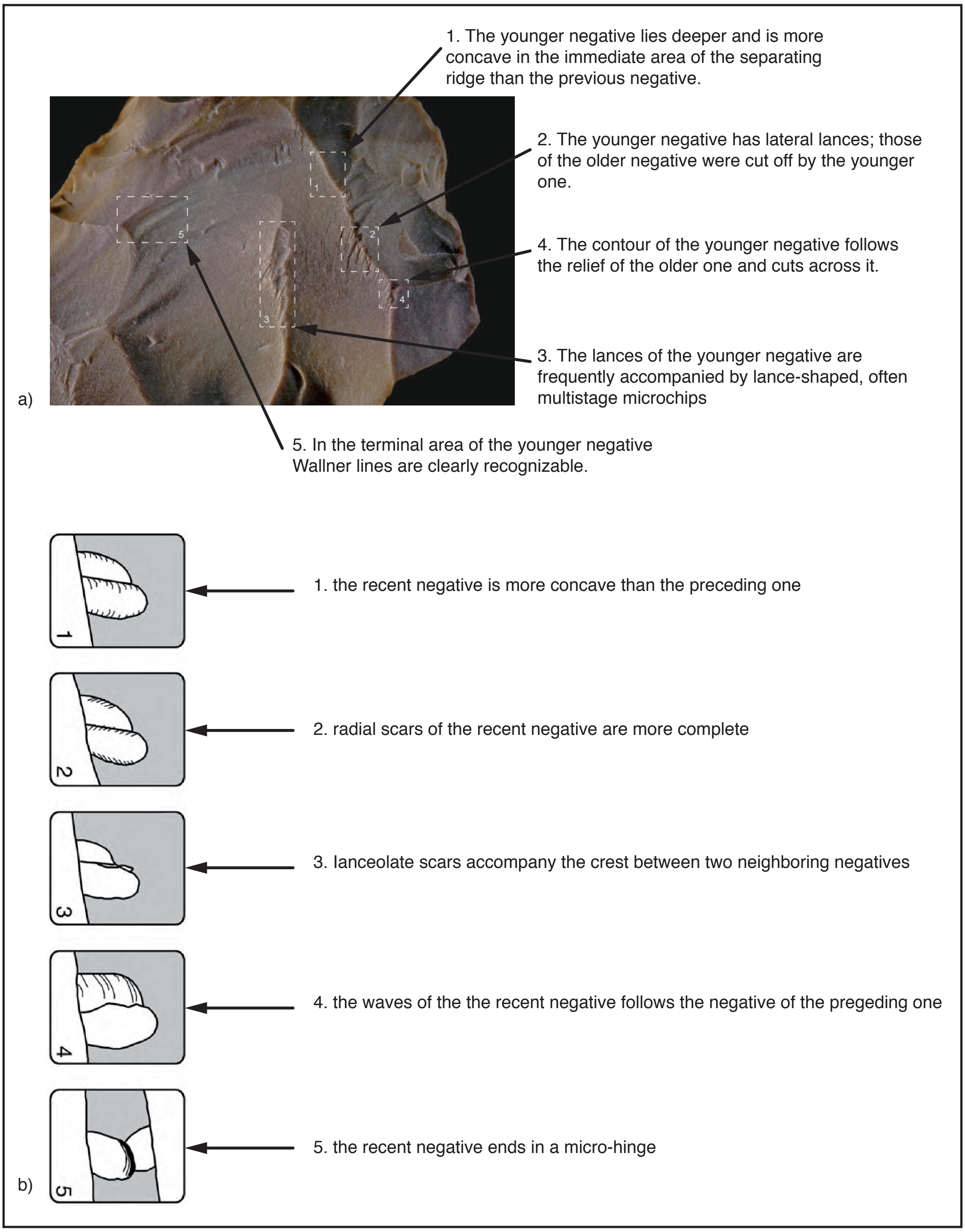

Fig. 91 - Attributes on neighboring negatives showing their chronological relation. a) Explanation after Pastoors et al. (2005: 67, fig. 2) and b) Explanation after Richter (2013: 7, fig. 7, picture) and Richter (2001: 234, fig. 13.1, text)

It is not aim of this dissertation to analyse every lithic object from Grotte de la Verpillière II in this way. This kind of analysis is done on selected artifacts for the display of the method (see chapter V.1.7).

V.3 Litho-technological term definitions

Like in all areas of science, the analysis stone artifacts needs definitions of different circumstances to avoid misinterpretation and inconsistencies. Here we will discuss terms such as system, concept, method, scheme, principle and technique. Mainly, because there are many definitions and sometimes some of these terms are used synonymous. The following chapter is an attempt to clarify and delineate these terms.

V.3.1 Lithic production system

As we would expect, a general term such as system possess many definitions. In a very general sense I. Kant described the term system as a unit of diverse knowledges under the same idea: „*Kant bestimmt den Begriff des Systems als „die Einheit der mannigfaltigen Erkenntnisse unter einer Idee“ und als „ein nach Prinzipien geordnetes Ganzes der Erkenntnis“; es ist eine „für sich stehende Einheit ..., in welcher ein jedes Glied, wie in einem organisierten Körper, um aller anderen und alle um eines willen da sind.*“ (Kwiatkowski & al. 1985).

The dictionary of the Grimm Brothers gives the following description: „*als gemeinsame grundlage fast aller bedeutungen und anwendungen hat system den allgemeinsten sinn ‚ein sinnvoll gegliedertes ganzes, dessen einzelne teile in einem zweckmäszigen zusammenhang stehen oder unter einem höheren prinzip, einer idee, einem gesetz sich zu einer einheit zusammenordnen*“ (Grimm & Grimm 1878). They described a system as a structured whole whose components have a coherence or are subsumed under a higher principle, an idea or a rule.

Sometimes the term system is used as a synonym for a concept (see for exampe Delagnes & Meignen 2006; Delagnes & Rendu 2011) or to describe a lithic *chaîne opératoire* in its relation and conjunction to subsistence and social activities (Shen 2001). We suggest that there is no need for a synonym of the term concept (see below) and therefore we will describe the term system following Shen (1997). As we can see, Delagnes & Meignen (2006) use the term system for different concepts of lithic blank production (Levallois, discoidal, Quina and blady) in a later work blade production and Levallois is unified to one production system (Delagnes & Rendu 2011).

Often the term production system is used for the whole production or processing of a specific feedstock (e.g., lithic versus ceramic production system), also the term production can be used synonymous in this way (Santley et al. 1989). Another example is the production of specific devices that is described as a system (e.g., the production of neolithic daggers; Apel 2008). Inizan et al. (1999) see all technical interactions of a group as technical system. In that meaning, there is a lithic sub-system, a bone sub-system and so on, which interacts with each other.

Shen (2001) provides a holistic definition of the term system. In his approach, a system combines *chaînes opératoires* with subsistence and social activities: *„Lithic production, according to Ericson (1982, 1984), is defined as a process of lithic material modification with the intent to form and use a particular object. [...] Thus, a lithic production system reflects a chain-of-relations of production which involves: raw material procurement in relation to access to and/or exchange of resources and products; manufacture and use of lithic products in relation to lifeway strategies; subsistence and social activities associated with tool utilization and maintenance such as specialization and labor allocation; and social organizations reflected by spatial patterning of lithic production, exchange or trade of lithic products, etc..*" (Shen 2001: 13). In this case a lithic production system provides the connection to the lifeworld of the people. Because it describes all connections between a lithic industry and other archeological sources to get a holistic overview of the lifeworld of the people.

In such a case, there are numerous study possibilities (exemplarily, we shortly describe one). For example, Delagnes & Rendu (2011) interlinked and compared the faunal and lithic record of the Middle Paleolithic of Southwestern France, and suggest correlation between the presence of specific reduction sequences and faunal components (see tab. 67).

Subject	Description	Literature
Relations between the presence of specific lithic reduction concepts and specific faunal elements in Middle Paleolithic assemblages from southwestern France	Levallois & Laminar - mostly OIS 7 to 5 - dominance of residential red deer and roe deer (available the whole year) MTA - mostly OIS 3 - non-selective hunting fauna Quina - mostly OIS 4 to 3 - highly mobile hunting fauna, such as rein deer Discoidal-denticulate - mostly OIS 3 - dominance of bison and horse	Delagnes & Rendu 2011

Tab. 67 - Example of a comparative study of lithic and faunal elements

Another possibilities are experimental studies. For example the connection between specific lithic objects and working steps on organic material (e.g., Tartar 2009). Or there are analysis of morphologies of lithic objects and specific use (Hardy 2009) and spatial studies of lithic recycling (Vaquero et al. 2012a).

A substantial idea behind such consideration is that lithic objects are not produced for its pure being (*l'art pour l'art*), they are objects of utility, are essential for daily life and are in contact with paleolithic people. They are implements used to modify other commodities (like stone, wood, leather, skin, bone or ivory), to procure commodities (hunting equipment or container for gathering) or they are used for many other purposes.

To conclude, we can say that using the term system implies a connection between things and should only be used if connections between can be established.

V.3.2 Litho-technological concept

The term of litho-technological concept can be defined as idea behind a lithic reduction sequence (but it can also be seen as a kind of receipt or instruction manual). It described the necessary morphology of a core, the way of reduction and the consecutive stages. For our knowledge, Boëda (1986) was the first using of the term concept for technological described lithic reduction concepts.

Defining the term of litho-technological concept

To define a technological concept for knapped lithic objects we first consult definitions of Boëda (1988a, 1991b, 1994) for Levallois reduction using a „volumetric" conception of the core: *„L'originalité du concept Levallois ou concept de prédétermination Levallois réside dans la conception volumétrique du nucléus à laquelle seront adjoints les critères techniques de prédétermination (convexités latérales et distale, plans de frappe préférentiels)."* (Boëda 1994: 13)

Richter (2012) explains a concept for stone artifact production as the principle with that a piece is interpret and structures as a spatial object. Or in his words: *„Unter einem Konzept der Steinartefaktherstellung ist das Prinzip zu verstehen, mit dessen Hilfe ein Werkstück (das für die Steinbearbeitung vorgesehene Gesteinsrohstück) als Raum-Objekt aufgefasst und gegliedert wird. [...] Dieses räumliche Konzept kann durch eine Methode oder auch mehrere, unterschiedliche Methoden umgesetzt werden."* (Richter 2012: 227).

Thus, a concept can be seen as „recipe" that has to be followed to reach the goal. In the case of lithic blank production the goal is to get blanks, probably in particular shape and volume, that can be used as tool to modify other material.

Mostly, a lithic concept base on criteria of the shape of a core and the technique of production. Boëda (1994, 1995b, 2013; Boëda et al. 2013) use six or seven criteria to define the Levallois concept (see also Frick & Herkert 2014). In general, these criteria and many more can be used to describe and define possibilities of lithic core reduction. For getting an idea of these criteria a (non exhaustive) list is presented in tab. 68 (see also Frick & Herkert 2014):

Criteria	Description	Example and explanation	Additional literature
Shape of the lithic object necessary to fulfill the concept	Round, or elongated nodules, disc shaped nodule, particular blank	For economizing a raw piece with specific shape is selected. For elongated blanks an elongated core is necessary?	Boëda 1994, Kuhn 1995, Floss 1994
Selection of volumes, surfaces and edges	A lithic object must be selected to begin flaking surfaces and included volumes as well as shape of the edge	Mostly it is not possible to use and edge angle greater than 90°. For splitting (bipolar) a particularly shaped pebble must be selected	Boëda 2013
Active (flaking) and passive (grasping) volumes	One volume is reduced while flaking, the other is for grasping and breakage mechanical purposes	A Levallois core has an exploitable volume and a residual volume that cannot be exploited	Boëda 1994 Frick 2010
Initialization process	Decortication of a raw piece	Finding and shaping of specific edges and their angle opening of a nodule by removing a cortical flake	definition from Frick & Herkert 2014
Configuration of a core	Shaping of the core's surfaces in a specific way that wanted flakes can be removed. We can separate the configuration into shaping along edges and on surface	Removal of shaping flakes for producing a Levallois core shaping along an edge (e.g., removal of an éclat débordant)	Boëda 1994
Reduction rhythm	Is it possible to remove one wanted blank after another or is a step of reshaping necessary?	Continuous removal of blades from a bullet core. Removal of long or short series of blanks before new core configuration	Roussel 2013 Slimak 2004
Homothety	A homothetic core and its reduction will not change its geometrical and morphological characteristics with continued reduction. A non-homothetic reduction process will change the geometrical and morphological characteristics of the core	A Levallois or laminar core is seen as homothetic. A discoidal core change its morphology with every removal	Boëda 2013
Auto-correlation	A removal of a wanted blank shapes a core that the next wanted blank can be removed	A Levallois reduction or the production of carinated pieces is an auto-correlation process	Boëda 1994, Frick & Herkert 2014
Auto-configuration	Negative and scars of previous detachments configure the surface for the next removal	Continuous reduction like on Discoidal cores produce negatives and scars that predetermine the shape of the next removal	Boëda 2013, Frick & Herkert 2014
Volumetry	Two or three-dimensional organization of a core, differentiation of planimetric (2D) and volumetric (3D) cores	Planimetry - Levallois volumetric - blade production	Van Peer et al. 2010, Leplongeon & Pleurdeau 2011

Hierarchy	Specific succession of the function of surfaces In a hierarchical system the function of a surface is not interchangeable	In a Levallois production sequence the reduction surface and the platform do not change their function	Boëda 2013, Frick & Herkert 2014
Direction of production	Visible in refits or on negatives and a reduction surface, if all negatives are in the same direction, then this is called unidirectional	Unidirectional, bidirectional and centripetal reduction of a surface of a core	Boëda 2013, Frick & Herkert 2014
Production sequences	A closed system of chronological steps that lead to the production of specific blanks, these can be single pieces (one object per sequence) or multiple object (more than one object per sequence)	Hierarchical, un-interchangable steps of reduction are visible inside a production sequences	Geneste 1985, Boëda 2013, Frick & Herkert 2014
Premisses	What shaped is necessary? How the core must be structured?	Shape of edges and surfaces, convexity of surfaces	Boëda 2013, Frick & Herkert 2014
Aims	What is produced?	A specific shape of the reduction surface leads to specific blanks	Boëda 2013, Frick & Herkert 2014
Confection	Term concerns tools (mostly modified blanks), the confection can be part of the production of the blanks or is done with retouch	A Levallois point can be immediately used, other blanks need to be retouched for having a specific shape	Boëda 2013, Frick & Herkert 2014
Predetermination	The shape of negatives and scares and therefore the shape of the reduction surface predetermines the shape of the wanted blank	Negatives and scares control the convexity of a reduction surface	Boëda 2013, Frick & Herkert 2014
Produced blankes	Morphology, morphometry and shape of the products what is produced?	Wanted blanks, wanted shapes	Boëda 2013, Frick & Herkert 2014
Waste during production	What products of a reduction process can be defined as waste?	What products cannot be used for wanted functions like cutting	Boëda 2013, Frick & Herkert 2014
Used raw material	Physical characteristics of the raw material Hardness, grain size, isotropy,…	Is the raw material able to fulfill the wanted function of the produced blank?	Floss 1994, Féblot-Augustins 1997
Technique	Which technique is necessary for the knapping process?	Different techniques introduce the force into the block differently. Medium can be (hard, medium hard or soft), the force can be indtruduced direct or indirect, the movemanet can be straight or tangential,...	Pelegrin 2000, Floss & Weber 2012, Boëda 2013, Frick & Herkert 2014
Identification in archeological context	Is it good visible in its context?	Easy to identify, vey specific shape of the core,...	Boëda 2013, Frick & Herkert 2014

Reuse and recycling, remoulding and reshaping	Further modification after use, with our without a gap in time	Are cores of a specific concept used in other ways after?	Frick 2010, Romagnoli 2015; Vaquero 2011; Vaquero et al. 2015
Chronological distribution	In which time period or assemblage cluster is it visible?	In which time the major distribution of this concept is visible	Boëda 2013, Frick & Herkert 2014

Tab. 68 - Criteria that can be used to define lithic reduction concepts (see also Frick & Herkert 2014)

In this case, a litho-technological concept can be described as a spatial conception of criteria how specific procedures has to be passed through to get to a specific goal. Sometimes there are different ways to pass through these procedures, these are called, methods, schemata and principles (see further below).

According to Van Peer et al. (2010), all lithic reduction concepts can be divided into two sub-systems: planimetric and volumetric reduction. Both mainly differ in their core organization. A planimetric concept is two-dimensionally organized (two volumes separated by an intersectional plane) and a volumetric concept is three-dimensionally organized (more than one intersectional planes). The following table lists features that are used by Van Peer et al. (2010) for separating these two sub-systems (tab. 69):

Feature	Planimetric reduction	Volumetric reduction
Intersectional plane, reference plane	Only one (which exists in configuration and production)	Two or three planes, one intersection in flaking direction, the others for configuration
Dimensional organization	Two-dimensional	Three-dimensional
Separated volumes	Two	More than two
Technique	Only hard-hammer	Hard- and/or soft-hammer
Orientation of product removals	Always parallel	Always parallel
Fracture morphology	Mainly plane parallel	Plane parallel and curvilinear
Control of blank morphology	Yes	Yes
Variation in blank shape	Varies in dependance to core shape	Varies in dependance to core shape
Length-width ratio of cores, respectively its flaking surface	L/W ratio normally not very large	L/W ratio is normally very large
Products	Normally flakes are produced If the core has a big L/W ratio a morphological blade can be produced	Normally blades are produced

Tab. 69 - Features of planimetric and volumetric reduction systems, according to Van Peer et al. (2010)

We might ask, if such a concept always has to refer to a complete lithic object (the core) or to a specific position at this core (with its combination of flaking and knapping surface). The consideration here is that in knapping there is the possibility to fulfill the criteria of one concept and in the next steps using another conception. For example the production of an exhausted Levallois core and using this core after reshaping to produce elongated blanks along one edge (a blade concept with a crest).

Primary and secondary concepts

A primary concept is defined as the first concept used on a raw piece. A secondary concept uses blanks produced with the primary concept to get blanks from these blanks (see also chapter V.5.6 or X.2). After all, it can be considered if modifications (of blanks and cores as well) are also classified as secondary concepts. Delagnes & Renu (2011) provided a devision into primary and secondary production that is quite similar to the one presented here, but the only include intentional knapping for blank provision. In general, a primary concept can also be interpreted as provisioning of blanks (or better initial objects). A secondary concept can follow. In this case a primary concept that supply blanks can be an intentional blank production or the selection of natural objects (like frost shards or fragments). In the context of the Middle Paleolithic numerous primary concepts from producing blanks are available. Many of these can produce blanks that can be use as cores for blanks. This hierarchy is also called ramification (Bourguignon et al. 2004; Rios-Garaizar et al. in press), because the second concept is only possible after the first. Bourguignon et al. (2004) describe three different operational chains for ramification:

- Removal of blanks (Kombewa) from modified and unmodified blanks produced with the Quina concept
- Removal of blanks (Kombewa) from modified and unmodified blanks produced with the Discoidal concept
- Removal of blanks (Kombewa, Kostenki, Pucheuil, Etouteville) from modified and unmodified blanks produced with the Levallois concept

As example we can also call the aurignacoid production of bladelets from carinated pieces a secondary concept:

- Primary concept - production (or more general provisioning) of a blank (or more general an initial object)
- Secondary concept - production of blanks from this initial object

A further example is the lithic production from Les Tares (Geneste & Plisson 1996) that also yields a tertiary concept.

For bifacial objects this hierarchy can also be used, in the case, a bigger flake is used to manufacture a hand axe. Firstly, an initial objects has to be provided. Secondly, this has to be shaped bifacially:

- Primary concept - production (or more general provisioning) of a blank (or more general an initial object)
- Secondary concept - bifacial shaping

To conclude, a secondary production is the production of blanks from initial objects. To provide a better overview this is listed in the following table 70:

Conceptual stage	Sequence	Lithic concepts
Primary concept	Raw piece -> core -> blank Raw piece -> frost core -> frost fragment	Levallois, Discoidal, Quina, …
Secondary concept	Blank as core for further blanks Frost fragment as core for further blanks	Dorsal reduction, ventral reduction, edge reduction (may also modification of surface and edges)

Tab. 70 - Primary and secondary concepts

As *Gedankenexperiment* we can also think that a secondary reduction might be a reduction within the same concept but with another method. Such a succession is e.g., explained by Richter (1997: 147f) for material from the Sesselfelsgrotte: „*Die Schemata sind nicht Ausdruck strikt getrennter Herstellungsprozesse, sondern zum Teil Stadien desselben Herstellungsprozesses (Konzeptes).*“ He recognized blended stages of unidirectional and bidirectional Levallois schemes. Another possibility is that a core produced within one concept is further exhausted in another. Bordes (1950b, 1961) described this for Discoidal cores, because his opinion was that they were former Levallois cores. An opportunistic use of specific cores is often visible. For example if a core is exhausted and cannot be reduced inside a concept. A possibility is then to re-configure the core or to reduce it in another way.

Multiple litho-technological concepts at one core?

For hierarchical core reduction (primary, secondary concepts, see above) we can see that multiple concepts can be realized. But is it possible to reduce a core within the framework of multiple concepts?

To explain such a phenomenon, we will firstly consider the Levallois and Discoidal concept. At first, Boëda (1994: 19, Fig. 4) describes how both faces of a Levallois core can be exploited and used as flaking surfaces (see fig. 92):

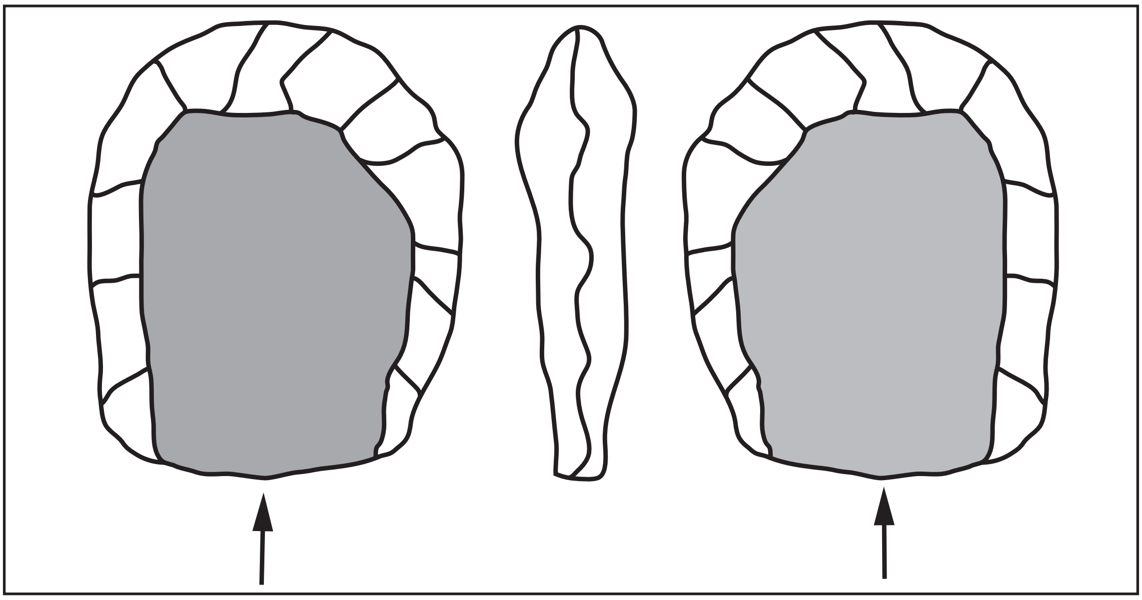

Fig. 92 - Exploitation of both faces of a Levallois core as described by Boëda (1994: 19, Fig. 4)

If we consider this option, the use of different surfaces (and the connected volumes) of a core can be referred to specific reduction concepts. In this way, for instance, there is the possibility (inside the rules of breakage mechanics) that one surface is exploited within a parallel reduction (e.g., a Levallois flaking surface or surface Levallois) and the opposite surface in a secant reduction (e.g., a discoidal flaking). One figure in Slimak (2004: planche 36) implies such an interpretation (redrawn in fig. 93):

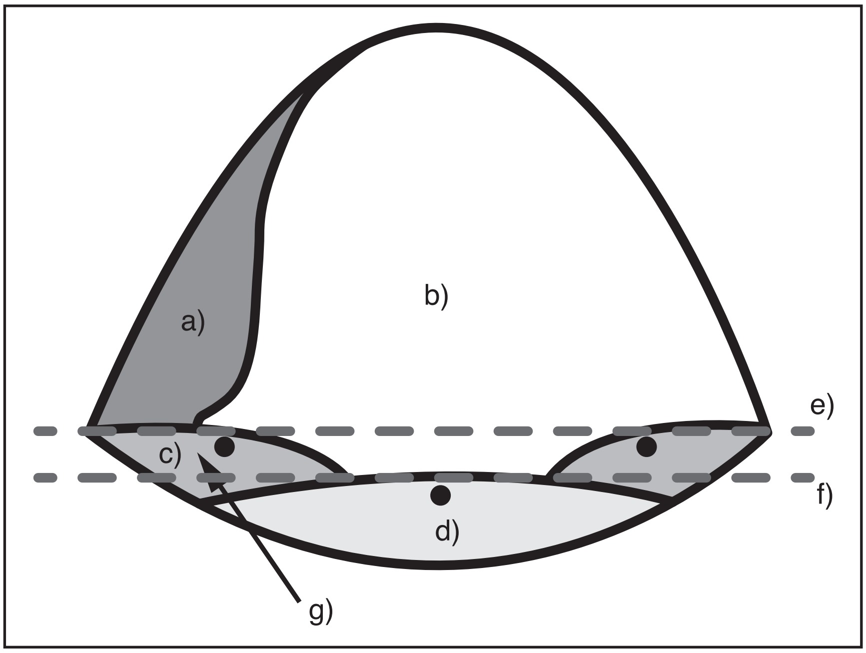

Fig. 93 - Two flaking concepts on one core, after Slimak (2004: planche 36)

But are there further possibilities to reduce a core within multiple conceptual frameworks? As explained in chapter V.4.1 there is a temporal relation between possible concepts on an object, but these are consecutive. Here, we are asking about realized concepts on different parts of the core that are without a consecutive relationship. During selection and analysis it is possible to realize such circumstances. The following elucidatory example can illumine this circumstance: Given that a thicker blade was modified on both ends in that way that other usable blanks are produced (e.g., a burin and carinated part), two different secondary reduction concepts are realized on one object. Maybe such a factor led Boëda (2013) to divide blocs in useful (the core sensu structo) and non-useful structures (similar to techno-functional divisions of parts), which are better denominated by using the therms volume of reduction and volume of grasping (see Frick & Herkert 2014).

To my knowledge, the simultaneous use of multiple conceptual frames for core reduction in only very seldom used (by Paleolithic people) or maybe not recognized (by researchers). A major reason for this is that a core is normally structured in that way that the knapper can follow a specific framework. On the other hand, if we would separate specific reduction processes, we could talk about multiple conceptions used on one core. If we reconsider the Discoidal reduction strategies as proposed by Slimak (2004) for sites in the Rhône Valley, there are different ways of reduction (centripetal, oblique and cordal) and each of these reduction directions can massively reshape the core and produce very different products.

Techno-types

We would expect that an idea behind a reduction sequence combines the way of lithic reduction and also the produced pieces. Newly, this combination is called techno-types (Boëda 1997, 2013; Koehler 2009). The origin of this approach is the idea of the knapper's knowledge how a blank will look like if a removal is done from a specific position of the core. Boëda (2013: 72/66) points out that the blade is the techno-type of a laminar production. Koehler (2009) refined his former ideas and defined over all n=60 techno-types:

- 24 types of triangular blanks
- 11 types of long rectangular and oval blanks
- 25 types of short rectangular and oval blanks

A simplistic explanation of techno-types might be: blanks of a specific shape produced inside the frame of a reduction concept (Boëda 1991a; Koehler 2009). It is not easy to find a good definition of the term techno-type. Koehler (2011: 21) explains it in this words: „*In addition to form and geometry, aspects of the objects such as edge delineation, profiles, size and distal form were also examined. This led to identification of 'technotypes', meaning that a given triangular object, for example, belongs to a given technotype number one because it is symmetric, robust, has convex edges, a narrow pointed distal end and a straight profile. For production modes, core initialization and exploitation techniques of the chaînes opératoires were examined.*"

Connection between technique, method and concept

Weißmüller (1995) gives a good explanation of the meaning of the terms *Technik* (technique), *Methode* (method) and *Konzept* (concept). For him the term technique names the kind of force transmission (like hard, soft or with a punch), method refers to the succession of technical steps (Which crest has to be used next? How to prepare the contact point?) and this choice of method depends of the concept. Weißmüller (1995) also discusses the term concept and gives a term definition as it is used for Levallois (compare with Boëda 1986): concept equals visualization of the prospective core. But he also ask what has priority, production of blanks or generation of a core? Is it a blank or a core concept? What is the difference between concept and strategy? If natural edges of a raw piece are searched and followed into the inner, he called this a strategy not a concept. As illustration for these terms he suggest a hierarchical pyramid, as it is illustrated in fig. 94:

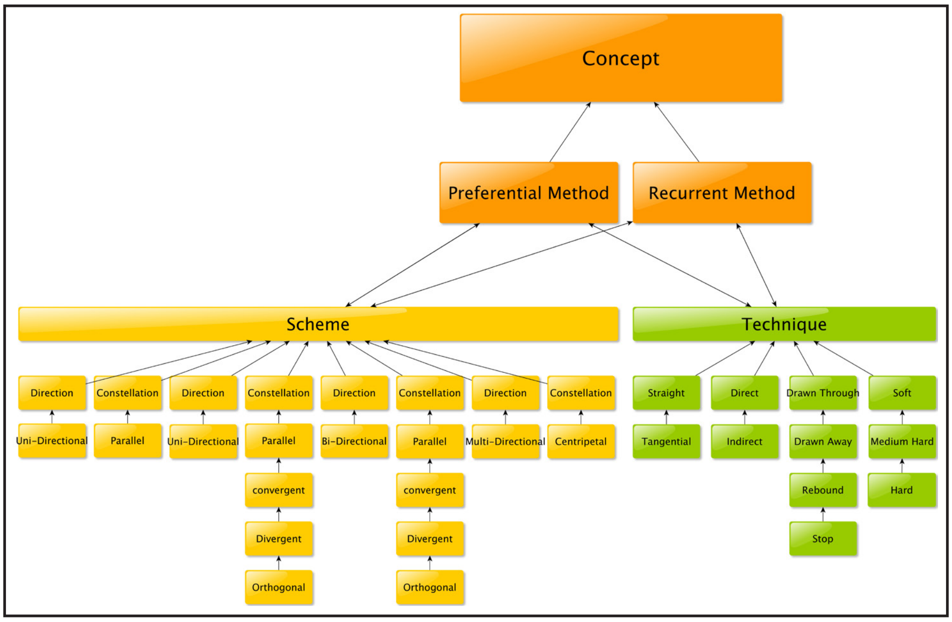

Fig. 94 - Hierarchical illustration of concept, method, scheme and technique, following ideas of Weißmüller (1995: 28)

How to find out the litho-technological conception of reduction?

There are many ways to find out how a reduction of a core was undertaken. To get an idea of the possibilities to examine ways of reduction, the following list sums up some study methods (it must be noted that normally a combination of them are used, see tab. 71):

Study method	**Example of a litho-technological concept for that this study method was used**	**Literature**
Diacritical study of core patterns, working step analysis, production analysis	Preferential and recurrent Levallois	Boëda 1986, Richter 1997, Pastoors 2001, Jöris 2001
Mental positioning of specific shaped blanks, called mental refitting	Levallois, Discoid, Production of blades for Châtelperronian points	Pelegrin 1986, Boëda 1994, Slimak 2004
Refitting	Bladelet production on carinated pieces Levallois reduction sequences	Le Brun-Ricalens 2005, Van Peer 1992
Blanks selection	Preferential Levallois	Bordes 1961
Raw material sorting	Levallois	Geneste 1985
Formation of raw material units	Levallois, Discoid, blade reduction	Roebroeks 1988, Hahn 1988
Formation of pieces belonging to one raw piece, seperation of single pieces (individual objects) and work pieces (many pieces of such a raw piece	Levallois, bifacial production	Weißmüller 1995 Uthmeier 2004
Separation of the surface of blanks and cores into sectors to study directions of negatives and constelation	Levallois	Tostevin 2003

Tab. 71 - Study methods to detect the reduction concept

Van Peer (1992) discuss different study systems (traditional approach, Boëda's and his own approach). The following tab. 72 reproduces his explanation in condensed form:

Stage	Traditional approach	Boëda's approach	Van Peer's approach
1	**Selection** of cores and blanks with a morphological (Bordes 1961) or morpho-technical (Tixier et al. 1980) criteria	**Selection** of cores after specific criteria, because the conception is most clearly present on cores (Boëda 1986: 45)	**Selection** of cores after Boëda's specific criteria, with the addition of the inspection of angles **Selection** of end products by morphology **Selection** of preparation products by morphology
2	**Analysis** of core, blank and butt type after Bordesian criteria (Bordes 1961, 1972, 1980)	**Analysis** using the assessment of diacritic patterns on the cores. Determining the relative order, orientation and function of each negative to find the method of preparation and exploitation, the shape of wanted forms and the number of exploitation surfaces	**Refitting** and reconstruction of reduction sequences on the upper surface
3	**Synthesis** via relative and absolute counts and calculation of indices	**Selection** of blanks that are specific for each method and surface	**Analysis** of methods, strategies, cores, end products,
4		**Analysis**, using the assessment of diacritic patterns on blanks.	**Synthesis** of cores, refittings and products
5		**Synthesis**, description, characterization of reduction strategies, types of products, methods of reduction and preparation and number of reduction surfaces	

Tab. 72 - Comparison of traditional, Boëda's and Van Peer's approach

A litho-technological concept always combines core configuration and production and therefore produce different useful (predetermined) and non-useful blanks (waste). Another impressive example that a concept can produce a huge variety of blanks is the so called Quina reduction (Bourguignon 1996, 1997). In the following (only for the impression) the range of predetermined blanks of this concept is listed (following Bourguignon 1996, 1997; Turq 1989):

- Raw-piece cap (*entame*)
- Blanks with natural backing
- Blanks with natural back (*éclats à dos naturels*, *sensu stricto*)
- Blanks (knives) with natural butt and short (*couteaux à dos naturel enveloppant*)
- Sausage-like blanks (*éclats en tranche de saucisson*; Cheynier 1953)
- Blanks with the butt as back

- Clactonian-type blanks (*éclat de type clactonien*)
- Blanks with a thick butt (*éclat à talon épais*)
- *Éclats à dos de débitage*
- Asymmetric blanks (*éclats asymétriques*)
- Citron-like blanks

V.3.3 Litho-technological methods

A litho-technological method is the way with that a litho-technological concepts can be accomplished. Boëda (1994) use the term method to split between the production possibilities of producing one predetermined lithic object (*préférentiel*, one target blank) and producing a series of predetermined lithic objects (*récurrent*, series of target blanks) within one reduction phase. If this division is captured for other concepts there are difficulties. For example, if we consider the Discoidal concept (e.g., Slimak 2004) or the Quina concept (Bourguignon 1997) we find no indication for a preferential method, because within a reduction sequence always multiple target blanks are produced. According to this, we refer the term method simply to the number of produced products per reduction sequence (tab. 73):

Method	Kind of production	Example
Preferential	Single piece production	Central target flake production from a preferential Levallois core
Recurrent	Series production	Serial production of blades

Tab. 73 - Separation of litho-technological methods by the number of produced target blanks, according to Boëda (1994)

If using this simple devision also edge production concepts can be integrated. For instance, the production of burin bladelets and also single (preferential) and recurrent (repeated) reduction of edge sharping blanks (para-burin blows). One, non or many, like for options in databases. Every reduction sequence within a concept can therefore referred to a preferential or recurrent way of production.

Van Peer (1991) use the following definition for Levallois methods: „*Levallois methods are defined as varieties in the organization of preparatory scars on the flaking surface (the face from which a Levallois flake is to be produced) of Levallois cores.*" This definition differs from Boëda's (Boëda 1986, 1988c, 1994) separation into preferential and recurrent methods. For the moment, the best disentanglement seem to use the following term definitions (tab. 74):

Term	Definition	According to which author
Litho-technological method for target products	Number of produced blanks per reduction cycle	Boëda (1986, 1988, 1994)
Litho-technological method for core configuration	Organization of negatives on the flaking surface of a core (before the reduction)	Van Peer (1991)

Tab. 74 - Term definition regarding litho-technological methods

V.3.4 Litho-technological schemata

Schemata are possibilities how a specific idea of configuration and production is implemented within a reduction phase: „*Ein solches Schema beschreibt die Strukturierung der Abbaufläche durch die besondere Anordnung der Formungs- und Zielabschläge zueinander.*“ (Richter 2012: 234). These schemata are given by negative directions on the flaking surface or cores. Bigger difficulties are shown if it is not possible to separate negatives from configuration and production sequences. The following tab. 75 displays an overview of reduction directions of target products and direction of configuration blanks within the Levallois concept (Boëda 1986, 1994; Frick 2010; Richter 1997, 2012):

		Preferential Levallois method (one target product per series)					**Recurrent Levallois method (multiple products per series)**				
Reduction direction of the configuration products (configuration scheme)		Parallel unidirectional	Convergent unidirectional	Orthogonal	Bidirectional	Centripetal	Parallel unidirectional	Convergent unidirectional	Orthogonal	Bidirectional	Centripetal
Resulting geometrical form of target blanks	Rectangular										
	Oval										
	Elongated										
	Triangular										

Tab. 75 - Resulting geometrical forms of target blanks for different configuration methods (red - impossible, yellow - possible but unlikely, green - very likely)

The next attempt is to separate negatives of the configuration from negative deriving from target blanks. We want to call them reduction schemata and configuration schemata. These reduction schemata are called schemata for blank production by Richter (2012).

Principally, there are the following patterns (combination of constellation and direction) of reduction or configuration negative (previous negatives) on flaking surfaces (see also fig. 95):

- Parallel unidirectional (parallel negatives, knapped in one direction)
- Convergent unidirectional (convergent negatives, knapped in one direction)
- Divergent unidirectional (divergent negatives, knapped in one direction)
- Orthogonal bidirectional (more or less rectangular negatives, knapped in two directions)
- Parallel bidirectional (parallel negative towards from opposing directions, knapped in two directions)
- Convergent bidirectional (convergent negative towards from almost opposing directions, knapped in two directions)
- Divergent bidirectional (divergent negative towards from almost opposing directions)

- Centripetal (negative from multiple directions)

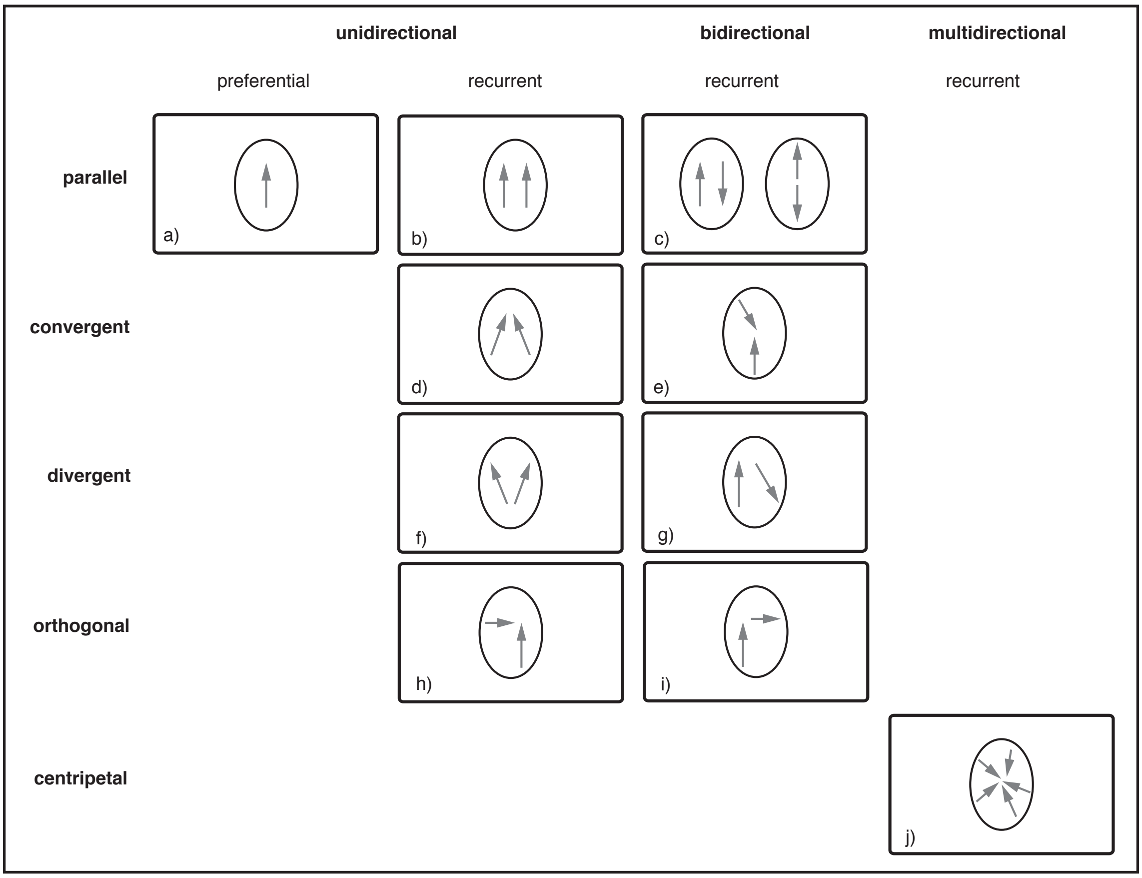

Fig. 95 - Patterns (combination of constellation and direction) of reduction or preparation negatives on flaking surfaces

These schemata, even though described for the Levallois concept, can be used for negative patterns of cores within other concepts. For example Discoidal cores normally are described as cores with a centripetal negative pattern. These cores normally show in configuration and production nearly the same negative patterns.

V.3.5 Litho-technological cycle

The reduction of a raw piece, core or initial objects run through several litho-technological cycles. They are not equatable to the phases of a lithic *chaîne opératoire* (Geneste 1985), because a cycle is always a combination of these lithic *chaîne opératoire* phases. A cycle describes how a reduction is production-technically proceeded. In the following, these lithic *chaîne opératoire* phases that can build a cycle are described (see tab. 76):

Cycle	Action	Result	Products
Initialization (decortication)	Opening of a raw piece, removing cortex, capping of a raw piece	Cortex is removed	Core cap blanks, cortical blanks
Initialization (preforming)	Finding and preforming edges, angles and surface	Edges, angles and surfaces are preformed that purposeful blanks can be removed	Blanks with and without cortex
Configuration	Shaping of a core in a very specific manner	Shaping of a core that it fulfill the criteria of a litho-technological concept	Surface configuration blanks, Edge configuration blanks
Preparation	Preparing the next blow, removing pendent angles, abrasion, controlling angles,	Edges, angles and surfaces are prepared that the production or the next removal of the configuration can start	Mineral dust, chips, small blanks
Production	Removal of target blanks	Getting target blanks for further modification or use	Target blanks

Tab. 76 - Litho-technological cycles

The main difference of cycles can be seen between preferential and recurrent methods. For preferential methods after every production of a target blank, the core surfaces need to shaped new by configuration and preparation, if a new target blanks is wanted. For recurrent methods only a little preparation step is mostly necessary between every production blow. Only after a series of target blanks, the next series can be removed if configuration and preparation is done again. The next table summarize this (tab. 77):

Method	Cycle	Rhythm
Preferential	Initialization -> configuration -> preparation -> production of one target blank-> configuration -> preparation -> production of one target blank -> …	Discontinuous production of single pieces within one cycle
Recurrent	Initialization -> configuration -> preparation -> production of a series of target blanks-> configuration -> preparation -> production of a series of target blanks -> …	Continuous production of lithic series within one cycle

Tab. 77 - Differentiation between preferential and recurrent methods in regard to cyle and rhythm

As displayed in tab. 76, there is a correlation between the terms method (Boëda 1994) and rhythm (Slimak 2004). The term method is correlated with the number of wanted blanks and the term rhythm to alteration of phases. We would expect that this correlation and determination can be used for many components of paleolithic assemblages and also for many litho-technological concepts.

V.3.6 Litho-technological techniques

The term of knapping technique mostly refers to the way and kind of the introduced energy. We prefer a tripartite term to define a knapping technique (1. force effect, 2. hardness of the hammer and 3. type of movement of the hammer). The following tab. 78 displays some (non-exhaustive) possibilities for each term:

Term	Possibility	Meaning	Additional literature
Force effect	Direct	The force effects the knapped objects directly	Inizan et al. (1999)
	Indirect	The force is transmitted by an interface	Inizan et al. (1999)
	Active	The hammer effects actively the knapped object	Inizan et al. (1999)
	Passive	The knapped object (core) is hold in hand	Inizan et al. (1999)
Hardness of the hammer	Hard	Hammerstones from materials such as granite, gneiss or quartzite	Inizan et al. (1999), Pelegrin 2000
	Medium hard	Hammerstones from materials such as sandstone or limestone	Roussel (2005, 2006), Pelegrin 2000
	Soft	Organic materials such as antler, bone or hard wood	Inizan et al. (1999), Pelegrin 2000
Type of hammer movement	Straight	The hammer hits the core in a straight line	Inizan et al. (1999)
	Tangential	The hammer hits the core in a bend line	Inizan et al. (1999)
	Straight-rebound	The hammer hits the core in a straight line and get actively rebounded	
	Tangential-rebound	The hammer hits the core in a bend line and gets actively rebounded	
	Straight-stopp	The hammer hits the core in a straight line and get actively stopped	
	Tangential-stopp	The hammer hits the core in a bend line and get actively stopped	
	Straight-pull	The hammer hits the core in a straight line and gets actively pulled (horizontally) away from the core	
	Tangential-pull	The hammer hits the core in a bed line and gets actively pulled (horizontally) away from the core	Bourguignon 2001; Romagnoli et al. (in press)
	Straight-push	The hammer hits the core in a straight line and gets actively pushed further	
	Tangential-push	The hammer hits the core in a bend line and gets actively pushed further	

	Pressure (hand-held pressure rod and hand-held core)	The force is not applied by a blow but by a hand-held pressure rod and the core is also hand-held	Mode 1a in Pelegrin 2012
	Pressure (hand-held pressure rod and fixed hand-held core)	The force is not applied by a blow but by a hand-held pressure rod and the core is hand-held with a grooved device	Mode 1b in Pelegrin 2012
	Pressure (shoulder crutch and fixed hand-held core)	The force is not applied by a blow but by a shoulder crutch and the core is hand-held with a grooved device	Mode 2 in Pelegrin 2012
	Pressure (short belly crutch and hand-fixed core on the ground)	The force is not applied by a blow but by a short belly crutch and the core is hand-fixed with a grooved device on the ground	Mode 3 in Pelegrin 2012
	Pressure (long crutch and fixed core)	The force is not applied by a blow but by a long belly crutch and the core is fixed with a grooved device on the ground	Mode 4 in Pelegrin 2012
	Pressure (lever and core fixed in a piece of wood)	The force is not applied by a blow but by a lever and the core is fixed with a piece of wood	Mode 5 in Pelegrin 2012

Tab. 78 - Tripartite description of litho-technological techniques

By consulting the literature about knapping techniques (e.g., Bourguignon 2001; Floss & Weber 2012; Inizan et al. 1999; Pelegrin 2000, 2003, 2012; Pelegrin & Inizan 2013; Roussel 2005; Roussel et al. 2009) it is obvious that not all listed techniques are immediately recognizable by attribute analysis on cores or blanks. In most of the cases a combination of stigmata (or features) will reveal the used technique for blank production (however, it is not aim of this work to display all features and stigmata on blanks and cores to detect all possible technique of knapping).

V.3.7 Disentangle term definition

To avoid confusion about these defined terms the following will summarize them. In a hypothetical way these terms are related and depends from each other. A litho-technological concept gives the work-frame or the rules how to structure the production. Litho-technological methods show a specific way for the configuration of a core, as well as the reduction sequence. The core scheme displays the constellation of negatives of the flaking surface and can be separated into negatives, deriving from the configuration of the core or deriving from the production of former target blanks. The litho-technological cycle display working-steps that are necessary for the entire lithic reduction process.

V.3.8 Litho-technological principles

Nearly every lithic reduction concept controls the shape of surfaces to get blanks with specific forms. The only exception we know is the production of chopper and chopping-tools, if these are seen as core-tools (Leakey et al. 1971; Toth 1985). If we take it that blanks tend to be triangular in its longitudinal section with a feathered finial and a knapper can control the position of the breakage surface, then the knapper will also be able to control the morphology of the knapping surface and therefore the shape of wanted blanks. The shape of the dorsal face of a blank is predetermined by the morphology of the knapping surface of the core. There are two possibilities distinguishable: Shape of a crest or shaping of a convexity.

Boëda (1994: 268-270) compares the exploitation of volumes for Levallois and crested blade cores and describes these two possibilities for whole cores and their reduction sequences. In doing so, he distinguishes between reduction on a surface (Levallois) and reduction of a volume (Upper Paleolithic blade core).

Both above described principles exist not exclusively in reduction sequences of the Middle Paleolithic. Mostly, they are in combination in different emphasis. Basically, both principles differ in its position at the core. At a crest two surfaces run to each other under an angle and build an edge. On the other hand, a convexity is a rise of a surface (see fig. 96).

Litho-technological crest principle

A crest is build of two surfaces that run to each other under an angle. This crest can be described as mountain crest, along that the knapping energy runs. The blank produced at this crest has a triangular cross section. If another blank is removed there are two possibilities of its reduction. Either the negative of the former blank is that small that the entire morphology can be seen as crest or only one of the edges of this negative is used as crest (see. fig. 96b). Blanks produced with the aid of a crest can be extremely long as blades from Grand-Pressigy flint from the Magdalenian or Neolithic times on livres de beurre demonstrate (Ihuel 2006; Mallet et al. 2004; Pelegrin 2002; Primault 2003). In general such a crest for the confectioning of a reduction sequence can occur naturally or can be built artificially.

The use of the crest principle is shown in very different lithic concepts. The following table sums up some characteristic examples (tab. 79):

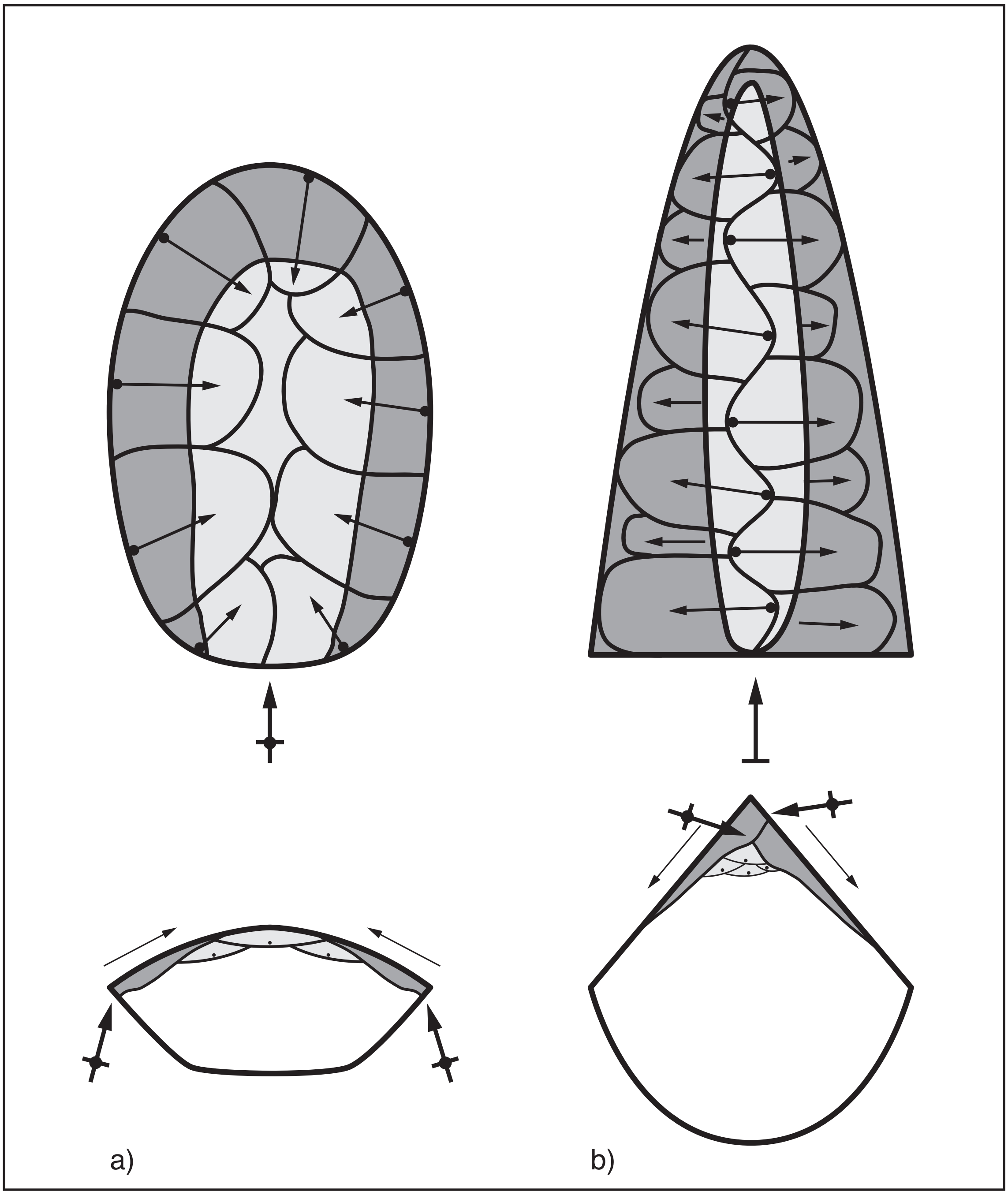

Fig. 96 - Illustration of the litho-technological principles of reduction. a) Convexity and b) Crest

Reduction activity	Associated lithic concept	Description	Literature
Burin blow	Edge reduction	Production of elongated blanks along an edge of a blank and of cutting edges	Chehmana et al. 2007
Tranchet blow	Mostly sharpening of a bifacial element	Removal of a blank for sharpening an edge	Jöris 2001, 2006
Removals of *éclats centripètes* and *éclats à crête*	Reduction on edges on discoidal cores	Removal of blanks along a crest in centripetal or cordal direction	Slimak 2004
Removals of *éclats débordants*	Reduction on edges on discoidal and Levallois cores	Removal of blanks along a crest in cordal direction	Boëda 1994, Slimak 2004

Removal of elongated objects (blades)	Crested blade configuration of blade cores	Removal of elongated blanks to get ridges and elongated negative for further removals	Floss 2012

Tab. 79 - Examples for using a crest as element of confection

As demonstrated the lithic principle of the crest is a procedure every lithic knapper needs to know to produce blanks.

Litho-technological convexity principle

In addition to the possibility to use a crest to reduce a core volume, a natural or artificial convexity can be used. Both, a crest and a convexity as well is used to advance the predetermination of wanted blanks (see fig. 96). A convexity is normally built by an entire flaking surface. If any natural convexity is unavailable the flaking surface has to be configured. The convexity principle is essential for Levallois reduction and is one of the criteria formulated by Boëda for the Levallois concept. In this case the flaking surface is artificially bulged and decided into lateral and distal convexity (e.g., Boëda 1994).

Another example for the use of convexity is a so called Janus flake (Tixier & Turq 1999). In this case, the convexity given by the bulb of percussion is used to get a flake with two „ventral" faces.

From case to case, the crest principle is used to produce a convexity by the reduction of *éclats* and *lames debordants* on the lateral edge. As Levallois demonstrates, the combination of convexities and crests is quite common in lithic reduction. The following table lists some other examples of these combination (tab. 79):

Lithic cores	Description	Literature
Carinated piece	Removal of bladelets along crests of former removals, the complete flaking surface is convex	Le Brun-Ricalens 2012
Crested blade cores	Removal of blades along crests of former removals, the complete flaking surface tends to be convex	
Discoidal core	Removal of blanks along crest for getting different shapes of blanks (e.g., *éclats débordants*, pseudo-Levallois points, *éclats centripètes*), the complete flaking surface is relatively convex	Slimak 2004

Tab. 79 - Examples for crest using to shape convexity

The reduction of central blanks from Levallois cores might also be separated into these two principles. There is a good case to believe that oval and rectangular blanks need a differently shaped flaking surface. We would suppose that for oval blanks an overall convexity is helpful and for rectangular blanks good defined crests (see fig. 97).

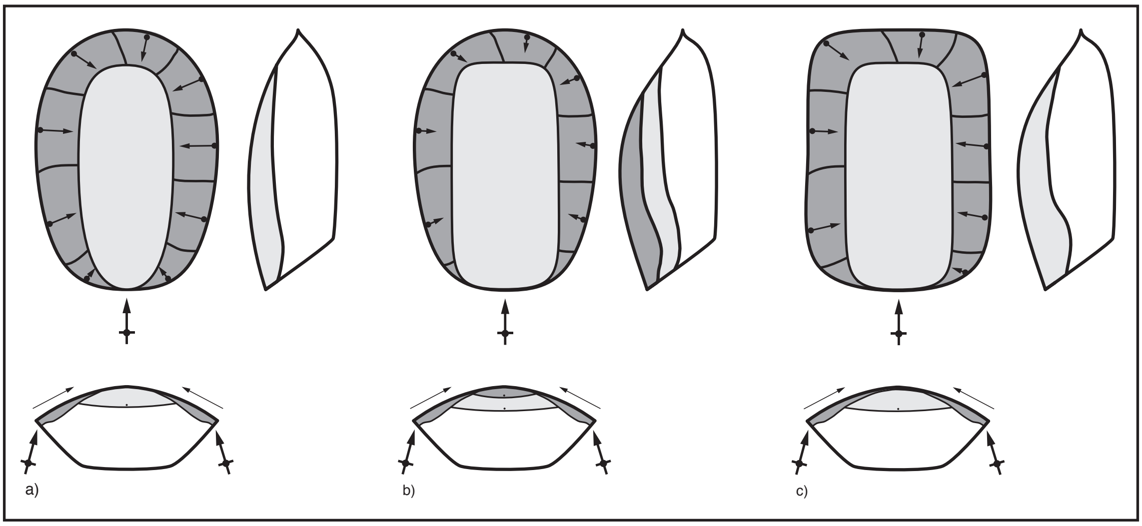

Fig. 97 - Supposed differences in flaking surface shape for oval and rectangular Levallois flakes (dark gray - configuration of the flaking surface; bright gray - central Levallois flake). a) Oval top view of the Levallois core, convex configuration of the flaking surface - first central flake is quite oval; b) Oval top view of the Levallois core, convex configuration of the flaking surface - second central flake is quite rectangular, c) Rectangular top view of the Levallois core, convex configuration of the flaking surface - first central flake is quite rectangular

Shape-control of flaking surfaces

In the former two paragraphs about crest and convexity principles were used to explain how flaking surfaces can be shaped and how the energy is guided. Boëda (1986) examined the guiding ridge principle for Levallois and distinguished three technical expressions (see also Van Peer 1992), as listed in tab. 80.

French term	English translation	Explanation	example
Nervure-guide d'appointement	Appointed crest	Convergent crests converge in terminal parts	The Y-shaped crests of a configured Levallois core for points
Nervure-guide longitudinal	Longitudinal crest	Longitudinally running parallel crests	Parallel crests of a uni- or bidirectional Levallois core for blades
Nervure-guide indirecte	Indirect crest	Crests that guide piece by piece	Centripetal crests that form a convexity

Tab. 80 - Function of scares for the shape-control of the flaking surface

Van Peer (1992) conclude that „*an important convexity would have the same effect as a physical guiding ridge.*" Therefore, the bulge of a flaking surface, either a crest or a convexity is the important factor of flaking surface shape. Van Peer (1992) demonstrated — with aid of the mathematical and physical explanation of Bertouille (1989) — that the exact shape of the bulked surface is not of high importance. However, the position of the fracture plane and how the core is shaped there is of vast importance. This plane leads the formation of a blank.

Litho-technological principles are summarized in the following. We showed that without a bulge of the flaking surface (wether it is a crest or a convexity), no volume is present that can be removed to produce blanks. The differences, wether a crest or a convexity was produced to bulge the flaking surface, leads to different morphologies of the future dorsal face of the blank. Of high importance is the position and shape of the fracture plane (Van Peer 1992). The position of the fracture plane is directed by the position of the knapping impact and its shape is a function of the flaking surface configuration, as well as the shock wave reflexion. The fracture plane in side view can be straight or in a S-shape (Bertouille 1989). If the energy is to high (plunging) or to small (hinge) the fracture plane is at its terminal end interrupted and bent (see fig. 98).

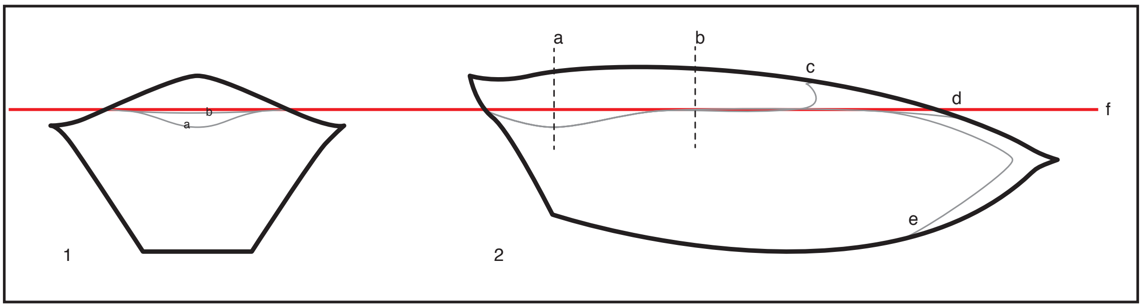

Fig. 98 - Shape and position of a fracture plane on an idealized Levallois core. 1) Cross section; 2) Longitudinal section. a) Position of the bulb's cross-section; b) Position of the mid-ventral face cross-section; c) Hinge because of to small introduced force, interruption of the fracture; d) Ideal finial, feathered end, following an S-shaped or straight (parallel) plane; e) Plunging because of to high introduced force, fracture follows parallel to the core surface

V.3.9 Connection between litho-technological schemes and specific blanks

Within distinct lithic schemes specific, morphologically distinct blanks can be produced. These blanks can be seen as proxy for specific reduction sequences and are therefore part of a so called mental refitting (Pelegrin 1995). Richter (1997: 165f) showed (for the G levels of the Sesselfelsgrotte) that specific artifact shapes correspond to particular production schemes. This is the case for Levallois points and Kombewa flakes, because they correspond to the unidirectional convergent Levallois reduction and respectively to the Kombewa reduction (ventral flaking). Boëda (1994) emphasized that the production of typological Levallois points can be done within different reduction concepts (Levallois, discoidal, pyramidal or crested).

In the authors opinion, only flakes that remove the bulb of another blanks can probably, if not certainly be attributed to only one concept (production of Janus flakes). No other concept can produce two „ventral faces".

For every other blank the allocation to a specific lithic concept is not always obvious, but often very suggesting. As always, further evidence are necessary.

A good example in this context is the correlation of blanks and cores of the discoidal concept from Champ Grand à Saint-Marice-sur-Loire in the Loire department, France. Here, Slimak (2003, 2004) demonstrated that a whole bunch of blanks can be attributed to specific positions on a core (mostly via mental refitting). These are so called Pseudo-Levallois flakes, *éclats* (*à dos*) *débordants*, *éclats centripètes* and *éclats à crête* that can be produced form specific removal directions and position of these cores.

V.3.10 Lithic production from specific core positions

In addition to specifically shaped lithic products that can be attributed to reduction schemes there are further blanks that can be removed from specific core positions. Such blanks can be generated within different reduction schemes but are specific for a particular morphology of the flaking surface. Exemplary, some reduction products are named here which are bound to very specific flaking surface morphologies.

Core tablets

Let us beginn here with so called core tablets (fr. *éclat de ravivage*). As such a lithic product is named when the knapping surface is renewed by removing a bigger removal from it to restore the exterior platform edge and the knapping surface (Hahn 1993; Inizan et al. 1999). The removal of a core tablet is therefore a necessity within many lithic concepts for further reduction. If such a lithic object is found it can be seen as good indicator for core re-configuration on-site and also for a discontinuity in core reduction. Because it rejuvenates a core after a reduction sequence for further reduction. Core tablets have characteristic shapes if they are e.g. removed from elongated pyramidal blade cores. Here the characteristic ridges of the negatives from the flaking surface can be visible as back. A rejuvenation of the knapping surface can be seen in other concepts, too. For example for maintenance Levallois cores to be prepared for the next reduction sequence.

Éclats débordants (débordant blanks or core edge flakes) and crested blanks

Other lithic products that are removed form a particular core position are so called *éclats débordants* (Beyries & Boëda 1983). They are described as *„flakes that remove the lateral edge of radial cores“* (Blinkhorn et al. 2012) or *„core edge flakes“* (Soressi & Geneste 2011). In a morphological sense (negatives, top view and cross section) they are quite similar to crested blades, because they are removed from core edges in its elongated direction (cordal). For the discoidal concept (e.g., Slimak 2004) they are part of the general form-spectrum. For the Levallois concepts (Boëda 1994) they are removed to maintain the convexity of the flaking surface. In these cases they suggest a continued reduction within the discoidal concepts and a discontinued within the Levallois concepts. But still, they can be wanted forms for further usage (use-wear analysis in Beyries & Boëda 1983). The cross section of these blanks is normally triangular and asymmetric (see fig. 99).

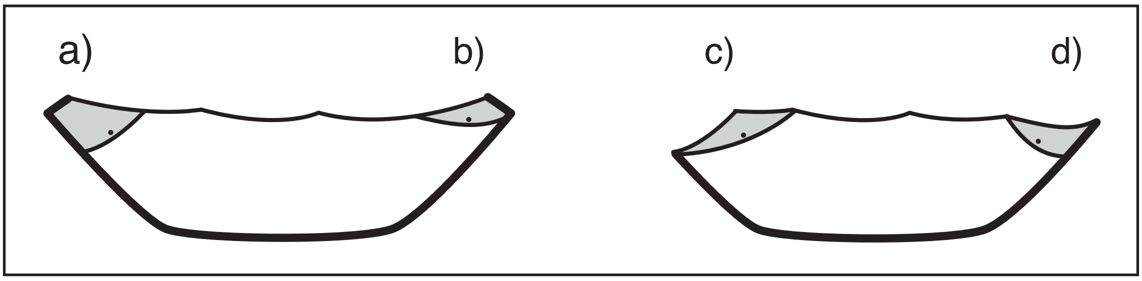

Fig. 99 - The cross-section morphology of éclats débordants varies from its removal position on Levallois cores. a) Asymmetrically trapezoid - two surfaces show negatives from configuration; b) Asymmetrically triangular - one surface shows negatives from configuration; c) Symmetrically triangular - no surface shows negatives from configuration and d) Asymmetrically triangular - one surface shows negatives from configuration

Slimak (2004) showed that *éclat débordants* (and also *éclat à dos débordant* and *éclat à crête*) can be morphologically very close to crested blades. That are removed to configure a flaking surface of a core in that way that long ridges are generated to produce blades along them. Highly characteristically for all of these blanks is (in its first series), that the negatives of there ventral surface start on the crest ridge and are directed to the lateral edges. For Levallois flakes for the first series of a reduction sequence normally the opposite is true, they show centripetal negatives. Crested blades can be an indication for blade reduction within concepts using the crest principle.

Cortical blanks and raw-piece caps

Other blanks are such with entire cortical cover on its dorsal face. They are placed on a very specific position. If they are visible on-site it is highly probably that they were removed to decorticate one or more raw pieces. They represent the decortication phase (phase 1 of Geneste 1985) — the start of intentional reduction of raw pieces. They cannot be attributed to a specific reduction concept, but prove the testing of raw pieces and the initialization (decortication) of raw pieces to simple cores on-site. We will call such blanks with entire dorsal cortex cover simply cortical blanks or raw-piece caps. They are primary if there dorsal face has a total cortical cover and they are secondary (and so on) if they also cover at least one negative. Primary cortical blanks can also be used as implements, but they need to be edge modified because the cortex is normally porous and soft and therefore cannot build a stable and sharp edge (Rottländer 1989).

Sausage and citrus blanks

The name *éclat de tranche saucisson* (Bourlon 1907; Cheynier 1953; Hiscock et al. 2009; Turq 1988, 1989, 1992, 2000) describes appropriately the shape of these blanks, they are characteristic for Quina reduction, as well as *éclats à dos naturel* (sensu stricto) and *couteaux à dos naturel enveloppant* (Turq 1989). Such sausage blanks resemble core tablets, but normally they carry on an edge rests of cortex (see fig. 100). Very often such Quina products yield thick butts (Richter 1997: 165).

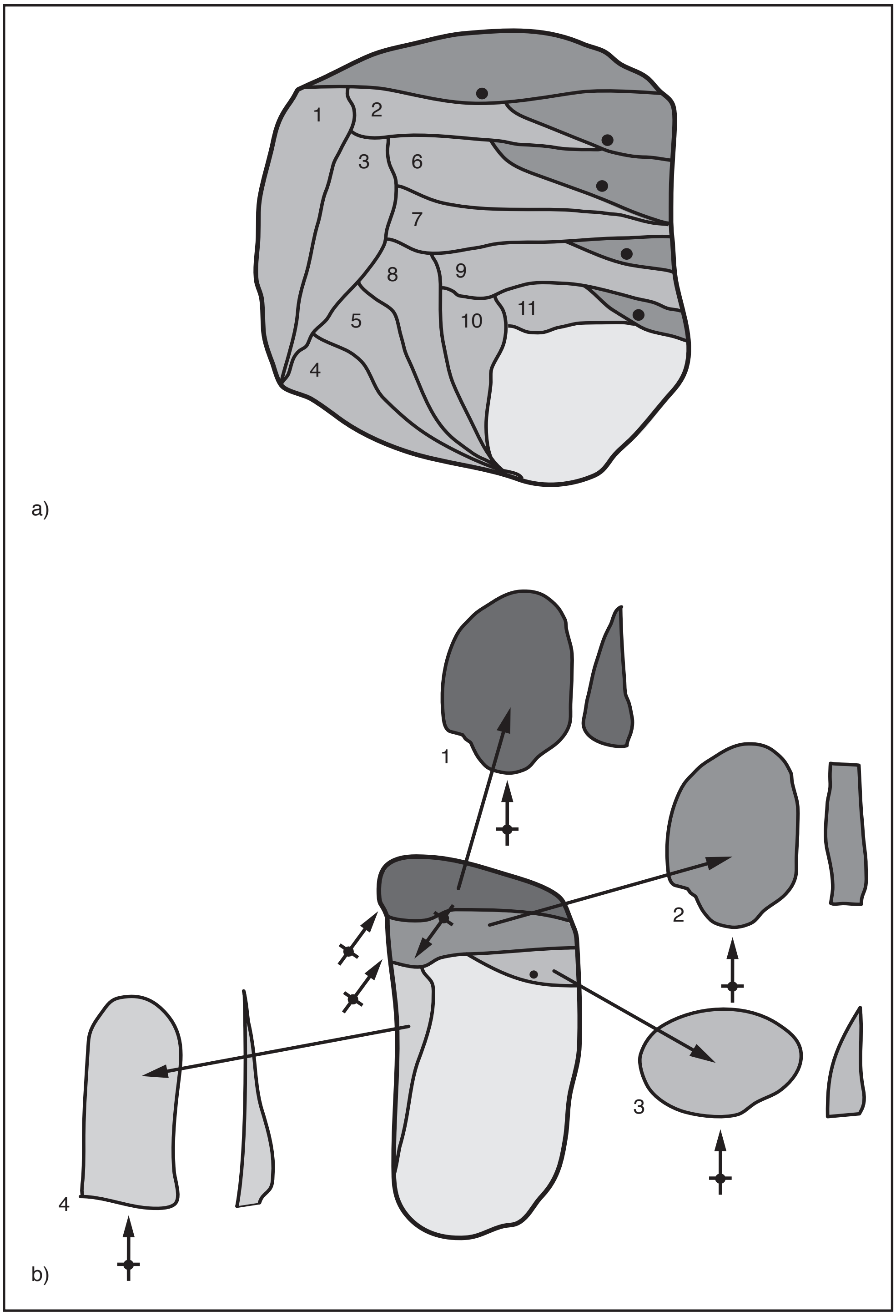

Fig. 100 - Blanks and sequence of Quina reduction. a) Reduction sequence after Bourguignon (1996); b) Blanks from Quina reduction, after Turq (1989), b1) Cortical flake to open the nodule, b2) Éclat de tranche saucisson, b3) Éclats à dos naturel enveloppant (citrus flake) and b4) Éclats à dos naturel

Surface-modification blanks of bifacial shaping

Another class of blanks on specific positions are produced in surface modification (modification 1). Very often they are produced by using a direct-soft-tangential blow. Normally they are flat, wide and sometimes in a trapezoid shape (Newcomer 1971). They are removed to shape a surface in a specific manner (e.c. Callahan 1979). Shape reworked objects (in a uni-, bi- or trifacial way) can be produced within different concepts. Therefore such blanks are not significant for a concepts but for shape reworking of surfaces. They can occur in the production of symmetrical MTA bifaces (Soressi 2002), asymmetrically bifacially backed knives (Jöris 2006) and others. They show a thinning of objects. After Boëda (1995c) there are three variants of surface rework distinguishable (see also fig. 101):

- Plane (façonnage plan)
- Convex (façonnage convexe)
- Plane-to-convex (façonnage plan-convexe)

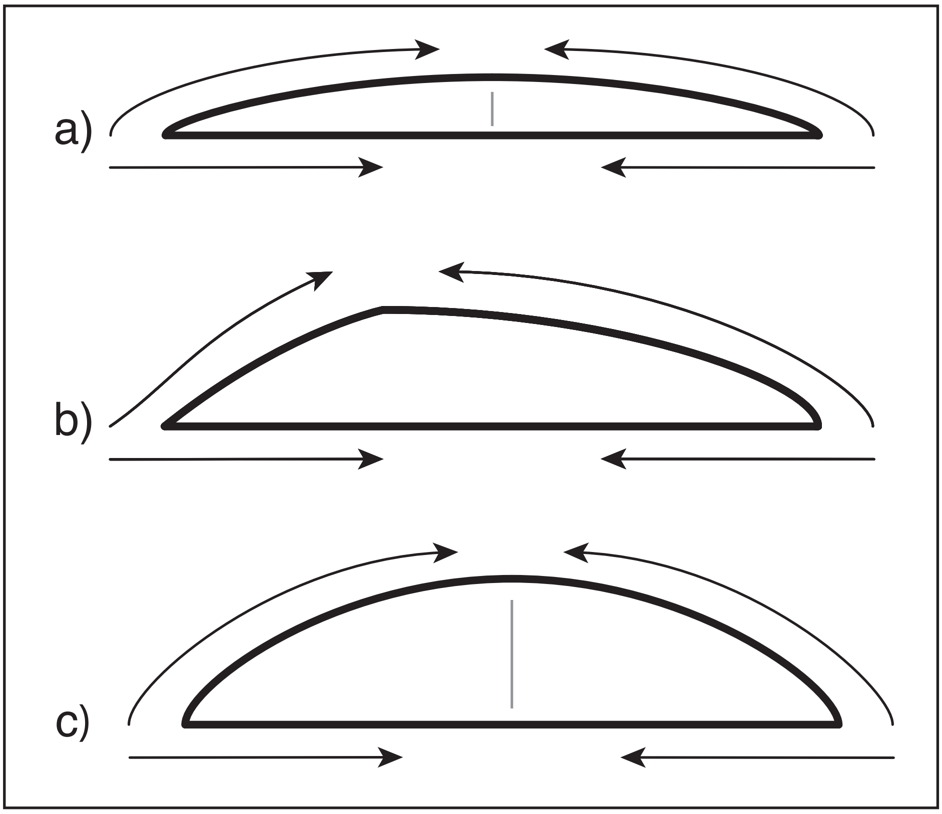

Fig. 101 - Plane, plane-to-convex and convex variation of surface shaping, after Boëda (1995)

Pastoors (2001: 69) describes these variants with the following words: „*Bei der planen Flächenbearbeitung wird eine Kante des Artefakts zu einer gratförmigen Schlagfläche präpariert, auf die anschließend das weiche Schlagwerkzeug senkrecht geführt wird. Dabei entstehen flache Abschläge, die meist in einem Angelbruch enden und einen gratförmigen Schlagflächenrest besitzen sowie dorsal reduziert sind. Für die konvexe Flächenbearbeitung wird die Kante neu präpariert (durch leichte Zähnung), so daß leicht zungenförmige Schlagflächen entstehen, auf die das Schlagwerkzeug tangential geführt wird. Der Abschlag wird dabei mehr abgerissen als abgeschlagen. Er zeigt einen präparierten, zungenförmigen Schlagflächenrest, dorsale Reduktion, deutliche Strahlenrisse auf der Ventralfläche und einen konkaven Längsschnitt. Die Negative der planen Flächenbearbeitung sind flach und enden meist in einem Angelbruch. Die Negative der konvexen Flächenbearbeitung sind aufgewölbt und haben in der Regel flache Distalpartien. In Abhängigkeit vom Ausgangsstück können auch Negative der Grundformproduktion mit in die Konzeption des Werkzeugs einbezogen worden sein.*“

We would like to decipher and complement these variants of surface shaping as shown in the following. These variants have in common that they are normally done with the aid of the direct-soft hammer technique, but they differ in handling. The plan variant has the aim to lower a surface in a flat and parallel manner (see fig. 102a). The inclination of the surface will stay nearly constant. If the processing surface is flat, hinges are mostly not avoidable, because a flat surface swallows the energy. With my own experience in knapping, I can say that such can also be done by using hard hammer technique. Normally the but of the blanks tends to be small, show abrasion of edge correction, as well as small dorsal negative of correction. If there are ridges on the processing surface, they can be used to direct the energy to get flat surfaces. If a convex surface is wanted (see fig. 102b), the produced blanks, as well as the negatives need to be longer and bent (direct-soft-tangential technique) or short and triangular in longitudinal section (direct-hard-linear technique).

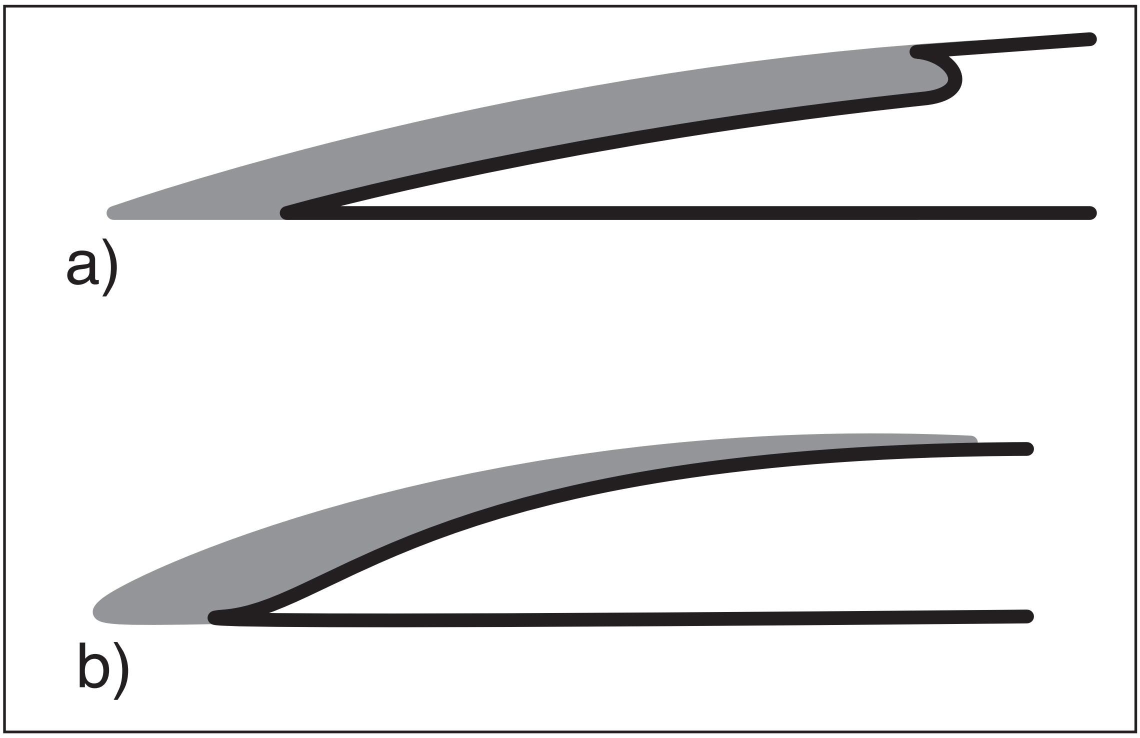

Fig. 102 - Flat and parallel surface shaping versus convex surface shaping. a) Flat and parallel surface shaping; b) Convex surface shaping. After description of Pastoors (2001: 69)

Both, Boëda and Pastoors describe a tongue or sinuous edge (from lateral viewed). For surface rework such an edge is of prime importance, because it guarantees an exact blow positioning. We would suggest that a convex surface rework is only possible in using crest and ridges or a convexity on the surface.

V.3.11. Similar shaped blanks within different reduction schemes

After the discourse of blanks that get their morphology because of their specific core position, we would like to discuss blanks that can be generated within the same concept but with other methods and core schemes.

Of course, these blanks get their shape also from the core position.

This is obvious if we have a look on the Levallois concept. Preferential and recurrent methods can be distinguished. Here, it has to bear in mind that these methods and there schemes can blend into each other (Richter 1997, 2012). For example, typological as Levallois flake denominated objects can occur within different schemes (1997: 166):

- Unidirectional Levallois reduction for a single target blank
- Orthogonal Levallois reduction for recurrent target blanks
- Centripetal Levallois reduction for recurrent target blanks

Richter (1997: 166) conclude, that it is in general rarely possible to attribute specific artifacts (cores and blanks) to a method, because often cores are that exhausted that the last removals are irregularly removed. Therefore these cores do not show the mostly used reduction scheme in the end. To verify distinct reduction schemes it is necessary to include the blanks or if possible do refittings and work piece formation.

Pseudo-Levallois points

A lithic product that can be produced with different flaking surface schemes of cores are so called pseudo-Levallois points (*pointe pseudo-Levallois*). They can be described as almost triangular lithic objects whose knapping axis are not congruent to their morphological axis (see also Bordes 1953c). They are not removed from preferential Levallois point cores, but rather from a centripetal reduction along a crest of discoidal cores (Slimak 2004). But this should not be taken as definitivum. In specific cases, if a configured Levallois core is not configured by-the-book (asymmetric convexity) a flake can be removed whose morphological axis is non-parallel to the knapping direction. In a typological sense this object would be classified as pseudo-Levallois points, but in its technological sense it is an asymmetric Levallois point. This also demonstrated that typological and technological denomination of artifacts should be clearly distinguished as Boëda (2013) points out (for a clarification in english see also Frick & Herkert 2014). Conversely, a typological as Levallois point denominated object can also be thought to derive from a discoidal core reduction as well (see also fig. 103).

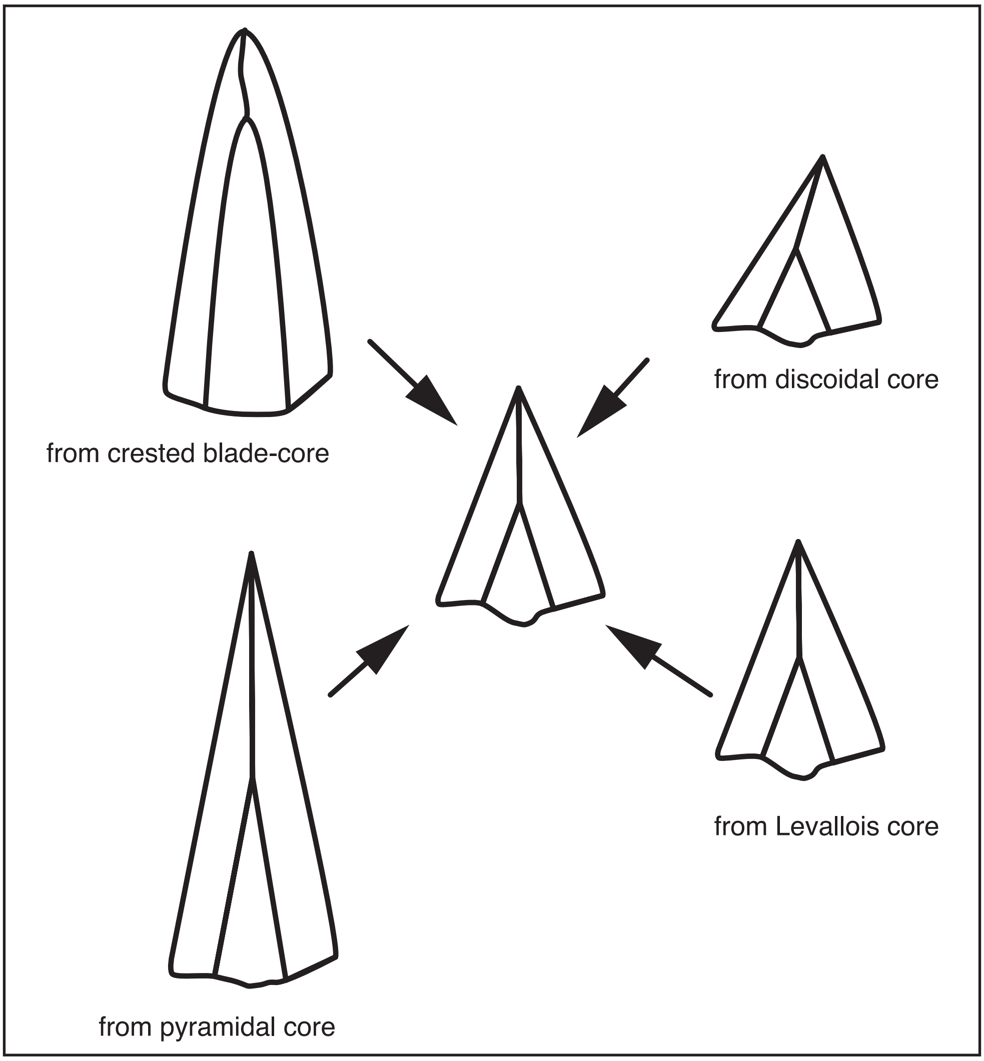

Fig. 103 - Typological Levallois points from different reduction concepts, after Boëda (1994, Fig. 177)

Blades

Another category of lithic objects with the same metrical definition can also be produced with very distinct concepts, methods and schemes. It is the blade. General metrical definitions say that a blade needs to be more as double that long as wide, with a minimum width of 10 or 12 mm (compare e.g., Andrefsky 2005; Bar-Yosef & Kuhn 1999; Floss 2012b; Hahn 1993; Inizan et al. 1999). If only this definitions are used, many ways of production can be thought. Révillion (1994) differentiate it in his compilation of Middle Paleolithic assemblages with blades in Levallois and Non-Levallois concepts of blade production. Within the Levallois concept the following variants can produce blades (Conard 2012; Frick 2010; Révillion 1994; Richter 1997):

- Unidirectional Levallois reduction with a single target blank in blade shape
- Unidirectional Levallois reduction with recurrent target blanks in blade shape
- Bidirectional Levallois reduction with recurrent target blanks in blade shape
- Reduction of lateral edges in the main direction for the production of lateral convexities (*lames débordants*)

But there are many more ways of blade production in Middle Paleolithic context (e.g., Bar-Yosef et al. 2010; Bar-Yosef & Kuhn 1999; Boëda 1988a; Boëda et al. 1990; Cabaj & Sitlivyj 1994; Conard 1990, 2012; Delagnes 2000; Depaepe 2007; Meignen 2000; Nishiaki 1989; Otte 1994; Otte et al. 1990; Révillion 1994; Révillion & Cliquet 1994; Révillion & Tuffreau 1994; Shimelmitz et al. 2011; Slimak 1999; Thissen 2006). Delagnes (2000) summarized known ways of Non-Levallois blade production and distinguished four variants (see also fig. 104):

- Semi-rotated (flaking surface ≈ half surface of a cylinder barrel)
- Rotated (flaking surface ≈ complete surface of a cylinder barrel)
- Frontal (flaking surface ≈ narrow side and edge of a cuboid)
- Facial (flaking surface ≈ convex broadside surface with lesser arc length as in semi-rotated)

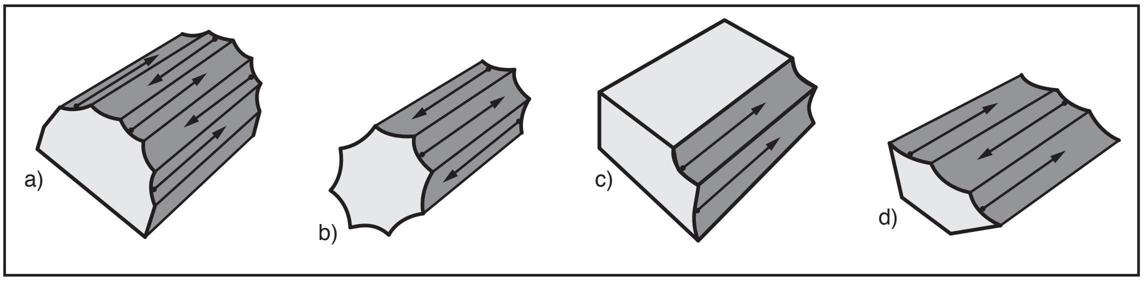

Fig. 104 - Non-Levallois blade production concepts, after Delagnes (2000). a) Semi-rotated; b) Rotated; c) Frontal and d) Facial

Essential here is that in these variants the entire flaking surface is used to produce blades. It seems like that in all of these variants direct-hard techniques are used (Delagnes 2000). A good example for this fact is the assemblage of sites in the Senonais (Yonne, France), because here direct-soft techniques are used to shape surfaces of bifacial objects but hard hammer techniques are used to produce blades (Deloze et al. 1994; Depaepe 2007). This seems to be a general trend. Soriano et al. (2007) write that the first use of direct-soft techniques for blade production is documented from the beginning of the early Upper Paleolithic (Châtelperronian in Western Europe and Early Upper Paleolithic in the Near East and Northern Africa).

To distinguish direct-hard and direct-soft techniques the experimental work of Roussel (2005) is of importance. He shows ways to distinguish between direct-hard-straight (e.g., quartzite), direct-semi-soft-straight (e.g., *pierre tendre*) and direct-soft-tangential (e.g., antler billet) techniques. Therefore it seems possible to assign specific production sequences to specific techniques and reveal patterns. Concerning the production of blades, the simple existence of them shows that they are produced but the distinguishable concepts, methods and schemes need to be detected. Hence, this is part of the interrogation in analyzing the material.

V.3.12 Correlation between shape of the raw piece and used technology

In this section we are discussing the question if the shape of a raw piece influences the used technological concept of reduction. For this we need a definition for the shape of raw pieces. A classification scheme for raw pieces classify them into three shape types (Floss 1994, 2012b), listed in tab. 81:

Raw piece shape	Description
Nodule	Spheroid, irregular, round, not flat, potato-shaped
Disc-shaped (Fladen)	Flattened, disc-shaped, lenticular, regular
Plate	Flat, banked, quite parallel surfaces

Tab. 81 - Shape types of raw materials pieces (Floss 1994, 2012b).

We would reckon that a knapper tests raw pieces and selects one that fits (shape, size, quality, etc.) for the task. Some examples shall illustrate this assumption. If large blades are wanted it seems that an elongated raw piece is more useful than a spheroid (example: *live de beurre* from Grand-Pressigy flint), above all concerning productivity and handling. Also we would assume that for the production of bifacial objects from raw pieces a flat one is preferred. But economy does not have to be the solitary factor. In the case of existence of huge amounts of raw material bigger pieces can also be reduced that long that the wanted product is generated. We would suggest that for secondary production (blanks from blanks) the correlation of raw piece shape and wanted blank is not that strong, because a secondary concepts can also be realized with wast products of the primary production.

Repeatedly, the correlation between concept and raw material is discussed if Levallois and discoidal concepts are discussed (but see also Stapert 2007a, b). An assumption is there that for Levallois reduction flat raw pieces (disc) are preferred and round ones (nodules) for discoid production. The following table shows correlations between raw piece shape and used lithic concept from literature (tab. 82):

Correlation visible?	Site	Common raw piece shape	Commonly used concept	Literature
Yes	Sesselfelsgrotte	Big nodules (jurassic chert)	Levallois and Kombewa	Uthmeier 2004
Yes	Sesselfelsgrotte	Nodules of high quality from distance (jurassic chert)	recurrent-parallel Levallois, recurrent-convergent Levallois	Uthmeier 2004
No	Zeitlarn	Every kind of raw material	Levallois	Uthmeier 2004
Yes	Zeitlarn	Primary jurassic chert plates	blades	Uthmeier 2004
No	Fumane	Every kind of raw material	Discoidal	Peresani 1998
No	En Roche à Germolles	Different shapes of nodules of flint from the argiles à silex and also from jurassic chert are used	Carinated pieces and burins	Herkert 2014

Tab. 82 - Listed correlations between raw piece shape and used lithic concept

V.3.13 Predetermining and predetermined blanks

Predetermination was accepted as one of the main criteria for the definition of Levallois blanks production (e.g., Boëda 1994; Bordes 1988; Commont 1909; Reboux 1873; Schlanger 2013). For Bordes (1950b) a Levallois flake was defined as follows: „[…] *nous appellerons éclat Levallois, un éclat à forme prédéterminée par une préparation spéciale du nucléus avant l'enlèvement de l'éclat*". For him, the predetermination of a flake depends on a special preparation (core configuration) of the core.

The predetermination of a blank (a blank with a wanted shape) depends on many factors. To get an idea what all is of importance to produce a blank that is shaped in the way as wanted, the following tab. 83 is provided (non exhausted):

Important factor	What is controlled?	Who or what controls this factor?	Example
Shape of the reduction volume (shape of the flaking surface)	Convexities or crests controls surface reflexion of the induced energy	The knapper while knapping in dependence of raw material factors	It is almost impossible to produce elongated blanks with a transversally wavy flaking surface
Shape of the reduction volume (shape of the knapping surface)	Position of the knapping point, relief and roughness of the surface control the necessary energy, accuracy of the blow, blow angles, the blow direction, propagation of energy in the core	The knapper while knapping in dependence of raw material factors	The better the exact point is hit the more accurate the blank can fulfill the wanted (predetermined) criteria
Accuracy of the blow	Control of the induced energy, accuracy of the blow, blow angles, the blow direction, propagation of energy in the core	The knapper while knapping in dependence of raw material factors	The more accurate a blow is conducted the more the blank can fulfill the wanted (predetermined) criteria
shape of the grasping volume	control of the surface reflexion of the induced energy and the absorption of energy into the hand, the thigh, the handle, the anvil, etc.	the knapper while knapping in dependence of raw material factors	a core must be hold or fixed in a specific way that a specific wanted blanks can be produced
raw material	energy transport, breakage features, knappability, shape possibilities	the knapper while raw materials selection in dependence of raw material factors	grain size, cohesion and adhesion forces influence the knapping properties

Tab. 83 - Important factors that are necessary to consider if it is wanted to produce a blank that is shaped in a wanted way as wanted

It is highly possible that there are many more factors that influence an accurately wanted shape of a blanks. If we talk in general, also factors like temperature, sun or rain, mood of the knapper, motivation, abilities, possibility of sitting, space and time and many more can influence a flint knapper and its used raw materials. After discussing this another aspect of blank production has to be discussed. This is how the shape of a knapping surface can default the shape of a manufacturing

product. In the following the design of a knapping surface is discussed. Substantially, there are two variations in shaping of a knapping surface: The generation of one or more crests (*Leitgrat(e)*) or of a convex surface (this is discussed later more extensive, see chapter V.3.8 and is denominated a litho-technological principle). Throughout the research history of the last decades it was shown that these both principles can exist parallel with minor chronological relevance. Indeed, the use of crests for production initialization is very common in Upper Paleolithic times but also earlier both principles are used.
We would expect that a knapper, who wants to produce blanks for further use, has an anticipation how a blank should look like. In this case, in the literature the contrastive pairs of predetermined and predetermining blanks is repeatedly thematized (e.g., Lourdeau 2011a; Mourre 2006). The predetermination of blanks was fully established by F. Bordes in his work about preferential Levallois (Bordes 1950b, 1961). But the first definition are much older. For example, J. Boucher de Perthes (1857) defined the production of such blanks: „*Ce sont des éclats dont on a d'abord préparé la surface en la taillant sur le bloc ou rognon de silex, ce qu' on reconaît aux deux ou trois arêtes qu' on voit à leurs parties convexes, puis qu' on a ensuite détachés de ce bloc d' un seul coup*." He described the configuration of core surfaces, noticed the convexity and described the removal of target blanks. Also G. de Mortillet (1883) described the morphology of Levallois blanks: „*Ce sont des éclats très grands et très larges, de forme ovale, belles pièces à arêtes vives, ce sont les plus grndes de cette époque*." Also V. Commont (1910) described Levallois production technological on material found in Northern France (collection of raw material, core preparation, target blank removal). Some years before, J. Reboux collected artifacts in Levallois and described the production of blanks in this specific manner (Schlanger 2013).
A simplistic classification into predetermining and predetermined forms of blanks is not always valid, as example for so called *éclats debordants*. These blanks are removed to control the lateral convexity of a Levallois core (Boëda 1994) or in the case of discoidal cores to remove a crested blade in cordal direction (Slimak 2004). Use-wear analysis on *éclats débordants* in Levallois production shows their use (Beyries & Boëda 1983), sometimes they are also retouched (Frick 2010) what suggests their use.
Another example are centripetal and orthogonal Levallois cores. For them it is extremely sophisticated to separate the produced blanks into predetermining and predetermined ones, because it is purposed that most of the blanks can have both functions.

Lourdeau (2011) classifies blanks as followed (tab. 84):

Determination	Products	Morphology
Predetermined blanks	Levallois blanks (points, flakes and blades)	Mostly facetted butt Morphology is predetermined by core's convexity
Predetermining blanks	Configuration blanks	No facetting of the butt Determination of the morphology of flaking and knapping surface

Tab. 84 - Lourdeau's (2011) division of predetermined and predetermining blanks

But we always have to bear in mind that every removed blank forms the flaking surface and therefore every blanks removal is predetermining for the following removals. A surface and volume argument can summ this up (tab. 85):

Argument	Explanation
Surface	A predetermining or predetermined blank can shape a surface in such a specific manner that the following blanks are also predetermined in their shape, independent from the facts if the following blanks are configuration blanks that are immediately discarded after removal or if the blanks are wanted and could be used for other tasks
Volume	A predetermining or predetermined blank is a volume that is removed from a core and is therefore a lost of volume of the formerly raw piece

Tab. 85 - Surface and volume argument of predetermining and predetermined blanks

The argument that has to follow is that all blanks can be predetermining for the following removals and some of them can be predetermined in that way that they can be used for further tasks. But also a blank that is removed to shape a surface needs to be predetermined in its shape to fulfill the wanted purpose to remove a specific volume from a core.

Ever and anon the impression is inspired that mostly blanks from the middle section of a flaking surface with very simple geometric forms are called predetermined.

Another question is, in which way a knapper is able to predetermine the shape of a blank. As we know, a knapper has to interact within the physical laws (breakage mechanical principles), but is able to control the kind of raw material (and its condition), the shape of surfaces and angles (configuration), as well as the kind of the introduced force (technique) or the kind of grasping the core (fixation). All these aspects influence if a wanted blank has its wanted shape.

By choosing a specific position for the impact point (in producing a blank) a knapper can control the shape of a blank (see chapter II.6). By coming back to ridges (the higher areas of the flaking surface), they play an important role. Van Peer (1992) shows contour lines on blanks and conclude that if the blanks is produces in parallel breakage the relief of the flaking surface will guid the outline of the blank (see also fig. 96 and 98). His main point is to focus on butt thickness that lead the thickness of a blank and therefore the position of the breakage plane.

He further focuses on the shape of the butt. A specific faceting (*chapeau de gendarme*) produce a lower isosurface and will result therefore in a wider blank (see also fig. 294). In this case it seems that the combination of specific shape of platform, platform edge and flaking surface will result in highly particular blanks that include wanted shapes in all dimensions.

V.4 Litho-technological concepts of the Middle Paleolithic

This chapter gives an overview on technological concepts for shaping and knapping of lithic objects in European Middle Paleolithic context proposed in the literature. The term litho-technological concept is defined earlier (chapter V.3.2). As seen above there are many definitions of lithic concepts. The following chapter tries to structure these concepts into a temporally hierarchical succession, because some concepts exist that can only be followed if other concepts are used before. The idea here is to structure working steps that are combined into a concept of lithic object production into their temporal succession. For comparison, occasionally lithic reduction concepts from extra-european concepts are mentioned, as well. Rarely only one concept or lithic reduction strategy is used to produce implements for further tasks and often other strategies can be found in the same find horizon. Subsequently, an overview is given of lithic concepts and core types (see also Boëda 2013; Floss 2012b; see also Frick 2010; Frick & Herkert 2014).

V.4.1 Consecutive concepts

As we discussed earlier (chapter V.3.2), a temporal division can be made between litho-technological concepts (we denominate them primary, secondary, tertiary, etc. concept of lithic reduction, but see the use of the term in e.g., Delagnes & Meignen 2006; Delagnes & Rendu 2011). A simplistic example can explain this circumstance. There are concepts that can provide blanks from the reduction of another blank. In this case, a blank that is used as core has to be produced first. In other words, a primary concept transforms a raw piece into core and blank(s), a secondary can use these objects for further production of blanks, a tertiary concept in turn use the secondary products for another production cycle. The subsequent table illustrates this hierarchical succession (Tab. 86):

Used object	Primary concept	Secondary concept	Tertiary concept	Example for products
Raw piece	Object has the potential to produce one or more blanks	Potential to produce blanks from blanks	Potential to produce blanks from blanks of blanks	Decortication (raw-piece caps)
Simple core	Object has the potential to produce one or more blanks	Potential to produce blanks from blanks	Potential to produce blanks from blanks of blanks	Opportunistic blanks
Configured core	Object has the potential to produce one or more blanks	Potential to produce blanks from blanks	Potential to produce blanks from blanks of blanks	Levallois blanks
Exhausted core	Object had the potential to produce one or more blanks	Products have the potential to produce blanks from blanks	Products have the potential to produce blanks from blanks of blanks	Reconfiguration of a core produces also blanks
Blank from core or raw piece	The primary concept produced the used object	Object has the potential to produce one or more blanks from other blanks	Potential to produce blanks from blanks of blanks	Ventral, dorsal or edge removals
Frost debris	Primary „concept“ was the formation of the frost debris	Object has the potential to produce one or more blanks from other blanks	Potential to produce blanks from blanks of blanks	Ventral, dorsal or edge removals
Heat debris	Primary „concept“ was the formation of the heat debris	Object has the potential to produce one or more blanks from other blanks	Potential to produce blanks from blanks of blanks	Ventral, dorsal or edge removals
Blank from a blank	Primary was the blank production	Secondary was the blank from the blank production	Potential to produce blanks from a blank that were removed from blanks	Les Tares

Tab. 86 - Temporally hierarchical division of primary, secondary and tertiary concepts of lithic production

But in all of these divisions, we need to keep in mind, that also highly sophisticated conceptual frames like Levallois that normally being thought to be a primary concept (shaping and reduction of a raw piece in a wanted way to produce specific blanks) can be used to transform primary products (e.g., blanks) into a core that can be able to produce blanks. As we can see, also an elaborated concept like Levallois can be thought as being a secondary concept. We do not believe that such division is just a sophistry, because in calculation and analyzing artifact biographies there is a temporal difference between a direct production (primary) of an implement (a used blank) and indirect production (secondary and tertiary). An example here is the calculation of time consumption for production and use of implements (Hallos 2005; Kind 1987; Löhr 1979; Uthmeier 2000). There is the possibility that the knapper performing a primary concept has in mind that there are different ways to do further work. The following list will give ideas what can happen with a product after performing the primary concept:

- Using a secondary concept to produce a blank from it
- Using the produced blank as an implement (i.e. unmodified blank)
- Modifying the produced blank to make a formal tool out of it (i.e. modified blank)
- Discarding of the produced blank

There is also the possibility to stretch the division into hierarchical concepts quite more. This can be seen in the moment a produced blank is retouched after production and is used after as core for further reduction. An example of such a long operational chain with the use of different reduction concepts is the reduction found in Les Tares à Sourzac, Dordogne (Geneste & Plisson 1996).

For the hierarchical division into working steps that have to follow each other, there is no need to start the discussion, if a lithic object is (just) a core or if it is a tool (for discussion to this subject see chapters in McPherron 2007). If we say a tool might be just a used object then it doesn't matter for this division here. It is possible to use an object as a tool or implement after every step of a *chaîne opératoire*.

V.4.2 How to combine unifacial and bifacial concepts of lithic reduction?

Unifacial products (objects made from blanks) are blanks produced from cores. In a following step they can be modified in a unifacial manner (e.g., retouch on their dorsal face) or in a bifacial way (e.g., bifacially retouched edges or one edge dorsally and the other ventrally). Bifacial (and trifacial) objects can also be queued into the idea of hierarchical reduction concepts. A bifacial object can be produced from a raw piece in the way as a core is produced (e.g., core-tool like an Acheulian hand axe) or can be produced from a bigger flake as often seen in the production of *Keilmesser* (Frick & Floss in press). In such a thinking the production concept of a bifacial implement can be primary (directly produced from a raw piece) or secondary (produced from a blank as matrix). A similar idea was formulated by Boëda et al. (1990) in separating bifacial production into *Biface outil* (biface is directly produced as a tool from a core) and *pièce bifacial support* (biface is produced from a flake, that is the matrix for shaping a tool).

V.4.3 Structuring Middle Paleolithic lithic conceptual frames

A lithic concept can be understood 1) as a closed operational chain from the procurement of raw material to the discard of all lithic objects produced from this raw material piece or 2) it can be thought as succeeding working steps for reduction of structured workable objects. The second view provides the frame to structure lithic concepts into a hierarchical system of succeeding sequences of working steps. Listed below — as illustrated in the previous paragraphs — are lithic concepts that can be found in the literature and the try to place them into a hierarchical frame (see tab. 87 and fig. 105):

Litho-techno-logical concept	**Hierarchical options, what can be used to perform this concept?**	**Cultural assignment, facies, techno-complex, space-time-unit in Europe**	**Literature**
Levallois	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	*Moustérien type Ferrassie* (Bordes' facies), *Moustérien typique* (Bordes' facies), *Moustérien à denticulés* (Bordes' facies), *Moustérien de tradition acheuléenne* (MTA, Bordes' facies), Lithic techno-complex Levallois (LTC Levallois), Bohunician, Szeletian, Micoquian,…	Boëda (1994), type F1 in Boëda (2013)
Discoidal	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	Mousterian typique (Bordes' facies), Moustérien à denticulés (Bordes' facies), Moustérien de tradition acheuléenne (MTA, Bordes' facies), Moustérien rhodanien (Combier's facies), Lithic techno-complex Discoidal (LTC Discoidal), Central & East European Micoquian	Peresani (2003), type E1 in Boëda (2013)
Quina	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	Moustérien type Quina (Bordes' facies), Moustérien à denticulés (Bordes' facies), Lithic techno-complex Quina (LTC Quina), Micoquien	Bourguignon (1997), Hiscock et al. (2009), Turq (1989, 1992), type not mentioned in Boëda (2013)
Barrenförmige Kerne	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	Early Middle Paleolithic	Bosinski & Sitlivyj (1990), Chabai & Sitlivyj (1993), type not mentioned in Boëda (2013), Chabai & Sitlivyj (1993) define this type as trifacial
Trifacial	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	Acheulian	Boëda (1993), type not mentioned in Boëda (2013)
Clacton, bipolar splitting	Surely, mostly used for opening of raw pieces (primary), but all kind of objects can be reduced with that concept (secondary and tertiary as well)	Lower & Middle Paleolithic	Mourre (2004), Mourre & Jarry (2010), type F3 in Boëda (2013)

Pyramidal	We would expect that for bigger cores a raw piece was used (primary), in bladelet production we can expect that blanks were used (secondary)	Middle Paleolithic, Upper Paleolithic	Spencer & Gillen 1912; Garrod & Bate 1937; Garrod 1956; Garrod & Kirkbride 1961; Jelinek 1975, 1981, 1982, 1990; Mulvaney 1975; McCarty 1976; Bordes 1977; Marks & Volkman 1983; Meignen 1993, 1994; Lhomme et al. 1999, type E2 in Boëda (2013)
Système par surface de débitage alterné	Can be performed on a raw piece or core (primary) or a bigger blank (secondary)	Late Lower Paleolithic, early Middle Paleolithic	Amiot (1993), Forestier (1993), type C1 in Boëda (2013)
Prismatic laminar reduction (rotating)	Because of the elongated blanks that are produced it is expected that raw pieces were selected to perform this concept (primary)	Middle Paleolithic, mostly OIS 5	Delagnes (2000), type F2 in Boëda (2013)
Semi-prismatic laminar (semi-rotating)	Because of the elongated blanks that are produced it is expected that raw pieces were selected to perform this concept (primary)	Middle Paleolithic, mostly OIS 5	Delagnes (2000), type F2 in Boëda (2013)
Laminar reduction along an edge (frontal)	Because of the elongated blanks that are produced it is expected that raw pieces were selected to perform this concept (primary)	Middle Paleolithic, mostly OIS 5	Delagnes (2000), type F2 in Boëda (2013)
Facial laminar reduction	Because of the elongated blanks that are produced it is expected that raw pieces were selected to perform this concept (primary)	Middle Paleolithic, mostly OIS 5	Delagnes (2000), type F2 in Boëda (2013)

Ventral reduction (Kombewa)	Removal of blanks from the lower surface, the ventral face of another blank (secondary)	Lower & Middle Paleolithic	Frick (2012, 2013), Tixier & Turq (1999), Newcomer & Hivernel-Guerre (1974)
Dorsal reduction (truncated-facetted pieces, Kostenki, Nahr Ibrahim, Sinew frayer)	Removal of blanks from the upper surface, the dorsal face of another blank (secondary)	Lower Paleolithic, Middle Paleolithic, Upper Paleolithic	Frick (2012, 2013), Tixier & Turq (1999), Newcomer & Hivernel-Guerre (1974)
Edge reduction (burin)	Using an edge of a blank as crest to remove burin spalls	Lower Paleolithic, Middle Paleolithic, Upper Paleolithic	Klaric (2003), Tomásková (2005), Zwyns et al. (2012)
Edge reduction (tranchet blow, Schneidenschlag)	Similar to burin reduction, performed in longitudinal direction of an edge that needs to be sharpened, not totally a removal of the edge, more removal on a surface with taken with a part of the edge	*Keilmessergruppen* (KMG), main distribution around 75, 65 and 55 ka BP	Jöris (2004, 2006, 2012)
Les Tares	Primary production with SSDA, use of these blanks as matrices for further reduction (secondary), these blanks can also be reduced further (tertiary)	OIS 6	Geneste & Plisson (1996), Faivre et al. (2010)
Le Pucheuil	Use of Levallois flakes from primary production to reduce them from their lateral in different ways (secondary)	beginning of OIS 6	Delagnes (1993), Delagnes & Ropras (1996), Lazuén & Delagnes (2014)
Production of Szeletian leaf points in Moravia	Thick blanks (secondary) are used as matrix	Szeletian (leaf point complex)	Neruda & Nerudová (2005, 2010)
Bifacial production of symmetrical bifaces	Use of raw pieces, cores (primary) and big blanks (secondary)		Soressi (2002)
Bifacial production of asymmetrical bifaces (also backed bifaces)	Use of raw pieces, cores (primary) and big blanks (secondary)	Keilmessergruppen (KMG), early Middle Paleolithic (Galería Pesada, La Micoque)	Jöris (2001, 2004, 2006, 2012), Frick & Floss (2015)

Tab. 87 - Compilation of lithic production concepts from Middle Paleolithic context with their used matrix and cultural assignment

The following fig. 105 provides a scheme how specific lithic reduction concepts can be hierarchically placed into a general reduction sequence system. The attempt here is (as described above) to show that some (in the literature) described reduction concepts have a specific position in a reduction sequence system and others can have different positions.
For the sake of completeness (tab. 88 to 91), we add here the overview of lithic production concepts published in Frick & Herkert (2014, tab. 5 to 8):

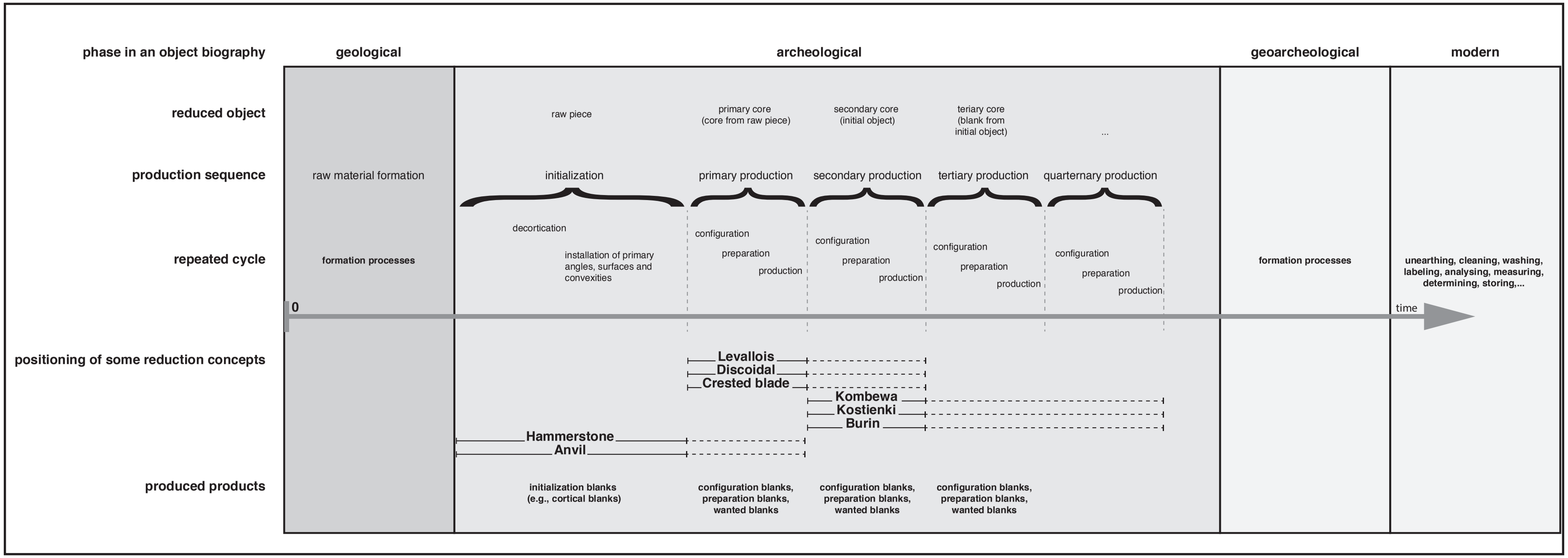

Fig. 105 - Conceptual attempt to structure lithic reduction concepts into a hierarchical reduction sequence system (non exhaustive, some of the aspects displayed here are explained in the next chapter)

Core type	Quina	Barrenförmige Kerne	Ventral face flaking	Dorsal face flaking	Edge flaking	carinated pieces
Concept	Flaking along two reference planes	Bidirectional removal of blanks from the lateral edge of a core	Removal of blanks from the ventral face of a blank, Kombewa	Removal of blanks from the dorsal face of a blank, Kostenki, Nahr Ibrahim, truncaded-faceted pieces	Removal of blanks from the edge of a blank, burin, para-burin	Removal of bladelets from a carinated piece
Sites or distribution	Western Europe	Germany	All over the world	All over the world	All over the world	Western Eurasia, Levante
Literature	Turq 1988; Bourguignon 19996, 1997, Hiscock et al. 2009	Bosinski & Sitlivyj (1990)	Owen 1938, 1940; Tixier & Turq 1999; Frick 2012, 2013	Tixier & Turq 1999; Klaric 2000; Frick 2012, 2013	Tixier & Turq 1999; Jöris 2001; Klaric 2003; Frick 2012, 2013	Hahn 1988; Chiotti 1999; Le Brun-Ricalens & Bordes 2007
Selection of used and unused Volumens and surfaces	Selection of a convexe flaking surface and a fitting striking platform	Selection of a long convex flaking surface and two opposite striking platforms	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface or a crest and a fitting striking platform	Selection of a crest, the lateral edge or a truncation	Selection of a thinker piece
Initialization	Unidirectional along two surfaces	Initialization of a convexe flaking surface and two fitting striking platform	Production of a blank as core	Production of a blank as core	Production of a blank as core	Production of a blank as core
Configuration	Configuration of interchangeable flaking surface and striking platform	Configuration of flaking surface and striking platforms	Flaking surface and striking platform are not interchangeable	Configuration of a striking platform	Configuration of a striking platform	Preforming the flaking surface
Rhythm	Continuous	Continuous?	Production of single pieces	Production of single pieces or small series, sparse configuration, production of single pieces or small series	Production of single pieces or small series, sparse configuration, production of single pieces or small series	Production of a large series
Homothety	Possible	Yes	No	No	No	Yes
Auto-correlation	Yes	Yes	No	No	No	Yes
Auto-configuration	with beginning of the production	Yes	No	No	No	Yes
Used Volume	The whole bloc is used	The whole bloc is used	Only a part is used	Only a part is used	Only a part is used	Only a part is used
Volumetry	Exploitation of two surfaces	Exploitation of one surface	Exploitation of one surface	Exploitation of one surface	Exploitation of one surface (edge), possibility to use other, too	Exploitation of one surface

Hierarchy	No	Yes	Yes	Yes	Yes	Yes
Direction of production	Unidirectional	Bidirectional	Unidirectional, bidirectional, centripetal	Unidirectional, bidirectional, centripetal	Unidirectional, possibly bidirectional	Unidirectional
Production sequence	Small series	Large series	Single pieces	Single pieces or small series	Single pieces or small series	Large series
Premiss	Alternating of striking platform and flaking surface	Convexity of the flaking surface	Convexity (bulbe)	Crest, scars	Long edges	Round flaking surface
Aim	Elongated cutting edges	Circular cutting edges	Circular cutting edges	Elongated cutting edges	Elongated cutting edges	Elongated cutting edges
Confection	Blanks can be retouched	Blanks can be retouched	Blanks can be retouched	Blanks can be retouched	Blanks can be retouched	Blanks can be retouched
Predetermination	For transformative and prehensile parts	For transformative and prehensile parts	For transformative and prehensile parts	For transformative and prehensile parts	For transformative and prehensile parts	For transformative and prehensile parts
Produced blanks	Oval and rectangular flakes	Oval and rectangular flakes	Oval flakes with two „ventral faces“	Elongated flakes, bladelets	Bladelets	Bladelets
Used raw material	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous
Technique	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight or direct-soft-tangential	Direct-hard-straight or direct-soft-tangential	Direct-soft-tangential
Identification in archeological context	Good visible	Good visible	Good visible	Good visible	Good visible	Good visible
Chronology	Middle paleolithic	Middle paleolithic	Lower Paleolithic to Neolithic	Middle Paleolithic to Neolithic	Middle Paleolithic to Neolithic	Mostly in the Aurignacian

Tab. 88 - List of some reduction concepts summarized with Boëda's conceptual criteria but missing in Boëda (2013), tab. 5 in Frick & Herkert (2014)

Core type	A	B	C1	C2	D1	D2	D2	D3	D3	E1	E2	F1	F2	F3
Concept	Unknown, „expedient“	Unknown	Opportunistic surface exploitation, System par surface de débitage alterné (SSDA)	Laminar	Victoria West, Proto-Levallois, Para-Levallois, Tabelbala-Tachenghit, Kombewa, TypeRocourt,…	Laminar	Lamellar	Centripetal, discoidal for axial (symmetric) triangular flakes	Centripetal, discoidal for non axial (asymmetric) triangular flakes	Discoidal	Pyramidal	Levallois	Laminar and lamellar	Reduction of rounded pebble stones
Sites or distribution	No	Lokalalei	High Lodge (UK), Point aux Oies à Wimereux; Montsaugeon en Haute-Marne (F); Monte Poggiolo (I); Gimpo, Guanyindong, Guizhou (CN)	Barbas, Saint-Valéry-sur Somme, Tourville-la-Rivière (F); Kaféine (SYR); Kapthurin (EAK)	Fejej (ETH); Korlolevo (UA); Barbas, Cagny-la-Garenne, Tares à Sourzac, Villiers-Adam-Val d'Oise, Ault Onival, Hermies (F);	Europe, Levant; Barbas (F); Kaféine, Umm el Tlel (SYR);	Europe, Levant; Umm el Tlel (SYR);	Villier-Adam-Val d'Oise (F); Umm el Tlel (SYR)	Villier-Adam-Val d'Oise (F); Umm el Tlel (SYR)	All over the world; Queyssac (F); Kůlna (CZ)	Amudien, Tabun, Zumoffen, Boker Tachit, Kaféine, (SYR, IL), Leiliras (AUS), Saint-Firmin-des-Prés (F)	Europe, Africa, Asia, Australia, South America	All over the world	South America, China (Longgupo, Bose), South East Asia (Hoabinien) and Italy
Literature	This book	Roche et al. 1999; Delagne & Roche 2005	Ashton et al. 1992; Forestier 1993; Perreto et al. 1998; Li 2011	Boeda 1997; De Heinzelin & Haesaerts 1983; Guilbaut & Carpetier 1995; Johnson & McBrearty 2010	Boëda et al. 1995; Boëda 1997; Bordes 1961; Van Riet Lowe 1945; Tixier 1957; Owen 1938, 1939; Otte et al. 1990; Lumely et al. 2004; Valin et al. 2006	Boëda & Bonilauri 2006;	Karlin & Ploux 1994; Nespuolet 1999; Schmider 2002; Bon 2002; Bordes 2006; Bordes & Shidrang 2009; Boëda et al. 2006; Boëda & Bonilauri 2006	Boëda 1991; Locht et al. 2003; Texier 1995; Bourguignon & Turq 2003	Boëda 1991; Locht et al. 2003; Texier 1995; Bourguignon & Turq 2003	Boëda 1993, 1995	Meignen 1993, 1994; Garrod & Bate 1937; Garrod 1956; Jelinek 1975, 1981, 1982, 1990; Garrod & Kirkbride 1961; Mulavaney 1975; Bordes 1977; McCarty 1976; Spencer & Gilles 1912; Marks & Volkman 1983; Lhomme et al. 1999	Boëda 1986, 1988, 1993, 1994; Boëda et al. 1990; Nami 1992; Morello 2005	Dauvois 1976	Pannochia 1950; Boëda et al. 2011; Hou et al. 2000; Colani 1927, 1929; Zeitoun et al. 2008
Identification in archeological context	Difficult to impossible	Difficult	Good visible	Good visible	Diffucult	Good visible, very often, together with C2, E2 and F2	Good visible, very often together with C2, E2 and F2	Good visible	Good visible	Good visible	Good visible	Good visible	Good visible	Difficult
Chronology	Early Lower Paleolithic	early Lower Paleolithic?	Late Lower Paleolithic	pre Saalian blade industries	Late Lower Paleolithic, Middle Paleolithic, before Levallois	OIS 8 to 3, after type C2, before type F2, contemporaneous to E2, Transitional industries, Aurignacian,	OIS 8 to 3, after type C2, before type F2, contemporaneous to E2, Transitional industries, Proto-Aurignacian, Gravettian, Magdalenian, Bardostien ancien (Zagros)	Middle Paleolithic	Middle Paleolithic	Acheulian, Middle Paleolithic, sometimes in Upper Paleolithic and later	Amudien, Middle Paleolithic	Widely spread from around 300 ka on until 40 ka, in the holocene also in South America	Beginning way more than 200 ka in Europe, Africa, Near East	All times

Tab. 89 - Table showing litho-technological concepts, sites and literature used by Boëda (2013) to define his core types. Words in italics are the additions of Frick & Herkert, tab. 6 in Frick & Herkert (2014)

Core type	A	B	C1	C2	D1	D2	D2	D3	D3	E1	E2	F1	F2	F3
Premiss	No	One striking and one flaking surface	Natural convexity	Natural convexity	Natural convexity	Distal and lateral convexity	Distal and lateral convexity	Distal and lateral convexity	Distal and lateral convexity	Removal secant to the reference plane (centripedal) or along to it (cordal)	Plane striking platform and convex flaking surface	Removal parallel to the reference plane	Plane striking platform and convex flaking surface	Splitt fracture
Used raw material	Everything that can produce a cutting edge	Everything that can produce a cutting edge	Everything that can produce a cutting edge	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	Everything that can produce a cutting edge, raw material should be more or less homogenous	
Selection of used and unused Volumens and surfaces	No	No	Selection of a convexe flaking surface	Selection of a convexe flaking surface	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform	Selection of a convexe flaking surface and a fitting striking platform
Initialization	No	No	Shaping of a striking platform or using of a natural striking platform	Shaping of a striking platform or using of a natural striking platform	Ventral exploitation, unidirectional parallel, centripetal	Unidirectional parallel, unidirectional convergent, crested	Ventral exploitation, unidirectional convergent, crested	Unidirectional convergent	Ventral exploitation, unidirectional convergent	Ventral exploitation, centripetal	Unidirectional parallel, unidirectional convergent	Unidirectional, bidirectional, centripetal	Unidirectional, bidirectional, centripetal	Bipolar split fracture of pebbles
Configuration	No	Striking platform	Striking platform	Striking platform	Configuration of a flaking surface and sometimes of the striking platform in different styles (Kombewa, Victoria West, „Levallois“)	Configuration of flaking surface (lateral and distal convexity, sometimes with crests) and striking platform	Configuration of flaking surface and striking platform	Configuration of flaking surface and striking platform	Configuration of flaking surface and striking platform	Configuration of flaking surface and striking platform	Configuration of flaking surface and striking platform	Configuration of a flaking surface (production of a lateral and distal convexity) and a convex striking platform	Configuration of a flaking surface (use of a natural crests, production of a bidirectional crest and a distal convexity) and a plane striking platform	No
Rhythm	Production of single pieces	Continuous	Alternating, exchange of flaking surface and striking platform	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Short flaking series, configuration, short flaking series	Long flaking series, configuration, long flaking series	Splitting and confection
Direction of production	Unidirectional	Unidirectional	Unidirectional, bidirectional	Mostly unidirectional, sometimes bidirectional	Preferntial, unidirectional parallel, centripetal	Unidirectional parallel, unidirectional convergent, bidirectional	Unidirectional parallel, unidirectional convergent, bidirectional	Preferential	Preferential, unidirectional convergent	Preferential, centripetal, cordal	Unidirectional parallel, unidirectional convergent	Preferential, unidirectional parallel, unidirectional convergent, bidirectional, centripetal	Unidirectional and bidirectional	Unidirectional
Production sequence	Single piece	Small series of similar pieces	Single pieces or small series	Single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces or small series	Preferential single pieces
Technique	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight or direct-soft-tangential	Direct-hard-straight or direct-soft-tangential	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight	Direct-hard-straight, direct-soft-tangential?	Direct-hard-straight	Direct-hard-straight, direct-medium hard-straight, direct-soft-tangential, indirect-soft-straight, pressure	Direct-hard-straight
Produced blanks	Non-standardized flakes	Non-standardized flakes	More or less normalized flakes	More or less normalized blades	Oval flakes of different sizes	More or less normalized blades	More or less normalized bladelets	Axial (symmetric) triangular flakes, éclats débordants	Points, non-axial (asymmetric) triangular flakes, éclats débordants	Centripetal direction (long or rectangular flakes, triangular flakes), cordal (éclat débordant, crested flakes and blades), see Slimak 2004, Terradas 2003	Long flakes and blades, triangular flakes and blades	Elongated, oval and rectangular flakes, triangular flakes, blades, éclats débordants	Blades in very different shape and dimension	Split flakes

Tab. 90 - Table showing preparation and production schemes attributed to the core types by Boëda (2013). Words in italics are the additions of Frick & Herkert, tab. 7 in Frick & Herkert (2014)

Core type	A	B	C1	C2	D1	D2	D2	D3	D3	E1	E2	F1	F2	F3
Homothety	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No
Auto-corre-lation	No	No	No	No	No	no	no	no	no	No	No	Yes	Yes	No
Auto-confi-guration	No	No	No	No	No	No	No	No	No	With begin-ning of the production	With begin-ning of the production	No, after re-moving a se-ries a confi-guration step is needed	With begin-ning of the production	No
Used Volu-me	Only one part of the bloc is used	Only one part of the bloc is used	Only one part of the bloc is used, the use volume is independent from each other used volume	Only one part of the bloc is used, the use volume is independent from each other used volume	Only one part of the bloc is used	Only one part of the bloc is used	Only one part of the bloc is used	Only one part of the bloc is used	Only one part of the bloc is used	The whole bloc is used, two volumes are separa-ted by a refe-rence plane (plan of inter-section)	The whole bloc is used	The whole bloc is used to form the core, a fla-king volume and residual volume are separated by a reference plane (plan of intersection)	The whole bloc is used, the flaking surface can rotate around an axis (refe-rence axis)	The whole bloc is used
Volumetry	Surface ex-ploitation	Surface ex-ploitation	Surface ex-ploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	Surface ex-ploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	Surface ex-ploitation	Surface ex-ploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	A possible surface ex-ploitation, but not structural; volumetric exploitation	Volumetric exploitation
Hierarchy	No	No	Flaking sur-face and stri-king platform are interch-angeable	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are interch-angeable	flaking surfa-ce and strik-ing platform are constant	Flaking sur-face and stri-king platform are constant	Flaking sur-face and stri-king platform are constant	No
Predetermi-nation	No, random shape of the blank	Only for transformati-ve part	For transfor-mative and sometimes for prehensi-le parts	Partial for transforma-tive and so-metimes for prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	For transfor-mative and prehensile parts	Normalizati-on of trans-formative and prehen-sile parts	Normalizati-on of trans-formative and prehen-sile parts	For transfor-mative and prehensile parts
Aim	Cutting edge at a blank	Normalized cutting edge at similar fla-kes	Cutting edge, mostly retou-ched	Cutting edge, mostly unre-touched	Cutting ed-ges on (more or less nor-malized) blanks	Elongated cutting edges	Elongated cutting edges	Elongated cutting edges	Elongated cutting edges	Cutting ed-ges on he-terogeneous products	Cutting ed-ges on he-terogeneous and homoge-neous pro-ducts	Planoconvex blanks, diver-sity of blanks	Planoconvex blanks, very similar blanks	Planoconvex blanks
Confection	No	No	Often retou-ched	No	No informa-tion	No informa-tion	No informa-tion	No informa-tion	No informa-tion	No informa-tion	No informa-tion	Can be re-touched	Can be re-touched	Circular re-touch

Tab. 91 - Table showing the litho-theoretical aspects and production aims pointed out by Boëda (2013). Words in italics are the additions of Frick & Herkert, tab. 8 in Frick & Herkert (2014)

V.5 Object biography

V.5.1 Introduction

The history of an object in its archeological (*sensu lato*) context can be described with the term object biography. The term biography is normally used to describe the life of persons. Kopytoff (1986) means it is possible to draft biographies of things. He compares the production with birth, use with life and the moment the thing is not involved in use processes with death. For a lithic object mostly its history is described as *chaîne opératoire* or transformation process. A lithic object starts to be in contact with prehistoric people by the time it is procured. It can pass through numerous transformation steps and if it is not functioning or desired anymore it will be discarded. At best, it will be buried in an archeological context and will be available via excavation or collection.

The whole biography (also: life history) of a lithic object can be divided in four phases (tab. 92):

Phase of the object biography	Context	Research discipline	Literature example
Geological phase	Geological formation of lithic raw material, embedding in geological context	Geology, petrography, material science, archeology (lithic raw material research)	Burkert 2001, Féblot-Augustins 1997, Floss 1994, Siegeris 2010
Archeological phase	Procurement, production, use, transformation and discard by man	Lithic archeology, production analysis, transformation analysis, *chaîne opératoire* analysis, use wear and residue analysis, heat treatment analysis,…	Thousands of examples
Geoarcheological phase	Second embedding in geological context	Geoarcheological analysis, taphonomic processes, embedding and mixing processes	Wißing 2012, Miller 2015
Modern phase	Availability for research and exhibition, storage or modern destruction	Excavation and survey methods, lithic object analysis, research history, museology	Dutkiewicz 2011, Frick & Hoyer 2009,2010, 2012

Tab. 92 - Phases of the object biography

This thesis will mainly shed light on the second phase of object biographies of lithic objects from Grotte de la Verpillière II (see chapter VII to X), but will also integrate its geological context (chapter IV), the used lithic raw material (chapter VI) and describes the site history (chapter IV).

V.5.2 Archeological phase of the object biography

The archeological phase of the object biography contains the lifetime of an object close to man. It starts with the procurement and selection of a lithic raw piece. It passes through phases of processing and use and will end with discarding the object. This object history is also called *chaîne opératoire* (Leroi-Gourhan 1964).

A lithic object can contain important aspects that can be analyzed (e.g., procurement, selection, transportation, initialization,configuration, preparation, production, preferred morphologies, transformation, confection, recycling or re-use). But also aspects of correlation between object and human (e.g., logic of lithic technicity, Boëda 2013; Frick & Herkert 2014; Leroi-Gourhan 1964, 1965). There are functional aspects like how to use a lithic object, the handedness (e.g., Uomini 2006), the hafting (e.g., Rots 2010), materials that can be transformed (e.g., skin, leather, sinew, meat, bone, antler, tooth, wood, fibers other stones, etc.). There are also aspects of cognition (Haidle 2010, 2012), hunting (Delagnes & Rendu 2011; Rendu et al. 2012), lifestyle (Conard & Richter 2011), settlement (Conard 2010b), used lithic raw material (Floss 1994) or all kind of resources, the environment (animals, plants, water) or climatic conditions (Van Andel & Davies 2003) and many more.

For the description of the archeological object biography of single lithic objects, work pieces or assemblages *chaîne opératoire* and transformation analysis methods need to be explained.

V.5.3 *Chaîne opératoire*

Mauss (1947) introduced the concept of *chaîne opératoire* (French for operational chain) into the ethnological discipline and Leroi-Gourhan (1964) as well as Tixier (1967) transformed this concept for prehistory. Essentially, in the 1980s french researchers applied this concept to lithic artifacts (e.g., Boëda et al. 1990; Cahen et al. 1980; Julien 1992; Karlin et al. 1991; Karlin et al. 1986; Pelegrin et al. 1988). „*La première utilité de la chaîne opératoire est de permettre une définition du temps dans un processus en distinguant des étapes, des séquences de gestes ou des gestes isolés*“ (Geneste 1991: 10).

Geneste (1985) studied Middle Paleolithic assemblages (with a dominance of Levallois production) from the Perigord with the help of it. He distinguished 6 phases (phase 0 to 5):

- Phase 0 - acquisition of lithic raw material (visiting a raw material source, collection and testing of fitting raw material pieces as well as the transport to the site)
- Phase 1 - preparation of the raw piece that it can be reduced (core formation)
- Phase 2 - flaking (*débitage*) and shaping (*façonnage*) to produce blanks
- Phase 3 - retouch of blanks into tools
- Phase 4 - use and maintenance of tools
- Phase 5 - discard of useless tools

Turq (1990) structured the lithic material from assemblages from La Borde (Dept. Lot) into 10 groups of artifact types, as it is illustrated in the following table 93:

Group	Task	Lithic representative
0	Acquisition of lithic raw material (collection and testing)	0.1 - Nodules, plates and tested cobbles
1	Decortication	1.1 - Cortical blanks 1.2 - Blanks with cortex (>50%) 1.3 - Fragments with cortex (> 3 cm)
2	Blanks with back	2.1 and 2.2 - Blanks with cortex back 2.3 and 2.4 - Typical and atypical backed knives
3	Common blanks and fragments of blanks >3 cm	3.1 - Common blanks without cortex 3.2 - Common blanks with some cortex 3.3 - Blank for the preparation of flaking surface 3.4 - Blades or blady flakes
4	Levallois blanks	4.1 - Levallois flakes 4.2 - Atypical Levallois flakes 4.3 - Levallois blades 4.4 - Levallois points
5	Blanks for preparation, renewing or recycling of cores	5.1 - Levallois flakes for ? 5.2 - *Éclats débordants* 5.3 - Flakes for edge forming 5.4 - Crested blades 5.5 - Tablet fakes 5.6 - Edge flakes 5.7 - *Lames débordantes*
6	Cores and fragments	6.1 - Spherical cores 6.2 - Discoidal cores 6.3 - Levallois cores for flakes 6.4 - Levallois cores for preferential flakes 6.5 - Levallois cores for points 6.6 - Levallois cores for blades 6.7 - Divers cores
7	Shaping and retouch	7.1 - Flakes of bifacial or scraper shaping 7.2 - Janus flakes 7.3 - Burin blanks
8	Debris and chips	8.1 - Debris > 3 cm 8.2 - Debris < 3 cm 8.3 - Normal flakes between 1 and 3 cm 8.4 - Chips < 1 cm
Bifaces	Bifacial objects	Bifacial objects

Tab. 93 - Turq's (1990) structuring of the lithic assemblages from La Borde (Dept. Lot) into 10 groups of artifact types

Boëda et al. (1990) identified different *chaînes opératoires* in Middle Paleolithic assemblages and discussed the differences between Levallois, bifacial and trifacial concepts. They found four shaping methods:

- Shaping (*façonnage*) - forming of nodules and flakes to produce pebble tools and bifaces (this is present in the Acheulian, Micoquian, *Moustérien de tradition acheuléenne*, Bohunician and Szeletian)
- Flaking I (*débitage* I) - removal of flakes from cores with different methods inside the Levallois, discoid or quina concepts
- Flaking II (*débitage* II) - production of blades, points and special flakes, particular production of special blanks

- Triface - production of blanks and after that use of the core as shaped tool

In the course of the research history different ideas to identify *chaînes opératoires* were formulated. As example (fig. 106) we are illustrating the production-sequence scheme used by Floss (1994, fig. 55):

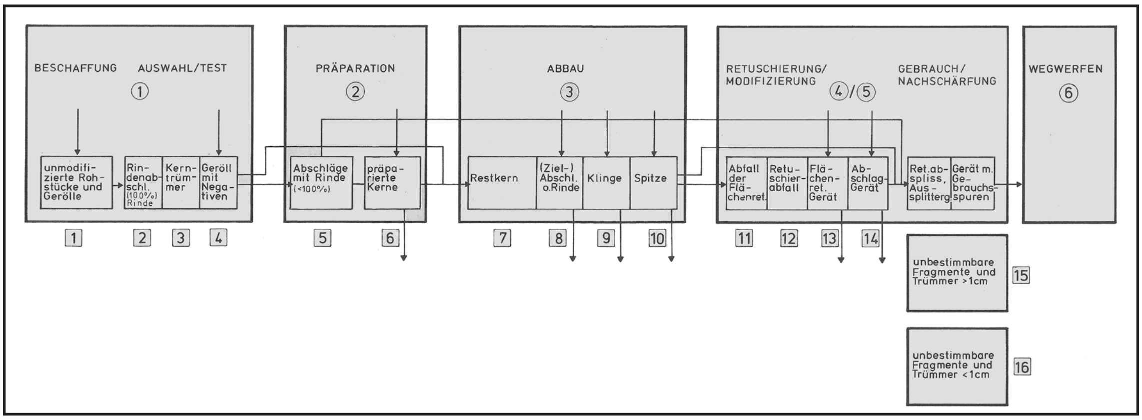

Fig. 106 - Scheme of production sequence used by Floss (1994, fig. 55).

V.5.4. Inter-wining of operational chains and litho-technological concepts

Operational sequences are always interwined with litho-technological concepts (discussed in a chapter before, chapter V.3). Such sequences illustrate the use of „cooking receipts“ (litho-technological concepts) in its authentic context. An operational sequence or operational chain demonstrate the way, how lithic objects were reduced on a site. Weißmüller (1995) explained the *chaînes opératoires* of Geneste (1985) as on-site segments of the complete lithic transformation which includes also import and export of lithic objects. Techno-economical approaches respect that an operational chain can be segmented into on- and off-site steps. For example if a finished formal object is brought into a site, the complete production sequence happened before off-site somewhere else. The other extreme occurs if the complete operational chain of lithic reduction happen directly on a lithic raw material source.

V.5.5 Transport and use

Our aim is to analyze every lithic object found in the site, therefore we would like to add two categories that can occur before and after every step (transport and use). Also a cascade is possible, the so called ramification (e.g., Bourguignon et al. 2004).

There are numerous possibilities how a lithic object can be transported. The following table tries to display some of them (tab. 94):

Kind of transport	Causer	Effect	Literature
River transport, fluvial processes, landslide, rock collapse, solifluction, glacial transportation	Geology	Raw material is not *in situ* anymore, difficulties in estimation of distances, destruction of find coherences	Floss 1994
Export of lithic raw material (raw pieces) from a lithic raw material source	Men	Raw pieces can be used elsewhere	Floss 1994
Export of lithic raw material from a lithic raw material source that was uses as workshop	Men	Cores and blanks can be used elsewhere	Floss 1994
Import of lithic objects into a site	Men	Lithic objects are on hand for further production and use	Richter 1997, Uthmeier 2004, Weißmüller 1995
Horizontal transport on a occupation floor	Men, animal, geology	Dissolution of artifact concentrations, transport between concentrations, accumulation of artifacts, palimpsest	Vaquero 2011, 2012
Vertical transportation between occupation floors	Men, animal, geology	Formation of palimpsests, mixing of different occupation events, bioturbation (terrier and roots), cryoturbation (freezing and thawing)	Araujo 2013, Galanidou 2009, Donald 2012, Hahn 1993, Machado et al. 2013, O'Brien 2006
Export of lithic objects into another site	Men	„lLack" of lithic objects in an assemblage	Richter 1997, Uthmeier 2004, Weißmüller 1995
Import of lithic objects into a depot	Men	Storage of lithic object at a special place	Arcelin 1875, Aubry et al. 2003, Cabrol 1940, Chabas 1874
Import of small rounded pebbles into a site	Birds and other animals	Birds and other animals can transport small stones for different purposes	No literature found

Tab. 94 - Assembly of possibilities to transport lithic objects

There is also the possibility that a lithic object was used after every step of a *chaîne opératoire*. But unfortunately, a specific use of a lithic object can only be seen if it was stored in specific conditions (e.g., Odell 1981). Normally, only the last enduring use is visible and can be documented. Every lithic object can be used, also unworked raw pieces (e.g., as hammerstone or anvil).

V.5.6 Transformation analysis

The transformation analysis established by Weißmüller (1995) bases on the *chaîne opératoire* approach of Geneste (1985) for Middle Paleolithic assemblages from Périgord and the ideas of Löhr (1979), Rieder (1982, 1992), Roebroeks (1988) and Hahn (1988). This analysis tries to visualize import and export conditions of lithic assemblages. The aim of this analysis is to reconstruct operational chains (*chaînes opératoires*) with the help of sorting lithic raw material to raw material varieties and original nodules. While developing this analysis, Weißmüller found out that in *chaîne opératoire* analysis the blank analysis is separated into raw materials but the so called preparation waste of raw pieces and cores formerly on-site is not integrated. He developed the following questions (Weißmüller 1995):

- *„Ist das Gesteinsstück als unbearbeitetes Rohstück, als Kern, als Abschlag oder als fertiges Werkzeug an die Fundstelle gekommen?"* (Did the piece arrive the site as unworked raw piece, as core, as flake or as finished tool?)
- *„Ist das Inventar überwiegend aus den Resten der Kernpräparation, des Grundformabbaus, der Werkzeugherstellung oder des Werkzeuggebrauchs zusammengesetzt, oder wurden die Artefakte ohne erkennbare Veränderung abgelegt?"* (Is the assemblage predominantly compounded of rests of core preparation, of blank production, of tool production or of tool use or are they discarded without visual change?)

The established *chaîne opératoire* is an integral component of this analysis and represent the actual state of an assemblage. But for using this analysis the following (tab. 95) circumstances have to be considered (Weißmüller 1995: 60):

Good circumstance	**Adverse circumstance**
Small number of finds per evaluation unit	High number of finds per evaluation unit
Good condition of the raw material (little post-depositional breaks and little Patina)	Bad condition of the raw material (many post-depositional breaks and fully patinated)
High variability of raw materials	Little variability of raw materials
Possibility to investigate the whole assemblage	No possibility to investigate the whole assemblage
Assemblages represent distinguishable living-floors	Finds are in a thick, homogenous package, without possibilities to separation
Almost no palimpsest visible	Heavy palimpsest

Tab. 95 - Good and adverse circumstances for the use of the transformation analysis

Another point to keep in mind is site facies (raw material source facies, reduction facies, modification faces and deposit facies) and distances to raw material sources. Weißmüller (1995) outlines assumed assemblage compositions of these facies, which are shown in the following illustration, fig. 107 (see alsoWeißmüller 1995, fig. 18):

This conclusion of this compilation is that these assemblage are not directly comparable (Bordesian method), wherein we agree.

The Transformation analysis shows how strong an assemblage is transformed before discard. Or in the words of Chabai et al. (2002): *„Mit Hilfe der Transformationsanalyse ist es möglich, zu bestimmen, wie stark ein Inventar transformiert wurde, ehe es zur Ablage kam. Sie dient zur Vermessung des Transformationsausschnittes, den das Inventar repräsentiert. Hierzu wird eine Gruppierung der Artefakte eines Inventars nach ihren Rohmaterialeigenschaften zu ursprünglich knollengleichen Stücken („Werkstücken") gestrebt. Auf der Ebene der knollengleichen Stücke kann beurteilt werden, in*

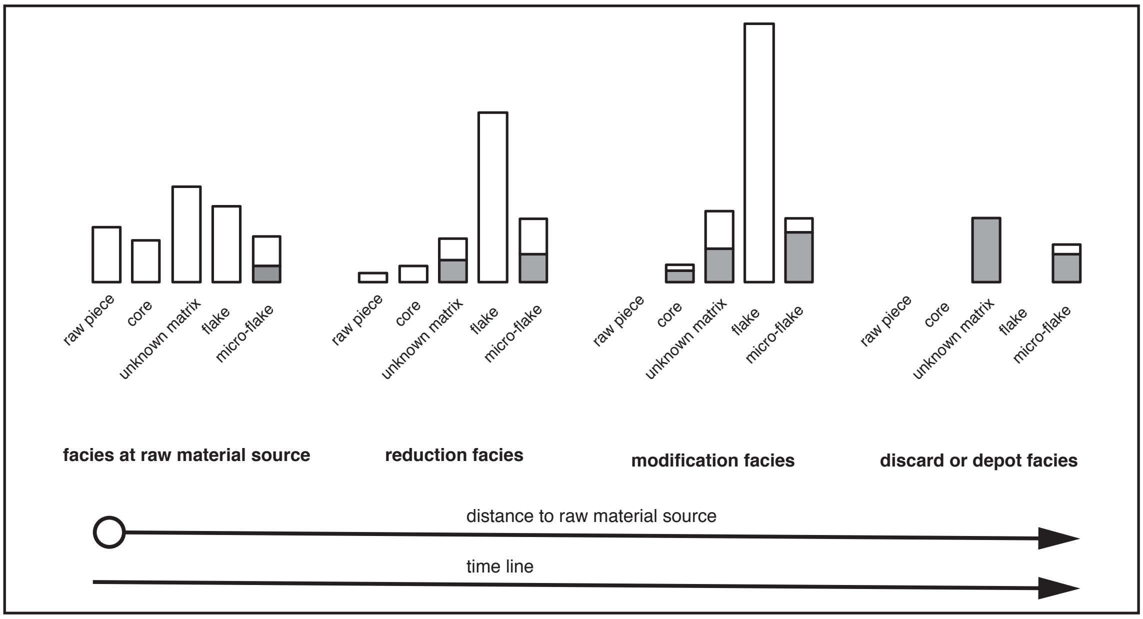

Fig. 107 - The assemblage of a site as transformation sequence. Outline of the site facies (see also Weißmüller 1995, fig. 18).

welchem Zustand ein Werkstück in die Fundstelle eingebracht wurde, welche Teile zur Ablage kamen und ob Artefakte die Fundstelle verlassen haben. Die zurückgelassenen Stücke ermöglichen darüber hinaus qualitative Aussagen über Zerlegungs- und Benutzungsprozesse.“

Raw material units and Workpiece assembly

The starting point of transformation analyses is the assembly of raw material units (RMU). It is the assumption that all pieces belonging to a raw material unit share the same raw material features. A raw material unit is build upon a single object or group of lithic objects by use of different lines of evidence that formerly belong to the same raw piece (Weißmüller 1995) and were removed in removal sequences (core and blanks). The plausibility of this assembly is shown with following features (see also Uthmeier 2004b):

- Number of the lithic objects of a workpiece and the estimated volume. Comparison with samples of raw material from the same source. Check if the number and the maximum length of lithic objects fit into the spectrum of the size of raw pieces
- Shape of raw pieces (i.e., nodule, bread or platte) and its geological origin (e.g., river terrace, residual *Lagerstätte*, primary source). All cortical pieces should show a similar variation of cortex
- Refittings are only possible inside the assemblage of a workpiece
- Normally, the technological character of all pieces inside a workpiece should be very similar
- Spatial distribution, if the lithic objects of a workpiece are *in situ* they should belong to one concentration (but see also Vaquero 2011)

In the assembly of raw material units three classes can be distinguished (Chabai et al. 2002; Uthmeier 2004b; Weißmüller 1995), as it is displayed in the following tab. 96:

Class	Definition	Assumptions
Single piece	A single lithic object, without any sharing raw material characteristics with other objects (e.g., „exotic“ material, particular variety, unmodified raw piece)	A single lithic object was imported in the state it was found during excavation, no transformation (retouch, removal, breakage,…) was done on the site
Work-piece	Two or more lithic objects, belonging to the same raw piece (same raw material characteristics)	Lithic objects of a reduced raw piece (reduction sequence) or lithic objects were transformed on site (retouch, reduction, breakage,…)
Series rest	Lithic objects which show features in such a way that they cannot refer to a workpiece or be a single piece (e.g., highly patination, heat influence, very small size, transparency)	Lithic objects that cannot be analyzed within the transformation analysis

Tab. 96 - Classes of workpieces

These classes of raw material units base on the assumption that lithic objects can be sorted with the aid of macroscopical and microscopical features in small units of raw material groups and to groups of pieces belonging to the same raw piece. Uthmeier (2004b) describes macroscopical features that suggest a very close similarity in raw material of different lithic pieces (tab. 97, see also Floss & Siegeris 2013):

Feature	Diagnostic
Shape of the raw piece	Nodule, disc-shaped, plate
Cortex	Color and structure
Geological find position	Primary, sub-primary, secondary, river,…
Breaks	Cracks, fissure, cemented fissures, fractures
Size comparison	Comparison of the size of raw pieces and single lithic objects
Fossils	Presence and frequency
Bands	Color, position and number
Steaks	Size, color and frequency
Patination	Color, structure, translucence

Tab. 97 - Diagnostic features for distinguishing raw material units

In addition to these macroscopical features, highly technical techniques and methods can be used to differentiate lithic raw materials (short and non-exhaustive selection):

- Microscopical analysis with reflected light microscopes for raw material pieces, transmitted light microscope of thin slices for classification and measurement of microfossils, grains, micro cracks, zoning, inclusions, etc. (e.g., Floss 1994)
- X-ray diffractometry (XRD) to determine mineralogical components and degree of quartz crystallization (e.g., Graetsch & Grünberg 2012)

- Scanning electron microscope (SEM) for the detection of components (e.g., Olsen 1988)
- Laser ablation inductively coupled plasma-mass spectrometry (LA ICP-MS) for chemical fingerprints of lithic raw material (e.g.,Neff 2012; Shackley 2008; Speakman et al. 2002)
- Or Cathodoluminescence (Pretola 2001)

In addition to raw material characteristics litho-technological analyses (see chapter VII to X) and especially in combination with refittings (see chapter X.5) can aid the assembly of raw material units (raw material togetherness).

To summarize the previous, there are in complete five different categories of raw material units that can be separated and described (see Uthmeier 2004b), as illustrated in tab. 98:

Category of raw material unit	Peculiarity	Temporal activity	Advantage and further questions of sorting
Single piece	Lithic object share no features with other objects Object is seen as import in its actual state	Lithic object was produces on another place It was imported as single piece (maybe used) and was discarded on-site	Recognition of an imported object with own (and often long) object biography Is it a part of the so called *Erstausstattung* (basic load)? Is it a particular object?
Workpiece	Two or more lithic objects (with and without refitting) belonging to the same raw material unit To share all the same raw material features is seen as equivalent to physical refittings	Lithic objects can show steps of the *chaîne opératoire*	Possibility of volume and shape estimation. Possibilities to control number and size of lithic objects that should belong to one workpiece. Refittings are only possible inside a workpiece. All objects should share similar technological features. Assumption that All objects of a workpiece should be from one concentration
Raw material variation	Two or more lithic objects of different raw material pieces, but with nearly the same features resample the variation inside a raw material source	Simultaneous import is assumed	Distance between position and raw material source can be seen Are there preferences of raw materials?
Raw material source	Two or more lithic objects of different raw material pieces, but with close the same features resample the variation inside a raw material source	Simultaneous import is assumed	Distance between position and raw material source can be seen Are there preferences of raw materials?
Geological formation	Two or more objects of the same geological formation, the same raw material, sharing the same formation processes	Simultaneous import is questionable	Distance between position and raw material source can be seen

Tab. 98 - Five different categories of raw material units (see Uthmeier 2004b).

Site Formation and raw material units

An essential factor that can compound the assembly of raw material units are so called transformation processes. The major is natural transformation of former living floors (e.g., cyroturbation or solifluction). Schiffer (e.g., 1976, 1999) called natural alteration after the archeological object biography (after discard) n-transforms. Cultural transformation (c-transforms) denotes all human activities in the time of the archeological object biography, like import, processing, export or discard (see Uthmeier 2004b). This can be interactions between artifact concentrations (transport between these) or between sites (see fig. 108).

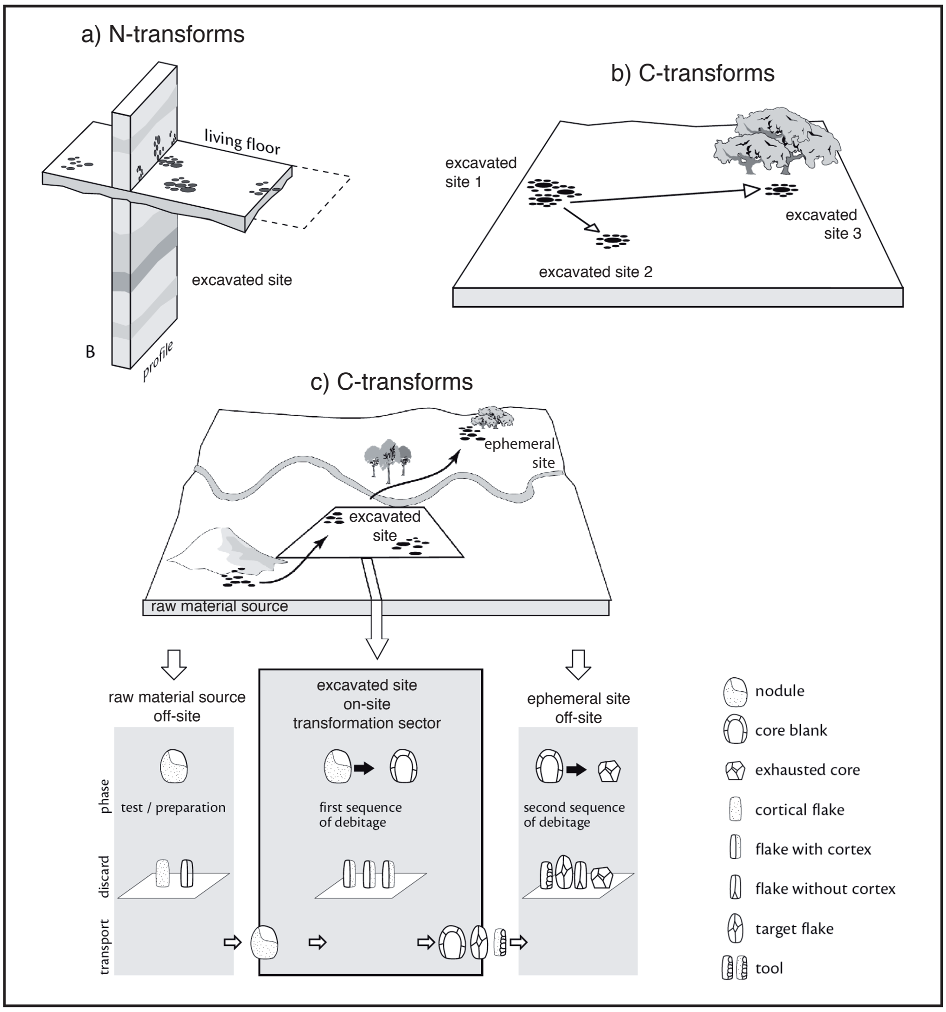

Fig. 108 - Illustration of n- and c-transforms. a) Vertical and horizontal distribution of raw material units; b) Interaction between concentrations of artifacts and c) Transformation analysis to reconstruct operational chains and on-site/off-site passes (Raw material source, Excavated site; Ephemeral site). Figure adopted from Uthmeier (2004b; Fig. 11-1, slighly modified)

Spatial analyses to verify raw material units

To matrix the assembly of RMUs spatial analysis can be undertaken (e.g., Richter 1997) because in some assemblages features of lithic objects can be very similar (fossils, texture, color, cortex, etc.). It is almost impossible to find workpieces: „*Je größer der Anteil homogener Materialsorten gleichbleibender Qualität in einem Inventar* *ist, um so mehr werden sich die einzelnen Werkstücke einander ähneln.*“ (Richter 1997). In this case it is possible to sort several workpieces into one. A possibility to avoid this can be to illustrate the three dimensional distribution of lithic objects assumed to be of one workpiece. The idea is, that objects of one workpiece should be very close to each other. The observation of this neighborhood is divided in four steps (Richter 1997):

- Assembly of raw material units with the aid of raw material immanent characteristics
- Find of typical raw material combinations inside the excavation units
- Addition of peripheral units and check the neighborhood
- Plotting of combinations and verifying the neighborhood

Nowadays, it is simply possible to generate three dimensional position models of single measured objects (so called scatter plots, we are using the software Voxler™ from Golden Software™). Therefore every assumption of a resembled raw material unit (a workpiece) can be piece-plotted easily and can be visually verified. Also such procedure is useful to find evidence to separate assemblage into smaller units (e.g., material belonging to one living floor, see chapter X.15).

Analysis of lithic operational chains on the basis of raw material units

There are many advantages for analyses in the assembly of lithic objects to workpieces. To repeat these (see above) and to add own ideas, these are listed in the following (the list is definitely not exhaustive):

- Only inside a workpiece refittings are possible
- Cores and blanks can be analyzed together in its reduction succession
- The completeness of a former raw piece can be analyzed
- The complete reduction process can be understood
- Possibility to see shifts in reduction strategies inside a workpiece
- Possibility to compare reduction strategies of different workpieces

In the case, a raw piece was reduced on-site and the whole workpiece can be recorded (which is assumed as ideal case), there is the possibility to test the separation of assumed operational steps as it can be found in the literature (e.g., Boëda 1994; Boëda et al. 1990; Geneste 1985; Karlin et al. 1991) and are newly formulated again (Boëda 2013). We are geared towards a good definition and separation of work steps in lithic reduction, because knapping is a hand craft and normally such work can be split into individual work steps.

Determination of import and export

There is the assumption that incomplete reduction sequences (lack of objects of a former raw piece) that can be seen on-site are the result of import and export of lithic pieces (see Uthmeier 2004b; Weißmüller 1995). Therefore, it is necessary to recognize the phases of reduction inside the RMU.

If there are merely lithic objects without cortex, it can be assumed that the initialization (explicitly the decortication and creating of fitting angles) was done off-site. On the other hand, if we find only blanks but no core, the assumption is ambivalent in that case that only the blanks were imported or the core was exported. This example illustrates that also small lithic objects like debris or chips has to be added, because if those blanks were produced on-site, there should be production waste visible.

If the raw material procurement is seen as activity integrated into the settlement event, the phases of the *chaîne opératoire* done outside the camp can provide information about activities before and after the settlement on-side. But there is discussion about the procurement of lithic raw material. Binford (1979) distinguished direct (special purpose procurement trips) and embedded procurement (procurement integrated in the context of other activities). Close (2000) separated procurement strategies into direct procurement (which is done by the group itself) and indirect procurement (done by social exchange). Duke and Steele (2010) combined these ideas and use additional adjectives for procurement in the following sense (tab. 99):

Kind of procurement	Meaning	Original literature
Direct	Procurement from a geological surce by the group that produce and use the lithic objects	Close 2000
Indirect	Procurement by exchange with another paleolithic group	Close 2000
Embedded	Procurement that is integrated into another activity	Binford 1979
Special purpose	Procurement trips for special purposes	Binford 1979: direct procurement

Tab. 99 - Classification of procurement as provided by Duke and Steele (2010)

Another approach is that paleolithic assemblages nearly always reflect an accumulation of short time single events and must be seen as palimpsest (see e.g., Henry 2012). But there is also the approach that single pieces and workpieces can be seen as such short time single events (Weißmüller 1995). The fewer lithic objects of one reduction phase are present, the shorter the residence time on-site and the longer objects were off-site. The more phases of the *chaîne opératoire* were done before import, the longer the object was underway and possibly the distance to the raw material source is farther. Likewise, we can assume that single pieces without cortex or workpieces with many modified objects have a longer archeological object biography (Uthmeier 2004b). An extreme case of import are lithic objects that were imported but stayed completely unmodified (we can call them unmodified manuports). The following tab. 100 shows a compilation of import possibilities into a site without reduction on-site or export:

Lithic object that was imported	**Phases of the *chaîne opératoire* in the past**	**Phases of the *chaîne opératoire* on-site**	**Lithic object that was found on-site**	**Lithic objects that are missing on-site**
Raw piece	0 - Acquisition	0 - Import 10 - Discard	Raw piece	None
Core	0 - Acquisition 1 - Test	0 - Import 10 - Discard	Tested raw-piece	First raw-piece cap
Core	0 - Acquisition 1 - Test 2 - Decortication	0 - Import 10 - Discard	Decorticated (simple core)	Cortical blanks, raw-piece cap
Core	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration	0 - Import 10 - Discard	Configured core	Cortical blanks, raw-piece cap and configuration blanks
Core and cortical blanks	0 - Acquisition 1 - Test 2 - Decortication	0 - Import 10 - Discard	Core and cortical blanks	Raw-piece cap
Core and non-cortical blanks	0 - Acquisition 1 - Test 2 - Decortication	0 - Import 10 - Discard	Core and non-cortical blanks	Core, cortical and non-cortical blanks
Core, cortical and non-cortical blanks	0 - Acquisition 1 - Test 2 - Decortication	0 - Import 10 - Discard	Core, cortical and non-cortical blanks	Raw-piece cap
Single cortical blank	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production	0 - Import 10 - Discard	Single cortical blank	Core, cortical and non-cortical blanks, raw-piece cap, chips
Single non-cortical blank	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production	0 - Import 10 - Discard	Single non-cortical blank	Core, cortical and non-cortical blanks, raw-piece cap, chips
Cortical blanks	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production	0 - Import 10 - Discard	Cortical blanks	Core, cortical blanks, raw-piece cap, chips
Non-cortical blanks	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production	0 - Import 10 - Discard	Non-cortical blanks	Core, cortical blanks, raw-piece cap, chips
Cortical blanks with modification 1 and/or 2	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6 - Modification 1 and/or 2	0 - Import 10 - Discard	Cortical blanks with modification 1 and/or 2	Core, cortical blanks, raw-piece cap, chips
Con-cortical blanks with modification 1 and/or 2	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6 - Modification 1 and/or 2	0 - Import 10 - Discard	Non-cortical blanks with modification 1 and/or 2	Core, cortical and non-cortical blanks, raw-piece cap, chips
Cortical and non-cortical blanks with modification 1 and/or 2	0 - Acquisition 1 - Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6 - Modification 1 and/or 2	0 - Import 10 - Discard	Cortical and non-cortical blanks with modification 1 and/or 2	Core, cortical and non-cortical blanks, raw-piece cap, chips

Tab. 100 - Compilation of import possibilities into a site without any export and the reduction phases of lithic objects that can be found on-site.

The picture appears different when the first phases are done on-site (i.e., 1 - test and 2 - decortication) but nothing was exported. In this case only raw pieces and cores were imported. The following tab. 101 shows this case for raw pieces (but is not exhaustive):

Lithic object that was imported	Phases of the *chaîne opératoire* in the past	Phases of the *chaîne opératoire* on-site	Lithic object that was found on-site
Raw piece	0 - Acquisition 0- Import	1- Test 2 - Decortication 10 - Discard	Core, raw-piece cap, cortical blanks
Raw piece	0 - Acquisition 0- Import	1- Test 2 - Decortication 3 - Configuration 4 - Preparation 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks, chips
Raw piece	0 - Acquisition 0- Import	1- Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks, chips
Raw piece	0 - Acquisition 0- Import	1- Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6-9 - Modification and recycling 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks, chips

Tab. 101 - Import, stay and export options of lithic objects, when only raw pieces are imported and nothing is exported

The following tab. 102 shows the above said for very simple cores (tested raw pieces) that are imported into a site (also non-exhaustive):

Lithic object that was imported	Phases of the *chaîne opératoire* in the past	Phases of the *chaîne opératoire* on-site	Lithic object that was found on-site	Lithic object that is missing on-site	Possible phases of the *chaîne opératoire* off-site in future	Lithic object that was exported
Tested raw-piece	0 - Acquisition 1 - Test	0 - Import 10 - Discard	Core	None	None	None
Tested raw-piece	0 - Acquisition 1 - Test	0 - Import 2 - Decortication 10 - Discard	Core, raw-piece cap, cortical blanks	None	None	None
Tested raw-piece	0 - Acquisition 1 - Test	0 - Import 2 - Decortication 3 - Configuration 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks	None	None	None
Tested raw-piece	0 - Acquisition 1 - Test	0 - Import 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks, chips	None	None	None
Tested raw-piece	0 - Acquisition 1 - Test	0 - Import 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6-9 - Modification and recycling 10 - Discard	Core, raw-piece cap, cortical and non-cortical blanks, chips	None	None	None

Tab. 102 - Import, stay and export options of lithic objects, when only tested raw-pieces are imported and nothing is exported

If lithic objects are also exported we need to do a nominal-actual comparison. This is only possible with the aid of exclusion criteria (what should be there and what is not there?). In the following (tab. 103) export conditions are presented (if only unmodified raw pieces are imported). Some of the scenarios are more unlikely than others (e.g., the export of waste from preparation, modification or recycling processes). It is certainly more likely that these (mostly tiny) objects declared as waste stayed on-site. Only cleaning and moving to dumping zones (e.g., Schiegl et al. 2003) or geological processes transfer such material.

Lithic object that was imported	Phases of the *chaîne opératoire* in the past	Phases of the *chaîne opératoire* on-site	Lithic object that was found on-site	Lithic object that is missing on-site	Possible phases of the *chaîne opératoire* off-site in future	Lithic object that was exported
Raw piece	0 - Acquisition	0 - Import	None	Raw piece	1-10	Raw piece
Raw piece	0 - Acquisition	0 - Import 1- Test 10 - Discard	Core	Raw-piece cap	2-10	Raw-piece cap
Raw piece	0 - Acquisition	0 - Import 1- Test 10 - Discard	Raw-piece cap	Core	2-10	Core
Raw piece	0 - Acquisition	0 - Import 1- Test 10 - Discard	None	Core and raw-piece cap	2-10	Core and raw-piece cap
Raw piece	0 - Acquisition	0 - Import 1- Test 2 - Decortication 10 - Discard	Core and/or raw-piece cap and/or cortical blanks	Core and/or raw-piece cap and/or cortical blanks	3-10	Core and/or raw-piece cap and/or cortical blanks
Raw piece	0 - Acquisition	0 - Import 1- Test 2 - Decortication 3 - Configuration 10 - Discard	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	4-10	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips
Raw piece	0 - Acquisition	0 - Import 1- Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 10 - Discard	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	6-10	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips
Raw piece	0 - Acquisition	0 - Import 1- Test 2 - Decortication 3 - Configuration 4 - Preparation 5 - Production 6-9 - Modification and recycling 10 - Discard	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips	10	Core and/or raw-piece cap and/or cortical blanks and/or non-cortical blanks, chips

Tab. 103 - Export conditions if only unmodified raw pieces are imported

The previously showed examples (tab. 101 to 103) of import, stay and export of lithic objects are only an extract of combination possibilities. We would expect that so called waste is not transported by man. The same is assumed for exhausted cores, broken blanks and debris. We would expect that it is more likely that such object are staying close to their place of production and use.

It should be also regarded that certain reduction steps can also be bypassed as the following example shall demonstrate: A natural frost shard is imported on-site and modified there. In this case the first phase of the operational chain (like decortication or production) are non-artificially, but the phase 0, acquisition was artificial.

How to compare blank production and shaping?

Blank production (*débitage*) and shaping (*façonnage*) are reduction processes (as explained in chapter V where the subtractive rule is described). In the case we consider the manufacture processes (the way to the finished lithic object) and not only the result (the finished lithic object) there are two possibilities to get a bifacially or trifacially shaped lithic object:

- The object is thought as a core that has to be exposed. Blanks are removes (*débitage*) as long as the wanted form is visible. The fine work (retouch) finishes the work
- The blank to shape the lithic object is a blank and this blanks has to be shaped that the wanted form is visible. To do so, blanks need to be removed (core-blank reduction). The blank to shape the object has to be modified.

Boëda et al. (1990) described this process in a slightly different way (*pièces bifaciales outils* and *pièces bifaciales support*). The important thing here isn't the matrix it is the shaping.

Normally, the analysis is divided into unifacial and bi-(tri-)facial objects (e.g., Boëda et al. 1990; Bordes 1988; Debénath & Dibble 1994; Inizan et al. 1995). From the viewpoint of a knapper this is not completely comprehensive, because the same procedures and techniques are used (also the physics behind is the same). For Leroi-Gourhan (1964) cores and bifaces are related forms. Volumetrically, they are very similar (e.g., there are at least two opossite convex surfaces which enclose a volume, Dibble 1989). Bifacial objects (and trifacial objects, as well) can be used as cores to produce blanks on the way from one camp to another, as it was formulated by Soressi and Hays (2003) for MTA-bifaces. There is also the possibility that big flakes were transported to camps to be transformed into bifaces. Copeland (1995) suggest that Levantine Levallois production derived from the production of bifaces in the Acheulian.

The following table (tab. 104) combines these reflections and shows the general phase of a *chaîne opératoire* (PCOs) used in this thesis:

PCOs	Activity	Denomination of lithic object before activity	Denomination of lithic object after activity
T1 to Tn	Transport of objects (can happen between all other phases)	Whole raw material unit or parts of it	Whole raw material unit or parts of it
U1 to Un	Use of objects (can happen between all other phases)	Whole raw material unit or parts of it	Whole raw material unit or parts of it
0	Acquisition of lithic raw material (finding and visiting a raw material source, containing raw pieces)	Raw piece	Raw piece
1	Test and check of raw piece, removing a raw-piece cap, splitting or opening a raw piece	Raw piece	Core, core fragments, raw-piece cap
2	Decortication of parts or the entire raw piece	Core	Core, cortical blanks
3	Configuration of a core, shaping to be ready to be reduced in the manner of a specific concept	Core	(Configured) core, cortical but mainly non-cortical blanks
4	Preparation of core edges to be ready for a big removal (removal of small blanks, mainly chips and abrasion)	(Configured) core	Prepared core, non-cortical blanks, chips
5	Removal of blanks, production	Prepared core	Reduced core, non-cortical blanks, chips
6	Modification 1 (alteration of surfaces)	All kinds of cores, blanks	Surface modified core, surface modified blanks
7	Modification 2 (alteration of edges)	All kinds of cores, blanks	Edge modified core, edge modified blanks
8	Remould of objects (Recycling 1), modification of modified objects, sharpening	Mostly modified objects, also unmodified, but used objects	Remoulded objects, objects have the same functionality as the had before
9	Reshaping of objects (Recycling 2), modification of modified objects, alteration	Mostly modified objects, also unmodified, but used objects	Reshaped objects, objects have another functionality as the had before
10	Discard	All kinds of objects	All kinds of objects

Tab. 104 - Reflective and combined steps of a general chaîne opératoire for lithic objects

These suggested PCOs shows the workflow (or receipt or schedule) that a knapper is working off during production of lithic objects. Important here is the possibility to place phases of transport and use between the other steps. Also, there is the possibility not to pass through all steps, as a side scraper (produced and used in a workshop on a raw material source) as example may be illustrate:

- Step 0 to 5 (PCO 0-5) to produce a blank
- Modification of this blank on its edge (PCO 7)
- Use of this object (U 1)
- Discard (PCO 10)

Some phases or steps were passed through (PCO 6, 8 and 9) and there was no off-site transportation.

Ramification and change of litho-technological concepts

Bourguignon et al. (2004) demonstrate how *chaînes opératoires* can be ramified, whereas the same or different by-products with the help of different reduction methods can be produced. This implicates that it is more difficult to deduce the used method (or concept) by inspection of end and by-products. „*Depending on the technology (Levallois, Quina, Discoide), the products of this ramification of chaine operatoire were most often the same, though sometimes chaine operatoire based on flake created sometimes different by-products such as, for example, denticulate type «core-tools» or «Kostenki knives.*" (Bourguignon et al. 2004: 37). For us the term ramification seems to be a bit fallacious, because such is more a continuation with another litho-technological concept. Such continuative concepts can also be called secondary or even tertiary concepts.

V.5.7. Techno-functionality

Techno-functional analysis try to partition a lithic object into units of different techno-functions and tries to explain the suggested functions of these parts. Techno-functional units were first described and theorized by Lepot (1993) a student of Boëda who explained the concept later in detail (Boëda 1997, 2001, 2013). A description of these techno-functional units (French: *Unités techno-fonctionnelles*, UTFs) introduced by Boëda can also be found in Frick & Herkert (2014). The following tab. 105 summarize the partition of lithic artifact found in literature (Boëda 2001, 2013; Frick 2010; Gouédo 2001; Klet 2010; Lepot 1993; Lourdeau 2010; Soriano 2001):

Literatur	Number of units	Unit for transformation of other materials	Unit for hafting and receiving energy
Albrecht & Müller-Beck (1988)	2	Functional surface	Non-functional surface
Lepot (1993: 26)	3	*Contact transformatif* (CT)	*Contact préhensif* (CP) *Contact réceptif* (CR)
Boëda (1997)	2	*Unité techno-fonctionnelle transformatif*	*Unité techno-fonctionnelle préhensif*
Boëda (2001)	2	*Unité techno-fonctionnelle transformatif*	*Unité techno-fonctionnelle préhensif*
Soriano (2001)	3	*Unité techno-fonctionnelle contact transformatif* (UTF CT)	*Unité techno-fonctionnelle contact préhensif* (UTF CP) *Unité techno-fonctionnelle contact réceptif* (UTF CR)
Gouédo (2001)	2	*Zone active* (ZA)	*Zone non-active* (ZNA)
Klet (2010)	2	*Unité techno-fonctionnelle contact transformatif* (UTF CT)	*Unité techno-fonctionnelle contact préhensif ou contact réceptif* (UTF CP/CR)
Lourdeau (2010)	3	*Unité techno-fonctionnelle transformatif* (UTFt)	*Unité techno-fonctionnelle préhensif* (UTFp) *Unité techno-fonctionnelle réceptif* (UTFr)
Boëda (2013)	3	*Unité techno-fonctionnelle transformatif*	*Unité techno-fonctionnelle préhensif* *Unité techno-fonctionnelle transmettrice*
Frick (2010)	4	Active edge (*aktive Kante*, AK) and active surface (*aktive Kantenpartie*, AKB)	Passive area (*passiver Bereich*, PB) hafting area (*Schäftungsbereich*, SB)

Tab. 105 - Partition of lithic objects in some studies using techno-function as criteria

To combine these ideas of units to partition a lithic object, in the following, we propose a combination of Boëda's (2013) latest tripartion and the separation into edges and volumes (tab. 106):

Unit	Abbre-viation	Meaning
Active edge	AE	Edge that is confected in that way that it can transform other materials
Active surface	AS	Surface that is confected in that way that it can transform other materials
Active volume	AV	Volume that is confected in that way that it can transform other materials
Passiv edge	PE	Edge that is not suggested to be used and can be removed without changing of the object's functionality
Passive surface	PS	Surface that is not suggested to be used and can be removed without changing of the object's functionality
Passive volume	PV	Volume that is not suggested to be used and can be removed without changing of the object's functionality
Grip edge	GE	Edge that is confected in that way that it can function as a handle
Grip surface	GS	Surface that is confected in that way that it can function as a handle
Gripe volume	GV	Volume that is confected in that way that it can function as a handle
Hafting edge	HE	Edge that is confected in that way that it can function as hafting contact
Hafting surface	HS	Surface that is confected in that way that it can function as hafting contact
Hafting volume	HV	Volume that is confected in that way that it can function as hafting contact
Transmitting edge	TE	Edge that is confected in that way that it can function as energy transmitter
Transmitting surface	TS	Surface that is confected in that way that it can function as energy transmitter
Transmitting volume	TV	Volume that is confected in that way that it can function as energy transmitter

Tab. 106 - Overview of techno-functional units, separated into edges, surfaces and volumes

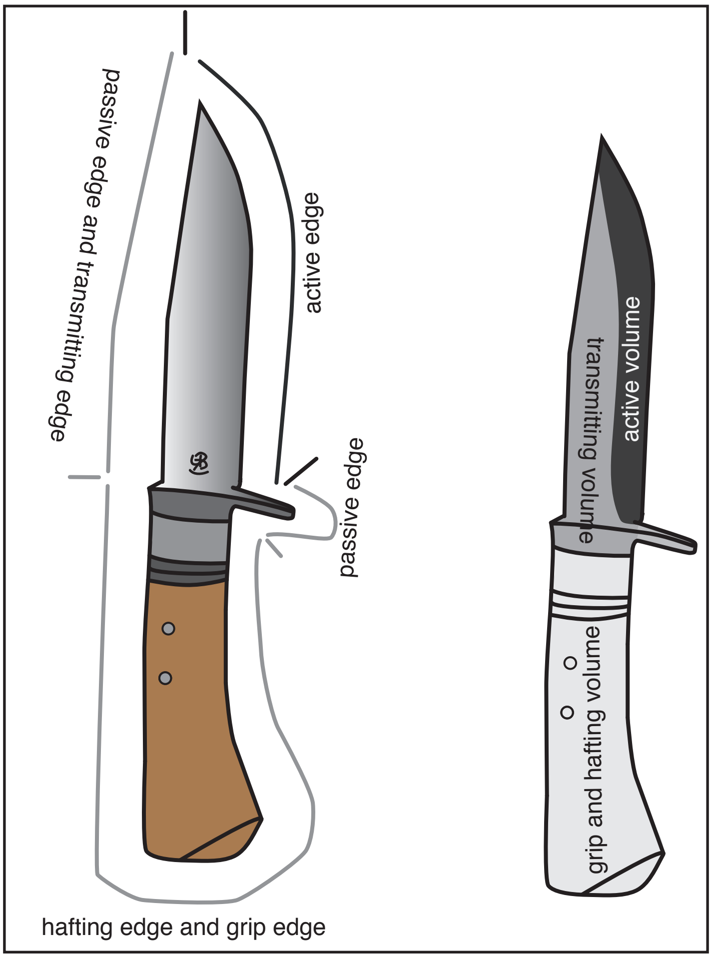

Fig. 109 - Possible functionality of edges and volumes of a modern steel knife

All of these edges and volumes are possible but not necessary, sometimes it is impossible to define the functionality of a part using macroscopical methods (naked eye, magnifier or binocular) because there are no traces visible or parts are broken afterwards. Fig. 109 illustrate the possible functionality of edges and volumes on a modern steel knife.
The major difficulty in studying techno-functional units of lithic objects is the differentiation between active and passiv parts (see fig. 109, above). We denote an edge and the corresponding volume as active if these were (or would have been) used to transform other materials, i.e., working edge or cutting edge. These parts can, but do not have to be retouched. However, either they were confectioned during production (e.g., shaping of the flaking surface) or they were confectioned after production (e.g., retouch of edges). But always, we have to bear in mind that there is the possibility of recycling and therefore multiple modification phases. In a strong sense of the idea of active part, only parts proven with the aid of use-wear analysis can be denoted as such. Another approach is detection of parts which would have the possibility to be used to transform other materials (this is the main approach of techno-functional analysis, see Boëda 2013). Very often, the degree of edge angles are used to determine a working edge (e.g., Iovita 2014; Lepot 1993; Rieder 1992; Soressi & Hays 2003). Mostly, these angles are said to be <70° (Rieder 1992; Soressi & Hays 2003).
The following tab. 107 presents analyses that can aid in the search of active parts (non-exhausted):

Analysis	Working methodology	Literature
Microscopical use-wear analysis	Analogical comparison of experimentally made traces with the archeological record	Cesaro & Lemorini 2011; Hayden 1979; Rots 2003; Stemp et al. 2009
Microscopical residue analysis	Analogical comparison of chemical traces of material stuck on surfaces of lithic objects	Fullgar et al. 1996; Hardy & Kay 1999; Wadley et al. 2004; Pawlik & Thissen 2011
Macroscopical analysis of edge modification	Detection of negatives, scars, abrasion, splits etc. with the aid of the naked eye, magnifier and binocular	e.g., Frick 2010 and thousands more
Microscopical hafting analysis	Analogical comparison of experimentally made traces with the archeological record	Rots 2010
Macroscopical hafting analysis	Detection of negatives, scars, abrasion, splits etc. with the aid of the naked eye, magnifier and binocular, determination of techno-functional units	Boëda et al. 1999; Boëda 2013
Experimental function analysis	Experimental made lithic objects used to transform different materials	Claud et al. 2009; Collins 2008; Crovetto et al. 1994; Domeier Stafford 1977; Rots 2010

Measurement of edge angles	Measurement of edge angles	Dibble & Bernard 1980; Eren 2013; Iovіţă 2014; Frick 2010; Lepot 1993
Functional experiments with lithic objects with different edge angles	Experimental made lithic objects with different edge angles used on the same material to analyse the edge stability and lifetime	no literature found

Tab. 107 - Analyses that can aid in the search of active parts.

Passive parts of lithic objects can have different functions. They are not actively (direct contact) involved in transforming other materials. They can be parts for grasping, hafting, transmitting energy or they can be totally without (visible) function.

V.5.8 Combining operational sequences, transformation, transport and use

After the recognition of lithic operational steps (or steps in reduction sequences) it is the aim to combine these ideas with transportation and transformation processes. In the same course it was found out that reworking of lithic objects was common in Paleolithic times. Dibble (1987) explained how a Middle Paleolithic scraper can systematically be reduced in that way that it would fall into another typological scraper category.

The transformation analysis established by Weißmüller (1995), modified by others (e.g., Richter 1997; Uthmeier 2004b) tries to explain in which stadium a lithic object was imported into a site and exported from a site. The more divers the used raw materials are the better this analysis works (just as a curiosity, if a lithic object is imported and exported without leaving traces or fragments this cannot be detected).

Wanted forms and preferred morphologies

This section deals with the following question: What is the intention of the producer(s) of lithic assemblages? This question is not easy to answer, but very different preferences can be examined: Form, shape, typology, morphology, technology, handling, techno-function, functionality, ability of recycling, ability of hafting, etc. In research history wanted forms and preferred morphologies were analyzed with typological methods (e.g., Bordes 1988). In this work ,we also want to do such, but not at the beginning of examination. A typology of wanted forms and preferred morphologies can only be formulated as a synthesis at the end of morphological, technological, biographical, functional analysis. This synthesis can show if partial aspects can compose a meaningful correlation. One of such approaches is the formation of so called techno-types (Boëda 2013; Frick & Herkert 2014; Koehler 2009).

Formation of techno-types
In addition to the positioning of lithic objects in operational chain steps seen on-site (e.g., Geneste 1985) and visualization of import-export options (Weißmüller 1995) it is possible to detect so called techno-types (Koehler 2009). The criteria used to formate these are diverse. To put it simply, techno-types are assumed to be wanted forms of lithic objects which can be produced only within a specific concept and a specific confirmation. The conception of techno-types can also be seen as further development of the ideas of predetermination (e.g., Mourre 2006) of the shape of lithic objects.

The formation of techno-types should not be seen as renewal of the Bordesian type concept, but in the same way as Monnier & Missal (2014) point out for techno-complexes, it involves the danger to take these techno-types as the true objects that paleolithic people wanted and not as a classification system in archaeology.

Techno-types are an attempt to find correlations between reduction concepts and produced objects. A simple explanation of Boëda (2013) can illustrates the circumstances very clear: „*Alors que la production laminaire est une lignée à part entière, qui ne produit qu'un techno-type : la lame.*" The techno-type of laminar production is the blade.

A slightly other use of the term techno-type (although described by Boëda), is summarized by Nicoud (2013) in showing differences in techno-types of bifaces: „*All assemblages described in the literature contain bifaces. But the biface is regarded as a typological entity, i.e., an artifact in the shape of a big almond with two faces intentionally worked. Several technical realities appear in fact within the biface concept. According to our interpretation (Boëda 1997; the words are translated there for the first time), these include the "biface used as a blank for tools" (pièce bifaciale supports d'outils), the "biface as a tool" (pièce bifaciale-outil) and "pebbles/blocks with bifacial removals" (galets ou blocs à enlèvements bifaciaux) (Fig. 3). The differences between one and the other techno-type of biface can seem subtle.*"

We see a vast difference in these two descriptions. On the one hand, the blade as the detached object is called a techno-type of a specific reduction sequence. On the other hand, a „core", the biface, the objects from that detachments were taken is called a techno-type. The overlap of these production sequences is that a specifically shaped object, as the result of a lithic subtraction was produced. Or with other words: a techno-type is described as the result or offspring of a specific lithic production and is therefore correlated to specific production steps and sequences, as well as morphologies of matrices.

For the denomination of techno-types Koehler (2009) use *études technométriques* (may be translated as: techno-metrical studies or studies for the measurement of technologies). The following tab. 108 summarizes the criteria used by Koehler

(2009) for their studies (she writes that she was inspired by Boëda 1991; Lepot 1993; Bourguignon 1997; Soriano, 2000, etc.):

Criteria	French formulation	Description and explanation
General shape	*La forme général*	Morpho-geometry of the top-view, the outline such as oval, triangle or rectangular
Geometry	*La géometrie*	Symmetry or asymmetry of the outline
Terminal end	*L'éxtémité distale*	Shape of the terminal end in top and side view
Course of edges	*La délinéation des bords*	Shape of the edges in top view
Profile (side view)	*Le profil*	Morpho-geometry of the top-view, the outline such as oval, triangle or rectangular
Dimensions (cross section)	*Les dimensions (sections transversales)*	Dimensions of the cross section
Position and number of non-cutting parts	*La position et le nombre des parties non coupantes*	Position and number of non-cutting parts

Tab. 108 - Criteria used by Koehler (2009) to define techno-types with added descriptions and explanations of these criteria

The above described criteria defines techno-types for Koehler (2009). She mentioned also that these types do not represent functions, but represent a „family" of similar features.

Artifact, geofact, intentional, non-intentional, reworked and non-reworked objects

There is a whole bunch of literature discussing the question what an artifact (a human made or modified object) is and how to distinguish artifact from geofact (Cyrek & Sudol 2012; Ellen & Muthana 2013; Haynes 1973; Lubinski et al. 2014; Peacock 1991; Schultz 2007; Wiśniewski et al. 2014). A geofact can also be classified about the originator of its artifact-like character (tab. 109):

Geofact type	Cause	Example for human use	Literature
Cryofact	Freezing and thawing can lead to cracks	Scraper out of an artificially modified frost debris	Hahn 1993
Biofact	Biological factors caused the modification (e.g., roots, gnawing)	Pressure of roots caused an intentionally retouch-like edge that was used	No literature found
Chemofact	Chemical causes altered the object (e.g., humic acid, solution)	?	No literature found
Gravifact	Gravity caused solifluction or rock fall	Use of naturally caused sharp edges	No literature found

Tab. 109 - Classification of geofacts

A lithic object can be discarded in a reworked or non-reworked condition.

A geological object that was only carried and shows no modification is called manuport (Leakey 1971). In our context, we call them unmodified raw pieces.

If small traces of use are visible, an objects needs to be classified as artifact. It is modified.

V.6 Methodology of lithic analysis

The methodology used in this lithic study is hierarchical, successive and pass the following working steps:

- Agreement and establishment of excavation standards (Frick & Hoyer 2009, 2011, 2012; Frick et al. 2013; Frick et al. 2014)
- Excavation and measuring of single finds, collective finds and findings
- Water screening, washing, drying, labeling
- Control of database
- Sorting into categories (like square meter, geological horizon, raw material, find number)
- Recording of data inherent of every lithic object (single measured objects)
- Recording of data inherent in collective finds
- Specific sorting of lithic pieces into groups after categories established in this thesis
- Recording data of these groups (e.g., raw material units, technologically similar objects)
- Analysis of collected data
- Writing down the thesis

After data collection these must be analyzed and therefore correlated and compared. In this case different analysis methods are used to illuminate different aspects of the single lithic objects, the assemblage and the whole site. The beginning of this section discuss terms and definitions used in this work.

V.6.1 Terms and definition of lithic data collection and analysis

To avoid confusion, essential for the understanding of the analyses of this work are the definition of terms. By surveying literature it was noticeable that some terms are used different. Mostly, as it suggests, the usage of terms is related to specific tasks and the „school" of the respective author.

This can be discussed on impressive examples. Beginning with the distinction with the help of metrical definitions of blades and bladelets it can be said that commonly they are seen as slit products that their length is at minimal the double width (e.g., Bordes 1988; Floss 2012b; Hahn 1993; Inizan et al. 1999). But there are also ratios of 2.5:1 to 4:1 mentioned (Bar-Yosef & Kuhn 1999). For these definitions the orientation of the lithic objects is in knapping direction. Also the distinction of blade and bladelets are difficult. In German literature often the cut is made at a width of 10 mm, wherein in French literature often the cut is made at 12 mm (Inizan et al. 1999).

Also for a general definition of lithic products we can detect the term of waste without explication. This is especially the case for burin spalls (e.g., Tomáŝková

2005). They can be defined as waste of burins or more neutral as burin bladelets with the possibility that the burin spall was also used.

V.6.2 Distinction between educt and product

In general, lithic objects can be categorized into educts and products. The following tab. 110 shows how they can be separated:

Category	Definition	Examples
Educt	An object from that something can be detached	Raw piece, core
Product	Initial objects and all kind of modified objects	Initial objects (e.g., flake), modified objects (e.g., modified core or retouched blade or a bifacial object)
Initial product	An object that was intentionally or not detached from an object	Blank, frost fragment, heat debris (e.g., pot lid)
Blank	An object suggested as intentionally detached from an object	Flake, blade, bladelet, chip
Split product	All kinds of modified and unmodified initial objects	E.g., a blade, a burin spall, modified or not

Tab. 110 - Classification of educts and products

The term educt is used for matrices (see the following section) from them other pieces can be detached (raw pieces and cores). A product is defined here as object that was detached from another or was modified in some kind.

V.6.3 Matrix or supply

The term matrix (pl. matrices) is used here to describe objects that were used as basis for further shaping. We would like to explain this with examples:

- If a bifacial object shall be produced, a blank, a core or a raw piece can be used as base material. The object used to shape it is called matrix (in French sometimes the term *support* is used, in German it is sometimes paraphrased with *die zugrunde liegende Form*).
- Boëda (2013) use the term matrice in a very similar manner. For instance, he use the term to describe that a Kombewa flake can serve as matrix for different tools: „*Eclats Kombewa servant de matrice pour la fabrication d'outils différent.*“ (Boëda 2013; fig. 66)
- Bourguignon et al. (2006) use the term matrice (as I understand it) in the same manner, as potentially exploitable volume for reduction purposes: „*Par ailleurs, nous avons fondé notre analyse sur les modes de gestion de ces industries au sein des territoires de subsistance, en définissant les matrices (volumes potentiellement exploitables soit pour des actions de débitage, soit pour leur utilisation directe – supports bruts – ou après retouche) qui circulent entre un territoire habité et un territoire parcouru.*“ Bourguignon et al. (2006: 75)
- Bourguignon et al. (2006) use the term supply as english translation for ma-

trice: „*But even if the form of supply may vary, the archaeological evidence shows that the technological provisioning patterns always include the transfer of « matrice » which could be considered as « general-purpose » tools as well as « tool-making potential »*.“ Bourguignon et al. (2006: 75)

- In English the word supply normally describes material that is procured from a raw material source to a site, independently from its shape and these supplied material can be raw pieces or blanks (Goodyear 1993; Keeley 1988; e.g., Meignen et al. 2006).

To avoid confusion, we prefer a separation of these terms (matrix and supply) in the following scheme (tab. 111):

Term	Definition
Matrix	Selected material for the production of lithic products and cores, which can be a raw piece, a core or initial object (e.g. a blank or a frost shard), an object that can be modified
Supply	Procured material in every form from raw material sources

Tab. 111 - Term separation of matrix and supply

V.6.4 Educts (raw pieces and cores)

Lithic raw pieces can have different shapes (see fig. 110). Mostly they are separated into nodules and plates. Floss (1994) added the term *Fladen* (can be translated with disc).

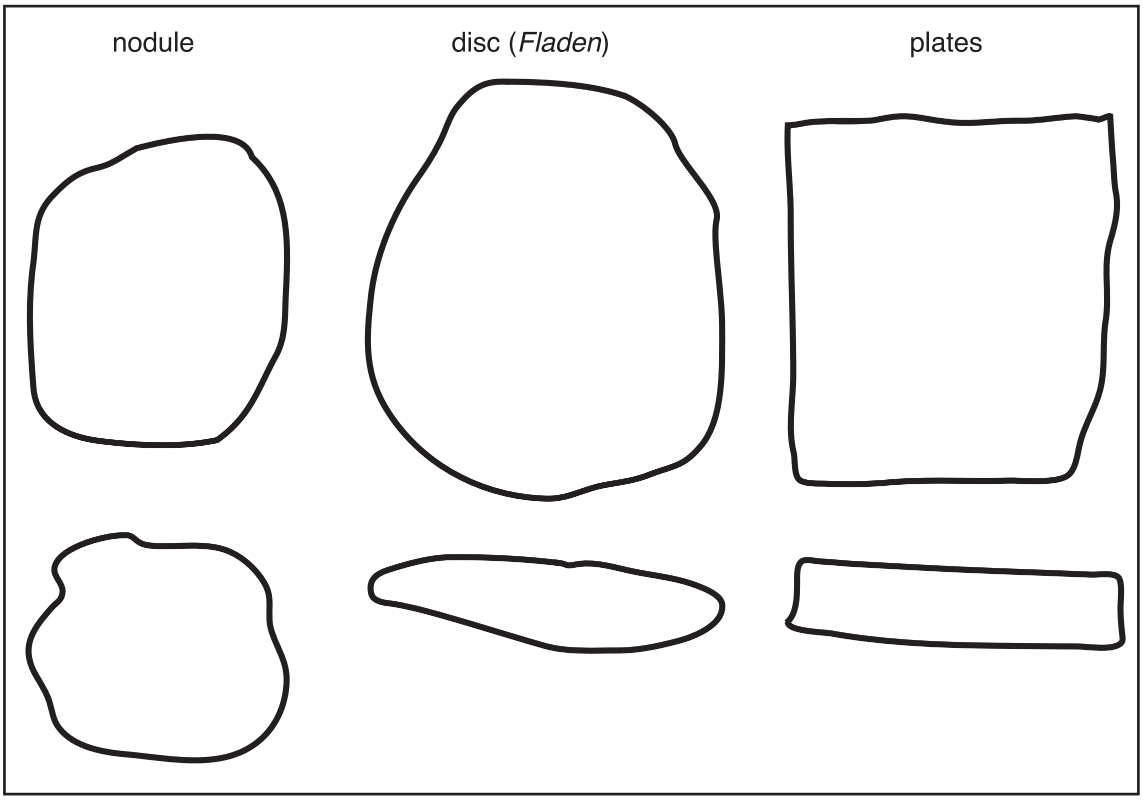

Fig. 110 - Classification of raw piece shape into nodule, disc and plate (above - top view, below - cross section)

Raw pieces are the underlying objects of any lithic use process. In this thesis we are sub-summing under the term lithic every kind of raw material that contains a high amount of silicon dioxide (SiO_2). All lithic raw material studied are discussed in chapter VI.

The following activities with raw pieces can leaves detectable marks (direct and indirect, not exhaustive, see tab. 112):

Denomination	Activity	Example	Visible marks	Literature
Import of manuports	Transportation of unmodified raw pieces into a site	Import of raw material nodules for reduction	External raw material, use attested by reduction negatives	Leakey 1971
Lack of objects	Detectable activities on-site, without the detection of raw pieces	Detectable reduction processes on site but without any hammerstones	Visibility of reduction sequences (including the very small garbage), but without any hammerstones	Weißmüller 1995
Use as hammer	Use of raw pieces on-site	Use of raw pieces as hammerstones	Crushed areas, sometimes negatives of a detached blank	Floss & Terberger 2002; Hardy et al. 2008; Häckel 2010
Use as grinder	Use of raw pieces on-site	Use of raw pieces as grinding stone	Crushed and abraded areas, smoothed surface	Sheets 1973; Tringham et al. 1974; Delgado 2009
Use as anvil	Use of raw pieces on-site	Use as underlay	Crushed areas, mainly on surfaces	Marchant & McGrew 2001; Mourre & Jarry 2010
Reduction to get blanks	Knapping of raw pieces	Initialization and configuration of a core	Visibility of negatives on the former raw piece	Many literature examples

Tab. 112 - Activities using raw pieces and visible marks on them

But simple detection of such features (i.e., visible marks) cannont be proove alone for an anthropogenic impact. More lines of evidence are necessary for the examination and verification (e.g., archeological context or integrity of sediments).

V.6.5 From raw piece to core

A simplified definition of the term core is: If at minimum one negative of a detachment is visible (intentional or not) the object will be classified as core (Frick & Hoyer 2012).

We can also say that a core is an object whose volume is reduced to its state of formation. In other definition much more than one negative of detachment has to be visible (Inizan et al. 1999). In this context, the simplistic definition yields advantages, because unused manuports (simple raw pieces without any sign of use) can be separated from objects that show use (such as negatives from detaching). In this way, a raw piece that carries a negative from frost-shard detachment is also called a core. The intension is here to compare similar objects of the archeological record with each other.

After the objects were used as core, it can be modified, as well. For example, a core can be retouched to use an edge as scraper edge. In this case, the objects is classified as modified core and therefore a product (for a definition of products, see chapter V.6.10).

V.6.6 Core

Definition

An objects can be determined as core if at least one negative of detachment is visible (Frick & Hoyer 2012). To specify a core, different planes, surfaces and volumes need to be defined (see tab. 113):

Feature	Specification	Description	Other names
Plane	Reference plane, intersectional plane	The reference plane seperates an active from a passive volume of the core	Plane of intersection (Boëda 1995), *plan d'intersection* (Boëda 1994), Referenzebene (Frick 2010),
Surfaces	Reduction surface, flaking surface	Surface from that blanks are remove for further use	Flaking surface (Chazan 1997), *débitage* surface (Inizan et al. 1999),
	Striking surface, surface of the platform	Surface that receive the blow of detachment, part of this surface forms the butt of a blank	Platform (Chazan 1997), striking platform (Inizan et al. 1999)
	Adjacent surface, additional surface	Additional surface to configure and correct the reduction surface	Surface of striking platforms for the configuration of the reduction surface (e.g. Boëda 1994)
Volumes	Active volume	Volume that will be removed during reduction	Exploited volume (Brantingham & Kuhn 2001), volume utile (Boëda 2013), active volume (Boëda et al. 2013)
	Passive volume	Grasping volume, residual volume	Volume non utile (Boëda 2013), passive volume (Boëda et al. 2013)

Tab. 113 - Core features

At least a core consists of one plane, one reduction surface, one striking surface and an active and passive volume. What could be called 1 (plane): 2 (surfaces): 2 (volumes) relation.

Types, classes and groups of cores

For displaying differences in cores we are using the terms type, class and group. The choice of these terms is quite random. The description of these three categories is displayed in the following tab. 114:

Category	Description
Core type	The core type represent steps of the operational chain
Core class	The core class represent what was done with these cores or the function of this core
Core group	The core group displays the matrix used to make this core

Tab. 114 - Short description of core type, core class and core group

Core types

Core types represent steps of the operational chain. The differentiation was made between simple cores, configured cores (Vollkern), reduced cores (Restkern), cores debris and modified cores. The following tab. 115 shows this classification:

Core type	Core class	Definition	Example
Simple core	Hammerstone	Object can be of different shape and raw material, at least on one end a crushed area, for being a core it owns a negative of removal that derives from split fracture by use	Ovoid river gravels with crushed area and removal, unopened nodule of different raw material, spherical object that can be a former specific core, as well
	Anvil	Object can be of different shape and raw material, at least on one end is a crushed area, for being a core it owns a negative of removal that derives from split fracture by use	Normally a cobble of tough and crystallin rock with a least one flat surface
	Tested raw piece	A raw piece with at least one removal negative, core is not attributable to a litho-technological reduction concept, test of raw material indicated that further reduction is not useful, because of raw material defects, initialization but no configuration	Partially or completely decorticated core that raw material shows cracks, fissures or coarse-crystallin areas
	Opportunistic core	Core show different removal negatives from cortication and maybe also configuration processes, one or some negatives indicate that the produced blank(s) were/was in a useful shape, core is not attributable to a litho-technological reduction concept, initialization and minimal configuration	Core with some removals on positions were it was easily possible
	Core-preform	Core was initialized and has some indications of configuration, but is not finalized	Ovoid raw-piece that was shaped to be a Levallois core, but the configuration is not finished
Configured core	Cores that represent a specific reduction concept	An object that was initialized and configured in that way that blanks can be removed in a specific manner; the finial removal (of wanted blanks) did not happen	A convex Levallois core without the removal of a preferential blank; a blade-core without the removal of the crested blade
Reduced core	Cores that represent a specific reduction concept	An object that was initialized and configured in that way that blanks can be removed in a specific manner; at least one of these wanted blanks were removed	A flat Levallois core from that one or several wanted blanks were removed
core debris	no further fractionation necessary	an object that shows removals but not in a specific manor, mostly a broken fragment of a former core; a fragment that can be attributed to be a former core; almost no conception left to detect	
modified core	e.g. scrapers-on-cores or burins-on-cores	a core with clear evidence to be modified after is function as core; normally this modification is retouch to make a tool out of it	a core whose edge was retouched to get a cutting edge

Tab. 115 - Classification of core types and groups

Core classes
The term core class is used to specify core types as it is displayed in tab. 115, above). The core class imply an affiliation of a core to a specific function or to a specific reduction concept.
Core group
The core group represents the matrix of the core. There are three possibilities imaginable:

- Core made out of a raw piece (core-on-raw-piece)
- Core made out of a blank (core-on-blank)
- Core made out of a frost shard (core-on-frost-shard)

Core type of modified cores
The modification of a core can be polymorphic, some possibilities are summarized below (see tab. 116):

Position of modification	Kind of modification	Aim of modification	Example
Edge modification	Retouch	Shaping of an active edge to modify other materials	Retouch of an edge that can be used as scraper (scraper-on-core)
Edge modification	Use	Modification is not intentional, it happened during use	Use of an edge for cutting, whittling, scraping etc. without former intentional modification
Edge and surface modification	Use	Modification is not intentional, it happened during use	Use of the core as hammerstone or anvil to modify other materials
Surface modification	Reduction	To reduce the core within another conceptual frame	A former parallel reduced core is modified to reduce blanks in a secant manner (e.g., Levallois core is getting a discoidal core)
Edge and surface modification	Reduction	To reduce the core within another conceptual frame	A former core is modified to transform it into a bifacial object

Tab. 116 - Modification of cores

V.6.7 Modified raw pieces (cobbles)

A raw piece with at least one removal becomes a core and is therefore modified. Also scares, shattering, abrasion, striae, scratch marks, and so on can occur on such pieces. Mostly tough but hard materials (normally grained) shows such minimal invasion (e.g., quartzite, quartz, quartzitic sandstone, granite, gneiss). Normally, these materials show rounded surfaces and features of fluviatile transportation.
These rounded stones can have various importance for paleolithic people. They can be used actively in hand (e.g., as hammerstone, as grinder or retoucher) or passively (e.g., as anvil). The differentiation between active and passive assume that an object can be moved and therefore it is mobile (Inizan et al. 1999). Beaune (1989, 1997) describe such mobil cobbles in a typological way.

More recently, Häckel (2010) studied hammerstones from Bilzingsleben and described there terminology, features and the energy used. In chapter VII.10.8, VII.10.9, VIII.3, IX.5.5 and X.12 we will dwell upon these cobbles and their functional interpretation.

V.6.8 Law of lithic subtraction

The production of lithic objects can be described as a subtractive process (Collins 1975). The opposite are additive processes like the production of ceramics, or weaving and the assembling of composite tools (Flenniken 1984) or baking of bread (Weißmüller 1995).

Subtraction can be visualized with the following words: „*The act of flaking stone is subtractive such that each step results in the reduction of the original mass and the generation of products and byproducts that are smaller than their source.*" (Baumler 1995: 11).

As a rule, a produced blank is always smaller than the original volume and in that way normally a produced blanks is smaller than the remaining core. An exception of such is a blank with a plunging (*outrepassé*, *Kernfuß*) that removes large parts of a core.

Successful knapping splits a volume of lithic raw material into at least two pieces. The object were a piece is split-off gets smaller (see fig. 111).

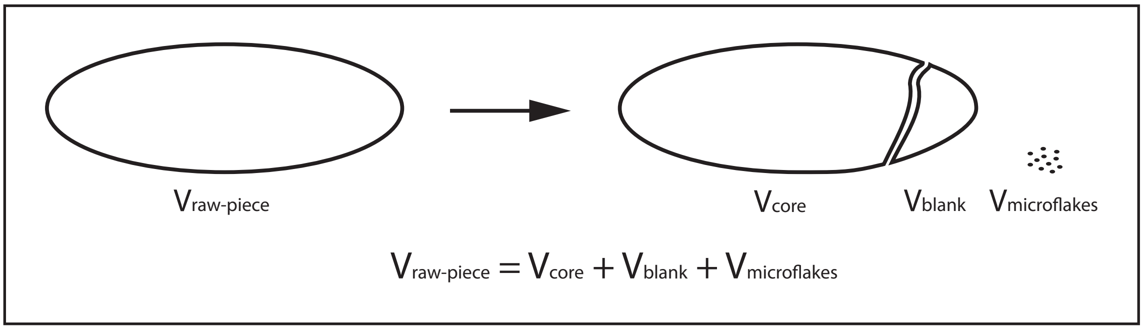

Fig. 111 - Illustration of the law of lithic subtraction

Weißmüller (1995) call this the subtractive law (*das subtraktive Gesetz*) which is valid for all materials that can be sculptured (e.g., stone or wood). He also distinguishes between three variations of subtractive shaping techniques (*Spalten*, *Retuschieren* und *Verstumpfen*, see Weißmüller 1995: 13-14). These variations are listed and explained in tab. 117.

Technique	Description	Volume before subtraction	Volumes after subtraction	Volume size	Force effect	Visibility with naked eye
Splitting	Intentional knapping in a larger scale	Complete volume, e.g. a raw piece or a core	Original volume is splits in at least two pieces (core and blank(s))	Removal of a bigger object	Split break initialized by a blow or pressure; at least one direction of force initialized a break	++
Retouching	Intentional knapping in a smaller scale	Complete volume, mostly a blank	Small volumes are removed from the original volume	Removal of many small objects	Split break initialized by a blow or pressure; at least one direction of force initialized a break	+
Blunting	Picking, grinding, sawing, drilling	Raw piece core blank	Small volumes are removed from the original volume	Removal of very many, very small objects	„Infinite“ repeated force effects	-
Breaking	Intentional or unintentional splitting, orthogonal to its longitudinal direction	Raw piece core blank	Original volume is splits in at least to pieces (core and blank(s))	Removal of a bigger object or removal of many small objects	Break is initialized by bending and results in a break, lever action	+

Tab. 117 - Subtractive shaping techniques

V.6.9 Initial object

A targeted (directed) force (hit or pressure) can split a lithic object into two or more pieces. The result is the separation of such an object into a core and a blank (Floss 2012b; Hahn 1993). The following tab. 118 summarize metrical features of blank types as used in this thesis:

Name	Metrical definition
Flake	L ≤ 2W, W≥10 mm
Blade	L ≥ 2W, W≥10 mm
Chip	L & W ≤10 mm, but not in the dimension of a bladelet
Bladelet	L ≥ 2W, W≤10 mm

Tab. 118 - Metrical definition of blanks

For a better illustration of these metrical features, see fig. 112:

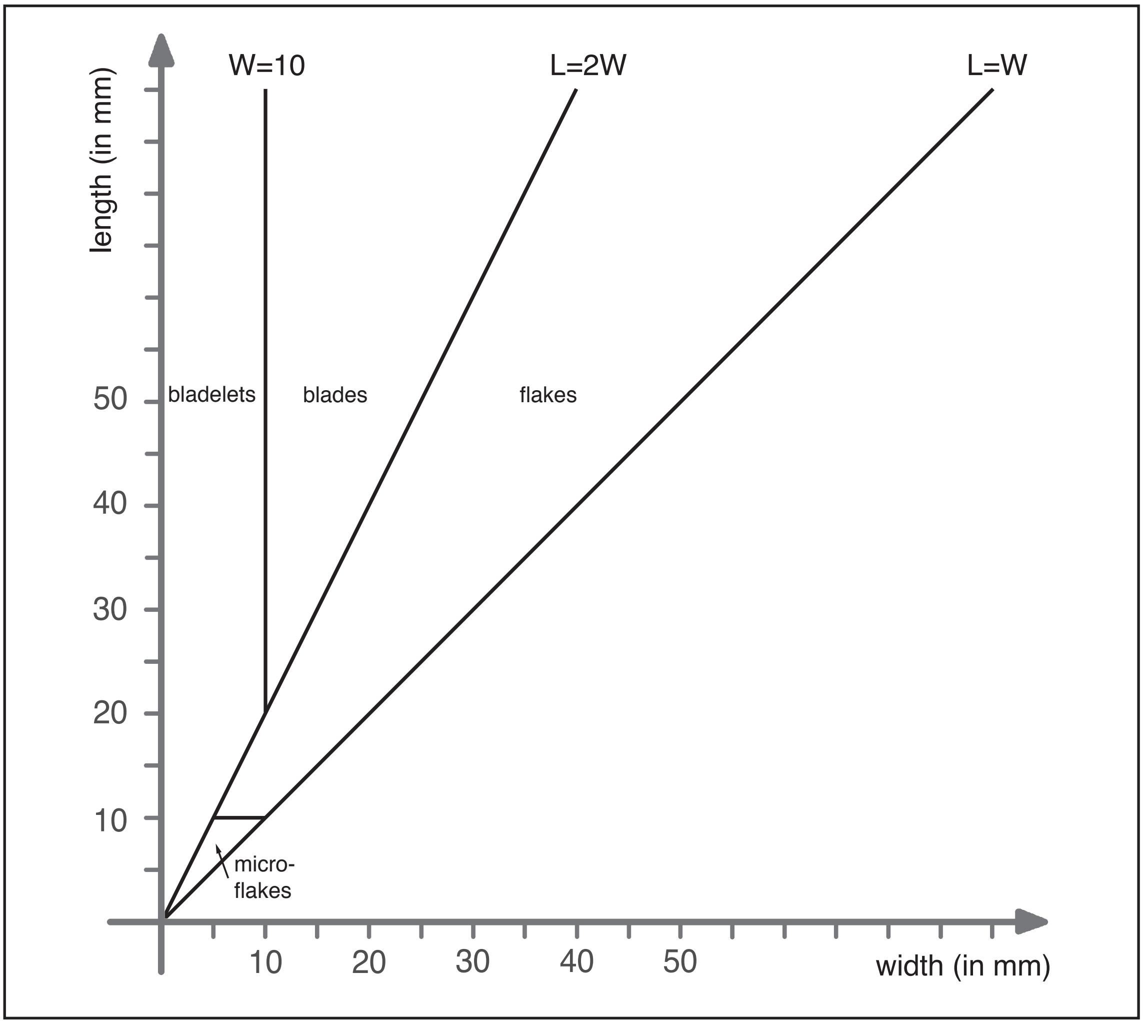

Fig. 112 - Metrical definition of blanks

We distinguish between blank type and blank class. Blank types are defined by their metrical dimension (see above). Blanks can also be distinguished by their position on a core or their affiliation to a specific litho-technological concept. The following tab. 119 lists all blanks classes used in this work:

Blank class	Specification	Position in reduction
Simple blank	A blank without cortex that cannot be places to a specific core position or be affiliated to a concept	Can occur in every reduction position, but not in the first steps of the initialization
Raw-piece cap	A blank with complete (or almost complete) cortex cover; (other names are cortical blank, entame blank, first flake, decortication blank,…)	These blanks are part of the transformation of a raw piece into a core, they are initialisation blanks to start the knapping process
Surface-correction blank	Blank removed from the inner part of a surface	These blanks are normally part of the core configuration process for shaping surfaces
Edge correction blank	Blank removed from the edge of a surface	These blanks are normally part of the core configuration process for shaping edges

Crested blank	Blanks with quite symmetrical cross-section that show former removals in opposite directions from the crest to the lateral edges	These blanks are removed from a core to start the reduction process, mostly for laminar reduction, sometimes very similar objects are removed from discoidal cores in cordal direction (Slimak 2004)
Débordant blank	Asymmetrical core edge flakes	These blanks are always longitudinally removed from the edge of a surface to correct the convexity
Core tablet	The dorsal face equals the core platform, one lateral edge (or the butt) shows removal negatives from the flaking surface of the core	These blanks are removed to correct the exterior platform angle or the platform surface of a core
Levallois blanks	So called target blanks from parallel reduction on Levallois cores	These are seen as wanted blanks for further use, characteristics are a good visible bulb, the butt is sometimes facetted (and dorsally reduced to lower the impact point), in sideview these blanks show a high parallelism, they can be seen as the real products
Ventral blank	Blanks that are removed from the ventral face of a blank (other names are Kombewa flake or if double bulbed Janus flake)	The dorsal face of these blanks show part of the ventral face of the blank-core, these blanks are evidence for a secondary reduction
Tranchet-blow blank	Blanks that are removed from the active edge to form a very sharp edge	These blanks show on one lateral edge bifacial modification or show at lest a second (former) negative on their ventral face, they are evidence for resharpening processes
Bifacial object made from blank	Bifacially reworked blanks	These are blanks that contain evidence that the matrix was a blank and not a raw piece, they are evidence for a secondary transformation of a blank into a tool
Blank deriving from retouch	Blank was removed from a retouched edge	These blanks are a sign that retouch happened on-site, they are evidence for the modification of blanks (or sometimes cores) by retouching processes

Tab. 119 - Blank classes used in this thesis

In addition to this blanks we would like to add two similar objects into the term initial object:

- Frost shard (German: *Frostscherbe*, also called frost fragment or frost debris)
- Heat debris

Normally these originate from non-intentional extension of water (freezing and heating) inside a lithic object (e.g., in fissures) that can detach a fragment (see also Frick et al. 2012).

Modified (retouched) frost fragments are described in Middle Paleolithic context (e.g., Boëda et al. 1990; Collina-Girard & Turq 1991; Gouédo 1993, 1994; Turq 2000). Mostly they have a central convex area on its „ventral face“ that is surrounded by Wallner lines. Sometimes the breakage surface is rough because is was a fissure (fig. 113).

Fig. 113 - Pot lit negative on ventral face of a blank, initialized by the break surface of a former blow (Hertzian cone left of the potlid negative)

Heat debris is highly polymorphic (e.g., Frick et al. 2012; Patterson 1995). Clearly detectable are so called pot lids and their concavities, but there are also very cubic variations (e.g., when the material is totally disintegrated). In general, it can be said that the shape of heat debris depends on the amount of water in fissures, the speed of heating and the grain size of the raw material. Frick et al. (2012) documented six main variations of breakage by heating flint from the *argiles à silex* (fig. 114):

- Complete disintegration
- Circular breakage pattern
- Pot-lid fracture
- Flake splitting
- Surface crazing

V.6.10 Products

The term product is used to combine initial objects and modified cores and to divide them from educts (raw pieces and unmodified cores). A definitional reduction sequence can be seen in tab. 120. Here, it is shown which lithic object will emerge from which object:

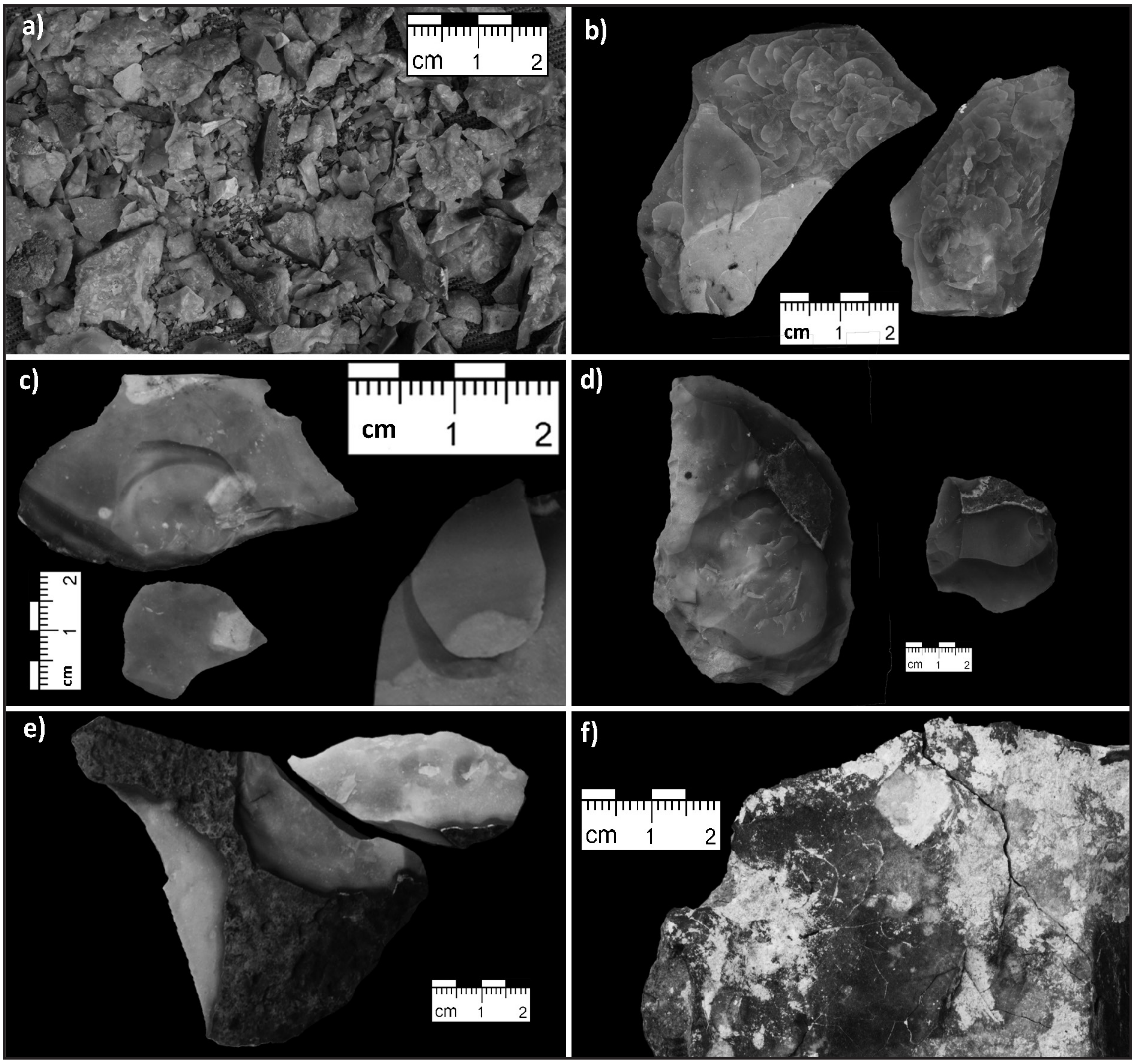

Fig. 114 - Six breakage pattern types of heat influenced breakage patterns (see also Frick et al. 2012, fig. 12)

Final good / Base material	Raw piece	Simple core	Product = modified core	Product = simple initial object	Product = modified initial object
Raw piece	=	->	≠	->	≠
Simple core	≠	=	->	->	≠
Product = modified core	≠	->	=	->	->
Product = simple initial object	≠	->	≠	=	->
Product = modified initial object	≠	->	->	->	=

Tab. 120 - Transformation of lithic object after a modification step (red = not possible, yellow = it stays the same, green = change of the category)

V.6.11 Reference plane

Further above, we described the axis of maximum length, that can separate an object in left and right parts (or volumes). Another parting plane to separate a lithic objects is the reference plane. Boëda (1994, 1995b) introduced the so called *plan d'intersection* that separates the upper and lower volume of Levallois cores. In our case, we are using the term reference plane for every lithic object to describe the devision of a lithic object into an upper and lower volume. The reference plan is quite often rectangular to the plan build by the axis of the maximum length. The following tab. 121 shows how reference planes can be defined on lithic objects (Boëda 1994, 1995b; Frick 2010; Gowlett 2013):

Educt or product	Denomination of volumes	Position of the reference plane	Example
Raw piece	Upper and lower volume	Parallel to axis of maximal dimension	Unused hammerstone
Core	Active volume and passive volume	Seperating the exploitable and unexploitable volumes	Levallois core
Blank	Upper (dorsal) volume and lower (ventral) volume	Reference plane in the plane of the circumferencial edge	A flake is used as core to produce Janus flakes
Bifacial object	Upper and lower volume	Reference plane in the plane of the circumferencial edge	Acheulian hand axe

Tab. 121 - Separation of volumes using reference planes

The only sense to define a reference plane on raw pieces is given, if particular feature on the surface lead to the necessity to structure the object for description. For better understanding, fig. 115 illustrates possible reference planes:

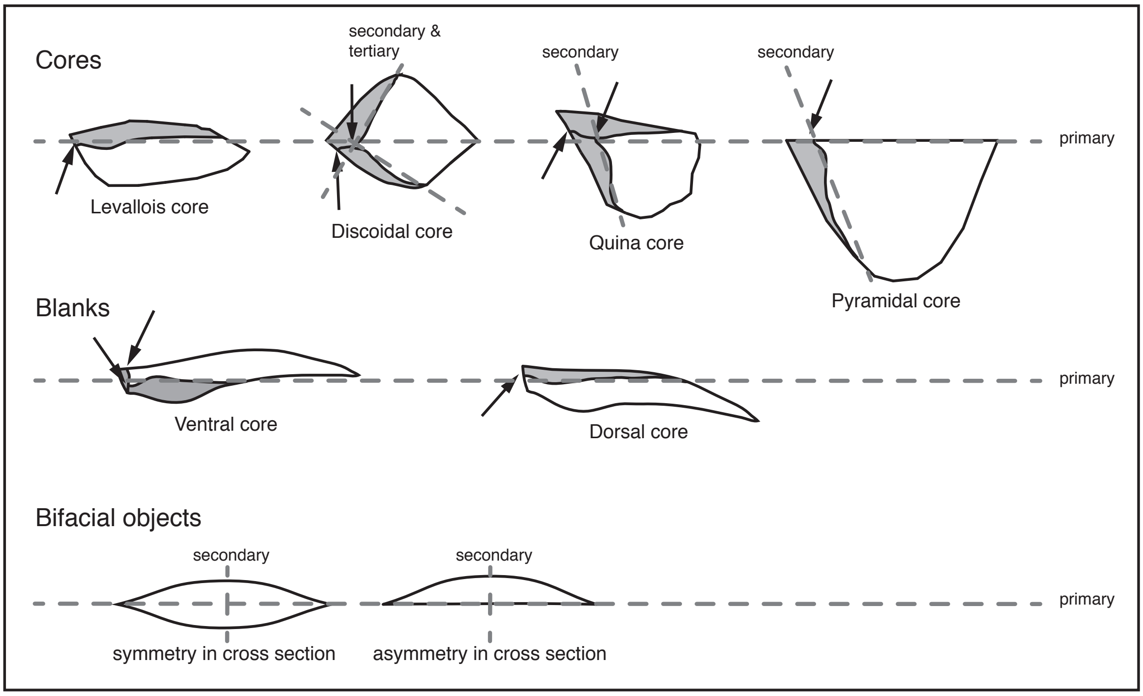

Fig. 115 - Hypothetical reference planes on cores, blanks and bifacial objects

V.7 Collection, analysis and representation of data

V.7.1 Introduction

This chapter describes the „operational sequence“ of data management of this thesis. In the following, the stages of data collection, analysis and representation are described. In the foregone, the subjects of this thesis and the used methodology was elaborated (see chapter III and V). The following displays a coarse scheme for the „operational sequence“ (working steps) for this thesis:

- Definition of the subject
- Elaboration of a methodology
- Data collection
- Data analysis
- Data representation

V.7.2 Collection of data and the database

All data collection was done with the help of databases. The specific description of the collected data is explained in chapter VI to X, here the process of data collection is shown.

Two kinds of databases were used for data collection. On the one hand, a Microsoft Access™ database for the collection of metrical and non-metrical (descriptive) features of all measurements from the excavation. This database contains, in addition to all spatial measured objects and topographical data, also objects from the bucket or sieve (finds from the collective finds). On the other hand, an Adobe Lightroom™ database was used to store and tag pictures, including photographs of excavation and artifacts, but also drawings and all produced figures of this thesis. In addition to these main sources of data other database were used, e.g., an Endnote® database that contains citations of used literature.

The Microsoft Access™ database has for each lithic artifact a total of 136 columns. These columns contain data from the total station on excavation (such as year of excavation, square meter, find number, coordinates or denomination), data about dimensions (such as length, width or thickness), data about the raw material (such as kind of raw material or cortex), if photographs or drawings were made, and specific data about the surfaces and edges of each artifact. For this thesis the database contains n=2682 datasets of lithic artifact were every possible column is filled with data (which means that for these artifacts at maximum 364.752 fields are filled with data). Over all the database contains almost 90.000 datasets (including artifacts, as well as topographical measurements). The Adobe Lightroom® databases contain about 20.000 pictures of the excavation, as well as artifacts (photographs, drawings and finished figures).

V.7.3 Analysis and representation of data

The analysis and representation of data is displayed in chapters VI to X. All necessary data is displayed with help of tables and plots. In addition to scatter-plots, box-plots or tertiary-plots, illustrations (drawings and photography) show relevant objects. Scatter-plots are used to represent metric data (e.g., length and width of objects) and spatial positions of objects. If box-plots are used, the whiskers represent the minimum and maximum of all displayed data (the box represent 50% of the data, each whisker represents 25% of the data). Tertiary plots can display coherences of three data sets (e.g., length, width and thickness).

Chapter VI: Lithic raw materials

„Flint“, Tanis said gravely.“I know you‘ll be terribly disappointed. But you‘ve only got a cold. You‘re not dying.” (Anthony & Porath 1991: 58)

VI.1 Introduction and overview

The following chapter discusses lithic raw material used and/or discarded on-site. The main data of lithic raw materials derive from all GHs. In total (2006 to 2014), n=6660 silicious and silicate objects are collected in the database (non-analysed collective finds definitely contain some hundred or thousand small objects, too). However, the material from the stratified Middle Paleolithic layers (GH3, 4x and 4) of the campaigns 2009 to 2014 are of particular importance.

It includes classical raw materials like flint and chert, but will also give an overview of the lithic raw material that are often neglected or only shortly discussed. These include raw materials like quartzite, quartz, varieties of sandstone, felsic rocks like granite, and some minerals. The common denominator of all of these rock materials is that they contain a high amount of SiO_2.

VI.2 Quantity of lithic raw materials from GH 3, 4x and 4

The amount of objects from lithic raw materials (2009-2014) inside the GH 3, GH 4x and GH 4 is quite different. GH 3 contains n=3770, GH 4x only n=27 and GH 4 n=211 (single finds and find from collective finds). In total n=4005 lithic objects were detected inside these three entities. Limestone in diverse varieties is not part of this discussion.

In an overview, the most of the lithic material was used for knapping purposes. Fine-grained lithic materials like flint and chert are the majority, but crystalline (plutonic) rocks (such as granite), sedimentary rocks (sandstone) and metamorphic rocks (e.g., quartzite or gneiss) are also to be found. Some materials are only present in small amounts (like minerals or volcanic material). In addition to these materials the amount of n=245 objects are made from a currently unknown lithic raw material.

The specific description of common lithic raw materials and the sourcing is not explicitly part of this dissertation. Many observations derive here from field campaigns undertaken by working group Floss and especially from observations made by Markus Siegeris (Siegeris in prep) and Klaus Herkert (Herkert in prep), because they study lithic materials in course of their dissertation.

VI.3 Flint from the *argiles à silex*

VI.3.1 Introduction

Flint from the *argiles à silex* (abbreviated with FAS) is the most common raw material for lithic objects in the entire site and maybe of the entire Paleolithic in the Côte chalonnaise. In the material excavated between 2009 and 2014 from GH 3, this raw material has a content of 74% (if all kind of silicious and silicate lithic

material is included). If we exclude materials that was found on-site but seemed not be knapped to produce lithic products, FAS has an amount of around 88%. By counting all lithic objects excavated between 2006 and 2014 from all GHs (that are collected in the database), n=3230 are made from FAS (which equals around 80,4%).
From its first appearance it seemed that there are different varieties, but further observations showed that these varieties are also to be found inside raw pieces as well. This is a fact that makes it very challenging to differentiate varieties between sources, as well as using simple macroscopic appearance for the formation of work pieces (see Uthmeier 2004b).
FAS appears in the site as raw pieces, cores, blanks, gelifacts (frost shards), heating debris and debris that is related to knapping and breaking.

VI.3.2 Origin of flint from the *argiles à silex*

FAS is a residual flint from the Upper Cretaceous epoch. The sediments of this geological epoch were eroded and deposited in the Paleogene (Dewolf 1970; Rat 2006). The French name *Silex de argiles à silex* derives from these secondarily deposited sediments (clay-with-flints, see Pepper 1973). But as the name suggest these raw material is not only deposited in clayish sediments. There are also sources known from sandy sediments containing nodules (e.g., the flint from a sandpit near Dulphy, Sable de Mont Macon)
We are using the term flint (*Feuerstein*) only for silicious raw material from the Upper Cretaceous epoch, as Floss (1994) recommended. The definitions of the terms silex, flint and chert used here are from conventions of working group Floss and mostly derive from Floss (1994). They are shortly summarized in tab. 122:

English term	German term	French term	Meaning
Silex	*Silex*	*Silex*	Lat. for pebble, used as a general term for silicious and silicate raw materials, used for all materials that contain SiO_2
Flint	*Feuerstein*	*Silex*	Used for microcrystallin, finegrained silicious raw material deriving from the Upper Cretaceous
Chert	*Hornstein*	*Chaille*	Used for silicious raw material deriving from Jurassic context

Tab. 122 - Meaning of the terms Silex, Flint and Chert as used by working group Floss for silicious and silicate raw materials

VI.3.3 Sources

FAS is the most common raw material in VP II and this seems also be real for the complete Paleolithic of the Côte chalonnaise. The nearest source of this raw material is around 150 m away (see Frick et al. 2012; fig. 2) and located on the hill slopes of the Montadiot massif (see fig. 116 and Frick et al. 2012).

This source can be classified as a close distance raw material source (for the discussion about distances to raw material sources and foraging radius, see chapter X.7). In a radius of 5 km many sources are known (see fig. 116). They are situated on the falling edges of hill ranges (e.g., Montadiot massif) as well as the plane valleys like in the area of Fontaines north of Germolles (pers. comm. M. Siegeris).

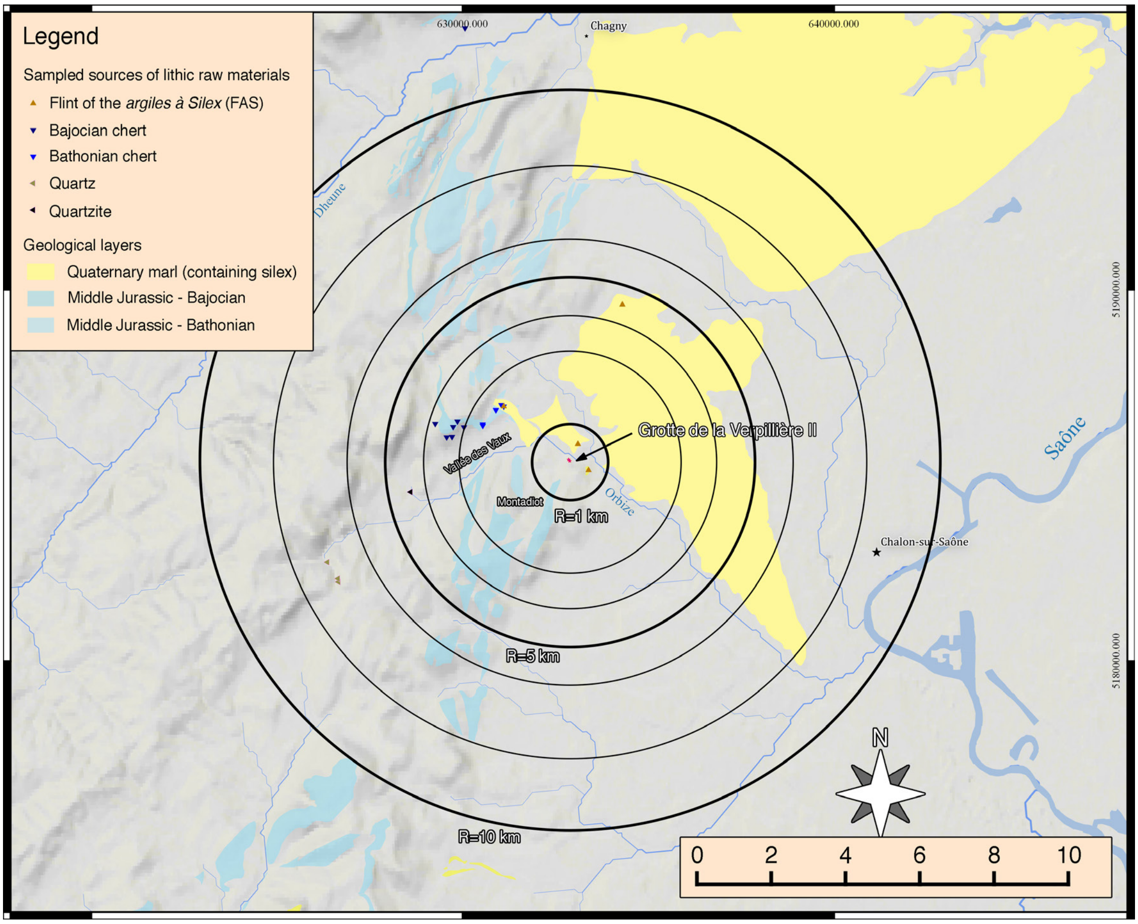

Fig. 116 - Map of the Côte chalonnaise with distribution of lithic raw material containing sediments and sampled spots (map provided by M. Siegeris, SFB 1070 B01)

Nowadays, known outcrops of FAS are mostly situated on agricultural fields in secondary position in these *argiles à silex*. Primary flint sources in Cretaceous sediments are mostly unknown in southern Burgundy. The only known small spot is near Cuiseaux (around 20 km west of Tournus) which contains sediments from the Lower and Middle Cretaceous (Rouyer 1910, 1912) and also flint nodules (pers. comm. M. Siegeris). Another small spot (in a distance of around 5 km northwards of the VPs) of cretaceous sediments on the pinnacle near the tower of Saint-Hilaire, commune Fontaine does not contain flint nodules (observation by K. Herkert, H. Würschem & J. A. Frick, May 21, 2016).

VI.3.4 Patination, color and impregnation

Patination

Nearly all pieces from the FAS are patinated (see fig. 117). The patination color for FAS range from whitish, grayish to beige. Some show also blueish and brownish parts, which derives from thinner patination in some parts. The majority of FAS objects are beige-gray to beige.

A small „experiment“ on FAS from the Sable-de-Mont-Macon near Dulphy showed that the patination process can happen very fast. Fresh knapped pieces on the knapping workshop in the garden of the excavation house were superficially altered within two week (the dark blue-grayish glassy surface altered to dull, light gray).

With the exception of patination, the majority of the FAS look quite fresh with sharp edges but heavily patinated. The fast altering of the FAS from the Sable de Mont Macon could be an explanation of this observation.

Some FAS show also a secondary alteration in color, a so called iron-oxide impregnation (*Imprägnierung*, term used by M. Siegeris to describe secondary color alteration, like in Bohnerzhornstein (bean-ore chert) from Breisgau, Germany). The term *Imprägnierung* was also used by Floss (1994) for Bohnerzhornstein alteration in the context of raw material analysis from the Rhineland.

Fig. 117 - Color range of patination of FAS. a) Whitish - GER10.226-058.239; b) Grayish - GER10.227-058.336; c) Beige - GER09.228-060.101.1; d) Impregnation (GER10.228-058.351)

Broken artifacts from fast dug test pits show another aspect of color and appearance. Obviously, patination „swallows“ differences that are well observable on fresh raw material pieces, such as microfossils, banding or color.

Banding and zonation

A general feature of most of the FAS is an orange (iron oxide) banding immediately under the cortex (fig. 119, see also Frick et al. 2012), which is normally some millimeters thick. As fig. 118 shows there are some clusters of objects from FAS with and without such a banding. But as further analysis suggests, these clusters do not present spatial scattered pieces from one knapping event. The real meaning of these clusters are still open for interpretation.

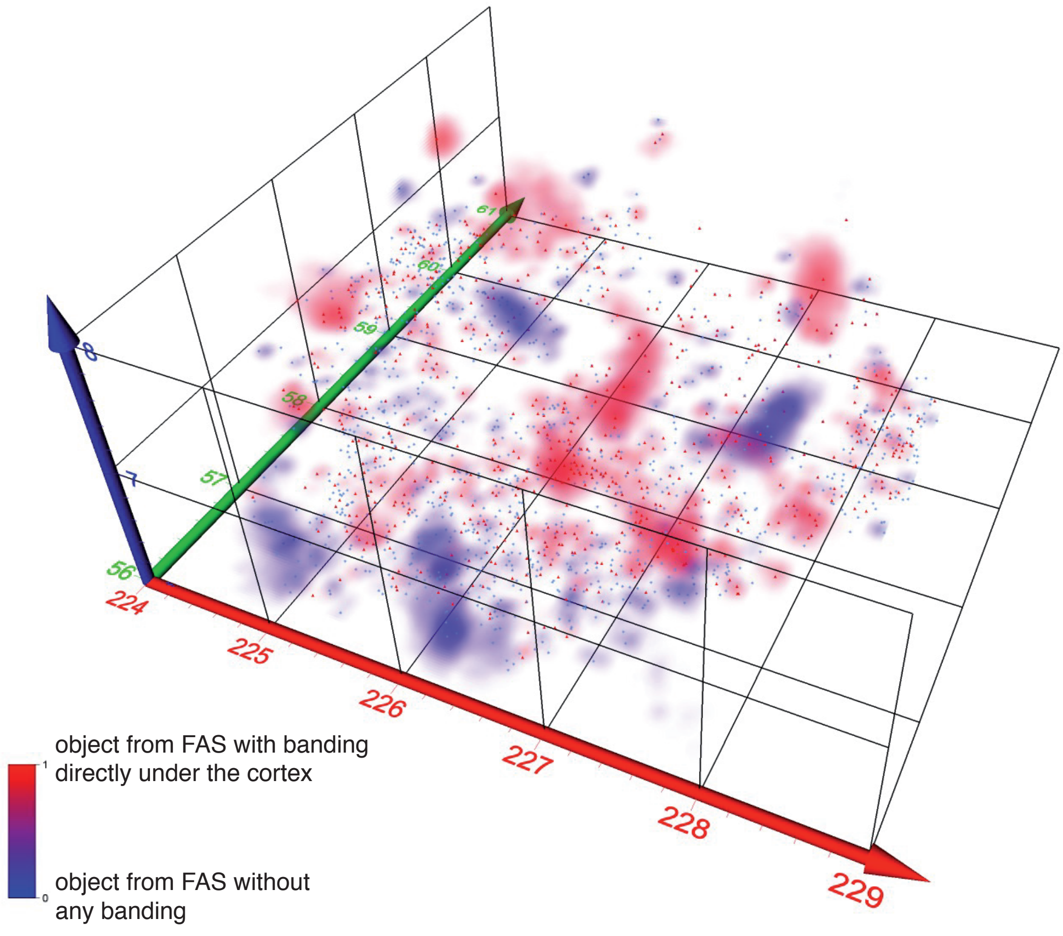

Fig. 118 - Scatter plot of objects from FAS with (red) and without (blue) banding directly under the cortex, from GH 3. The colored volume render represent zones with a high density of these objects

The interior (unpatinated, fresh) varies in color and granularity, also inside of the same raw piece (see fig. 119). The color ranges from gray to gray-brownish. Generalized, the brighter (light gray) and more opaque the material the coarser it is (and contains calcite). The very fine grained, more homogenous parts can be glassy and translucent on its edges.

Fig. 119 - Unpatinated variety of FAS from a cow pasture 100 north of the Château de Germolles, see also Frick et al. (2012)

VI.3.5 Energy flow in coarse-grained and fine-grained parts

Knapping tests on FAS demonstrated clearly, that if the material is fine-grained and homogenous it is of excellent knapping quality (Frick et al. 2012) and comparable to other high quality flints (such as baltic flint, flint from the Parisian basin or flint from the Senonais). But nodules can also contain coarse-grained parts that swallow energy in the knapping process. This is also well visible in the archeological record. Blanks of FAS with such coarse-grained parts contain often many ring cracks (many tries to detach the blank) or hinges (not enough energy). A phenomenon which is often visible is that if the material changes inside from fine to coarse-grained (from basal to terminal) a hinge is situated on the contact zone of these material variations

VI.3.6 Microfossils

The amount of detectable microfossils as evidence for work-piece division or raw-material source detection is very low, which is a function of the nearly complete opaque patination and the amount of microfossils. The detection and denomination of microfossils inside FAS is not part of this thesis and will be discussed elsewhere (see Siegeris in prep).

VI.3.7 Cortex

The cortex of FAS is not as variable as the interior. For the majority of the lithic objects with cortex, it can be simply described as a bright beige, rough, rolled, homogenous and fine-pored. But sometimes cortex can be also dark brown, smooth or dapple. The following tab. 123 displays the found cortex features and their number.

Feature of cortex nature	Number of objects from GH 3 with this feature	Number of objects from GH4x with this feature	Number of objects from GH4 with this feature	Total
Rough	1104	13	85	1202
Smooth	111	0	0	111
Fine-pored	943	9	73	1025
Coarse-pored	8	0	0	8
Inhomogenuous	20	0	4	24
Homogen	981	13	72	1066
Rolled	1046	12	73	1131
Dapple	98	0	10	108

Tab. 123 - FAS Features of cortex nature and number of objects from GH 3, 4x and 4 with this feature

The thickness of cortex on FAS is displayed in fig. 120 as boxplot and shows that the „standard" cortex thickness is less than 1 mm (fig. 121). The measured minimum thickness is 0.1 mm, the maximum is 8 mm (the box-plot values are in tab. 124).

Value	Cortex thickness on FAS
Minimum	0,1
Q1	0,5
Median	0,8
Q3	1,3
Maximum	8

Tab. 124 - Boxplot values of cortex thickness on FAS

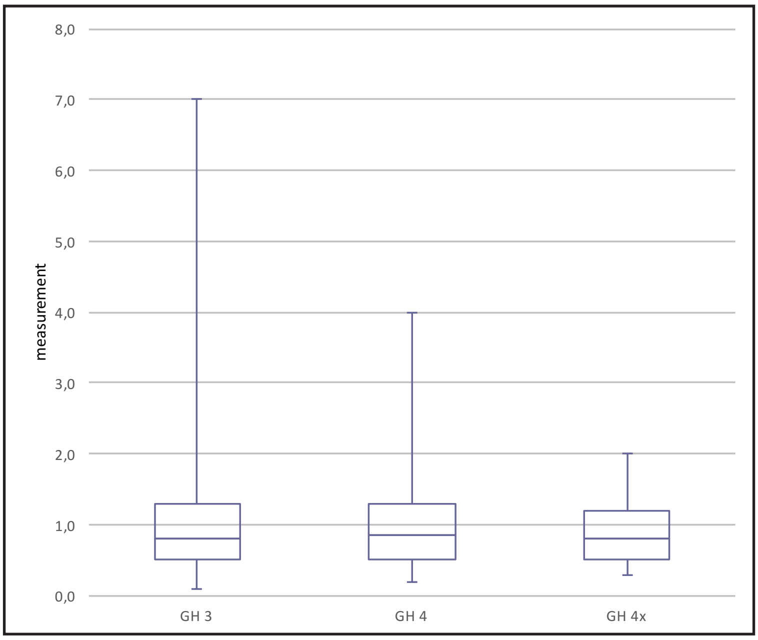

Fig. 120 - Boxplot comparison of cortex thickness on FAS objects from GH 3, 4x and 4

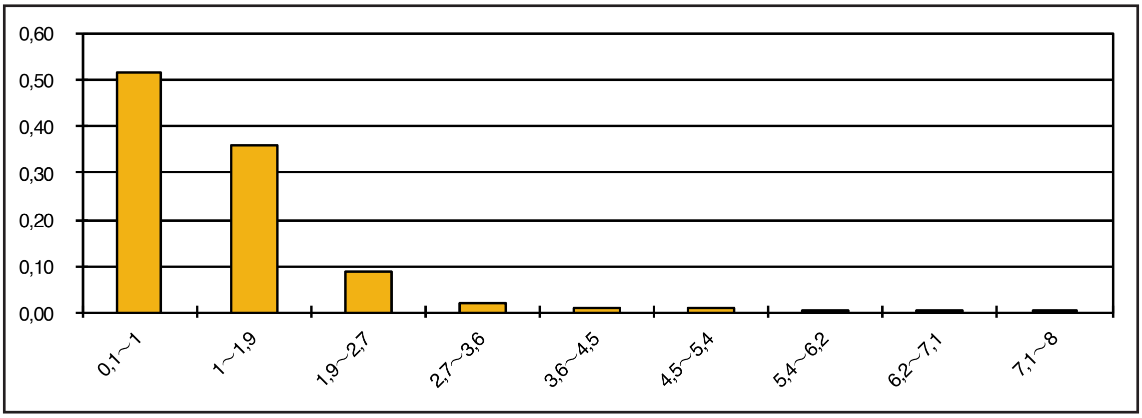

Fig. 121 - Histogram of cortex thickness from GH 3

The cortex color of FAS is diverse, but there are preferences visible (see tab. 125). The majority is beige and has a bright, homogenous color.

Cortex color	Number of objects from GH 3 with this feature	Number of objects from GH4x with this feature	Number of objects from GH4 with this feature	Total
Beige	997	11	79	1087
Brown	338	7	25	370
Gray	78	3	4	85
Black	10	0	3	13
White	381	5	17	403
Bright	985	8	71	1064
Dark	499	8	29	536
Homogenous in color	1046	13	66	1125
Dapple in color	163	0	19	182
Brighter in the interior	224	1	23	248
Darker in the interior	231	0	19	250

Tab. 125 - Color of cortex on FAS

VI.3.8 Distribution in GH 3

FAS is the major lithic raw material in GH 3 and spread all over this geological unit. The densest zones of FAS (single finds) are in the South (mainly square meter 227-057) and in the East (square meter 229-059). In its hight, the zone between a Z-value of 6.8 to 7.10 bears the densest distribution of FAS (see fig. 122).

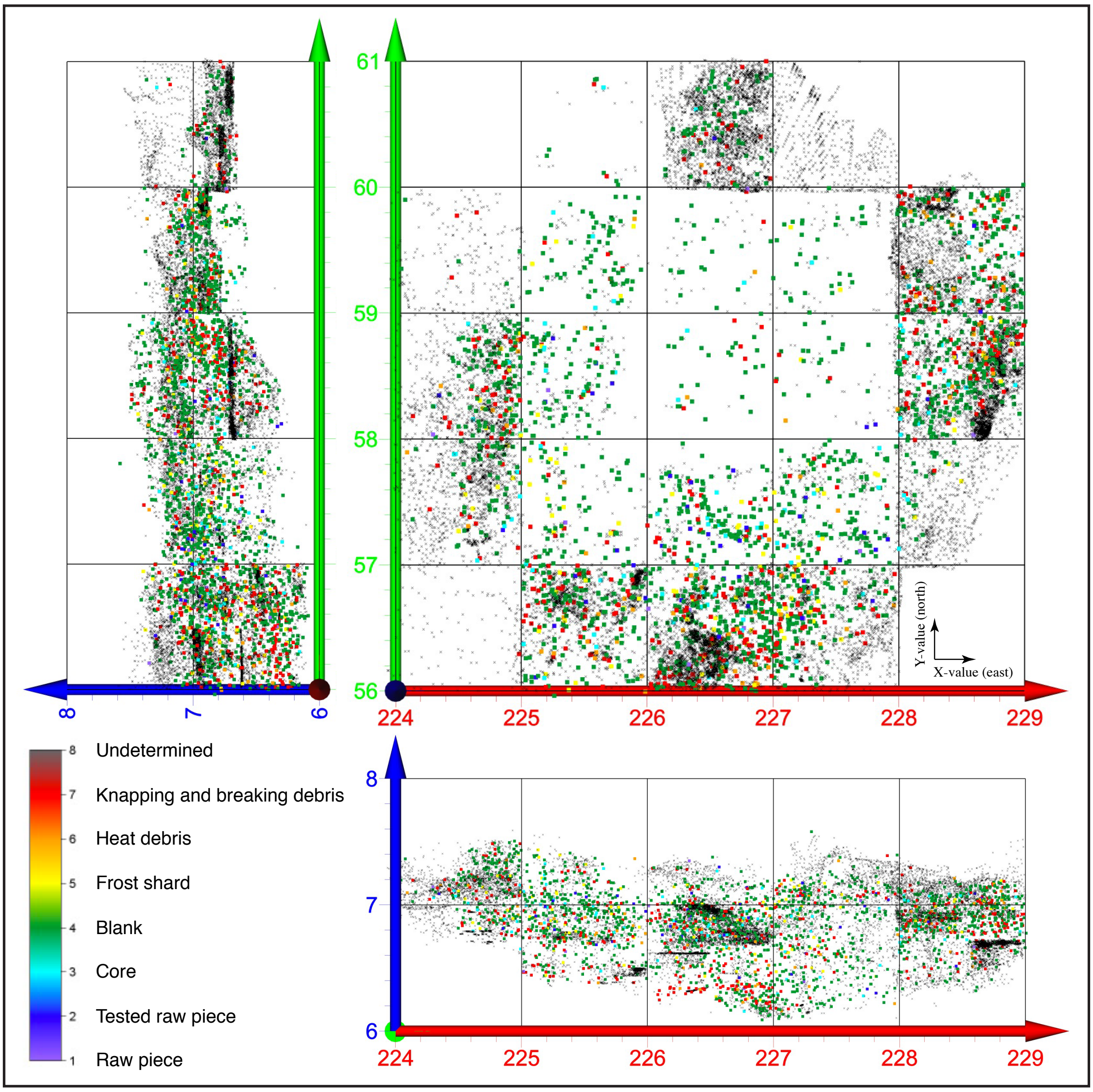

Fig. 122 - Total distribution of FAS inside GH 3.

The zone with the lowest distribution (Z-value of 6.0 to 6.2) is in the South (eastern part of square meter 227-057, and western part of square meter 228-057). At a Z-value of around 6.4 the distribution of FAS spreads to the South and south-eastern parts of the excavation area (square meters 226-057, 227-057, 228-057, 228-058 and 229-059). In the next step, at a Z-value of around 6.6, the distribution spreads more. It contains now also some single-finds in square meter 226-058, 227-058, 228-059 and one in 227-060. Now, at a Z-value of 6.7 the FAS spread in nearly all square meters, except the western row (row 225, i.e., square meter 225-057 to 225-061) and between 6.7 and 7 the distribution of FAS stays quite constant. At a Z-value of 7 to 7.1 the most intensive spatial distribution of FAS is reached and more or less constantly decrease to the highest points. The highest points of the FAS in GH 3 are spread between a Z-value of 7.3 and 7.5. They are scattered unequal and can be found in square meter 225-058, 225-059, 226-057, 227-057 (with higher density), only some artifacts in 226-061, 228-060, 227-058, and one point in 225-060, 226-060, 227-060 and 229-061.

VI.3.9 Distribution in GH 4x

The number of objects from FAS in GH 4x is that small that no spatial correlations makes sense. Only n=22 objects are made from FAS and are distributed in a small band of objects in the western part of the excavated area. They are from square meters 226-058, 226-059 and 227-058 from 2010. The general distribution of objects from this GHs is discussed in chapter VIII (there a spatial distribution plot is displayed, too).

VI.3.10 Distribution in GH 4

GH 4 contains n=139 objects from FAS. They are distributed in the complete volume of the GH 4 sediment and no distinct spatial pattern is visible, concerning the total distribution of artifacts from GH or of the categories of lithic objects (see fig. 123).

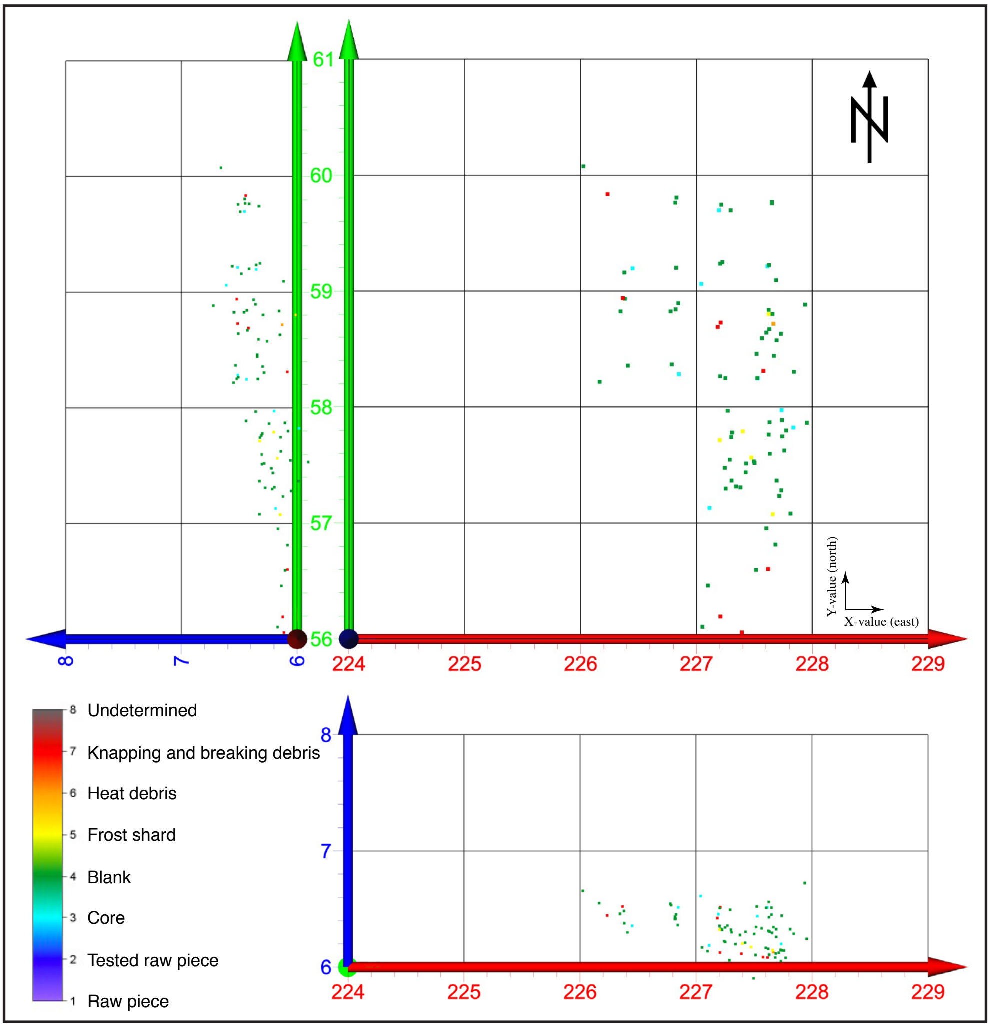

Fig. 123 - Distribution of FAS inside GH 4

VI.4 Jurassic chert (*chaille*)

Another fine-grained raw material for knapped lithic artifacts are varieties of chert of the Middle Jurassic epoch (in French the material is often called *chaille*). From the entirety of GH 1, 2, 3 and 4, there is data of n=102 objects from this material. A major similarity of FAS and chert is that the formation of internal varieties is challenging. Here too, different varieties can exist in one raw piece (variety in grain-size, color or banding). At the moment it seems not really possible to separate these chert varieties to a defined source or exact geological stage. Both, the Bathonian and Bajocian stage provides chert. From the research of M. Siegeris it seems possible that most of the varieties derive from a Bajocian context, but all known sources of chert are in secondary position in weathering soils on top of these geological entities (pers. comm. M. Siegeris). The varieties recently observed by Siegeris & Floss (2015) are present in the lithic source context, but are not defined in the archeological, yet. They defined one variety from the Bathonian (j2) and n=11 from Bajocian (j1) context. Futur research should be able to classify the varieties visible in the archeological context. In this thesis the neutral term chert varieties as protective cloak is used. From field research of K. Herkert and the author it is likely that fine- and coarser grained varieties with rose colors derive from La Roche à Saint-Martin-sous-Montaigu and gray varieties from Culles-les-Roches.

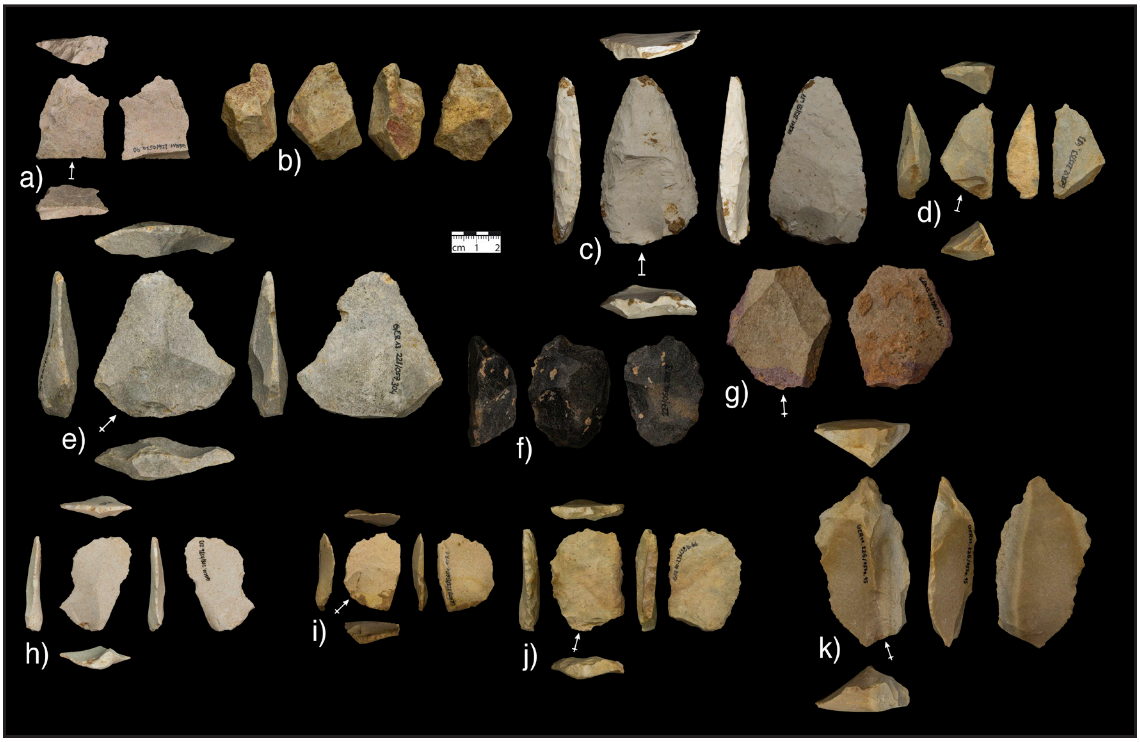

Fig. 124 - Color varieties of chert from GH 1 to GH 4. a) Red variety (GER11.226-057.90); b) Red-beige (GER12.227-057.609); c) Light gray with microfossils (GER12.229-059.637); d) Medium gray variety (GER12.225-059.483); e) Dark-gray variety (GER13.228-057.304); f) Black variety (GER13.227-056.275.3); g) Green-gray and red variety (GER12.227-057.695); h) Beige-gray variety with yellow dots (GER10.228-058.253); i) Light brown (GER09.228-060.107.1); j) Brown-gray (GER10.226-058.66) and k) Brown and gray (GER11.226-057.95)

VI.4.1 Features and varieties

Chert varieties are in general quite colorful and a bit coarser in grain than FAS. They can be red, red-beige, rose, gray, black, green-gray, red-gray or brown (see fig. 124). And despite the individuality and distinctiveness of these pieces othing could be refitted. According to M. Siegeris and from own observations different varieties can (again) occur in one nodule (see fig. 125, cores). This fact makes the formation of distinct units quite challenging.

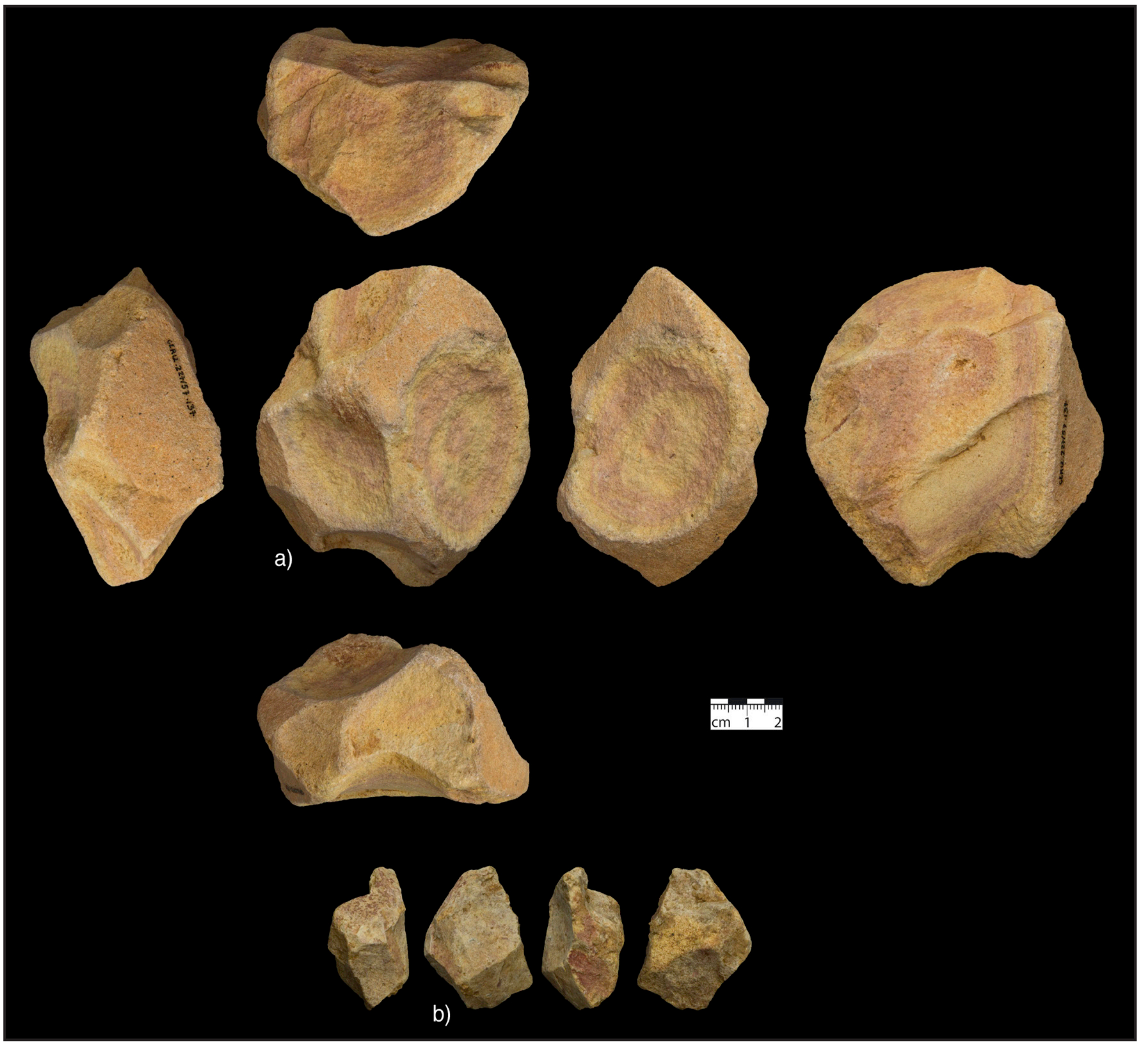

Fig. 125 - Cores of chert with more than one color. a) Rose-beige (GER12.227-057.137) and b) Green-gray and red (GER12.227-057.448.2)

Here the varieties of the lithic sources of the surrounding area are reproduced (see Siegeris & Floss 2015) and displayed as tab. 126 and fig. 126:

Geological stage	Denomination	Description
Bathonian (j2)	Type I	Contain a higher percentage of bioclasts and a few onkoids. They usually show a lot of silica between the clasts with zones of higher tightness of the allochems.
Bajocian (j1)	Type I and II	Contain a higher percentage of bioclasts and a few onkoids. They usually show a lot of silica between the clasts with zones of higher tightness of the allochems.

	Type IV, V and VI	Can be classified as cherts with a different matrix (translucent) and only less than 10% bioclasts. The grade of silicification varies inter- and intra-types.
	Type III, VII and IX	Show more grains like onkoids and pelloids but very less than 10% bioclasts. The matrix is a mixture of more opaque than translucent parts surrounding the clasts.
	Oolithic type Ia and Ib	Have a high amount of ooids and onkoids packed together in the patinated area but this pattern is less visible in the interior.

Tab. 126 - Variety types of chert defined by Siegeris & Floss (2015) from Côte chalonnaise

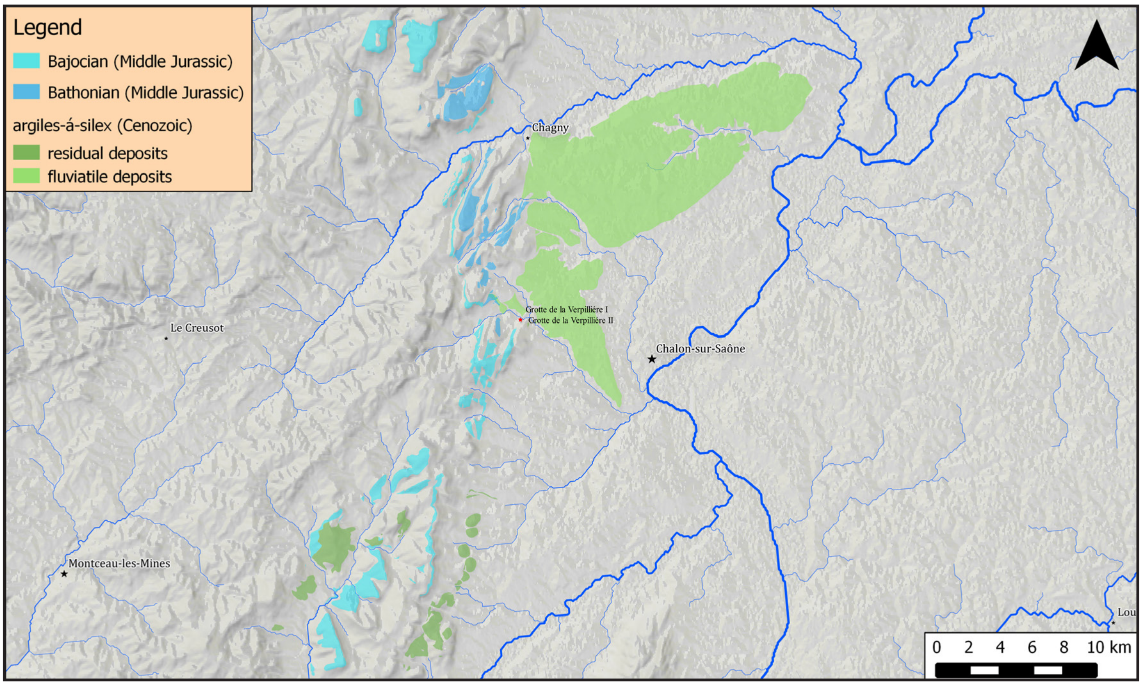

Fig. 126 - Mapping of sediments containing lithic raw materials in the Côte chalonnaise, with positions of geological samples. Map from Siegeris (SFB 1070 B01)

VI.4.2 Sources

Jurassic sediments from the Bathonian and Bajocian age are situated along the eastern flank of the western hill ranges of the graben system and build a line between Mâcon and Chalon-sur-Saône (see fig. 126, above). Bathonian sediments are distributed north and west of the VPs in a minimal distance of 2 km.

The closest known source of chert is situated in the next valley (Vallée de Vaux) at La Roche à Saint-Martin-sous-Montaigu (and very likely the source for rose chert). The chert nodules can be found in secondary position under the cliff face on the vine fields. This site is denominated as raw material outcrop and was also occupied in the Middle Paleolithic and Aurignacian (Gros 1964; Gros & Gros 2005; Herkert 2014; Pouliquen 1982a, b, 1983a).

VI.4.3 Distribution in GH 3

Chert is quite homogenous scattered in GH 3. In top view the highest density can be seen in square meter 226-057, 227-057 and 228-057 (see fig. 127).

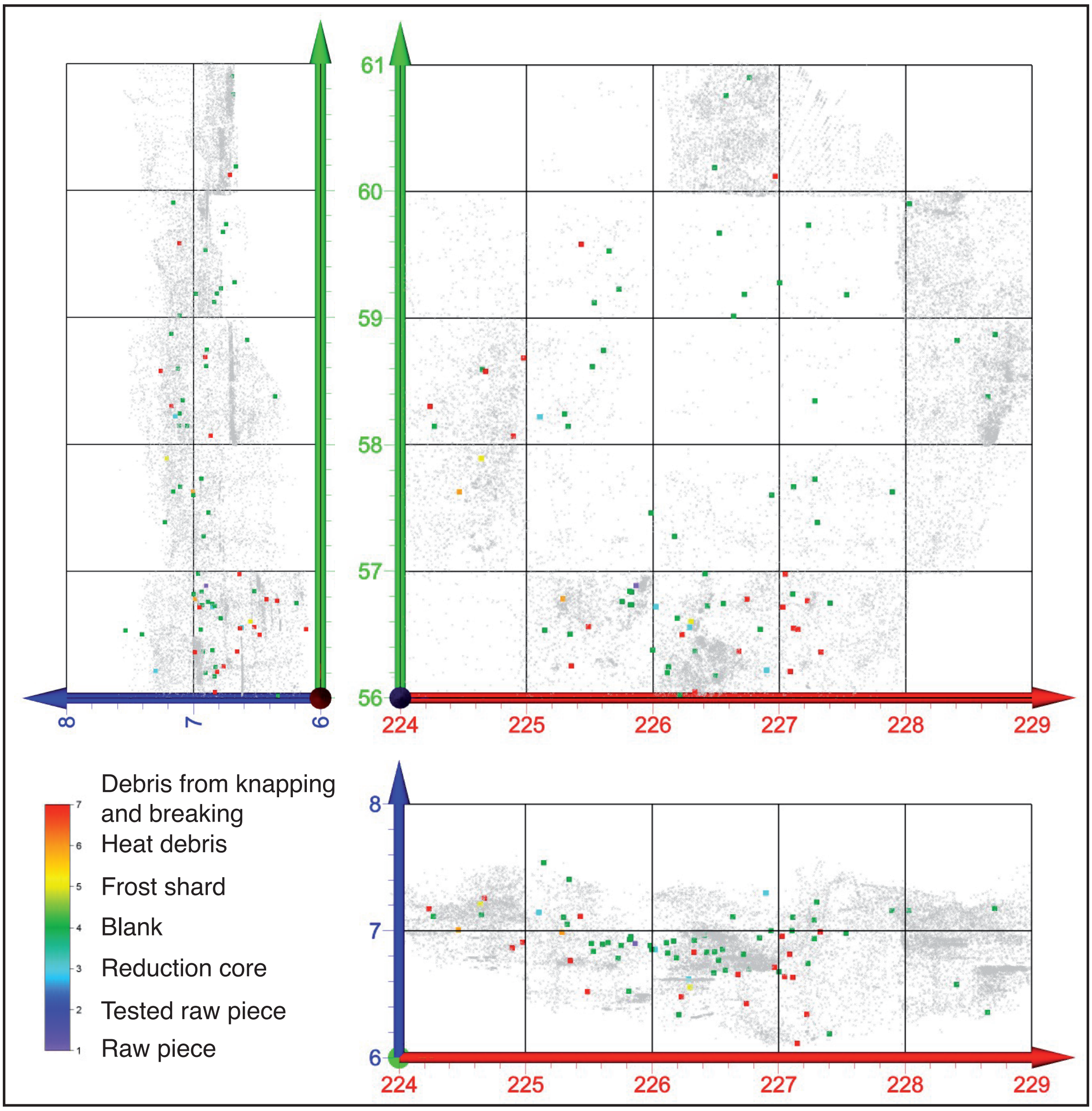

Fig. 127 - Distribution of chert artifacts from GH 3

In the lowest parts of GH 3, only some objects can be found. The highest density of chert is to be found around a Z-value of 6.7 to 7. In the case, separating the distribution of chert inside GH 3, we would say that in the southern part chert can be found from a Z-value of 6 to 7.6. We can separate the lower southern zone between Z-value of 6.0 to 6.6, the middle zone on the whole area between Z-value of 6.8 and 7.2 and only three pieces above 7.2 in the South (see fig. 127, above).

VI.4.4 Distribution in GH 4x

The context of GH 4x yields no chert objects.

VI.4.5 Distribution in GH 4

GH 4 yielded n=5 objects from chert that are listed in the following (tab. 127) and displayed in their spatial distribution in fig. 128. They are scattered in top view, north of the center of the find distribution of GH 4. In Z-value, they are present in the top part of GH 4 (around z=6.4), as well as in the mid (around z=6.1).

Find-number	Explanation
GER09.227-059.160.1	Flat raw piece (plate?), maybe also used as anvil, flat surface with a kind of polish
GER09.228-059.149.1	Debris
GER09.228-059.154.2	Small raw piece (nodule), highly weathered
GER10.228-058.517	Debris, maybe heat influenced
GER10.228-059.266.1	Basal blank fragment, a flake, Levallois flake with traces of a hafting rest

Tab. 127 - List of chert objects in the context of GH 4

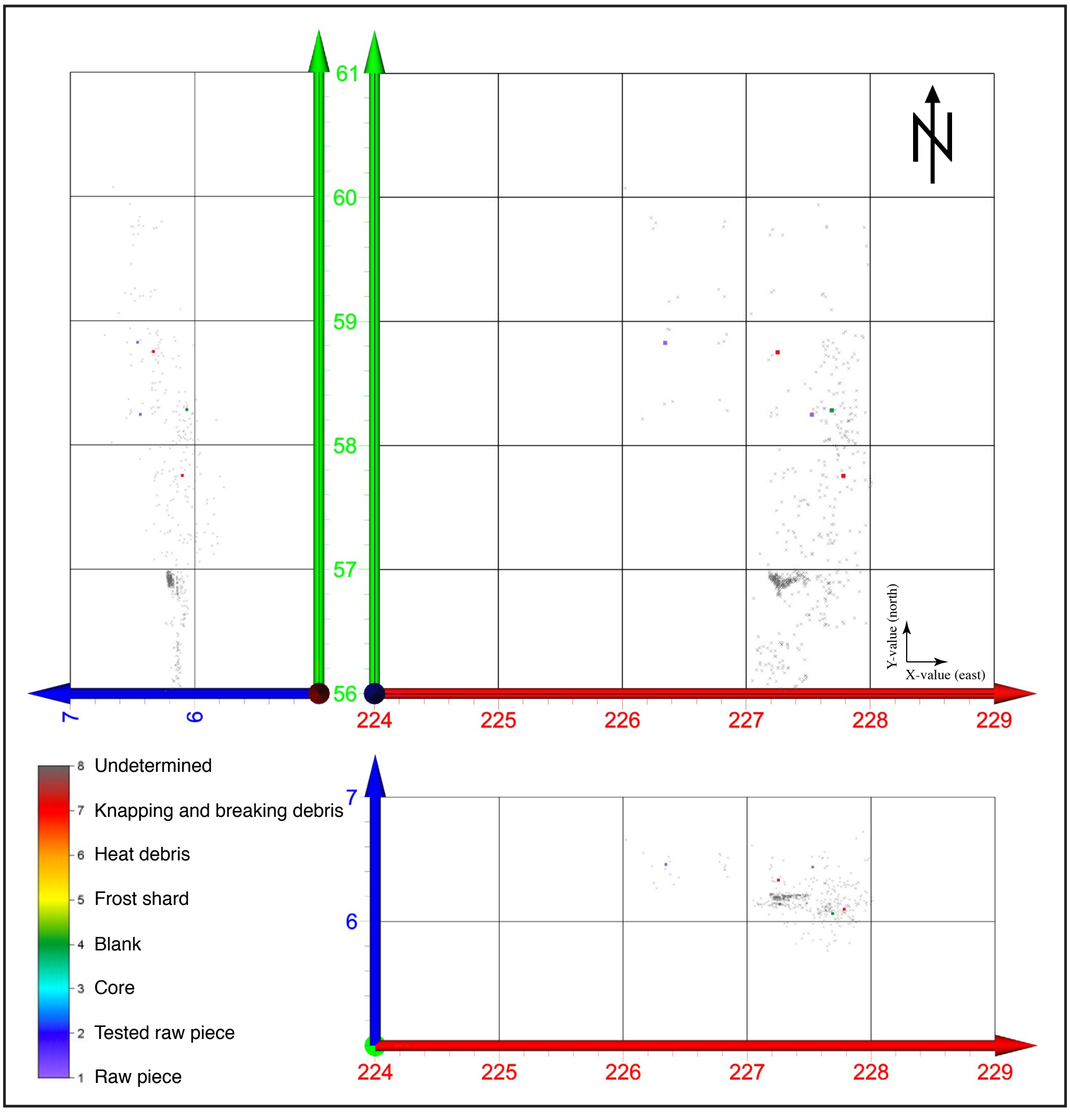

Fig. 128 - Spatial distribution of chert objects inside GH 4

VI.5 Quartzite

VI.5.1 Introduction

Quartzite is a coarse-grained, metamorphic raw material. In VP II this material seems to be used exclusively for hammerstones and anvils. The database contains n=270 objects of this material and in the context of GH 3, 4x and 4 there is evidence of n=255 pieces (raw pieces, cores, blanks and debris). The „cortex“ (exterior surface) of these pieces is mostly dark-beige or brown, and quite homogenous in color. Most of the pieces seem to have an affinity of carrying quite stable sinter.

If the exterior surface of quartzite objects is present, it is rounded and smoothed, but in that way that the blocky (cuboid) raw shape of the blocks is still visible. This is evidence for water rolling and transport but not over large distances (maybe some kilometers).

The coalesced quartz-grains are well sorted. Often bright and grayish grains are mixed in the matrix of the quartz piece. The interior of this material is quite distant to the exterior. Fresh broken pieces have different gray shades. Broken pieces from GH 3 instead have beige (sometimes brown) and beige-gray shades, but never plain gray shades (see fig. 129).

Fig. 129 - Ancient broken block of quartzite block (used as anvil) showing the affinity for sinter sediment and the beige interior (GER10.226-060.202)

VI.5.2 Sources

In the contiguity of the VP II, there is no evidence for geological bedrock containing such material. The next geological source for fresh raw pieces is situated around 4 km (beeline) to the West in the next valley (Vallée de Vaux). Rounded but still blocky pieces are also present today in the riverbed of the little creek Orbize, in a minimal distance of around 120 m eastwards of the site.

VI.5.3 Distribution in GH 3

Objects from Quartzite are scattered in the complete area, with higher densities in the North (square meter 227-061), in the East (square meter 229-059 and 229-060) and the complete southern zone (square meters 225-058, 226-058, 227-058, 228-058 and 226-057, 227-057, 228-057). In the hight densities can be seen at a Z-value of 6.0 to 6.6 in the South, at 6.6 to 7.0 at the whole area and a minor density between 7.0 and 7.4, as well (see fig. 130).

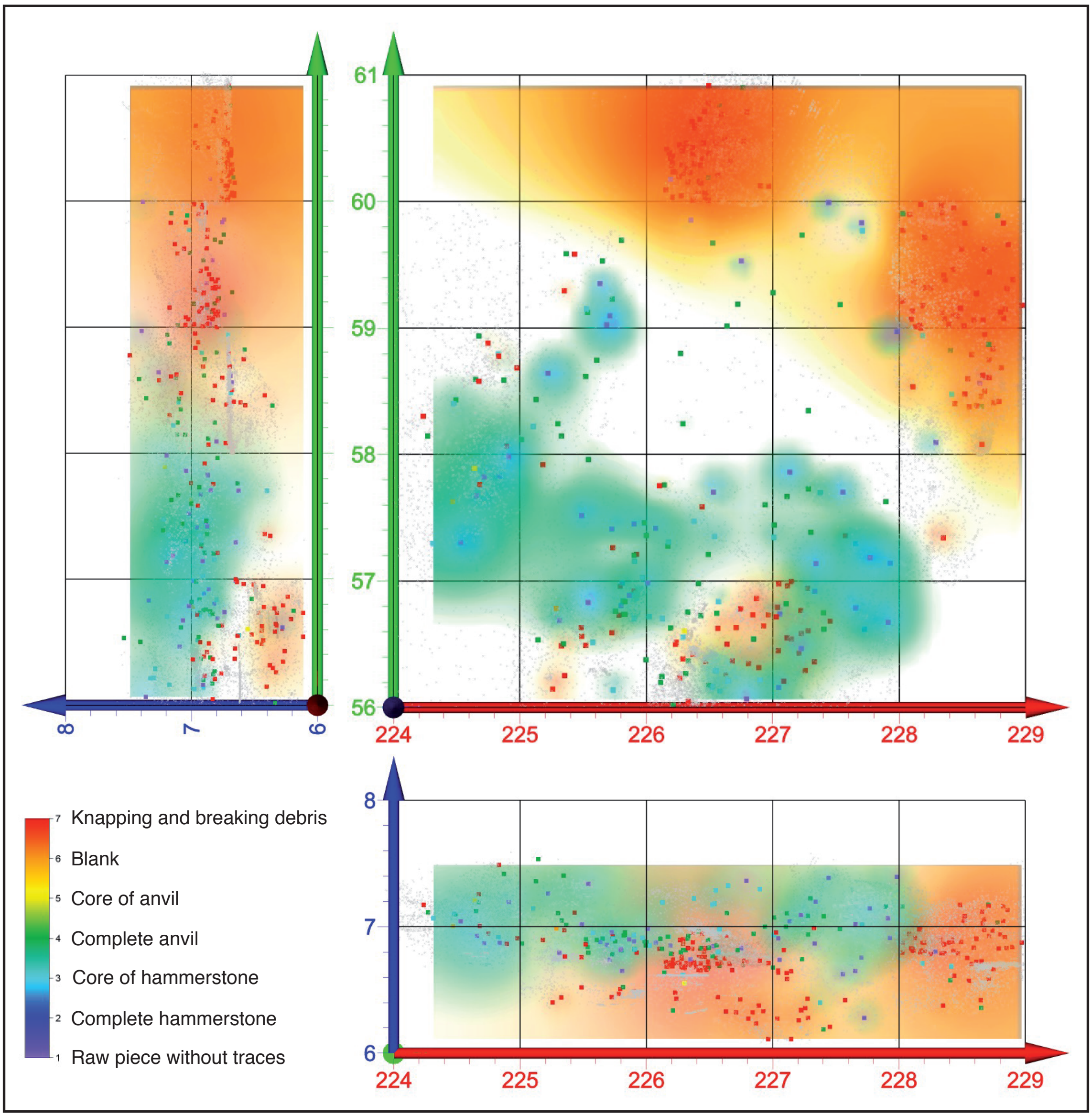

Fig. 130 - Distribution of quartzite artifacts in GH 3.

The distributional comparison of raw-pieces, cores, blanks and débris made from quartzite show an interesting feature (see fig. 130, above). Debris (red) and blanks (green) are scattered in the Northeast and in small clusters in the South. They are distinctively separated from cores and raw-pieces of this lithic raw material.

VI.5.4 Distribution in GH 4x

GH 4x contains n=2 objects from quartzite (a flake and an anvil, but they cannot refitted). They are listed in tab. 128:

Find-number	Explanation
GER10.226-059.343	Small flake, maybe deriving from a hammerstone
GER13.225-059.1343	An anvil, showing detachments of some blanks in the same direction (from knapping?)

Tab. 128 - List of objects from GH 4x from quartzite

VI.5.5 Distribution in GH 4

The assemblage of objects from quartzite from GH 4 is only slightly bigger. Only n=6 objects were detected (all from square meters 228-058, 228-059 and 228-060). With the exception of one (which is a debris) all are hammerstones and show signs of use (crushed areas and detached parts).

VI.5.6 Dimension of quartzite objects from GH 3

The maximum dimension (maximum length) of objects from quartzite range from 8.7 to 183.4 mm (fig. 131). The median of debris is small, followed by raw pieces without use traces. The median of complete and objects showing detachment that are uses as hammerstones (91.2 vs 89.2), as well as anvils (12.7 vs 109) are quite similar to each other (see tab. 129 and fig. 132). But anvils are mostly larger that hammerstones.

Value	Raw pieces without use traces	Raw pieces used as hammerstones	Cores of hammerstones	Raw pieces used as anvils	Cores of anvils	Blanks of hammerstones and anvils	Debris
Minimum	18,7	52,6	49,9	91,9	83,2	19,1	8,7
Q1	21,8	79,1	66,1	98,3	97,8	30,6	12,2
Median	24,8	91,2	89,2	112,7	109,0	34,8	18,9
Q3	36,3	104,1	100,6	122,4	125,6	49,1	26,3
Maximum	65,1	149,2	108,3	183,4	132,0	93,5	83,8

Tab. 129 - Boxplot values of maximum dimension of objects from Quartzite of GH 3

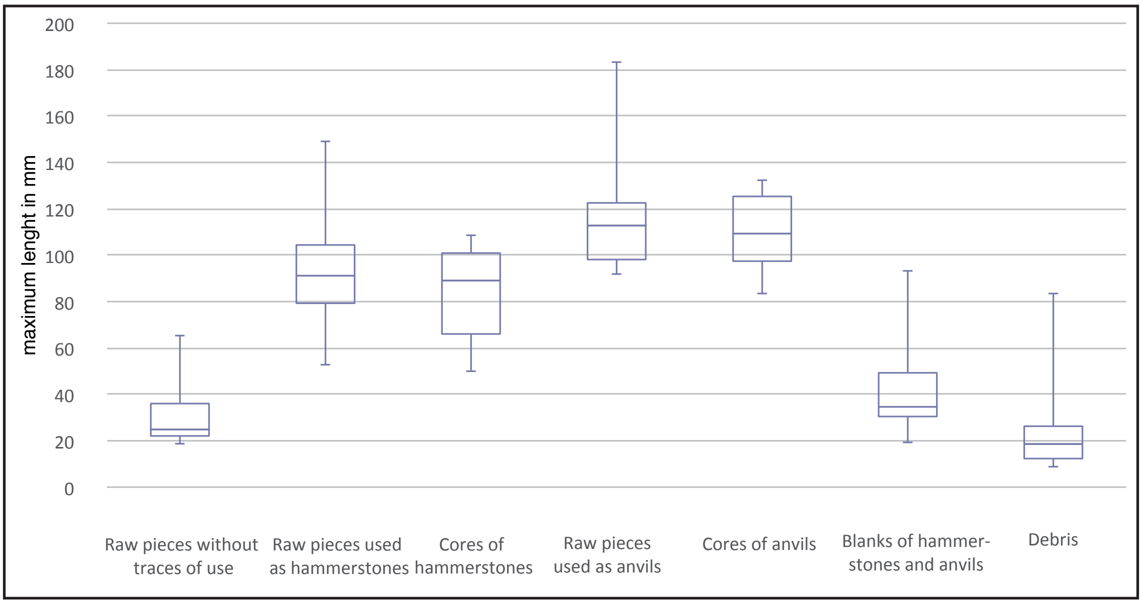

Fig. 131 - Boxplots of maximum dimension of objects from Quartzite of GH 3

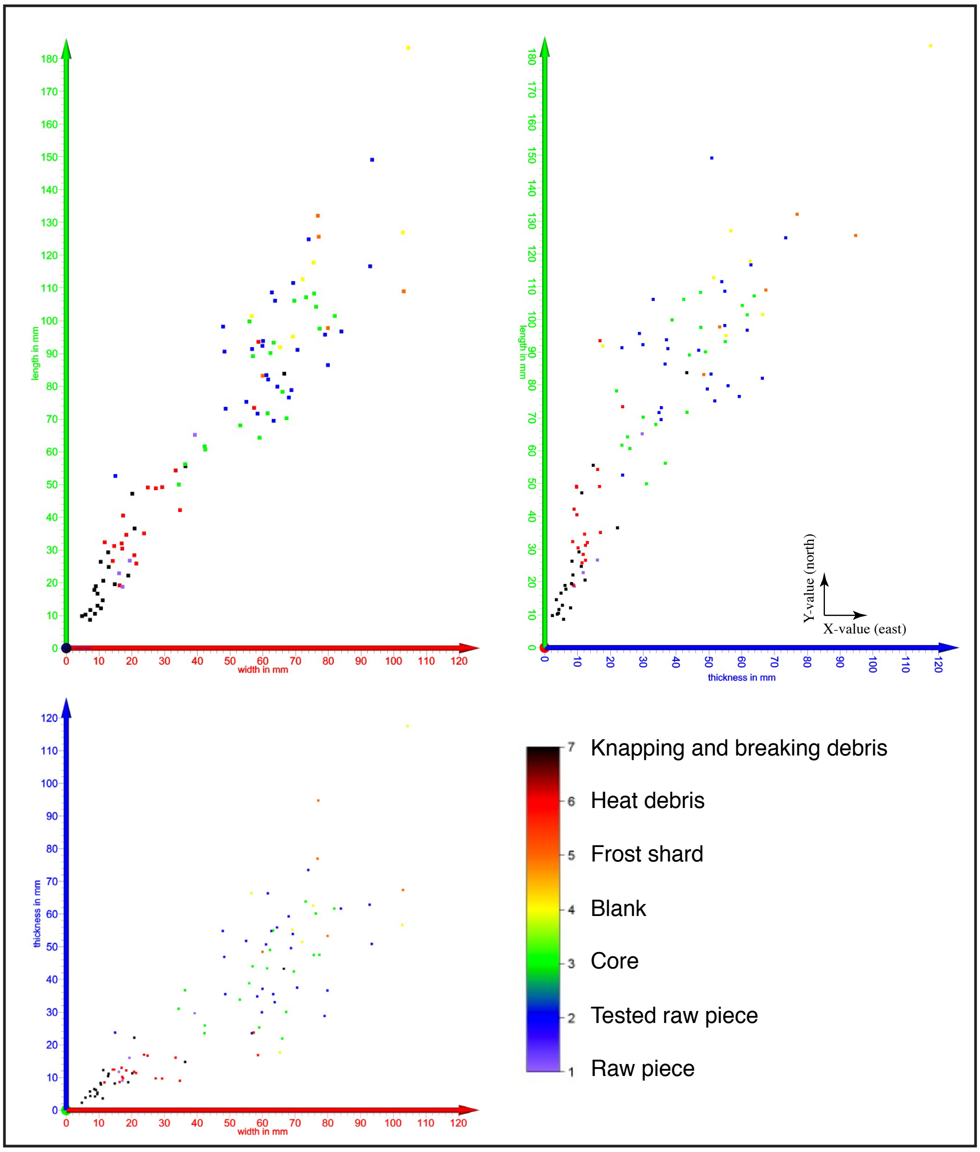

Fig. 132 - Scatterplot of dimensions of objects from Quartzite of GH 3

Some quartzite objects are quite heavy (the heaviest is around 4 kg), which is displayed as box-plot in fig. 131. The median is at around 140 grams (see tab. 130).

Value	Mass of quartzite objects
Minimum	0,1
Q1	6,7
Median	141,8
Q3	348,4
Maximum	4000,0

Tab. 130 - Boxplot values of masses of quartzite object from GH 3, 4x and 4

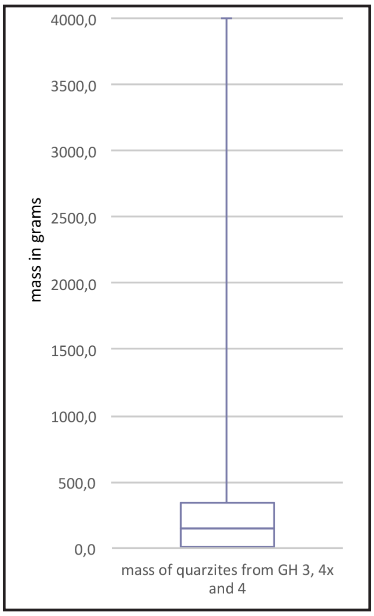

Fig. 133 - Mass box-plot of quartzite objects from GH 3, 4x and 4

VI.6 Quartz

VI.6.1 Introduction

Quartz is present in GH 1, 2, 3 and 4. The stratified context of GH 3 and 4 yield n=162 objects. Most of them are debris of milk quartz and if the exterior is present, it is rolled. Only one piece of rock crystal is present (GH 3, GER12.227-057.395.4), which is also debris. Quartz was also used as hammerstone and anvil, but unused raw pieces are present, too. The following list (tab. 131) shows the assemblages from GH 3 and 4:

Denomination	Number in GH 3	Number in GH 4	Total
Raw piece (no traces of use)	8	0	8
Raw piece used as anvil	2	0	2
Raw piece used as hammerstone	4	0	4
Core used as anvil	1	0	1
Core used as hammerstone	1	1	2
Opportunistic flake-core	1	0	1
Simple flake	10	0	10

Flake derive from hammerstone	2	0	**2**
Edge correction flake	1	0	**1**
Flake with lateral retouch, a knife	1	0	**1**
Debris	128	2	**130**
Total	**159**	**3**	**162**

Tab. 131 - Assemblages of Quartz from GH 3 and 4

VI.6.2 Sources

One possible origin of quartz was detected around 4 km northwestern direction in a northern side valley of the Vallée des Vaux (pers. comm. M. Siegeris, see also fig. 116). The creek of this valley is a tiny tributary of the Orbize. But quartz pieces can be also found in the Orbize creek as well as the River Saône. Therefore the option to get access to this material is directly in the Orbize Valley (minimum distance of 120 m), on a route of around 2 km long in the Orbize and in this little valley (I couldn‘t find the name of it) with the detected outcrop.

VI.6.3 Distribution in GH 3

Lithic objects from quartz are distributed in nearly all square meters where GH 3 was excavated. From the top view of the distribution we can assume four concentrations of this material (in the North, the South, the West and the Northeast). The small cluster in the North consists only of debris (red), whereas the other clusters contain also blanks, cores and raw pieces (see fig. 134). In regard to Z-value, the upper part of GH 3 contain more raw pieces, cores and blanks from quartz. But in general, quarz is in Z-value present in the entire thickness of GH 3.

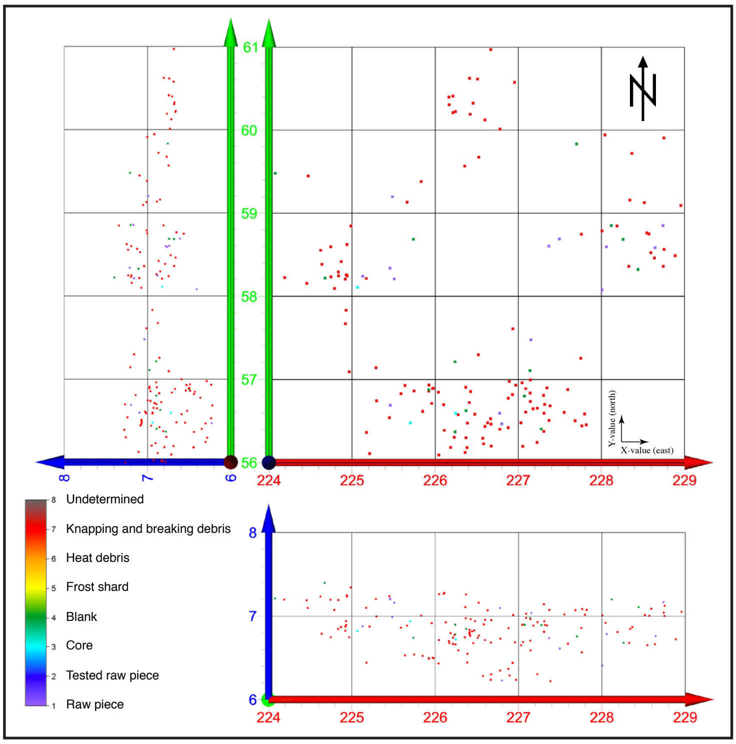

Fig. 134 - Distribution of lithic objects from Quartz in GH 3

VI.6.4 Distribution in GH 4x

GH 4x contains no lithic objects from Quarz

VI.6.5 Distribution in GH 4

Inside GH 4, only three objects are made for Quarz. All are situated in the row X=228 and are listed in the following tab. 132:

Find-number	Z-value	Denomination
GER09.228-059.157.8	6,51	Debris
GER10.228-058.507	6,144	Core-from-hammerstone with one detachment negative
GER14.228-057.1207	6,133	Debris

Tab. 132 - Quarz objects from GH 4

VI.6.6 Dimension of quartz objects from GH 3

Objects from quartz scatter in dimension, but show a cluster in small dimension (see fig. 136). Bigger objects are used as hammerstones and anvils (as for quartzite). The median of maximum length of raw pieces used as hammerstone (91.5) and anvils (113.4) differs noticeable. The median of blanks and debris is small (fig. 135). Interestingly, the maximum length of raw pieces without use traces scatter remarkable (tab. 133).

Value	Raw pieces without use traces	Raw pieces used as hammerstones	Core of hammerstone	Raw pieces used as anvils	Opportunistic flake-core	Blanks	Debris
Minimum	6,1	67,0	84,3	65,8	75,9	7,2	0,0
Q1	20,0	79,2	84,3	89,6	75,9	15,6	10,9
Median	33,8	91,5	84,3	113,4	75,9	20,4	14,6
Q3	82,8	98,8	84,3	116,2	75,9	27,2	19,4
Maximum	113,1	106,0	84,3	119,0	75,9	38,9	90,8

Tab. 133 - Boxplot values of maximum dimension of objects from Quartz of GH 3

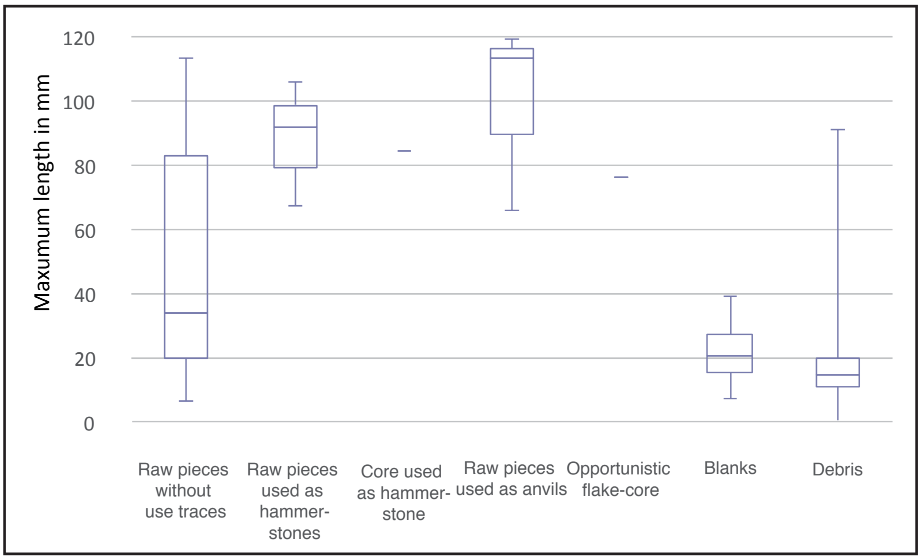

Fig. 135 - Boxplots of maximum dimension of objects from Quartz of GH 3

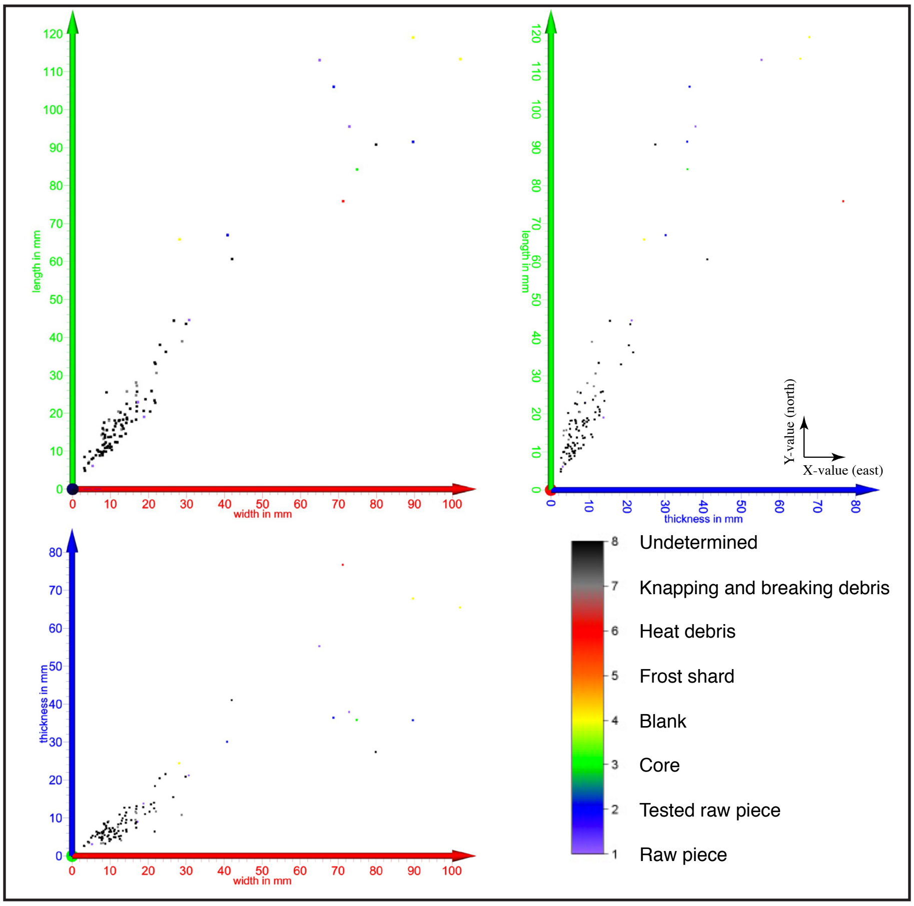

Fig. 136 - Scatterplot of dimensions of objects from Quartz of GH 3

VI.7 Quartzitic sandstone

VI.7.1 Introduction

Quartzitic sandstone is defined as small quartz grains that stick together by minor melting processes. It ranges between a sedimentary rock (sandstone) and metamorphic rock (quartzite). The transition is gradational. The term quartzitic sandstone is used here with the following (maybe weak) definition. In quartzite all grains stick (melted) together, without easily break out grains. In sandstone they are not melted together, so it is easily possible to break out grains. Quartzitic sandstone fills in the gap between. It is possible to break out grains, but with force (because some grains are melted together). If a piece of quartzite, quartzitic sandstone and sandstone lay next to each other the differences are visible with a magnifier and palpable with fingers. Yet, no experiments about the strength or resistance to force are made, because no natural outcrop of this material was detected. From its appearance, it is situated between quartzite and sandstone (so to speak between hard and medium-hard).

From the geological map, such material should be located in the Vallée des Vaux, as well as quarz, quartzite and sandstone. If so, this would result in a close dis-

tance range for this material (closer than 6 km).
Inside GH 3, 4x and 4 only n=31 objects are made from this material and the majority (n=22) of the pieces are linked to hammerstones (cores-of-hammerstones, blanks-of-hammerstones). They are listed in the following tab. 134.

Denomination	GH 3	GH 4x	GH 4	Total
Anvil	0	1	0	1
Complete hammerstone	4	1	1	6
Core-of-anvil	1	0	0	1
Core-of-hammerstone	10	0	0	10
Blank-from-hammerstone or blank-of-anvil	4	0	0	4
Debris	9	0	0	9
Total	**28**	**2**	**1**	**31**

Tab. 134 - Lithic objects made from quartzitic sandstone from GH 3, 4x and 4

VI.7.2 Distribution in GH 3, 4x and 4

Lithic objects from quartzitic sandstone are mostly distributed in the southern part of GH 3, with the exception of two pieces (one in the North and one in the West). Most of them are situated below Z=7. Inside square meter 226-057 and 227-057 a binary division in Z-value can be assumed (see fig. 137).

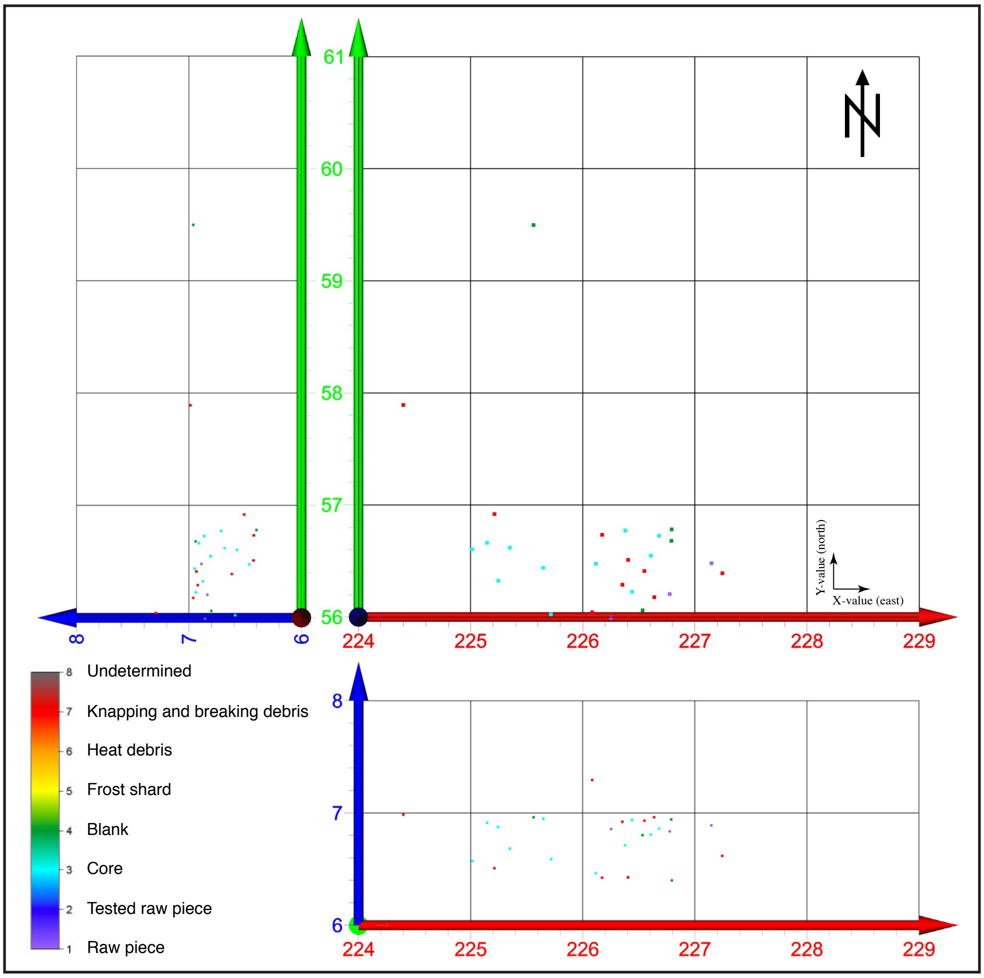

Fig. 137 - Distribution of lithic objects from quartzitic sandstone inside GH 3

GH 4x yielded two objects (one hammerstone and one anvil). They are situated in square meter 226-059 (anvil, GER10.226-059.329, Z-value of 6.68) and in 225-058 (hammerstone, GER13.225-058.1325, Z-value of 6.74).
In so far, GH 4 yielded only one piece (a hammerstone) in square meter 227-060 (GER09.227-060.174.1) at a Z-value of 6.27.

VI.7.3 Dimension of quartzitic objects from GH 3

Objects from quartzitic sandstone range in maximum length from 11.8 to 123.3 mm and span a bandwidth as similar as for quartz or quartzite (see fig. 138).

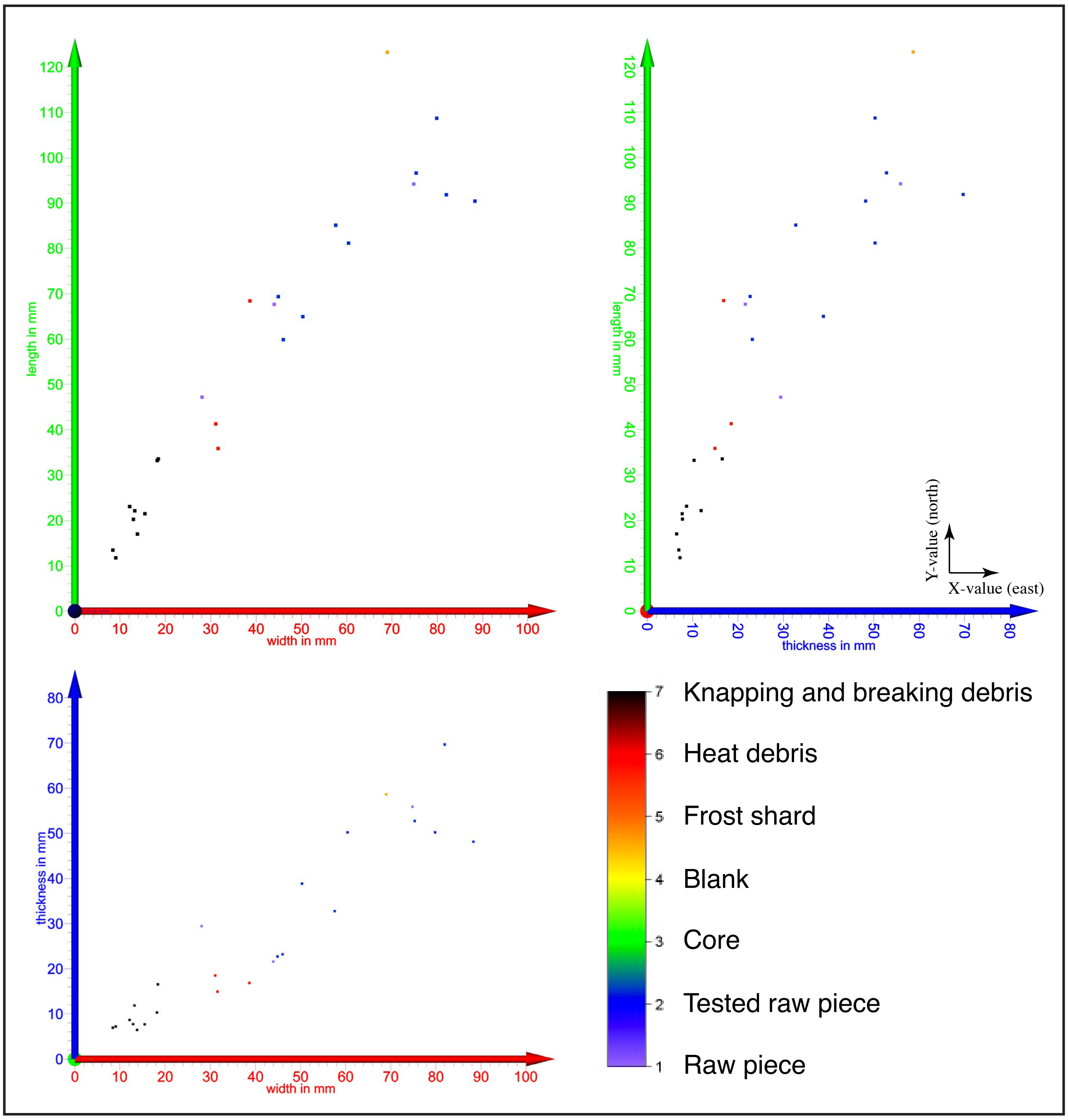

Fig. 138 - Scatterplot of dimensions of objects from quartzitic sandstone of GH 3

The box-plot values are listed in tab. 135 and show the hammerstones with detachment are as median bigger that raw pieces. Blanks are normally small (median of 41.3) and debris is quite small (see also fig. 139).

Value	Raw pieces used as hammerstones	Cores of hammer-stones	Core from anvil	Blanks	Debris
Minimum	47,2	59,9	123,3	35,9	11,8
Q1	57,4	69,3	123,3	38,6	17,0
Median	67,6	85,1	123,3	41,3	21,5
Q3	80,9	91,9	123,3	54,9	23,1
Maximum	94,2	108,7	123,3	68,4	33,6

Tab. 135 - Boxplot values of maximum dimension of objects from quartzitic sandstone of GH 3

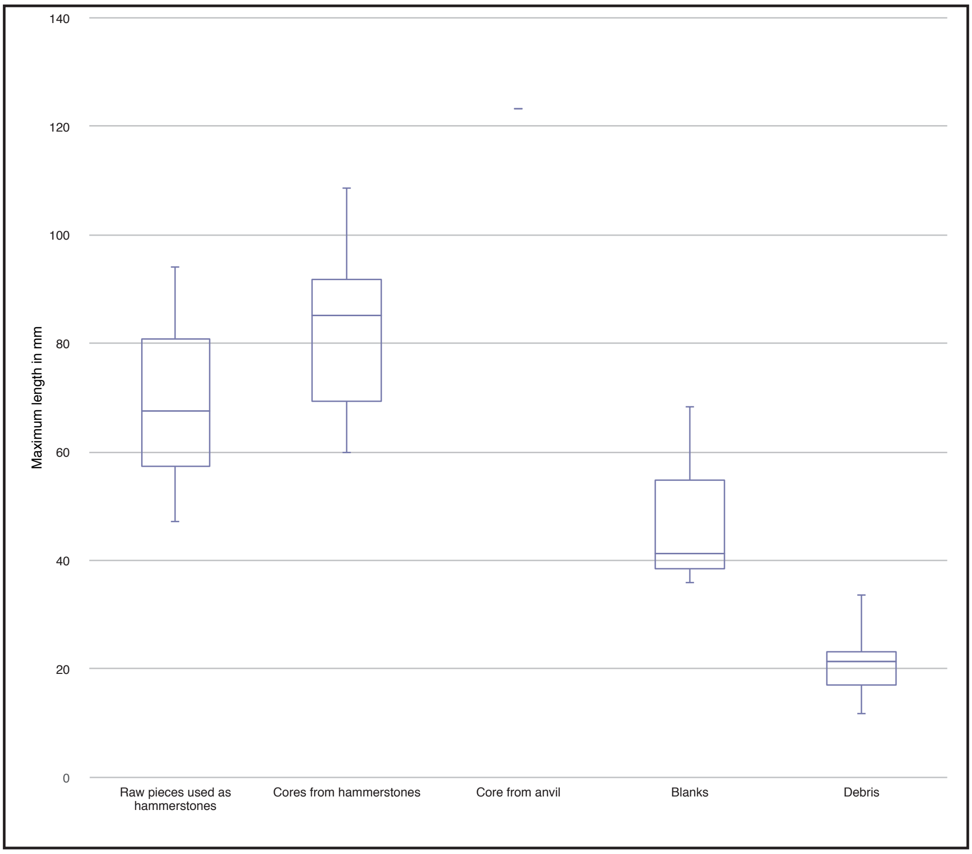

Fig. 139 - Boxplots of maximum dimension of objects from quartzitic sandstone of GH 3

VI.8 Sandstone

VI.8.1 Introduction

The division between sandstone and quartzitic sandstone is explained in chapter VI.7 (see above). Objects from sandstone are situated in GH 2, 3 and 4 (n=90, see tab. 136).

Denomination	GH 2	GH 3	GH 4	Total
Raw piece without use traces	0	4	2	6
Complete anvil	0	2	0	2
Complete hammerstone	0	6	0	6
Core-of-hammerstone	0	17	0	17
Core-of-anvil	0	1	0	1
Opportunistic flake-core	0	1	0	1

Blanks-from-hammerstone or blank-from-anvil	0	7	0	7
Debris	1	43	6	50
Total	**1**	**81**	**8**	**90**

Tab. 136 - Lithic objects from sandstone inside GH 2, 3 and 4

The majority of objects are debris (n=50), followed by cores-of-hammerstones (n=17). Only some blanks (n=7) and complete raw-pieces (n=8 used and n=6 unused) are present. From the observations of M. Siegeris, it is likely that sandstone was also procured from the Vallée des Vaux and the Orbize, as it was detected for quartzite.

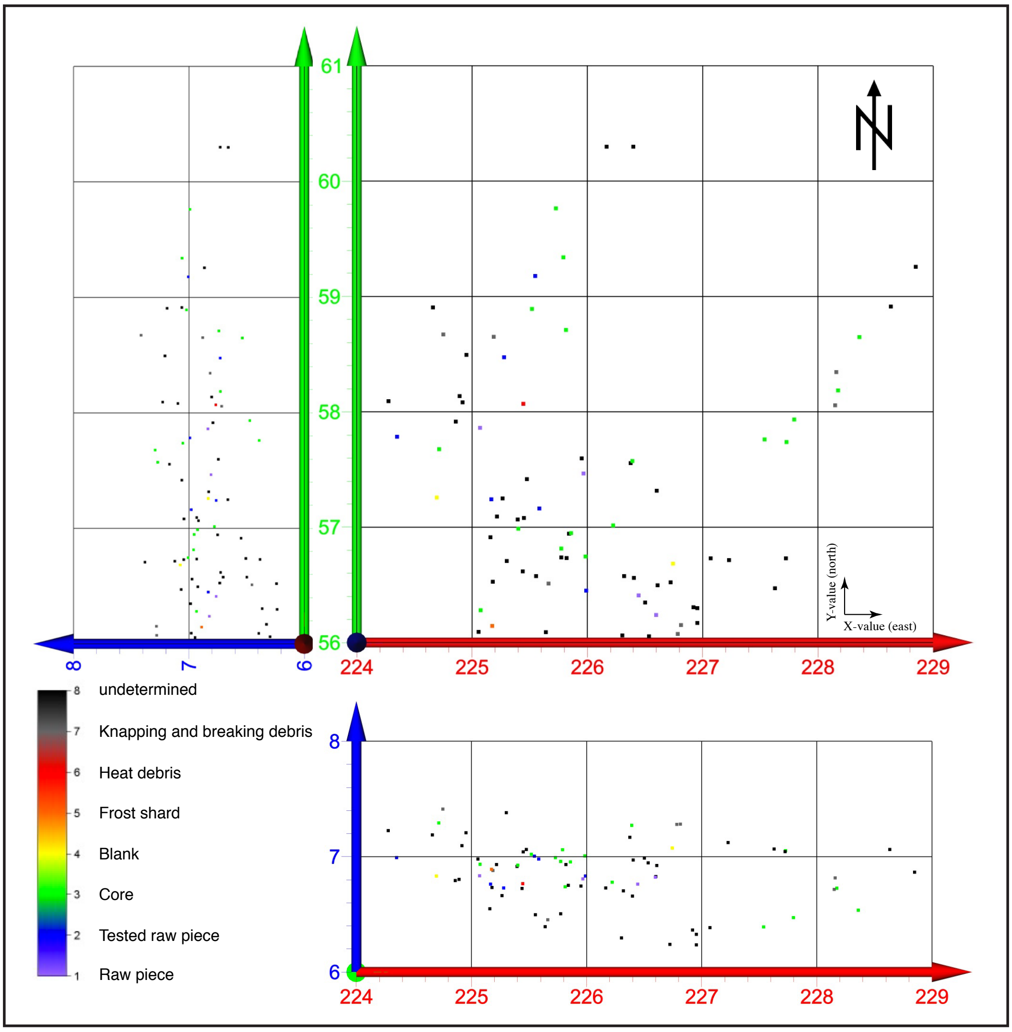

Fig. 140 - Distribution of sandstone objects from GH 3

VI.8.2 Distribution in GH 3 and 4

Inside GH 3, objects from sandstone are mostly scattered in the southwestern part of the excavated area (see fig. 140). By using an isosurface to separate of raw pieces and cores from blanks and debris, it is visible that the latter are more intensive clustered than cores and raw pieces. In regard to Z-value, objects from sandstone are scattered from 6.2 to 7.4. Raw pieces and cores are much more concentrated in a spectrum between 6.8 and 7.2.

The distribution of sandstone objects from GH 4 is sparse. Objects are present in three square meters (227-059, 228-059 and 228-057). Both raw pieces frame the presence of the debris, but in regard to Z-value they scatter from around 6.1 to 6.7.

VI.8.3 Dimension

Objects from sandstone inside GH 3 are scattered in dimension. Raw pieces without any traces of use are small as debris or quite large. Cores from hammerstones are visibly clustered in the mid dimensional range (fig. 141).

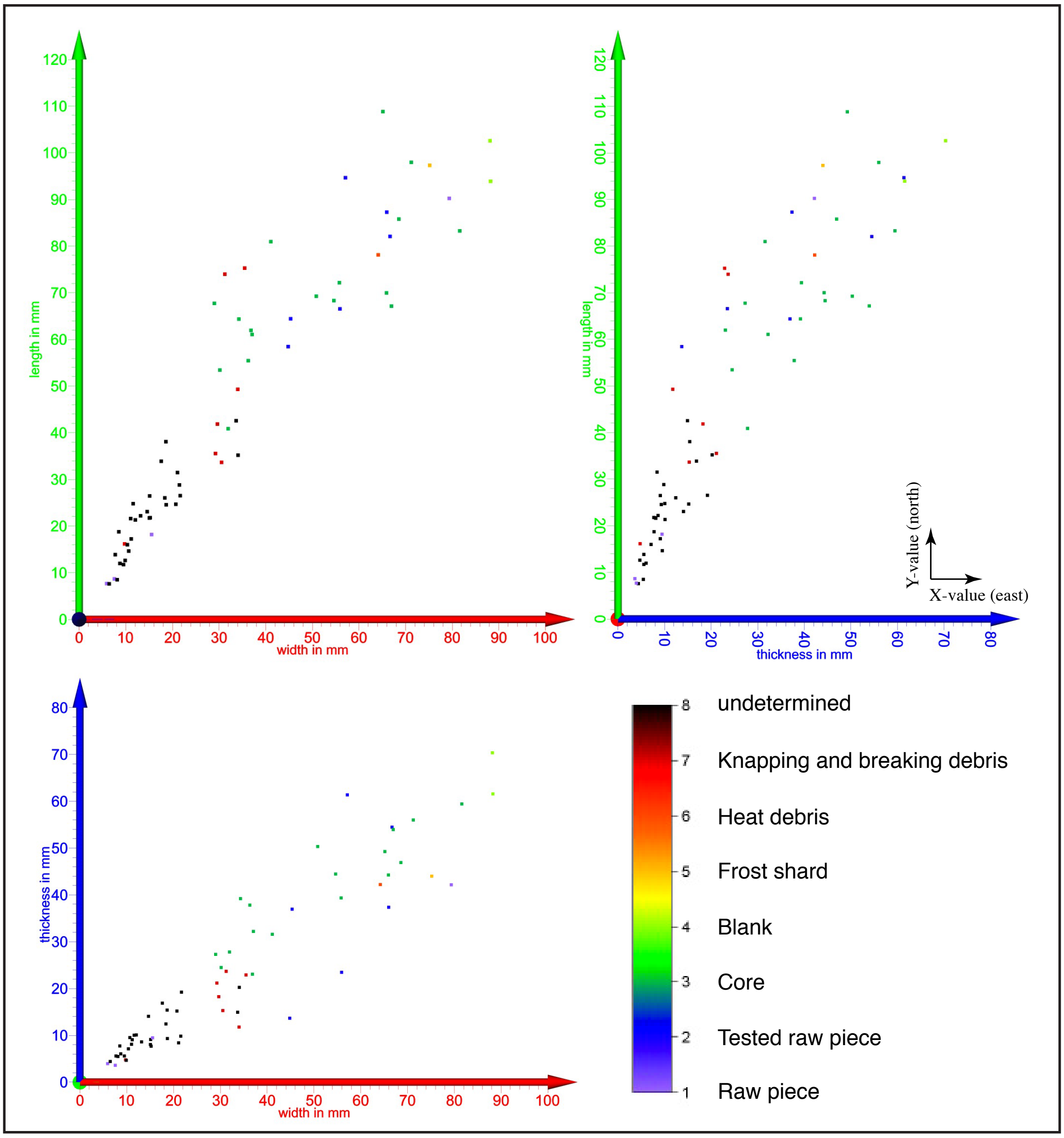

Fig. 141 - Dimensions of sandstone objects from GH 3

The median of raw pieces and cores used as hammerstone and anvil from this material is larger than of non-used raw pieces. Blanks from sandstone vary much more than for other coarse-grained raw materials from GH 3 (see fig. 142 and tab. 137).

Value	Raw pieces without use traces	Raw pieces used as hammer-stones	Cores from hammer-stones	Raw pieces used as an-vil	Core from anvil	Oppor-tunistic core	Blanks	Debris
Minimum	7,7	58,5	40,9	93,9	97,3	78,1	16,2	7,6
Q1	8,4	64,9	62,0	96,1	97,3	78,1	34,6	15,7
Median	13,4	74,3	68,3	98,3	97,3	78,1	41,9	22,0
Q3	36,2	86,0	81,0	100,4	97,3	78,1	61,6	26,5
Maximum	90,2	94,7	108,8	102,6	97,3	78,1	75,3	42,5

Tab. 137 - Box-plot values for maximum length of sandstone objects from GH 3

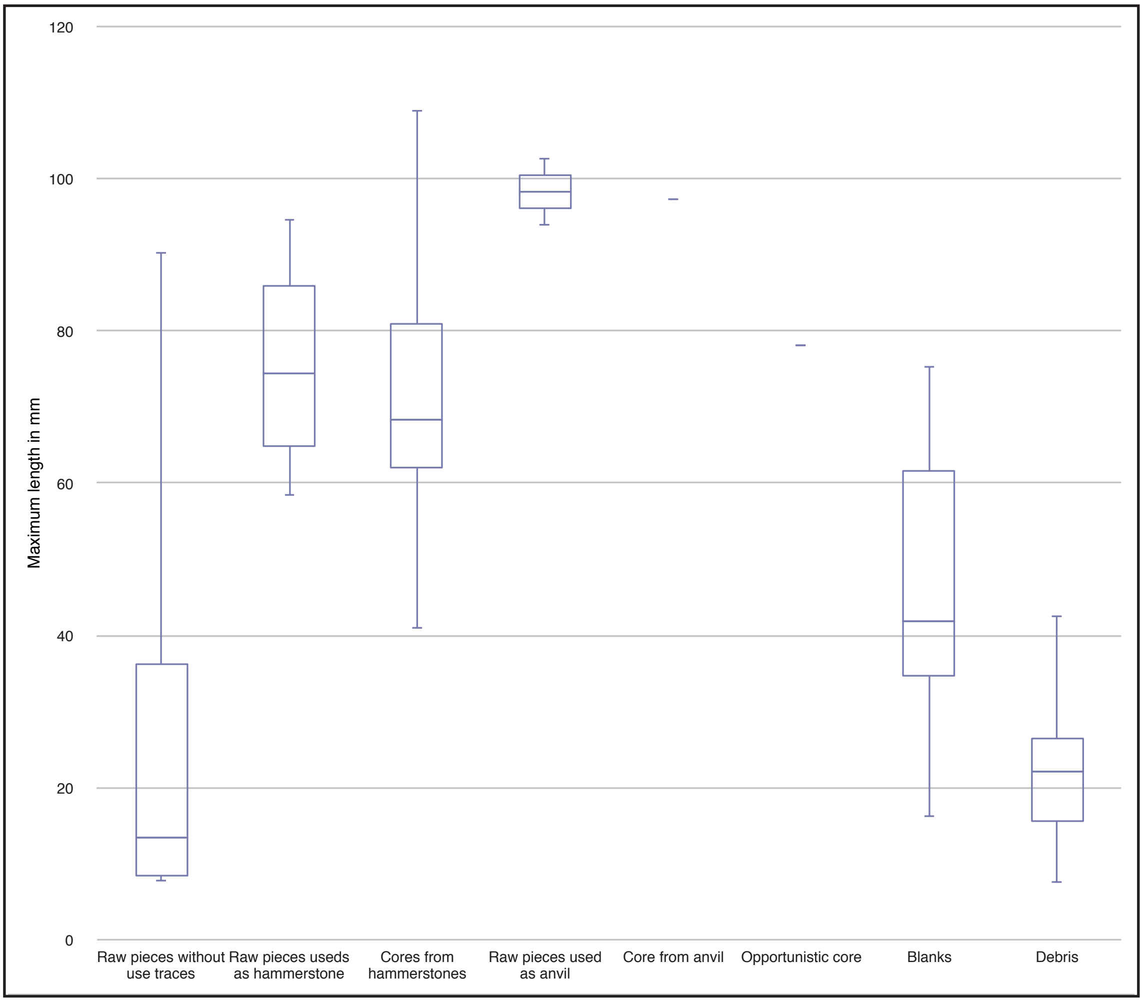

Fig. 142 - Box-plot for maximum length of sandstone objects from GH 3

Sandstone objects from GH 4 are small (see fig. 143) and show on the one hand no traces of use (raw pieces, n=2) or unclear pattern of breaks (debris, n=6).

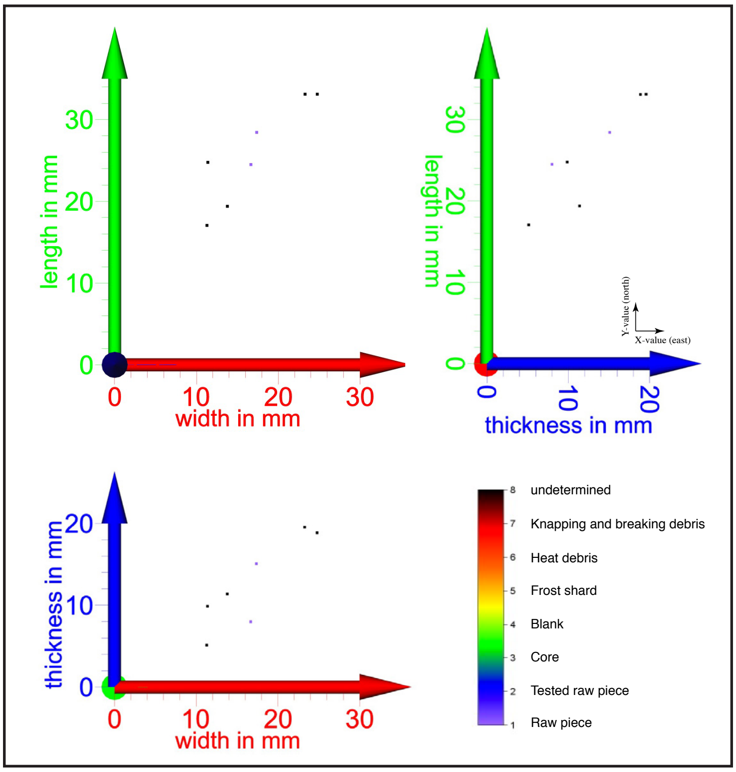

Fig. 143 - Dimensions of sandstone objects from GH 4

VI.9 Felsic crystallin rocks (granite and gneiss)

In total, there are n=51 objects from GH 3 and 4 in this category combining granite and gneiss (they are listed in the following tab. 138). There are n=49 objects from GH 3 and n=2 from GH 4, whereas n=49 are from granite and n=2 are from gneiss.

Raw Material	Raw pieces from GH 3	Debris from GH 3	Raw pieces from GH 4	Debris from GH 4	Total
Granite	0	47	1	1	**49**
Gneiss	0	2	0	0	**2**
Total	**0**	**49**	**1**	**1**	**51**

Tab. 138 - Objects from granite and gneiss from GH 3 and 4

The sources of these materials are yet unknown. The next geological formation containing such material is situated at the end of the Vallée des Vaux, around 7 to 8 km away from the site (northwestern direction). Also there is the possibility that the Orbize creek transported such material very close to the „Verpillières“, because it connects both valleys.

The majority of these objects are n= 47 debris objects from GH 3 from granite. Up to now, no raw piece or core is present from this material. In speculating about the origin of this debris, one idea might be that the original hammerstones were removed from the site and this debris is the rest that was discarded on-site (because of usage). In general all of the objects from both materials are quite small (see box plot of mass, fig. 144).

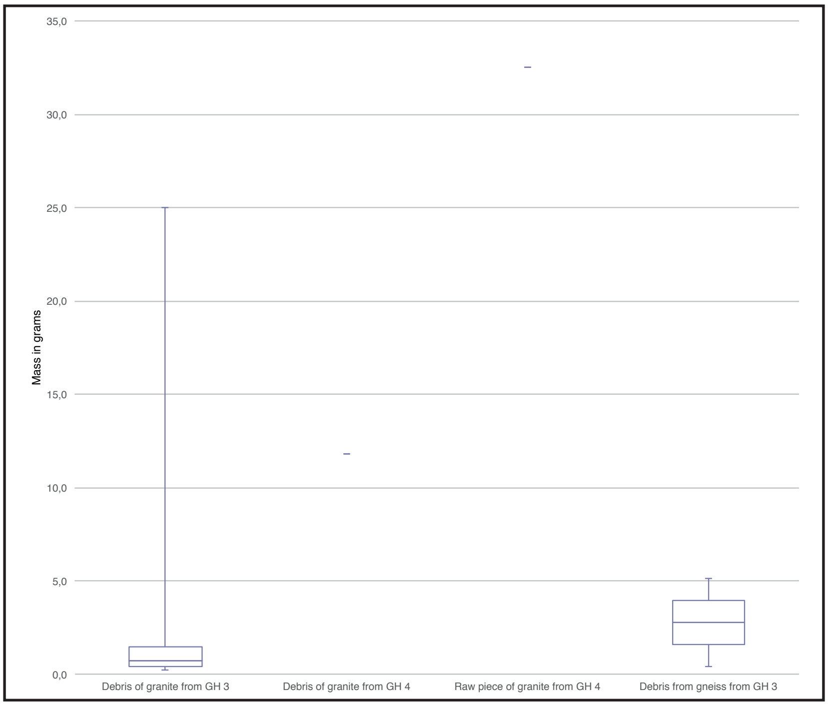

Fig. 144 - Boxplot of mass for granite and gneiss from GH 3 and GH 4

The scatter plot of distribution for objects from granite (black) and gneiss (red) show a high concentration in the southern part of the excavated area. But also in the West (square meters 225-058 and 225-059) objects from these materials are distributed. In a more scattered way, some objects are also present in the central and western part (see fig. 145). As it is visible for other lithic raw materials, they are present all over the thickness of GH 3 and in the most highest parts of GH 4 (from 6.3 to 7.3) . A binary division in height is visible in square meter 227-057.

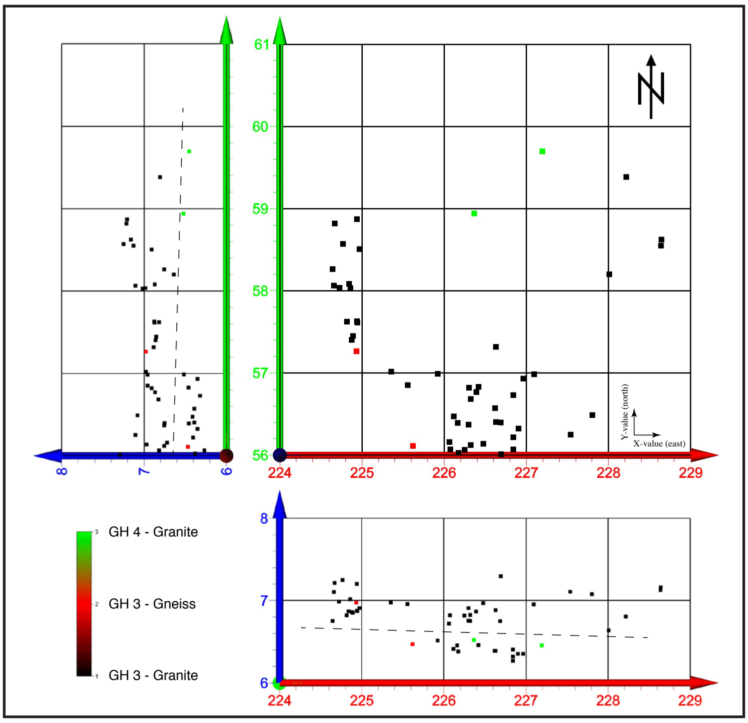

Fig. 145 - Distribution of objects from granite (black) and gneiss (red) from GH 3 and GH 4

VI.10 Minerals

Mineral objects (lager than 5 to 5 mm) are seldom (and just known from GH 3). There is evidence from at least n=15 pieces (including a pieces of Manganese dioxide and a Pyrolusite, that is categorized as pigment). All other minerals are present as small debris fragments. The following tab. 139 displays them:

Raw material	Structural formula	Number	specific literature
Feldspar	$(Ba,Ca,Na,K,NH_4)(Al,B,Si)_4O8$	**10**	
Mica	$D\ G_{2,3}\ [T_4O_{10}]\ X_2$	**3**	Smith et al. 1998
Pyrolusite	MnO_2	**1**	
unspecific Manganese oxide	MnO_2	**1**	
Total		**15**	

Tab. 139 - Minerals from GH 3

It is very likely that there are still minerals in unsorted bags of collective finds present.

VI.11 Other silicious materials

In addition to the described fine-grained and coarse-grained lithic raw materials, or minerals and felsic rocks, there are a few other silicious materials left to describe, namely arkose (a sandstone-like material containing quartz grains and feldspar), conglomerate, argillite, volcanic material and unknown silicious material (tab. 140).

Raw material	Number from GH 3	Number from GH 4x	Number from GH 4	Total
Arkose	2	0	0	**2**
Conglomerate	1	0	0	**1**
Argillite	12	0	0	**12**
Volcanic material	2	0	0	**2**
Unknown silicious material	241	0	42	**283**
Total	**258**	**0**	**42**	**300**

Tab. 140 - Other silicious raw materials in the context of GH 3, GH 4x and GH 4

Two aspects are interesting about these materials. On the one hand, one of the objects from arkose is quite large and show traces of the use as hammerstone. On the other hand, the unknown silicious materials contain mostly fine-grained objects that might be generally describes as silex (flint or chert or others). It is very likely that different specific raw materials or known materials are hidden in this category. A specification of the raw material attributes and the grouping of these objects is not part of this thesis. But for the overview these objects are listed in the following tab. 141:

Object class	Number in GH 3	Number in GH 4	Total
Raw piece with out use traces	0	2	2
Raw piece used as hammerstone	0	1	1
Tested raw piece	1	0	1
Opportunistic flake-core	4	6	10
Simple flake	163	24	187
Specific flake	9	2	11
Simple Blade	1	1	2
Specific Blade	1	0	1
Micro-flake	12	0	12
Bladelet	1	0	1
Heat debris	22	0	22
Debris	27	6	33
Total	**241**	**42**	**283**

Tab. 141 - List of objects from unknown silicious raw material

The reason for the classification as unknown silicious raw material is mostly related to very intensive patination and impregnation (impossibility to see the „interior" and specifics of known silicious raw materials). Objects from such unknown silicious raw material are scattered in the entire area of the excavated GH 3 (see fig. 146), but the density is higher in the southern and western part. In regard to hight such objects are scattered over the entire volume on GH 3, as well.

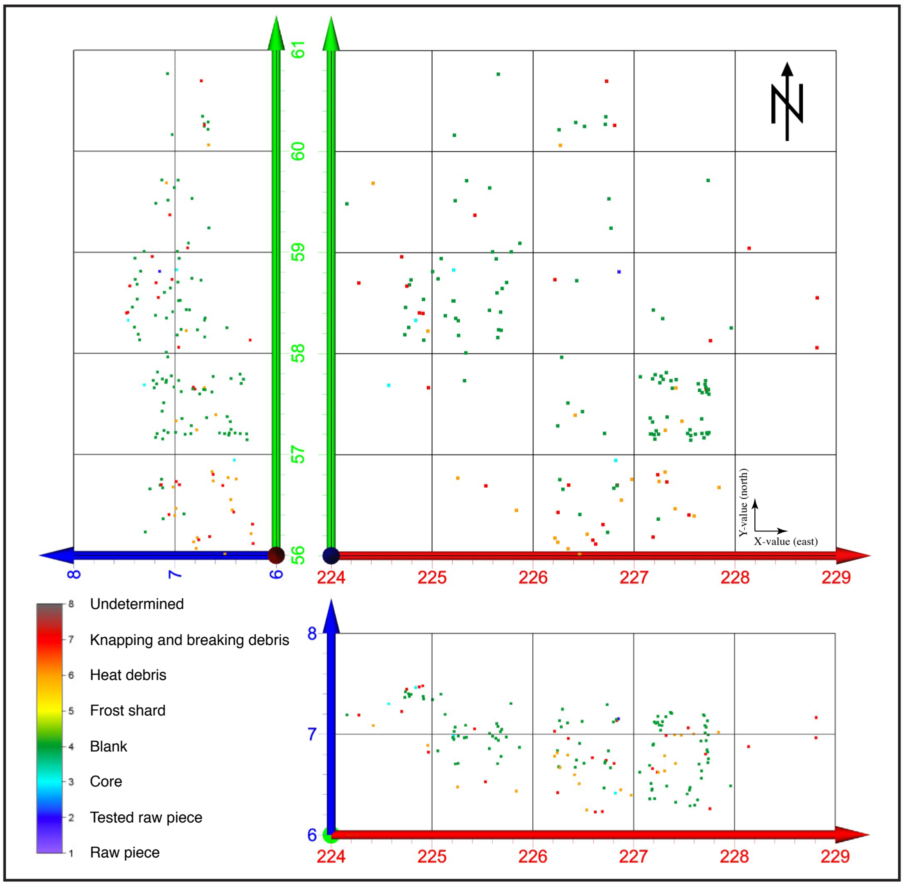

Fig. 146 - Distribution of objects from unknown silicious raw material from GH 3

VI.12 Summary and conclusion

Both, fine-grained and coarse-grained lithic raw-materials are present in all three stratified Middle Paleolithic geological sediment layers. Both were integrated in knapping processes. Mostly fine-grained material was knapped and coarse-grained materials were used as hammerstones and anvils, but not exclusively (see chapter X.12).

FAS and quartzite are the prevalently used materials in all GHs concerning number and mass, as well. All other materials are present in smaller amount. Both, FAS and quartzite are small-distance materials and from their majority, it is very likely that they had a good accessibility, even in climates with permafrost and snow-cover.

FAS is an almost omnipresent raw material in the Côte chalonnaise, whereas quartzite seem to be more concentrated in specific spots (quartzite-bearing geological formations and rivers). FAS can be procured in the planes and valleys (eastwards), as well as on hills ranges (westwards). Other raw materials in much smaller amount are mostly related to sources (closest known) northwards of the site (e.g., chert or lacustrine flint).

Raw-material group	Number in GH 3	Mass in GH 3 (in grams)	Number in GH 4x	Mass in GH 4x (in grams)	Number in GH 4	Mass in GH 4 (in grams)	Total number	Total mass
Fine-grained raw material	2934	36433,88	23	1278,5	146	2761,3	3103	40473,68
Coarse-grained raw material	567	41939,28	4	651,62	20	1529,9	591	44120,8
Minerals and other silicates	28	40,4	0	0	0	0	28	40,4
Unknown silicious raw material	241	72,3	0	0	42	602,9	283	675,2
Total	**3770**	**78485,8**	**27**	**1930,12**	**208**	**4894,1**	**4005**	**85310,08**
Fine-to-coarse ratio	5:1	0,9:1	5,8:1	2:1	7,3:1	1,8:1	5,3:1	0,9:1
Fine (including unknown silicious raw material) to coarse-grained	5,6:1	0,9:1	5,8:1	2:1	9,4:1	2,2:1	7,7:1	0,9:3
Fine-grained in percent (%)	78 %	46 %	85 %	66 %	70 %	56 %	77 %	47 %
Coarse-grained on percent (%)	15 %	53 %	15 %	34 %	10 %	31 %	15 %	52 %

Tab. 142 - Comparison of lithic raw material clusters from GH 3, GH 4x and GH 4

The stratified assemblages of VP II contain fine- and coarse-grained lithic raw materials in different rates (see tab. 142). In GH 4x and GH 4, more (in regard to number and mass) fine-grained material is present. This is different in GH 3. Here, The number of fine-grained lithic objects is 5 times higher than that of coarse-grained, but the coarse-grained materials have more mass. In the status of excavation, this fact should not be overrated, because the excavated volumes of these three GHs differ vastly.

For instance, GH 4 has still the potential to get thicker into eastern direction.

However, all thee GHs show that both, fine- and coarse grained raw materials are present in the same geological layer. The co-presence of both is another evidence that knapping and/or breaking processes where progressed on-site.

Chapter VII: Evaluation and analysis of lithic objects from GH 3

„The Paleolithic hunters who painted the unsurpassed animal murals on the ceiling of the cave at Altamira had only rudimentary tools. Art is older than production for use, and play older than work. Man was shaped less by what he had to do than by what he did in playful moments. It is the child in man that is the source of his uniqueness and creativeness, and the playground is the optimal milieu for the unfolding of his capacities." (Eric Hoffer)

Nevertheless:
„Du immer mit deinen Kernen!" (You always with your cores, H. Floss to J. A. Frick in 2011)

VII.1 Introduction

This chapter describes conducted litho-technological and techno-morphological analyses of the lithic industry of the (most upper) stratified unit GH 3 of Grotte de la Verpillière II, in combination with spatiality. It has a deductive character starting with general observations about the lithic material of GH 3, followed by detailed descriptions of observations on specific groups of objects.

The description follows the *chaîne opératoire*, starting with un-flaked raw-material pieces and flaked cores, followed by flaked and shaped objects and finishing with observed modifications, as well as other used objects such as hammerstones and anvils. This chapter follows the terminological descriptions and definitions as written in chapter V.

The assemblage of lithic objects of GH 3 is the biggest convolute in VP II. From its discovery in 2009 till now, it was continuously excavated and is present in all excavated square meters in the entrance of the cave tunnel.

The database of the campaigns 2009 to 2014 yields n=3,770 siliceous objects, comprising both single finds and finds from collective finds. However, it has to bear in mind that many collective finds (containing small to very small objects) are still not analysed. Therefore the amount of e.g. micro-flakes should grow with every analysed collective find.

General descriptions and denominations are present for all n=3,770 objects. For n=2,444 objects fine-scaled observations are available, including mass, dimension, detailed raw-material descriptions, as well ass (*sic*!) descriptions of attributes of surfaces and edges. Scatter plots showing the distribution of objects contain data from the entire assemblage (n=3,770), because all objects got three-dimensional position data (measured as single find or inside a collective find). Descriptions and plots related to dimension, weight and specific attributes use data from these n=2,444 objects. The difference between both contains small finds (like debris and micro-flakes).

VII.2 Features of the lithic assemblage

VII.2.1 Edge sharpness

The most obvious feature by observing the lithic assemblage of GH 3 is that nearly all objects own quite sharp edges. Some of these edges look quite fresh produced, with the exception that the majority of the lithic objects are patinated, sometimes with an iron oxide impregnation (*Imprägnierung*, term used by M. Siegeris to describe secondary color alteration, like in Bohnerzhornstein (bean-ore chert) from Breisgau, Germany). The only exception from this „sharp-edge rule" are some artifacts that were excavated in 2009 (directly under the today's cave-tunnel entrance). Here the patination fades into a kind of a dissolution of the surface and therefore edges are slightly rounded. But this seems to be a very narrow-restricted phenomenon.

VII.2.2 Horizontal orientation

Another interesting feature of all lithic objects from GH 3 is their horizontal orientation in the sediment. This is true for flat objects like flakes but also for rounded coarse-grained objects. Without having a good explanation, it mostly looks (during excavation) that all of this objects laid on a quite flat surface during sedimentation. The same horizontal artifact orientation was detected for bones and teeth.

The only exception of this rule are three pieces in the East (square meter 229-058) that were wedged between many smaller limestones (diameter of around 5 to 8 cm, square meter diary of 2012). Over all, at maximum a dozen lithic objects were not horizontally orientated during the time of excavation.

A few pieces were refitted that showed the same patina (patinated as the rest of the surface) on breakage surfaces and laid directly next to each other (see chapter X.5). This might be another indication that the movement by bio- and cryoturbation was quite small and maybe if than in horizontal direction.

VII.2.3 Sinter-crusts on lithic objects

Crusts of sediment (often small quartz grains in a calcitic matrix) is a phenomenon that is nearly omnipresent in the site. Lose varieties were removed using toothbrushes and water (during the after-excavation processing in the excavation house). Sometimes the crusts are that hard that an object would brake if it would be tried to remove them. Two methods were used to get rid of these crusts. On the one hand, the objects were water-soaked and the more lose crust was removed using bamboo sticks. On the other hand, an ultrasonic bath containing water with a bit of soap and diluted muriatic acid was used and gave excellent results. The use of diluted acid is for instance described in Rots (2010). As it is obvious from the pictures in this work, not all lithic objects were processed in that way, therefore some still carry sinter on their surfaces. Coarser surfaces seem to have an affinity of carrying more and harder sinter on it.

VII.3 Quantitative overview of the lithic assemblage of GH 3

As written, the database of the campaigns 2009 to 2014 yields n=3770 siliceous objects from GH 3, comprising both single finds (*Einzelfunde*) and finds from collective finds (*Funde aus Sammelfunden*). They are in a ratio of 3.7:1 (single finds n=2960 and finds from collective finds n=810). The following tab. 143 shows the composition of the assemblage from GH 3 in relation to silicious raw material and object category:

Matrix	Blank			Core			Silex						
Raw material	Flake	Blade	Micro-flake	Bladelet	Core on raw piece	Core on flake	Core on frost shard	Raw piece	Heat debris	Unmodified frost shard	Modified frost shard	Knapping and break debris	**Total**
FAS	1587	109	136	40	125	39	12	16	98	111	4	523	**2800**
Chert varieties	42	6	3	1	4	0	0	1	5	2	0	16	**80**
Lacustrine flint	4	0	0	0	0	0	0	0	0	0	0	0	**4**
Arkose	0	0	0	0	1	0	0	0	0	0	0	1	**2**
Feldspar	0	0	0	0	0	0	0	0	0	0	0	10	**10**
Mica	0	0	0	0	0	0	0	0	0	0	0	3	**3**
Gneiss	0	0	0	0	0	0	0	0	0	0	0	2	**2**
Conglomerate	0	0	0	0	0	0	0	0	0	0	0	1	**1**
Granite	0	0	0	0	0	0	0	0	0	0	0	47	**47**
Quartzite	19	0	0	0	24	0	0	43	12	0	0	148	**246**
Quartzitic sandstone	4	0	0	0	11	0	0	4	0	0	0	9	**28**
Quartz	14	0	0	0	3	0	0	15	0	0	0	128	**160**
Sandstone	7	0	0	0	19	0	0	12	0	0	0	43	**81**
Argillite	0	0	0	0	0	0	0	0	0	0	0	12	**12**
Pyrolusite	0	0	0	0	0	0	0	0	0	0	0	1	**1**
Volcanic material	0	0	0	0	0	0	0	0	0	1	0	1	**2**
Unknown flint	39	3	0	0	2	3	0	0	0	0	0	3	**50**
Non-determined silicious raw material	172	2	12	1	5	0	0	0	22	0	0	27	**241**
Total	**1888**	**120**	**151**	**42**	**194**	**42**	**12**	**91**	**137**	**114**	**4**	**975**	**3770**

Tab. 143 - Composition of the GH 3 assemblage showing the number of pieces from different silicious raw materials and category (red fields containing no objects)

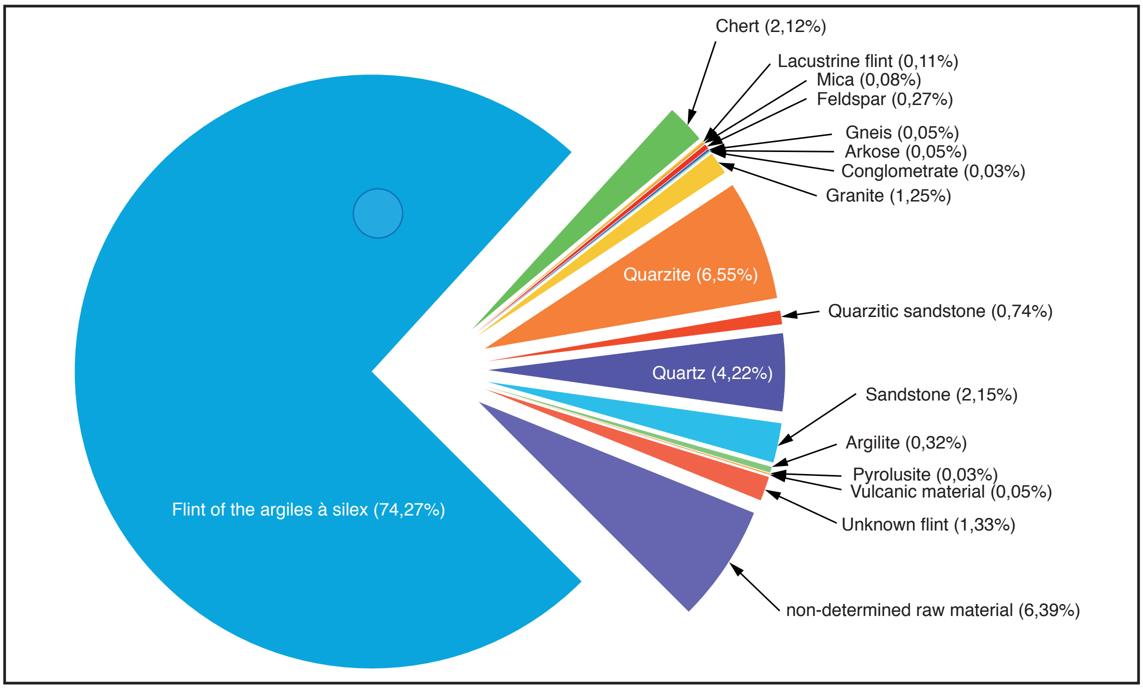

Fig. 147 - Percentage share per silicious raw material of GH 3 in regard to number of objects

The total number of pieces per silicious raw material varies. 74% of all silicious raw materials are from FAS, 7% is from quartzite and 6% of undetermined silicious raw material. Quartz is represented with 4%, chert varieties and sandstone with 2%. All other silicious raw material are quite rare. The percentage share of silicious raw materials can be seen in fig. 147:

VII.4 Ratios of educts and products

Ratios are used in this context to detect relations between dependent features of the lithic assemblages (Blades 2002; see Dibble & Lenoir 1995; Manninen & Knutsson 2014; Marks et al. 1991), mainly to observe relations between educts (raw pieces and cores) detached products.

The majority of lithic objects from all silicious raw materials are blanks (n=2201), followed by objects that are by-products of knapping (such as debris) or are not related to knapping processes (n=1321). Cores are represented with n=248 pieces. By dividing all lithic objects into the major categories of educts and products (see chapter V.6.2), there is a educt-to-product ratio of around 1 : 12 (285 : 3485), see tab. 144.

	Educt		Product							Total
	Raw piece	Core on raw piece	Core on flake	Core on frost shard	Modified frost shard	Unmodified frost shard	Blank	Heat debris	Knapping and break debris	
Total	91	194	42	12	4	114	2201	137	975	**3770**
Total by major category	**285**		**3485**							**3770**

Tab. 144 - Ratio of all educts and products by mean of numbers.

If we would expect that the lithic legacy of GH 3 is complete, in the meaning that only raw pieces were imported, all reduction happened on-site and nothing was exported (which is more than unrealistic), we would predict that the core-to-blanks ratio of cores and knapped products (194 : 2243) is 1 : 11.56, and this would lead to an assumption that every core produced around 11 blanks.

A much more realistic ratio can be drawn by the exclusion of objects used as hammerstones, anvils and abrasion stones, and by the exclusion of objects that derive from this objects due to usage (e.g., blanks from hammerstones detached by use). In this case we need to extract objects from crystallin raw material, suche as arkose, feldspar, mica, gneiss, conglomerate, granite, quartzite, quartzitic sandstone, quartz, as well as the rare materials, such as argillite, pyrolusite, volcanic material and non-determined raw material. Now, left are flint from the *argiles à silex*, chert varieties, lacustrine flint and unknown flint, which are classical lithic raw materials used in knapping processes, see tab. 145:

Matrix	Blank			Core			Silex						
Raw material	Flake	Blade	Microflake	Bladelet	Core on raw piece	Core on flake	Core on frost shard	Raw piece	Heat debris	Unmodified frost shard	Modified frost shard	Knapping and break debris	Total
FAS	1587	109	136	40	125	39	12	16	98	111	4	523	2800
Chert varieties	42	6	3	1	4	0	0	1	5	2	0	16	80
Lacustrine flint	4	0	0	0	0	0	0	0	0	0	0	0	4
Unknown flint	39	3	0	0	2	3	0	0	0	0	0	3	50
Total	1672	118	139	41	131	42	12	17	103	113	4	542	2934

Tab. 145 - Composition of the GH 3 assemblage (only FAS, chert varieties, Lacustrine flint and unknown flint) showing the number of pieces from different silicious raw materials and category

Here we can see a slightly different ratio for educts and products (147 : 2489) and by comparing cores and blanks (185 : 1672) from flint and chert (see tab. 146), there is a core-to-blank ratio of 1 : 9 to detect.

	Educt		Product							Total
	Raw piece	Core on raw piece	Core on flake	Core on frost shard	Modified frost shard	Unmodified frost shard	Blank	Heat debris	Knapping and break debris	
Total number	17	131	42	12	4	113	1970	103	542	2934
Total number by major category	148		2786							2934

Tab. 146 - Ratio of educts and products from FAS, chert varieties, Lacustrine flint and unknown flint by mean of numbers

Further ratios will be displayed in the respective chapter. In the following, the ratios concerning the educts and products of the lithic assemblages of GH 3 are summarized (tab 147):

Denomination	Raw material section	Number of products	Number of educts	Ratio
Educt-to-product	All silicious lithic objects	3485	285	12.23:1
Core-to-blank	All silicious lithic objects	2243	194	11.56:1
Core-to-blank	Silicious lithic objects, intensionally knapped	1672	185	9.04:1

Tab. 147 - Ratios concerning the total lithic assemblage of GH 3

VII.5 Ratios in regard to raw material diversity

The following section depicts ratios concerning raw material diversity with the aim to display the proportions of educts and products. Firstly, the ratio between raw material used for knapping lithic artifacts (flint and chert) and material used as hammerstones, anvils and a varieties of other (mostly unknown) tasks is 2934 : 834 (3.51 : 1). In my opinion, this does not necessary mean that knapping and the resulting sharp edges are more relevant than other tasks, it illustrates much more that other raw material aspects and technological (behavioral) concerns were also of importance (if we take the simple number of objects into account).

VII.6 Mass comparison by category of matrix

Independent from its silicious raw material the mass-to-number ratio shows that raw pieces and core-on-raw pieces are the heaviest objects, as we would expect it, if these are objects imported into the site for different tasks (e.g., fragmentation of bones for marrow exraction, use as hammerstones or anvils). The average mass of flakes and blades are equal (around 6 to 7 grams). The mass and number of micro-flakes and debris are definitely underrepresented (with a simple reason: for this thesis, the micro-*débitage* ought not be analysed). The average mass-to-number ratio for all categories of matrix is 32.20. Masses, number and mass-to-number ratio of all lithic objects from GH 3 are listed in tab. 148 and illustrated in fig. 148.

We see that frost-fractured objects are not seldom. A fact that can be related to the presence of faunal elements that represent medium-to-cold adapted animals (see chapter IV).

Category of matrix	Mass (in grams)	Number	Mass-to-number ratio
Raw piece	25055.6	76	329.68:1
Core-on-raw piece	34171.1	174	196.39:1
Core-on-flake	1964	37	53.08:1
Core-on-frost shard	819,7	15	54.65:1
Flake	11794.1	1279	9.22:1
Blade	796	105	7.58:1
Micro-flake	7,2	46	0.16:1
Bladelet	7,9	19	0.42:1
Unmodified frost shard	1057.7	98	10.79:1
Modified frost-shard	46,8	1	46.80:1
Heat debris	342	55	6.22:1
Knapping and break debris	2637	539	4.89:1
Total	**78699.1**	**2444**	**32.20**:1

Tab. 148 - Mass-to-number ratio of all analysed lithic objects displayed by is category of matrix

VII.7 Mass comparison by raw material

The relationship between all silicious raw materials differs enormous if the mass is taken into account (but mind, not all objects were weighted). The total mass of n=2,444 objects from all silicious lithic raw materials of the years 2009-2013 is 78,699.1 grams (analysis of weight by measuring individual objects and adding together). Mass, numbers and mass-to-number ratio are listed in tab. 149 and displayed in fig. 149.

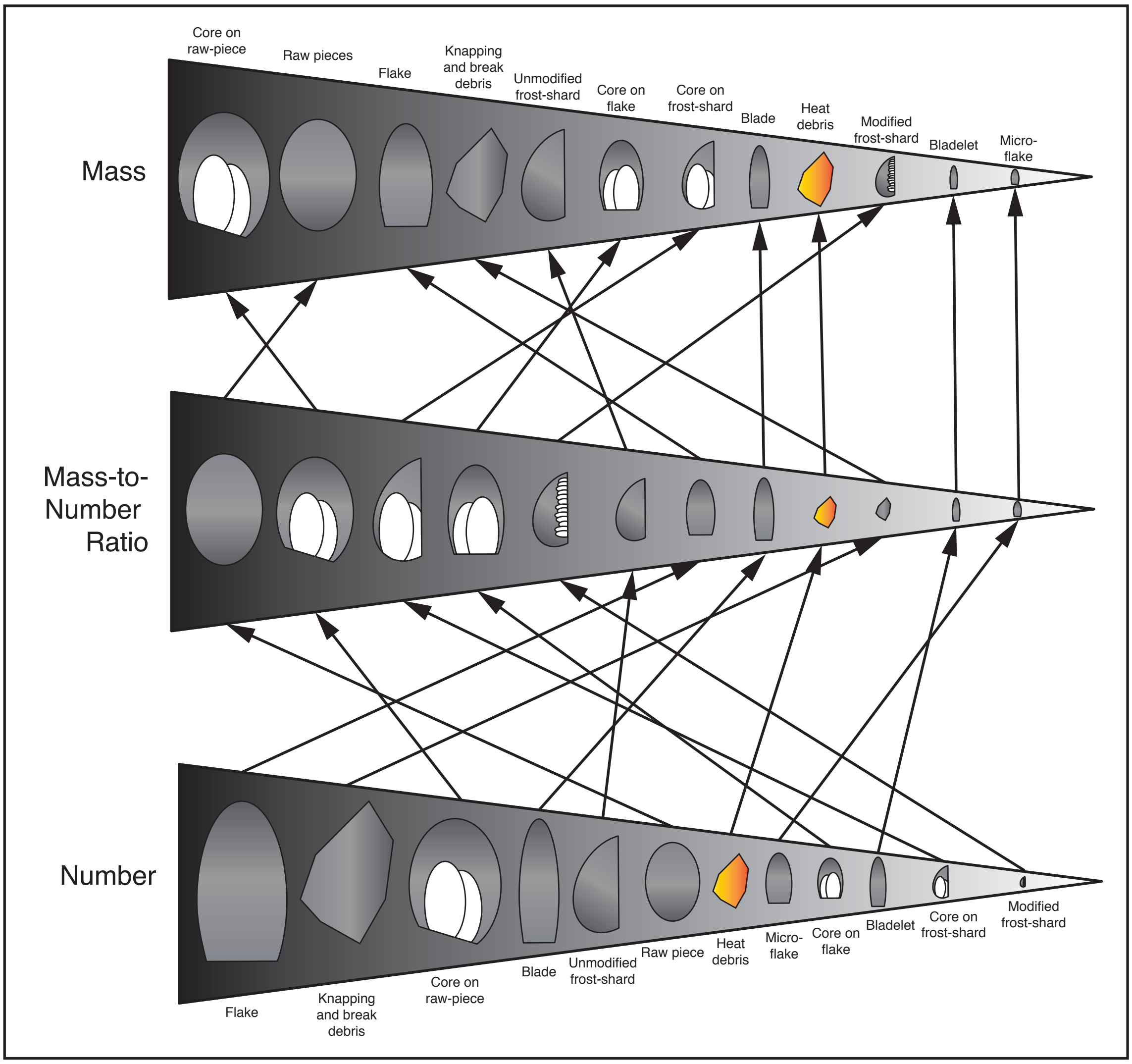

Fig. 148 - Decrease in size of all lithic objects from GH 3 in regard to mass-to-number ratio of object classes

Silicious raw material	Mass (in grams)	Number	Mass-to-number ratio
FAS	34021,4	1965	17,31:1
Chert varieties	1815,3	64	28,36:1
Lacustrine flint	1,8	1	1,80:1
Arkose	288,5	2	144,25:1
Feldspar	5,9	5	1,18:1
Gneiss	5,5	2	2,75:1
Conglomerate	0,3	1	0,30:1
Granite	80,6	38	2,12:1
Quartzite	26701,9	100	267,02:1
Quartzitic sandstone	4206,7	26	161,80:1
Quartz	4065,1	117	34,74:1
Sandstone	6590,6	66	99,86:1
Pyrolusite	10,5	1	10,50:1
Volcanic material	23,8	2	11,90:1
Unknown flint	808,9	38	21,29:1
Non-determined raw material	72,3	16	4,52:1
Total	**78699,1**	**2444**	**32,20**:1

Tab. 149 - Mass-to-number ratio of silicious raw material from GH 3

The mass-to-number ratio gives an insight into the average mass of an object from the detected silicious raw materials. Here we can see that objects from quartzitic sandstone, arkose, quartzite, and sandstone are in average quite heavy (mass-to-number ratio > 90).

The next group of raw materials (10 < mass-to-number ratio < 90) contains materials such as FAS, chert, quartz, pyrolusite, volcanic material and unknown flint. A third group (1 < mass-to-number ratio < 10) contains lacustrine flint, feldspar, gneiss, granite and unknown raw-material. The last group of mass-to-number ratio < 1 just contains conglomerate.

By comparing the total mass per raw material, flint (m=33870.56 g) is followed by quartzite (m=26429.2 g), sandstone (m=6590.6 g), quartz (m=43337.88g) and quartzitic sandstone (m=4206.7g). All other material is represented by convolutes < 2,000g.

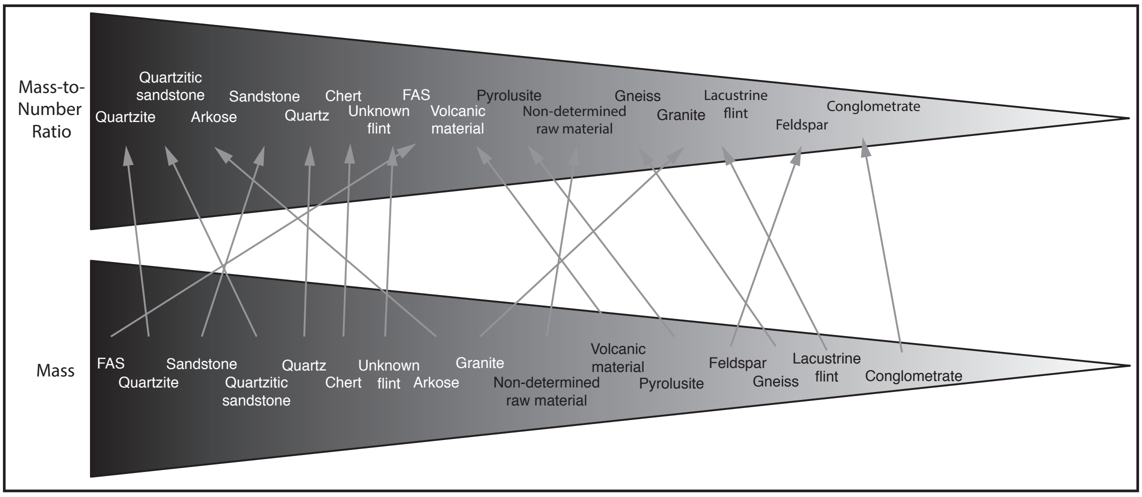

Fig. 149 - Decrease in size of mass-to-number ratio and mass in regard to lithic raw material from GH 3

VII.8 Metrical dimensions

The metrical dimension of lithic objects presented here takes maximum dimensions into account (maximum length, width and thickness). In displaying these dimensions all silicious lithic objects a steadily increase can be seen (fig. 150). Unsurprisingly, the category of blades and flakes do not differ much and is displayed quite congruent. The reason here is that the denomination depends on its technological habit and not on maximum dimension. Highly visible is here that raw pieces and cores (educts) are in general larger than products (as we saw it also in regard to mass, previous chapters).

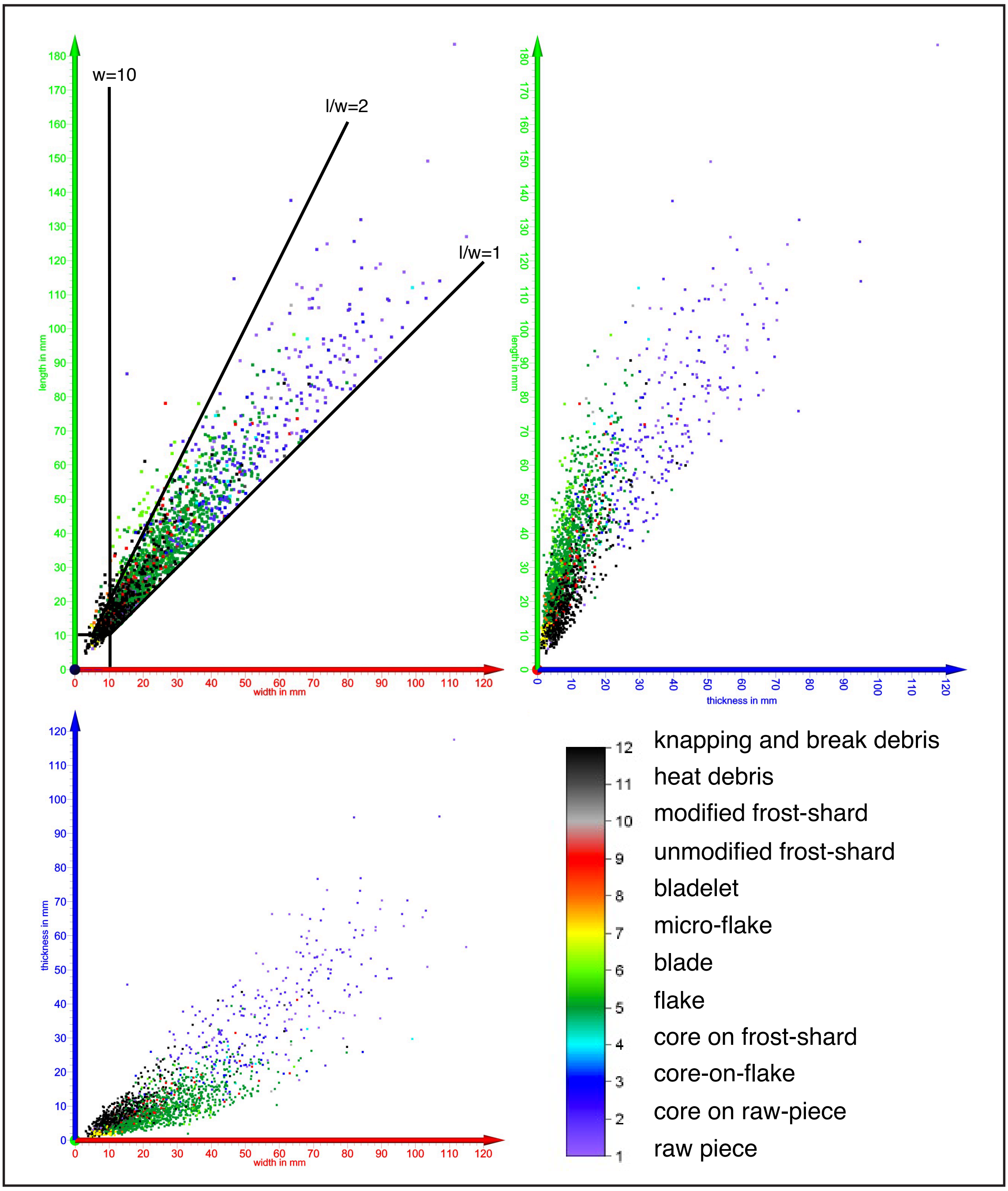

Fig. 150 - Maximum dimension of all measured lithic objects from GH 3. Top left - length-to-width; top right - length-to-thickness; bottom left - thickness-to-width and bottom right - legend

VII.9 Raw pieces

VII.9.1 Introduction to raw pieces

In GH 3, n=91 were detected (definition of raw pieces, see chapter V.6.4). They are from FAS (n=16), chert variety (n=1), quartzite (n=44), quartzitic sandstone (n=4), quartz (n=14) and sandstone (n=12, see tab. 150). The raw pieces include unused nodules, rounded and tiny pebbles, hammerstones and anvils (including a possible rubbing stone). All of the raw materials are quite local (see chapter VI).

Raw material	Number	Kind
Flint from the argiles à silex	16	Complete nodules, sometimes with frost or heat features
Chert variety	1	Nodule
Quartzite	44	Many hammerstones and anvils
Quartzitic sandstone	4	All are hammerstones
Quartz	14	Hammerstones, anvil and small pebbles
Sandstone	12	Hammerstones and anvils
Total	**91**	

Tab. 150 - Raw pieces of GH 3

VII.9.2 Mass-to-number ratio

The average mass-to-number ratio for all raw pieces is 275.34:1. Quartzite, sandstone, quartzitic sandstone and quartz has a high ratio (see tab. 151). For flint the average raw piece has a mass of around 100 g. The small chert raw-piece is independent with is ratio of 6.5.

Silicious raw material	Mass (in grams)	Number	Mass-to-number ratio
FAS	1714.9	16	107.18:1
Chert variety	6.5	1	6.50:1
Quartzite	16612.8	44	377.56:1
Quartzitic sandstone	763.1	4	190.78:1
Quartz	3211.78	14	229.41:1
Sandstone	2746.6	12	228.88:1
Total	**25055.68**	**91**	**275.34:1**

Tab. 151 - Mass-to-number ratio of raw pieces from GH 3.

VII.9.3 Dimension

The dimension of raw pieces (see fig. 151) is scattered allover the dimension range of all lithic objects). From its length and width ratio, they are quite similar to each other, which is represented in a line. In length-to-thickness this picture is not homogenous. Here, no linear relationship is visible. The same is true for the thickness-to-width ratio.

Quartzite raw pieces represent the biggest pieces, followed by quartz. The maximum dimension (90X70mm) of flint and chert nodules is much smaller. In length and width two groups can be assumed. The first are smaller objects of <60x40mm and a bigger second group. Both groups contain the same raw materials.

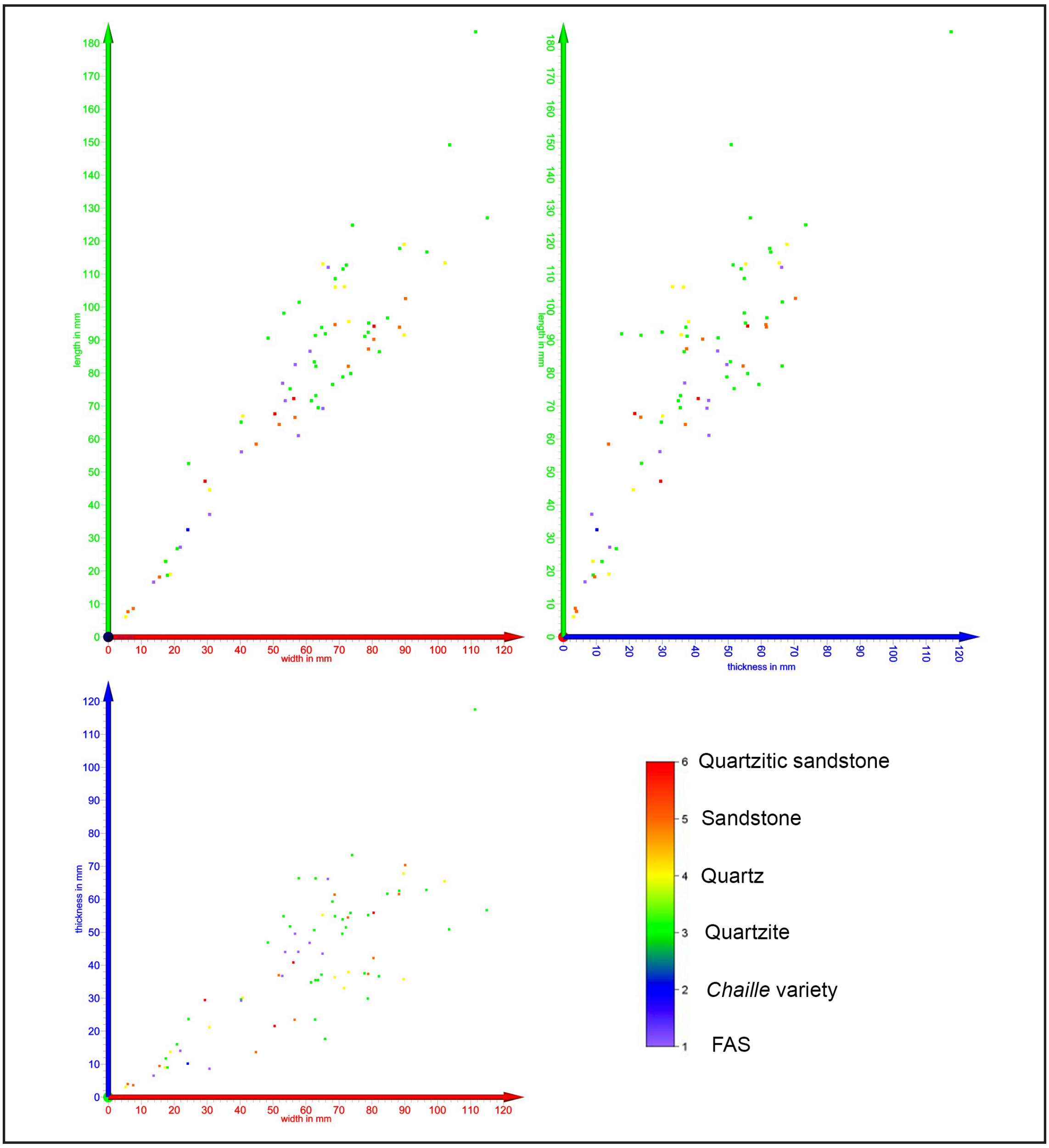

Fig. 151 - Dimensions of lithic raw pieces of GH 3

VII.9.4 Distribution

By distributional reflection about the raw pieces (see fig. 152), it is obvious that raw pieces from sandstone (orange) and quartzitic sandstone (red) are scattered in the western and southern part of the GH 3 distribution. Raw pieces can be found in nearly every square meter containing sediments of GH 3. They are also scattered in the complete thickness of GH 3, with the exception of a gap at a Z-value of around 6.5 to 6.6 m. Most of these lithic raw pieces are much to big to be moved by normal aeolian transportation (transportation by particle motion, see also Livingstone & Warren 1996) or fluviatile motion (transportation by particle motion, see also Zasada 2013). In the knowledge that they are not originated in the geological conditions of the Upper Oxfordian (as the site is), they need to be artificially transported by human action.

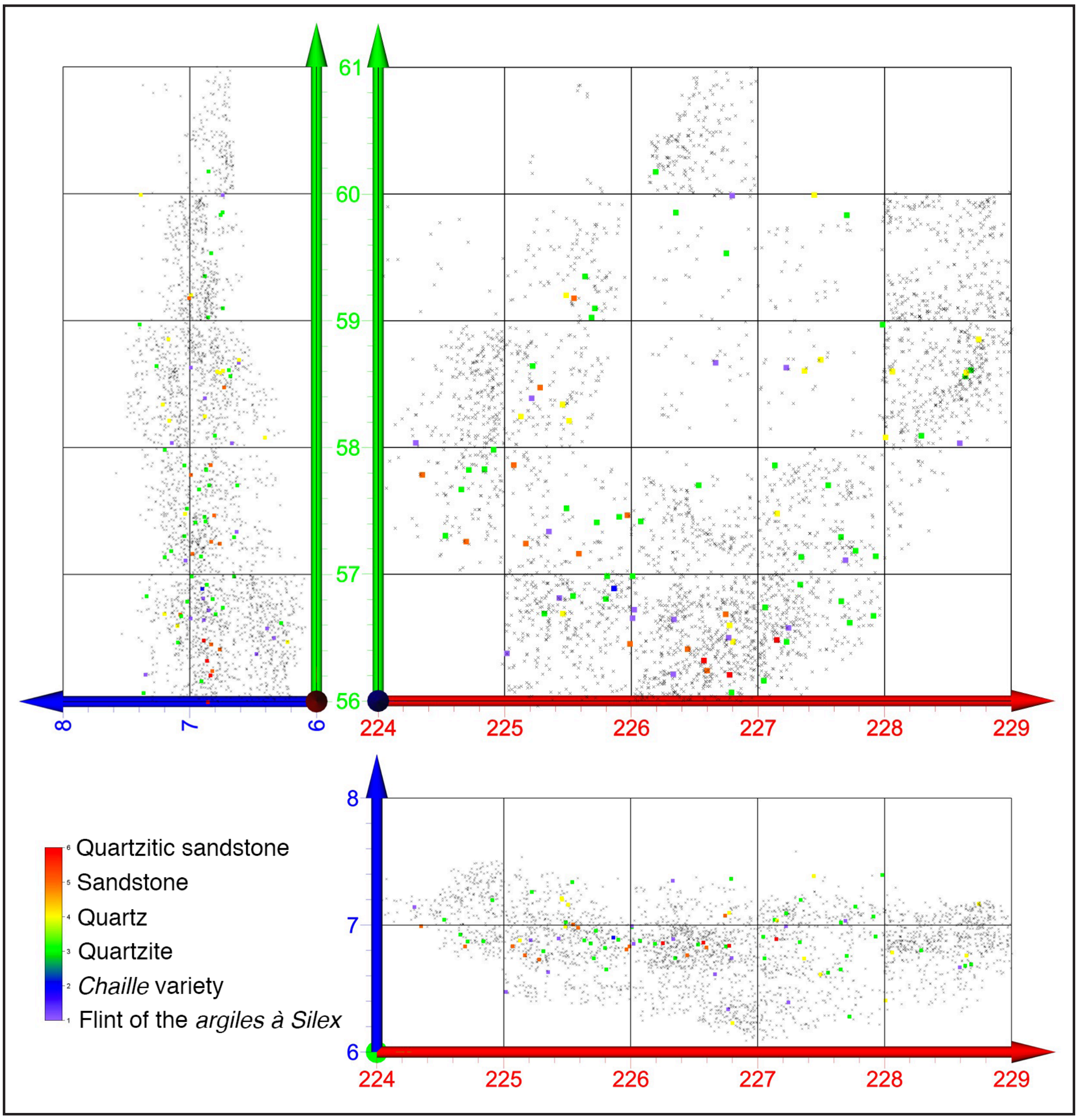

Fig. 152 - Distribution of lithic raw pieces inside GH 3

VII.9.5 Morphology and appearance

Here we describe the general morphology and appearance of lithic raw pieces found in GH3. The huge amount of raw pieces are from quartzite and very likely used as hammerstones (see fig. 153) or anvils (see fig. 154). They show slight modification like marks from knapping or grinding (objects that show big anthropogenic modifications like negatives from knapping are classified as cores, as discussed in chapter VII.10). Quartzite raw pieces are mostly blocky and rectangular. They are rounded but the original blocky character is very good visible. This lead to the assumption that they were transported by water but not far (less than 10 km, see Zeil 1990). An example of this roundness, but blockiness is GER13.225-058.795 (fig. 153).

Fig. 153 - Rounded, but blocky quartzite raw piece used as hammerstone (GER13.225-058.795)

Other examples show an intensive natural surface alteration by water transportation. The surface in smooth and the edges are rounded (an excellent example is GER11.227-057.98, see fig. 154).

Fig. 154 - Water smoothed and edge rounded quartzite from GH 3 used as anvil (GER11.227-057.98)

Quartzitic sandstones are also rounded and blocky, but the cohesion of the quartz grains is lower as for quartzite. This lead to the fact that the surfaces show much more alteration, even if they are lesser used. Example there is GER13.227-057.1911 (see fig. 155).

Fig. 155 - Rounded but blocky raw piece from quartzitic sandstone (GER13.227-057.1911)

Raw pieces from Quartz are also rounded and blocky (very similar to quartzite objects), sometimes they show alterations at the terminal ends, in the form of marks (probably because of use as hammerstone). An example here is GER10.226-059.239 (see fig. 156).

Fig. 156 - Rounded and blocky raw piece from quartz (GER10.226-059.239)

The appearance of raw pieces from sandstone is quite diverse. They range from forms such as a fluviatile shaped discus (GER10.226-060.152, see fig. 157a), to rounded but blocky cobbles (e.g., GER10.226-058.70, see fig. 157b), broken and rounded (e.g., GER13.225-058.843, see fig. 157c). One rounded sandstone is of particular interest, because it has a concave surface that appears as being used as grinding surface (GER13.225-058.956, see fig. 158).

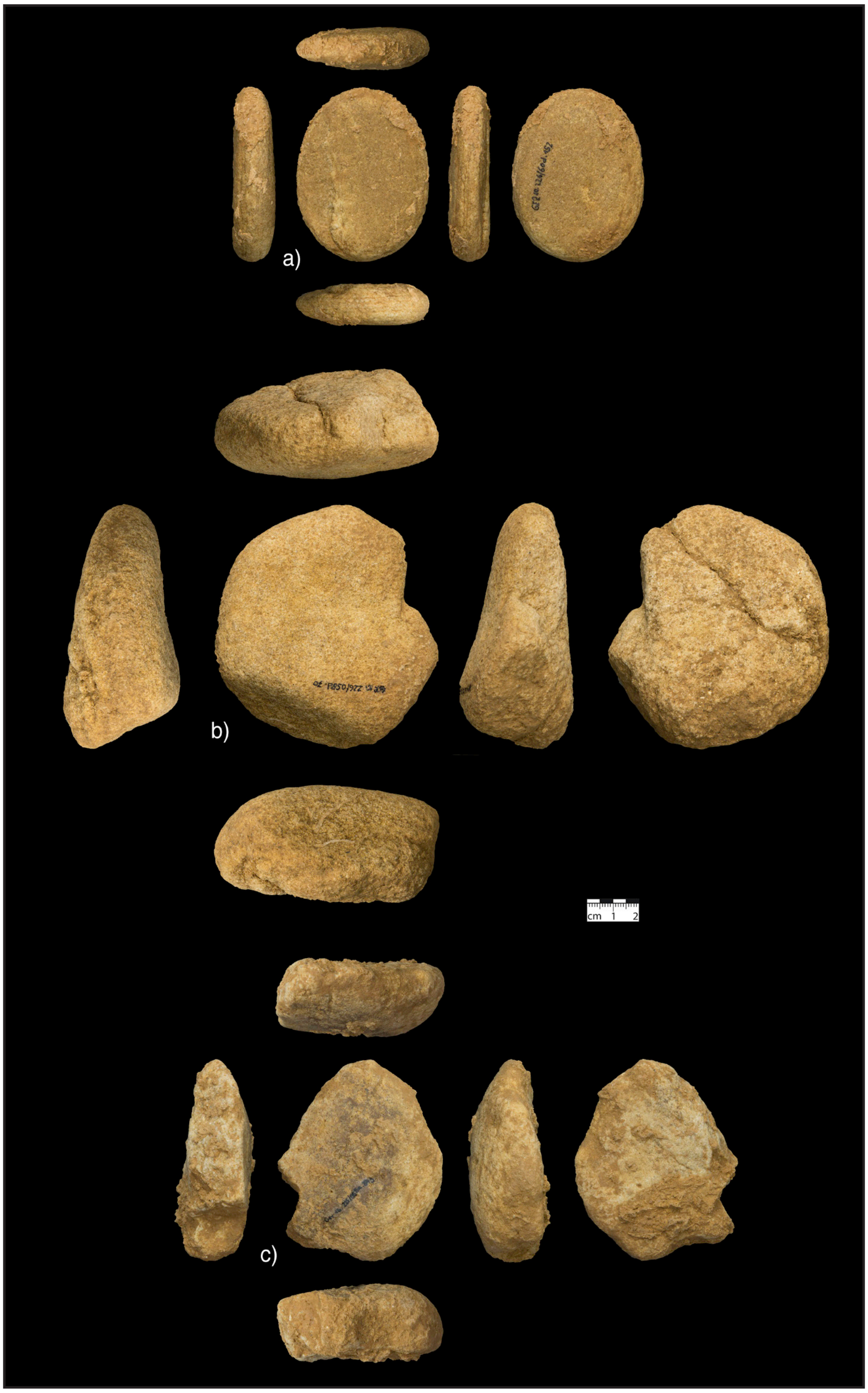

Fig. 157 - Diversity in shape of raw pieces from sandstone. a) Shaped as a disc (GER10.226-060.152); b) Rounded but blocky (GER10.226-058.70); c) Broken and rounded (GER13.225-058.843)

Fig. 158 - Sandstone raw piece with supposed grinding surface (GER13.225-058.956), indicaded by a white arrow

FAS raw pieces are mostly round or oval and if heat or frost have broke them it is visible that they are from bad material. This observation lead to the idea that visibly good (or better) nodules are used as cores and the bad ones (as it can be seen from outside) are just brought to side and were discarded (this aspect will be discussed later). Examples are GER10.226-059.238 (heated nodule, see fig. 159a) or GER12.226-057.588 (complete nodule, see fig. 159b).

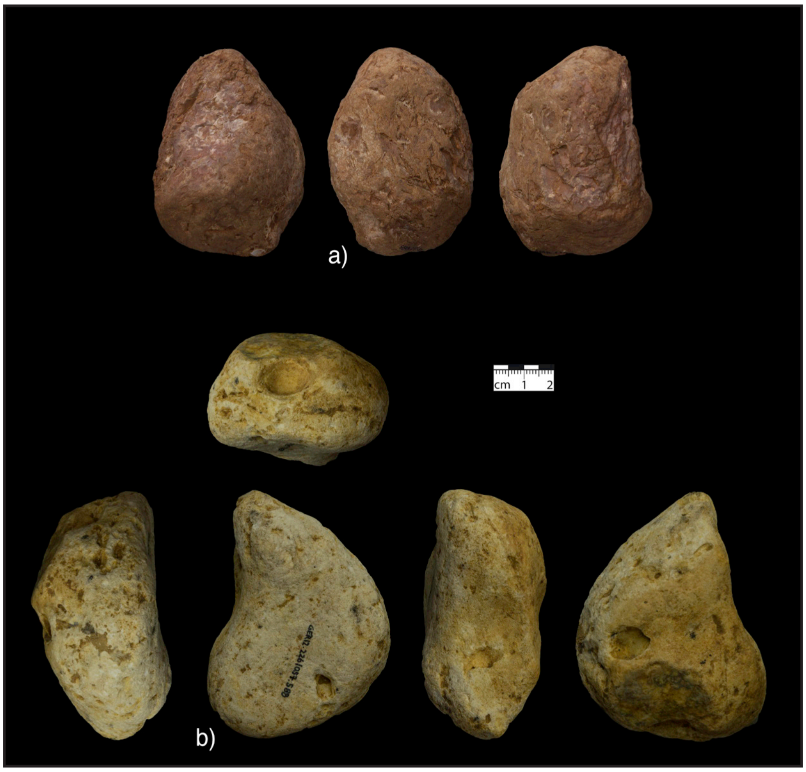

Fig. 159 - Examples of FAS nodules from GH 3. a) Nodule with heat influence (GER) and b) Nodule without heat influence (GER12.226-057.588)

Additional to raw pieces from FAS, only one raw piece from a chert variety was found (GER12.226-057.610).

VII.9.6 Functionality as hammerstones

The raw pieces from GH 3 were used for two major purposed. At the one hand as hammerstones and on the other hand as anvils. The functionality as hammerstones is indicated in crushed areas of the surface. They are localized at rounded edges (mostly the terminal part) and not in the center of surfaces. This can be seen for example on hammerstones from Bilzingsleben (Häckel 2010). The localization of crushed areas is different for so called retouchers, here the surface shows these crushed areas (e.g., for bone retouchers, Abrams et al. 2014).
N=94 objects were identified as hammerstones (this includes objects classified as raw pieces and cores). In this section we are only discussing objects without vast removals (negatives, objects with removals will be discussed in chapter VII.10.8). So n=44 objects were classified as hammerstones that show crushed areas but without split breaks. The areas of crushing show their (sometimes intensive) use for hitting other materials (e.g., crushed quartz grains, gaps of broken out grains, removal of the natural weathering surface). The raw material of these hammerstones is mostly quartzite, followed by quartzitic sandstone, quartzite and sandstone (see tab. 152):

Raw material	Number
Quartzite	30
Quartzitic sandstone	4
Quartz	4
Sandstone	6
Total	**44**

Tab. 152 - Raw material and number of hammerstones without vast removals (raw piece used as hammerstone)

On some of these hammerstones, the contact zone (crushed area) is very clear visible (e.g., GER10.226-060.213 or GER13.227-057.1861, see fig. 160). On some of these objects there is more than one crushed zone visible. In total, there are n=13 hammerstones with over all n=38 crushed areas (see tab. 153):

Objects number	Raw material	Number of crushed areas	Position of the crushed area
GER13.225-058.795	Quartzite	2	All edges show crushed areas, surfaces and edges show also abrasion
GER12.226-057.715	Sandstone	2	Terminal and basal end show a crushed area
GER10.226-058.90	Quartzite	3	All three edges show a crushed area
GER10.226-058.96	Quartzite	4	Terminal and basal end show a crushed area, both plane surface show abrasion

GER10.226-059.239	Quartz	4	All four edges show a crushed area, one is intensive
GER10.226-060.152	Sandstone	4	Terminal and basal end show a crushed area, lateral edges and both plane surfaces show slight abrasion
GER10.226-060.213	Quartzite	4	All four edges show a crushed area
GER13.227-056.278	Sandstone	2	Terminal and basal end show a crushed area, abrasion on the flat surface
GER10.227-057.70	Quartzite	2	Terminal (intensive) and basal end show a crushed area
GER13.227-057.1861	Quartzitic sandstone	2	Terminal (intensive) and basal end show a crushed area
GER13.227-057.1911	Quartzitic sandstone	2	All three edges show a crushed area, one surface-edge area shows a groove (under rest of sintered sediment)
GER10.227-058.345	Quartzite	3	All edges show crushed areas, edges show also abrasion, only slight abrasion on the surfaces
GER13.228-057.574	Quartzite	4	All four edges show a crushed area
total: n=13		**38**	

Tab. 153 - Complete hammerstones with more than one crushed area

Fig. 160 - Hammerstones with use wear. a) GER10.226-060.213 with abraded zones and b) GER13.227-057.1861 with crushed zones. Arrows indicate the area of interest

VII.9.7 Functionality as anvils

From visual observation, there are two classes of anvils made from raw pieces in GH 3. The first are bigger cobbles with one or more (normally flat) surfaces with signs of abrasion (n=10). The other class is a flat quartzite (see fig. 154, above). All anvils are listed in tab. 154. The range of performable tasks on this anvils is extensive. From macroscopical observation it can be assumed that fragmentation of stone and bones and the use as retoucher were the main tasks.

Maybe some kind of abrasion work was also performed.
One interesting case is GER13.225-058.956 (see fig. 158, above). The biggest surface of this sandstone gravel is slightly concave. This surface shows intensiv abrasion, polished parts, small gaps of broken out grains and striae. We rate these observations as evidence for performed tasks of grinding or abrasion.

Objects number	Raw material	Number of abraded areas	Position of the abraded or crushed areas
GER13.225-058.956	Sandstone	1	Largest surface is slightly concave and show abrasion with small gaps of broken out grains, polished zones and striae
GER10.226-060.154	Quartz	1	Largest surface is flat and shows minimal abrasion
GER10.226-060.232	Quartzite	2	slightly convex surface shows abrasion, more convex surface shows crushed zone
GER11.227-057.98	Quartzite	1	Flat surface shows abrasion
GER12.227-057.429	Sandstone	5	All five surfaces show slight abrasion
GER11.228-057.71	Quartzite	6	All six surfaces and the edges show abrasion
GER13.228-057.451	Quartzite	1	One flat surface show slight abrasion
GER10.228-058.43	Quartzite	2	One flat and one convex surface show slight abrasion
GER10.228-058.286	Quartzite	2	Two surfaces show abrasion
GER10.228-058.358	Quartzite	1	One flat surface show slight abrasion
GER12.229-059.605	Quartz	1	One flat surface show slight abrasion
Total: n=11		**23**	

Tab. 154 - Raw pieces from quartzite, quartz and sandstone showing abraded and crushed areas on their surface

VII.10 Cores

VII.10.1 Introduction to cores

GH 3 yielded n=248 objects classified as cores (see tab. 155 and for core definition see chapter V.6.6). Over all, there are three categories of cores. They are made from raw pieces (n=194), flakes (n=42) and frost-shards (n=12).

Category of matrix (core group)	Mass (in grams)	Number	Mass-to-number ratio
Core-on-raw piece	34108.4	194	175.82:1
Core-on-flake	2038.4	42	48.53:1
Core-on-frost shard	609.08	12	50.76:1
Total	**36755.88**	**248**	**148.21:1**

Tab. 155 - Cores from GH 3, displayed in means of mass, number and mass-to-number ration (see also tab. 156)

At a more specific itemization by means of raw material per group (see also tab. 155, above and 156, below), we see that cores from FAS are most common (n=176).

The range of cores is vast (therefore they are organized in core types, classes and groups, see chapter V.6.6 for definition). They can be quite simple (just one or some removals), specifically configured, reduced cores or completely exhausted cores. We extracted three classes of cores (core-on-raw piece, core-on-flake and core-on-frost shard, see tab. 156).

Raw material Category of matrix	FAS	Chert varieties	Arkose	Quartzite	Quartzitic Sandstone	Quartz	Sandstone	Unknown flint	Non-determined raw material	Total
Core-on-raw piece	125	4	1	24	11	3	19	2	5	194
Core-on-flake	35	0	0	0	0	0	0	3	0	38
Core-on-frost shard	12	0	0	0	0	0	0	0	0	12
Total	**172**	**4**	**1**	**24**	**11**	**3**	**19**	**5**	**5**	**244**

Tab. 156 - Core classes and related raw material

VII.10.2 Mass-to-number ratio per class

The mass-to-number ratio (see tab. 155, above) of all objects classified as cores is 148.21:1. The mean mass of cores is around 150 grams. As we would assume it, the mean mass of cores-on-raw piece is much higher than for cores-on-flake or cores-on-frost shard. The mass-to-number ratio of cores-on-flake and cores-on-frost shard is quite equal. Here we can think about a preferred size of secondary cores.

VII.10.3 Dimension in regard to raw material

With the exception of two objects (GER11.225-058.91 of unknown raw material and GER10.228-058.121 from arkose), cores are in a length-to-width ratio of <30x30mm (see fig. 161). The biggest object is a core from a chert variety (GER10.226-059.203).
Concerning the relation between thickness and width, cores from FAS are much more clustered than other raw materials.

VII.10.4 Dimension in regard to core classes

In regard to dimension of cores plotted by core class, we observe remarkable features (see fig. 162). The most of the specific cores (cores that represent a specific core reduction concept) are apparently clustered (blue dots and green isosurface in fig. 162). It shows that this cluster is visible in all three dimensions. Another observed feature is that the majority of objects classified as hammerstones, anvils, tested raw pieces and preforms is clustered in bigger dimensions (see yellow isosurface in fig. 162).

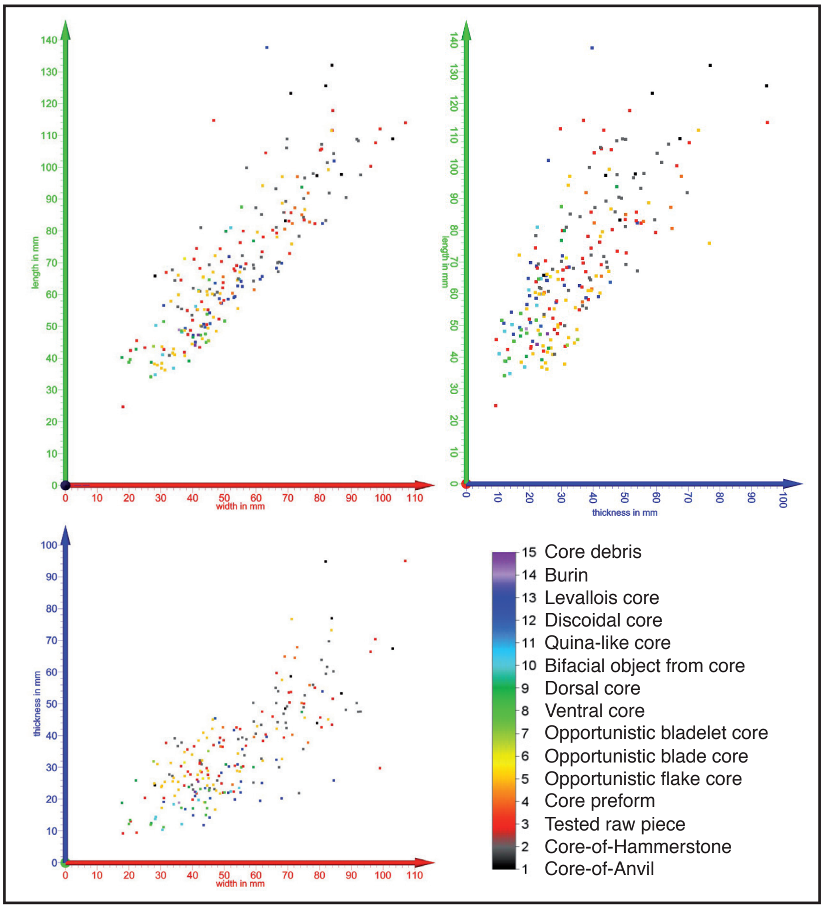

Fig. 161 - Dimension of cores in regard to raw material from GH 3

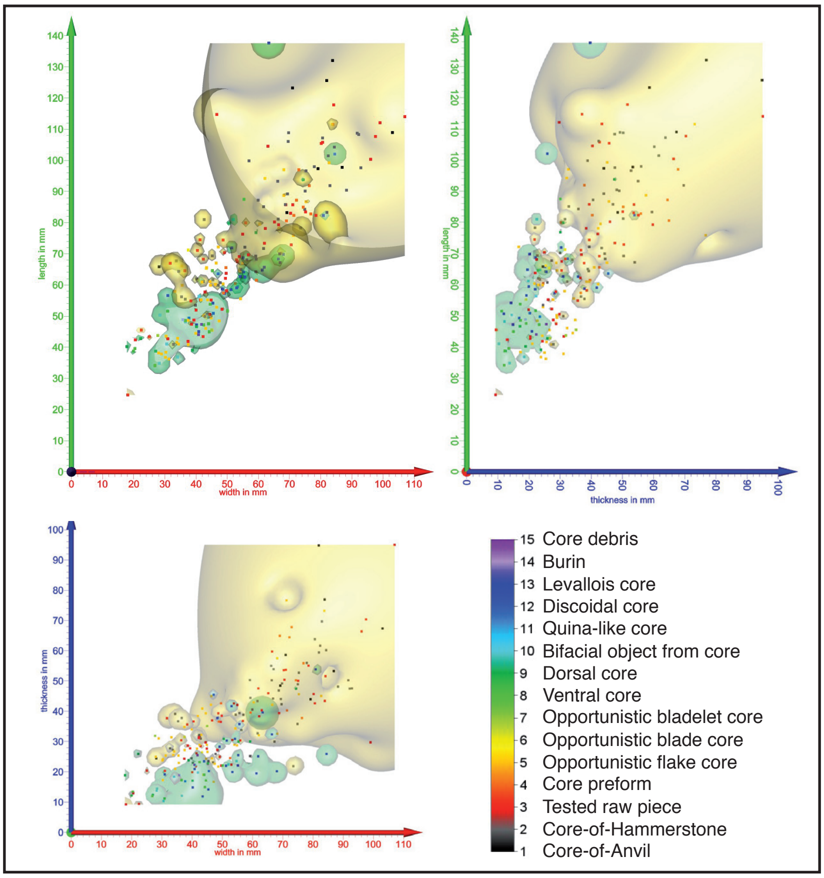

Fig. 162 - Dimension of cores in regard to core classes from GH 3, with isosurfaces separating a) Preforms from reduced cores (yellow) and b) Unspecific core classes from specific core classes (green)

VII.10.5 Distribution in regard to raw material

Cores are distributed all over the excavation area of GH 3 (see fig. 163). This is especially true, if we look on the distribution of cores from FAS. Chert cores instead are in the West and South. Cores from crystallin rock (quartzite, quartzitic sandstone, quartz and sandstone) are to find in all areas, except in the north-eastern corner.

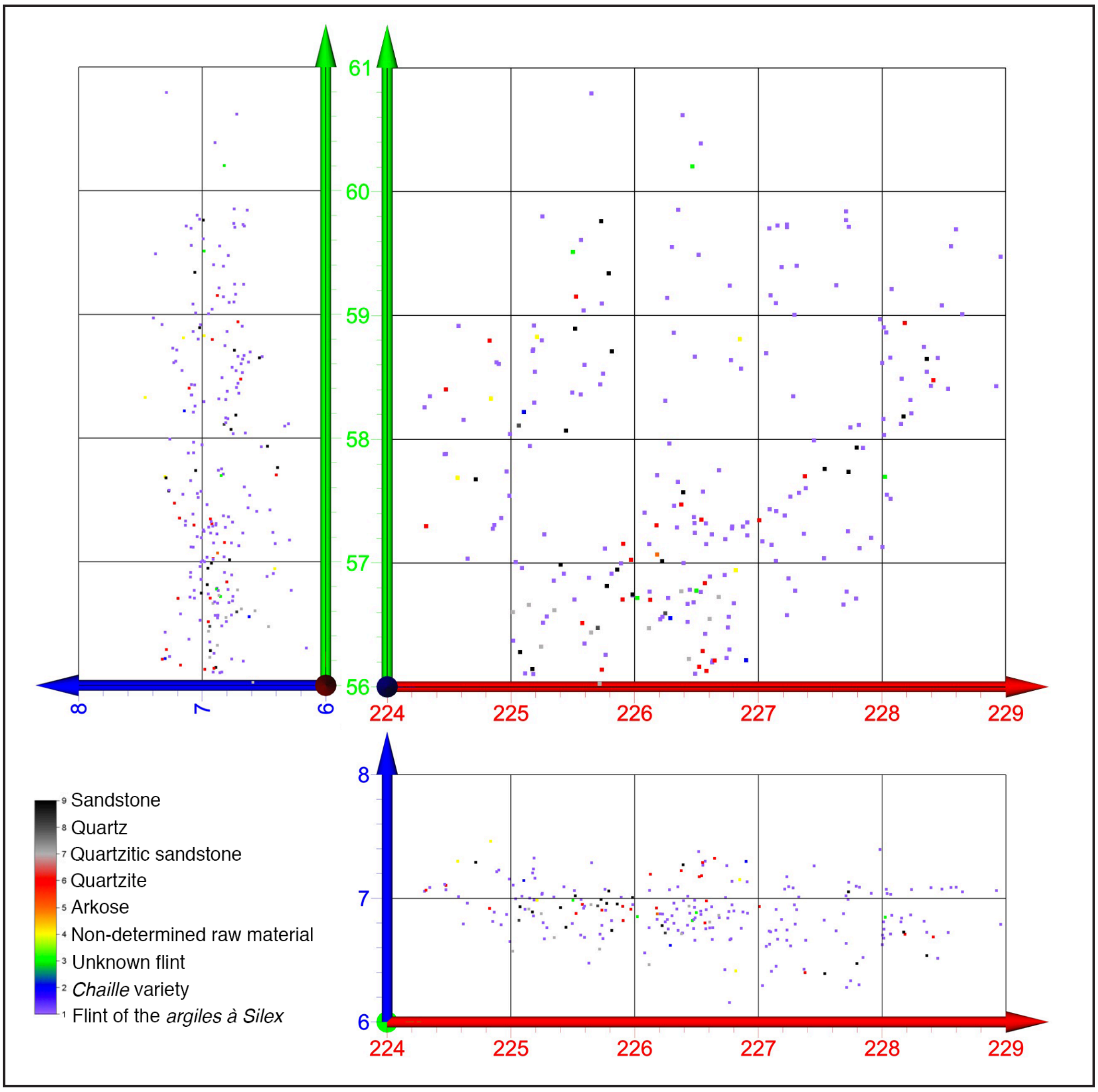

Fig. 163 - Distribution of cores in regard to raw material from GH 3

Also if we look on the distribution of cores in regard to depth in the stratigraphy, cores from FAS are distributed in the complete thickness of GH 3. Cores from quartzite are mostly spread in the upper half of GH 3.

VII.10.6 Distribution in regard to core class

By distributional plotting of cores of GH 3 in regard to their core class, we observe unspecific patterns. This is also visible if isosurfaces (with the same distinction as for dimensions, as visible in fig. 163) are added (see fig. 164).

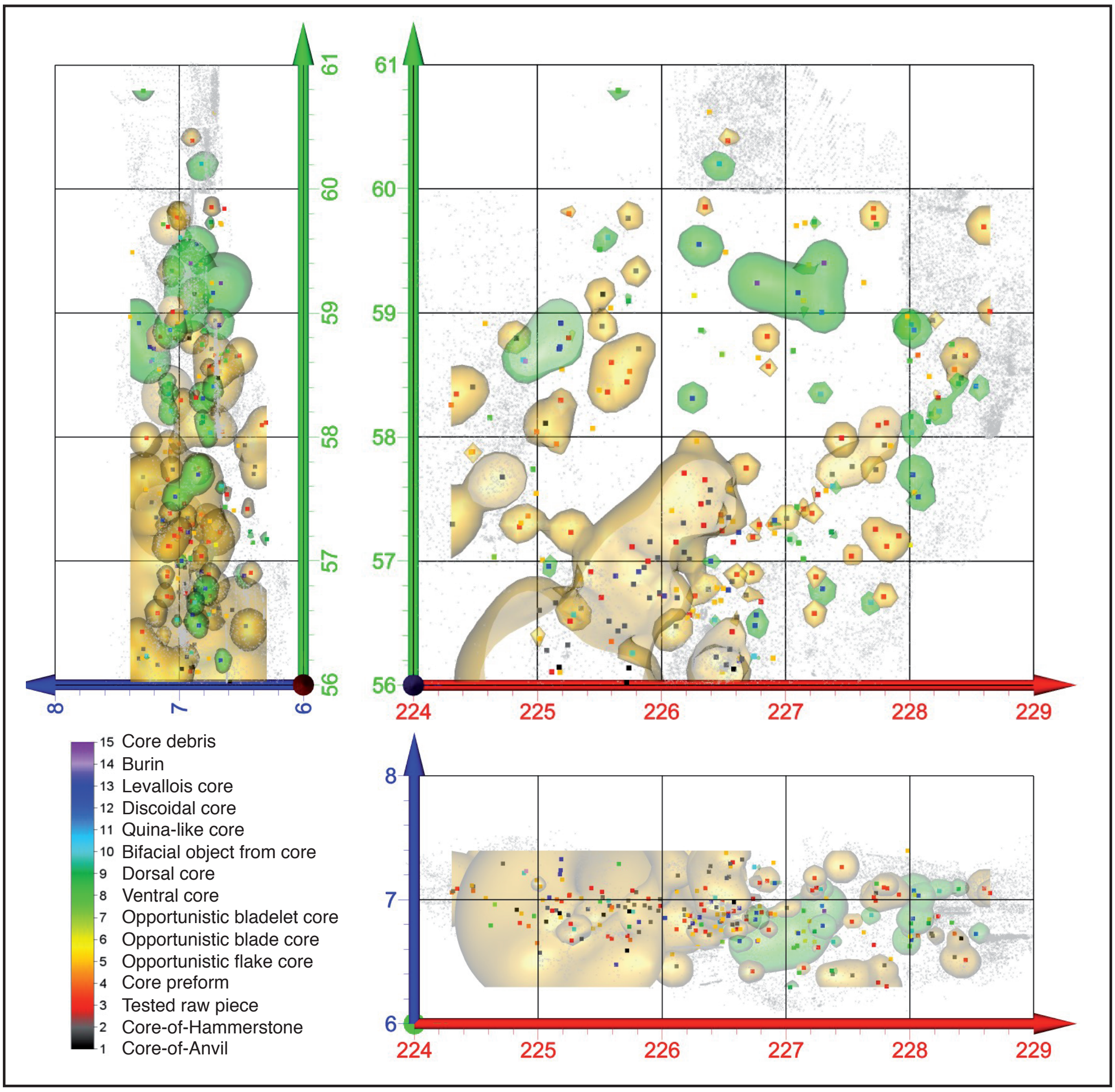

Fig. 164 - Distribution of cores in regard to core classes from GH 3, with isosurfaces separating a) Preforms from reduced cores and b) Unspecific core classes from specific core classes

The only observation (which is similar to the plotting by raw material, see fig. 163) is that crystallin objects (in this case hammerstones and anvils, but also tested raw pieces) have their major distribution in the southwestern corner of the excavated area of GH 3.

VII.10.7 General morphology and appearance of cores from GH 3

Cores appear polymorphic. They have a vast variety in shape and size (see above). Because of this variety a general overview cannot be given. As we saw in the beginning of this chapter, they are made from raw pieces (n=194), flakes (n=42) and frost-shard (n=12). Now, there would be two possibilities to describe these cores. The one would be to describe the classified cores inside the groups of cores-on-raw piece, cores-on-flake and cores-on-frost shard. The other possibility would be to describe the observed core classes and specify them further. Tab. 157 shows this correlation between core-group and core-class:

Core class / Core group	Core-on-raw piece	Core-on-flake	Core-on-frost shard	Total
Hammerstone	48	0	0	**48**
Anvil	8	0	0	**8**
Tested raw piece	51	1	5	**57**
Preform of a specific core	12	0	0	**12**
Opportunistic flake-core	48	5	4	**57**
Opportunistic blade-core	2	0	0	**2**
Opportunistic bladelet-core	2	0	0	**2**
Ventral reduction core	0	10	0	**10**
Dorsal reduction core	0	6	1	**7**
Ventrally and dorsally reduced core	0	6	0	**6**
Bifacial object made on core	3	0	4	**7**
Core with Quina-like reduction	1	0	0	**1**
Discoidal core	2	1	1	**4**
Levallois core	15	9	0	**24**
Core-debris	2	0	0	**2**
All tools-on-cores from the classes above (extracted)	3	6	1	**10**
Total	**197**	**44**	**16**	**257**

Tab. 157 - Correlation between core class and core group (empty fields are marked in red)

By marking empty fields (see tab. 157, above), certain assessments show relation between class and group (from top to bottom):

- Hammerstone-on-cores are always raw pieces with a more or less big removal (deriving very likely from the blow)
- The same is visible for anvils. Here the visible removal negative derives also very likely from blows)
- Tested raw pieces show only some removals, but not from their use as hammerstone but from the initialization of the object as core. In every case the internal raw material shows bad quality
- Preforms are made from raw pieces. The knapper started the configuration for specific reduction (unfinished conceptualization) but did not finish it
- Simple flake-cores are mostly made from raw pieces. These are cores showing flake removals but lack a specific classification
- For blade-cores and bladelet-core this observation is similar, but they are solely made from raw pieces
- Cores with ventral or dorsal reduction must (*per definitionem*) be made from blanks
- Bifacial objects are made from raw pieces, flakes and frost-shards
- Only one core shows a Quina-like reduction (GER2014.227-061.148)
- Discoidal cores are made from all core groups, but the stay quite seldom
- For specific cores, cores with Levallois reduction dominate. They are made

from raw pieces and flakes
- Tools-on-cores are quite seldom
- Only two core-debris were detected (in can be assumed that in the debris are more destroyed cores but could not be classified further)

In the following, the objects of the core classes are described in regard to morphology, appearance, raw material, reduction and functionality.

VII.10.8 Cores-of-Hammerstones

Introduction

This section describes n=48 hammerstones which show negatives of detachments. It can be assumed that this pieces were brought to site in complete condition to be used as hammerstones. On-site they functioned as hammerstones and broke during use. A subsequent synthesis about all hammerstones is given in chapter X.12 (in regard to unbroken hammerstones, split and flaked hammerstones and fragments of them). Detailed descriptions about hammerstone without removals were given in chapter VII.9.6, above.

Raw material and appearance

The n=48 hammerstones are made from a small variety of raw materials (see tab. 158):

Means and ratios / Raw material	Mean mass	Mean length	Mean width	Mean thick-ness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thick-ness ratio	Number
Arkose	284.50	87.21	59.93	40.56	1.46:1	2.15:1	1.48:1	**1**
Quartzite	281.97	83.06	66.25	41.13	1.25:1	2.02:1	1.61:	**19**
Quartzitic sandstone	270.15	74.81	61.29	38.86	1.22:1	1.93:1	1.58:1	**10**
Sandstone	168.96	64.44	48.24	36.48	1.34:1	1.77:1	1.32:1	**17**
Quartz	221.80	84.27	74.88	35.84	1.13:1	2.35:1	2.09:1	**1**
Total mean	**245.48**	**78.76**	**62.12**	**38.57**	**1.28**:1	**2.04**:1	**1.62**:1	**48**

Tab. 158 - Mean and ratios of raw material components of cores-of-hammerstones

These objects are characterized by their shape, as well as the combination of removal negatives and an adjacent crushed area with chronological hierarchy: 1. crushed zone 2. removal negative(s). The hierarchical combination indicates the use as hammerstone and subsequent breaking through knapping.

Mean ratios

By comparing the mean values of the hammerstones, we can deduce that the mean hammerstone (that show break) has a mass of 245 g, is around 79 mm long, 62 mm wide and 39 mm thick, with a LW ratio of 1.28:1, a LT ratio of 2.04:1 and a WT ratio of 1,62:1 (see tab. 158). The ratios of hammerstones from different raw material are in a close range to each other and indicates a similar shape of them.

Dimension

Dimensional plotting indicates no separation in means of size and raw material (see fig. 165).

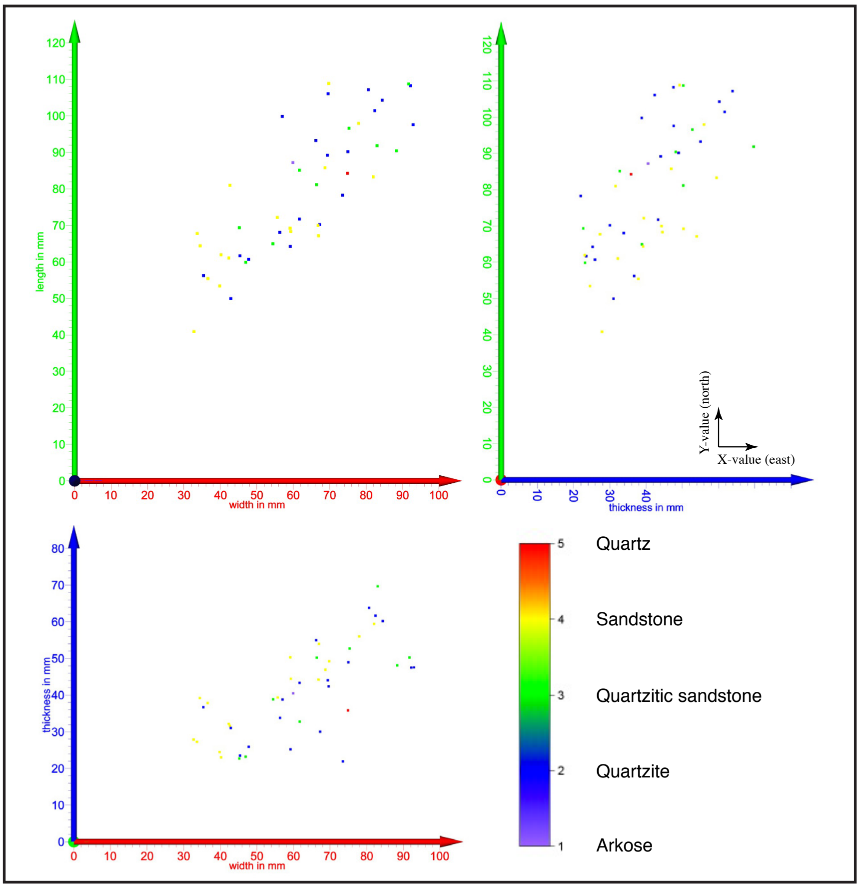

Fig. 165 - Dimensions of cores-of-hammerstones from GH 3

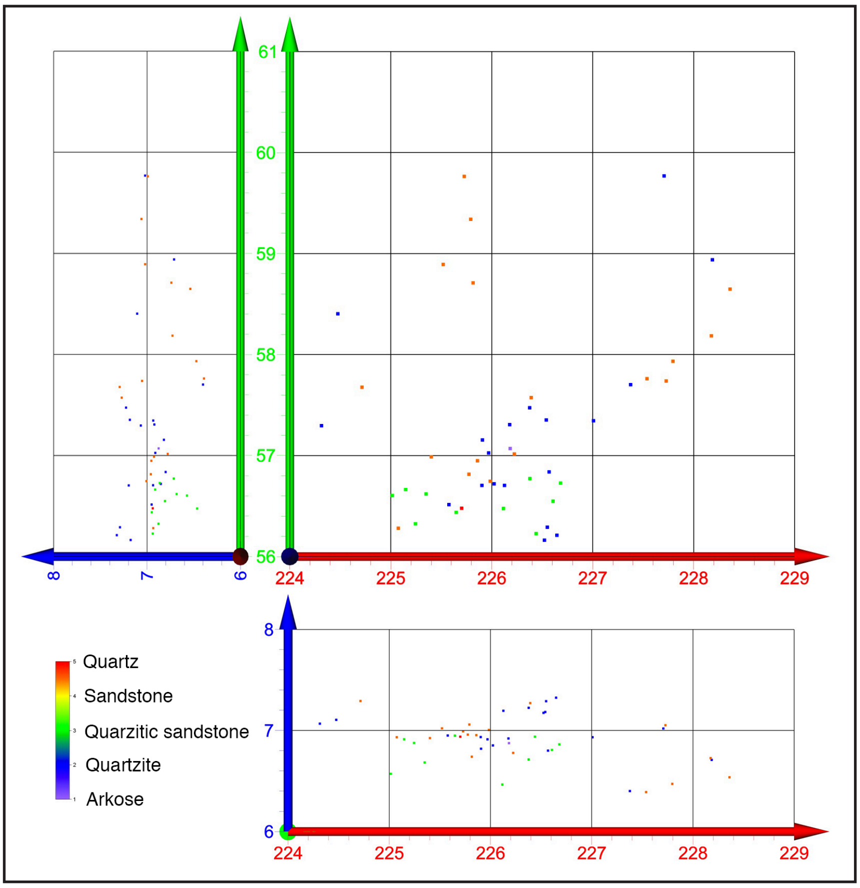

Fig. 166 - Distribution of cores-of-hammerstones from GH 3.

Distribution
Cores-from-hammerstones are mainly distributed in the southern part of the excavated area of GH 3 (see fig. 166). This is mostly true for hammerstones from quartzite. Hammerstones from quartzitic sandstone are to be found in two square meters (226-057 and 227-057) in the South. They show no specific distribution in regard to depth.

VII.10.9 Cores-of-anvils

Inside GH 3, n=8 objects from coarse-grained lithic materials were found that show at least one flat surface and use-wear on surfaces and edges (crushed or abraded zones), as well as negatives of removals.

Raw material and appearance
The majority of cores-of-anvils are made from quartzite (n=5). The remaining cores-of-anvils are made from sandstone, quartz, and quartzitic sandstone.

These objects are characterized by their shape and the combination of removal negatives and an adjacent crushed area (they are also chronologically related). It is hardly imaginable that these objects were used as normal hammerstones for one-hand-knapping tasks. A remarkable example of these definitely used anvils is GER.12.227-057.399 (see fig. 167). On this object the distinctive shape and the chronological relationship between removal negatives and an adjacent crushed area is obvious.

Fig. 167 - Example of a coarse-grained cobble used as anvil (GER12.227-057.399)

The following fig. illustrate the use of these objects as anvils and the subsequent breaking through knapping processes (see fig. 168) .

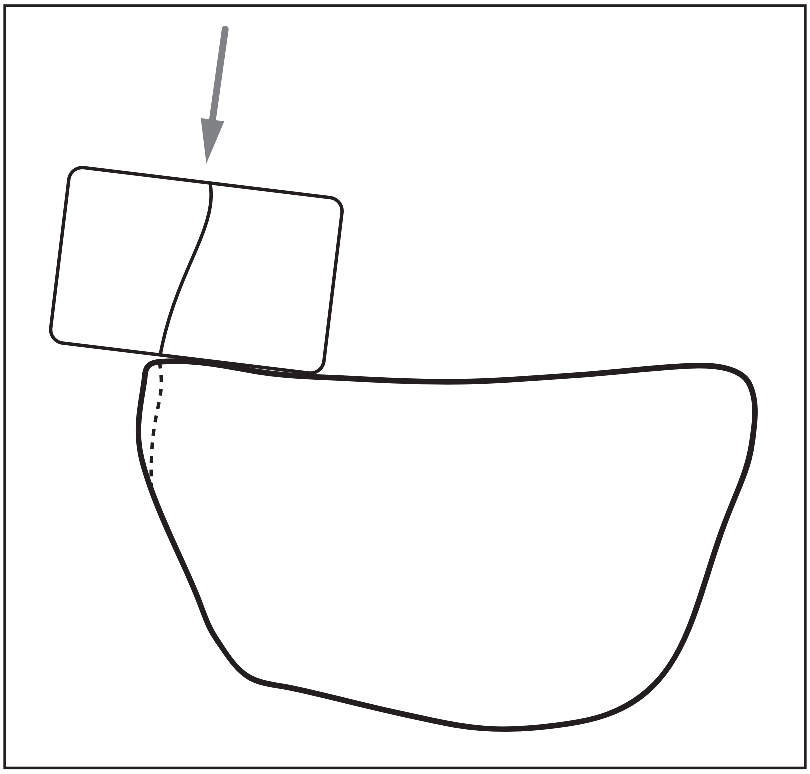

Fig. 168 - Schematic drawing of using and subsequent breaking of an anvil

Mean ratios

The mean ratios of dimension indicate the possibility that different raw materials of these anvils are used for different purposes. They differ in dimension and mass (see tab. 159). The number of only n=8 also shows that they were probably not of high importance.

Means and ratios Raw material	Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
Quartzite	758.88	109.51	84.96	68.16	1.29:1	1.61:1	1.25:1	5
Quartzitic sandstone	613.60	123.26	70.93	58.65	1.74:1	2.10:1	1.21:1	1
Sandstone	309.80	97.31	79.17	44.00	1.23:1	2.21:1	1.80:1	1
Quartz	60.00	65.83	28.16	24.43	2.34:1	2.69:1	1.15:1	1
Total mean	**435.57**	**98.98**	**65.81**	**48.81**	**1.65**:1	**2.15**:1	**1.35**:1	**8**

Tab. 159 - Mean and ratios of raw material components of cores-of-anvils

Dimension

Cores-of-anvils are bigger objects. They are bigger than 70x80mm, with one exception (see fig. 169).

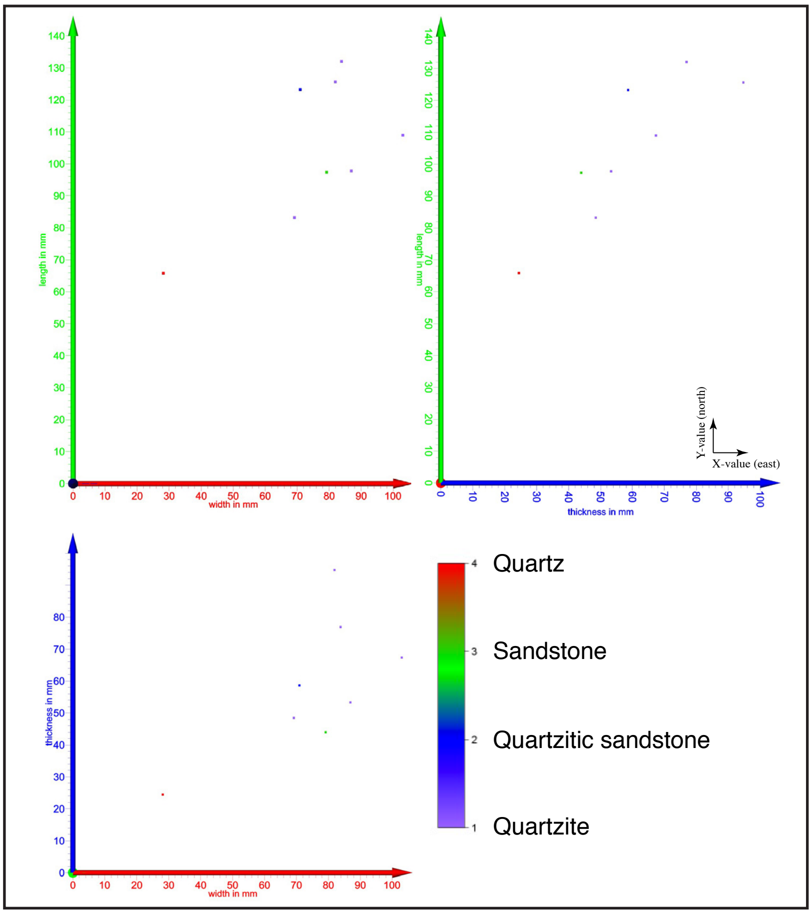

Fig. 169 - Dimensions of cores-of-anvils from GH 3

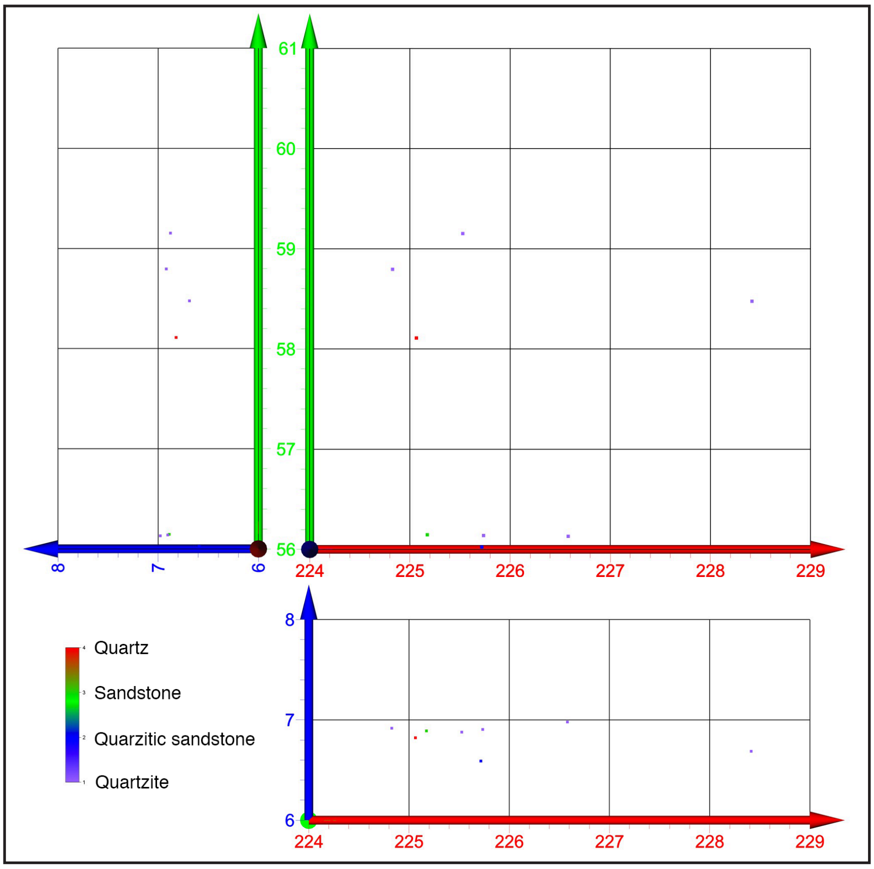

Fig. 170 - Distribution of cores-of-anvils from GH 3.

Distribution
Anvils-on-core are distributed in three spots. One in the South (square meters 226-057 and 227-057), as well as in the West and one in the East of the excavated distribution of GH 3. They are quite restricted in distribution in depth. Most of them are clustered between a Z-value of 6.8 and 7 (see fig. 170).

VII.10.10 Tested raw pieces

Introduction
Tested raw pieces are cores that show some removal negatives and contain indications for reasons why they were refused to be used as regular cores. They belong to the core group of simple cores.
Inside GH 3, n= 57 tested raw pieces were detected. The most are made from raw pieces (n=51), one is made on a flake and n=5 are made on frost-shards (see tab. 160).

Core group Core class	Core-on-raw piece	Core-on-flake	Core-on-frost shard	Total
Tested raw piece	51	1	5	57

Tab. 160 - Core classes of tested raw pieces from GH 3.

Raw material and appearance
The main raw material for tested raw pieces is FAS, one other tested raw piece is made fron an unknown silicious material.
A reason for the presence of many tested raw pieces from FAS might be that the next potential source of this raw material is in close distance (around 150 m away). Therefore they could easily brought to site in the condition of fresh or tested raw pieces.
We have evidence from the refitting of one tested raw piece (GER12.225-059.911) and the corresponding raw-piece cap (GER12.229-058.234) for the import of complete raw pieces to the site and add-on testing on-site (see also chapter X.7). For others there is the possibility that they were brought to site in tested condition (and immediate discard because of bad material) or the corresponding raw-piece cap is still present in unearthed parts of GH 3, or the detached blanks was modified or even exported.
Probably the main reason for immediate discard of tested raw piece is the condition of the interior raw material, because it can contain among others, fissures, older hertzian cone breaks, frost cracks, inclusions of non-silicified spots, concavities or differences in granularity. As tests on FAS from west of Château de Germolles show, the exact condition of the interior is not always visible without opening. If the raw material in Middle Paleolithic times had the same or similar condition as it is visible nowadays, it is very comprehensible that many raw pieces needed to be tested (on-site or on the source, because of the small distance to carry).

Mean ratios

The mean mass for tested raw pieces from GH 3 is 103.1g, with a mean length of 70 mm and width of 50 mm at a thickness of 37 mm. The bandwidth in size is big, visible in mass. The smallest has only 3.7 grams, whereas the biggest has a mass of 1,288.3g (see fig. 171 and tab. 161).

Tested raw pieces can have one to 6 reduction surfaces. The majority has only one reduction surface, but there also objects showing two reduction surfaces (n=5), three reduction surface (n=6), one with n=4, four with n=5 and one with six reduction surfaces. A possible reason for testing a raw pieces on different parts is, that the interior FAS raw pieces can vary vastly in quality.

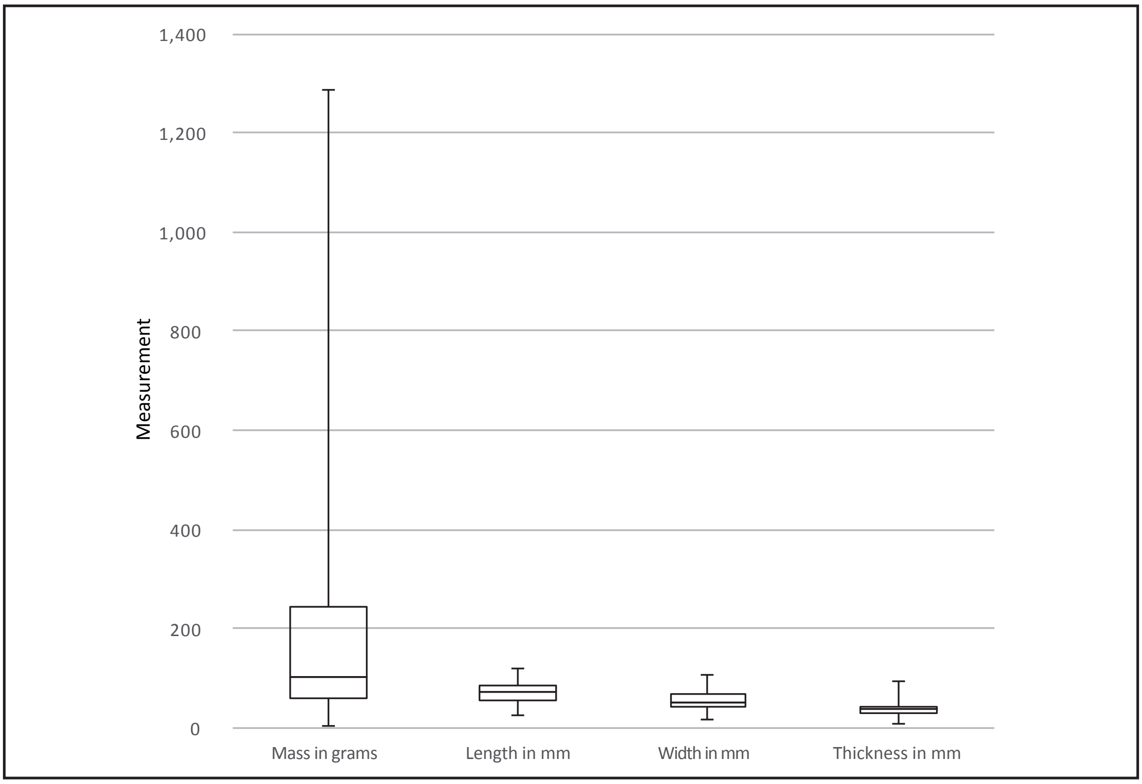

Fig. 171 - Boxplot of mass, length, width and thickness of tested raw pieces from GH 3

Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
103.10	70.00	49.70	36.60	1.41:1	1.91:1	1.36:1	57

Tab. 161 - Mean ratios of tested raw pieces from FAS

Dimension

Tested raw pieces are dimensionally scattered in length-to-width ratio as well as length-to-thickness ratio (see fig. 172) and show three clusters (small, medium and big). The small cluster contains one piece. The medium cluster contains the majority of objects and the big cluster seems to be exploded. Despite the three size clusters, the ratio of length-to-width seems to be quite stable. The picture differs if we consider the thickness-to-width ratio.

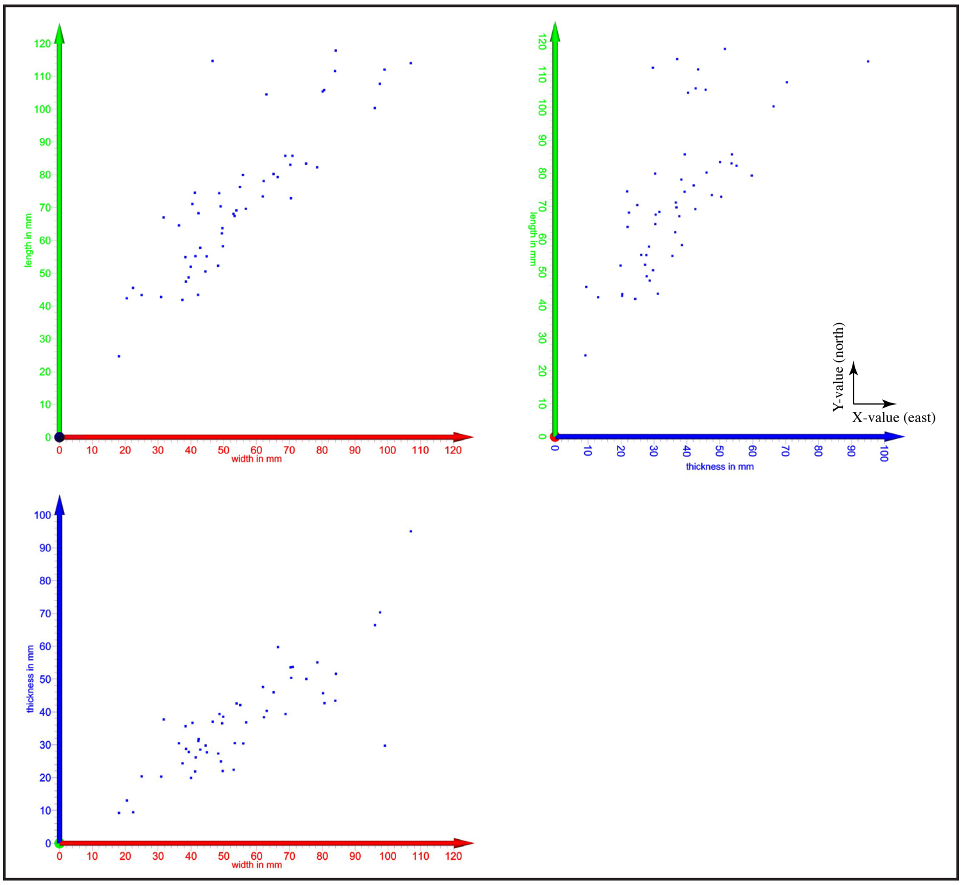

Fig. 172 - Dimensions of tested raw pieces from GH 3 (only FAS)

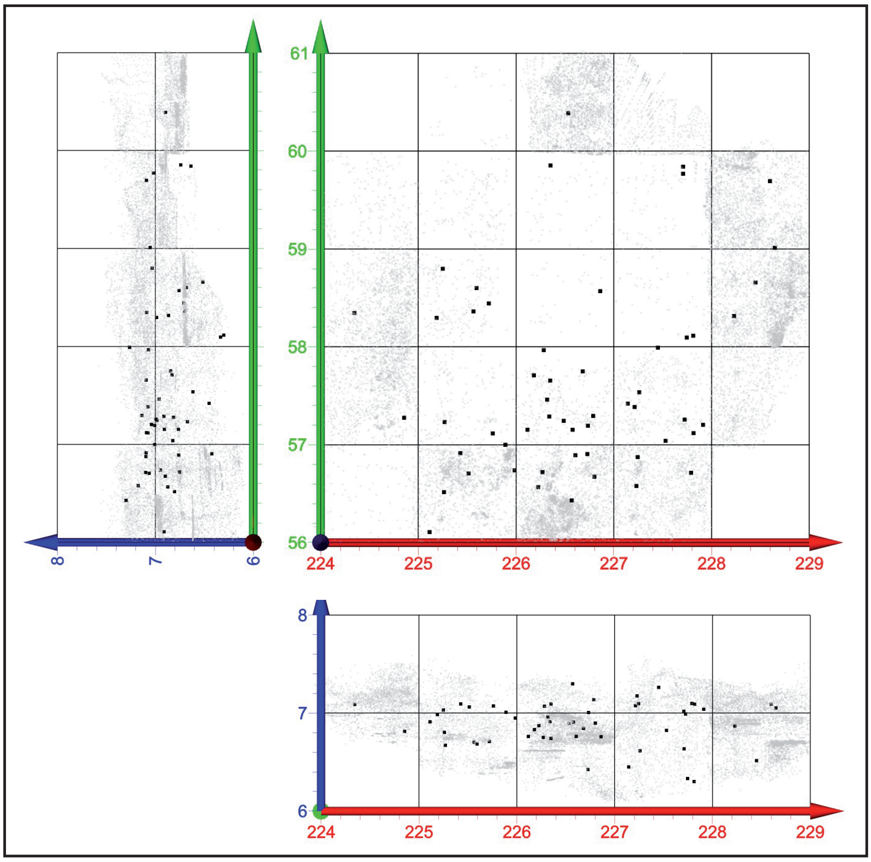

Fig. 173 - Distribution of tested raw pieces from GH 3

Distribution

Tested raw pieces are scattered with a density in the southern part of the excavated area (see fig. 173). In the Z-value they are distributed in the complete thickness of GH 3, but with a density between Z=6.6 and 7.1.

VII.10.11 Core-preforms

Introduction

Inside GH 3, n=12 core-preforms were detected. They are all attributed to be preforms of Levallois cores (except one, a preform of a pyramidal core) and are made from FAS. The reasons for non-finalizing these cores are manifold. All of this cores show phases of initialization and partial configuration.

Raw material and appearance

The raw material of these preforms is local FAS. It makes sense that no other (more far-off) raw material shows such initialized and partially configured cores, because it can be assumed that they would be discarded on the workshop. On these cores there is good evidence for the interruption of configuration (examples are listed in the following tab. 162):

Evidence for interruption	Example
Druse	GER13.255-058.1096 (fig. 174a)
Fissures	GER13.225-059.1065 (fig. 174b)
Hinges	GER12.226-057.373 (fig. 174c)
Inhomogeneous raw material	GER10.227-058.378 (fig. 174d)
Shape mistakes	GER13.225-058.679 (fig. 174e)

Tab. 162 - Evidence for the interruption of core configuration on core-preforms.

An impressive example for a core-preform is GER13.225-058.679 (fig. 174e). This core is probably made out of a thick, old flake (double patination). It shows convergent configuration negatives on the flaking surface. The platform shows also some negatives, but is not finished. From its shape it is suggested that this core can deliver a point if it would have been finished. Interestingly, this preform has no evidence of raw material errors.

Mean ratios

The mean „standard“ core-preform has a mass of 200 grams, is around 71 mm long, 60 mm wide and 44 mm thick (see tab. 163).

Dimension

Preforms of cores are dimensionally clustered in two groups, which is visible in all three dimensions (see fig. 175).

Distribution

The top view of the distribution of these cores shows three density clusters (see fig. 176). One in the East with two objects, one in the South containing three objects and one in the western part of the area with n=7 objects. In its Z-value (6.6 to 7.1) core-preforms are also clustered (6.6 to 7.1) and do not spread.

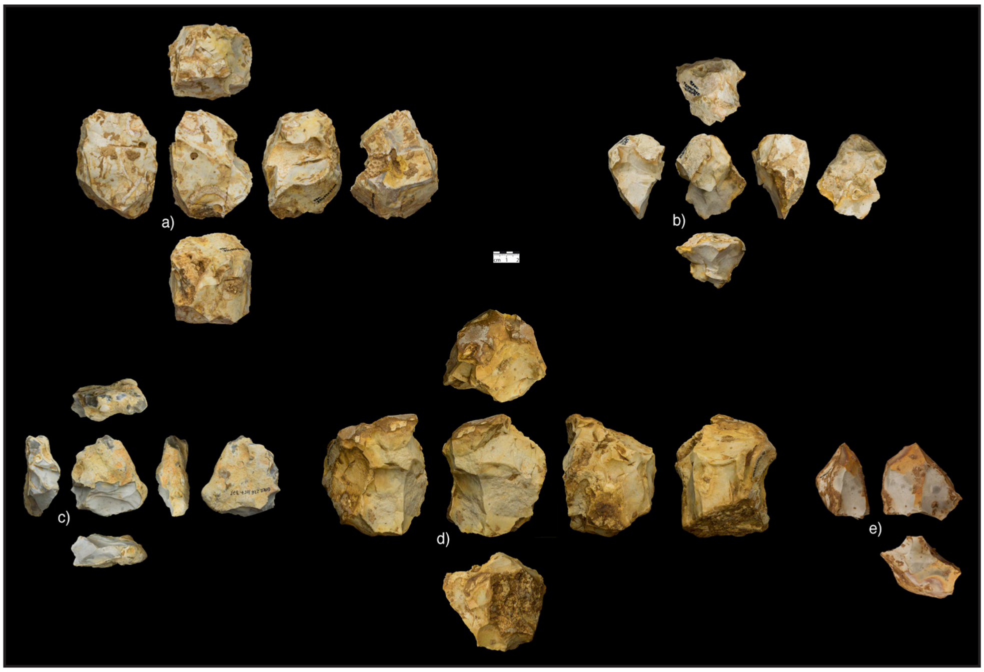

Fig. 174 - Examples of core-preforms showing evidence for the interruption of the reduction process. a) Surfaces showing some druses (GER13.225-058.1096), b) Interior contain some fissures (GER13.225-059.1065), c) Hinges as knapping mistakes interrupted the decortification process (GER12.226-057.373), d) Differences in granularity (GER10.227-058.378) and e) Reduction on the platform made a concave surface and the correction would reduce the volume of the core intensively (GER13.225-058.679)

Raw material	Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
FAS	200.10	70.96	60.29	43.74	1.18:1	1.62:1	1.38:1	12

Tab. 163 - Mean ratios of core-preforms.

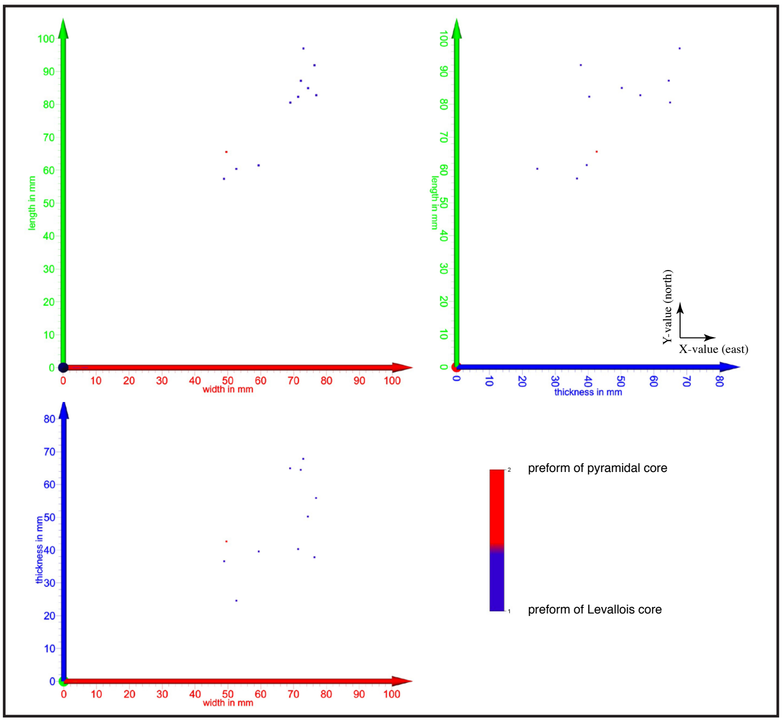

Fig. 175 - Dimensions of core-preforms from GH 3

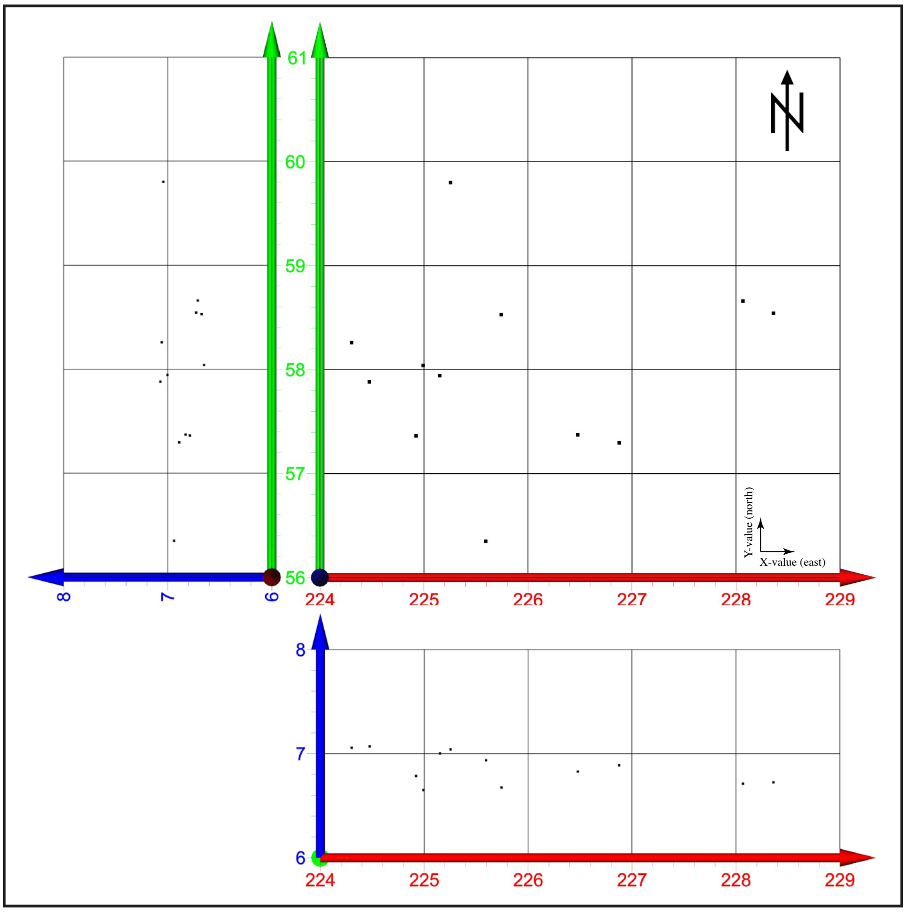

Fig. 176 - Distribution of core-preforms from GH 3

VII.10.12 Opportunistic cores

Introduction

N=62 cores are classified as opportunistic cores, whereas n=5 show further modification. They all show initialization and a diversity of configuration, but without the possibility to group them within a specific reduction concept. Mostly these cores are opened raw pieces with removal negatives from divers directions. In general it can be said that these cores provided blanks but without intensive core configuration. They are optimistic reduced in that way that reduction was done on core position were surfaces, edges and angles were acceptable to produce blanks. Some of them are quite small and made from blanks (n=3) and frost shards (n=4). It has to be said that opportunistic cores are a reservoir for cores that show no specific reduction sequence. Every core was turned and rotated that some blanks could be produced. It is worth considering if these cores represent objects that are also preforms or if they are cores made from novices (this will be discussed in chapter X.14).

Raw material and appearance

These cores are far from consistence in appearance. They are big and small in size, and polymorph. Mostly suitable core positions are used to get a blank.

The evaluation and visualization of three categories at the same time (raw material, core class and core group) is a very challenging issue. So we have to separate it. First the relation between raw material and core-group (see tab. 164). FAS is the main material, all other raw materials are underrepresented. The majority of objects is made on raw-pieces. Only for FAS all three core-groups are represented.

Core group Raw material	Core-on-raw-piece	Core-on-blank	Core-on-frost-shard	Total
FAS	43	4	4	**51**
Unknown flint	0	1	0	**1**
Chert variety	4	0	0	**4**
Quartz	1	0	0	**1**
Sandstone	1	0	0	**1**
Unknown raw-material	4	0	0	**4**
Total	**53**	**5**	**4**	**62**

Tab. 164 - Correlation between raw material and core-group for opportunistic cores (empty fields in red)

If we correlate raw material with core class (see tab. 165), we see the majority are flake-cores from FAS. The few cores that produced blades and bladelets are also made from FAS. All the other cores are flake-cores from different raw materials.

Core class Raw material	Flake core	Blade core	Bladelet core	Total
FAS	47	2	2	**51**
Unknown flint	1	0	0	**1**
Chert variety	4	0	0	**4**
Quartz	1	0	0	**1**
Sandstone	1	0	0	**1**
Unknown raw-material	4	0	0	**4**
Total	**58**	**2**	**2**	**62**

Tab. 165 - Correlation between raw material and core-class for opportunistic cores (empty fields in red)

The third correlation in this context is core-group to core-class (see tab. 166). Here we see that the majority of opportunistic cores are flake-cores made from raw-pieces. Blade- and bladelet-cores are also made from raw pieces. All the cores made from blanks and frost-shards produced flakes. In combining these three correlation, the majority of opportunistic cores are flake-cores on raw-pieces made on FAS.

Core class Core group	Flake-core	Blade-core	Bladelet-core	Total
Core-on-raw-piece	49	2	2	**53**
Core-on-blank	5	0	0	**5**
Core-on-frost-shard	4	0	0	**4**
Total	**58**	**2**	**2**	**62**

Tab. 166 - Correlation between core group and core class for opportunistic cores (empty fields in red)

Mean ratios

The „standard“ opportunistic core has a mass of 139 grams, is 60 mm long, 50 mm wide and 34 mm thick. In regard to ratios, a „standard“ opportunistic core is 1.23 times longer than wide, 1.85 times longer than thick and 1.5 times wider than thick (see tab. 167). Compared to its width, cores from FAS and chert are the longest.

Raw material	Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
FAS	64.08	46.18	35.67	24.88	1.29:1	1.86:1	1.43:1	**51**
Unknown flint	46.20	50.15	42.49	28.88	1.18:1	1.74:1	1.47:1	**1**
Chert variety	313.03	94.78	73.50	43.09	1.29:1	2.20:1	1.71:1	**4**
Quartz	250.50	75.88	71.22	58.24	1.07:1	1.30:1	1.22:1	**1**
Sandstone	158.80	78.11	66.53	42.20	1.17:1	1.85:1	1.58:1	**1**
Unknown raw material	1.40	15.61	11.43	7.17	1.37:1	2.18:1	1.59:1	**4**
Total mean	**139.00**	**60.12**	**50.14**	**34.08**	**1.23:1**	**1.85**:1	**1.50**:1	**62**

Tab. 167 - Ratios of opportunistic cores in regard to raw material diversity

Dimension

In regard to raw material, FAS are much more clustered in length-to-width than other materials (violet). Chert cores are the biggest (green on fig. 177). By core class plotting, the blade and bladelet cores are longer in regard to their width (see fig. 178). The cluster from length-to-width is invisible in thickness-to-width and in a small amount in length-to-thickness.

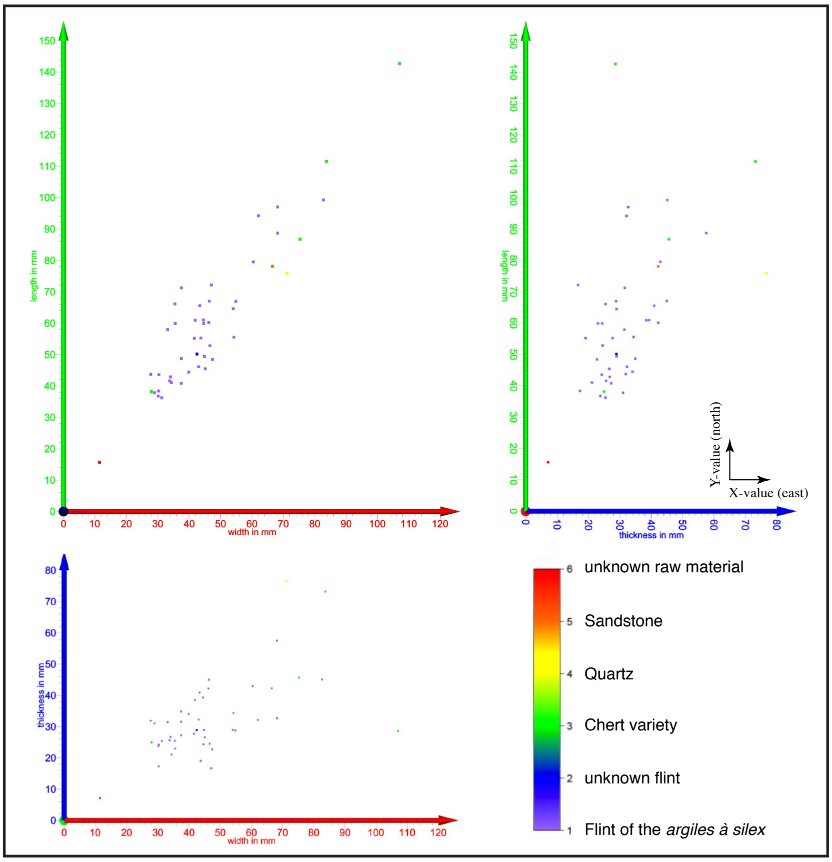

Fig. 177 - Dimensions of opportunistic cores from GH 3 in regard to raw material

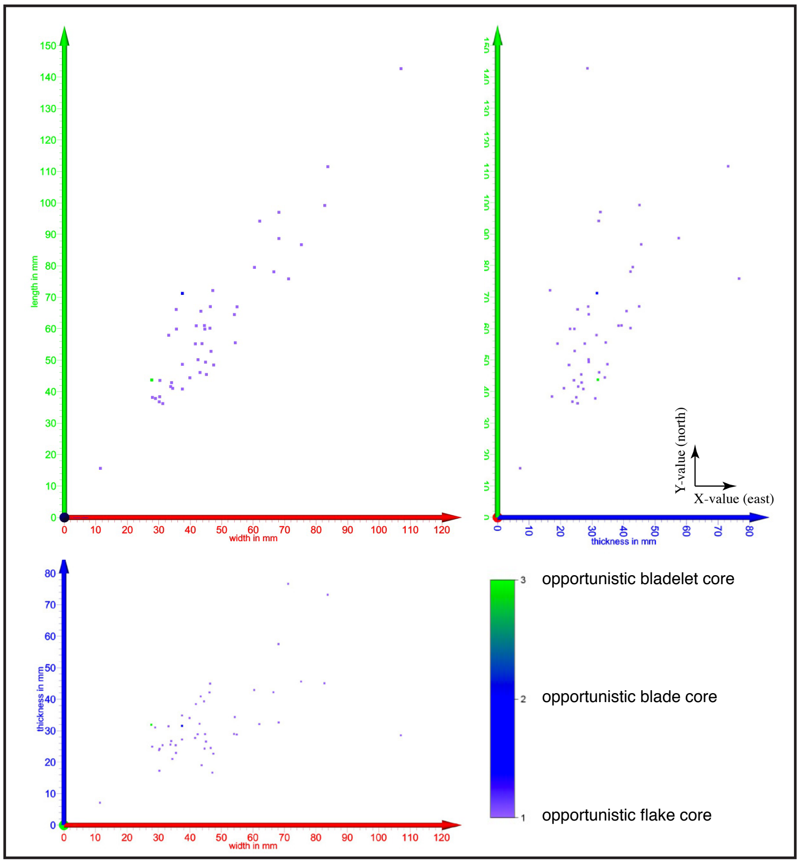

Fig. 178 - Dimensions of opportunistic cores from GH 3 in regard to core class

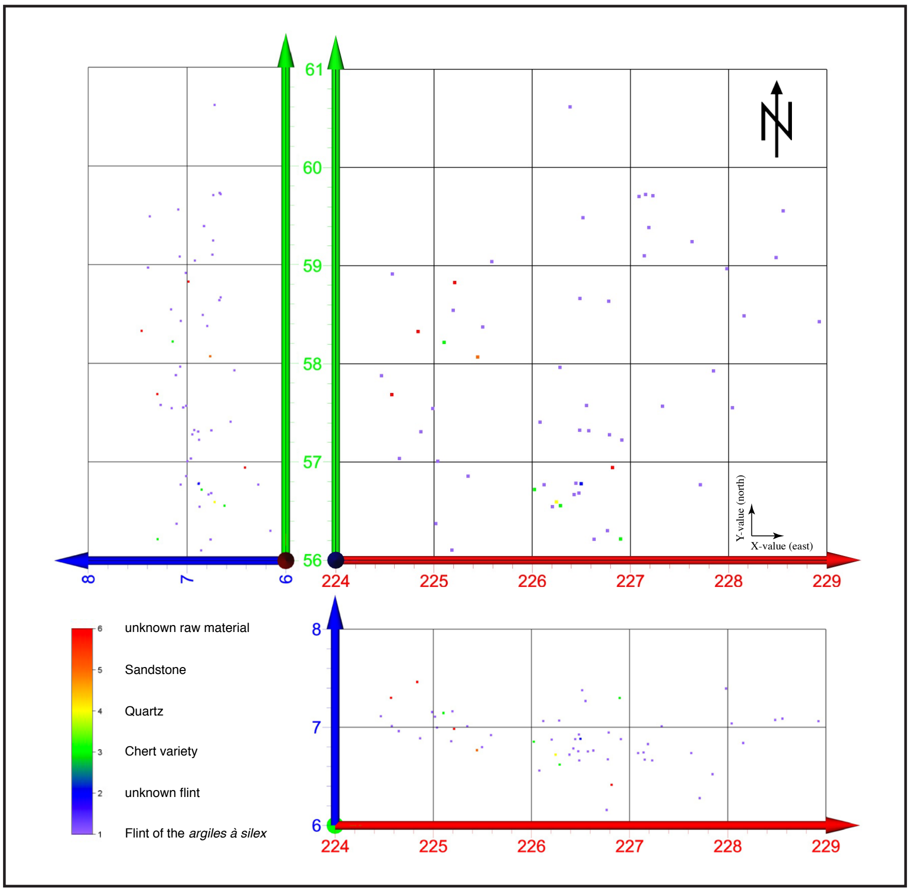

Fig. 179 - Distribution of opportunistic cores from GH 3 in regard to raw material

Distribution

Opportunistic cores from non-flint material are scattered in the southern and western part of the excavated area of GH 3. Cores from FAS are distributed in nearly all square meters. In regard zu Z-value, no specific cluster is detected (see fig. 179).

By plotting opportunistic cores in regard to their core class, the same is visible (see fig. 180). Flake-cores are distributed in nearly are square meters. The blade-core and the bladelet-core are insignificant positioned.

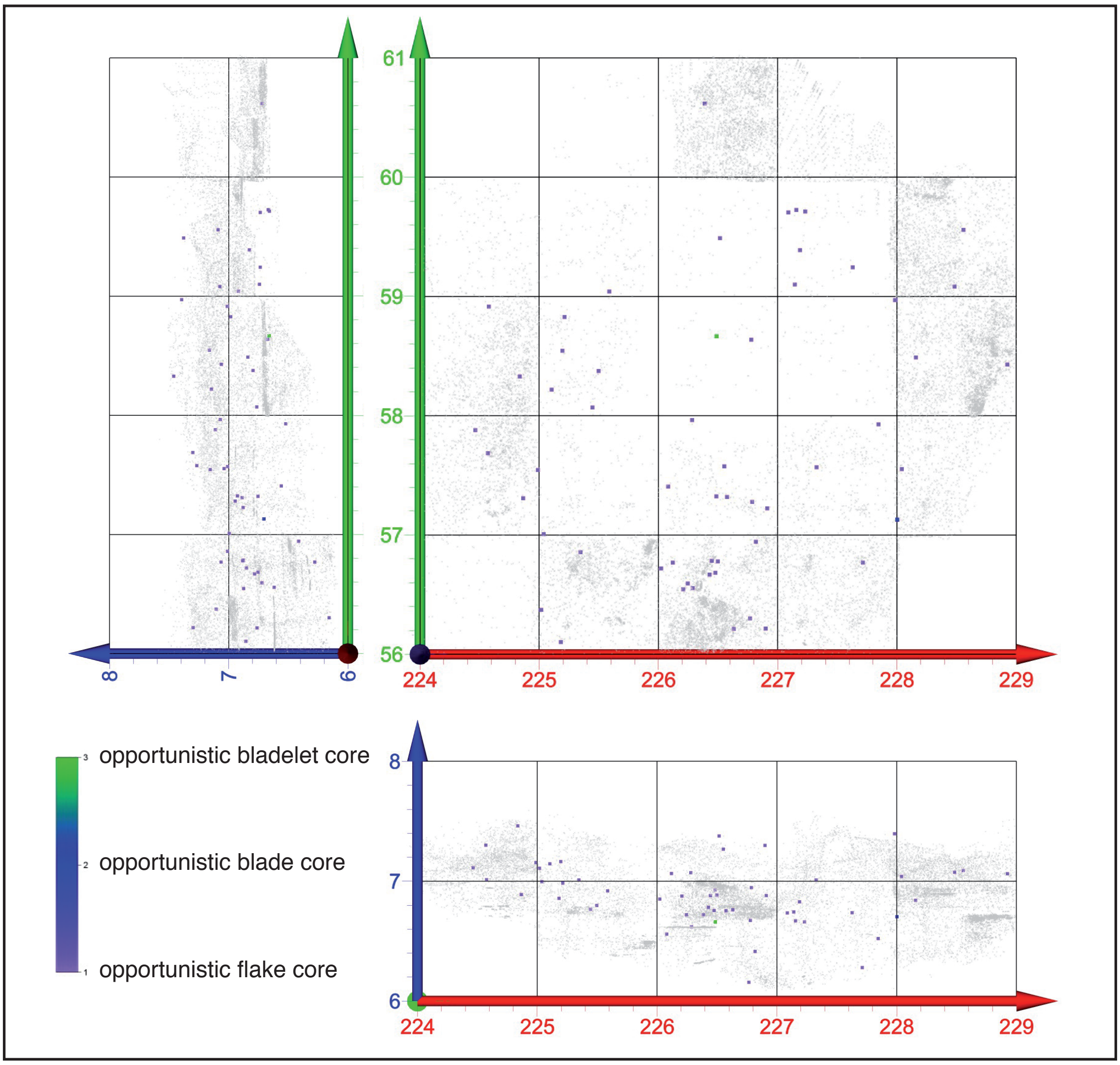

Fig. 180 - Distribution of opportunistic cores from GH 3 in regard to core class

VII.10.13 Ventral reduction cores

Introduction

In GH 3, there are only n=10 cores-on-blank with solely ventral reduction (ventral reduction is the general term for reduction of ventral surfaces of blanks). All (except one from chert) are made from FAS. All blanks are in the dimension of flakes (see tab. 168).

Raw material	Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
FAS	36.31	50.66	36.38	18.27	1.39:1	2.77:1	1.99:1	9
Chert variety	24.20	53.79	44.55	17.16	1.21:1	3.13:1	2.60:1	1
Total mean	**30.26**	**52.23**	**40.47**	**17.72**	**1.30:1**	**2.95:1**	**2.29:1**	**10**

Tab. 168 - Ratios of ventral reduction cores from GH 3.

A „standard" ventral reduction core has a weight of 30 grams, is 52 mm long, 40 mm wide and 18 mm thick. The length-to width ratio is in the spectrum of flakes. The mean objects are nearly three times as long as thick and 2.3 times as wide as thick (see tab. 168).

In n=4 cases, the ventral reduction removed the bulb of percussion. On n=5 objects, the ventral reduction removed one blank. On other objects, there is evidence for multiple removals (one with n=17 removals, one with n=9, one with 5, one with n=3 and one with n=2 removals).

As other scholars assumed (e.g., Boëda 1994), detachments on ventral surfaces can also be assumed as a kind of configuration for planimetric cores (in his case Levallois cores). But other cases are also thinkable. At first, the reduction of a bulb of percussion can produce a Janus flake (two seemingly ventral surfaces) or at second, a negative of detachment can be used for thinning processes. Also in this cases, it seems that a separation into processes that produce convexities and processes that consume convexities is sensible. Ventral cores of GH 3 show both. One flake (GER13.225-059.1254) show many negative in a centripetal manner for the formation of a convexity, but the process was interrupted (maybe because of the production of hinges, see fig. 181).

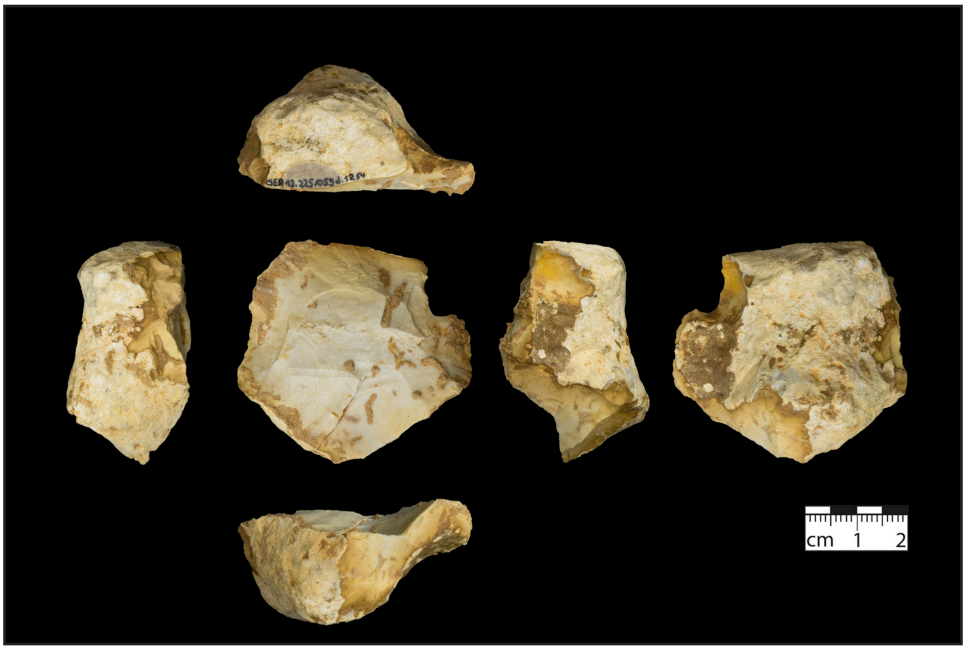

Fig. 181 - Ventral core with centripetal negatives and hinges (GER13.225-059.1254)

Dimension

In regard to dimension, no specific clustering is visible. The chert core is more or less in the center of the dimensional range (fig. 182).

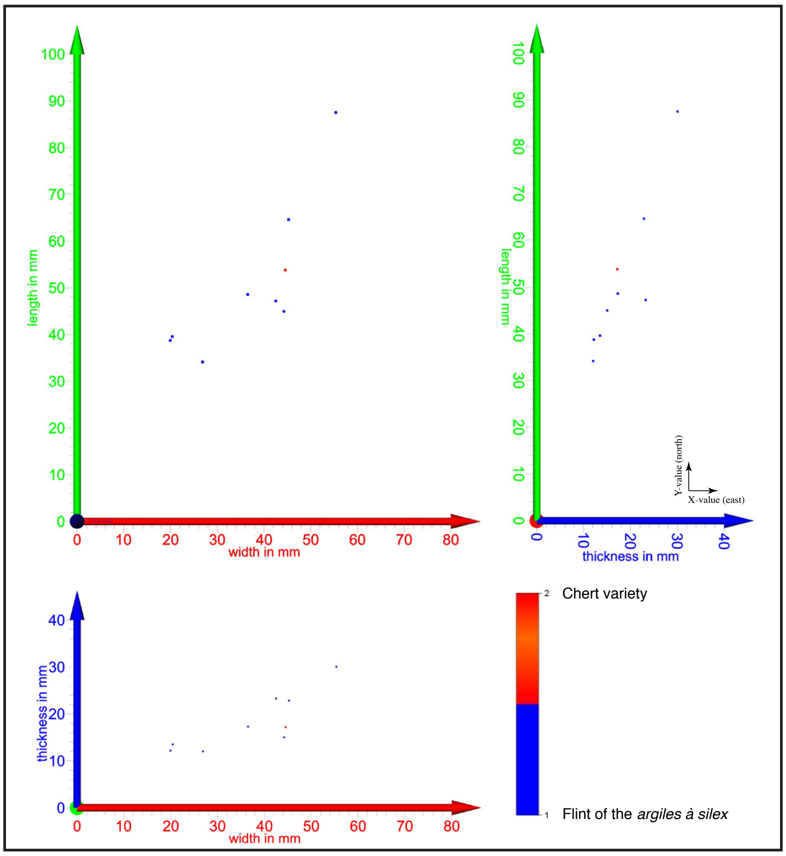

Fig. 182 - Dimension of ventral cores from GH 3 in regard to raw material

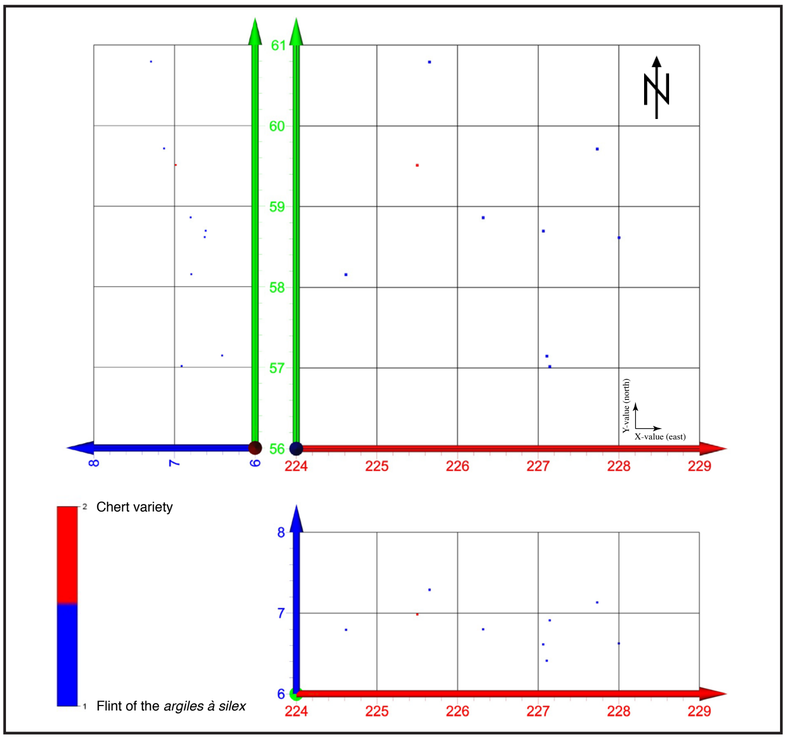

Fig. 183 - Distribution of ventral cores from GH 3 in regard to raw material

Distribution
Ventral cores are mostly scattered in the northern half of the excavated GH 3 area. The chert core is from square meter 226-060 in the North-West. In regard to Z-value no specific clustering is visible (see fig. 183).

VII.10.14 Dorsal reduction cores

All n=8 dorsal reduction cores are made from FAS on flakes. From the amount of knapping mistakes (hinges and steps) it is possible that these flakes were uses as „training" cores for novices. Only one example (GER10.228-058.420) appears as specifically shaped object. This object is morphological close to a carinated piece, but also shows many step fractures and a reduced bulb, as well. Another example (GER12.229-059.358) possesses an afterwards produced bigger negative on its former completely cortical dorsal face (see fig. 184).

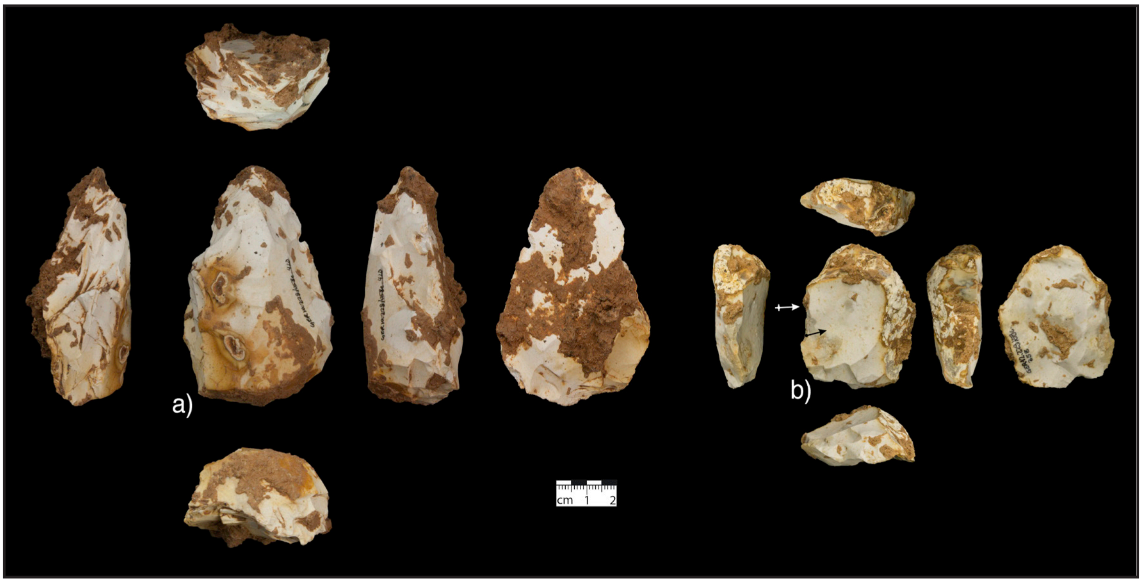

Fig. 184 - Two examples of dorsal reduction cores from GH 3. a) „Carinated piece" on flake (GER10.228-058.420) and b) Cortical flake extraction on flake (GER12.229-059.358)

Raw material	Mean mass	Mean length	Mean width	Mean thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio	Number
FAS	69.89	57.24	41.26	25.83	1.39:1	2.22:1	1.60:1	8
Total mean	**69.89**	**57.24**	**41.26**	**25.83**	**1.39:1**	**2.22:1**	**1.60:1**	**8**

Tab. 169 - Ratios of dorsal reduction cores from GH 3.

Mean ratios
As displayed in tab. 169, the „standard" dorsal core has a mass of 70 grams, is 57 mm long, 41 mm wide and 26 mm thick.

Dimension
In regard to length-to-width and length-to-thickness dimension, we see two clusters (see fig. 185). In thickness-to-width, this cluster is invisible.

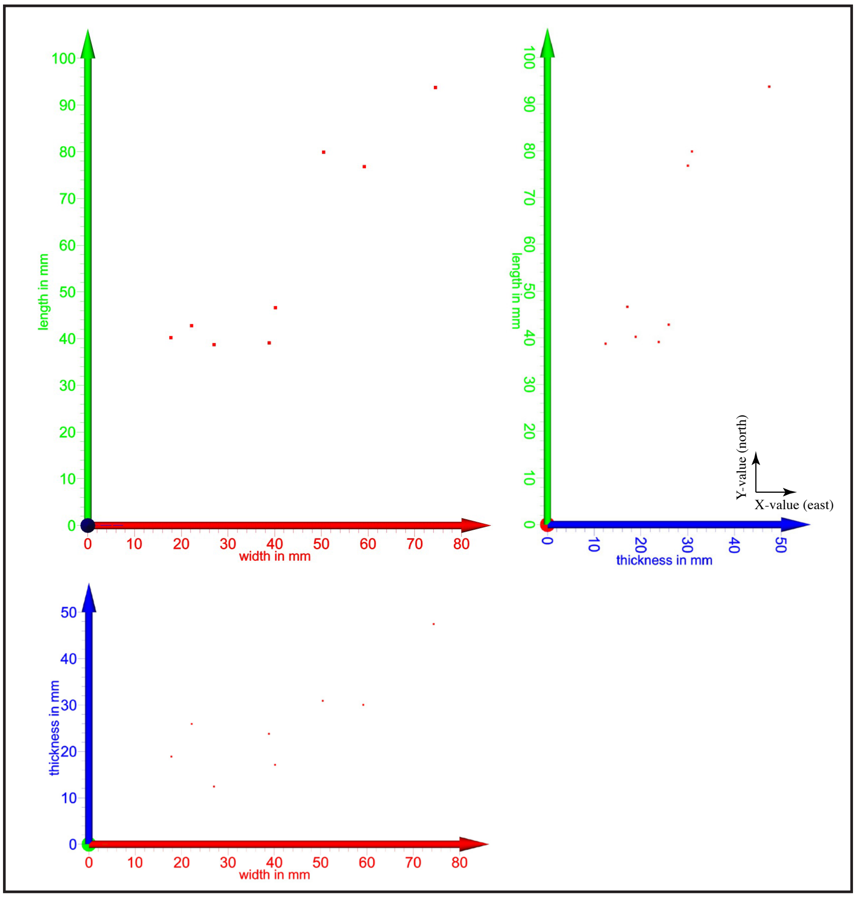

Fig. 185 - Dimension of dorsal cores from GH 3

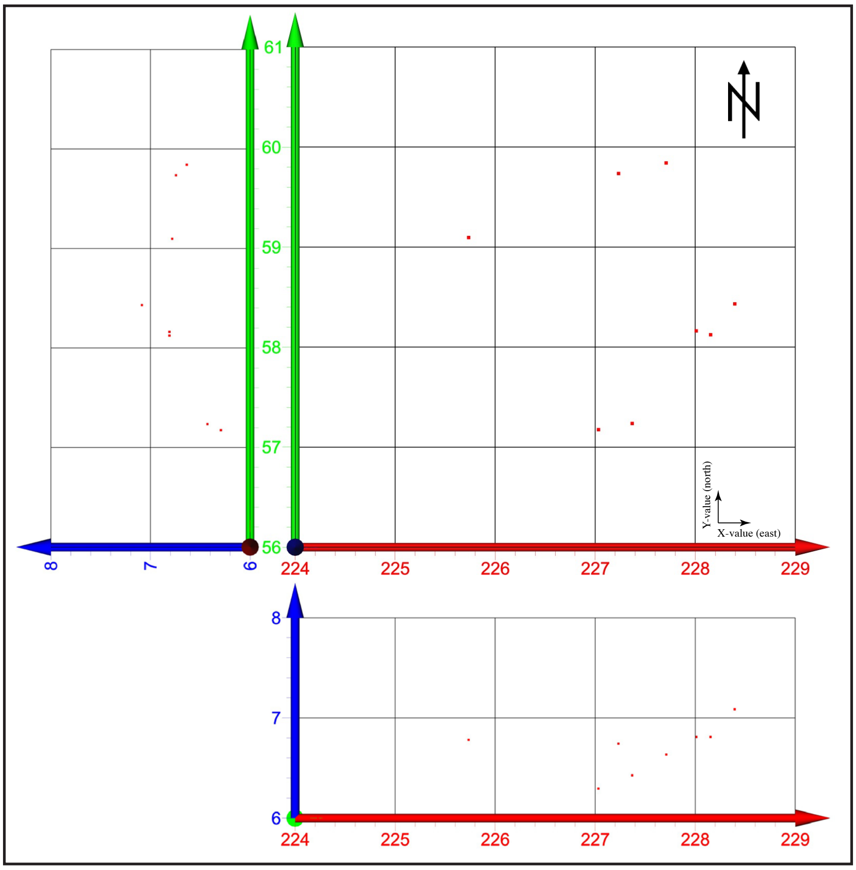

Fig. 186 - Distribution of dorsal cores from GH 3

Distribution

In top view, dorsal reduction cores from GH 3 are clustered in two spots (see fig. 186). In the Z-value this cluster is invisible, but most of the cores are distributed in a depth of less than 7.

VII.10.15 Bifacial objects made on cores

This section is focusing on bifacial objects that are made from cores. Bifacial objects made on blanks are discussed in chapter VII.11.13. The complete discussion about all bifacial objects is to be found in chapter VII.14. Specific aspects of these bifacial objects are also discussed in Frick & Floss (in press). N=3 bifacial objects were detected that are transformed raw pieces (and therefore cores). Two of them are bifacial preforms (GER09.228-059.116.5 and GER12.229-059.124, see fig. 187a) and one is a Keilmesser with tranchet blow (GER12.229-059.428, see fig. 187b).

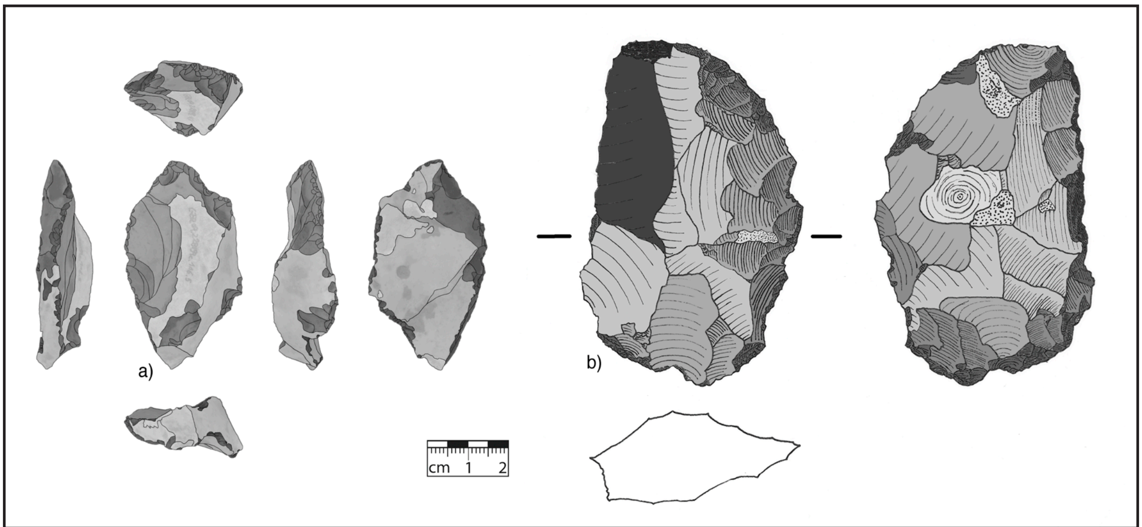

Fig. 187 - Bifacial objects made on cores. a) Bifacial preform made (GER09.228-059.116.5) and b) Keilmesser with tranchet blow made on core (GER12.229-059.428)

All three are made from flint from the argiles à silex. The distribution of these objects is displayed in chapter VII.14, as well as the dimensional plotting. The dimension, mass and resulting ratios of these three objects-on-cores are displayed in the following tab. 170:

Find-number	Denomination	Mass (in grams)	Length	Width	Thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio
GER09.228-059.116.5	Bifacial preform	13.6	50.29	28.43	14.45	1.77:1	3.48:1	1.97:1
GER12.229-059.124	Bifacial preform	47.2	61.21	41.88	19.76	1.46:1	3.10:1	2.12:1
GER12.229-059.428	Keilmesser with tranchet blow	82.5	80.99	52.00	22.47	1.56:1	3.60:1	2.31:1
Mean	**N=3**	**47.77**	**64.16**	**40.77**	**18.89**	**1.60**:1	**3.39**:1	**2.13**:1

Tab. 170 - List of bifacial objects made on cores from GH 3

These three objects are classified as cores because either they show patches of cortex on both surfaces or they are totally modified. Anyway, in any case they miss signs for having a blank or frost-shards matrix.

VII.10.16 Core with Quina-like reduction

In the totality of GH 3, only one object was detected that has similarities to Quina reduction (GER14.227-061.148, see fig. 188), but this attribution is quite euphemistic. The object was made from a small spherical nodule and shows two knapped surfaces. The platform shows two negatives and on its surface the minor quality of the raw material (micro-fractures) is visible. The reduction surface shows at least nine negatives. But because of the minor raw-material quality some step fractures are visible. By adding a Bezier curve as former outline of the nodule, it is highly visible that only a little volume was removed (see fig. 188). The mass and dimension of this core is displayed in tab. 171. No further expression of cores reduced in this way were detected so far.

Find-number	Denomination	Mass (in grams)	Length	Width	Thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio
GER14.227-061.148	Quina-like core on small nodule	62.7	45.10	42.51	31.44	1.06:1	1.43:1	1.35:1
Mean	**N=1**	**62.70**	**45.10**	**42.51**	**31.44**	**1.06:1**	**1.43:1**	**1.35:1**

Tab. 171 - Mass, dimension and dimensional ratios of GER14.227-061.148.

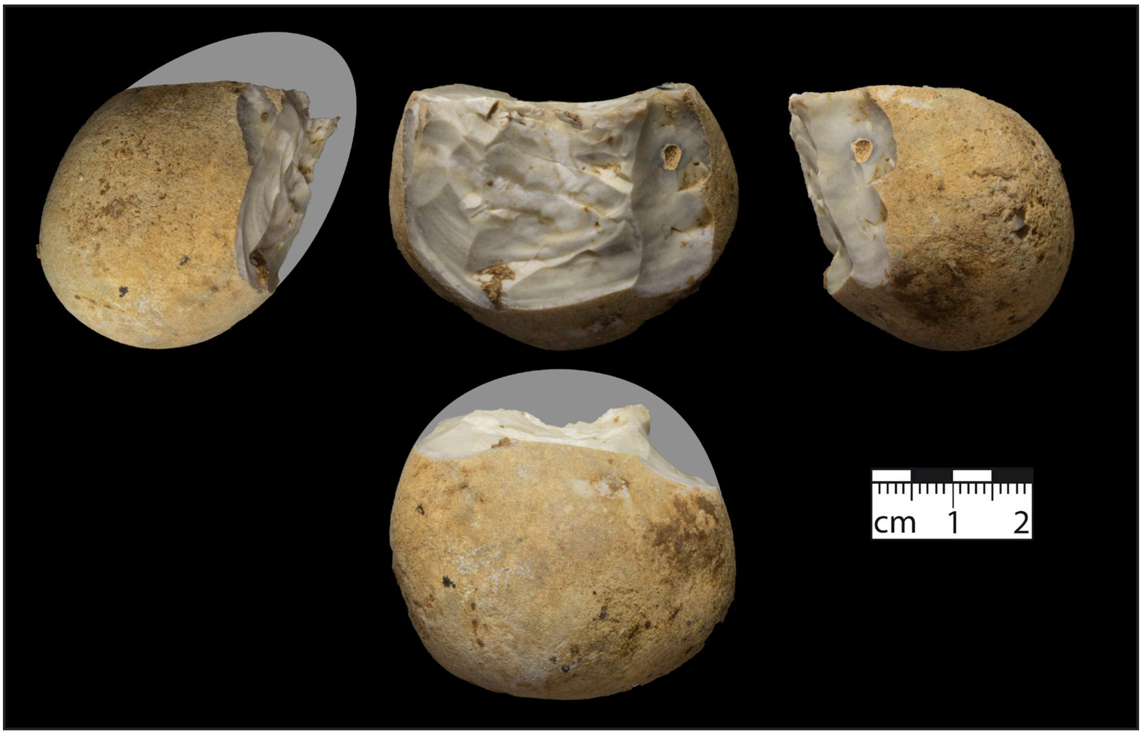

Fig. 188 - Quina-like core from GH 3 (GER14.227-061.148). The gray shade indicate the outline of the complete raw piece used

VII.10.16 Discoidal cores

In GH 3, only n=4 objects were found showing a secant reduction on the flaking surface. Two are made from raw pieces, one on flake and one on frost-shard (see tab. 172).

Find-number	Denomination	Mass (in grams)	Length	Width	Thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio
GER10.227-058.197	Unifacial discoidal core-on-raw-piece	45.8	49.72	43.94	23.49	1.13:1	2.12:1	1.87:1
GER09.228-060.80.3	Unifacial discoidal core-on-frost-shard	47.0	50.85	45.52	20.28	1.12:1	2.51:1	2.24:1
GER12.229-059.213	Bifacial discoidal core-on-flake	22.5	49.33	37.70	16.86	1.31:1	2.93:1	2.24:1
GER12.229-059.673	Unifacial discoidal core-on-raw-piece	110.7	63.58	47.11	45.45	1.35:1	1.40:1	1.04:1
Mean	**4**	**56.50**	**53.37**	**43.57**	**26.52**	**1.23:1**	**2.24:1**	**1.85:1**

Tab. 172 - Mass, dimension and dimensional ratios of discoidal cores.

Raw material and mean ratio

All four are made from FAS. The „standard" discoidal core has a mass of 56,50 grams, is 53 mm long, 44 mm wide and 27 mm thick.

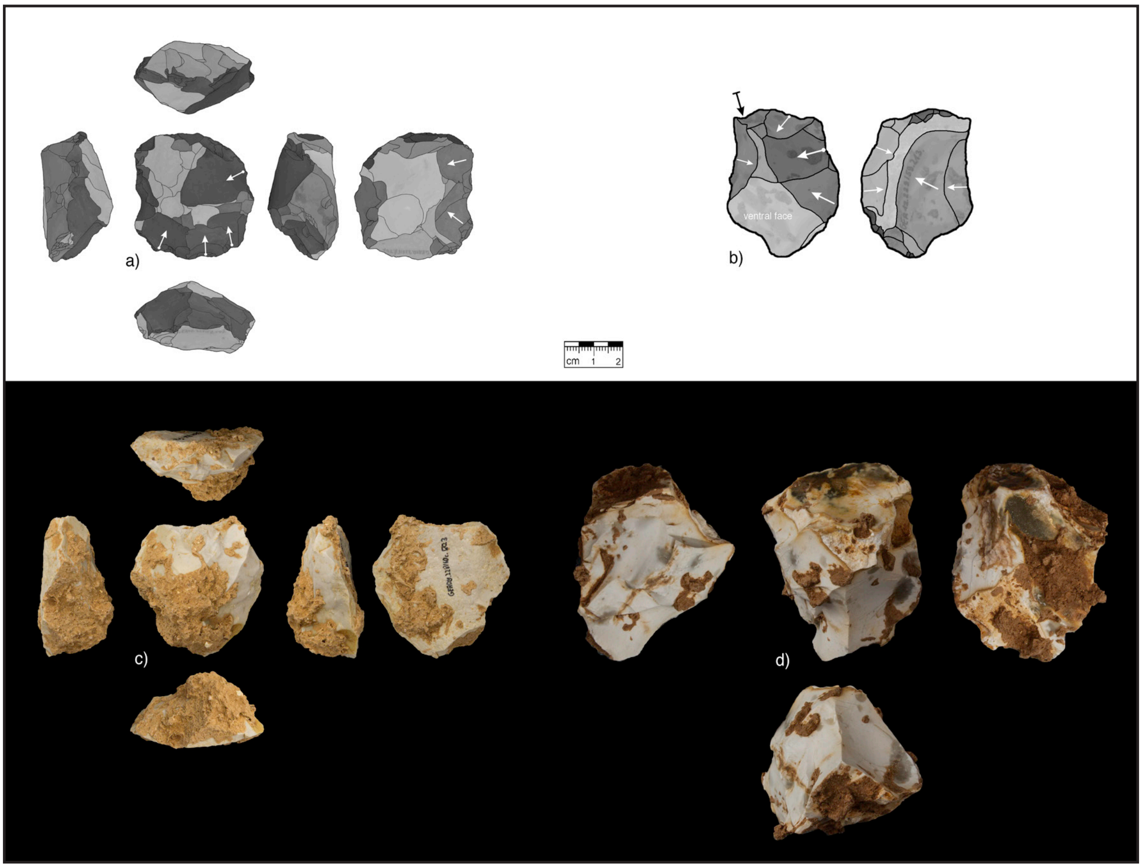

Fig. 189 - Discoidal cores from GH 3. a) Bifacially discoidal core (GER10.227-058.197); b) Unifacially discoidal core made from a flake (GER12.225-059.213); c) Unifacially discoidal core (GER09.228-060.80.3) and d) Unifacially discoidal core (GER12.229-059.673)

Appearance and reduction sequence
GER10.227-058.197 (fig. 189a) and GER09.228-060.80.3 (fig. 189c) show a centripetal reduction on one surface (so called top side). The other surface (bottom side) is quite plane and show only some configuration and correction negatives. The last removals on both cores are quite small. Only for GER10.227-058.197 the shape of produced blanks can be assumed, because one negative is quite rectangular (possibly of a éclat centripète after Slimak 2004). Another is deltoid in shape and can refer to the production of a Pseudo-Levallois point (which can also be called discoidal point, see also Frick & Herkert 2014). For GER12.225-059.213 small oval and rectangular flakes were produced (see fig. 189b). The products taken from GER12.229-059.673 seems to be quite rectangular (see fig. 189d).

Dimension
The dimensional relation of all four objects can be seen in fig. 190. Three of them are clustered together.

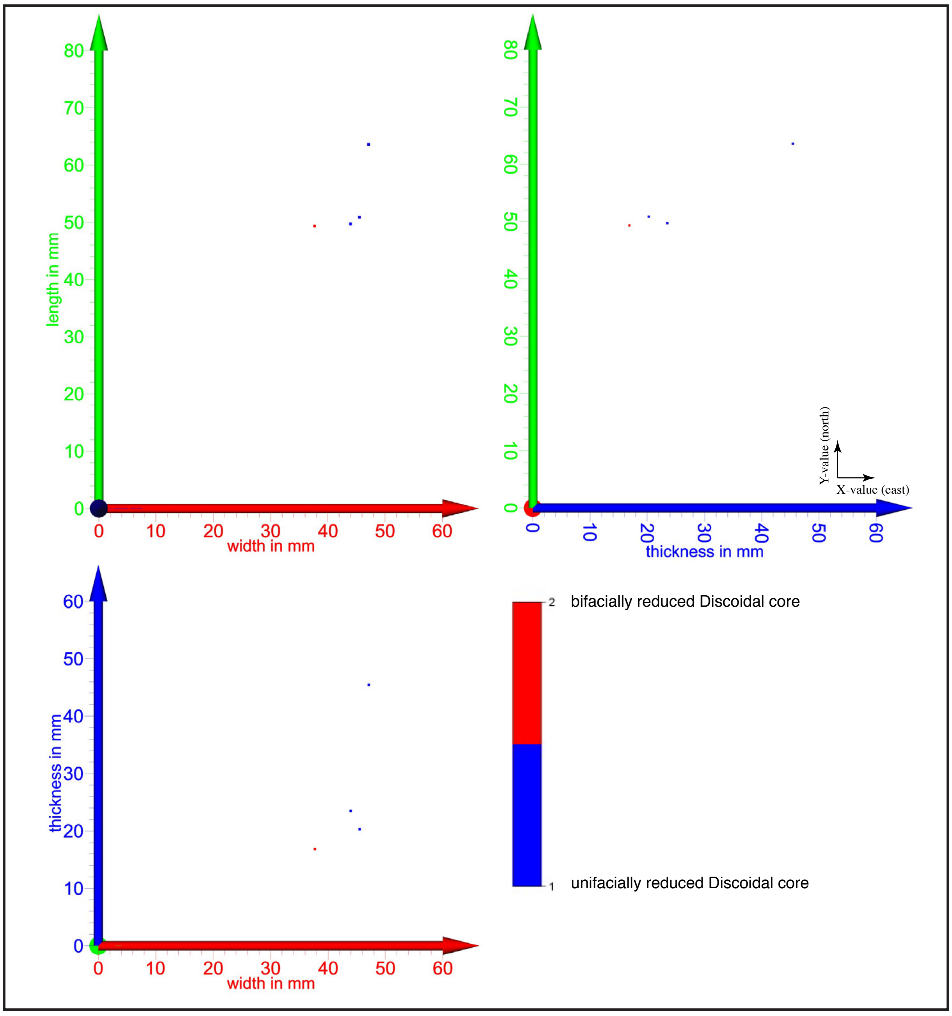

Fig. 190 - Dimension of discoidal cores from GH 3

Distribution
All discoid cores are situated in the eastern half of the excavated area of GH 3 and are distributed around a Z-value of 6.6 to 7.1 (see fig. 191).

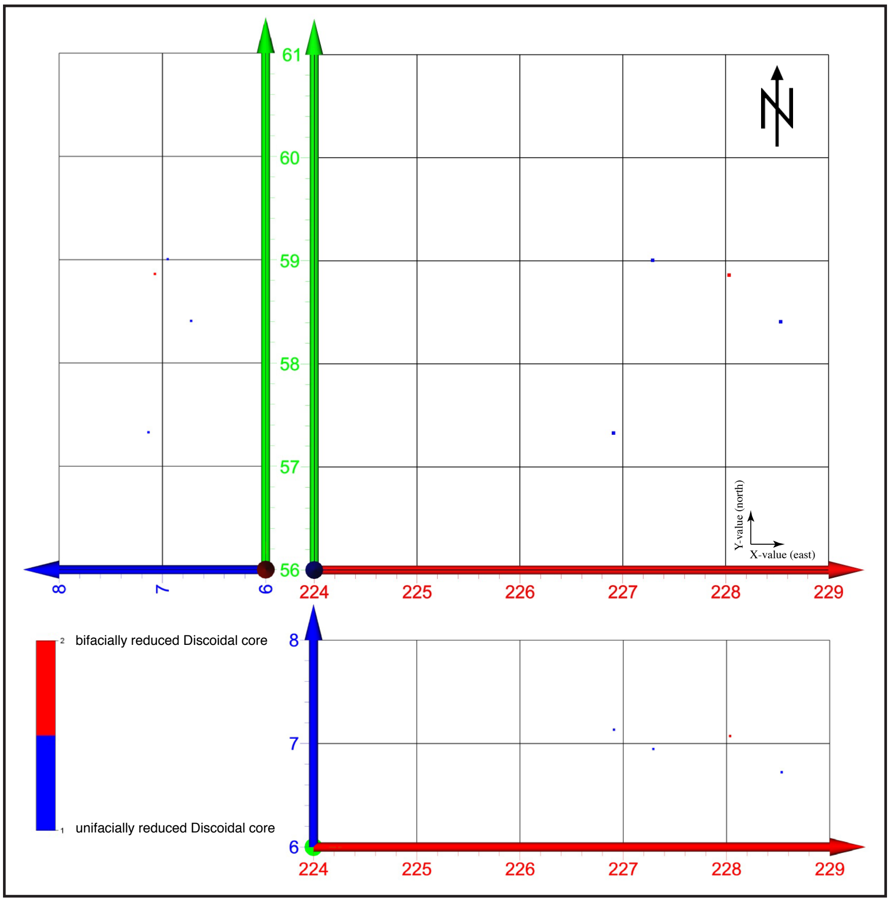

Fig. 191 - Distribution of discoidal cores from GH 3

VII.10.17 Levallois cores

Introduction

There are overall n=34 cores that are attributed to be Levallois cores. As we saw, there are n=11 cores attributable as preforms of Levallois cores (see chapter VII.10.11). Additionally, there are n=2 Levallois cores that were uses as tools after reduction (they are discussed in chapter X.11, tools-on-cores). Levallois reduction (i.e., synopsis of cores and blanks) is discussed in chapter VII.15.4. In this section we are discussing n=21 Levallois cores that are neither preforms nor afterwards modified.

Raw material and appearance

These n=21 cores are made from blanks (n=8) and from raw pieces (n=13). With the exception of one core which is made from a green-gray variety of chert, the rest is made from FAS.

For Levallois cores the shape of the matrix (see chapter V.6.3) is of importance. For two cores (GER13.227-057.2510 and GER09.228-060.101) it is very likely that discuss-shaped matrices were used, for another n=6 rounded nodules were used (GER10.226-059.103, GER12.227-057.448.3, GER12.227-057.693, GER09.227-059.134 and GER12.229-058.109). Unfortunately, for n=13 there is not enough evidence to determine the shape of the used matrix (because of intensive negative of removal overprinting).

The Levallois cores are all quite exhausted. The reduction surfaces are mostly quite flat or even concave, because of the last (mostly) central removals without new lateral edge configuration.

Reconstruction of the last removal sequences

The constellation of negatives (core schemata) on the reduction surface gives information about the last removal sequence of cores. There are cores showing preferential (n=5) and recurrent (n=16) methods of reduction (three times more repeatedly reduced cores). The detected last removal sequences on the reduction surfaces are listed in tab. 173:

Method	Negative constellation	Hypothetical shape of the target blank(s)	Number
Preferential	Uni-directional	Rectangular	**1**
Preferential	Uni-directional	Oval	**2**
Preferential	Uni-directional	Convergent	**2**
Recurrent	Uni-directional, parallel	Rectangular	**4**
Recurrent	Bi-directional, parallel	Rectangular	**4**
Recurrent	Bi-directional, orthogonal	Oval	**2**
Recurrent	Centripetal	Oval	**6**
Total			**21**

Tab. 173 - Method, negative constellation and hypothetical shape of target blanks of Levallois cores from GH 3

The following fig. 192 shows the last negative constellation on the reduction surface of some Levallois cores. The constellation of negatives represent the last visible reduction sequence(s) and gives only small information of repeatedly reduction sequences or a change of the core reduction schemata. For some of the cores, there is evidence that the reduction sequence was quite schort. A good evidence here is the presence of cortical parts on reduction surfaces. The following tab. 174 summarizes evidence about the length of the reduction cycle of n=21 Levallois cores.

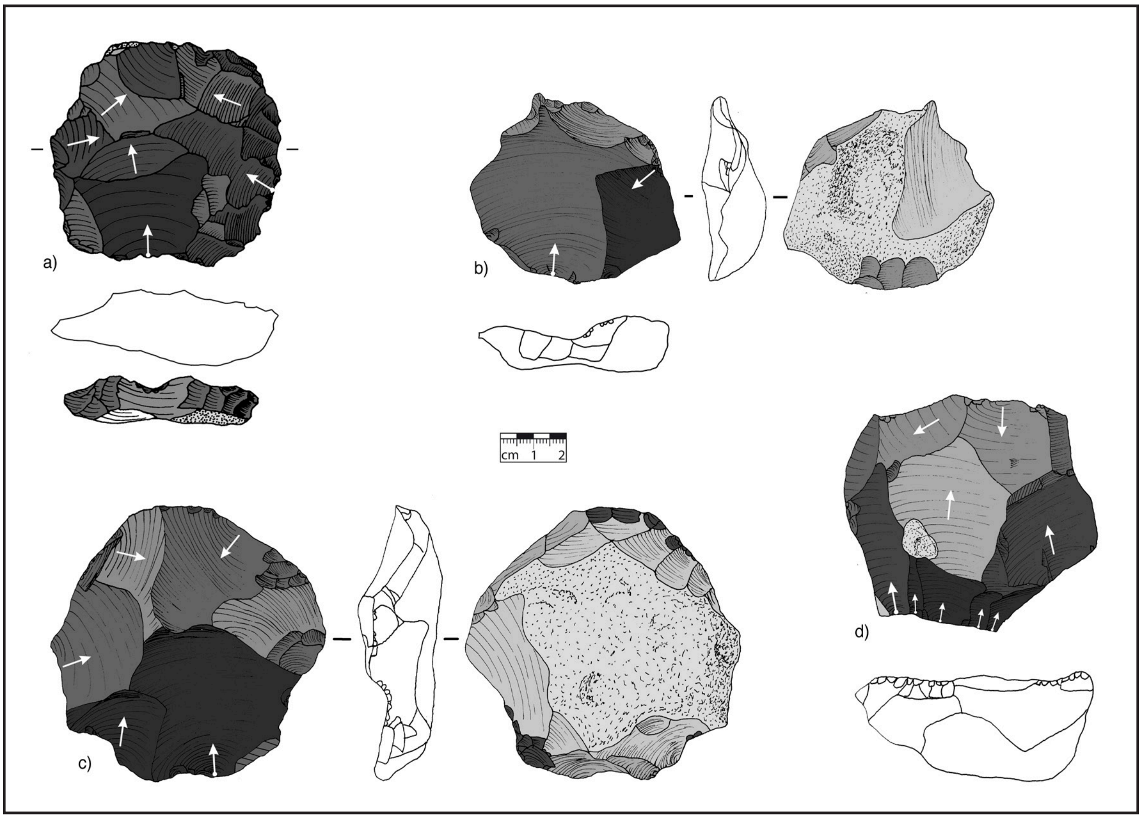

Fig. 192 - Last negative constellation on the reduction surface of some Levallois cores. 1) GER12.226-057.444 showing a final centripetal scar pattern; 2) GER10.227-058.235 showing an almost orthogonal final scar pattern (removal of a large flake covering almost the entire surface and a small rectangular flake from the right side); 3) GER10.227-058.299 showing a final centripetal scar pattern and 4) GER10.226-059.141.1 showing an almost unidirectional scar pattern

Find-number	Evidence for the length of the reduction sequence	Number of cycles	Number of effectively visible negative that produced usable flakes	Matrix
GER12.226-057.444	Rest of the original ventral face of the flake visible, first cycle seems to be the removal of a preferential oval flake (ventral reduction of the bulb?), second cycle removed three oval flakes, the other negatives derive from surface configuration after the first cycle	2	4	Flake
GER12.226-057.688	After convergent configuration of the reduction surface, it was tried two times to remove a point shaped flake; from an inclusion visible on the reduction surface it can be assumed that this removal broke during detachment, the second removal ended in a hinge	1	Non?	Non-detectable
GER13.226-057.1649	Weak evidence that this flake was a quite flat and the dorsal convexity was used to get a bigger flake, artifact broke after reduction	1	1 or 2	Flake
GER10.226-059.103	Lateral patches of cortex on the reduction surface; after the detachment of two bigger flakes in bi-directional manner, small flakes were bi-directionally removed	2	2	Nodule
GER10.226-059.141	Centripetal configuration; detachment of one oval flake; a second reduction failed because of fissures	1	1	Non-detectable
GER10.226-059.143.1	Patch of cortex on the reduction surface, maybe from a concavity; first cycle was a preferential oval flake; second cycle bi-directional detachment of small oval to rectangular flakes	2	3	Non-detectable

GER12.227-057.448.2	Configured core showing two uni-directional removals that ended in hinges, maybe the bigger one was usable	1	1	Non-detectable
GER12.227-057.448.3	It is assumed that the matrix was a flat nodule; detachment of one oval flake; centripetal removal of small oval and rectangular flakes	2	2	Nodule
GER12.227-057.682	Small nodule with less configuration; uni-directional detachment of at least four semi-oval flakes	1	4	Nodule
GER12.227-057.693	Nodule showing the removal negative of one pentagonal flake	1	1	Nodule
GER13.227-057.2510	Raw piece seemed to be shaped as a Levallois core; preferential removal of a rectangular flake, orthogonal removal of at least six oval flakes	2	6	Disc
GER10.227-058.235	Minimal centripetal configuration; detachment of one big preferential flake (ventral reduction); secondary removal of small rectangular flake in the same direction	2	2	Flake
GER10.227-058.299	Made from a rectangular flake, reduction surface showing centripetal configuration, a preferential detachment of a rectangular flake and a secondary detachment of a small flake	2	2	Flake
GER09.227-059.134.1	Detachment of one oval flake from the ventral face of a pentagonal flake (bulb detachment), beginning of reconfiguration which was stopped by a geode	1	1	Flake
GER09.227-060.142.1	Intensively reduced core, showing a centripetal core schema of rectangular and oval negatives; former reduction cycles are non-visible	1	4	Non-detectable
GER13.228-057.560	Last removal was a triangular flake; the core is centripetal configured; it is the option that the last removal was supposed to be a rectangular flake but ended in a hinge	1	1	Flake
GER09.228-060.101.1	Made from an oval cortical flake, centripetal reduction-surface configuration	1	1	Flake
GER09.228-060.101.2	Small discuss-shaped nodule with removal negative forming a T. The first preferential removal was cortical, the second series removed small flakes orthogonally	2	1	Disc
GER12.229-058.109	Bigger core with highly abraded cortex showing convergent configuration negatives; the wanted convergent flake ended in a hing	1	non	Nodule
GER12.229-059.534	Core, in a way similar to Nubian Type 2 (Crassard & Hilbert 2013). The first preferential removal ended in a hinge; after that repeated configuration. The secondary preferential flake ended in a hinge as well	2	non?	Flake
GER14.229-060.1315	Preferential removal of a point-shaped flake, probably from the ventral face of a flake	1	1	Non-detectable
Total (n=21)		**30**	**36 or 37**	

Tab. 174 - Exploring the length of the reduction cycle of Levallois cores.

Constructed mean variation of reduction

A phenomenon seen on many Levallois cores (as listed in tab. 174) is that they show a first (preferential) central removal. After this reduction often the core was centripetally reduced. The normalized procedure of core reduction (operational chain) in Levallois „style“ at Verpillière II (as seen in GH 3) observed on the cores is listed in the following:

- Selection of a round or oval but flat raw piece or a corresponding flake
- A raw piece needs an initialization (opening of a completely cortical object, finding or installation of angles to start the configuration)
- Centripetal or convergent configuration of the prospected reduction surface

in a convex way (for flakes these surfaces are often ventral faces; for raw pieces the objects need an initialization)

- Establishing a (sometimes facetted) striking platform
- Removal of a central flake
- Centripetal re-configuration of the reduction surface
- Reduction of multiple small flakes in diverse directions

Fig. 193 illustrates this constructed „standard" procedure for the reduction of cores from GH 3 that are associated with the Levallois concept, as established by Boëda (1994).

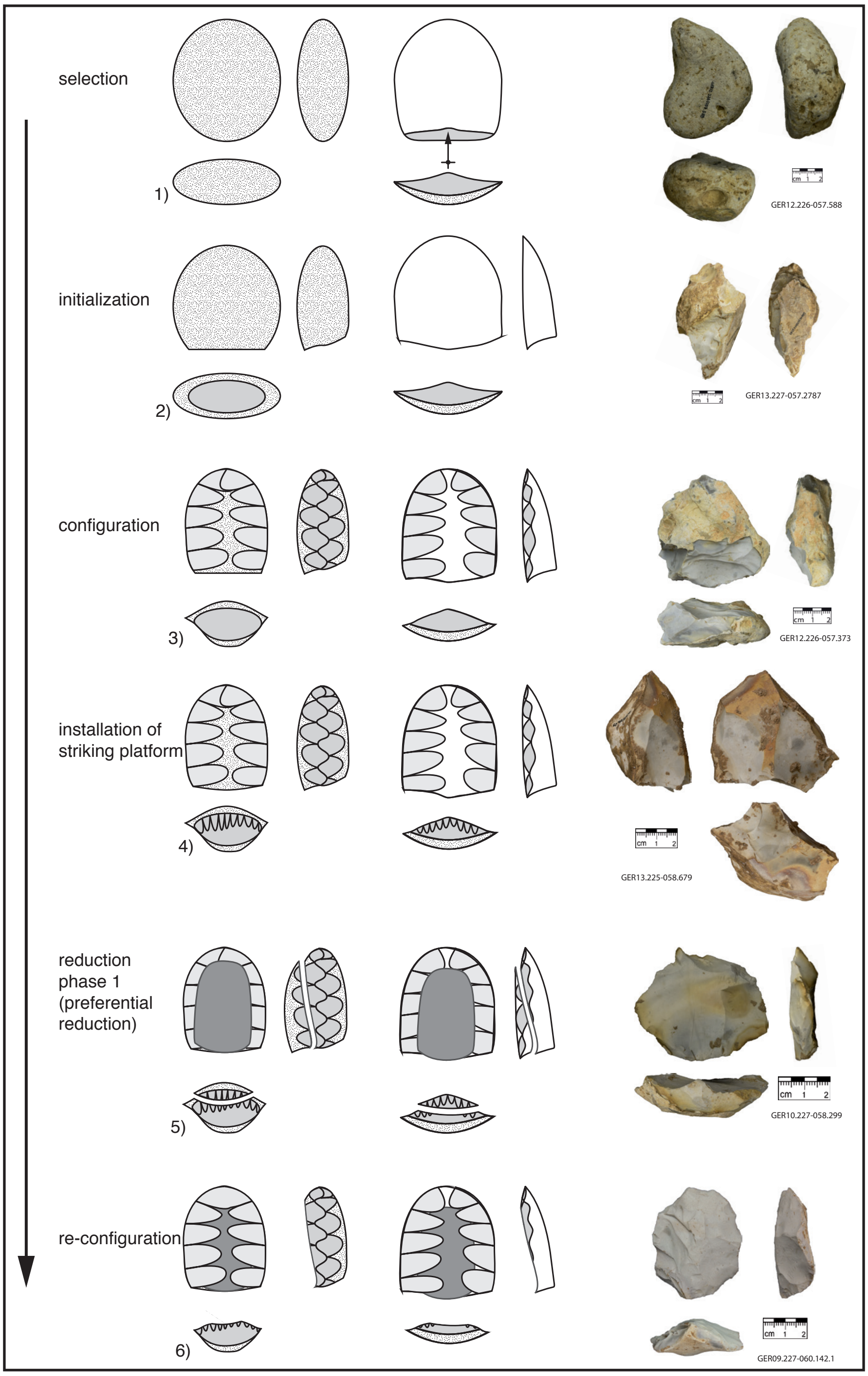

Fig. 193 - Constructed „standard" procedure for the reduction of Levallois cores from GH 3. Displayed as drawn synopsis (left) and illustrated with the aid of Levallois cores from GH 3 (right)

Features and ratio of reduction surfaces

The median in the dimensional range in length and width of the reduction surface of these cores is 53,3 resp. 54,1 (see fig. 194 left). The variation in width is bigger than for the length of the reduction surface. From the point of length-width comparison their reduction surface seem to be quite rectangular. But in comparison to total dimension of the cores, there is variation. The cores are distinctively longer than wide, despite their quite rectangular flaking surface (compare fig. 194 right and left).

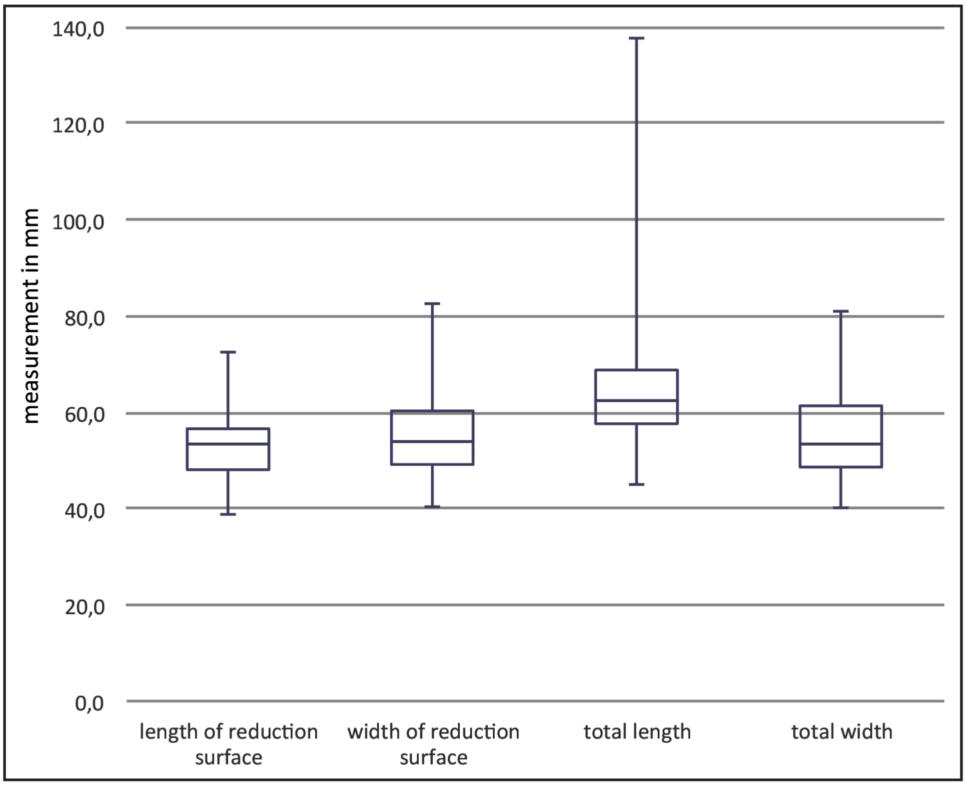

Fig. 194 - Boxplot of length and width of the reduction surface (left) and the total dimension of n=21 Levallois cores from GH 3

The mean ratio of the reduction-surface dimension (length/width) is 0.96, whereas the mean ratio of the total dimension of the cores is 1.2. This displays the same result as seen in the box-plot (fig. 194, above). The reduction surface appears quite rectangular and the core in total is a bit longer than wide.

Despite metric comparison, these cores yield further features or their reduction surface. At first, there is the number of negatives, visible on the reduction surface (fig. 195, a negative was counted when it was larger then 5 to 5 mm). The number ranges from 1 to 19, with a median of 11 negatives.

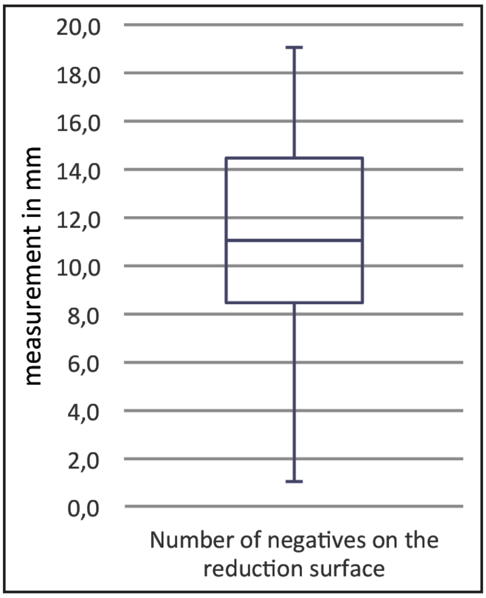

Fig. 195 - Number of negatives on the reduction surface of n=21 Levallois cores from GH 3

Features and ratio of striking platforms

For every of these n=21 cores the dimension of the biggest platform was measured. The median of all is 43,5 mm in length and 19,8 mm in width (see fig. 196, left). The number of negatives on the biggest platform of these cores varies between 1 and 18, with a median of 5.5 negatives. The angle between the platform and the reduction surface on the biggest platform varies between 53° and 84°, with a median of 72° (see fig. 196, right).

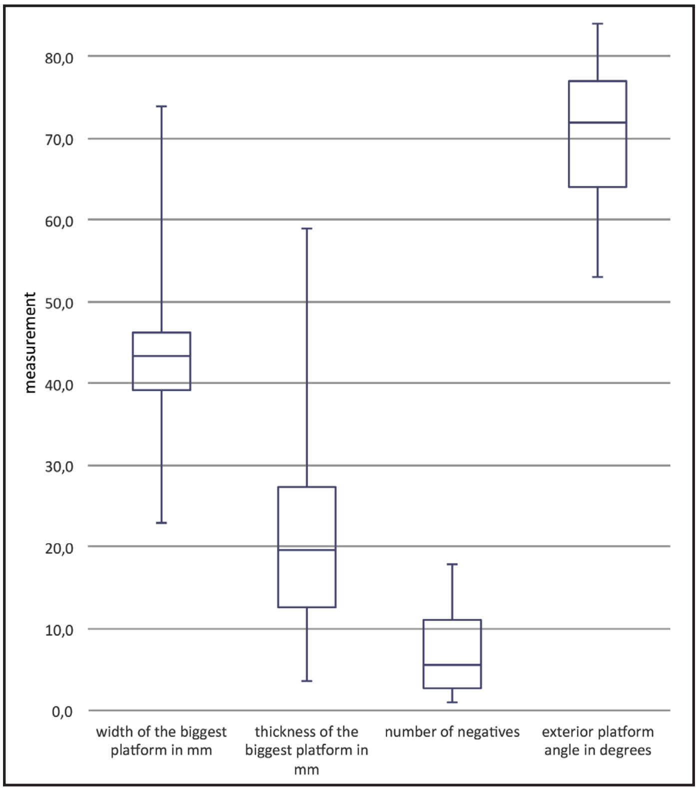

Fig. 196 - Boxplot of features of the biggest platform on n=21 Levallois cores from GH 3. Left: width and length of the platforms; Right: number of negatives on the platform and degree of exterior platform angle

Shape of the platform	Number
8-shaped	1
Arch	3
D-shaped	2
Triangular	2
Pentagon	2
Sinus-shaped	1
Rectangular	1
Trapezoid	4
Undetermined	5
Total	**21**

Tab. 175 - Shape of the platform of Levallois cores from GH 3

As tab. 175 shows the variety in shape of the platform is quite high.

Mean ratios of mass and dimension

The mean mass of a Levallois core from GH 3 is 79 grams (see tab. 176). Such a „standard" Levallois core is around 61 mm long, 51 mm wide and 25 mm thick. By comparison of cores with one and two reduction cycles, we see clearly that cores with one reduction cycle are heavier, longer and thicker, and cores with a second visible reduction cycle are in regard to their width, as well as their length much thinner.

Number of reduction cycles	Mean mass (in grams)	Length	Width	Thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio
One	95.83	63.98	49.29	29.15	1.30:1	2.19:1	1.69:1
Two	62.32	58.89	52.94	20.85	1.11:1	2.82:1	2.54:1
Mean	**79.08**	**61.44**	**51.12**	**25.00**	**1.21:1**	**2.51:1**	**2.11:1**

Tab. 176 - Mass, dimension and mean ratios of Levallois cores with one and two (visible) reduction cycles

Dimension

With the exception of a few cores, the relation between length and width of these cores stays quite constant (see indication in fig. 197). This appears differently if we compare thickness and width, as well as length and thickness. Here, the only distinctive pattern is that cores showing two reduction cycles are always thinner than 30 mm.

Distribution

There are much more Levallois cores distributed in the southern part of the excavated area of GH 3 (see fig. 198). There is no real pattern visible, if we divide the Levallois cores into its number of reduction sequences (as described above, see also tab. 174). In regard to hight, the only observation is that most of the cores are distributed between a Z-value of 6.6 and 7.

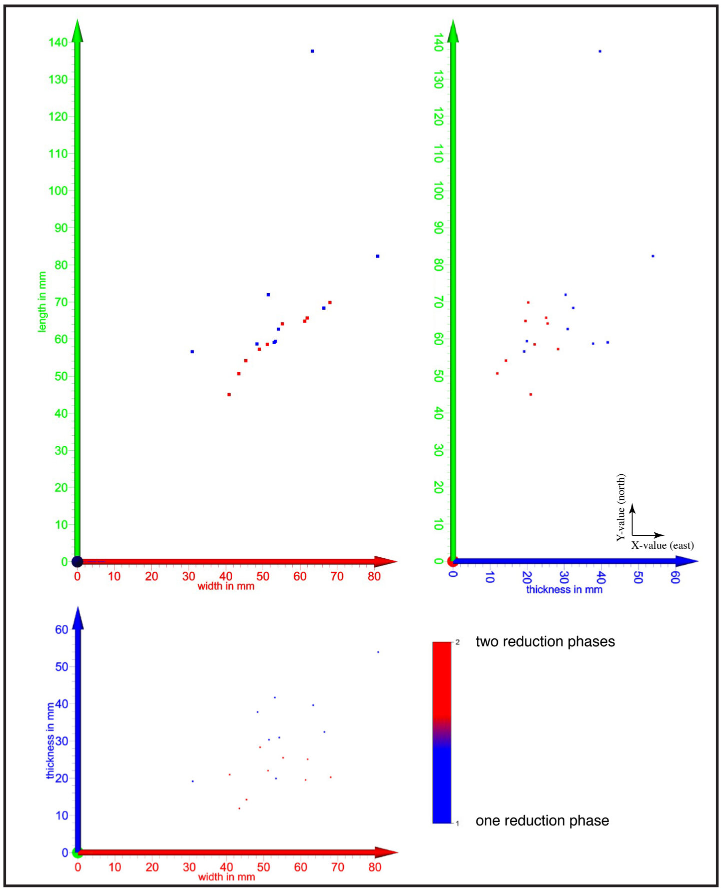

Fig. 197 - Dimension of Levallois cores from GH 3, separated by the number of reduction phases

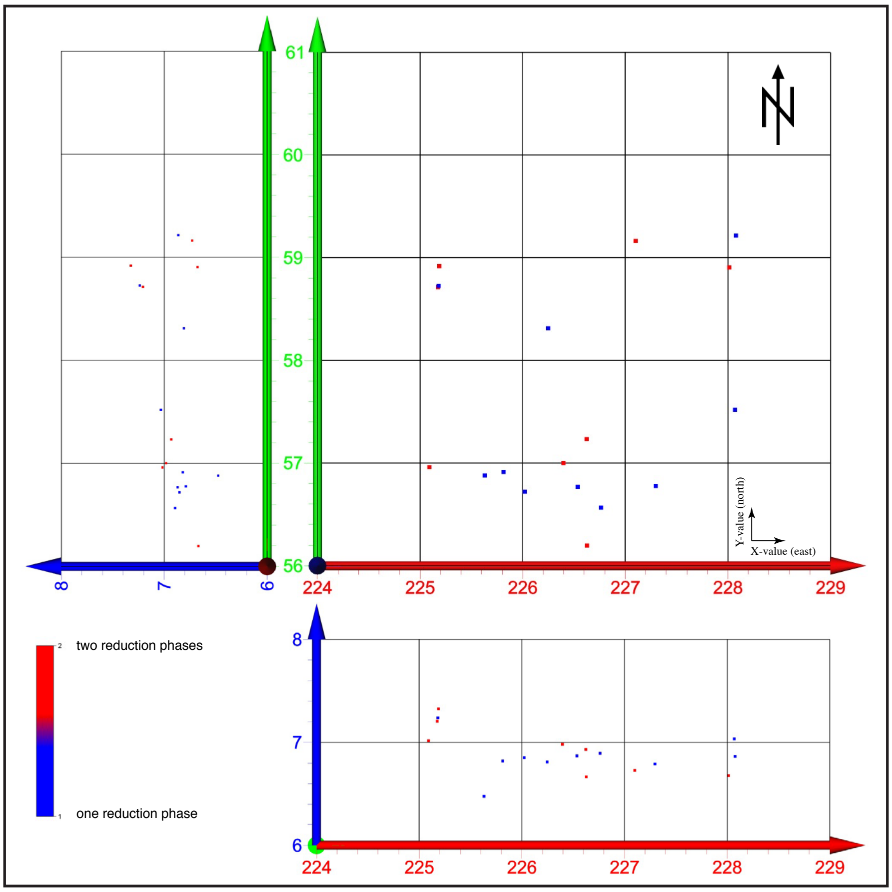

Fig. 198 - Distribution of Levallois cores from GH 3, separated by the number of reduction phases

VII.10.18 Tools-on-cores

Introduction

Tool-on-cores are lithic objects that were formerly used as cores and were further modified into tool. In GH 3 there are n=10 examples to find (see tab. 177).

Find-number	Core group	Core type	Core class	Tool-on-core	Modification
GER12.225-059.724	Core-on-frost shard	Simple core	„Dorsal“ core	Burin	Combination of surface (Kostenki) and edge removals (burin) on a frost-shard. Traditionally seen as tool but in this case it is obviously a core for small elongated blanks
GER10.228-058.212	Core-on-blank	Reduced core	Dorsal and ventral core	Burin	After detachment negative on ventral and dorsal face, detachment on an edge (burin)
GER13.225-058.971	Core-on-blank	Reduced core	Opportunistic core	Scraper	A cortical blank was highly reduced on its ventral face, after that one lateral edge was softly retouched
GER13.227-057.1892	Core-on-blank	Simple core	Opportunistic core	Scraper and notch	After removal on the dorsal face, confection of terminal and left lateral
GER09.227-060.130	Core-on-raw piece	Reduced core	Opportunistic core	Scraper	A small oval nodule was initialized and some smaller blades were removed (4 blade negatives remain visible), after that a lateral edge was unidirectionally modified (in a crest-like way) with an angle of around 80 to 90 degrees
GER13.227-057.1929	Core-on-raw piece	Reduced core	UnidirectionalLevallois core	Denticulate	After the remaining Levallois cycle was finished, one lateral edge was highly retouched to produce four retouched notches, these notches have different radii (for different purposes?)
GER12.229-058.206	Core-on-blank	Reduced core	UnidirectionalLevallois core	Scraper	After the remaining Levallois cycle was finished, the basal and terminal edge was slightly modified by retouch
GER12.229-059.389	Core-on-blank	Simple core	Ventral core	Scraper	After ventral reduction, the terminal edge was retouched, later the piece broke
GER12.226-057.540	Core-on-raw piece	Simple core	Opportunistic core	Bowl	After reduction of many blanks from nearly all surfaces, the core was used as bowl with a handle
GER13.228-057.415	Core-on-blank	Reduced core	UnidirectionalLevallois core	Scraper	After ventral reduction of a blank for shaping and consumption of a convexity, formation of a scraper retouch

Tab. 177 - List of tools-on-cores from GH 3

As tab. 177 displays, the cores were modified as burins (n=2), scrapers (n=5), but also one with tooth and notches are produced. An exception is the formation of a bowl with handle (this exceptional object will be discussed later in chapter X.13). The reshaping could have happened directly or a timespan after their use as cores (objects showing evidence for reuse or recycling are discussed in chapter X.11). One of these modified cores is a modified frost-shard, n=6 are modified blanks and n=3 objects are raw pieces.

Raw material and appearance

With the exception of one object (GER12.229-058.206), which is made from red-whitish unknown flint (with a possible heat influence), all are made from FAS. The patination of FAS are whitish-beige and double patination is quite good visible. The topic of reuse and recycling is part of chapter X.11 and is intensified there. All objects show that they were modified after their use life as cores. The former cores seems to be highly reduced and not suitable for further reduction (without re-configuration).

Mean ratios and dimensions

Tools-on-cores cannot be a homogenous group of artifacts. This is good visible if there dimensional ratios are compared. For example, their length-to-thickness ratio vary from 1.26 to 4,60. A „standard" tool-on-core would have 70 grams, a length of 63 mm, a width of 51 mm and a thickness of around 27 mm (see tab. 178 and fig. 199).

Find-number	Denomination	Mass (in grams)	Length	Width	Thickness	Length-to-width ratio	Length-to-thickness ratio	Width-to-thickness ratio
GER12.225-059.724	Burin	27.0	48.88	35.75	18.91	1.37:1	2.58:1	1.89:1
GER10.228-058.212	Burin	13.6	51.56	30.89	11.21	1.67:1	4.60:1	2.76:1
GER13.225-058.971	Scraper	45.2	51.65	50.11	22.12	1.03:1	2.33:1	2.27:1
GER13.227-057.1892	Scraper and notch	50.4	60.32	48.67	21.77	1.24:1	2.77:1	2.24:1
GER09.227-060.130	Scraper	74.3	65.33	43.29	26.48	1.51:1	2,.47:1	1.63:1
GER13.227-057.1929	Denticulate	84.7	62.58	55.67	35.73	1.12:1	1.75:1	1.56:1
GER12.229-058.206	Scraper	207.2	102.00	84.50	25.90	1.21:1	3.94:1	3.26:1
GER12.229-059.389	Scraper	19.3	47.55	44.03	19.07	1.08:1	2.49:1	2.31:1
GER12.226-057.540	Bowl	148.9	79.52	60.39	41.15	1.32:1	1.93:1	1.47:1
GER13.228-057.415	Scraper	32.1	58.32	53.13	46.4	1.10:1	1.26:1	1.15:1
Mean	**8**	**70.27**	**62.77**	**50.64**	**26.87**	**1.26:1**	**2.61:1**	**2.05:1**

Tab. 178 - Dimensions and mean ratios of tools-on-cores

Distribution

The distribution of tools-on-cores in GH 3 takes place in two spots. One is visible in the south-eastern part, the other in the central western part. In regard of their Z-value, they are positioned around z=6.6 to 7.15 with a peak at around z=6.9. From their distribution in hight, three levels are suggested (see fig. 200).

VII.10.19 Core-debris

Introduction

Two objects (GER09.228-060.86.1 and GER09.227-060.159.5) can be attributed to core-debris. Both are debris of raw-pieces. These both objects are core fragments, but for the moment a further attribution to their former specific core-class cannot be given.

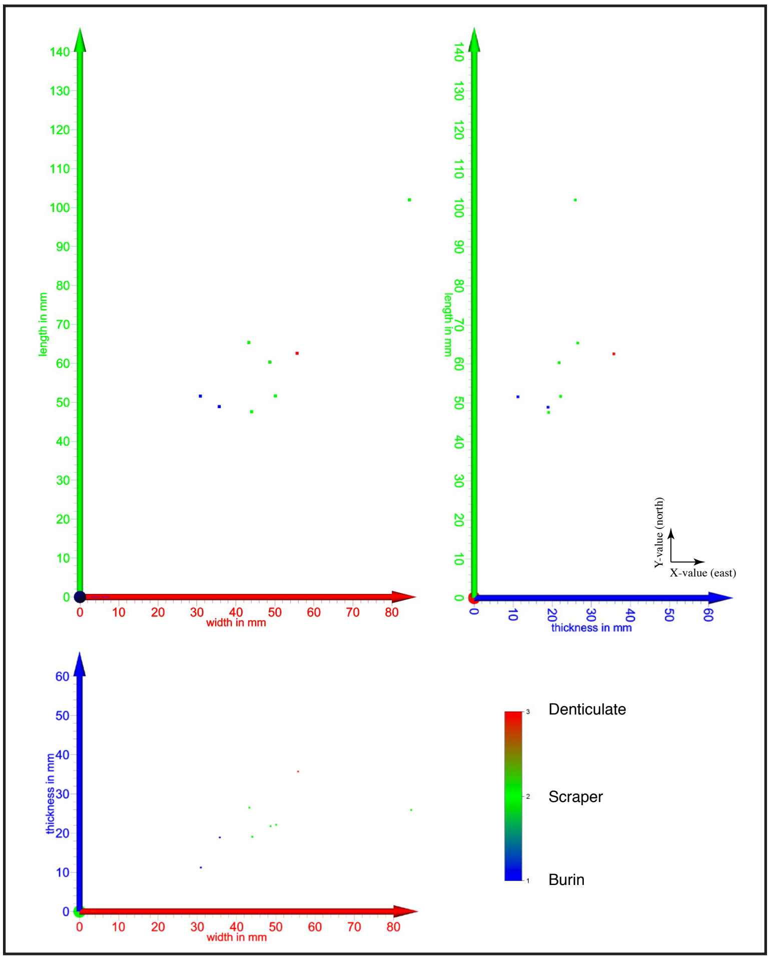

Fig. 199 - Dimensions of tools-on-cores from GH 3

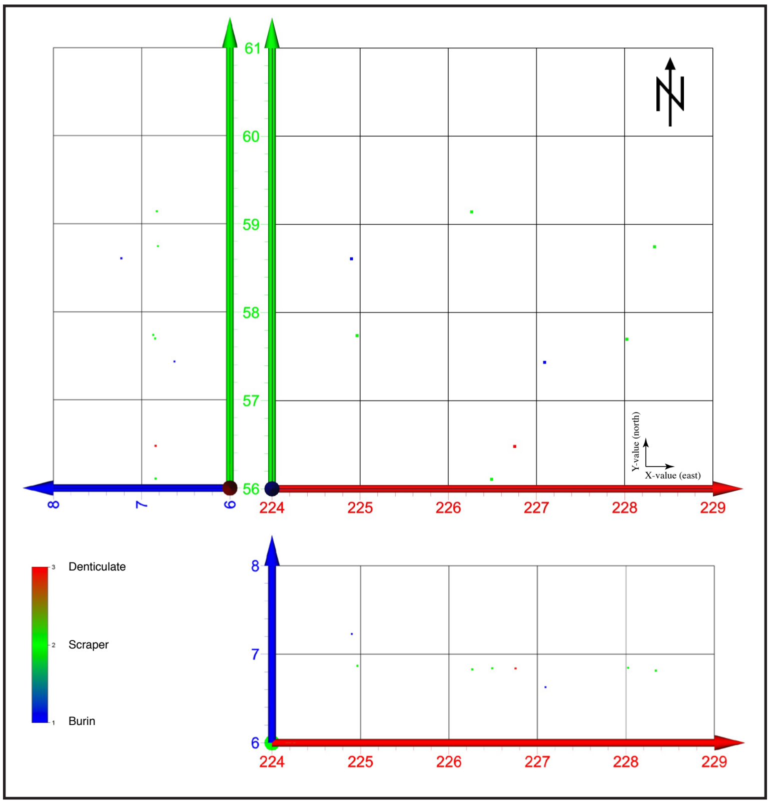

Fig. 200 - Distribution of tools-on-cores from GH 3

Raw material and appearance

Both objects are made from FAS. The left negatives on both show evidence of a hard hammer technique. The fracture planes show the same patination as the other surfaces. A refitting attempt showed that both are not from the same former object.

Mean ratios

The mean ratios for both core-debris can be seen in tab. 179:

Find-number	Denomination	Mass	Length	Width	Thick-ness	Length-to-width ratio	Length-to-thick-ness ratio	Width-to-thick-ness ratio
GER09.228-060.86.1	Core- debris	37.2	44.01	40.77	22.34	1.08:01	1.97:1	1.82:1
GER09.227-060.159.5	Core- debris	49.2	47.32	41.78	36.29	1.13:1	1.30:1	1.15:1
mean	**N=2**	**43.20**	**45.67**	**41.28**	**29.32**	**1.11:1**	**1.64:1**	**1.49:1**

Tab. 179 - Mean ratios for both pieces of core-debris

We can summarize that a „standard" core-debris has around 43 grams, is around 46 mm long and 41 mm wide and has a thickness of 29 mm.

Dimension

Both core-debrises are in regard to length, width and thickness quite similar (see fig. 201).

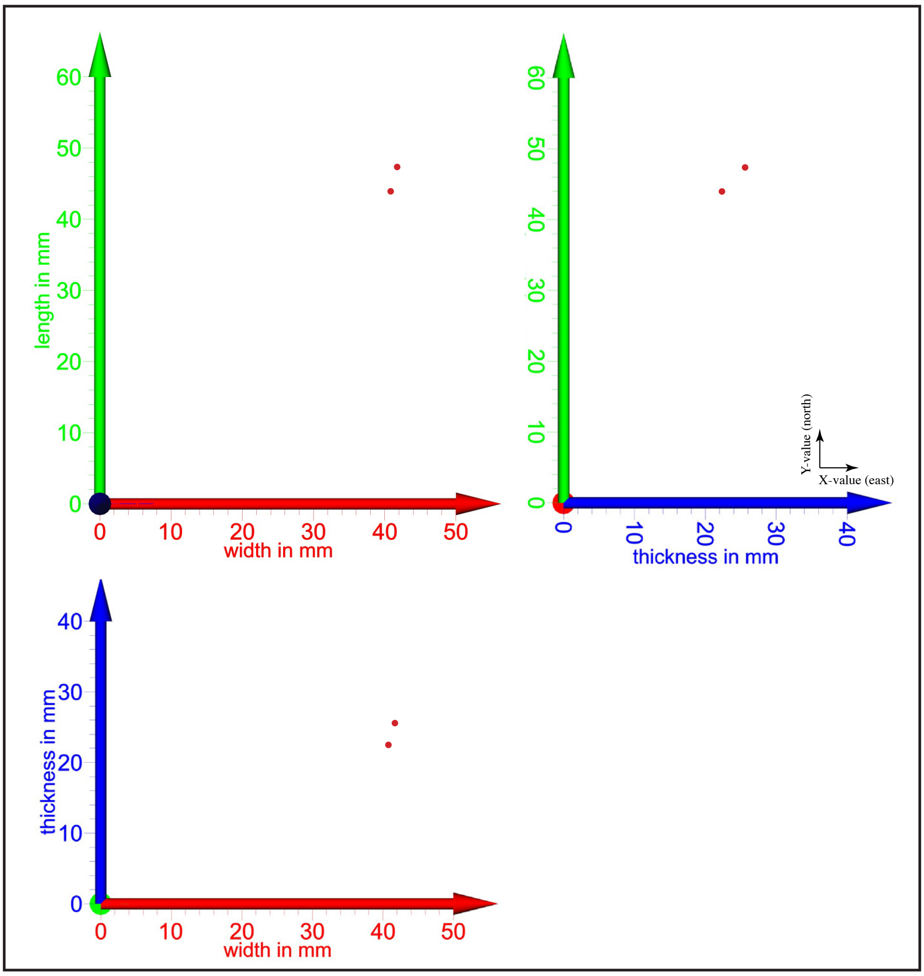

Fig. 201 - Dimension of both pieces of core-debris in GH 3

Distribution

Both objects are quite close to each other (see fig. 202). But are situated in different hight levels (around z=6.6 resp. 6.9).

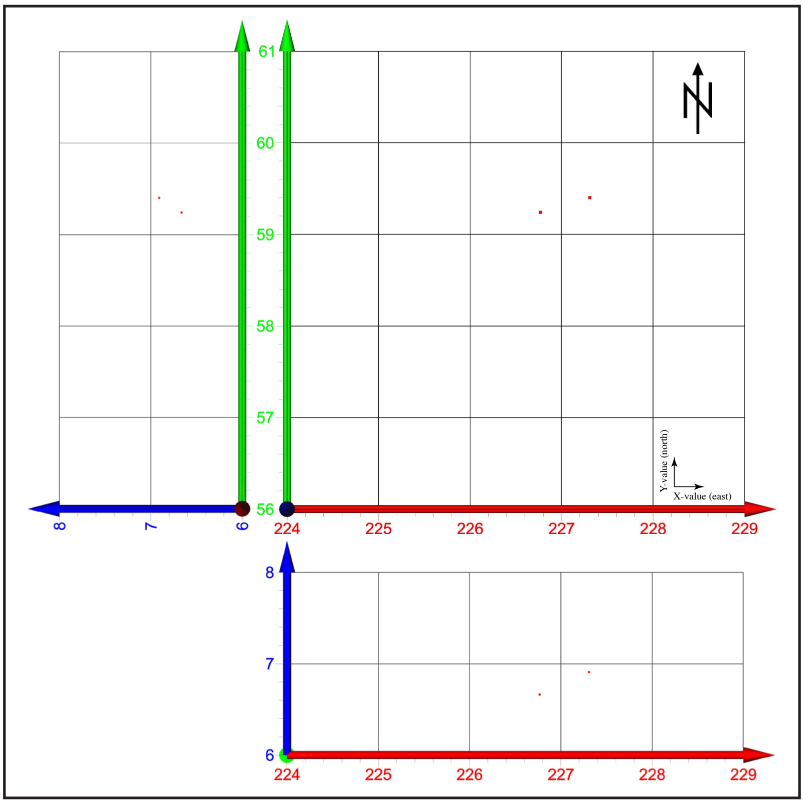

Fig. 202 - Distribution of core-debris in GH 3

VII.11 Blanks

VII.11.1 Introduction

The following section describe blanks from GH 3. Over all, there are n=2243 blanks recorded from GH 3 (single finds and objects from collective finds). From them n=38 are attributed to be modified as cores (see chapter V.10). Hereafter, the remaining n=2205 blanks are described and discussed.

From these remaining blanks, n=1582 are measured as single finds. The rest of n=623 are from collective finds. In the course of this dissertation, only a distinctive number of objects were completely (dimensionally) measured and analysed in detail (n=1452), the rest of n=753 blanks remains to be analysed in detail for further research. These are mostly smaller objects, or objects from collective finds, as well as finds from the year 2014.

Despite this circumstances different lines of evidence about the assemblage of GH 3 can be drawn (similar to the study of a distinctive size class of objects from an assemblages, such as all lithic objects > 2 cm, or the so called *Serienrest* from Weißmüller 1995). Nevertheless, for each of all n=2205 blanks there are distinctive information available, for example find-number, spatial position, GH, denomination, size class or raw material. That was is missing for these n=753 artifacts are specific measurements and attribute like mass, dimension and attributes concerning surfaces, techniques, modifications, and so on. In the following section, first we describe features of all n=2205 blanks, after that, specifics of the n=1445 artifact that where analysed in detail.

VII.11.2 Quantity in total

Over all there are n=2205 blanks collected in the database (n=1452 with detailed analyses, n=753 with coarse features). In regard to blanks type see tab. 180:

Blank type	Detailed analysis	Coarse analysis	Total
Flake	1282	607	**1889**
Blades	105	16	**121**
Micro-flakes	46	107	**153**
Bladelets	19	23	**42**
Total	**1452**	**753**	**2205**

Tab. 180 - Blank types and degree of analysis

The degree of analysis equals 1445:753=1,92.

Quantity of blank types

All n=2205 analysed blanks are split into n=1889 flakes (around 86%), n=121 blades (5%), n=153 micro-flakes (7%) and n=42 bladelets (2%; see also fig. 203)

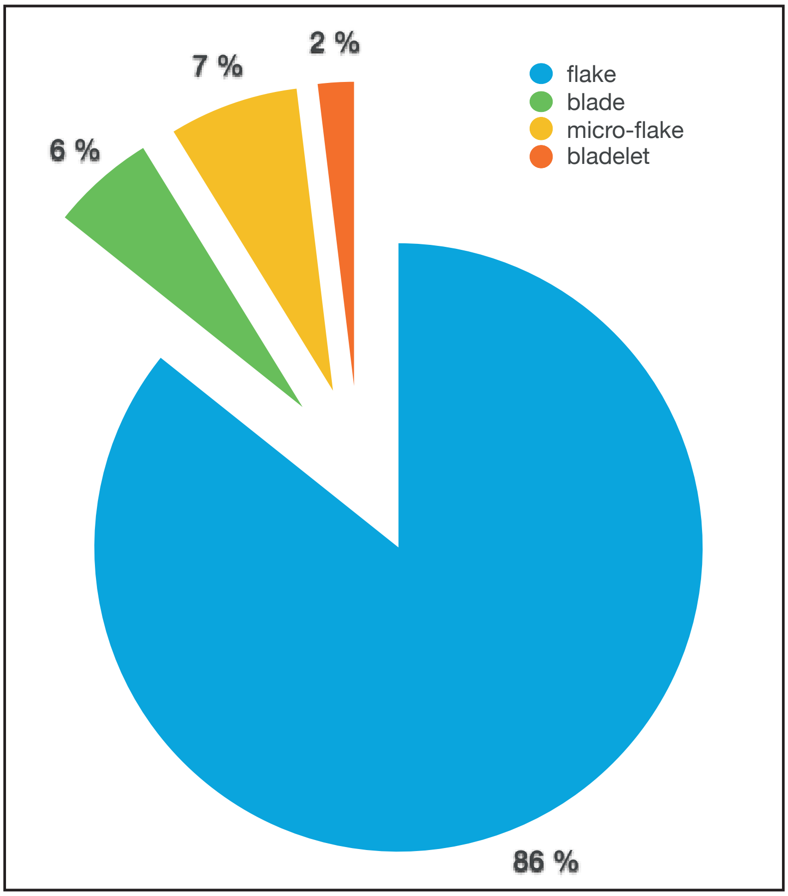

Fig. 203 - Percentage quantity of blank types from GH 3

Quantity of raw materials used for blank production

Over all n=9 lithic raw materials were detected (percentage in fig. 204).

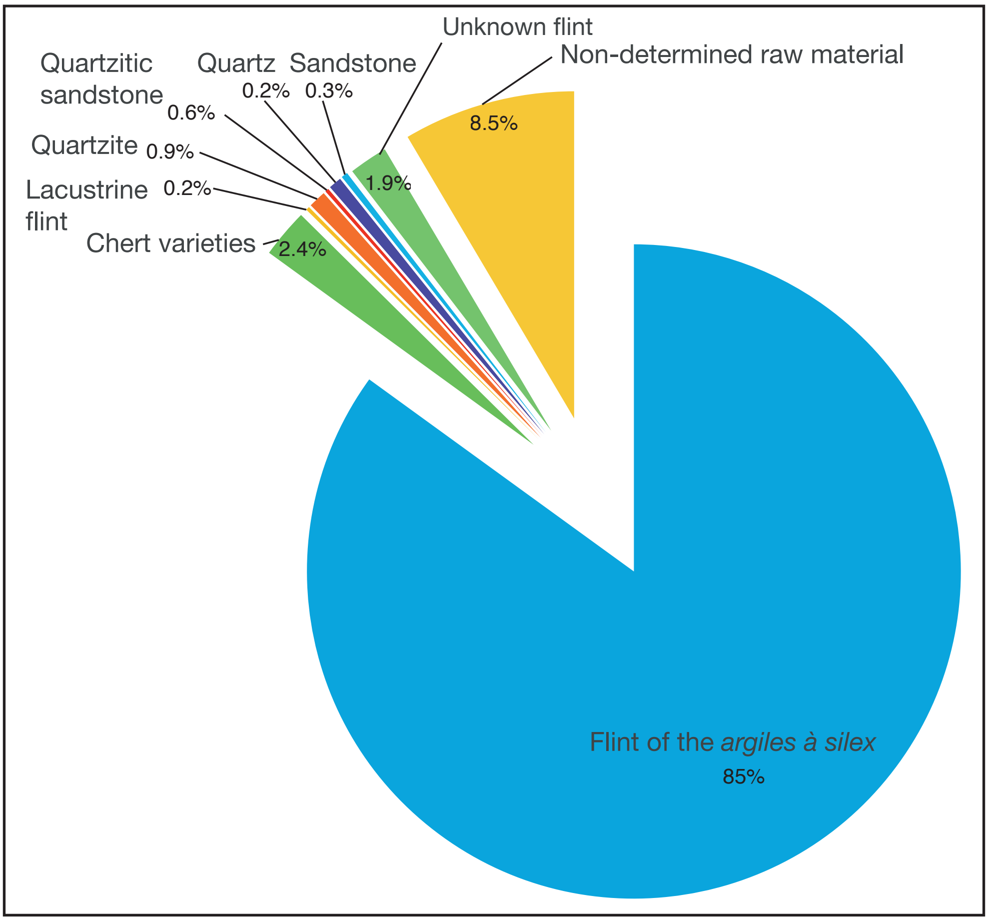

Fig. 204 - Percentage of raw materials used to produce blanks

The following tab. 181 gives an overview of the amount of blank types per raw material. FAS is the main raw material (n=1868), followed by currently non-determined raw material (n=187). There are n=53 blanks from chert varieties. Felsic raw material, such as quartzite, quartzitic sandstone, sandstone and quartz are present with n=44 blanks. N=4 blanks were identified as lacustrine flint. The additional n=42 unknown flints are either part of the FAS or from currently unknown raw material sources.

Matrix	Blank type				
Raw material	Flake	Blade	Micro-flake	Bladelet	**Total**
FAS	1589	110	136	40	**1875**
Chert varieties	43	6	3	1	**53**
Lacustrine flint	4	0	0	0	**4**
Quartzite	19	0	0	0	**19**
Quartzitic sandstone	4	0	0	0	**4**
Quartz	14	0	0	0	**14**
Sandstone	7	0	0	0	**7**
Unknown flint	39	3	0	0	**42**
Non-determined raw material	172	2	12	1	**187**
Total	**1891**	**121**	**151**	**42**	**2205**

Tab. 181 - Raw material and quantity of blanks

Quantitative ratios in regard to blank type and raw material

At first, we display the amount of blank types if we compare the main raw material (FAS) with the totality of all other raw materials. For flakes the ratio is 1582/302=5.24:1, as it can be seen in tab. 182). This is quite close to the total ratio for all blank types (1868/330=5.66:1). The ratio of blades, as well as of micro-flakes is quite close to each other. In contrast, the ratio of bladelets differs vast.

Matrix	Blank type				
Raw material	Flake	Blade	Micro-flake	Bladelet	**Total**
FAS	1582	110	136	40	**1868**
Other raw materials	302	11	15	2	**330**
Ratio	**5.24:1**	**10:1**	**9.07:1**	**20:1**	**5.66:1**

Tab. 182 - Contrasting FAS with all other raw materials used to produce blanks in GH 3

Another rational comparison is given by contrasting fine and coarse grained silicious raw materials (i.e., flint and chert versus felsic materials; see tab. 183). Here we get rid of the non-determined raw material group for a moment, to contrast determined materials with each other. As it shows (and it is clearly suggested) fine grained raw materials are the major source for blanks. In total the contrast is a ratio from 53.16:1.

Matrix	Blank type				
Raw material	Flake	Blade	Micro-flake	Bladelet	**Total**
Fine grained raw materials	1668	119	139	41	**1967**
Coarse grained raw materials	37	0	0	0	**37**
Ratio	**45.08:1**	**-**	**-**	**-**	**53.16:1**

Tab. 183 - Contrasting fine-grained (flint and chert) and coarse-grained (felsic) raw materials used to produce blanks in GH 3 with each other

The analysis shows that all of the coarse grained blanks (from quartz, sandstone, quartzitic sandstone and quartzite) should derive from hammerstones. In combination with damaged hammerstones (counted as cores because of visible negatives) they are good evidence for knapping activities on-site.

Quantity of techniques

There is evidence for the use of hard hammerstones, organic billets and anvils (bipolar) to knapp lithic objects (tab. 184). The ratio of hammerstones-to-billets is 1124/124=9.06:1.

Technique	Kind of percussion tool	Number of blanks showing such features
Direct-hard-straight	Hard hammerstone	**1124**
Direct-hard-straight or direct-soft-tangential	Hard hammerstone or organic billet	**7**
Direct-soft-tangential	Organic billet	**124**
Direct-hard-straight (bipolar)	Hard hammerstone and anvil	**2**
Unknown	Unknown	**948**
Total		**2205**

Tab. 184 - Detected techniques in GH 3 for lithic knapping

Quantity of modification

From all n=2205 blanks n=405 show modification after their production. This equals a ratio of 1800/405=4.44:1 (unmodified to modified). Therefore 22,65% or the blanks are modified. In a coarse typological description we can conclude that these retouched objects contain borers, denticulates, notches, side scrapers, truncated pieces, laterally retouched pieces, burins, hafting rests, backed knifes, bifacial objects, Groszaki, a Kombewa flake with terminal tranchet-blow negative, crested blades with slight lateral retouch, end scrapers and simply retouched objects (see tab. 185). It has to be considered that in tab. 185 there are not the counted objects but the techno-functional counting (in the meaning that some objects can have more than one active part, i.e., multiple tools).

Active techno-functional unit	Number
Splintered piece	1
Borer	3
Denticulate	13
Notch	14
Side scraper	85
Truncated piece	11
Lateral retouched	36
Burin	3
Hafting rest	105
Backed knife	42
Bifacial object	19
Groszaki	3
Moustier point	2
Blank with tranchet-blow negative	5
End scraper	24
Simply retouched object	77
total	442

Tab. 185 - Count of active techno-functional units on modified blanks from GH 3

This means that n=405 modified blanks have 442 retouched and denominated edge parts. Concerning objects with more than one active techno-functional unit (n=13), the following tab. 186 lists gives an overview:

Find-number	Tool combination	Matrix
GER09.228-059.135.1	Lateral retouch and scarper retouch	Simple flake
GER09.228-060.77.1	Lateral retouch and truncation	Levallois flake
GER10.226-058.239	Lateral retouch and Moustier point	Levallois flake
GER10.226-058.241	Side scraper and lateral notch	Levallois flake
GER10.226-059.245	Lateral retouch and scarper retouch	Simple flake
GER10.226-060.87	Lateral retouch and scarper retouch	Simple flake
GER10.226-061.116	Lateral retouch and truncation	Levallois flake
GER10.226-061.124	Truncation and scraper retouch	Simple flake

GER10.228-058.318	End scraper and notch	Levallois flake
GER12.225-059.672	Truncation and lateral retouch	Simple blade
GER12.229-059.365	Denticulate and side scraper	Levallois flake
GER12.229-059.520	End scraper and lateral retouch	Simple flake
GER13.225-058.1035	Lateral retouch and scarper retouch	Simple blade
n=13		

Tab. 186 - List of modified blanks with more than one active techno-functional unit

Quantity of blank classes

Here, we are describing the division of blanks into blank classes. The classes here are the same as in the following section that describes spatial distribution. The biggest class are simple blanks (n=1054), followed by blanks from surface correction (n=381). Some blank classes contain only a small number of object, such as core tablets (n=2) or crested blanks (n=6). The ratio between simple flakes and all other blank classes equals 1054/1144=0.92:1. From all n=21981 blanks an amount of 52,4% of all blanks are particularly classified.

Blank class	Unmodified	Modified	Total
Simple blank	868	187	**1055**
Raw-piece cap	200	28	**228**
Blank of surface correction	340	39	**379**
Blank of edge correction	204	15	**219**
Crested blanks	4	2	**6**
Éclat débordant and lame débordant	35	15	**50**
Core tablet	1	1	**2**
Levallois blanks	58	98	**156**
Kombewa flakes	11	2	**13**
Tranchet-blow blanks	9	0	**9**
Bifacial objects on blanks	0	19	**19**
Blank deriving from retouch	68	1	**69**
Total	**1798**	**407**	**2205**

Tab. 187 - Number of blanks in the defined blank classes from GH 3

VII.11.3 Spatial distribution of all blanks

Introduction

Blanks are distributed in all square meters where GH 3 was excavated (see fig. 205 to 209). The spatial distribution was plotted against blank type (fig. 205), raw material (fig. 206), used technique for blank production (fig. 207 and 208) and modifications of these blanks (fig. 209).

Spatiality of blank types

The spatial distribution of the four defined blanks types can be seen in fig. 205. The fractionation in flakes, micro-flakes, blades and bladelets was done by metrical constraints. Flakes, as well as blades are spread all over the area (with a higher density in the southern part). Blades are more common in the upper parts of GH 3 and flakes are spread all over the entire thickness of GH 3. After the stage of work, the plots imply that the distribution of small objects take place on the edges of the excavation area. This is truly an artifact of the analysis, because smaller objects from collective finds are not completely analysed in detail (see fig. 205).

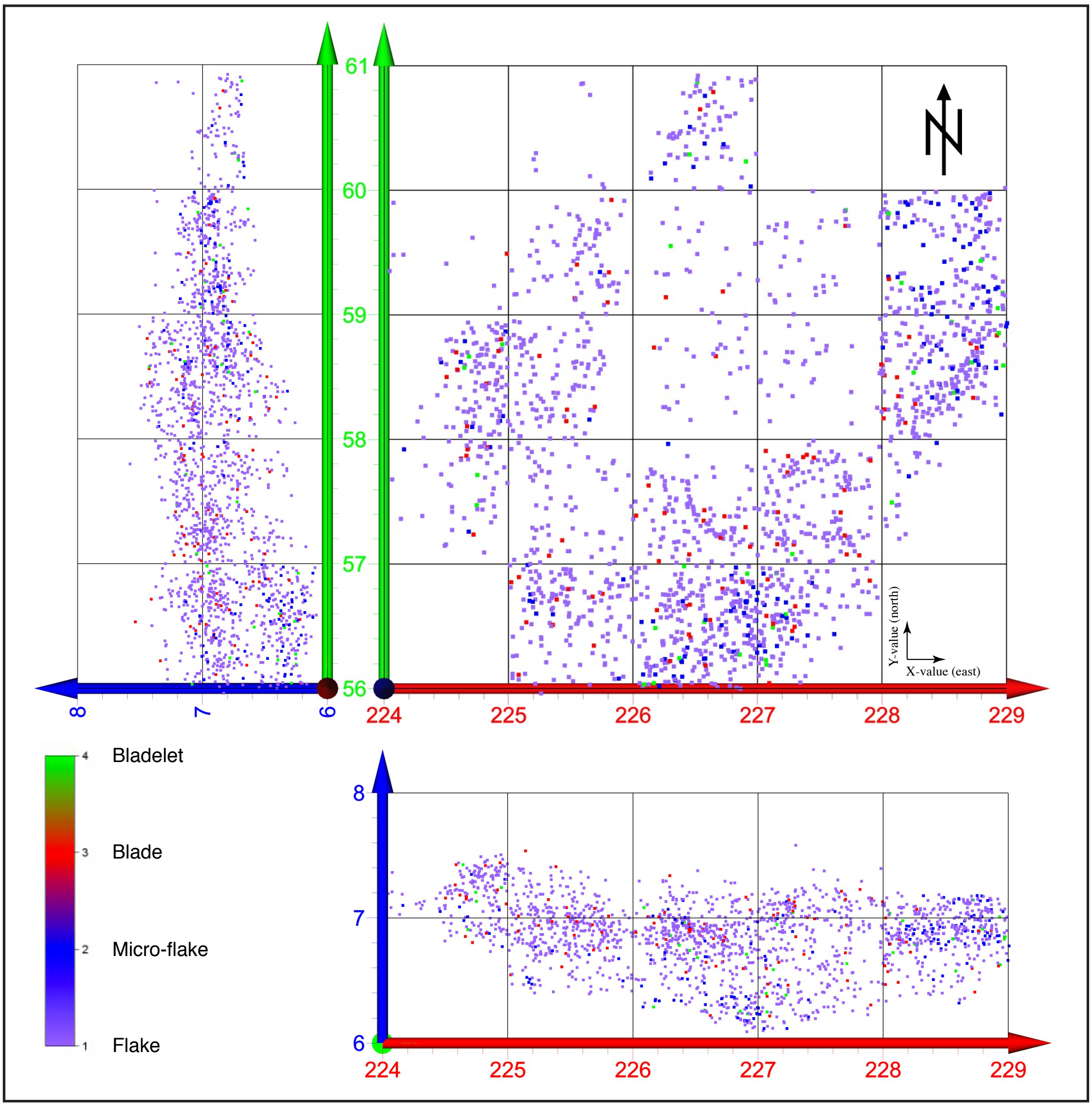

Fig. 205 - Spatial distribution of blank types (flakes, micro-flakes, blades and bladelets) from GH 3

Spatiality of blanks by raw material

By plotting blanks according to their lithic raw material, we see a different picture (see fig. 206). Blanks from FAS (violet) are spread over the entire excavation area. The same takes place for blanks from chert (blue), they are more concentrated in the southern part. Blanks from quartzite (red), quartzitic sandstone (bright gray), quartz (dark gray) and sandstone (blank) are much more spread in the South and the West. Blanks from currently unknown flint (green) or silex in general (orange) seem to be concentrated in spots in the South and the West. Concerning the spatial distribution in hight, we can conclude that FAS is spread all over the sequence of GH 3.

In the upper parts the diversity is much higher than in the lower parts. Blanks from chert and quartzite are distributed almost completely in the upper part of GH 3.

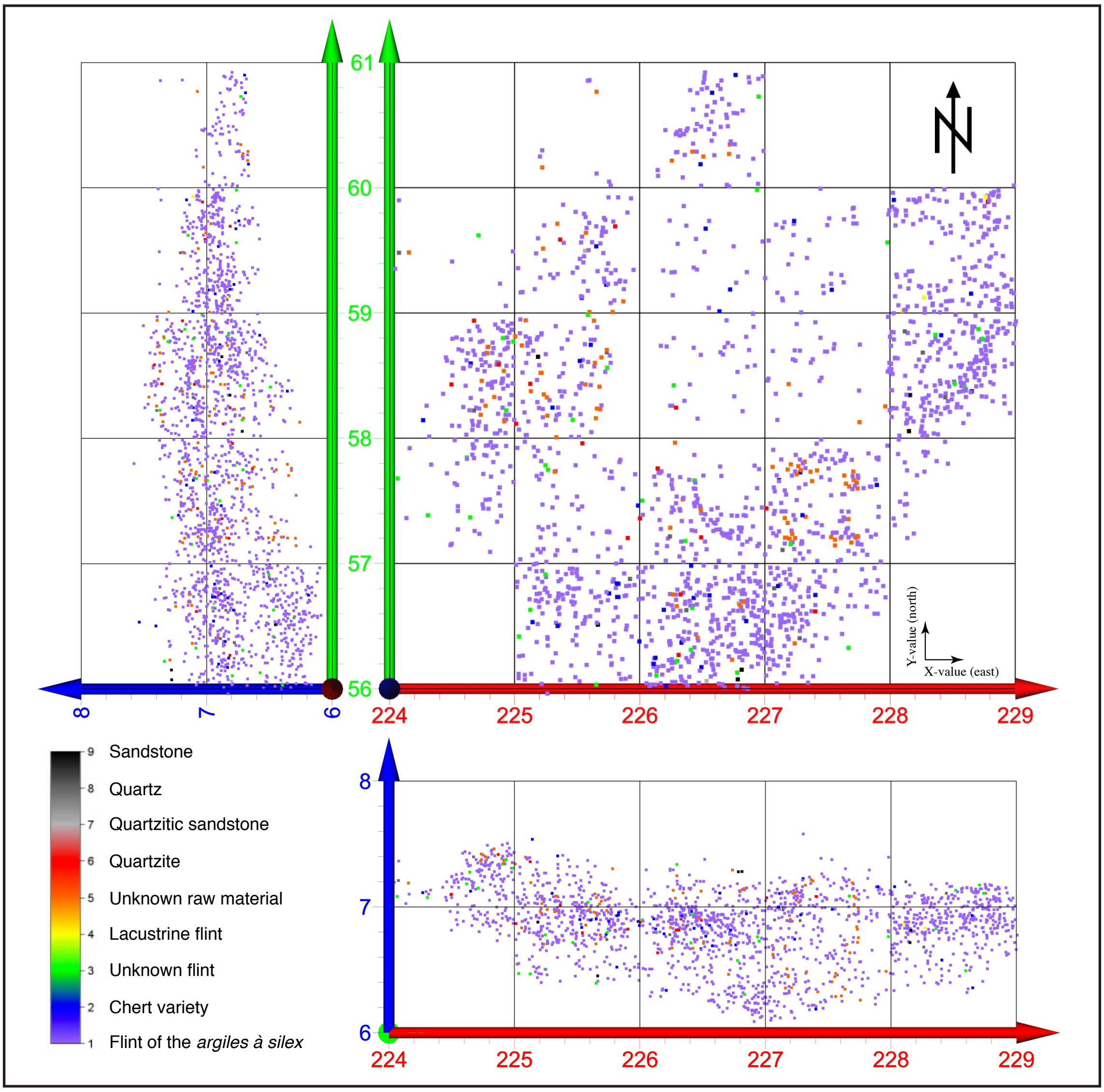

Fig. 206 - Spatial distribution of blanks from GH 3 by raw material

Spatiality of blanks made with different techniques

In general, three blank production techniques were identified. We were able to differentiate direct-hard-straight (hammerstone), direct-soft-tangential (organic billet) and direct-hard-bipolar (hammerstone and anvil) techniques of percussion (see also chapter V.3.6).

The hard-hammer percussion (direct-hard-straight with hammerstone) is omnipresent in the entire GH 3 (see fig. 207). Soft-hammer percussion (direct-soft-tangential blow with an organic billet) instead seems to be slightly more horizontally but not vertically concentrated as isosurface plots suggest (see fig. 208). Only n=2 examples of bipolar splitting were detected so far. Both examples are situated almost on the same hight.

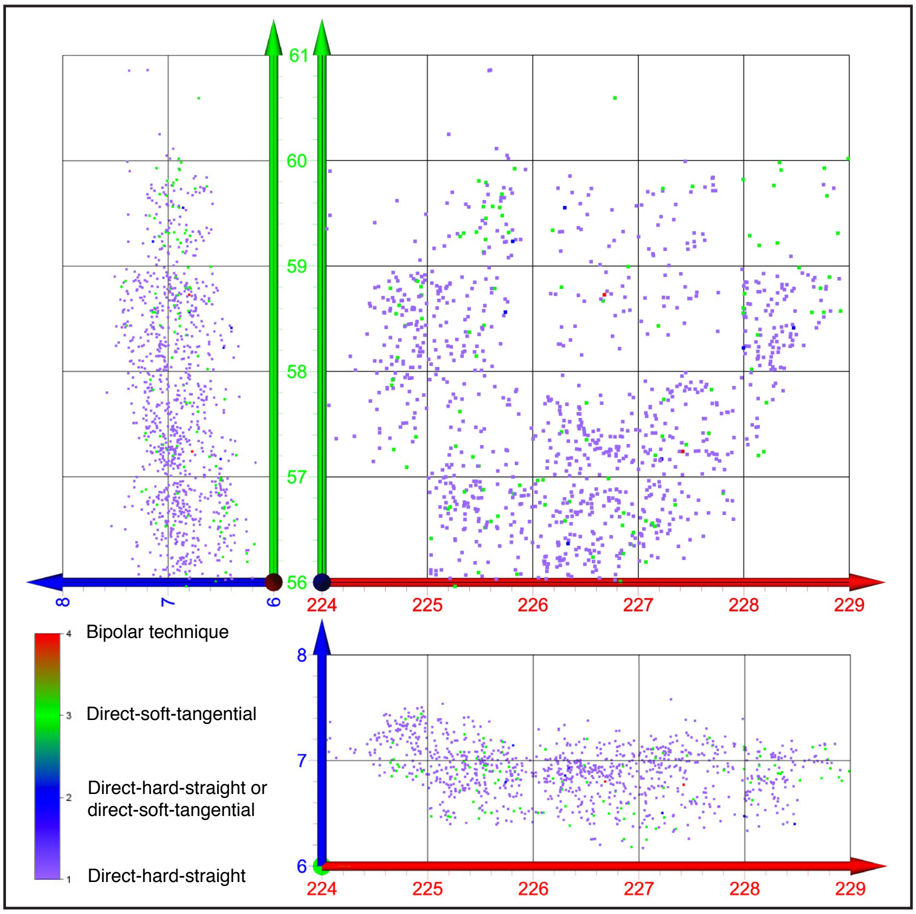

Fig. 207 - Spatiality of blanks production techniques in GH 3

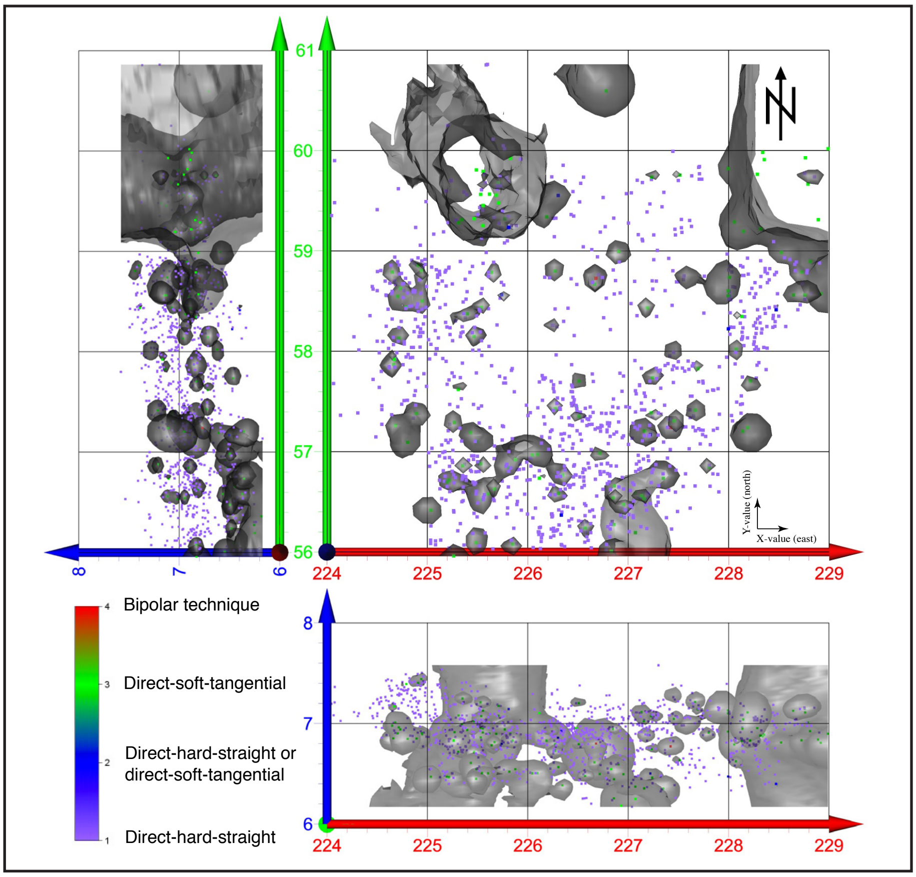

Fig. 208 - Spatiality of blanks production techniques in GH 3 with isosurface

Contrasting the spatiality of modified and unmodified blanks from GH 3

In a site with a later Upper Paleolithic context it would not be surprising to find a spatial segregation of blank production and blanks modification, such as Pincevent in the Parisian basin (Julien & Karlin 2015; Stapert 1989) or Gönnersdorf in the Neuwieder Becken (Jöris et al. 2011b). An excellent example from a Middle Paleolithic context is Abric Romaní, Capellades where a spatial differentiation of reduction stages, but also proposed sleeping areas are visible (Carbonell 2012; Vaquero et al. 2012b).

The following plot tests this spatial pattern for the Middle Paleolithic layer of GH 3 (see fig. 209). But as the plot suggests, unfortunately, there is no spatial segregation of modified and unmodified blanks visible. Both kinds are spread allover the area of GH 3 and also in a vertical view, the same takes place.

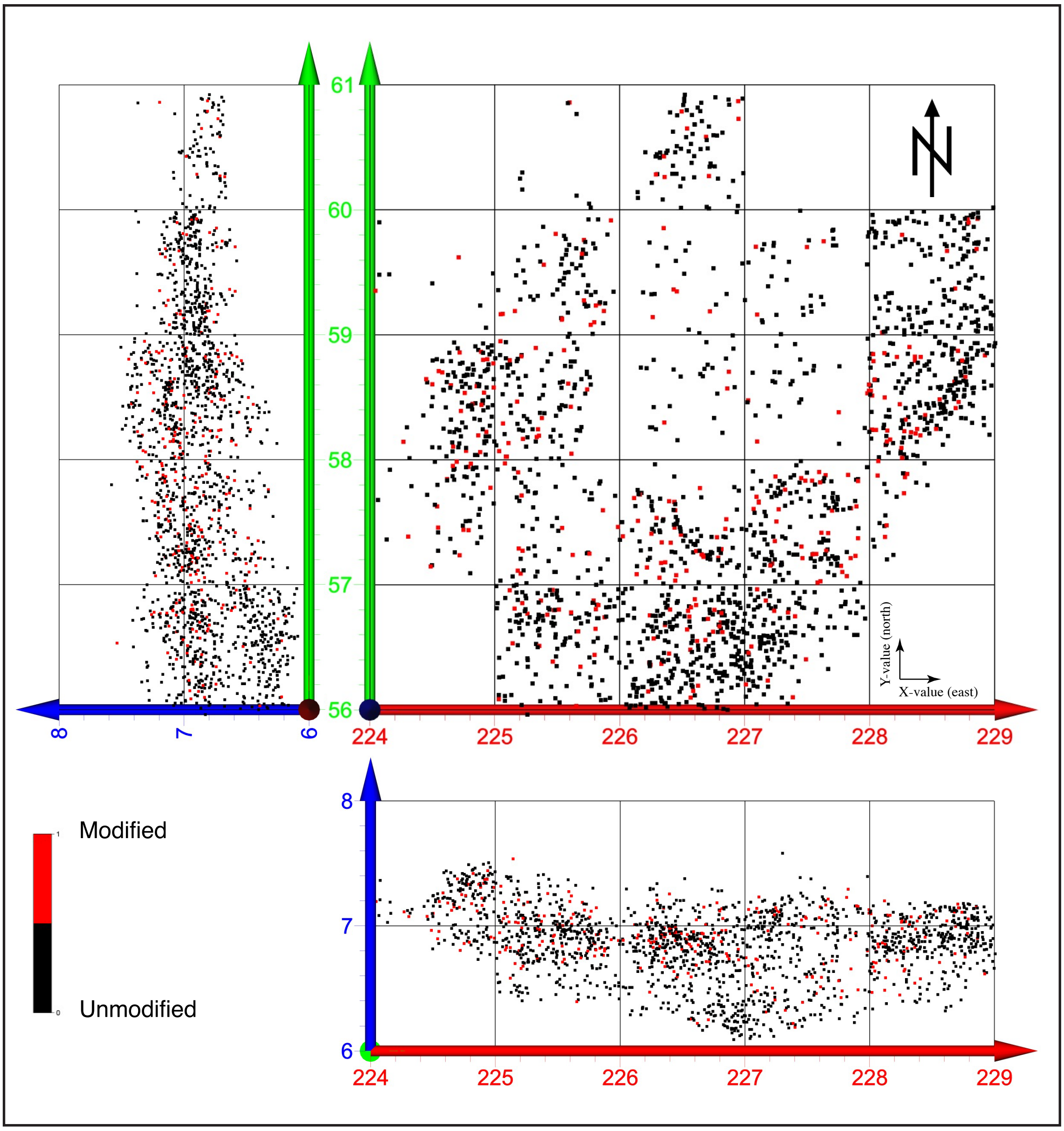

Fig. 209 - Contrasted spatiality of modified (red) and unmodified (black) blanks from GH 3

Spatial distribution of blanks by class

If we show the distribution of blank by class, a colorful picture is presented (fig. 210). Due to the multitude of colors from 16 categories singular distribution pattern are hardly visible. However, some features can be examined. Firstly, gray dots (unidentified blank class) take place in nearly all square meters. In vertical view it is visible that most of them are from lower levels (representing volumes excavated in 2014). Another aspect is that violet (cortical blanks) and blue dots (surface and edge correction blanks) are spread over the entire area.

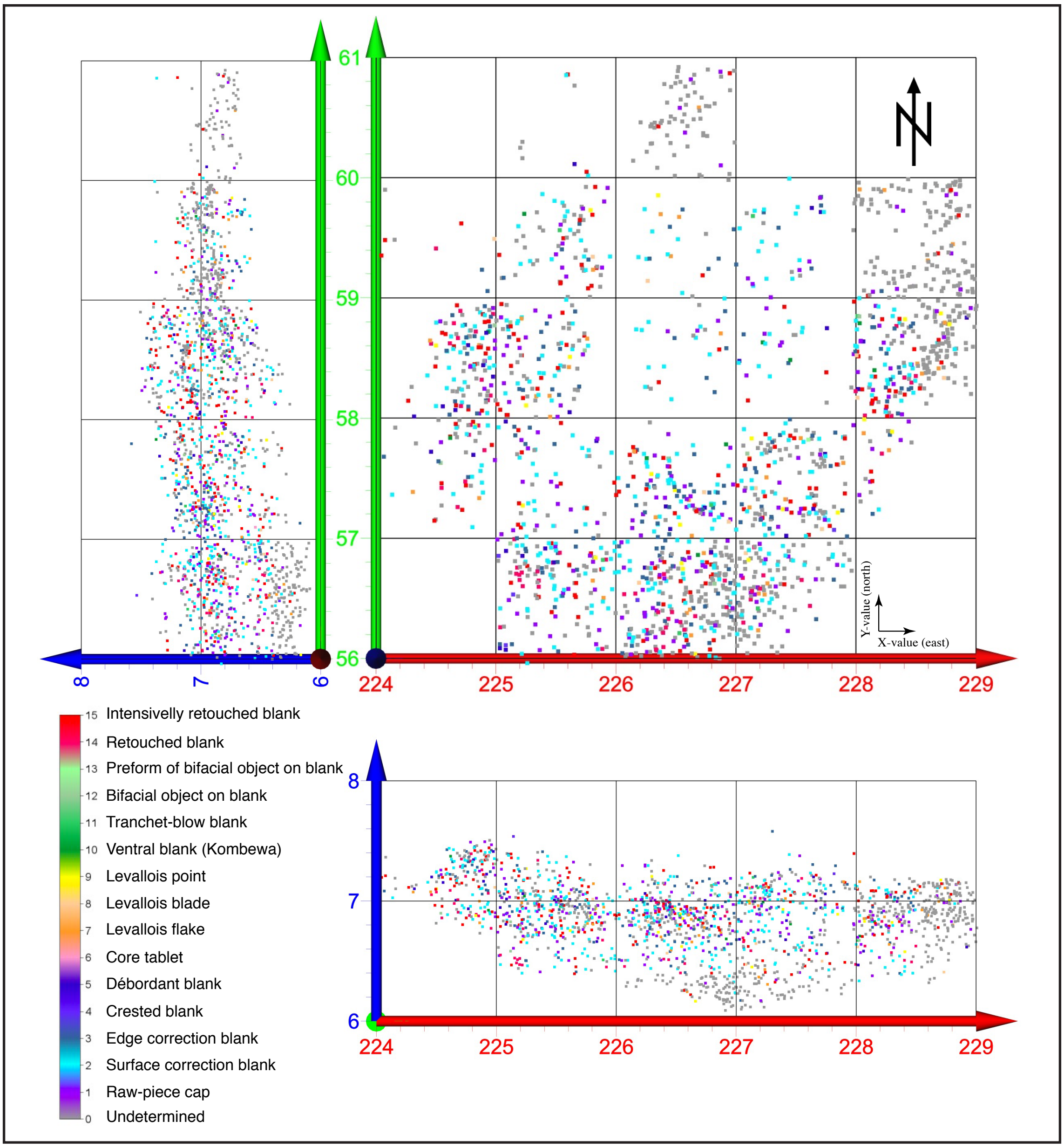

Fig. 210 - Spatial distribution of blanks from GH 3 divided into 16 blank classes

In a condensed consideration of the blank classes (see fig. 211) by grouping these blank classes, the picture gets much more clearer. It is evident that initialization and configuration blanks (blue) are spread allover the area of GH 3, Levallois blanks (green) are much more concentrated, blanks from ventral reduction (yellow) are situated mostly in the South. Bifacial elements (bifacial objects and tranchet-blow blanks, orange) and intensively modified blanks (red) are also highly scattered. The bifacial elements (so far) are situated in the upper half of GH 3.

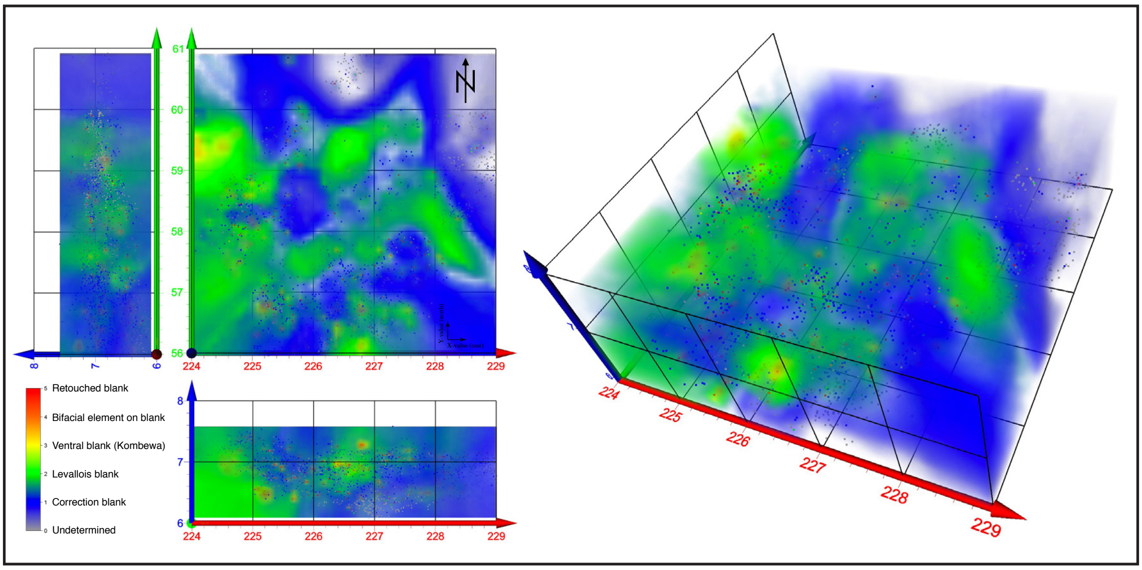

Fig. 211 - Spatial distribution of blanks from GH 3 divided into condensed blank classes. The volume render shows the density of blanks of the condensed blank classes

Conclusion of spatial blank distribution

As it could be observed from the above referred spatial distribution of blanks (fig. 210 and 211), is seems that lithic objects from GH 3 are hardly clustered, neither in regard to blank types, raw material, modification, percussion technique nor blank classes. As matters stands, there are no clear spatial distribution patterns of lithic objects visible. Correction blanks and Levallois blanks seem to be separated by their density. Bifacial objects on blanks and retouched blanks seem to cluster together. Only some objects seem to be slightly more clustered (e.g., blanks produced with soft-hammer technique). This observation will be more studied in detail in chapter VII.14, by plotting bifacial elements in its entirety (bifacial objects, tranchet-blow blanks and bifacial-trimming blanks).

VII.11.4 Dimension of all blanks

Introduction

This section is applied to the dimension of blanks. It discusses the same grouping as in the section above about spatial distribution. Here, we are mostly comparing total length, with total width and total thickness, or i.e. the maximum dimensions.

Dimension of all blanks

The simple dimensional plot of all blanks from GH 3 shows a quite homogenous picture (fig. 212 and 213), without outliers. The highest density of artifacts is located in the lower third of the dimensional range (length-to-width). The picture is quite similar for length-to-thickness and thickness-to-width. The box-plot values are displayed in tab. 188:

Values	Length	Width	Thickness
Minimum	6.2	2.5	0.8
Q1	21.4	15.1	4.6
Median	29.8	21.0	7.1
Q3	41.7	30.4	10.8
Maximum	100.1	79.8	39.4

Tab. 188 - Boxplot values of the dimensional range of all blanks from GH 3

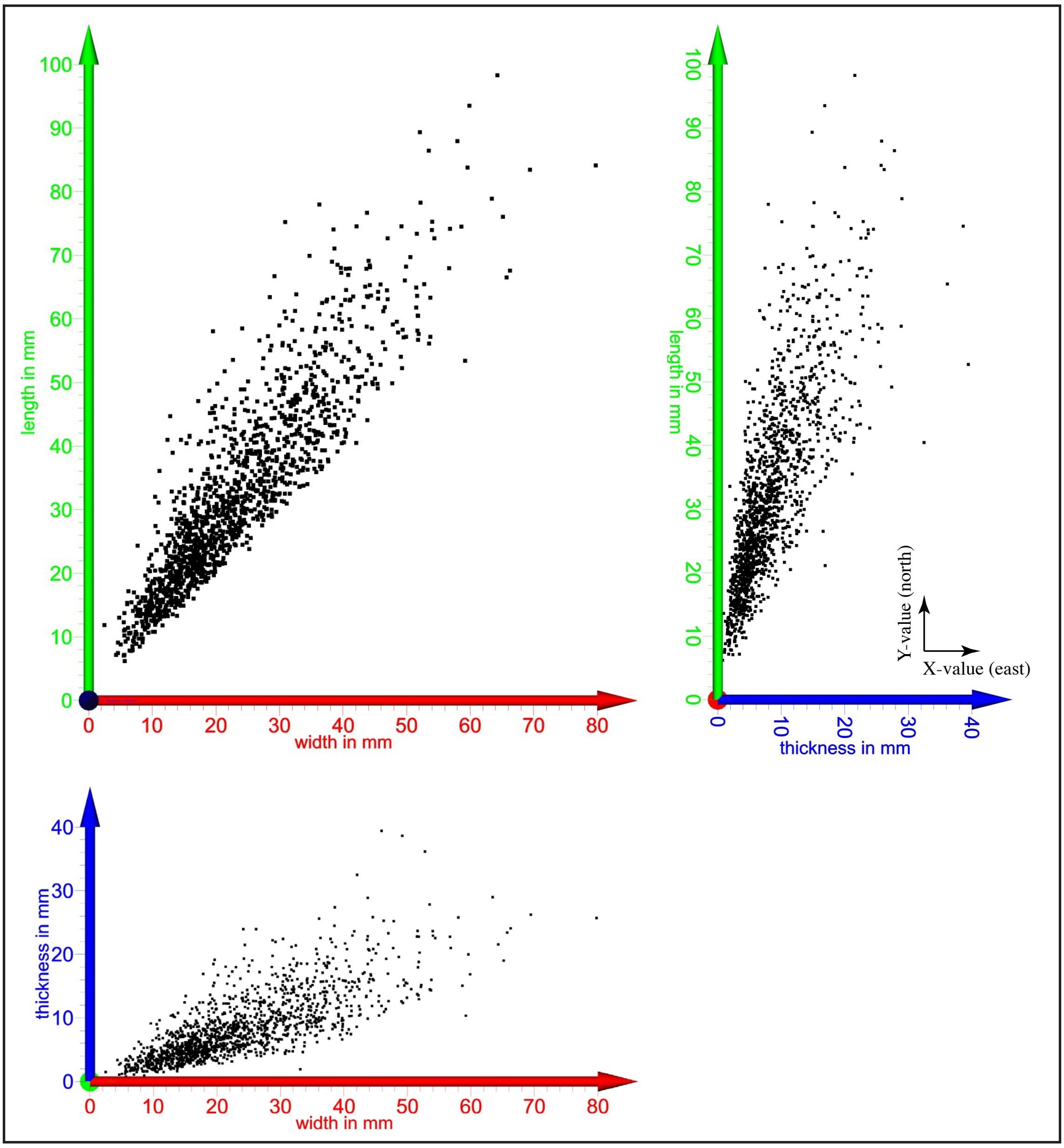

Fig. 212 - Scatterplot of the dimensional range of all blanks from GH 3 together

Dimensional ratios

This section describes observations made by dimensional ratios, as established by Weber (1991, 1995). The approach here is to take data from each artifact, such as length and width, counting the ratio for each artifact and counting the mean for all measured blanks. We measured total length as well as length in blow-direction and therefore have the possibility to compare them.

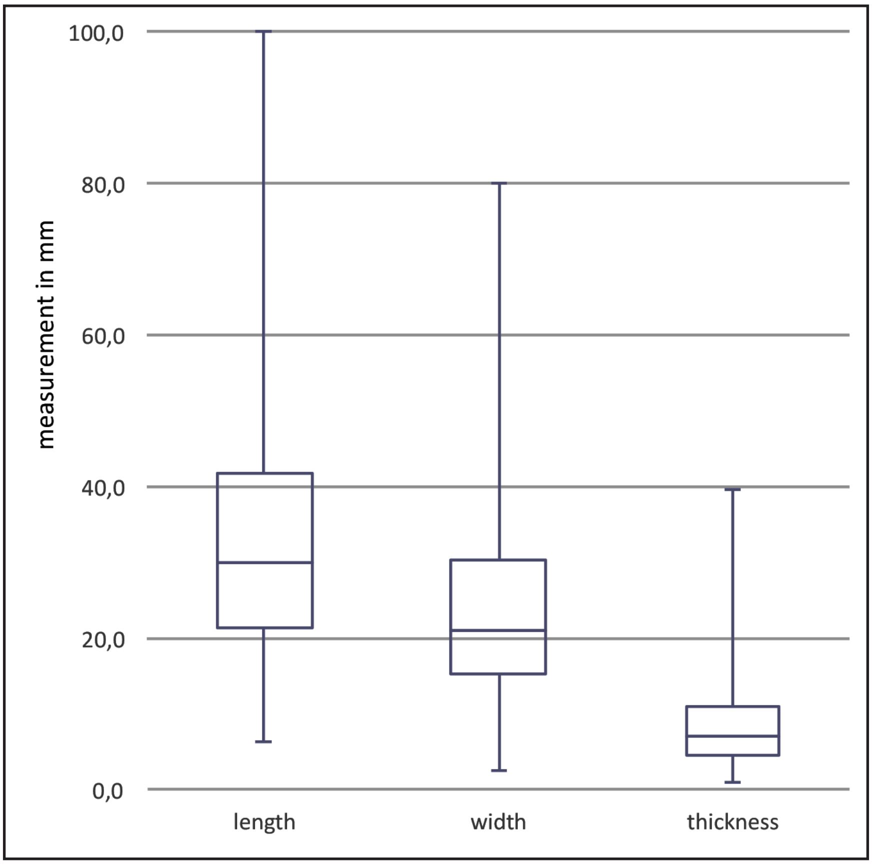

Fig. 213 - Boxplot of the mass and dimensional range of all blanks from GH 3

The length-to-width ratio for one blank (maximum dimension) is easily counted: LW ratio = L/W. which means that if all LW ratios of all measured blanks are counted it equals 1.45:1. The width-to-thickness ratio for one blank is WT ratio = W/T and results in a mean of 3.19:1 for all blanks. Another ratio that was counted is the relative-thickness ratio, which is rT 1 ratio = T/(0.5*(L+W)) (values below 1) or rT 2 ratio = 200T/(L+W). The rT 1 ratio is 0.29:1 for all blanks and rT 2 ratio is 29,34:1. For a better overview of the ratios for blanks they are all together displayed in the following tab. 189:

Ratio	Abbreviation	Formula	Mean value of all measured blanks
Total length to total width	LW_{total}	L_{total}/W_{total}	1.45:1
Total length to total thickness	LT_{total}	L_{total}/T_{total}	4.49:1
Total width to total thickness	WT_{total}	W_{total}/T_{total}	3.19:1
Relative total thickness 1	rT_{total} 1	$T_{total}/(0.5*(L_{total}+W_{total}))$	0.29:1
Relative total thickness 2	rT_{total} 2	$200*T_{total}/(L_{total}+W_{total})$	29.34:1
Length in blow-direction to width of the ventral face	LW_{blow}	L_{blow}/W_{blow}	1.32:1
Length in blow-direction to total thickness	LT_{blow}	L_{blow}/T_{total}	3.87:1
Blow-directional width to total thickness	WT_{blow}	W_{blow}/T_{total}	1.35:1
Relative blow thickness 1	rT_{blow} 1	$T_{total}/(0.5*(L_{blow}+W_{blow}))$	0.32:1

Relative blow thickness 2	rT_{blow} 2	$200*T_{total}/(L_{blow}+W_{blow})$	31.73:1
Length of ventral face to width of ventral face	$LW_{ventral}$	$L_{ventral}/W_{ventral}$	1.15:1
Length of dorsal face to width of dorsal face	LW_{dorsal}	L_{dorsal}/W_{dorsal}	1.17:1
Total length to length in blow-direction	$L_{total}L_{blow}$	L_{total}/L_{blow}	1.18:1
Ventral to dorsal face	VD	$(L_{ventral}/W_{ventral})/(L_{dorsal}/W_{dorsal})$	0.99:1

Tab. 189 - Dimensional ratios of all measured blanks from GH 3

Size classes of blanks

For all blank a size class was determined. This size class orientates on geological size classes for sediment particles (see also Frick et al. 2014). The following tab. 190 displays the amount of blanks belonging to these defined size classes:

Size class	Size spectrum	EN ISO 14688	Number of blanks in this size class
XXXS	0 to 2 mm	Clay, silt and sand	**5**
XXS	2 to 20 mm	Gravel	**743**
XS	20 to 60 mm	Gravel	**1168**
S	60 to 150 mm	Stones	**87**
M	150 to 300 mm	Stones	**0**
L	300 to 600 mm	Stones	**0**
XL	600 to 1000m	Blocks	**0**
XXL	1000 to ∞	Blocks	**0**
Undetermined	-	-	**202**
Total			**2205**

Tab. 190 - Amount of blanks from GH 3 belonging to defined size classes

Dimension of blank per blank types

Upon first sight, the dimensional plot per blank types (fig. 214) shows a quite familiar picture. Micro-flakes are situated in the low range, bladelets, too. Blades and flakes represent the larger dimensional range. But we have to bear in mind the following constraints:

- The maximum dimensions for each blank are plotted (maximum length, the width at the half of the maximum length and the thickness at the same position)
- This plot represent complete blanks and fragments as well
- The denomination of blanks types was done using blow direction as main axis

By comparing the maximum length (L_{max}) to length in blow-direction (L_{blow}), we can recognize these differences (see fig. 215). Here, at y=x (drawn line) Lmax equals L_{blow}. The points cloud above y=x shows the differences between L_{max} and L_{blow}. As it is illustrated there are objects with a L_{max} more than twice L_{blow}.

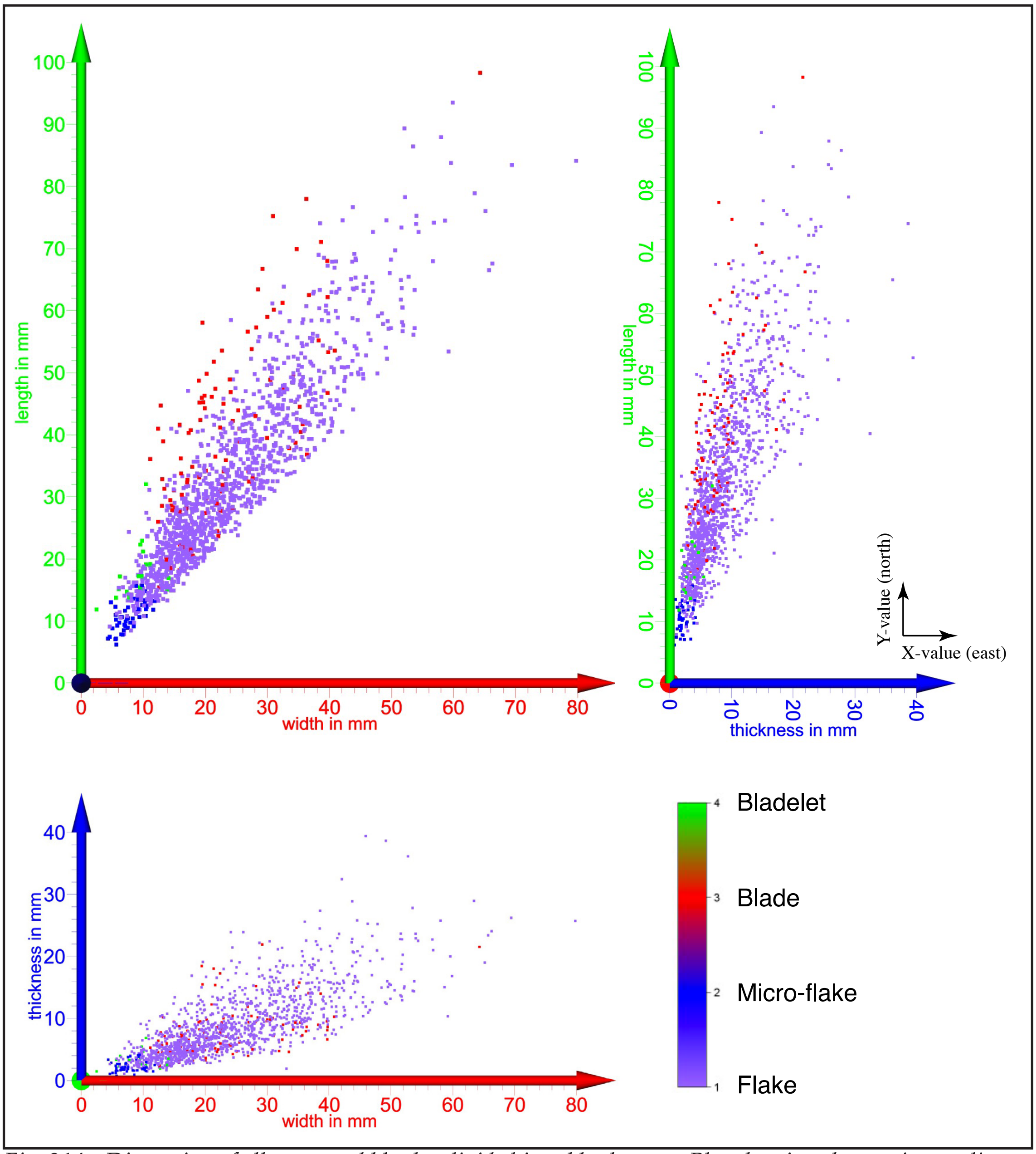

Fig. 214 - Dimension of all measured blanks, divided into blank types. Plot showing the maximum dimension of complete blanks and fragments from GH 3

Unfortunately, the angle between the direction of L_{max} and L_{blow} wasn't measured. This would give us information about knapping strategies concerning the use of litho-technological principles and the knowledge about parallel reduction from flaking surfaces (see also Boëda 1986c; Van Peer 1992). The longer (in relation to width) a blank is the more L_{max} will normally equal L_{blow}.

Dimension of blanks per raw materials

FAS is the main lithic raw material for blank production and set the dimensional range of blanks. This is highly visible in fig. 216 (violets dots). Blanks from chert (blue dots) as well cover the complete dimensional range. Blanks from quartzite are more centered (we can assume that objects from quartzite are still to be find in the collective finds, which are not a focal point of this thesis).

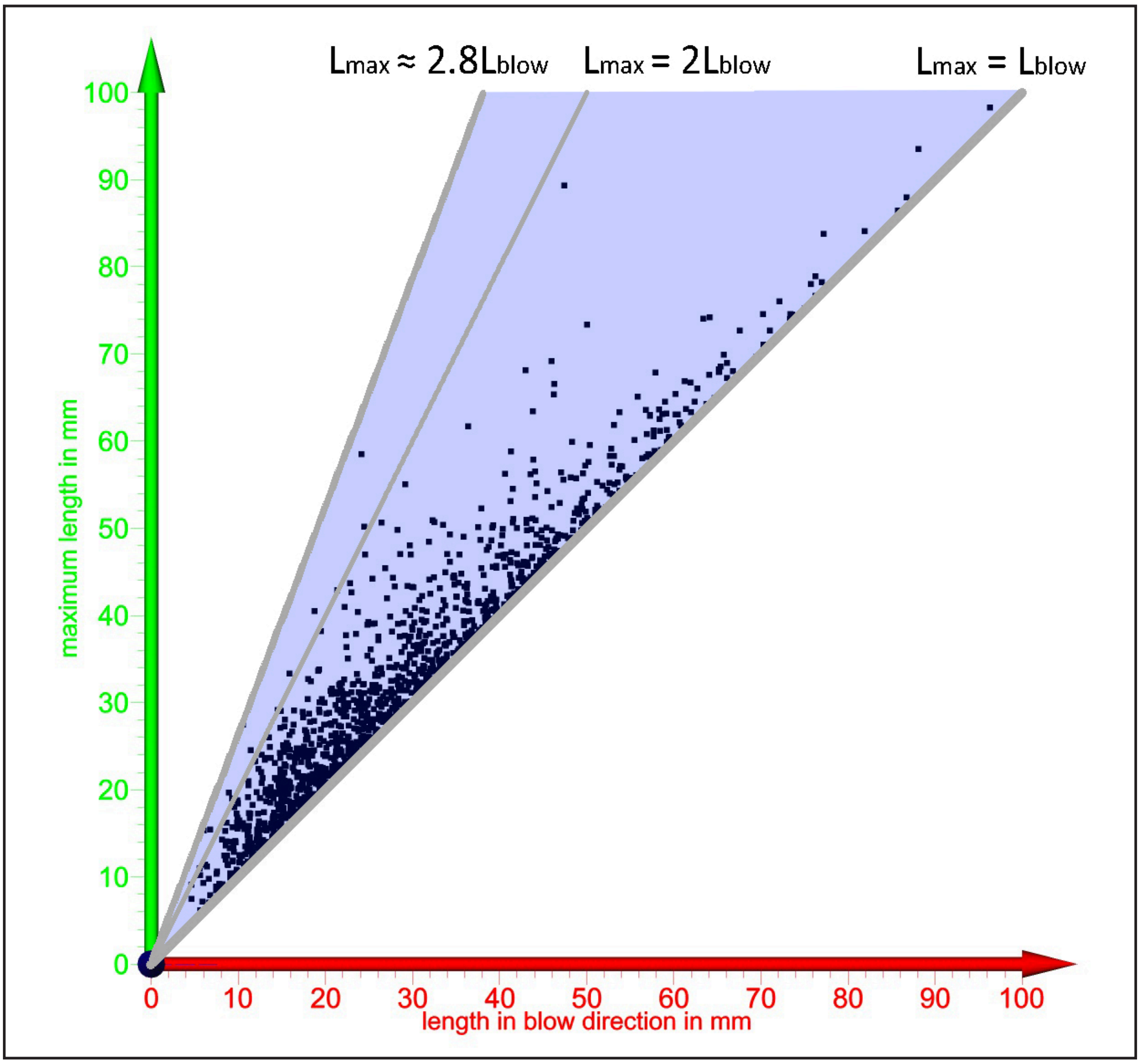

Fig. 215 - Difference between maximum length (L_{max}) of a blank to it length in blow direction (L_{blow}), illustrated by using blanks from GH 3

The dimensional range for fine-grained lithic raw material can give us information about the raw piece dimensions used (later we will also compare cortical blank dimension with raw piece and core dimension from the same raw material).

Dimension of blanks per percussion techniques

By comparing different techniques of percussion with the dimensional range of blanks, there is a grouping visible (see fig. 217). Hard hammer technique was used to produce blanks in all dimensions (violet dots). On the other hand, banks produced by soft hammer techniques are normally small (see green dots). Both blanks produced with bipolar technique share the same width (red dots). Blanks that are produced either with hard or soft hammer techniques (blue dots) are spread in the dimensional range of both, soft and hard hammer techniques. Blanks produced by soft hammer technique are normally flatter than the bulk of hard hammer blanks. Both bipolar blanks are quite thick.

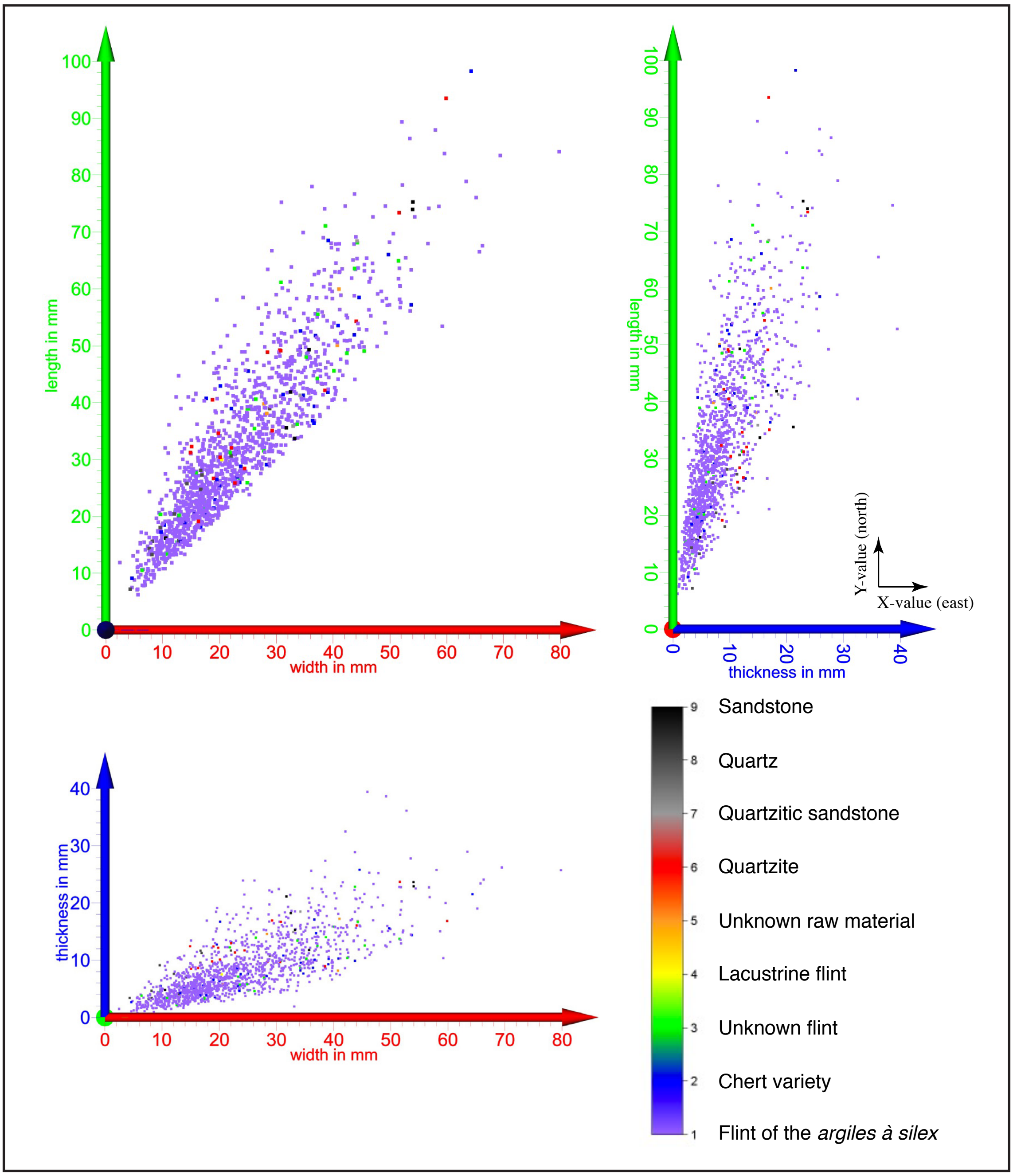

Fig. 216 - Dimension of blanks separated by their raw material

Dimension of blanks per modification

Contrasting blanks with (red dots) and without (blank dots) modification after production (fig. 218), there are some observations to be made. In tendency, modified blanks are larger in length. Unmodified blanks are covering the whole dimensional range but mostly they are quite small. Concerning thickness, modified tend to be a bit thicker that the vast amount of unmodified blanks.

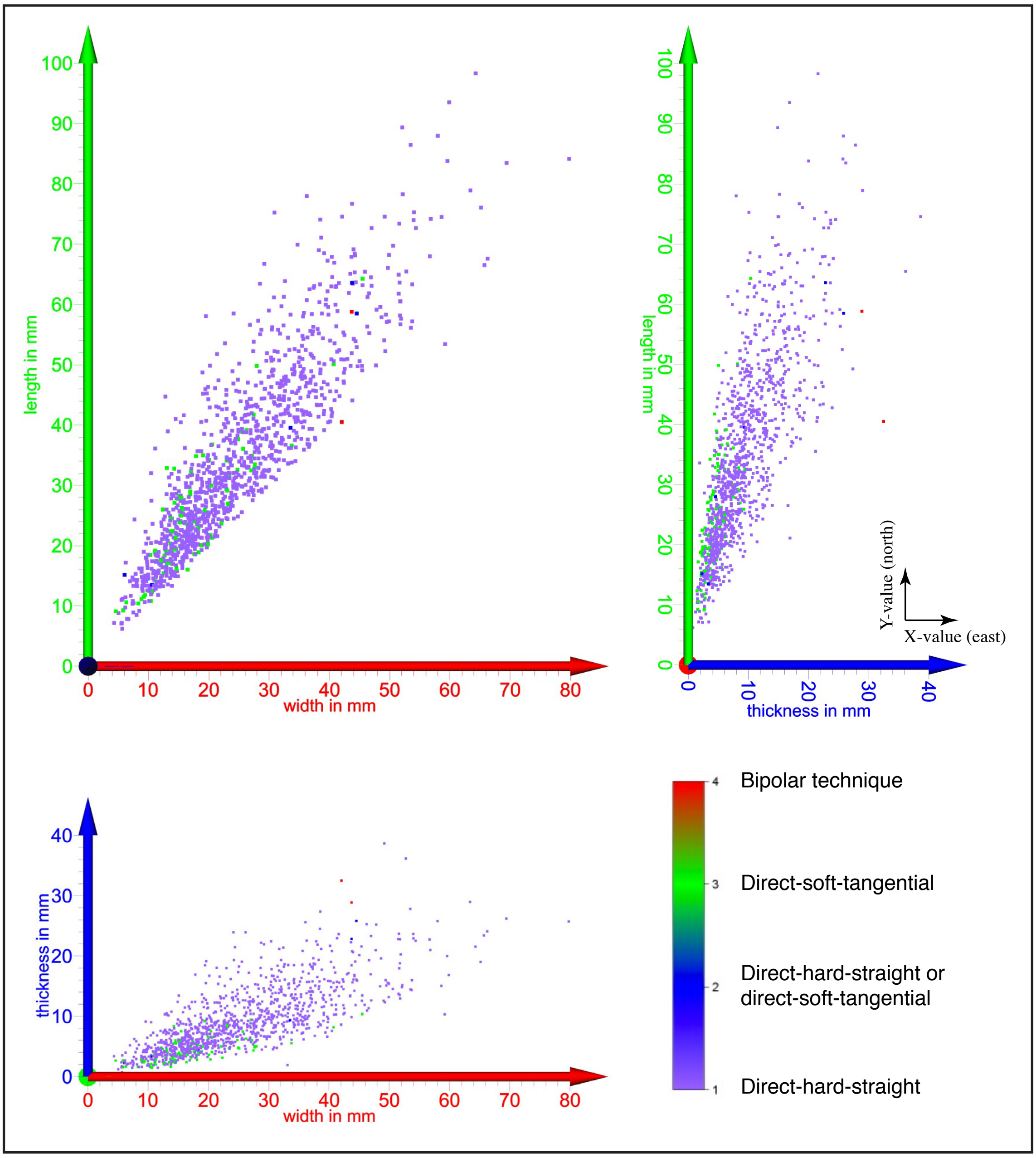

Fig. 217 - Dimension of blanks from GH 3 separated by their percussion technique

Dimension of blank per classes

By splitting the blanks from GH 3 into their blank class a quite colorful picture can be presented (see fig. 219) but gives an idea about their dimensional range. In the condensed version of the blank classes (fig. 220), the picture gets more clear. Levallois blanks are mostly in the medium range and formate a cluster (green dots). Blanks for initialization and configuration (blue dots) spread all over the whole range but in tendency they are more clustered in smaller half. Bifacial elements (bifacial objects and tranchet-blow blanks) are badly visible (orange dots). Modified blanks (formal tools) and modifying blanks (blanks removed by retouch) are displayed in red.

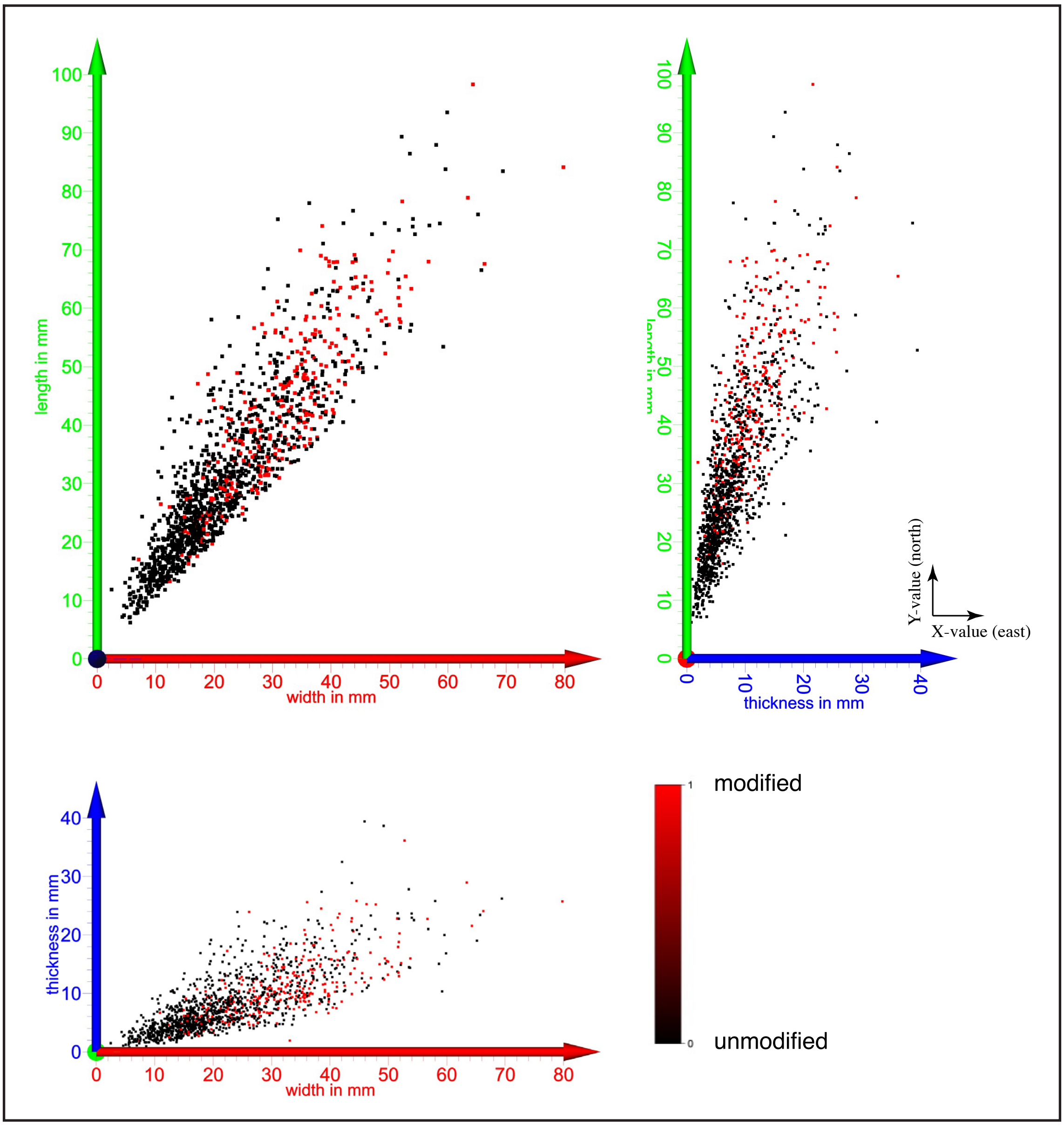

Fig. 218 - Comparison of dimension of modified and unmodified blanks from GH 3

Comparison of ventral and dorsal face dimension

A simple comparison plot of lengths in blow direction and widths of dorsal and ventral faces results in a scatter-plot (fig. 221), but demonstrates that they are differing (which we would expect from simple artifact morphology). In this section, the results of measurement are presented, an interpretation and use of these data is not aimed in this context, but will be done in later discussion.

Mass of blank types

This paragraph compares mass of the different blank types (see fig. 222). For n=1444 blanks mass were measured (flakes n=1274, blades=105, micro flakes n=46 and bladelets n=19). The median of mass for the blank types differs visible (flakes 3.5 g, blades 4.3 g, micro-flakes 0.1 g and bladelets 0.4 g). Interestingly, the average blade is a bit heavier than the standard flake.

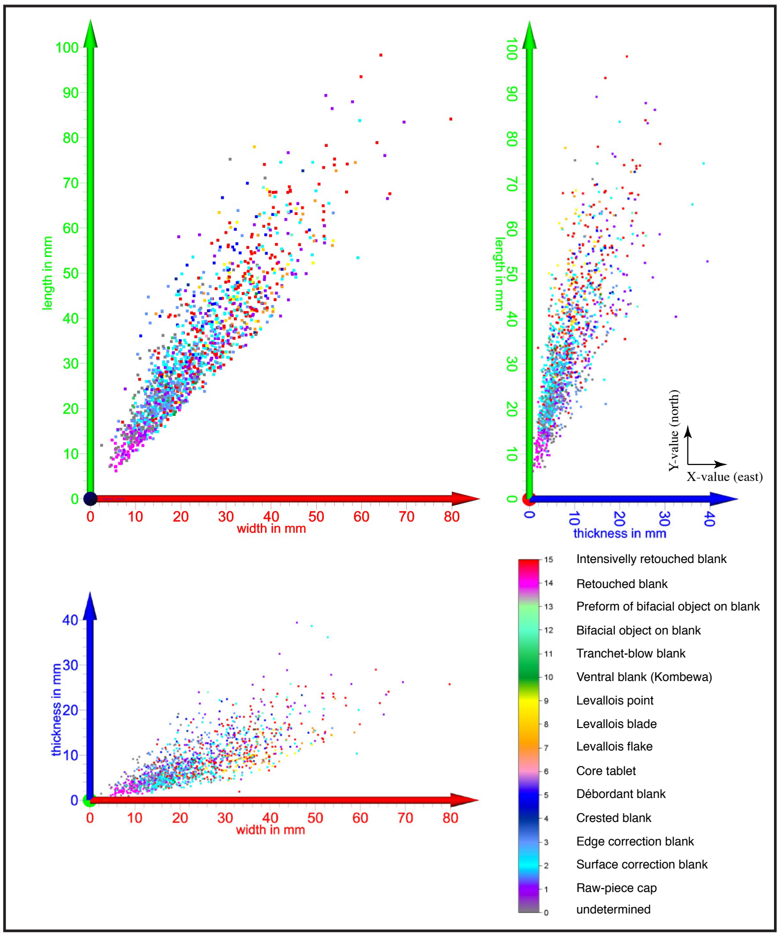

Fig. 219 - Dimensional comparison of blanks by their blank class

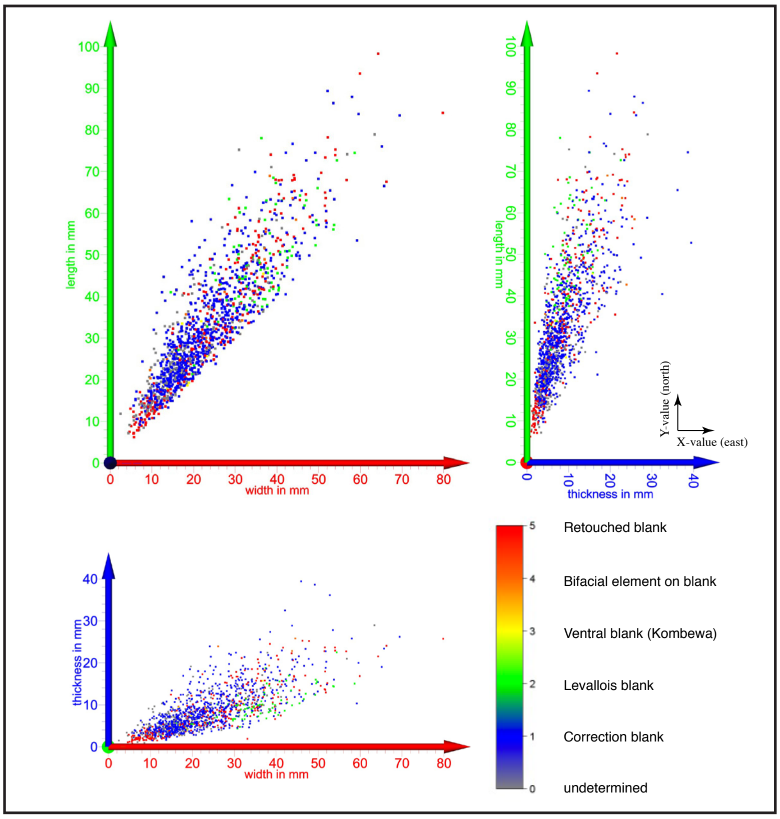

Fig. 220 - Dimensional comparison of blanks by their condensed blank class

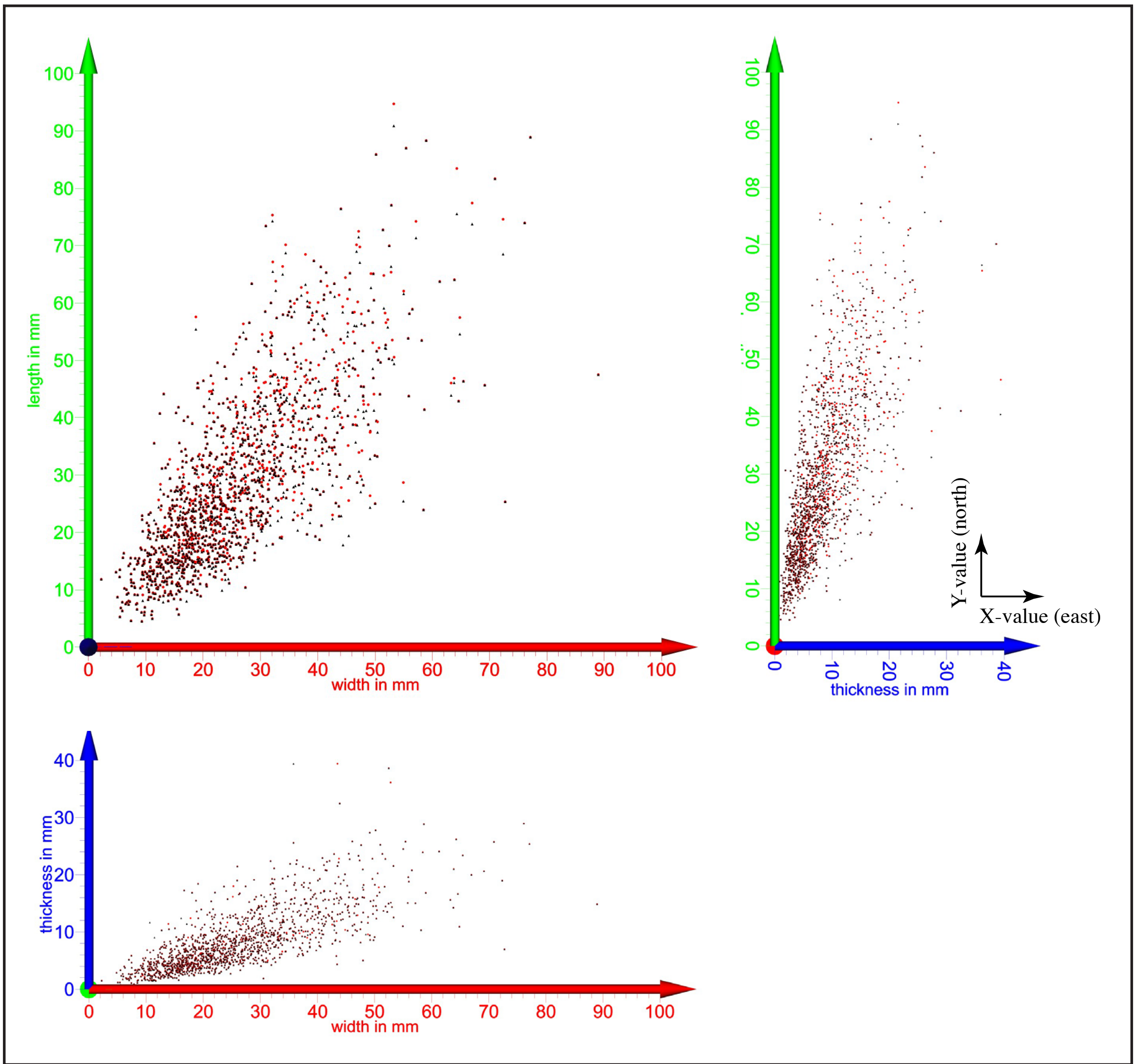

Fig. 221 - Comparison of all measured length in blow direction and widths of dorsal and ventral faces from blanks from GH 3 (ventral face dimension in black triangles and dorsal face dimension in red dots)

VII.11.5 Non-metrical blank features

The following section takes a look on non-metrical features of blanks (for a description see chapter V.2.2). In the following, cortex, blank finials, techniques of blank production, fragmentation, edge damage, morpho-geometry, angles, thermal influence, and many more features of blanks are discussed.

Cortex

Data about cortex was collected for n=1449 blanks. To avoid confusion: the amount of cortex was calculated for the entire surface of an artifact. The following tab. 191 displays the number of blanks in each category:

Amount of cortex on the entire artifact surface	Number of flakes	Number of blades	Number of micro-flakes	Number of bladelets	Total
Without cortex	568	55	30	14	**667**
Up to 10%	321	26	6	4	**357**
Up to 25%	165	13	6	1	**185**

Up to 50%	214	11	3	0	**228**
Up to 75%	5	0	1	0	**6**
Up to 99%	1	0	0	0	**1**
Complete cortex cover	1	0	0	0	**1**
Total	**1275**	**105**	**46**	**19**	**1449**
Total of blanks with cortex	707	50	16	5	**778**
Cortex ratio	0,80	1,10	1,88	2,80	**0,86**

Tab. 191 - Amount of cortex on the entire surface of blanks from GH 3

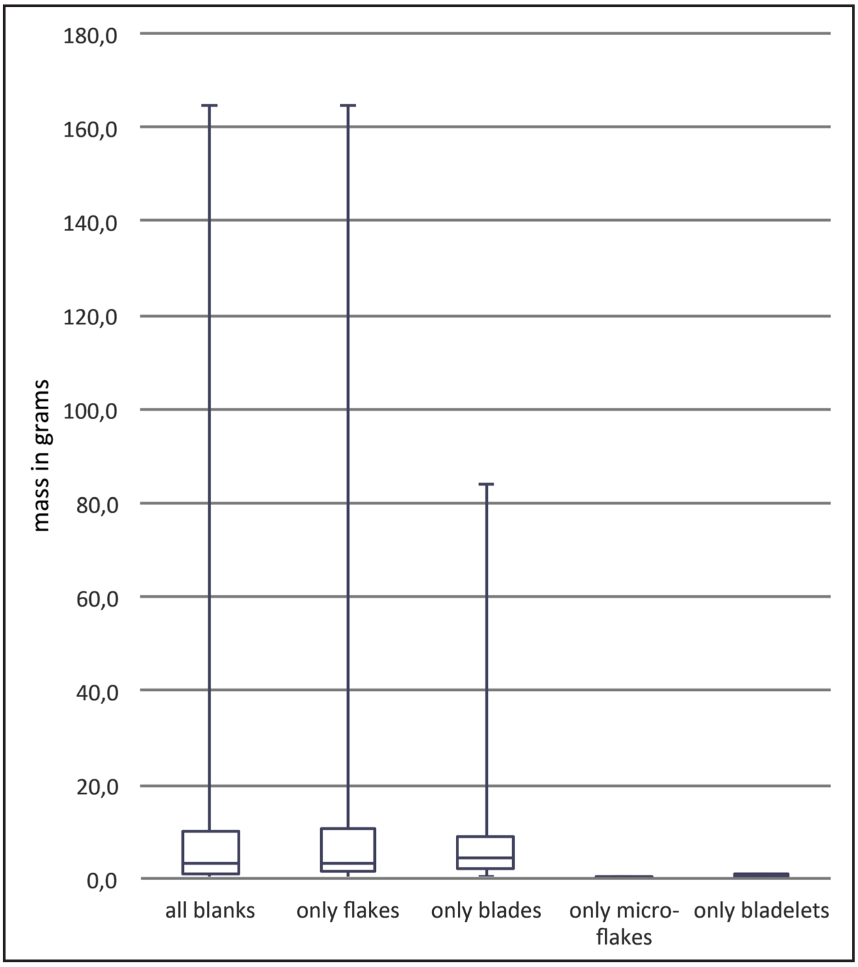

Fig. 222 - Boxplot of blank mass for all measured blanks from GH 3, as well as separated into blank types

The ratio of blanks with/without cortex equals 667:778=0.86 or 46,16% of all blanks have cortex. The analysed part of the assemblage of GH 3 therefore yields more blanks with than without cortex. The cortex ratio for the blank types is displayed in the lowermost row of tab. 191. This ratio differs for every blank type. Whereas for flakes the amount of blanks without cortex is lower than for cortical blanks, for all other blank type this ratio is the other way round. There is almost the same amount of cortical and non-cortical blades. For micro-flakes and for bladelets the number of non-cortical blanks is much higher than for cortical blanks. The overall thickness of cortex on all measured blanks (from all kinds of raw material) show similarities (fig. 223). The majority of cortex on all these blanks range in thickness between 0.5 and 1.3 mm. The longest whiskers are visible for flakes, with a range up to 7 mm in cortex thickness.

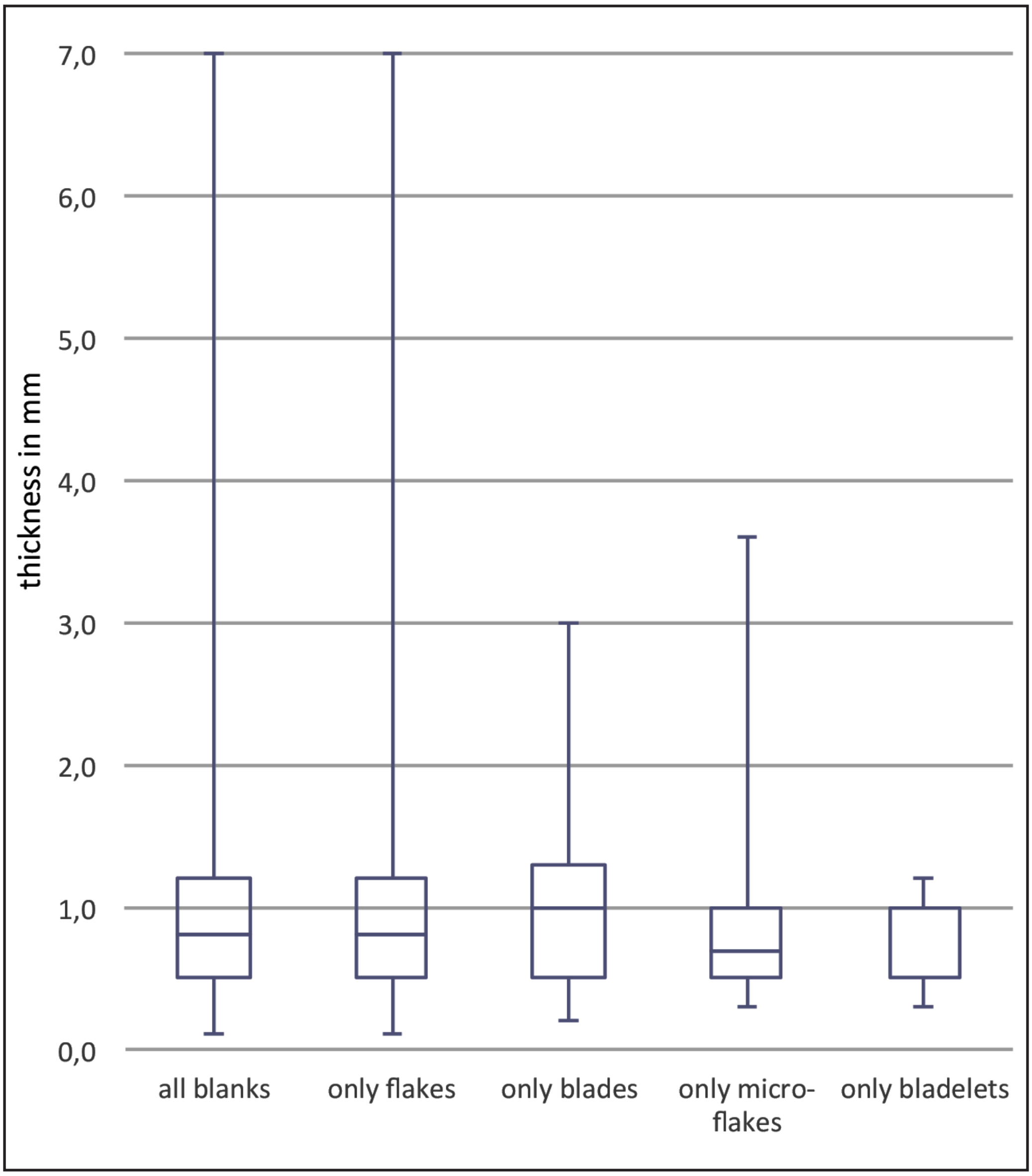

Fig. 223 - Thickness of cortex for all blanks, as well as the blank types from all raw materials from GH 3, displayed as box-plot

By splitting into raw material categories, the picture differs (see fig. 224). FAS has the biggest range in cortex thickness. Crystallin rocks, such as quartzite, quartz, quartzitic sandstone and sandstone have a small range. The box-plot values for raw material splitting are displayed in tab. 192:

Values	FAS	Chert varieties	Unknown flint	Unknown raw-material	Quartzite	Quartzitic sandstone	Quartz	Sandsto-ne
Minimum	0,1	0,3	0,2	0,8	0,2	1,0	0,2	1,0
Q1	0,5	0,8	0,5	1,2	0,3	1,0	0,2	1,0
Median	0,8	1,1	1,0	1,5	0,5	1,0	0,2	1,0
Q3	1,2	1,3	1,7	2,3	0,5	1,0	0,2	1,0
Maximum	7,0	2,0	4,0	3,0	1,3	1,0	0,2	1,0

Tab. 192 - Box-plot values for all blanks divided into raw material categories from GH 3

If we compare the amount of cortex of blanks with their size (fig. 225), we see that blanks without cortex (violet) scatter over the whole range in length and width, with the exception that in big dimensions there are less of these. The other blanks (with cortex) scatter also over the whole range in length and width. The picture differs for the view on thickness. Blanks without cortex are in their majority obviously thinner than blanks with cortex.

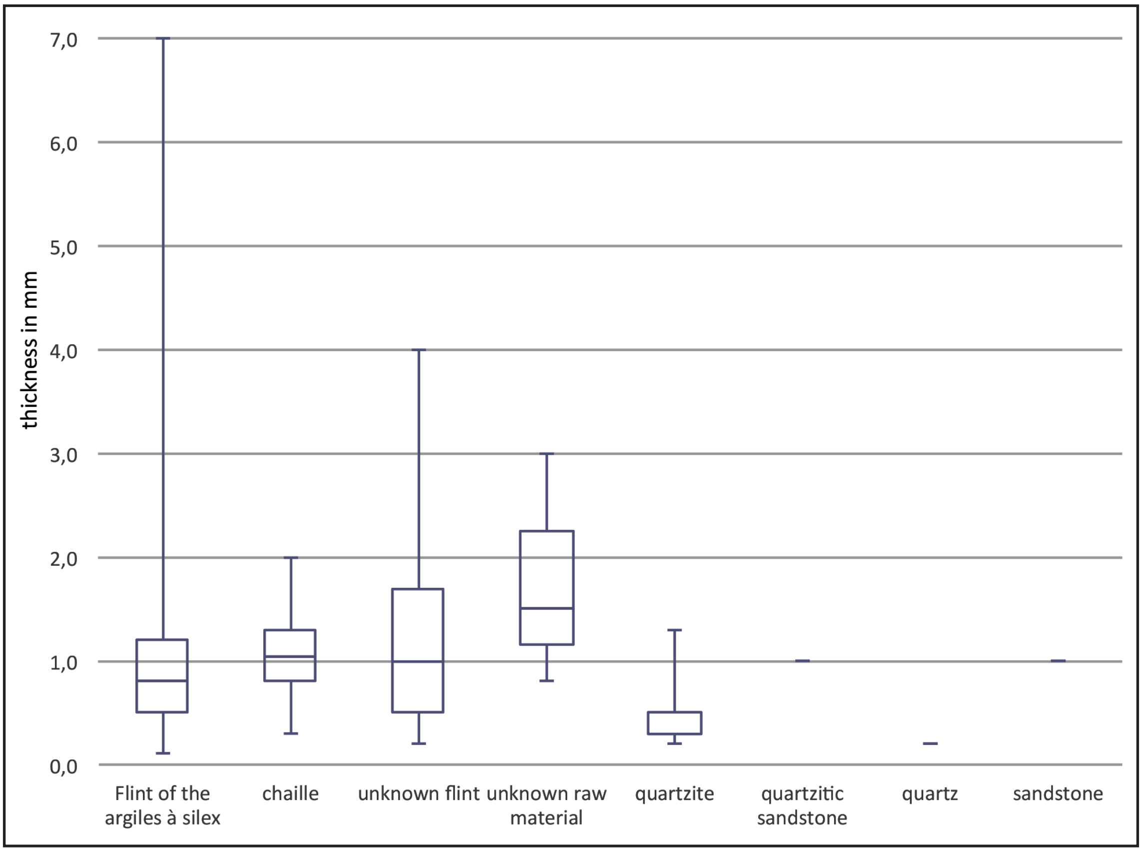

Fig. 224 - Thickness of cortex for all blanks divided into raw material categories from GH 3, displayed as box-plot

This observation is good visible in box-plots of blank thickness for the different amount of cortex (fig. 226).

Blanks (from FAS) with and without cortex show differences in size distribution. In tendency blanks without cortex are smaller than blanks with cortex. However both size distributions are quite close to each other, as displayed in fig. 227. But the bigger a blank is the more often it is covered by cortex.

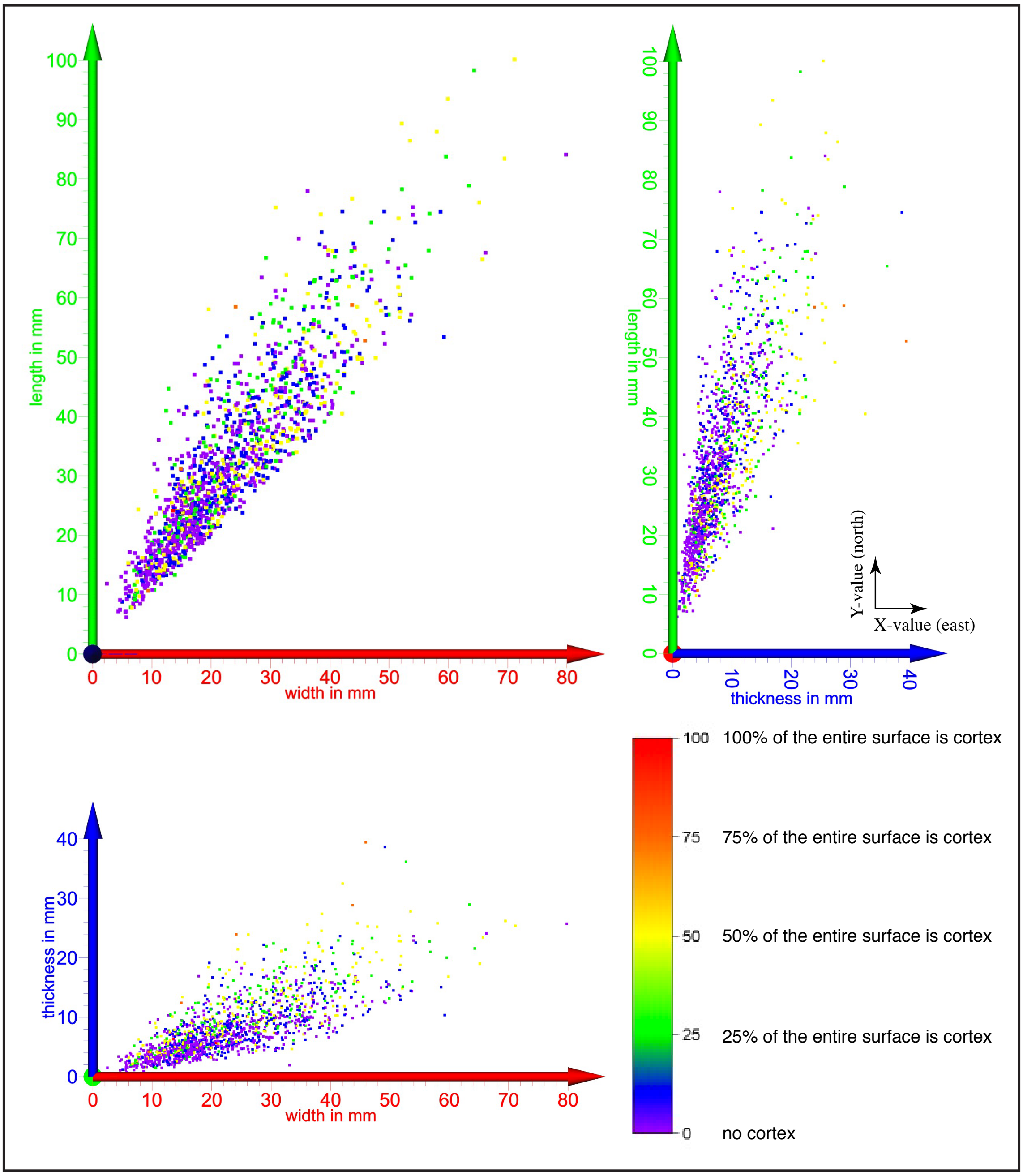

Fig. 225 - Scatterplot of the size of blanks from GH 3 sorted by their amount of cortex

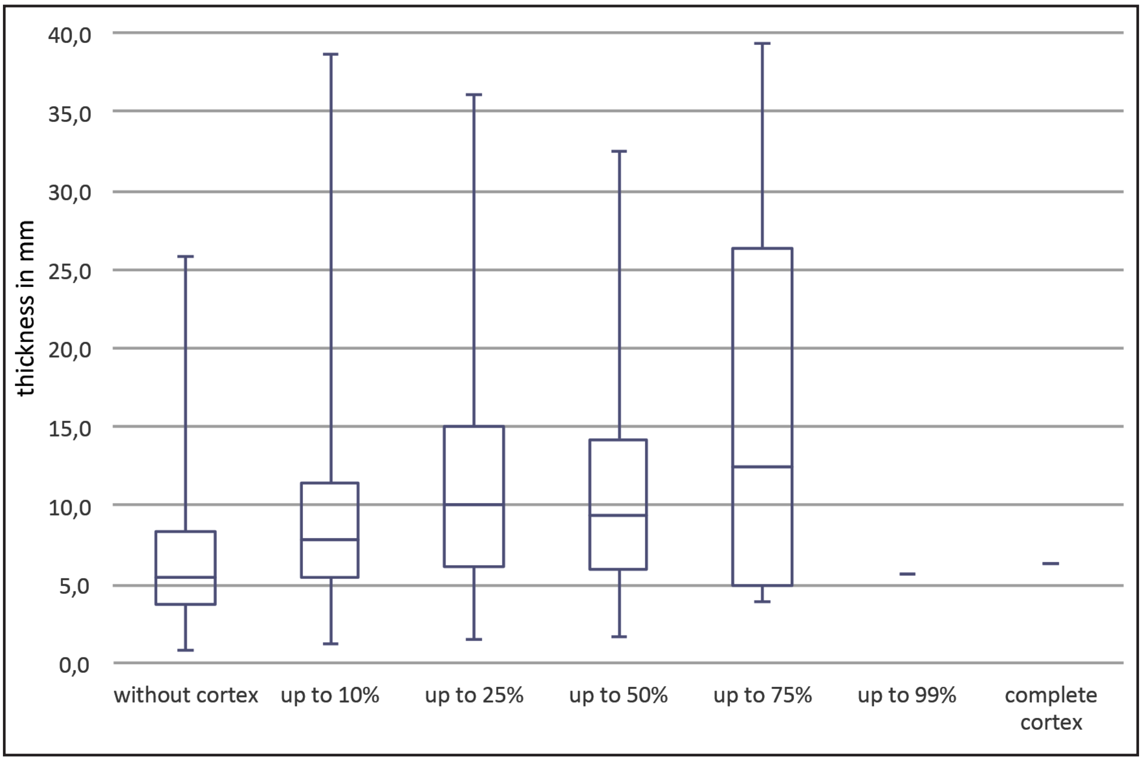

Fig. 226 - Boxplot of the thickness of blanks from GH 3 sorted by their amount of cortex

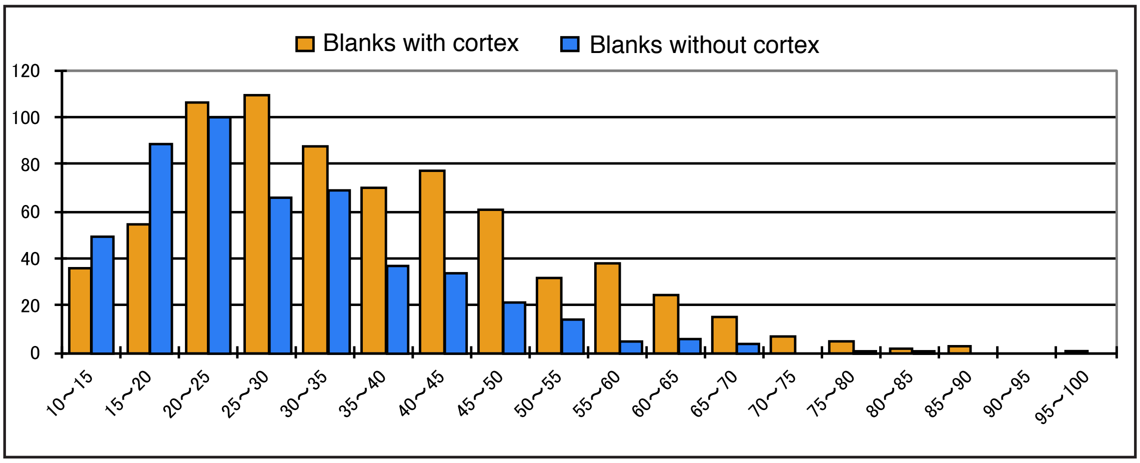

Fig. 227 - Blanks from FAS (from GH 3) with and without cortex, plotted by frequency in size distribution

Blank finials

Finials of blanks (the shape and structure of the terminal end of a blank) can only be compared for terminal fragments (n=330) or complete blanks (n=773). As it can be seen in tab. 193, there is a column with other fragments. These are fragments that broke in such a way that they cannot be classified as terminal fragment or complete blank or the kind of fragmentation is visible because the terminal end is modified. An example here would be an object from that at left lateral terminal position a piece was removed. The following tab. 193 lists them:

Finial	Terminal fragments	Complete blanks	Other fragments	Total
Feathered	180	390	67	**637**
Hinge	42	71	13	**126**

Plunging	24	42	12	**78**
Inflexed	19	48	9	**76**
Reflexed	6	18	3	**27**
Undetermined	60	208	993	**1261**
Total	**331**	**777**	**1097**	**2205**

Tab. 193 - Finials on blanks from GH 3

If we rivet on determined finials of terminal fragments and complete blanks, we see that feathered finials are the majority (n=637). If we further declare hinges, plunging, as well as inflexed and reflexed finials as consequence of knapping mistakes (n=307), there is a ratio of 637:307=2,07. This might be interpreted as every third blank of them ended in a finial failure. This observation leads to questions about the raw material as well as the expertise of knappers.

Comparison of features related to the technique of blanks production

This paragraph compares evidence of hard and soft hammer percussion on blanks from GH 3. In the course of data collection, the type of hammer for the production of blanks was determined for n=1230 blanks. The following tab. 194 shows the main criteria and number of blanks where the type of hammer was assumed:

Number **Criteria**	**Number of detected criteria at blanks assumed to be produces with hard hammer technique**	**Number of detected criteria at blanks assumed to be produces with soft hammer technique**
Bulb of percussion	806	74
Hertzian cone	773	36
Bulbar scar	577	25
Hackles	759	84
Ripples	1044	107
Lip	79	82
Number of blanks that show evidence of hard or soft hammer techniques	**1096**	**134**

Tab. 194 - Criteria and numbers of blanks made with hard- and soft-hammer techniques from GH 3

For better visualization of the differences, the following fig. 228 displays the data for tab. 194 as spider chart for hard and soft hammer (as done by Roussel 2005):

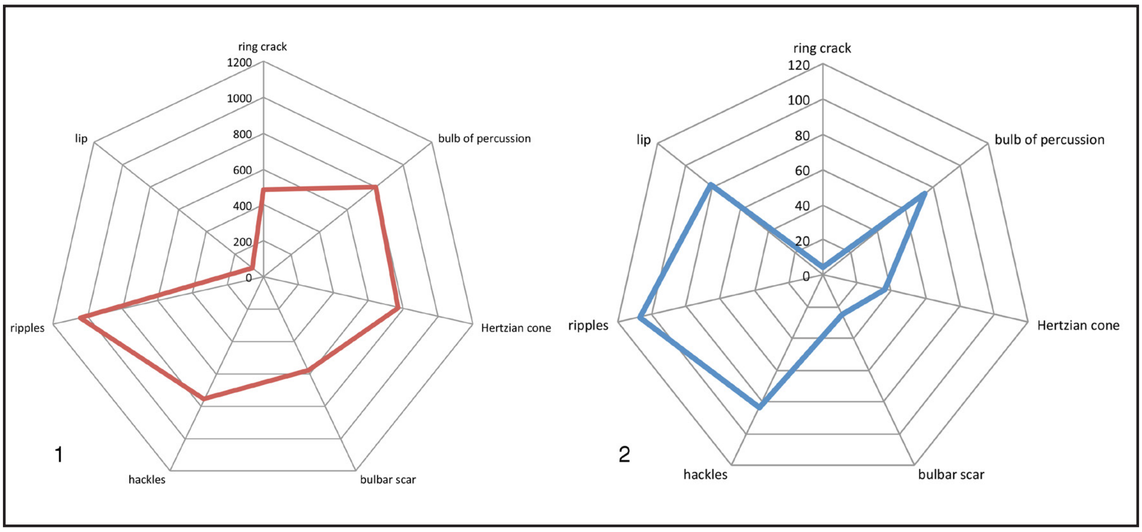

Fig. 228 - Comparison of criteria for the characterization of technique used in blank production of GH 3. 1) Hard hammer percussion; 2) Soft hammer percussion

The majority of blanks (where the type of technique has been characterized) seems to be produced using hard hammer techniques. The ratio of hard-to-soft hammer percussion is 1096:134=8.18:1 or in other words, 89% of the blanks are made with hard-hammer techniques.

Blank fragmentation

This section discuss blank fragmentation. The types of blank fragments are defined in chapter V.2.2. From GH 3 n=1033 blank fragments were detected. The following tab. 195 lists the defined fragment types and their counts:

Type of blank / Type of fragment	Flake	Blade	Micro-flake	Bladelet	Total
Basal	372	39	21	10	**442**
Basal right lateral	1	0	0	0	**1**
Basal left lateral	1	0	0	0	**1**
Medial	143	22	12	9	**186**
Right lateral	29	1	0	0	**30**
Left lateral	41	0	2	0	**43**
Terminal	285	20	20	4	**329**
Terminal right lateral	1	0	0	0	**1**
Terminal left lateral	0	0	0	0	**0**
Total	**873**	**82**	**55**	**23**	**1033**
Complete	704	31	30	8	**773**

Tab. 195 - Count of blank fragments from GH 3

For a better view, the following fig. 229 displays the total of all types of blank fragments as bar graph.

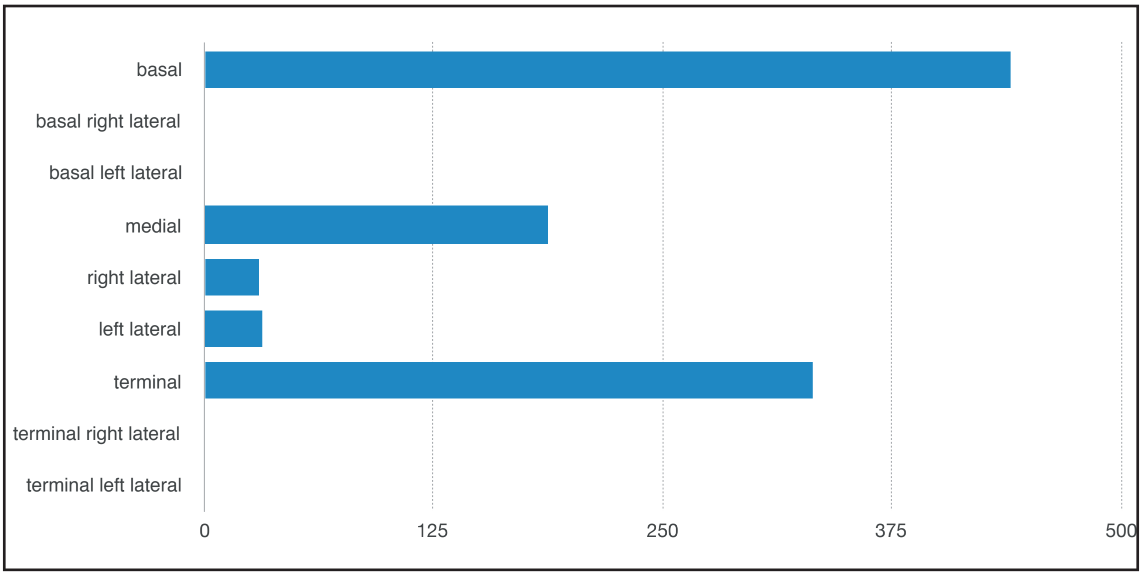

Fig. 229 - Bar graph of blank fragmentation from GH 3

The majority are basal fragments of flakes (n=372), followed by terminal fragments of flakes (n=285). This observation suggests some ideas of actions happened on-site. On the one hand, basal fragments could be the rest left in a haft, therefore re-tooling of hafts that contain broken insets could have happen on-site (see chapter X.9). On the other hand, the number of terminal fragments as well speaks for usage, break and discard of stone artifacts on site. It is noticeable that in total the majority of fragments from blanks are basal fragments.

Concerning their mass, the following box-plot shows that the majority of all measured fragments are quite light (see fig. 230). The median for flake fragments is at 2.8 g, for blade fragments 3.5 g, for micro-flake fragments 0.1 g and for bladelet-fragments 0.4 g.

The spatial distribution of blank fragments is shown in fig. 231. The scattering of complete blanks (black) and fragments (violet to red) suggest no obviously distinct distribution pattern (in top view, as well as in side views).

The next step is now to compare fragmentation with blank dimension (fig. 232). All types of fragmentation, as well as complete blanks (black) are scattered over the entire range of blank dimension.

Comparison of edge damage

The display and comparison of edge damage can give hints about taphonomic movement processes or repositioning during site occupation. Despite the fact that most of the artifacts show quite sharp edges, however there is evidence for edge damage. From all n=2205 blanks from GH 3, n=903 show different stages of damage on their edges. This range from very small outbreaks (I would assume from decomposition of the raw material) to fractures that removed bigger part of the edge. The vast amount of blanks showing fractures have breakage surfaces that own the same patination as the other surfaces (see tab. 196).

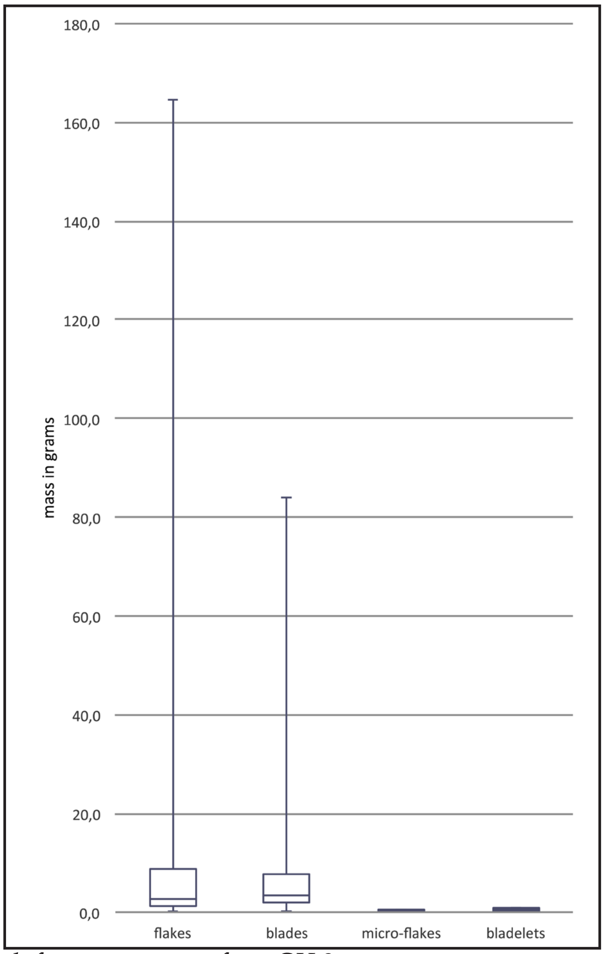

Fig. 230 - Boxplot of blank-fragment masses from GH 3

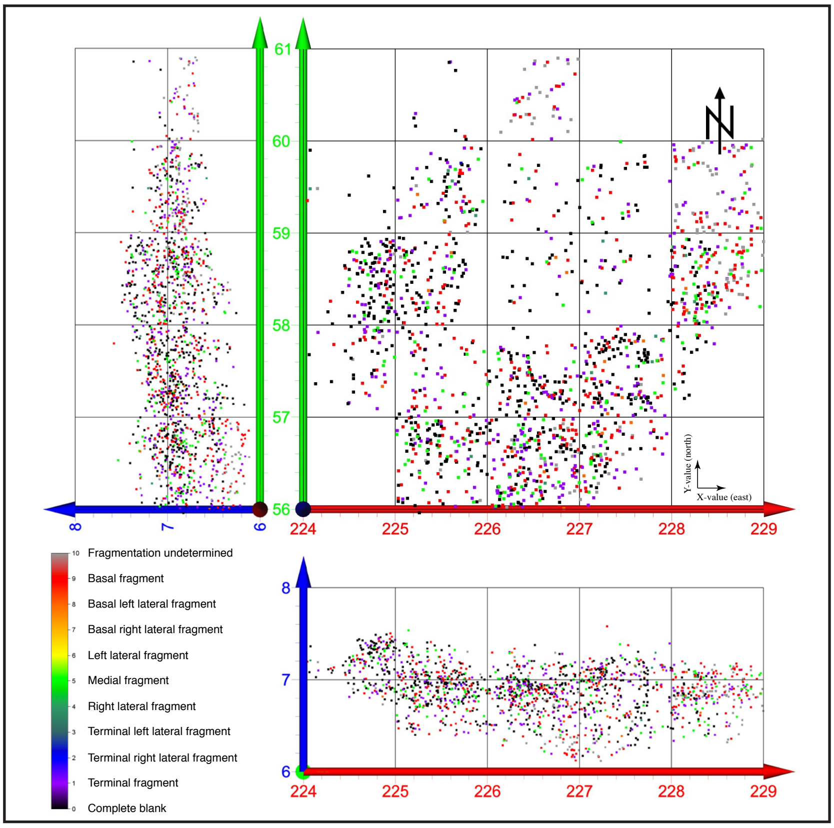

Fig. 231 - Spatial distribution of blank fragments from GH 3

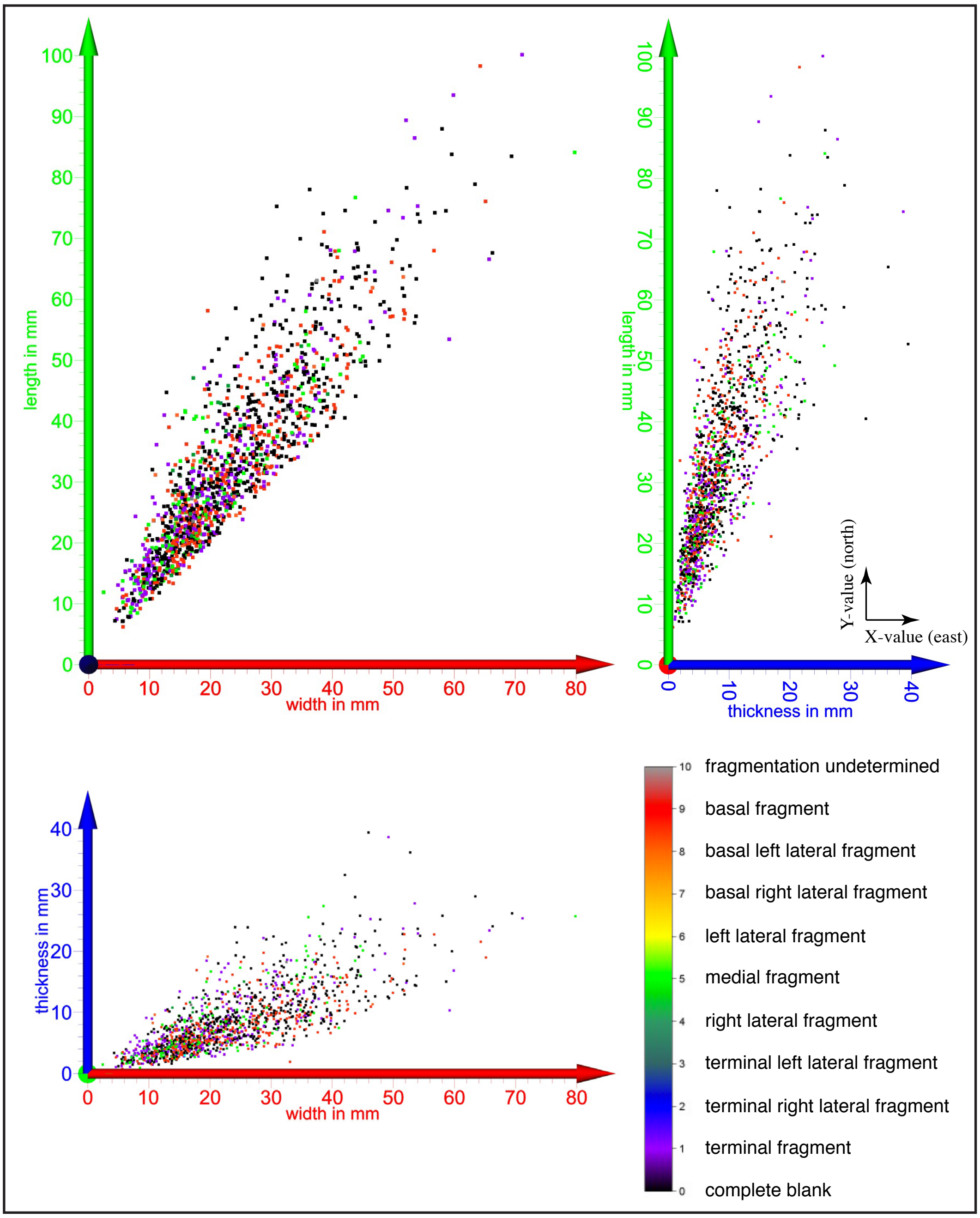

Fig. 232 - Dimensions of complete (black) and fragmented (color) blanks from GH 3

Fragmentation Edge damage	Complete blanks	Basal fragments	Medial fragments	Terminal fragments	Total
Small outbreaks	183	64	18	50	**315**
Fractures	6	243	175	24	**448**
Number of blanks showing outbreaks and fractures	183	286	191	243	**903**

Tab. 196 - Edge damage on blanks from GH 3

We have to pay attention, because it is not possible to do a simple addition of the kinds of edge damage. One blank can have or not have small outbreaks on some edges and also have or not have fractures on edges too. But we see that in total blank fragments show much more heavy damage (fractures, n=442) than complete blanks (n=6).

Morpho-geometric comparisons of blanks

For blanks, three kinds of morph-geometric outlines were determined, the outline in top-view, the outline in side-view and the outline of the cross section. For n=1435 blanks the outline in these three views were determined. The following tab. 197 gives an overview about morpho-geometric features of these blanks:

Morpho-geometry	Top-view	Side-view	Cross-section	Number per morpho-geometric type
Triangular	93	330	528	**951**
D-shaped	108	88	196	**392**
Parallelogram	34	66	19	**119**
Rectangular	113	54	14	**181**
Trapezoid	238	462	316	**1016**
Oval	237	4	6	**247**
Round	1	0	0	**1**
Deltoid	9	1	1	**11**
Pentagon	371	181	89	**641**
Arch	30	124	24	**178**
Octagon	1	0	0	**1**
Hexagon	153	36	24	**213**
Heptagon	19	1	1	**21**
L-shaped	10	0	1	**11**
Lenticular	4	78	213	**295**
Sinus-shaped	2	8	3	**13**
Polyangular	3	0	0	**3**
Drop-shaped	3	1	0	**4**
Quadrant (a quarter of a circle)	6	1	0	**7**
Total	**1435**	**1435**	**1435**	

Tab. 197 - Morpho-geometry of n=1435 blanks from GH 3 (red fields are empty)

As tab. 197 shows, trapezoid (n=1016), followed by triangular (n=951) are the majority. If we have a closer look on cross-section, we seen more triangular shaped blanks (n=528) than trapezoid (n=316). Which could mean that much more blanks were produced without preceding blank detainment on the same geometric plane (see fig. 233).

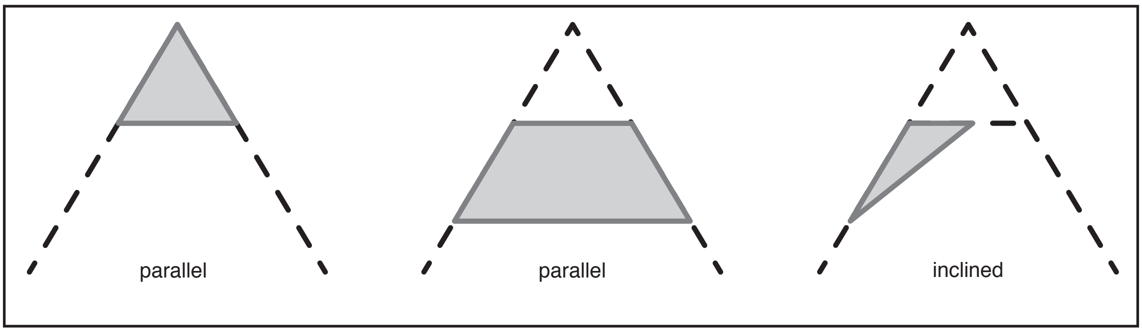

Fig. 233 - Shape of a flaking surface (in cross section) for triangular and trapezoid blanks in regard to orientation of the geometric plane of preceding and following blanks

In discussions about techno-types (Koehler 2009b) or predetermination of blank shape (e.g., Mourre 2006; Shimelmitz et al. 2014; Van Peer 1992), blank shape normally refers to the shape in top-view. For blanks the reference is normally the view on the dorsal face.

By comparing the outline of the top-view of blanks from GH 3, n=19 different morph-geometric types were realized. The mean of these types is 75.5, which is used to separate them into morpho-geometric types with less than 75.5 numbers and more. Types with a small number are parallelogram, round, deltoid, arch, octagon, heptagon, L-shaped, lenticular, sinus-shaped, polyangular, drop-shaped and quadrant. Type with a high number of pieces are triangular, D-shaped, rectangular, trapezoid, oval, pentagon and hexagon. In a simplistic equation we would say that these shapes of the top-view of blanks are the wanted shapes, because they are present in a high number of pieces. Pentagonal, oval and trapezoid outlines of blanks were therefore the most favored morpho-geometric types for blanks during the occupation visible in GH 3.

The side view reflects at first litho-mechanical properties, such as the convexity of the bulb of percussion, the flat plane after the bulb and the normally quite S-shaped outline of the ventral face of a blank (Bertouille 1989; see also Van Peer 1992). For that reason, the shape of the side-view of a blanks is quite limited (mostly a triangle, here n=528), if the blank is complete and produced without knapping mistakes (feathered finial). Other shapes of the side-view should be influenced by core morphology, blank modification or knapping results.

Dorsal scar patterns on blanks

The directions and constellation of negatives on the dorsal face of blanks reflect previous detachments of a core's surface. The following tab. 198 presents these scar patterns for blanks of GH 3. Overall, for n=1291 blanks the direction and constellation of negatives was determined:

Direction of negatives on the dorsal face	All blanks
Unidirectional-parallel	**632**
Unidirectional-convergent	**151**
Unidirectional-divergent	**9**
Unidirectional-orthogonal	**133**
Bidirectional-parallel	**113**
Bidirectional-convergent	**32**
Bidirectional-divergent	**0**
Bidirectional-orthogonal	**0**
Centripetal	**223**
Non-determinable	**134**
Non-determined	**778**
Total	**2205**

Tab. 198 - Scar patterns on dorsal faces of blanks from GH 3

By comparing these dorsal scar patterns with the total size of the blanks, there is a significant correlation visible (fig. 234). On the one hand, unidirectional scar patterns are much more often present on flat blanks. On the other hand, centripetal pattern (as well as in a smaller amount bidirectional) are more often situated on thicker blanks (see fig. 235). The median from unidirectional is at 6.0 mm, for bidirectional at 8.3 mm and for centripetal at 9.2 mm. The thickness of blanks without detectable scar pattern (mostly cortical blanks) scatter much more. The values of the box-plot are displayed in tab. 199:

Values	Unidirectional scar pattern on dorsal face	Bidirectional scar pattern on dorsal face	Centripetal scar pattern on dorsal face	Non-determinabel scar pattern on dorsal face
Minimum	0.8	1.2	2.3	1.6
Q1	4.1	5.5	6.6	6.1
Median	6.0	8.3	9.2	9.7
Q3	9.3	11.9	13.1	14.2
Maximum	32.5	38.7	36.2	39.4

Tab. 199 - Boxplot values of blank thickness compared to dorsal scar pattern

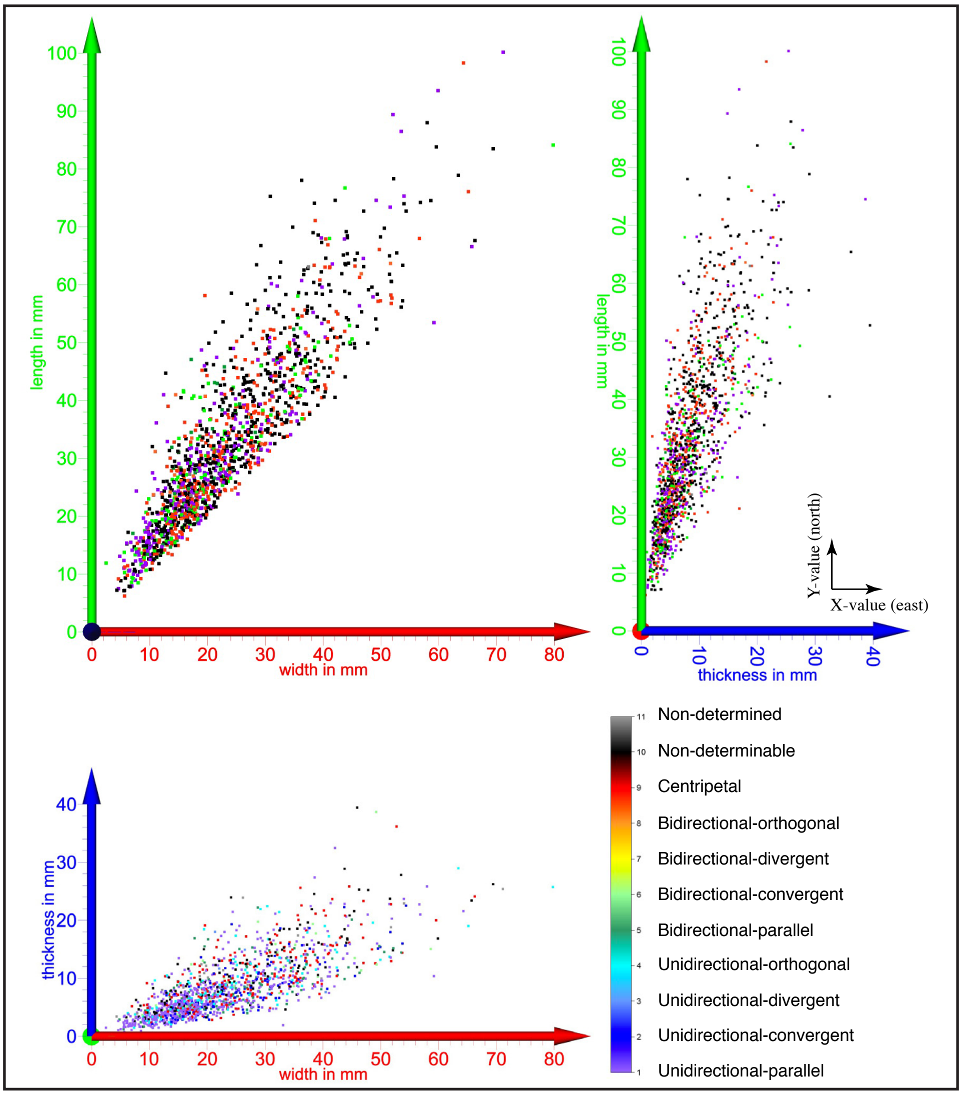

Fig. 234 - Scatterplot of dorsal scar pattern and total size of blanks from GH 3

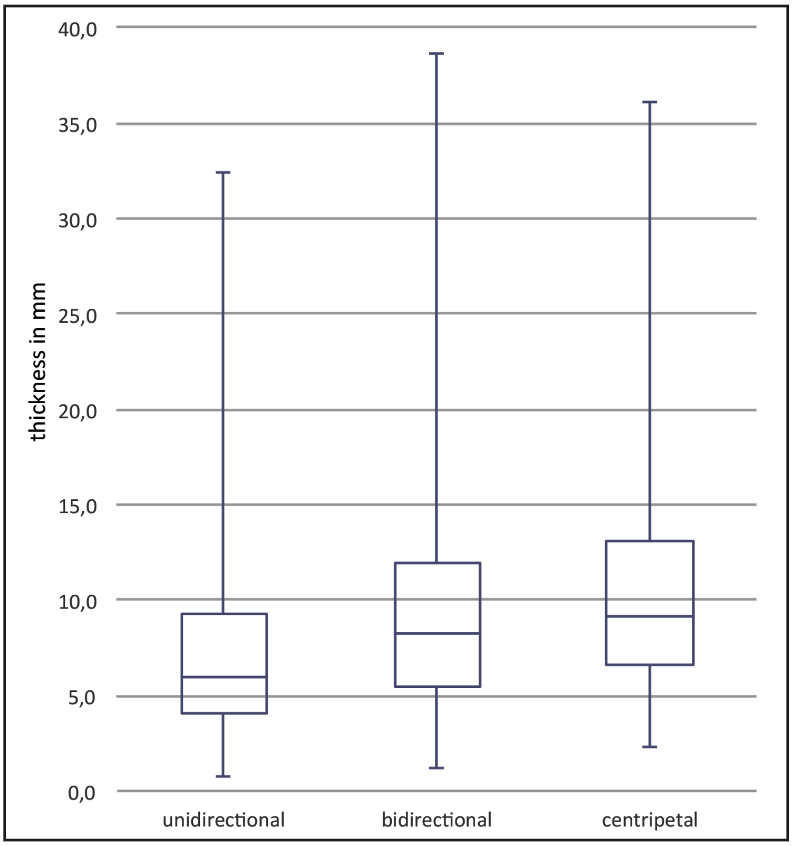

Fig. 235 - Boxplot of dorsal scar direction and thickness of blanks from GH 3

Blanks with heat or frost influence

There are n=44 blanks showing influence of heat. The observable features of heat influence visible on flint of the *argiles à silex* (FAS) are listed in Frick et al. (2012). N=36 are from FAS, n=4 are from chert, one is from Quartz, n=2 are from unknown flint and one from an unknown raw material.

The distribution of these heat influenced blanks is displayed in fig. 236. They are loosely scattered over the area of the excavated GH 3. The smaller objects (blue dots, micro-flakes) are scattered only in the north-eastern part. In side-view, they are scattered between a Z-value of 6.4 to 7.1. It is observable that in row 225 (the area in front of the West wall of the cave tunnel), there are no heated artifacts visible.

Heated blanks are in size in a medium range (see fig. 247), with a median in their maximum length of 35,8 mm. Only n=5 blanks were detected that show influence of frost. All are flakes from FAS. The dimensional measurement is displayed as box-plots in fig. 238. From the observed features of heat influence on FAS (see Frick et al. 2012) an important reason could be that FAS contains often micro-cracks which can contain water. This circumstance leads to explosive expansion during heating processes. In the heating experiments done in 2012 in a fire place, as well as in a muffle kiln this was very obvious. Therefore it is assumed that the early humans at VP II knew that too.

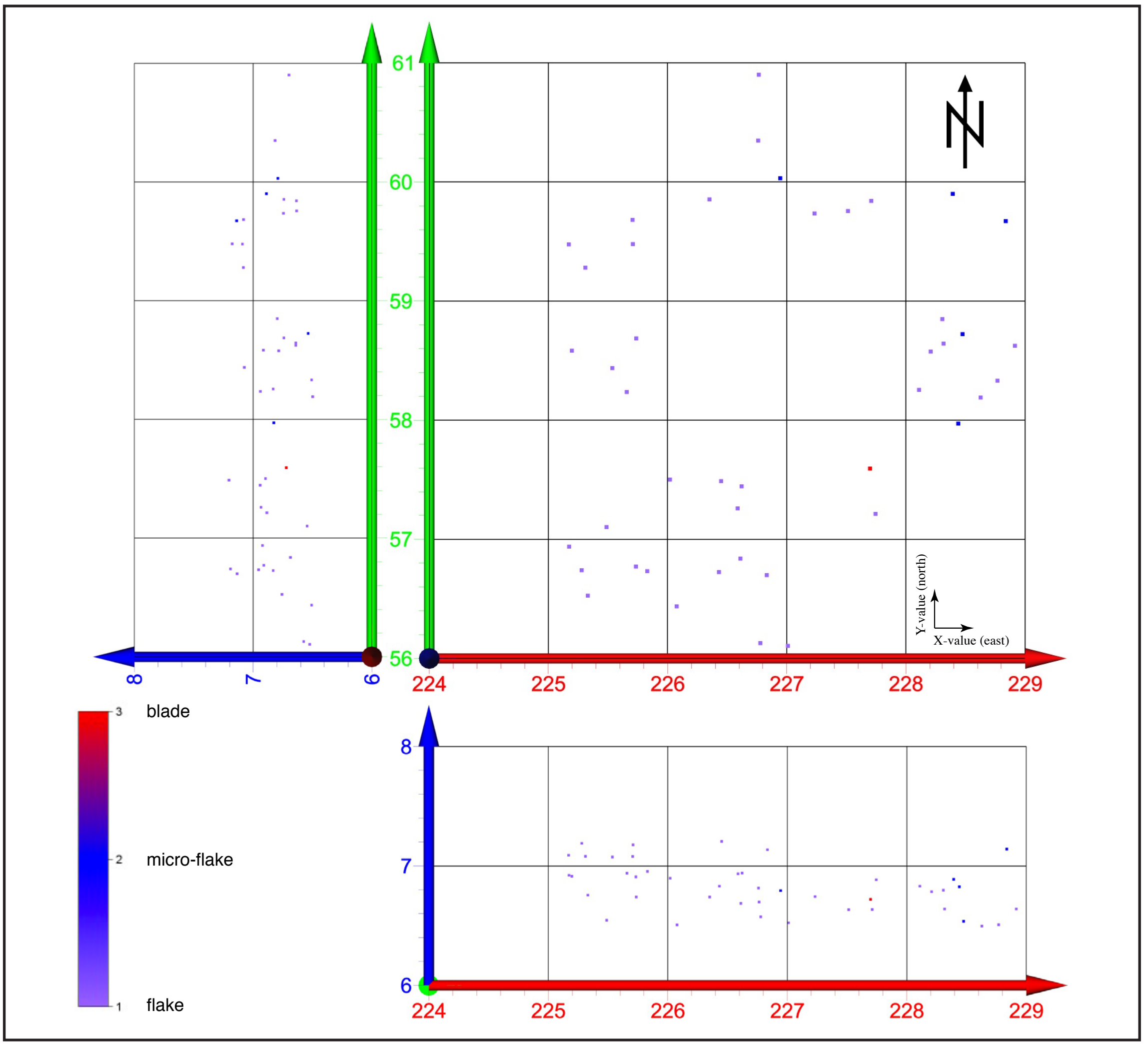

Fig. 236 - Spatial distribution of blanks with heat influence from GH 3

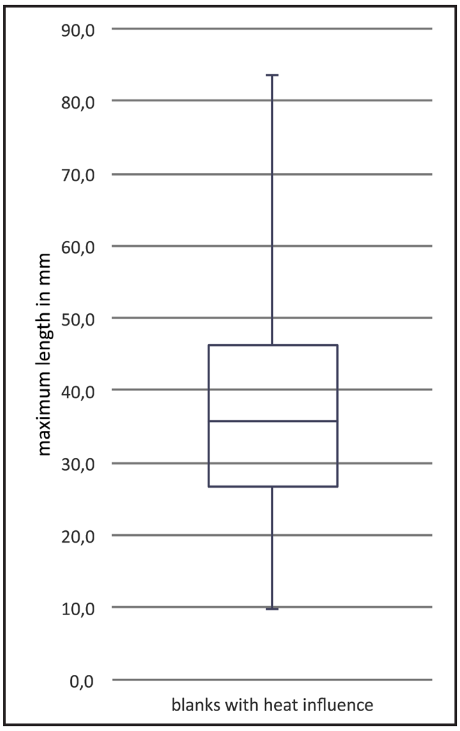

Fig. 237 - Boxplot of maximum length of blanks with heat influence from GH 3

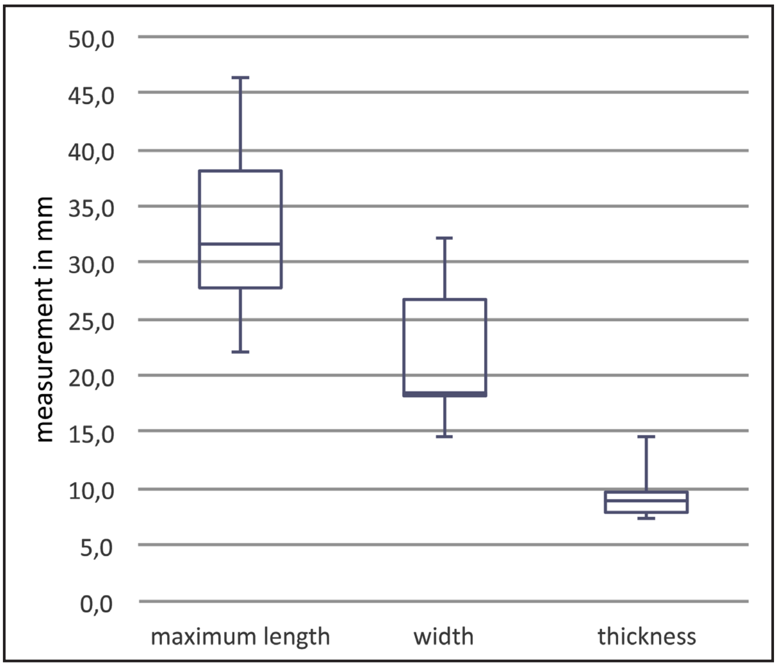

Fig. 238 - Boxplot of dimensions for five blanks showing influence of frost from GH 3

VII.11.6 Blank platforms

Introduction

In addition to measurement of dimension (width and thickness), as well as exterior and interior platform angle, non-metrical features of blank platforms were also collected (see tab. 200). In total n=952 blank platforms were measured and/or determined.

Non-metrical feature	Description of the feature
Shape of the platform	Arch, broken, chapeau de gendarme, D-shaped, lenticular, line, oval, parallelogram, rectangular, removed, round, sinus-shaped, splintered, trapezoid, triangle
Number of negatives	Numbers of negatives visible on the platform
Is there cortex left on the platform?	Presence of cortex on the platform
Morphology of the edge between platform and ventral face	Broken, concave, convex, nosed, removed, sinus-shaped, straight
Morphology of the edge between platform and dorsal face	Broken, concave, convex, nosed, removed, sinus-shaped, straight
Position of the impact point(s)	Centered, left side, right side, unknown
Number of impact points	One, two, three, four, unknown
Is the ring crack visible	Visibility of the ring crack
Morphology of the lip, if there is one	Broken, broken off, clearly visible, non, only slightly visible, splintered
Morphology of the bulb of percussion	Broken after production, broken during production, broken off, flat, highly visible and big, removed, splintered, stepped, two, wide, small
Morphology of the hertzian cone	Broken after production, broken during production, broken off, diffus, indistinct, non visible, removed, two or three visible, very big, wide

Tab. 200 - List of non-metrical features on blank platforms

Dimension of blank platforms

Thickness and width of blank butts are shown in fig. 239. Flake butts (violet) are dimensional spread over the complete range. Butts of blades (red) are scattered in the lower half of the dimensional range. Butts of bladelets (green) and micro-flakes (blue) are small.

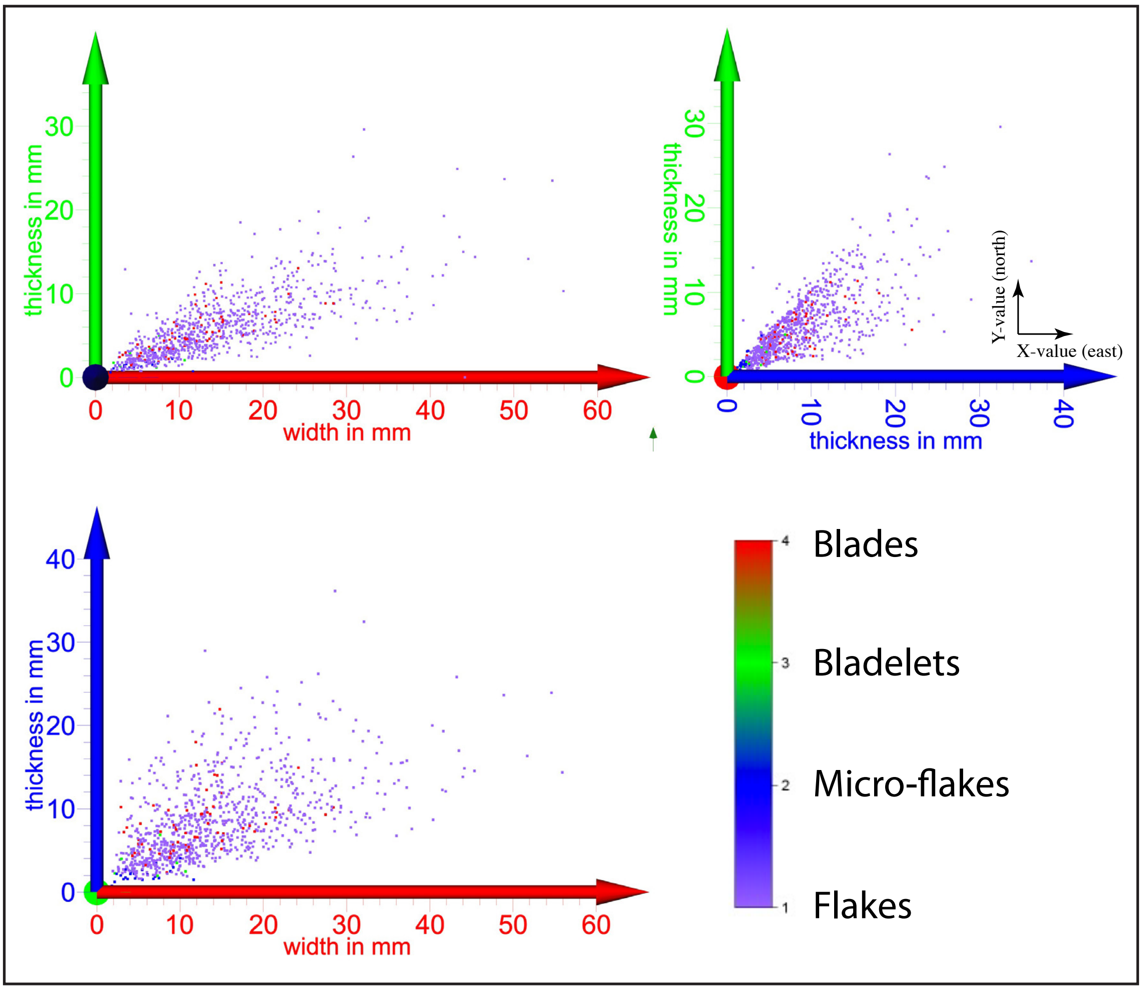

Fig. 239 - Scatterplot of thickness and width of blank butts of the different blank types from GH 3

Boxplots offer more information about platform dimension. On closer consideration of the platform dimension of all measured blanks from GH 3 (fig. 240), the range in width runs from 0.2 to 55.9 mm and the thickness from 0.6 to 29.6 mm. The median for width lays at 12.2 mm and for thickness at 5.1 mm.

The comparison between platform dimension of flakes (fig. 241) and blades (fig. 242) is given in tab. 201. The values for flakes a quite close to all blanks. Blade platforms are in average smaller that flakes platforms.

Platform dimension	All blanks		Only flakes		Only blades	
Values	Platform width	Platform thickness	Platform width	Platform thickness	Platform width	Platform thickness
Minimum	0.2	0.6	0.2	0.8	2.9	1.4
Q1	7.9	3.1	8.2	3.2	8.3	3.4
Median	12.2	5.1	12.6	5.2	11.8	4.8

Q3	18.2	7.6	18.7	7.7	15.0	6.9
Maximum	55.9	29.6	55.9	29.6	28.4	13.0

Tab. 201 - Boxplot values for platform width and thickness of all measured blanks, of only flakes and only blades from GH 3

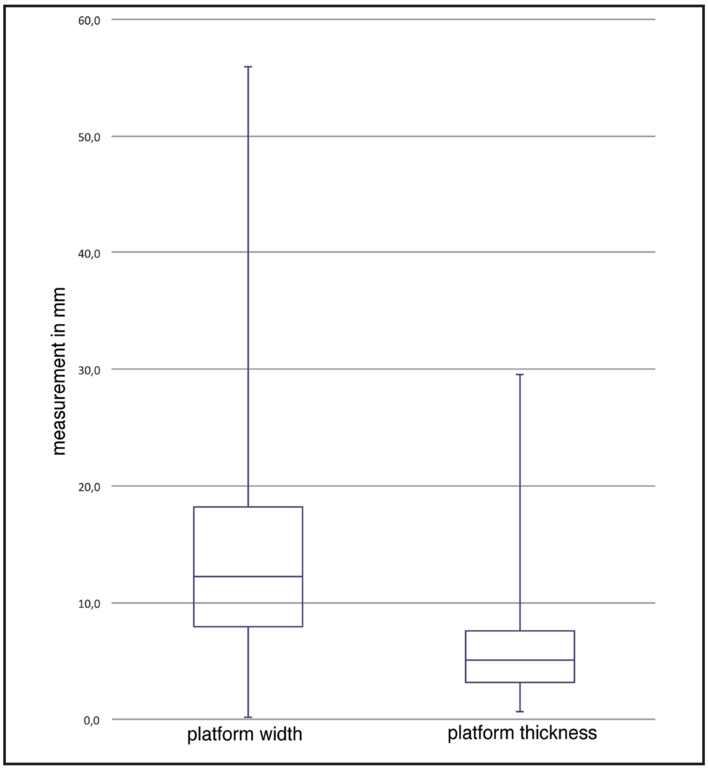

Fig. 240 - Boxplot for platform width and thickness for all measured blankes from GH 3

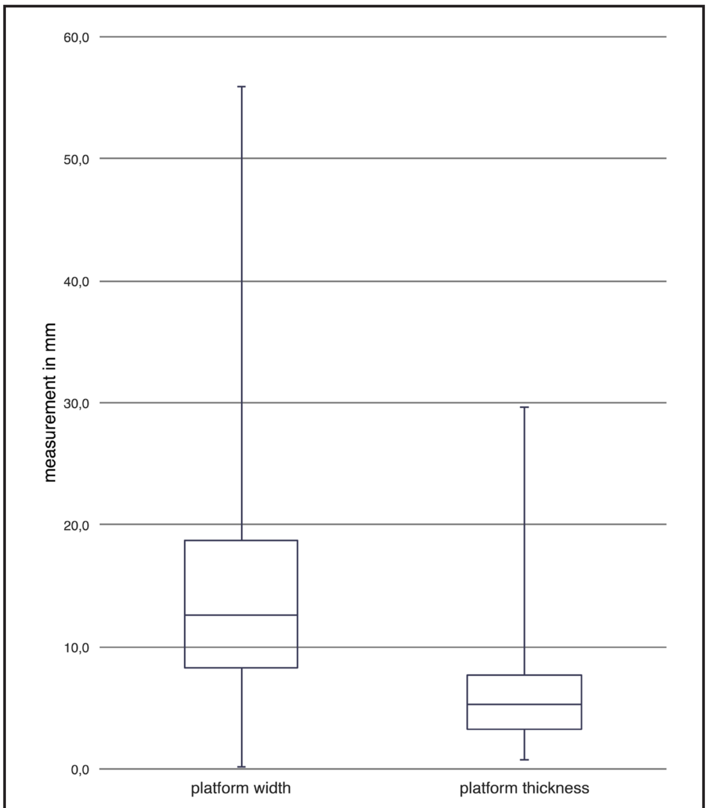

Fig. 241 - Boxplot for platform width and thickness for flakes from GH 3

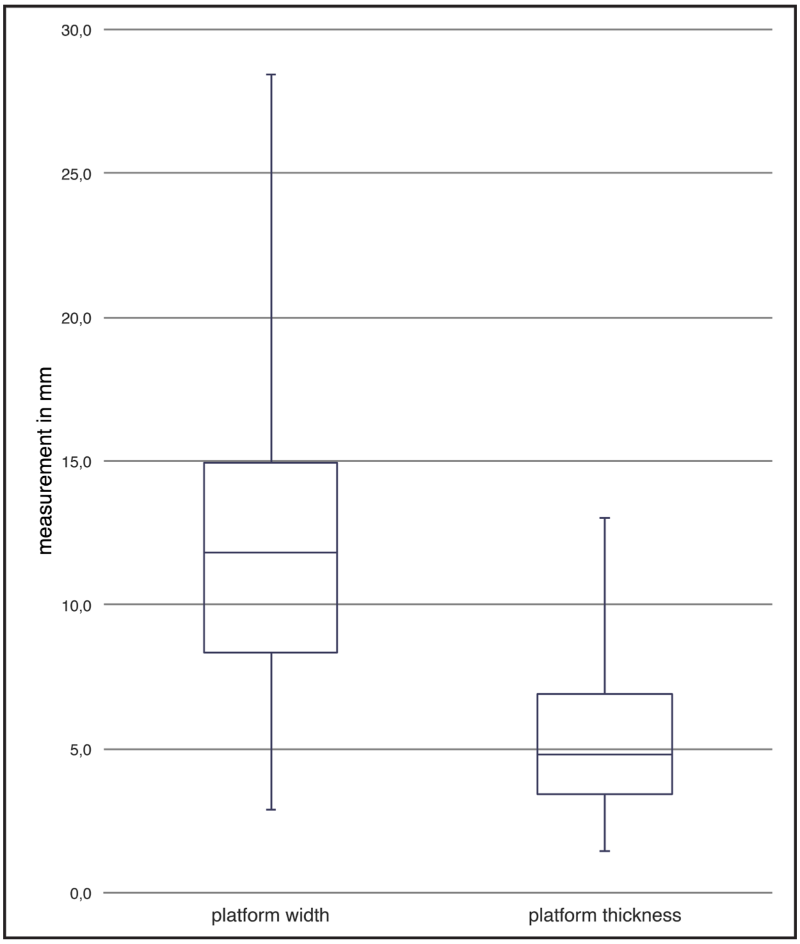

Fig. 242 - Boxplot for platform width and thickness for blades from GH 3

Exterior and interior platform angle

For at least n=886 blanks (n=794 flakes and n=67 blades), the exterior (EPA), as well as the interior (IPA) platform angle was measured (see the box plot in fig. 243 to 245). The median of all exterior platform angles (for the complete series, as well as for flakes or blades) is 73°. For the interior platform angle the median differs only slightly (for all blank and also for the flakes at 116° and for blades at 115°). So at first, the working hypothesis is that for the knappers during GH 3, an exterior platform angle of 73° is ideal. The following tab. 202 display these boxplot values:

Platform dimension	All blanks		Only flakes		Only blades	
Values	Exterior platform angle	Interior platform angle	Exterior platform angle	Interior platform angle	Exterior platform angle	Interior platform angle
Minimum	29	17	29	17	48	92
Q1	64	108	64	108	67,5	109
Median	73	116	73	116	73	115
Q3	79	124	79	125	80	122
Maximum	117	151	117	147	98	151

Tab. 202 - Boxplot values for exterior and interior platform angle of all measured blanks, as well as of only flakes and only blades from GH 3

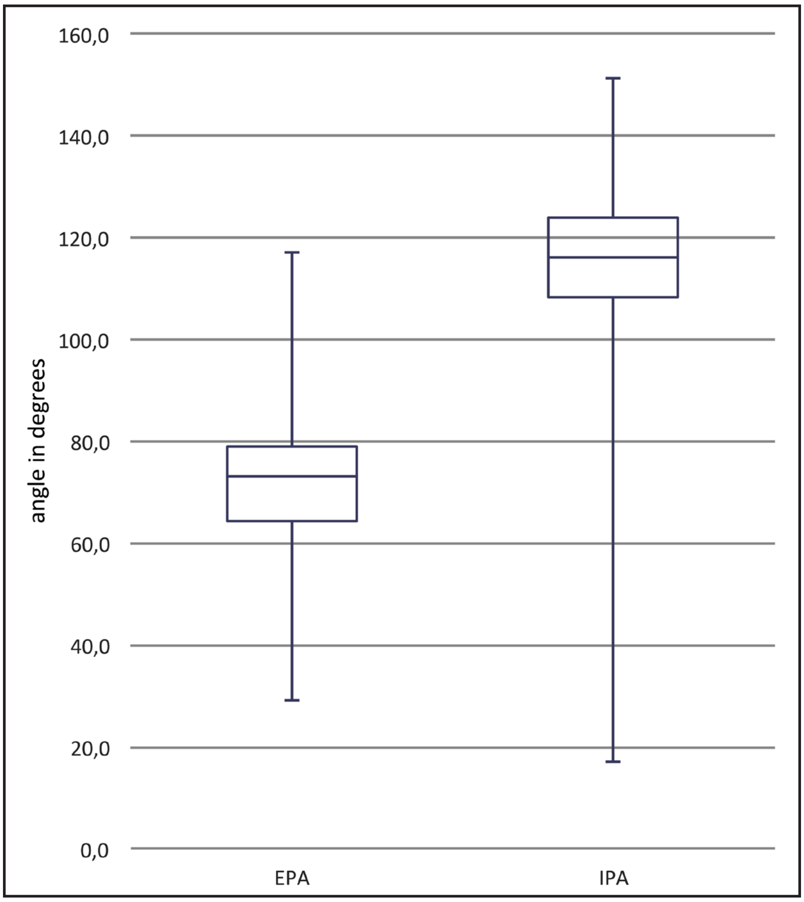

Fig. 243 - Boxplots of the exterior and interior platform angle of all measured blanks from GH 3

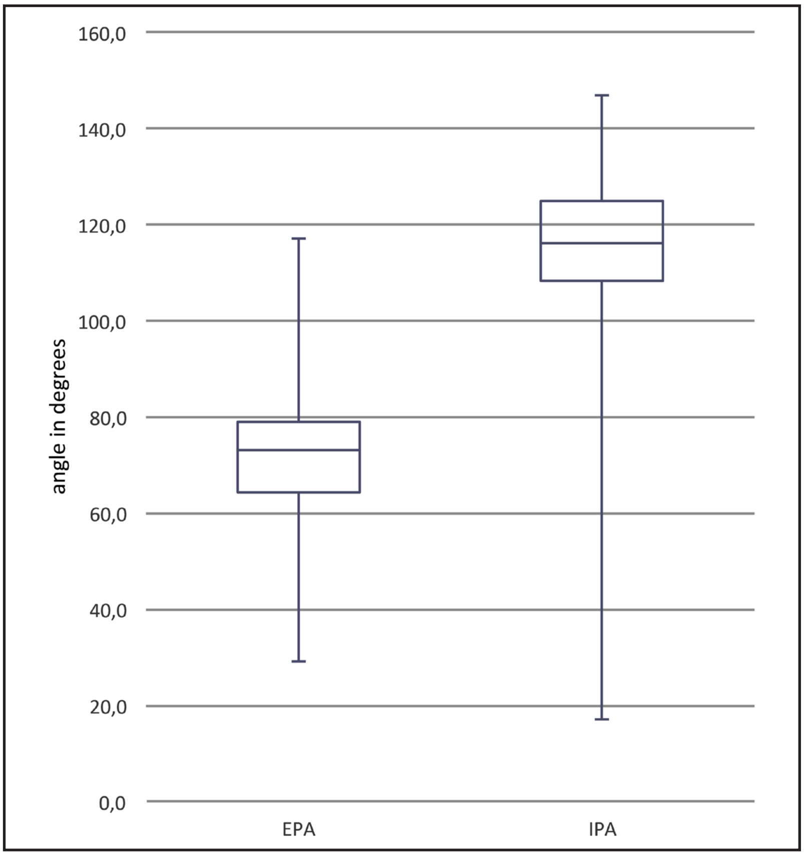

Fig. 244 - Boxplots of the exterior and interior platform angle of all measured flakes from GH 3

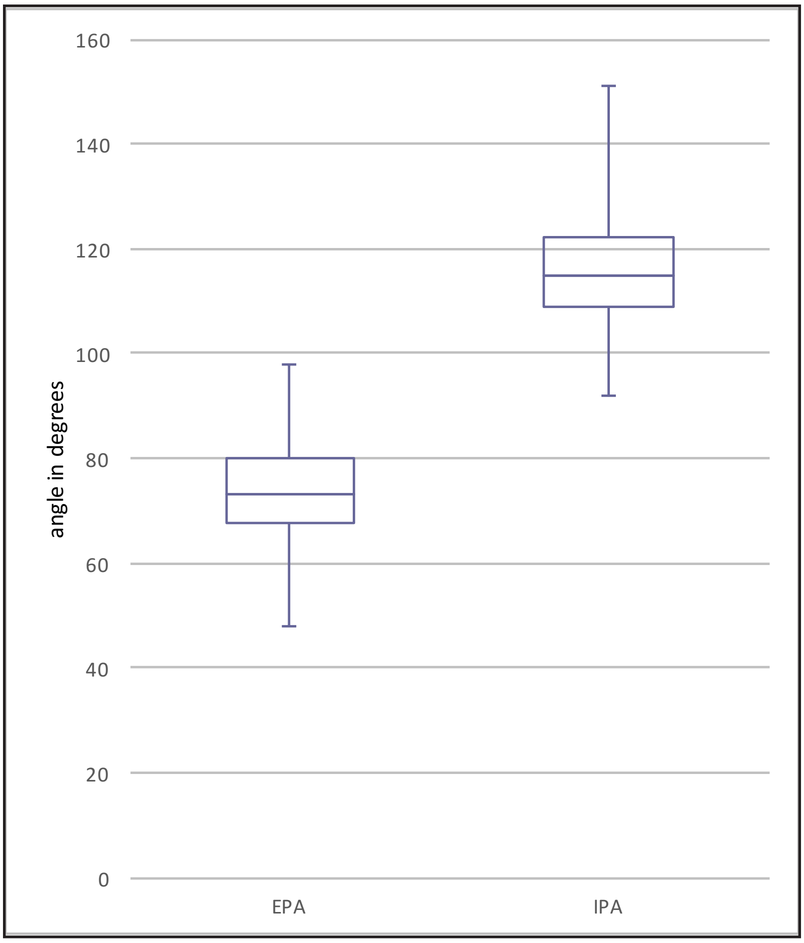

Fig. 245 - Boxplots of the exterior and interior platform angle of all measured blades from GH 3

But if we compare EPA and IPA of hard (n=800) and soft hammer (n=76) techniques, the differences are quite distinctive (fig. 246). Angles of hard hammer techniques are in median bigger than for soft hammers. The boxplot values are visible in tab. 203:

Platform dimension	Hard hammer		Soft hammer	
Values	Exterior platform angle	Interior platform angle	Exterior platform angle	Interior platform angle
Minimum	29	17	40	81
Q1	65	109	55	102,8
Median	73	116	65	113,5
Q3	79,3	124	74,3	122,5
Maximum	117	146	115	151

Tab. 203 - Boxplot values for EPA and IPA for hard and soft hammer techniques for blanks from GH 3

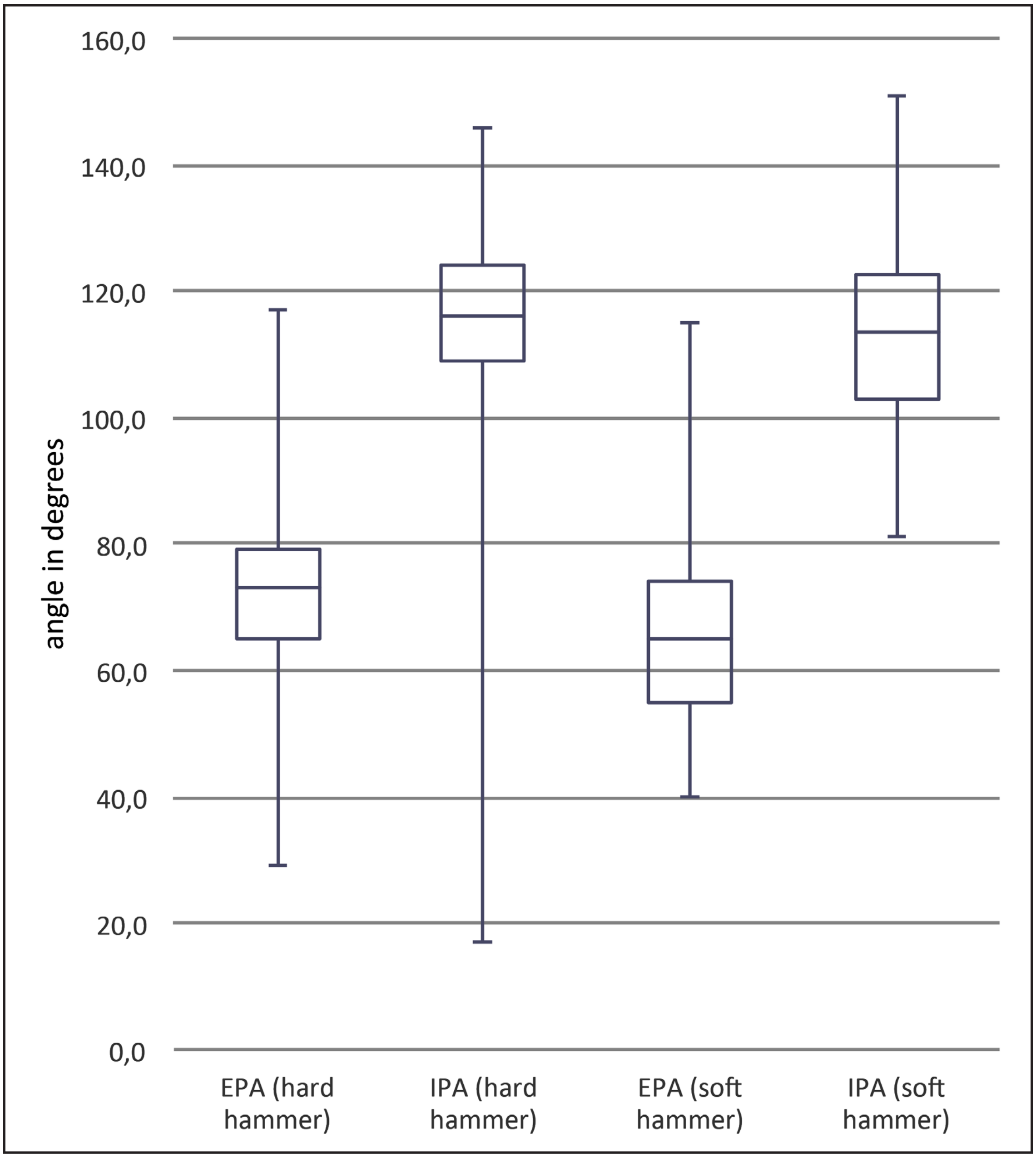

Fig. 246 - Comparison of EPA and IPA for hard and soft hammer techniques for blanks from GH 3

The mean of the ratio of EPA-to-IPA (EPA/IPA) equals 0,63 for all measured blanks. By comparison of platform dimension and exterior platform angle with the help of a ternary plot (see fig. 247) a highly interesting pattern of three clusters appears (the values for platform width and thickness are multiplied with hundred). The corners represent 100% of the value written. But without further division (e.g., soft versus hard hammer, blank type or blank class) there is no obvious explanation for this pattern.

If the ternary plots are separated by detected knapping technique (soft hammer versus hard hammer), the pattern still exists (see fig. 248). At the moment this pattern cannot be explained by a separation into two different knapping techniques (which was obviously a hope in this context).

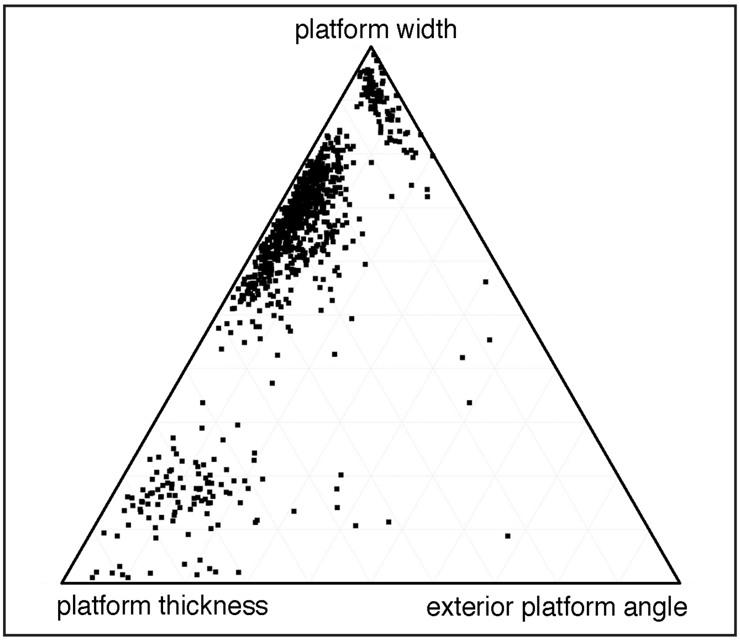

Fig. 247 - Ternary plot of platform width and thickness (multiplied with hundred) and exterior platform angle

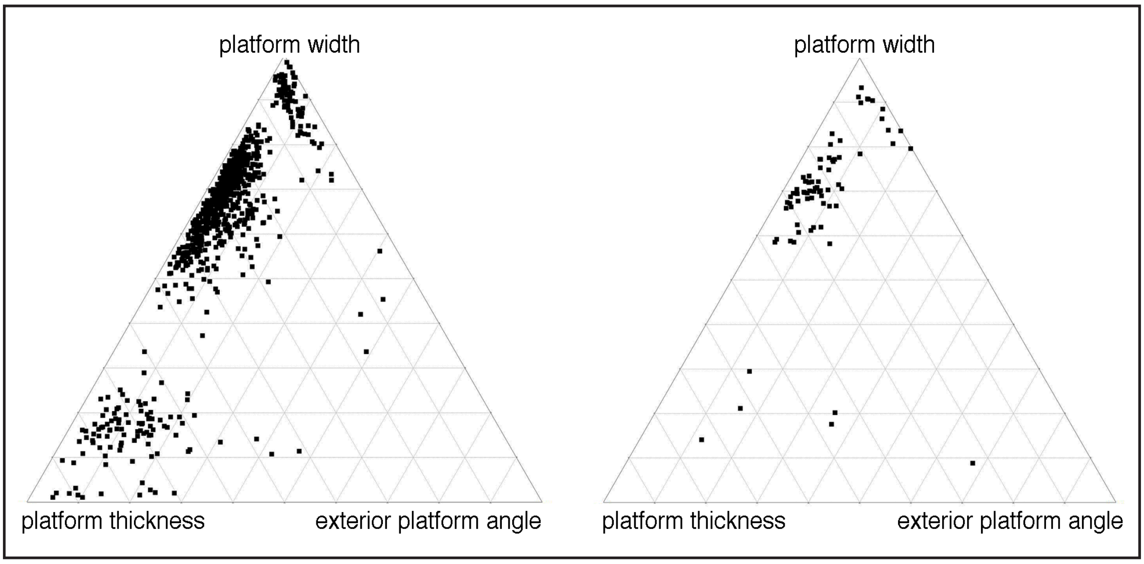

Fig. 248 - Ternary plot of platform width and thickness (multiplied with hundred) and exterior platform angle. Left - Hard hammer and right - Soft hammer

Morphology of blank platform

The morphology (or better the outline) of the blank platform is directed by the shape of the edge between the platform of the core and the flaking surface of the core, but also by the position of the impact point and the knapping technique (including the knapping angle, the kind of movement and the kind of hammer used). We used the following terms to describe the outline of the blank platform: arch, chapeau de gendarme, D-shaped, lenticular, line, oval, parallelogram, rectangular, round, sinus-shaped, trapezoid, triangle (as listed in tab. 204). For n=955 blanks the morphology of the platform was determined (see tab. 204).

Morphology of the blank platform	Number
Arch	134
Chapeau de gendarme	12
D-shaped	103
Lenticular	187
Line	10
Oval	70
Parallelogram	63
Rectangular	23
Round	1
Sinus-shaped	53
Trapezoid	135
Triangle	164
Total	955

Tab. 204 - Morphology of blank platform for blanks from GH 3

The majority of the blanks is lenticular shaped (n=187), followed by a triangular morphology (n=164). Overall, there are n=14 platforms showing breakage and all of them are lenticular in shape.

Negatives and cortex on blank platforms

A platform can have none, one or many negatives on its surface. It can also carry cortex or be a joint (geological fracture surface), with and without cortex rests. Overall there are n=955 blanks with a butt (complete ones and fragments)

The number of negative on platforms range from non to 51, as it is illustrated in fig. 249. The median (or better average) is 2 and around 50% of all blanks (that contain platform negatives) have between one and 6 negatives. N=122 blank butts carry cortex, but sometimes also with knapping negatives (range of 1 to 26).

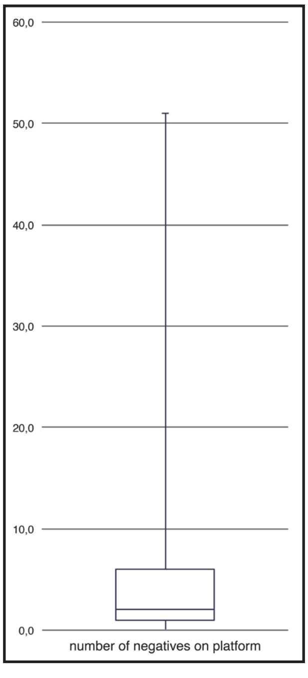

Fig. 249 - Boxplot of number of negatives on blank platforms from GH 3

Morphology of the edge between platform and ventral face

Over all, n=1441 edges between blank platform and ventral face were analysed. These edges can be removed, broken, straight, convex, buckled, concave, nosed or sinus-shaped. The numbers of these edge morphologies are listed in the following tab. 205:

Morphology of the edge between blank platform and ventral face	Short description	Blank produced with a hard-hammer technique	Blank produced with a soft-hammer technique	Other or non-determined technique	All blanks
Removed	Intentionally removed	4	1	0	**5**
Brocked	Blank is a fragment without platform	221	18	234	**473**
Straight	Straight, bulb and/or cone is not lift out	95	6	2	**103**
Convex	Convex, bulb and/or cone is lift out	572	69	10	**651**
Buckled	Buckled, bulb and/or cone is lift out	40	1	0	**41**
Concave	Concave, seldom and unusual	7	2	0	**9**
Nosed	Nosed, bulb and/or cone formes a nose	6	0	0	**6**
Sinus-shaped	Sinus, edge is concave and convex in some parts	143	7	3	**153**
Total		**1088**	**104**	**249**	**1441**

Tab. 205 - Morphology of the edge between blank platform and ventral face

The most common morphology of the edge between platform and ventral face (the edge of the interior platform angle) is convex (n=559), followed by broken pieces (n=472). A correlation between knapping technique and morphology of the edge shows that sinus-shaped and buckled varieties occurs much more often at blanks produced with hard-hammer technique.

Morphology of the edge between platform and dorsal face

The morphology of the edge between blank platform and dorsal face is dependant from the way it is (mostly intentional) shaped. A knapper can influence how the force of blow will enter into the knapped object (as discussed in chapter II.6). Additionally, shaping with removals abrasion is another possibility. As in the paragraph above about the interior edge, the same terms for the description of the edge are used (removed, broken, straight, convex, buckled, concave, nosed and sinus-shaped). It was possible to analyse n=1045 edges. The following tab. 206 shows the results for all blanks, as well as for knapping techniques:

Morphology of the edge between blank platform and dorsal face	Short description	Blank produced with a hard-hammer technique	Blank produced with a soft-hammer technique	Other or non-determined technique	All blanks
Removed	Intentionally removed	2	0	0	**2**
Broken	Blank fragment without platform	7	1	85	**93**

Straight	Straight, bulb and/or cone is not lift out	138	19	2	**159**
Convex	Convex, bulb and/or cone is lift out	315	39	4	**358**
Buckled	Buckled, bulb and/or cone is lift out	88	4	3	**95**
Concave	Concave, seldom and unusual	139	11	2	**152**
Nosed	Nosed, bulb and/or cone for-mes a nose	1	0	0	**1**
Sinus-shaped	Sinus, edge is concave and convex in some parts	172	13	0	**185**
Total		**862**	**87**	**96**	**1045**

Tab. 206 - Morphology of the edge between blank platform and dorsal face

Position and number of the impact point(s)

The position of the impact point was evaluated for n=946 blanks. From them, n=810 own one point of impact, but a total of n=136 own more than one impact point, as it is displayed in tab. 207:

Number of impact points visible on blank platform	Number of blanks
1	**810**
2	**92**
3	**33**
4	**11**
Total	**946**

Tab. 207 - Number of blanks and the number of impact points from GH 3

In total, blanks from GH3 show that at least n=1137 blows were performed (the total number of impact points visible on blank platforms). For n=998 of these impact points, the position was determined (n=588 in the mid position, n=208 on the left side and n=202 on the right side). This is a relevant observation, because Bargalló & Mosquera (2013) detected from experimental studies (knapping performed by inexperts) that an interplay of features can show tendencies of handedness of the knappers. One of these features is the position of the impact point (left-handed knappers tend to produce left positioned impact-points and right-handed knappers tend to produce right positioned impact-points). In the sample of blanks from GH 3, there is nearly the same amount of left-positioned (n=208) and right-positioned (n=202) impact points visible. In addition to the position of the impact-point other features showing the tendency to be of relevance (e.g., ridge of the bulbs, *éraillure* scar, hackles, ripples or the inclination of the platform). We can assume that the assemblage of GH 3 yield knapping products from more than one knapper. This is also obvious if we focus of knapping mistakes.

Ring crack

A ring crack on the surface of a blank platform is an indication for linear knapping techniques and that the hammer hit a specific small-scale point on a surface.

As the own knapping experience suggest, the visibility of a ring crack is related to the hardness of the raw material, the type of hammer used for knapping, as well as the angle of blow. A hard-hammer, moved in a quite linear way and with enough force will produce a ring crack on a striking platform of a core. This is also confirmed by a vast range of experiments (e.g., Bradley 1977; Pelegrin 2000; Roussel 2005).

In total for GH 3, n=656 ring cracks on n=492 blank platforms were determined. Some of the blanks carry more than one ring crack. The following tab. 208 list the amount of ring cracks visible on the blanks from GH 3:

Number or ring cracks visible on the blank platform	Number of blanks carrying these ring cracks	Total number of ring cracks
1	377	377
2	77	154
3	27	81
4	11	44
total	**492**	**656**

Tab. 208 - Ring cracks on blank platforms from GH 3

From the experience (without detailed experiments conducted) it can be stated that on FAS a visible ring crack is an indication for very homogenous and hard (brittle) raw material on the spot where the platform is hit. If the material is coarse grained (e.g., from incomplete silicification, as visible in fresh raw pieces from FAS) the material is too soft and malleable to form a ring crack.

But as we see, some blanks carry more (up to four) visible ring cracks on their blank platforms, which is an indication that the force, the angle, the platform, edge or flaking surface morphology was not ideal. Another possibility is related to the volume. Raw pieces of FAS can have (for the knapper at first) invisible raw-material faults, such as coarse crystallin zones or fissures (see e.g., Frick et al. 2012). This zones „swallow" energy. The blow needs to have much more force for the detachment (see also chapter X.8).

Morphology of the lip

Lips on the interior platform angle can be an indication for soft-hammer percussion and/or tangential movement of the hammer (Driscoll & García-Rojas 2014; Pelegrin 2000; Schindler & Koch 2012). In the most experimental studies about this subject, researchers try to find relations between type of hammer and lips. At the moment (also without detailed experimental data) my personal knapping experience let me assume that more than the type of hammer, the technique (the movement, how the hammer touches the surface of the platform or the edge of the core) is of importance for the production of a lip.

The assemblage of blanks from GH 3 yields evidence for n=163 blanks with lips. These are present on blanks with (n=41) and without ring cracks (n=122).

N=14 of the blanks with lip and ring crack have more than one ring crack, which might be determined as a change in the applied technique (and/or a change of the knapper). For example in that way that a novice tried to detach a product but failed and an expert helped and detached it.

The following fig. 250 shows exterior (EPA) and interior platform (IPA) angle on blanks that yield a lip:

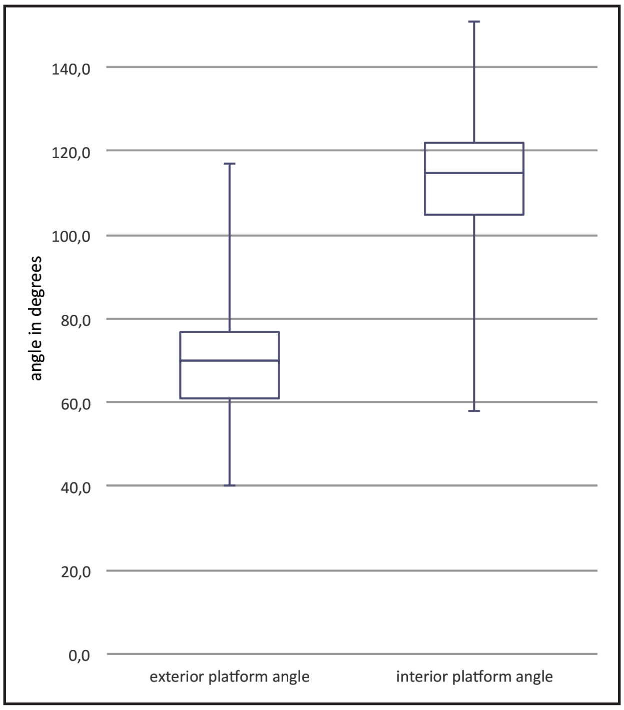

Fig. 250 - Boxplot of the exterior and interior platform angle of blanks that owns a lip from GH 3

The median for the EPA is 70°, for the IPA it is 115°. The values of the box-plot are displayed in tab. 209:

Values	Exterior platform angle	Interior platform angle
Minimum	40	58
Q1	61	105
Median	70	115
Q3	77	122
Maximum	117	151

Tab. 209 - Boxplot values of EPA and IPA of blanks with lips from GH 3

For n=71 of the blanks with lips a soft-hammer technique was assumed and for n=87 a hard-hammer technique. For n=5 there was no assumption possible.

Morphology of the bulb of percussion

From all n=1443 measured blanks, n=941 possess a bulb of percussion and n=502 do not have a bulb of percussion. For the blanks without bulb, n=462 are fragmented objects that cannot contain a bulb. Therefore only n=40 blanks exist that have a platform but have no bulb of percussion. In coarse grained raw materials (n=9), this is a not unknown phenomenon. For n=30 fine grained materials (FAS, chert and an unknown flint) explanations might be a fissure as detachment surface or the use of tangential soft-hammer techniques.

VII.11.7 Detailed analysis of blank classes

The morphology (as well as the understanding of the function and position in reduction) is essential for the formation of blank classes. In the following they are described in more detail. Subsequently, n=1064 blanks are discussed in this section (under exclusion of n=1054 simple blanks that were not further classified, see tab. 210).

Blank class	Unmodified	Modified	Total
Simple blank	869	185	**1054**
Raw-piece cap	201	27	**228**
Blank of surface correction	341	40	**381**
Blank of edge correction	204	15	**219**
Crested blank	4	2	**6**
Éclat débordant and lame débordant	34	15	**49**
Core tablet	1	1	**2**
Levallois blank	58	98	**156**
Ventral flakes (Kombewa flakes)	11	2	**13**
Tranchet-blow blank	9	0	**9**
Bifacial objects on blank	0	19	**19**
Blank deriving from retouch	68	1	**69**
Total	**1800**	**405**	**2205**

Tab. 210 - Numbers of blanks that correspond to a blank class from GH 3

General morphological features of all the detailed analysed blanks from GH 3 are presented above. Here, the aim is to present specific features of blanks that are incorporated into a blank class.

VII.11.8 Raw-piece caps

The morphology of these blanks is easy to describe. They are blanks with a complete cortex cover. On raw pieces with cortex, raw-piece caps (RPCs) are the first blanks to be removed to get access to the interior of the raw piece (were the hopefully homogenous lithic raw material is). For the opening of a raw piece, sometimes angles have to be used that are far from the expected ideal angle of 70 to 80°. Therefore these RPCs have often a somewhat different morphology as a mechanically ideal blank. This is also the case if a raw-piece cap derive from testing a raw piece, if the interior material is of bad quality.

Inside the excavated area of GH 3, n=228 raw-piece caps were detected. Some of them (n=27) were also modified after production. The ratio between unmodified and modified blanks equals 7,44 (11,8% are modified).The list (tab. 211) gives an overview.

Kind of modification after production	Number
Non	**201**
Denticulate	**4**

Notch	3
End-scarper	4
Lateral retouch	2
Knife	2
Side-scraper	9
Hafting rest	2
Ventral core	1
Total	228

Tab. 211 - Raw-piece caps from GH 3. Some of them were also modified.

Modifikation on blanks is discussed in chapter VII.13. Only around the half of the raw-piece caps (n=101) are complete. The fragmentation is listed in tab. 212:

Fragmentation	Number
Complete	101
Basal	30
Left lateral	3
Medial	23
Right lateral	4
Terminal	47
Undetermined	20
Total	228

Tab. 212 - Fragmentation of raw-piece caps from GH 3

A total of n=4 blanks show traces of heat influence and one influence of frost. A scatterplot of dimension for this pieces show that complete blanks (black) are scattered over the entire range. Some fragments are quite big (above right) and suggest that the original blank was bigger than the recorded complete blanks. The majority of the fragments is quite small (see fig. 251).

In regard to knapping technique, it is suggested that n=172 of these RPSs are made with hard-hammer technique, whereas n=1 for one a medium-hard-hammer was used and for n=5 a soft-hammer. Additionally, n=2 show signs of bipolar flaking and for n=48 the technique could not be elicited. These two bipolar flaked blanks are the only objects showing of this technique in the entire GH 3.

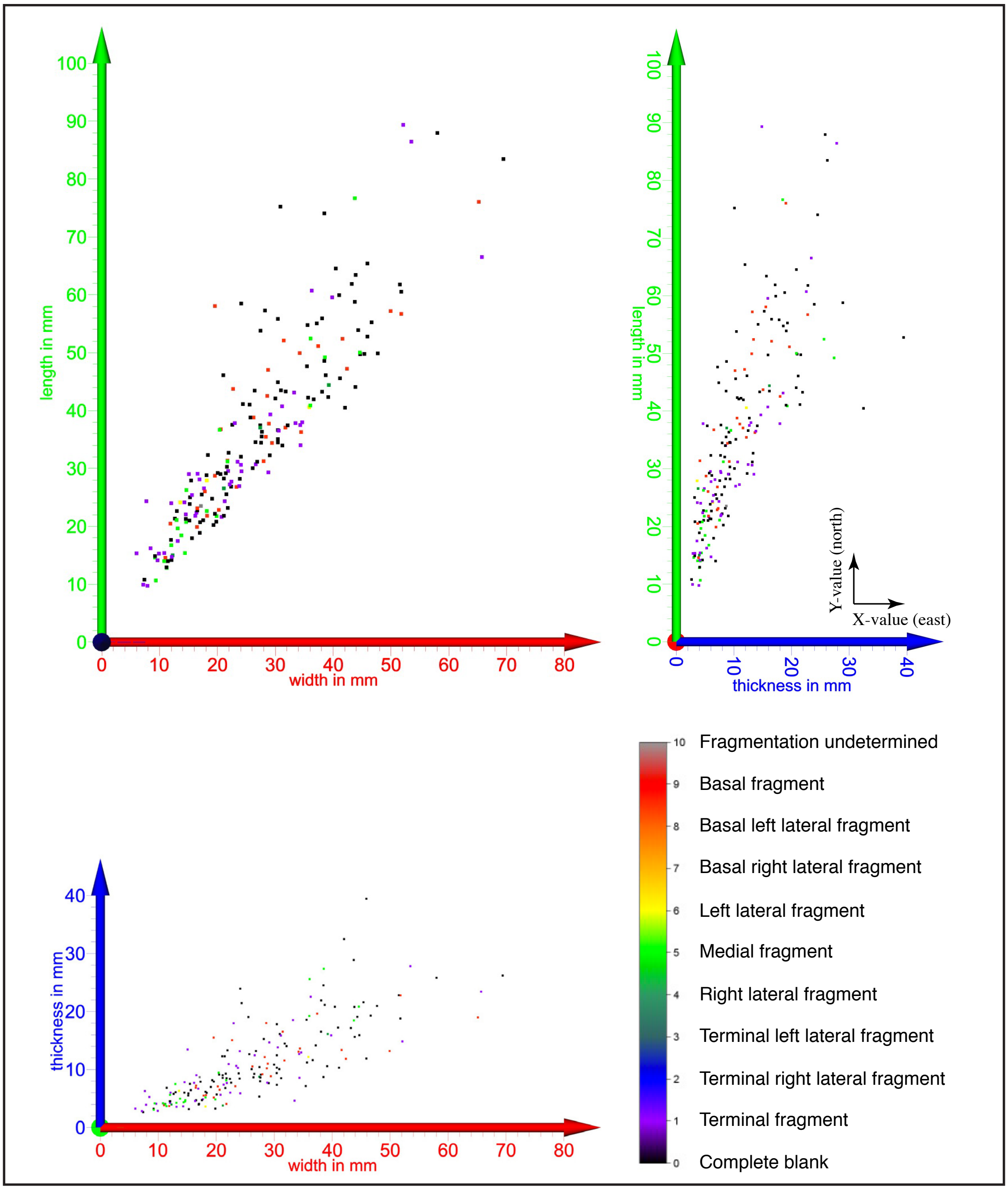

Fig. 251 - Dimensional scatterplot of raw-piece caps from GH 3, separated by fragmentation

VII.11.9 Correction blanks

This blank-class unites products that are assumed to be detached because of correction purposed. This correction can take place during the configuration of a core or between reduction steps. It contains surface correction blanks (removed to shape a surface, mostly convexity of a surface) and edge correction blanks (removed to shape an edge). Specified edge correction blanks such as *éclats débordant* are also integrated here, as well as blanks that correct both surface and edge such as core tablets (see examples in fig. 252).

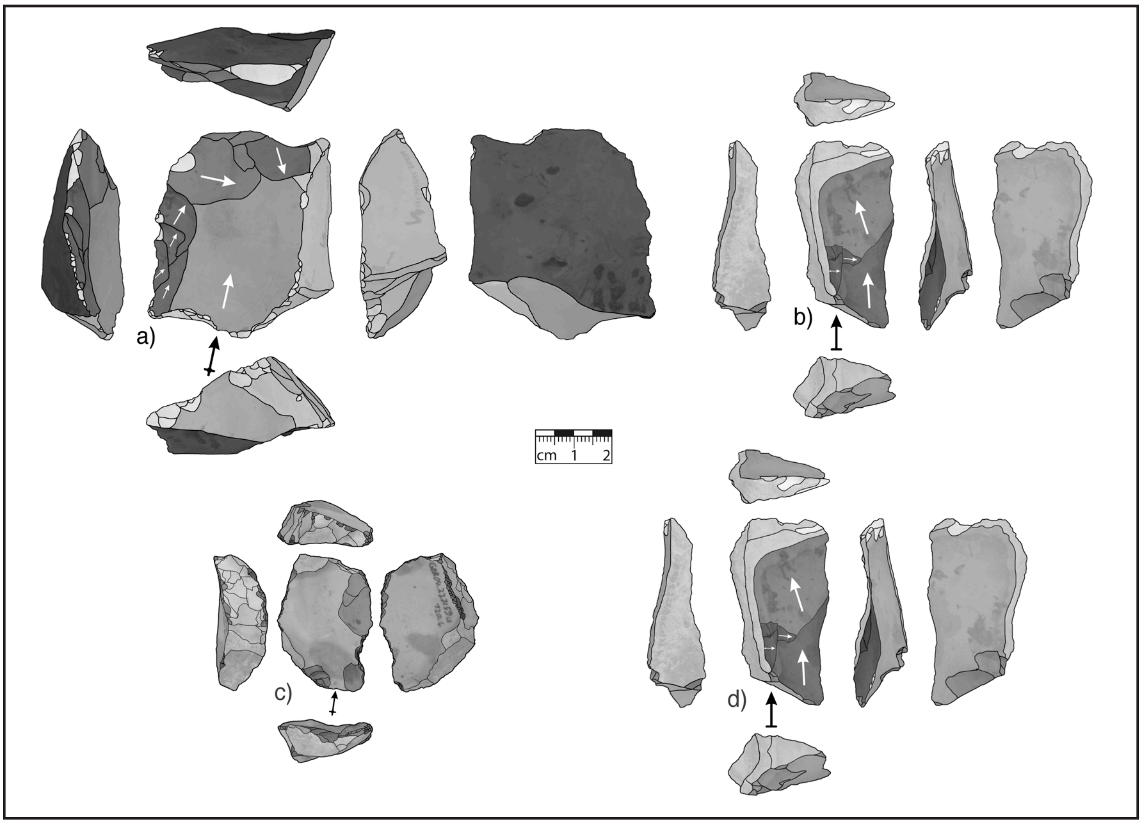

Fig. 252 - Examples of débordant blanks from GH 3 and 4. a) GER09.227-059.162.1 (GH 3); b) GER09.227-060.173.4 (GH 4); c) GER09.227-059.120.4 (GH 3) and d) GER09.227-060.173.4 (GH 3)

Some of these correction blanks were also modified (n=73). Overall GH 3 yields n=656 blanks classified as correction blanks (see tab. 213). Despite their position in an operation sequence as blanks for correction purposed, these blanks (as shown by modification) had also other functions. The discussion about these modified blanks can be read in chapter VII.13.

Fragmentation Correction blank	Fragments	Fragmentation undetermined	Complete	Unmodified	Modified	Total
Surface correction	193	6	181	341	40	**380**
Simple edge correction	94	4	121	204	15	**219**
Éclat débordant & lame débordant	16	1	32	34	15	**49**
Crested blanks	5	0	1	4	2	**6**
Core tablet	2	0	0	1	1	**2**
Total	**310**	**11**	**335**	**584**	**73**	**656**

Tab. 213 - Overview to correction blanks from GH 3

The ratio between unmodified and modified correction blanks equals 8 (11,1% are modified). On consideration about dimension (fig. 253), surface correction blanks (blue) are scattered over the entire range, edge correction blanks however are small (green), *éclats* and *lames débordant* are mostly in the mid-range (yellow), as well as crested blanks (orange) and core tablets (red). Surface correction blanks are mostly a bit thinner than edge corrections. An attempt in a dimensional separation of surface and edge correction blanks using isosurface show that surface correction blanks are in general a bit thicker and a bit longer. Unfortunately, this is only visible in rotating the scatterplot, but also visible in box-plots (see fig. 254). The box plot values are listed in the following tab. 214.

Values	Length of surface correction	Length of edge correction	Thickness of surface correction	Thickness of edge correction
Minimum	10,8	9,2	1,5	2,4
Q1	22,6	20,2	4,2	4,9
Median	29,2	25,5	5,7	7,0
Q3	37,6	34,2	8,9	10,1
Maximum	83,8	63,9	38,7	19,3

Tab. 214 - Boxplot values of length and thickness of surface correction and edge correction blanks from GH 3

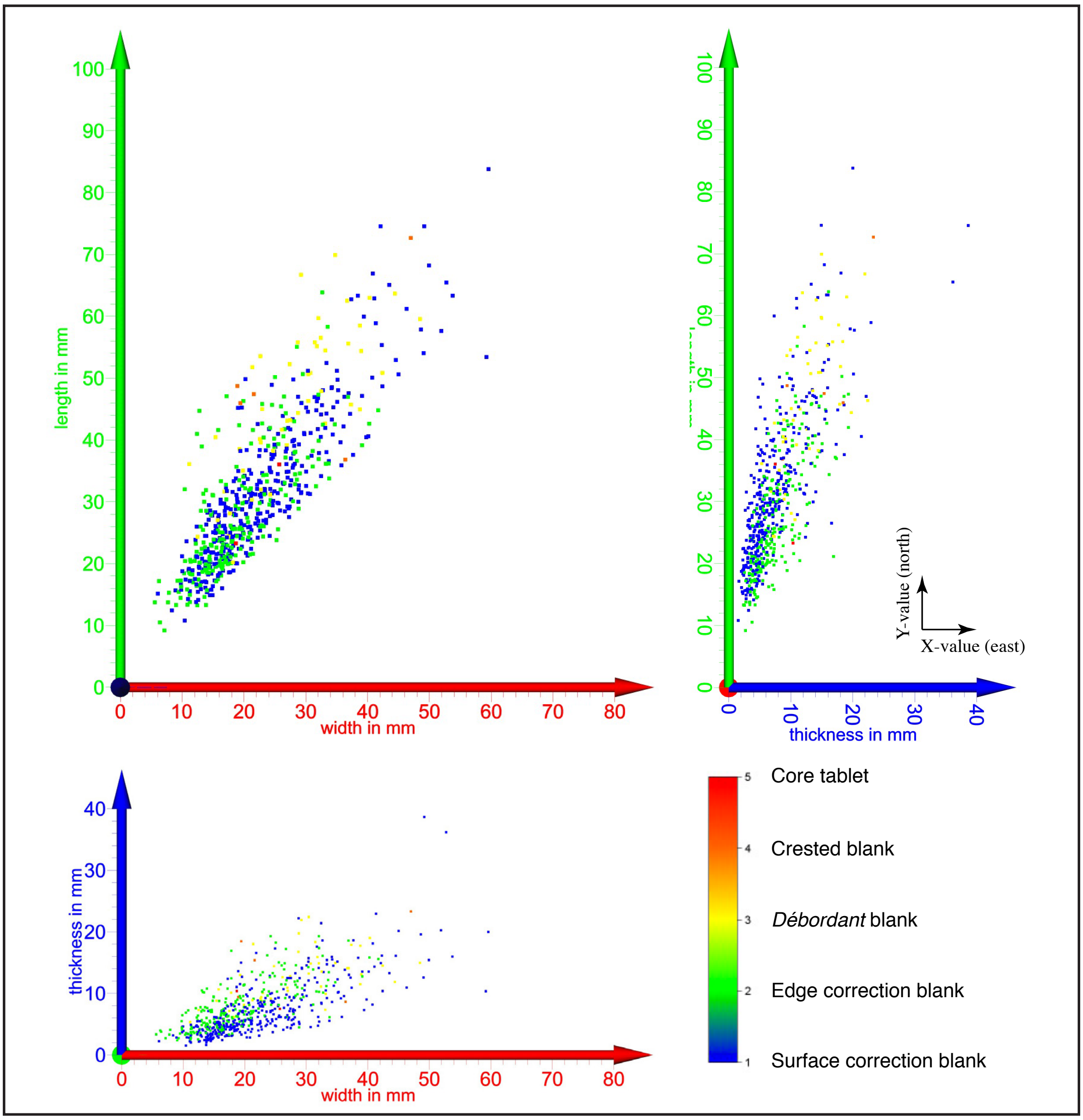

Fig. 253 - Scatterplot of the dimensional range of correction blanks from GH 3

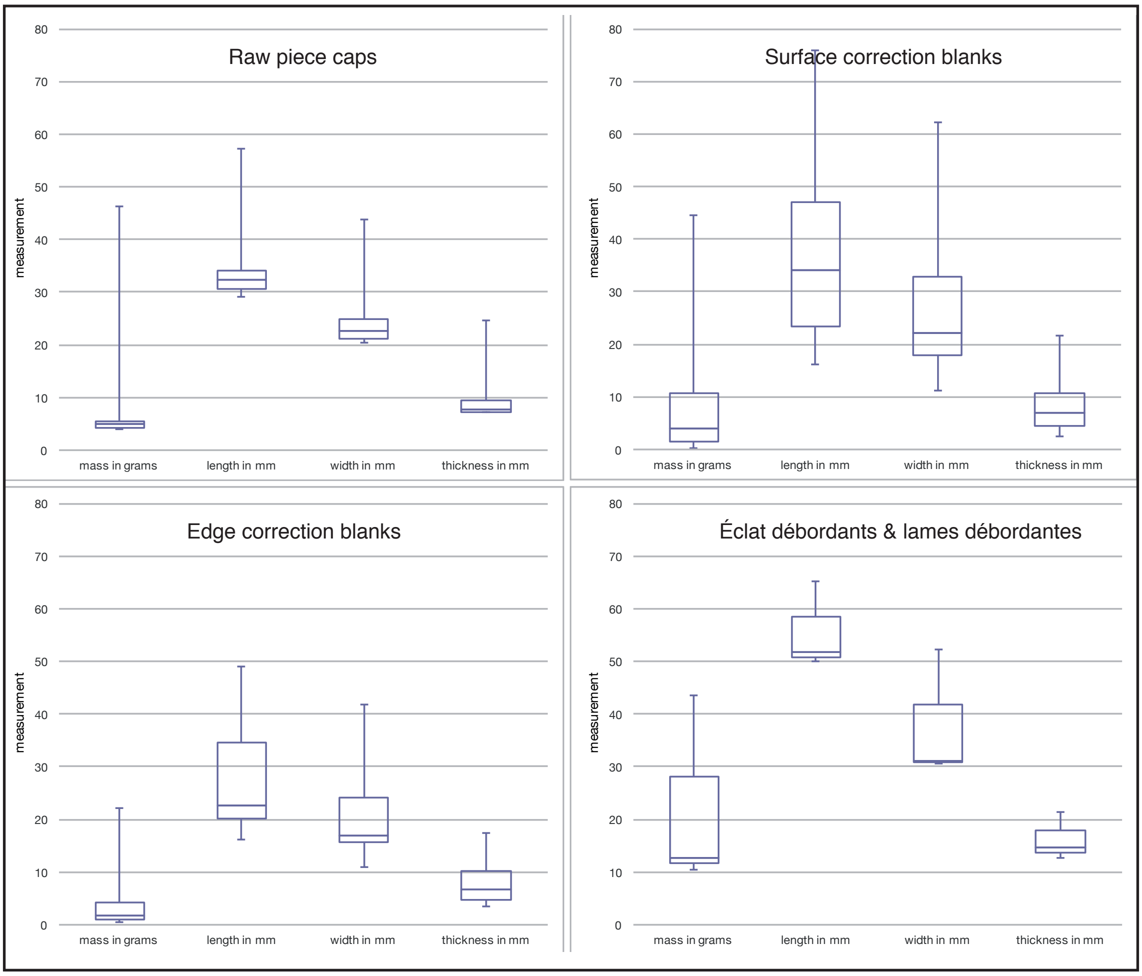

Fig. 254 - Boxplot of length and thickness of surface correction and edge correction blanks from GH 3. Top left - Raw piece caps; top right - Surface correction blanks; bottom left - Edge correction blanks and bottom right - Débordant blanks

VII.11.10 Levallois blanks

Overall, n= 156 blanks are denominated as blanks derived from Levallois reduction (in the sense of target blanks, see chapter I.5.2). These are blanks that use the convexity of a Levallois core and do not produce them. Therefore the term target blanks from Levallois reduction would be more adequate. The following tab. 215 lists them in regard to their typological trichotomy (flakes, blades and points) as it was used by e.g. Bordes (1961).

Fragmentation Levallois blank	Complete	Fragments	Unmodified	Modified	Total
Flake	40	74	38	76	**114**
Blade	5	13	13	5	**18**
Point	9	15	11	13	**24**
Total	**54**	**102**	**62**	**94**	**156**

Tab. 215 - Fragmentation and modification of the typological trichotomy of Levallois blanks from GH 3

The amount of unmodified and modified blanks equals almost (62/94=0.66:1). 66% of all Levallois blanks are modified after production. This is different for complete and fragmented blanks (54/102=0.53:1). The first attempted here is to compare size (fig. 255). Because of the difficulty in seeing the separation of these three types, complete blanks and fragments are separated. The separation of flakes and blades is metrical, therefore a dimensional separation is given. The separation of Levallois points to the others is morphological and is hardly to see in dimensional plots.

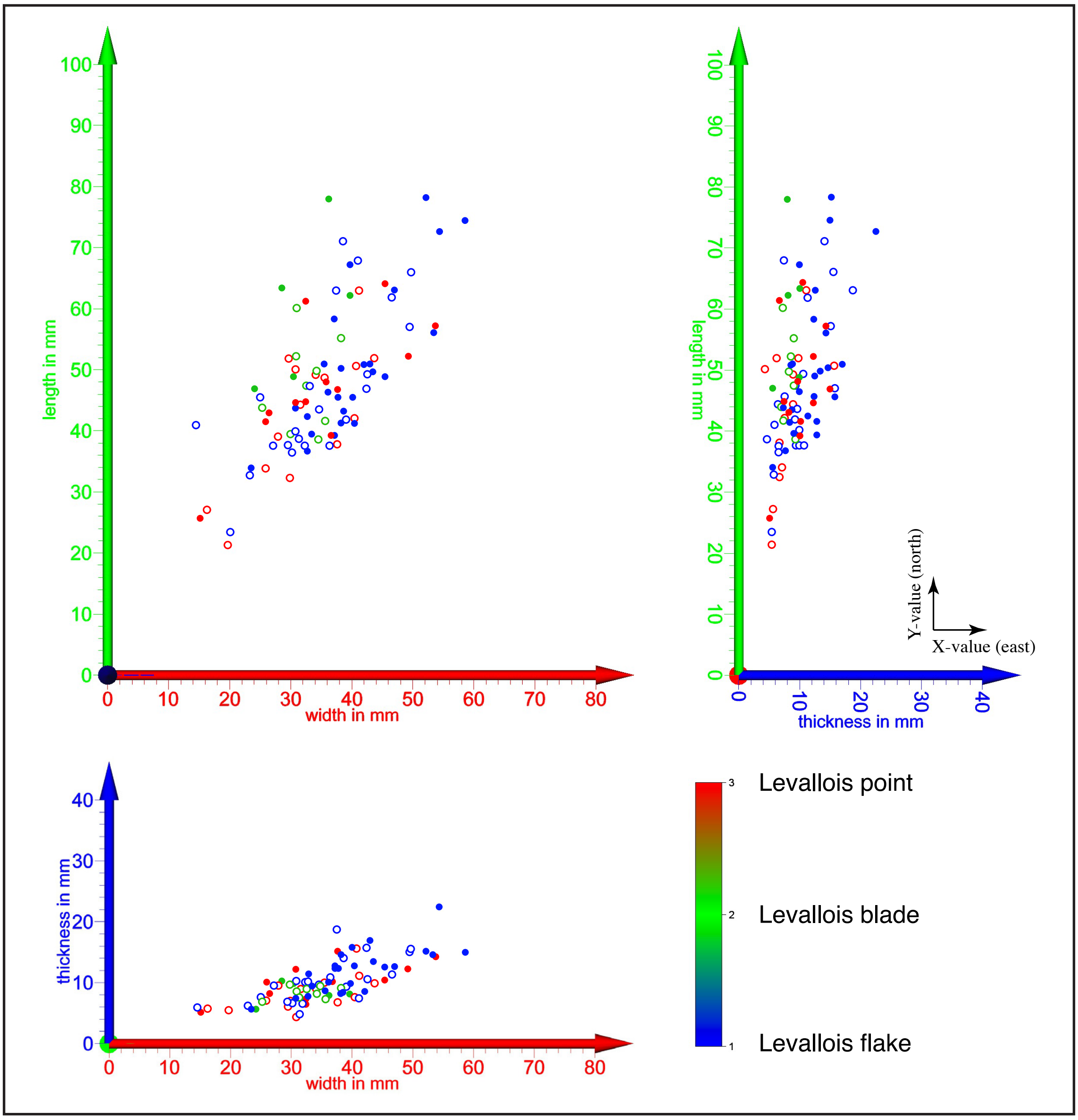

Fig. 255 - Dimensional comparison of typological Levallois blanks from GH 3 (complete blanks - filled circle and fragments - circle)

The dimensions are much better visible in using box-plots (for all Levallois blanks see fig. 256, for the three types see fig. 257). The values of the boxplots from fig. 257 are displayed in tab. 216.

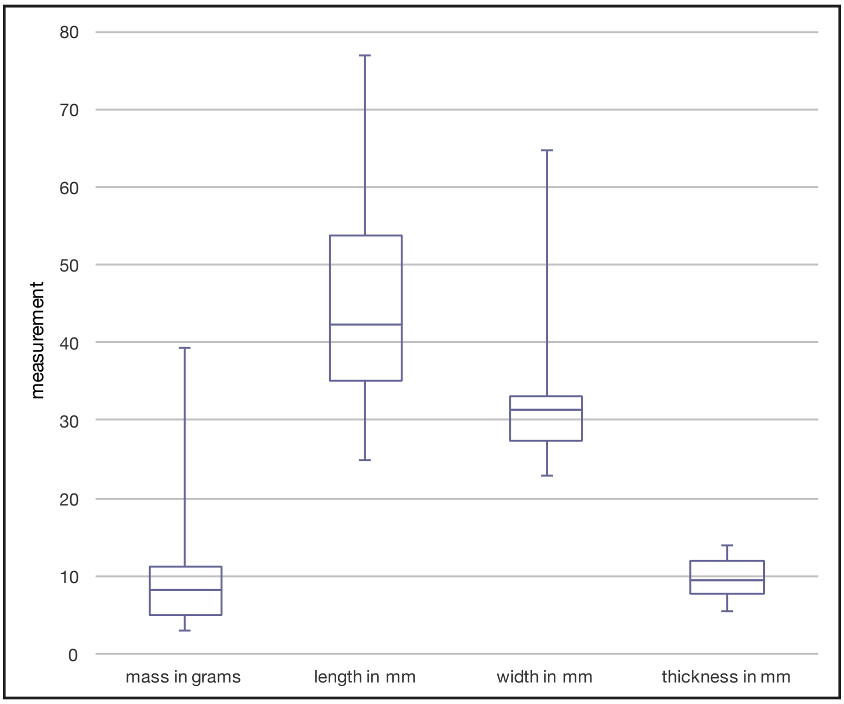

Fig. 256 - Boxplot of mass and dimensions of all typological Levallois blanks from GH 3

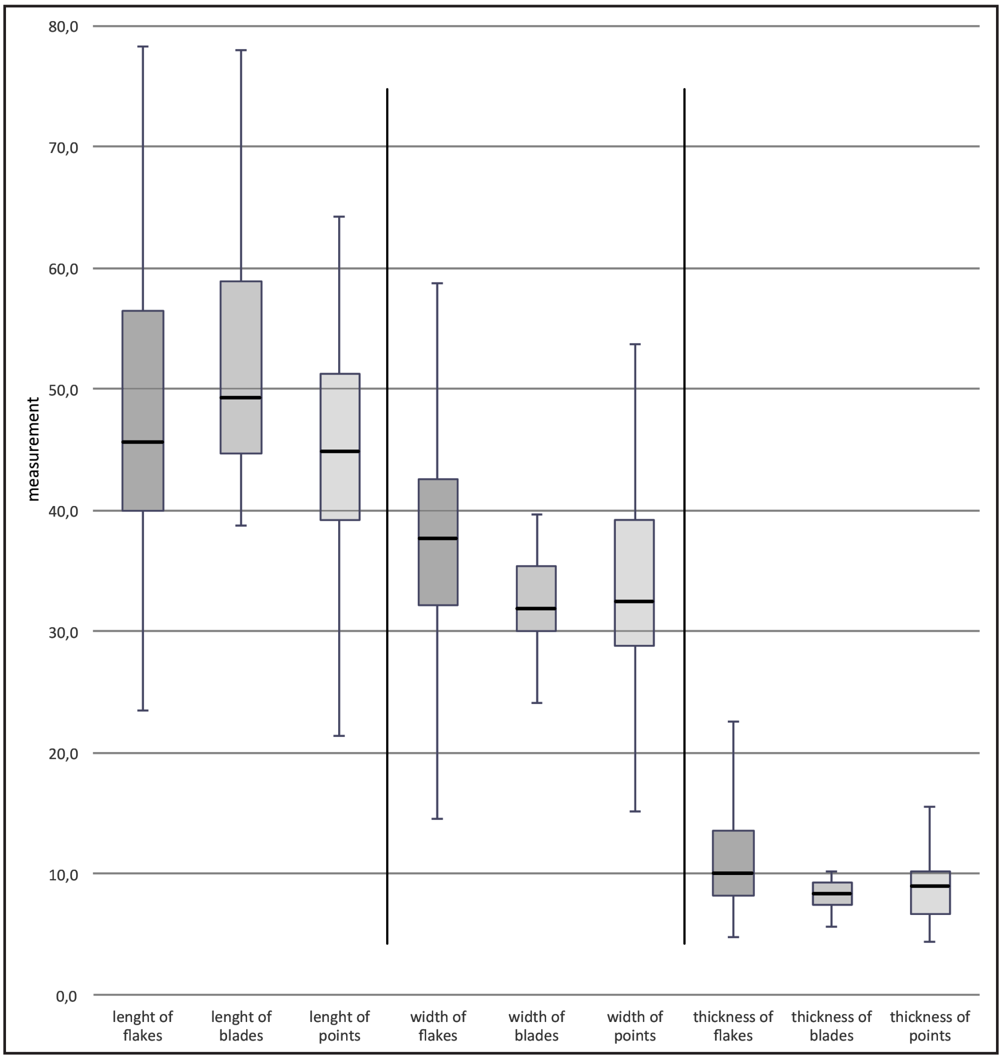

Fig. 257 - Boxplot of dimensions of all typological Levallois blanks from GH 3, separated into types

Dimension	Length			Width			Thickness		
Values	Length of flakes	Length of blades	Length of points	Width of flakes	Width of blades	Width of points	Thickness of flakes	Thickness of blades	Thickness of points
Minimum	23.4	38.7	21.4	14.5	24.1	15.1	4.8	5.6	4.4
Q1	39.9	44.7	39.2	32.2	30.1	28.8	8.1	7.4	6.7
Median	45.6	49.3	44.8	37.6	31.8	32.5	10.1	8.4	9.0
Q3	56.4	58.9	51.3	42.5	35.4	39.1	13.6	9.2	10.3
Maximum	78.3	78.0	64.3	58.7	39.7	53.7	22.5	10.2	15.6

Tab. 216 - Boxplot values of dimensions of all typological Levallois blanks from GH 3, separated into types

The scar patterns (pattern of dorsal face negatives) of Levallois blanks are displayed in tab. 217 and show a familiar pattern. Levallois flakes show nearly all constellations, but unidirectional-parallel and centripetal are prevalent. Levallois blades show mostly parallel negatives, and points feature much more divergent that convergent negatives. This might be an indication that points are prevalently constructed by subsequent confection, than using a reshaped convexity of the core's reduction surface.

Blank type Direction and constellation	Levallois flakes	Levallois blades	Levallois points	Total
Unidirectional-parallel	28	5	4	**37**
Unidirectional-convergent	15	3	2	**20**
Unidirectional-divergent	1	0	11	**12**
Unidirectional-othogonal	9	0	0	**9**
Bidirectional-parallel	13	7	2	**22**
Bidirectional-convergent	5	0	2	**7**
Bidirectional-divergent	0	0	0	**0**
Bidirectional-orthogonal	0	0	0	**0**
Centripetal	21	1	2	**24**
Undetermined	22	2	1	**25**
Total	**114**	**18**	**24**	**156**

Tab. 217 - Directions and constellations of negatives on typological Levallois blanks, separated by type, from GH 3

As we see, there is a correlation between typological Levallois blanks and their scar pattern identifiable. This is not surprising because the overall shape is guided by the shape of the reduction surface, which is again guided by the direction and constellation of removals.

The next stepp in analysis is now to compare the real morpho-geometric outline of these blanks with their scar patterns to find significant correlations. This time only complete blanks are taken into account. The following tab. 218 presents the data about the outline and scar patterns of complete Levallois blanks:

Outline Direction and constelation	Oval	Rectan-gular	Trian-gular	Trape-zoid	D-shaped	Penta-gon	Hexa-gon	Hepta-gon	Arch	Paralel-logram	Qua-drant	Undeter-mined	Total
Unidirectional-parallel	3	2	1	0	0	3	0	1	0	0	1	0	**11**
Unidirectional-convergent	2	1	3	0	0	2	1	0	0	0	0	0	**9**
Unidirectional-divergent	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Unidirectional-othogonal	0	0	0	1	0	0	1	1	0	0	0	0	**3**
All unidirectional	**5**	**3**	**4**	**1**	**0**	**5**	**2**	**2**	**0**	**0**	**1**	**0**	**23**
Bidirectional-parallel	4	2	2	0	0	0	0	0	1	0	0	0	**9**
Bidirectional-convergent	1	0	1	1	0	1	0	0	0	0	0	0	**4**
Bidirectional-divergent	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Bidirectional-orthogonal	0	0	0	0	0	0	0	0	0	0	0	0	**0**
All bidirectional	**5**	**2**	**3**	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**13**
Centripetal	5	1	0	1	0	2	3	0	0	0	0	0	**12**
Undetermined	0	0	0	0	0	0	1	0	0	1	0	4	**6**
Total	**15**	**6**	**7**	**3**	**0**	**8**	**6**	**2**	**1**	**1**	**1**	**4**	**54**

Tab. 218 - Directions and constellations of negatives on complete Levallois blanks with different morpho-geometric outlines from GH 3 (empty fields are red shaded)

For rational comparison, for scar patterns and outline we condense the rows to direction of negatives and display them as bar graph (fig. 258) .

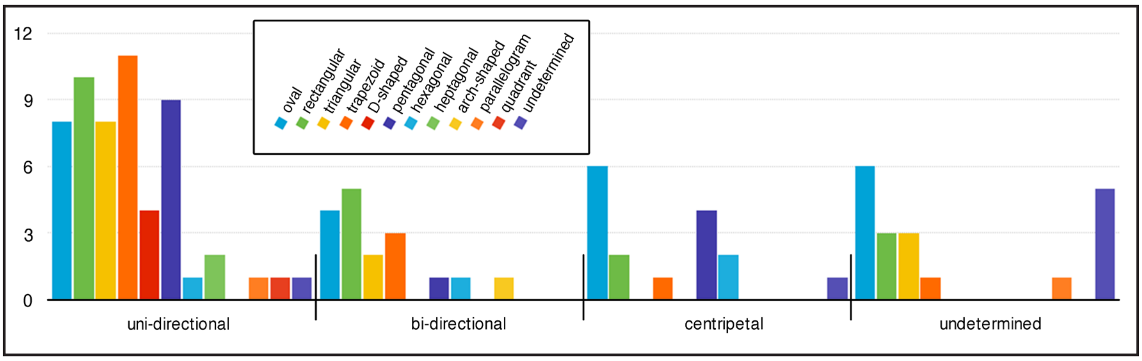

Fig. 258 - Direction of dorsal negatives in correlation of outline of Levallois blanks from GH 3, displayed as bar graph

The majority of negative directions of complete Levallois blanks is uni-directional (n=23), the numbers of blanks for bi-directional (n=13), centripetal (n=12) and undetermined (n=6) are lower. As this pattern suggest, uni-directional reduction is the preferred variety in Levallois, producing in majority oval, pentagonal and triangular blanks. A selection of Levallois blanks showing this uni-directional pattern is presented in fig. 259. Modifications on Levallois blanks are discussed in chapter VII.13.

Fig. 259 - Levallois blanks with uni-directional scar pattern from GH 3. a) Constructed point on Levallois flake (GER12.226-057.1200); b) Levallois flake with denticulated retouch (GER10.226-059.309); c) Levallois flake with intensive, lateral scraper retouch (GER11.225-060.55); d) Constructed point on Levallois flake (GER13.226-057.1959) and e) Levalloid overshot flake (GER14.227-057.3026)

VII.11.11 Ventral blanks (Kombewa blanks)

The number of blanks from ventral reduction is quite low (n=12). Two of them are subsequently modified. One flake is showing a multiple, transversal tranchet-blow on the terminal end of the dorsal face (GER12.229-059.530, see fig. 260). Another terminal fragment of a flake shows a convex retouch on the terminal end.

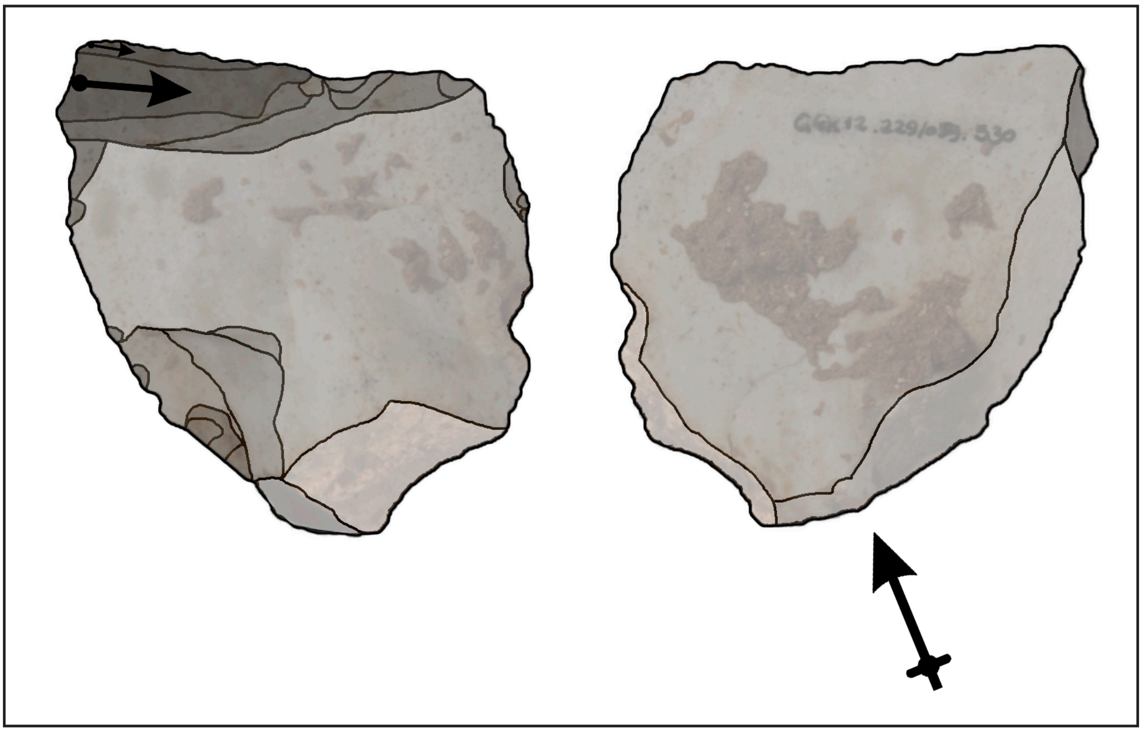

Fig. 260 - Modified ventral flake from GH 3 with a tranchet-blow (GER12.229-059.530)

From the small amount of pieces that derive from reduction of ventral faces of blanks they can be listed in total (see tab. 219):

Find-number	Fragmentation	Description
GER09.228-058.6.1	Complete	Removed a part of lateral retouch on a blank
GER09.228-059.118.3	Terminal	Removed a part of a quite flat ventral face on a blank
GER09.228-059.125.2	Terminal	Removed a part of a quite flat ventral face on a blank, the terminal end is convex retouched
GER10.226-060.120	Terminal	Removed a part of a quite flat ventral face on a blank
GER10.227-058.323.1	Complete	Removed a part of a quite flat ventral face on a blank
GER10.227-058.431	Basal	Removed a part of a quite flat ventral face on a blank
GER11.225-058.54	Complete	Removed a part of a quite flat ventral face on a blank
GER12.227-057.702	Complete	Removed a part of a quite flat ventral face on a blank
GER12.229-059.352	Left lateral	Removed a part of a quite flat ventral face on a blank
GER12.229-059.530	Basal	Multiple transversal tranchet-blow at the breaking surface of a basal fragment, object was removed from a quite massive blank
GER13.225-058.983	Basal	Removed a part of a quite flat ventral face on a blank
GER13.225-059.1119	Basal	Removed a part of a quite flat ventral face on a blank
total (n=12)		

Tab. 219 - Blanks from reduction on ventral faces of blanks from GH 3

The small amount of ventral blanks indicates that this variety of reduction was only used in some cases and suggest that the reduction on ventral faces of blanks was not a common way to modify or reduce blanks. This is also indicated in blanks showing removals on their ventral face (see chapter VII.13.18).
The distribution of these blanks is displayed in fig. 261 and shows in top view two clusters of them. In the view-to-north, as well as view-to-west these clusters are exploded and show the distribution in a hight between 6.6 to 7.4. The blank with the tranchet-blow is located in the lower half of this distribution.
In dimension all of these blanks (with the exception of the one with a tranchet-blow) is quite small (fig. 262) and also suggest that the intension in detaching them was removing.

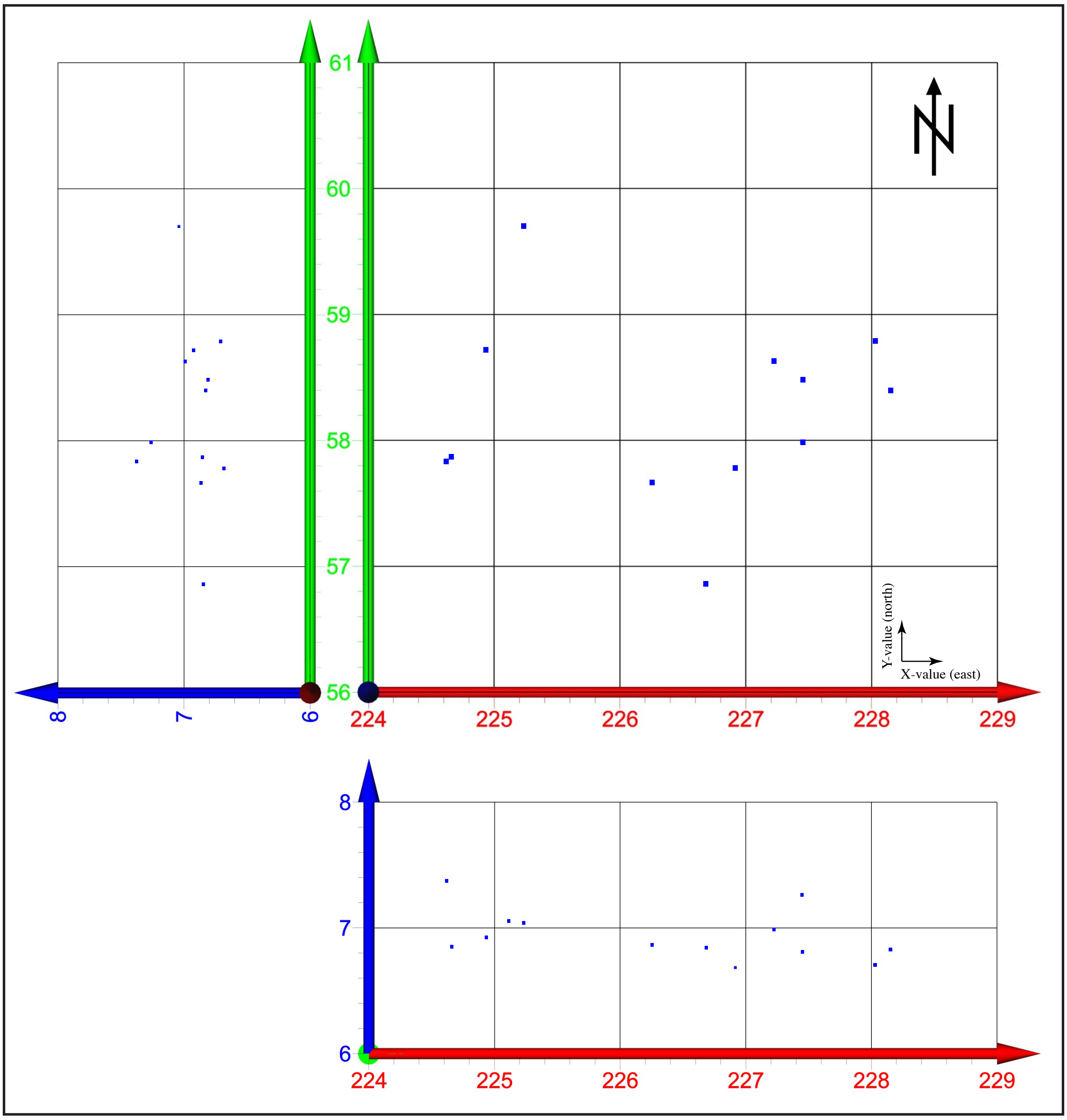

Fig. 261 - Distribution of ventral blanks from GH 3

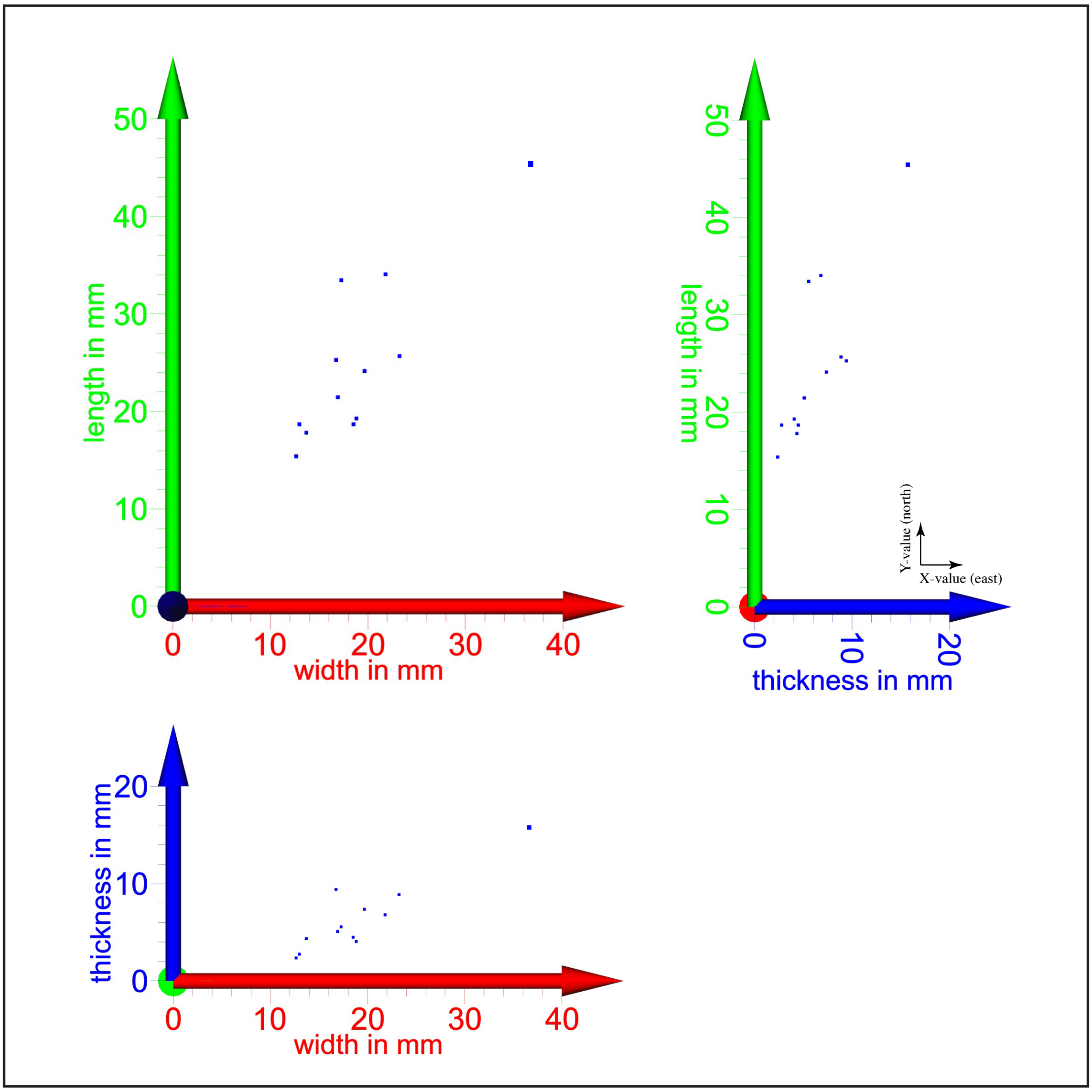

Fig. 262 - Dimension of ventral blanks from GH 3

VII.11.12 Tranchet-blow blanks

Overall GH 3 yields n=9 tranchet-blow blanks (see fig. 263), which are discussed in more extension in Frick and Floss (in press). There are n=5 primary and n=4 secondary tranchet-blow blanks. The observed features of them are displayed in tab. 220:

Feature	Specification	Number
Blow technique	Direct-hard-straight blow technique	**8**
	Direct-soft-tangential blow technique	**1**
Fragmentation	Complete	**3**
	Basal fragment	**5**
	Medial fragment	**1**
Position of the second ventral face negative	Right sided	**2**
	Left sided	**7**
	Initial or primary	**5**
Position in tranchet-blow reduction sequence	Consecutive or secondary	**4**

Tab. 220 - Features of tranchet-blow blanks from GH 3

They are distributed in the northern and southern part of the excavated area of GH 3 and mostly located in the upper half part of GH 3 (see fig. 264). In dimension they are quite small as we would expect it (fig. 265).

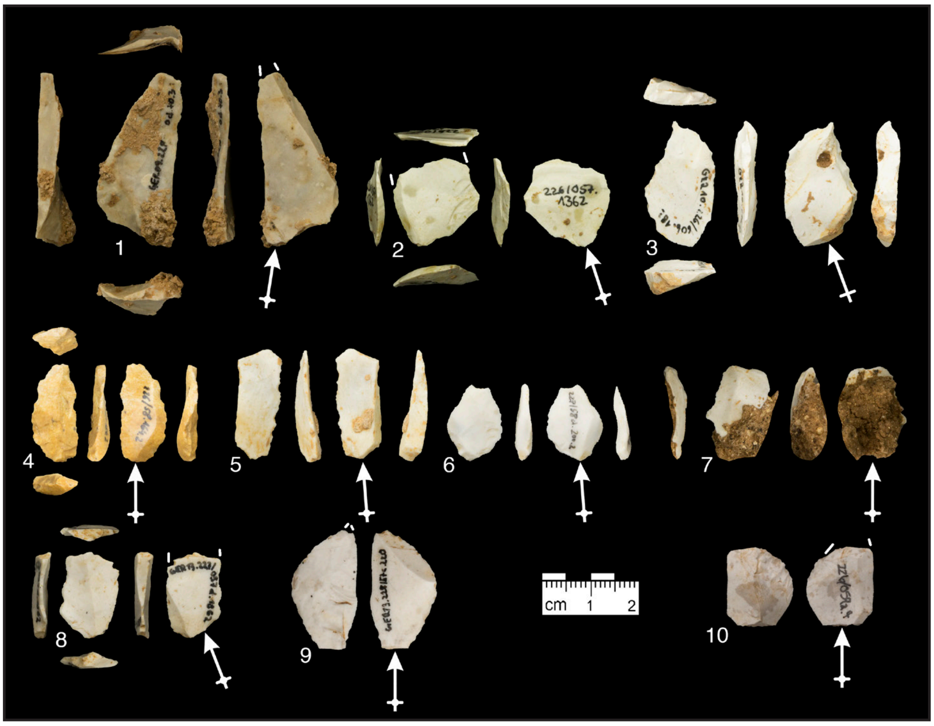

Fig. 263 - All n=9 tranchet-blow blanks from GH 3 (No. 4 is from GH 4x)

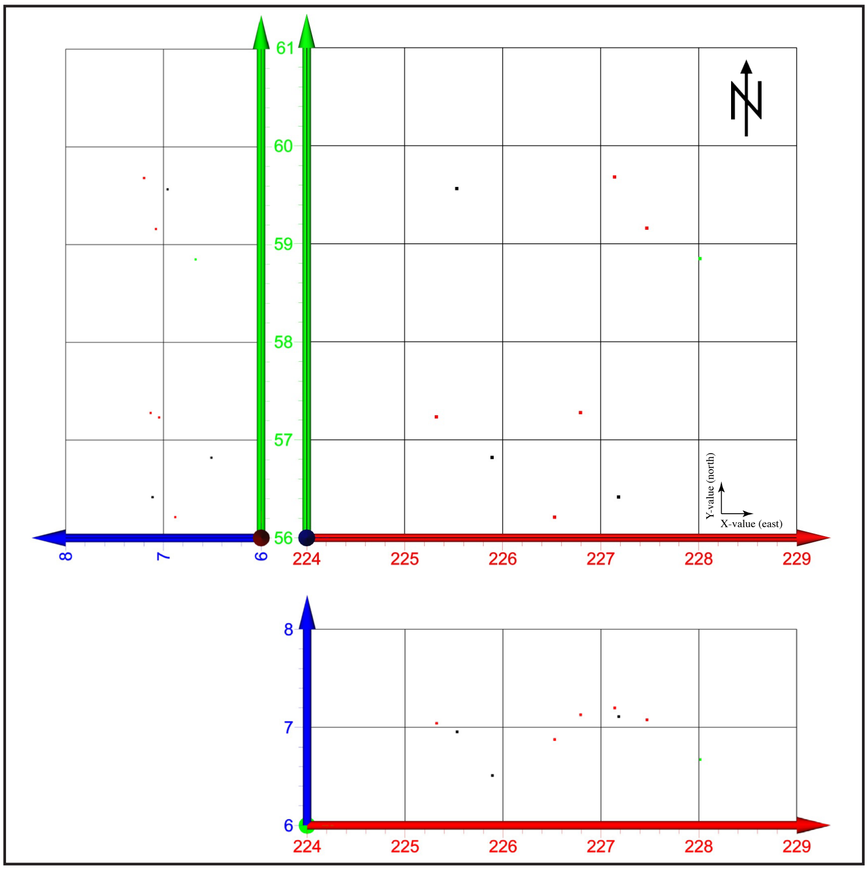

Fig. 264 - Distribution of tranchet-blow blanks from GH 3 (black - complete, green - medial fragment, red - basal fragment)

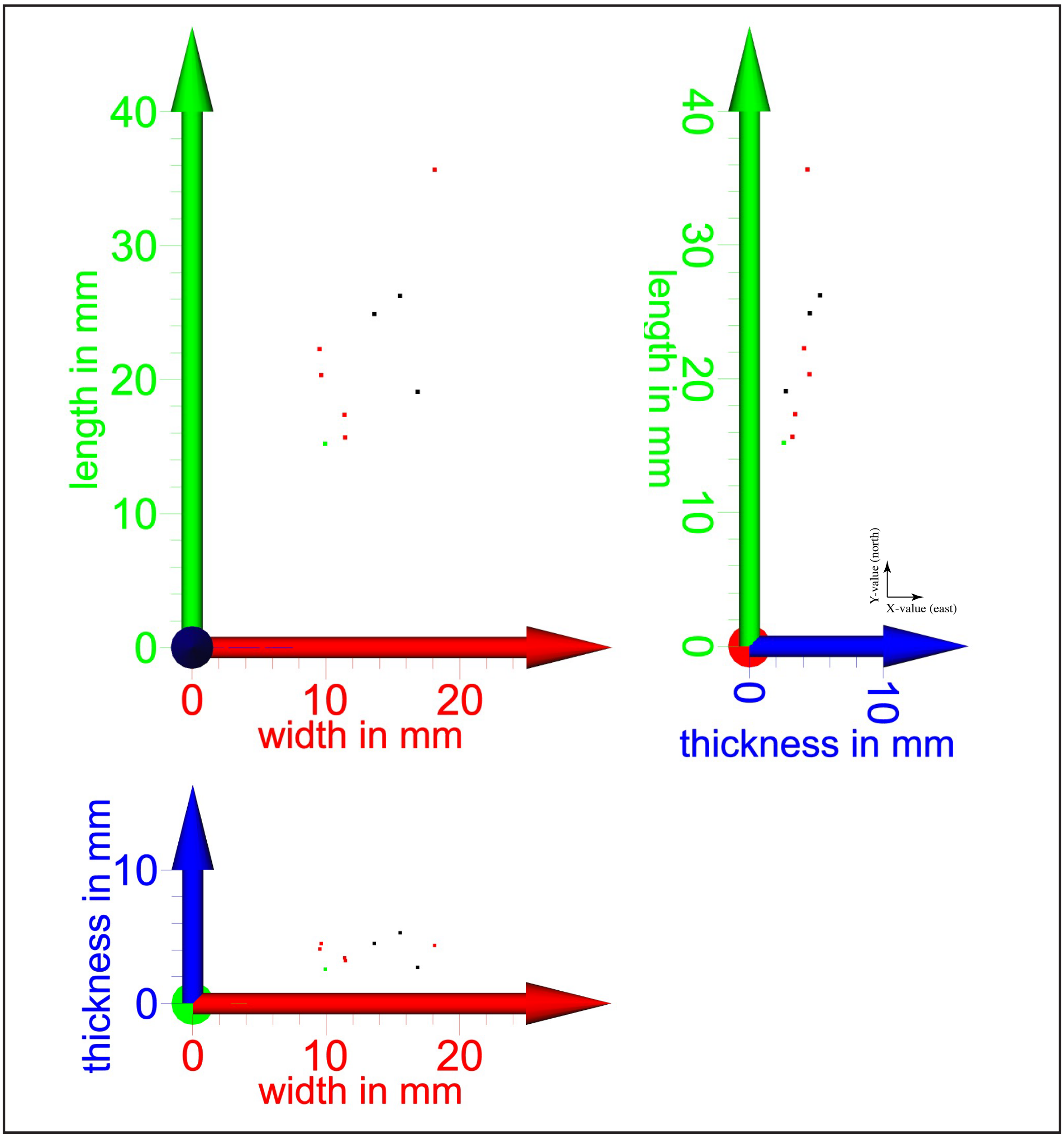

Fig. 265 - Dimension of tranchet-blow blanks from GH 3 (black - complete, green - medial fragment, red - basal fragment)

There is a variety of objects with tranchet-blow negatives (n=6), which are two *Keilmesser* (GER12.226-057.1227 and GER12.229-059.428), a knife (GER10.228-058.276), a scraper (GER12.227-057.689), a ventral blank (GER12.229-059.530) and a *lame débordant* (GER12.229-059.585). They are displayed in fig. 266. The variety of objects that got a tranchet-blow negative is notable, because in many sites only *Keilmesser* showing such a cutting edge modification. Exceptions for the production of tranchet-blow negatives on simple unifacially modified blanks are known e.g. from Buhlen (Jöris 2001) or Abri du Musée (Bourguignon 1992; Coudenneau 2005).

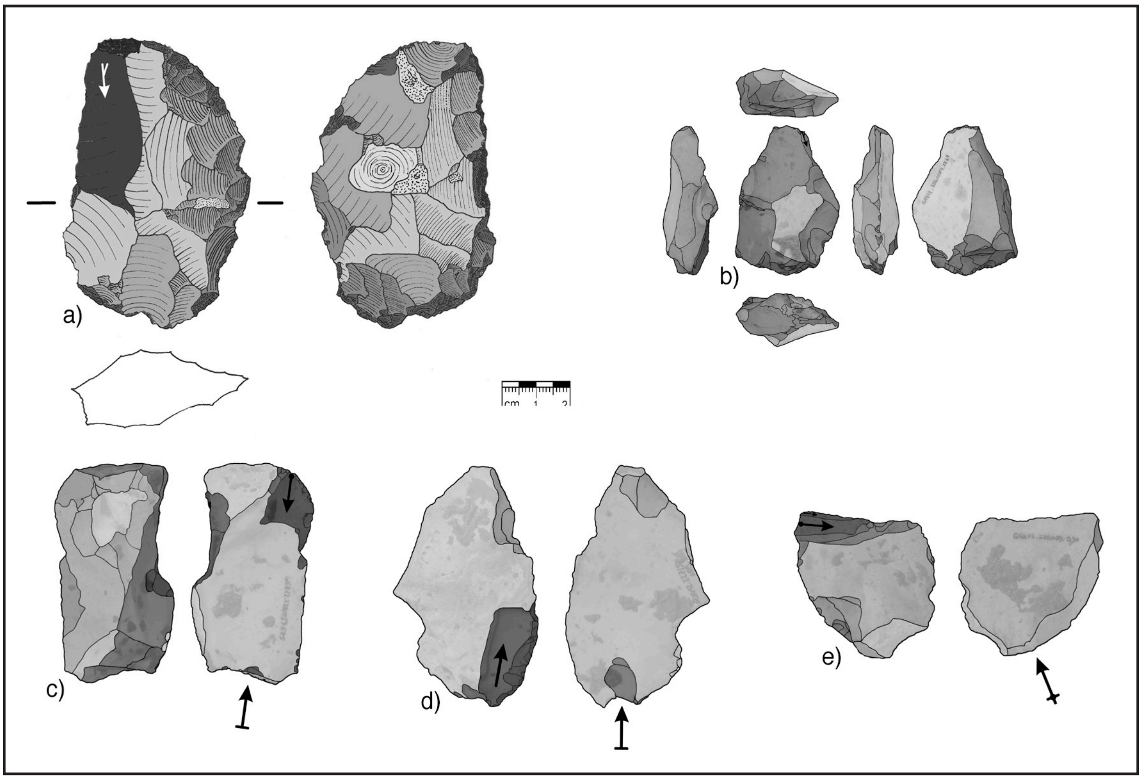

Fig. 266 - Objects subsequently modified with a tranchet-blow negative from GH 3. a) Keilmesser (GER12.229-059.428); b) Keilmesser (GER12.226-057.1227); c) Lame débordant (GER12.229-059.585); d) Scraper (GER12.227-057.689) and e) Ventral blank (GER12.229-059.530)

Unfortunately, till the writing of this thesis it was not possible to refit any of these tranchet-blow blanks to the observed tranchet-blow negatives on other lithic objects. The interpretation of the meaning of these objects is displayed in chapter VII.14 and will not further extend here.

VII.11.13 Bifaces-on-blanks

Introduction

In total, there are n=26 bifacial objects known from GH 3. In this section we are discussing n=19 bifacial objects of them that were made on blanks. Bifacial objects made on cores are discussed in chapter VII.10.15. A comparison and summary of all observed bifacial objects is written in chapter VII.14, but see also Frick and Floss (in press). The bifaces-on-blanks are listed in the following tab. 221 and displayed in subsequent pictures (fig. 267 to 269).

Find number	Fragmentation	Description
GER09.228-059.116.8	Complete	Bifacially worked object
GER10.226-059.196	Complete	Bifacially worked object
GER10.226-059.301	Complete	Simple *Keilmesser*
GER10.227-058.219	Complete	Bifacially worked object
GER10.228-058.58	Terminal	Bifacially worked object
GER10.228-058.200	Complete	Bifacially worked object
GER10.228-058.252	Left lateral	Preform of a bifacial object

GER11.225-059.222	Undetermined	Asymmetrical biface with restricted backing
GER12.225-059.385	Undetermined	Asymmetrical biface with restricted backing
GER12.225-059.702	Complete	Preform of a bifacial object
GER12.226-057.861	Complete	Preform of a bifacial object
GER12.226-057.1227	Complete	*Keilmesser* with tranchet-blow
GER12.227-057.141.1	Undetermined	Asymmetrical biface with restricted backing
GER12.227-057.420	Complete	*Fäustel*
GER12.227-057.457	Complete	Asymmetrical biface with restricted backing
GER12.229-059.533	Terminal	Simple *Keilmesser*
GER13.225-058.913	Undetermined	Simple *Keilmesser*
GER13.227-057.1790	Complete	*Fäustel*
GER13.228-057474	Terminal	Asymmetrical biface with restricted backing
Total (n=19)		

Tab. 221 - List of bifacial objects made on blanks from GH 3

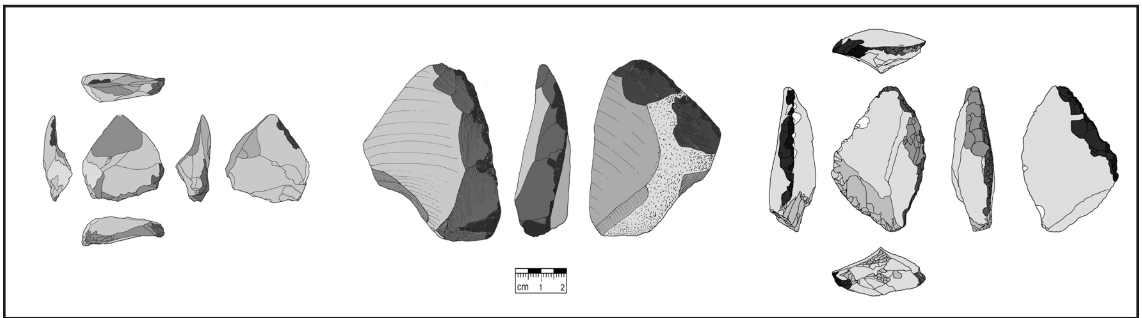

Fig. 267 - Bifacially worked objects made on blanks from GH 3. a) GER10.226-059.196; b) GER09.228-059.116.8 and c) GER10.227-058.219, see also Frick & Floss (in press, fig. 9)

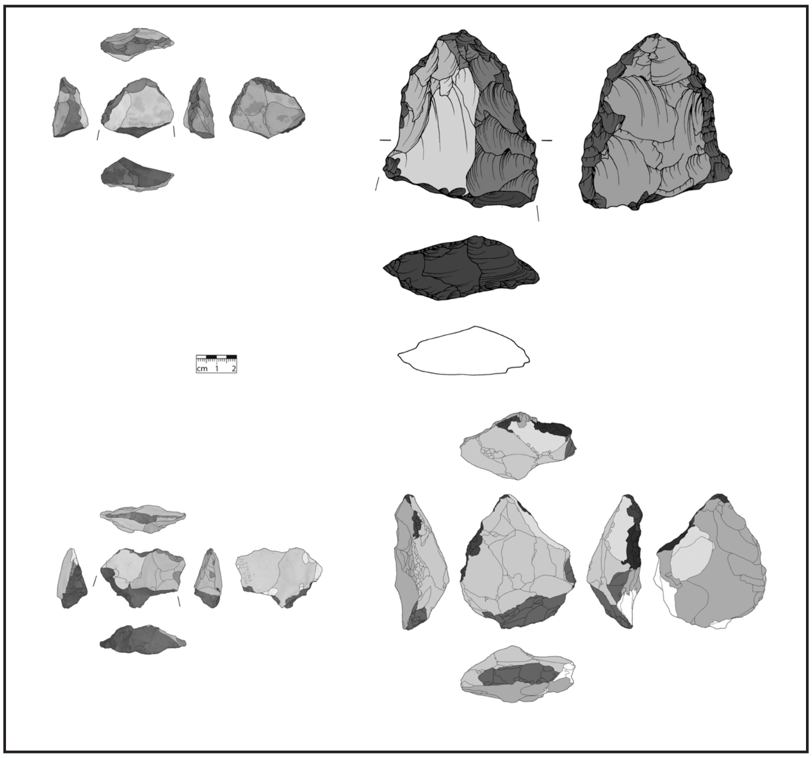

Fig. 268 - Asymmetric bifaces with small restricted backing from GH 3. a) GER13.228-057.474; b) GER11.225-059.222; c) GER12.227-057.141.1 and d) GER12.227-057.457

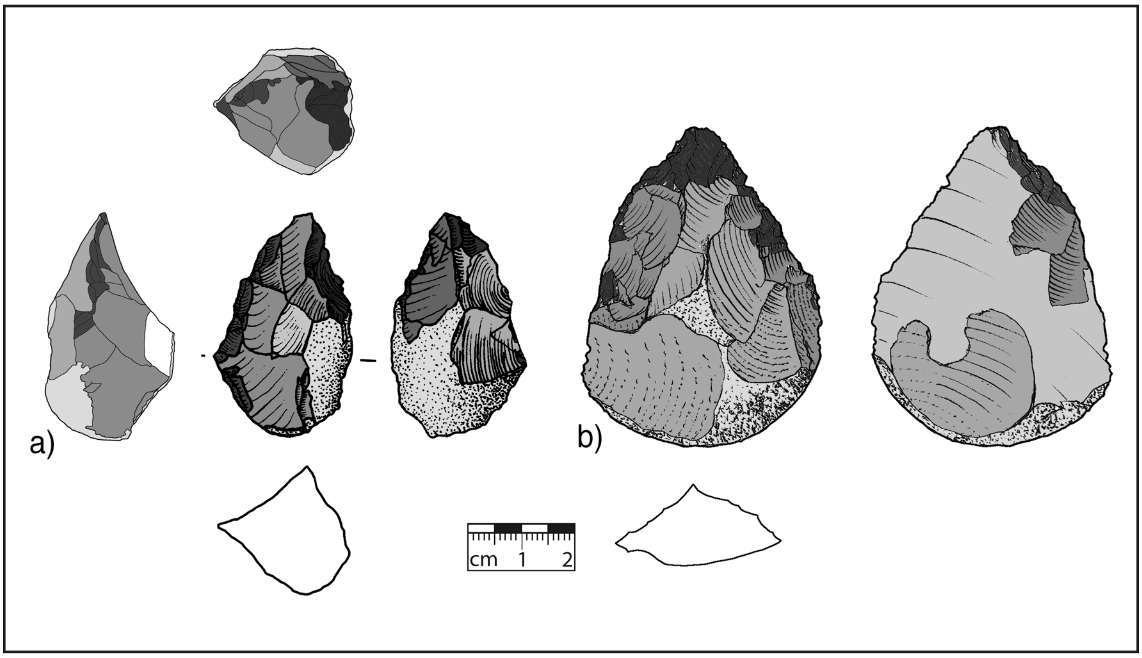

Fig. 269 - Small bifaces with plane-to-convex surfaces. a) GER12.227-057.420 and b) GER13.227-057.1790

There are n=5 asymmetric bifaces with a restricted backing, n=5 bifacially worked objects, n=3 simple *Keilmesser*, n=2 Fäustel (small symmetric bifaces with plane-to-convex surfaces), one *Keilmesser* with a tranchet blow and n=3 bifacially modified preforms (see also fig. 270).

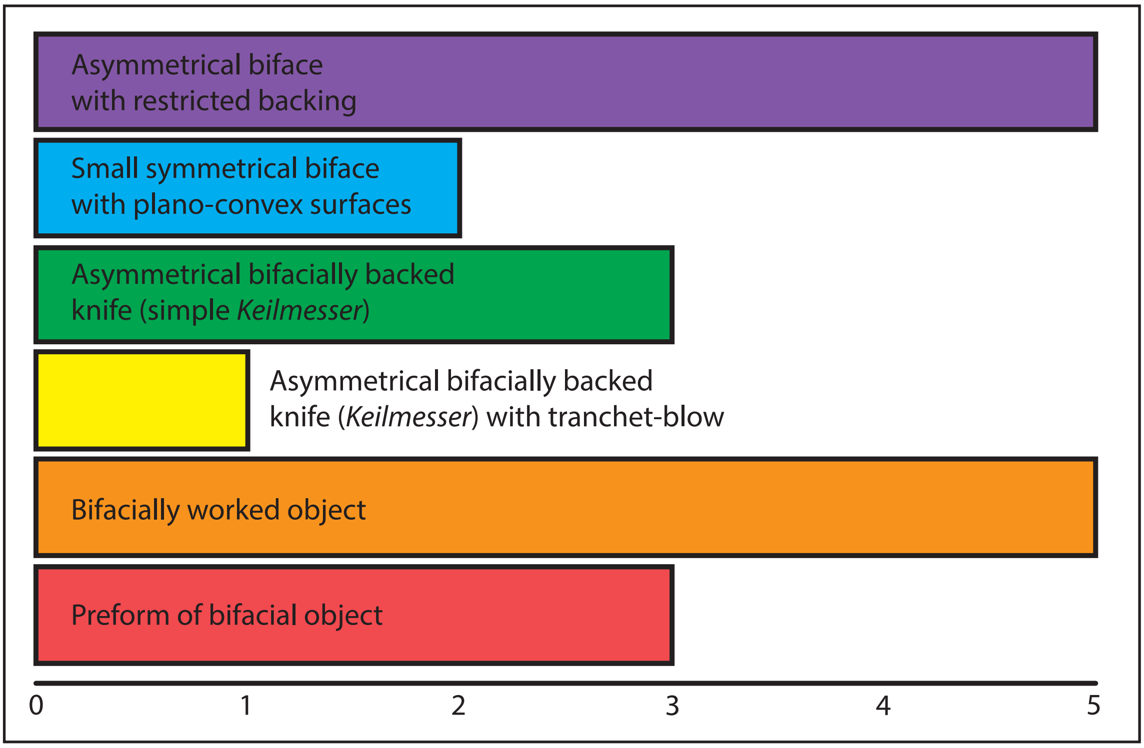

Fig. 270 - Bar graph of the numbers of bifacial objects made on blanks from GH 3

Conceptual framework

All of these bifacial objects are produced inside the same conceptual framework as it is very common for the *Keilmessergruppen* (see Frick & Floss in press). A characteristic of all bifacial objects is the plane-to-convex (see the definition in chapter VII.14.2) reduction on each surface and the alternating unidirectional edge reduction (AUER, *wechselseitig gleichberichtete Kantenbearbeitung*, see also Bosinski 1967). Weißmüller (1995, fig. 37) explained this specific production with turning and rotation of the object in the course of production (see fig. 271 and 272).

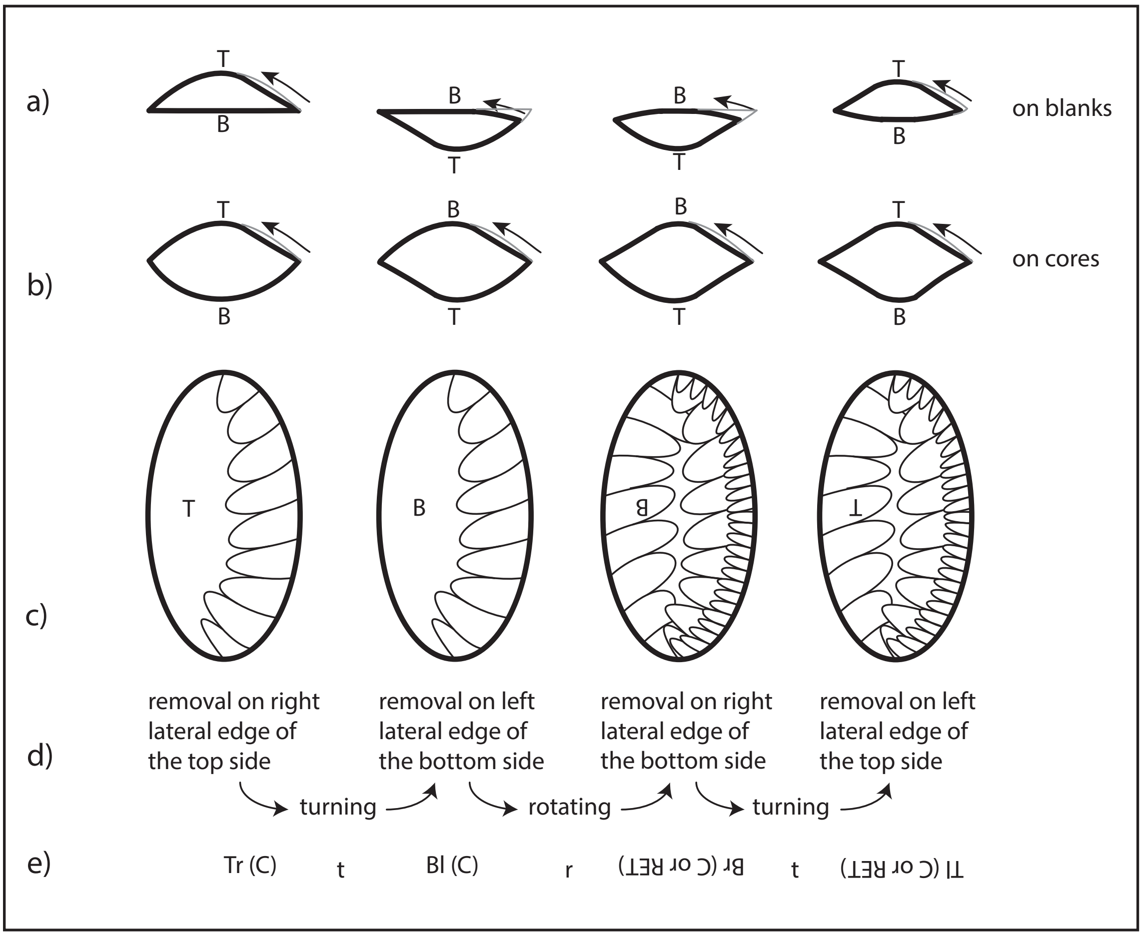

Fig. 271 - Description of the reduction analysis for symmetric bifaces using cross sections and top views, from left to right. a) Cross-section of alternating unidirectional edge reduction for blanks; b) Cross section of alternating unidirectional edge reduction for cores; c) Top view of this reduction sequence; d) Description of the reduction in each step and the turning or rotation while knapping; e) Reduction code for this sequence (T - top side, B - bottom side, r - right edge, l - left edge; C - surface configuration and RET - retouch). a) to d) Illustration of Weißmüller (1995) description for alternating unidirectional edge reduction from Bosinski (1967), see also Frick & Floss (in press, fig. 15)

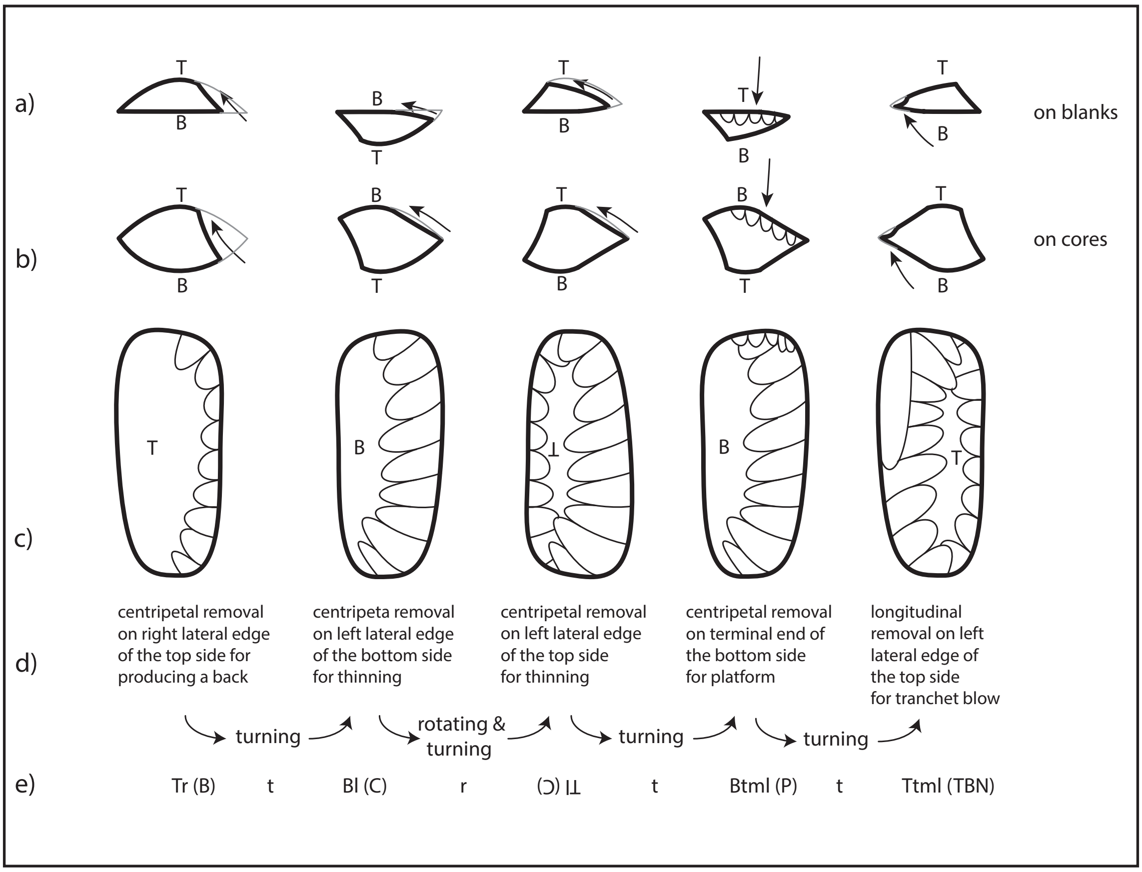

Fig. 272 - Description of the reduction analysis for asymmetric bifaces (Keilmesser) using cross sections and top views, from left to right. a) Cross section of backing, surface configuration, platform installation and tranchet blow for blanks; b) Cross section of backing, surface configuration, platform installation and tranchet blow for cores; c) Top view of this reduction sequence; d) Description of the reduction in each step and the turning or rotation while knapping; e) reduction code for this sequence (T - top side, B - bottom side, r - right edge, l - left edge, tml - terminal end; in brackets B - back configuration, C - surface configuration, P - platform installation and TBN - tranchet-blow negative), see also Frick & Floss (in press, fig. 16)

Distribution

The distribution of these bifacial objects inside GH 3 is displayed in fig. 273. They are all spread in the southern part of the excavated area of GH 3 and show in top view a slightly clustered pattern. Almost all asymmetrical bifaces with restricted backing, as well as small symmetrically bifaces with plane-to-convex surfaces are spread in the southern-most part of GH 3. They are distributed in a Z-value between 6.6 and 7.4.

Dimension

In regard to dimension of these objects the values are much more scattered (see fig. 274) and not clustered as we see in the distribution.

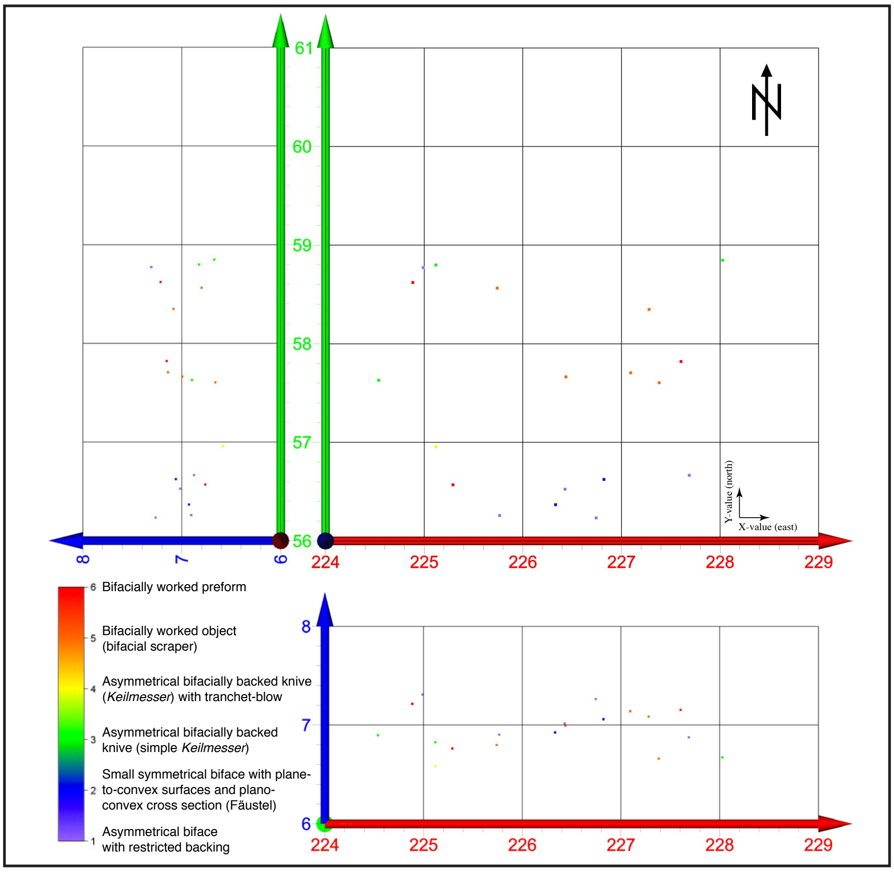

Fig. 273 - Distribution of bifacial objects made on blanks from GH 3

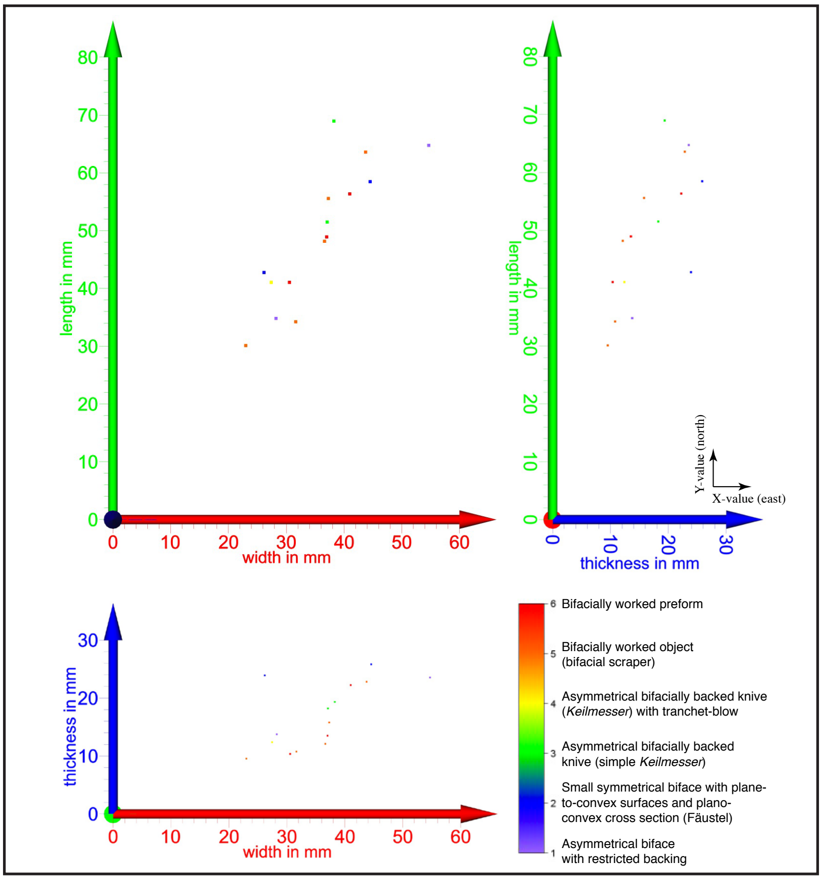

Fig. 274 - Dimension of bifacial objects made on blanks from GH 3

VII.11.14 Blanks deriving from modification

In total n=69 blanks were detected that were attributed as deriving from modification processes on lithic objects. As we clearly see in the distribution of these objects (fig. 275) they cannot represent the total amount of these objects (as we know from sorting). The reason is simply that the sorting, labeling, determination and analyses of collective finds (water-screened sediment from buckets) is still in process (due to the default of working capacity). The displayed objects are all single-finds. The complete distribution of these objects should radically change in the progress of work.

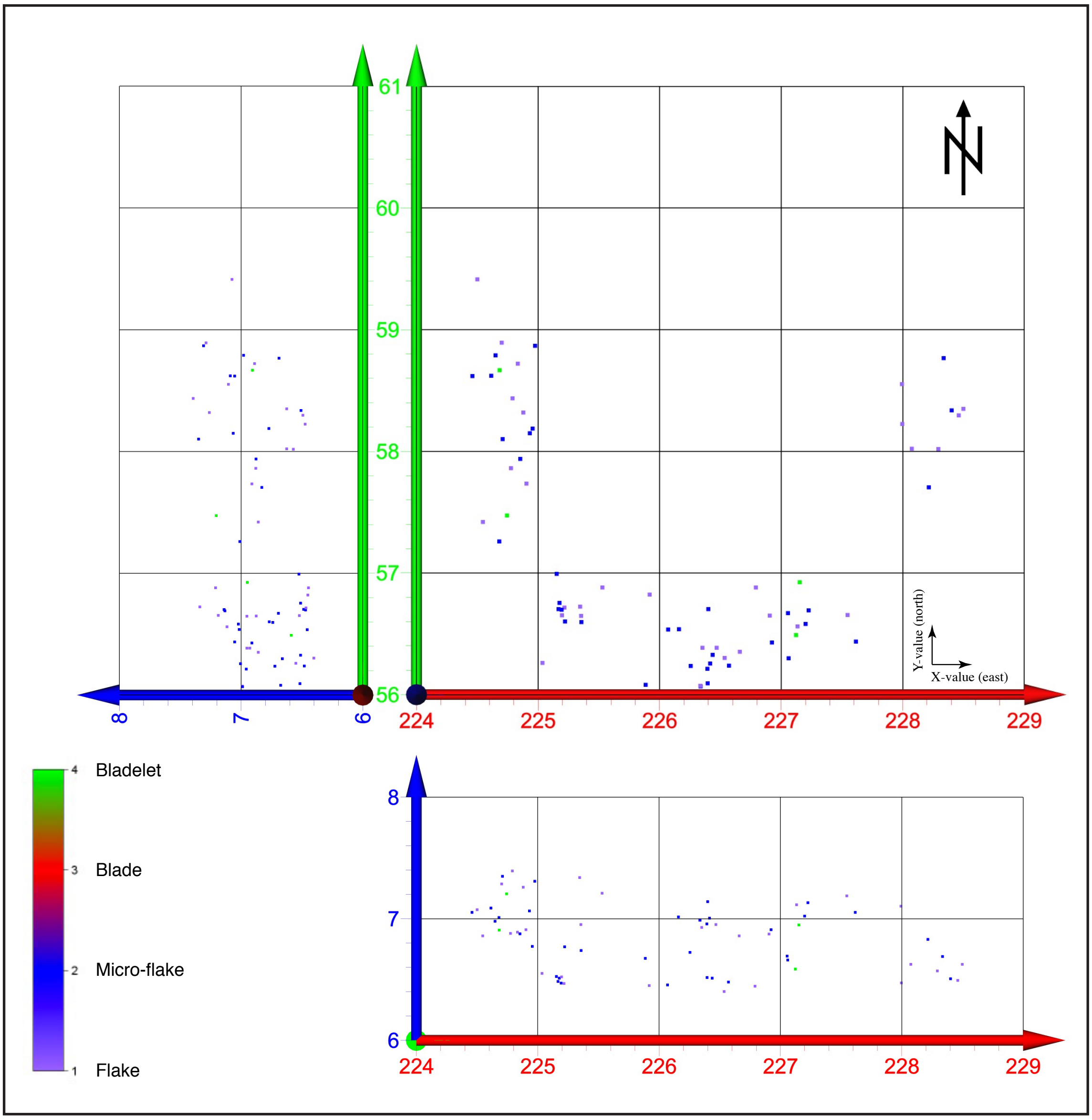

Fig. 275 - Distribution of blanks deriving from modification of other blanks (only single finds) from GH 3

Therefore the dimensional range of these artifacts can also not be seen as complete (see fig. 276), but it is visible that they are in mean quite small

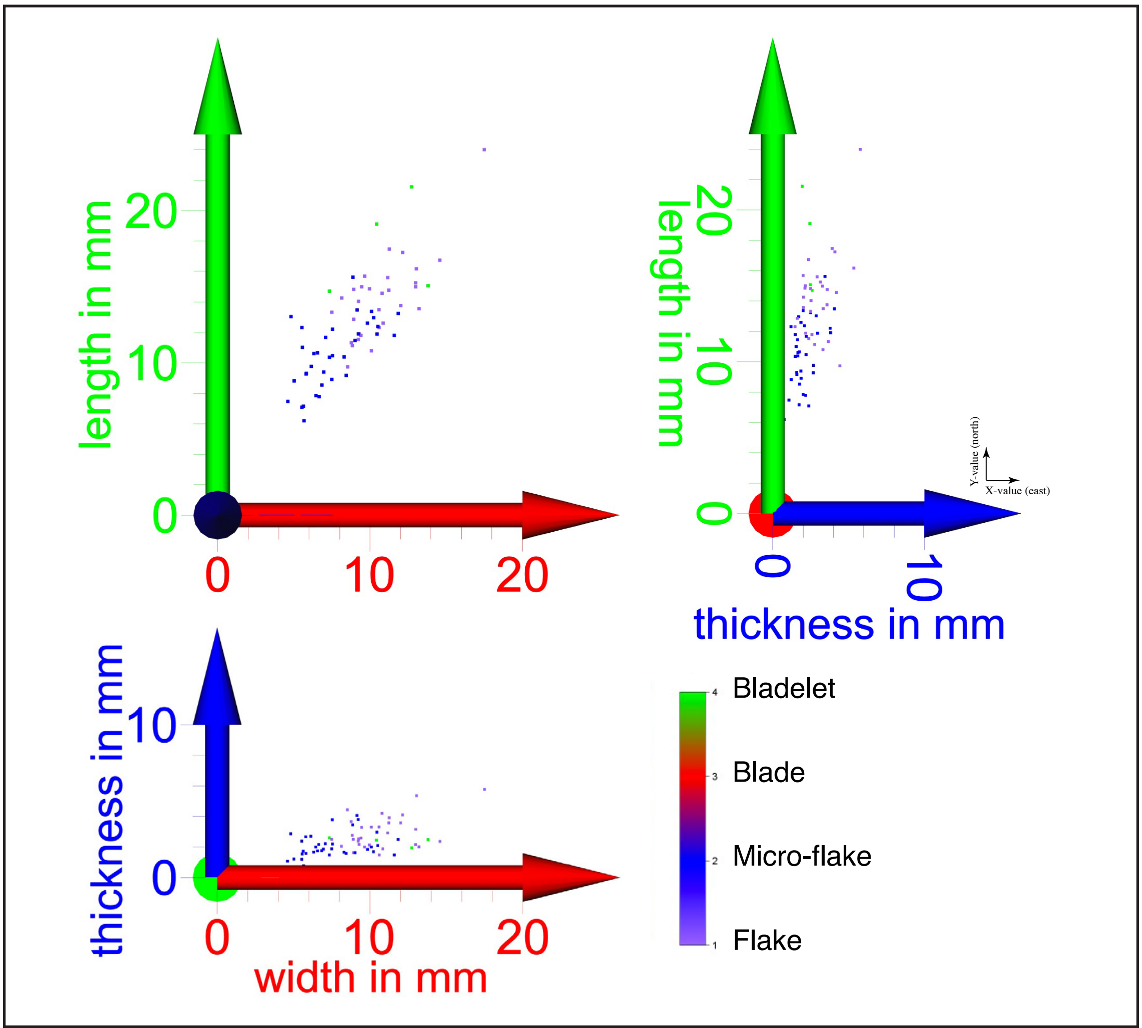

Fig. 276 - Dimension of blanks deriving from modification of other blanks (only single finds) from GH 3

VII.12 Conclusion of detailed blank analysis

The detailed analysis of blanks from GH 3 demonstrates the high diversity in the morphology of blanks and indicates that different production concepts are integrated. Additionally, there is some evidence for preferences present. The following list summarizes the observed evidence.

- There are many modified blanks (around 18% of the n=2205 analysed blanks) if it is taken into account that blanks >5 mm are integrated in the analysis
- In regard to number, Levallois is the dominant detected reduction concept for blanks
- Levallois blades are dominated by parallel negatives on the dorsal face, which is another evidence that they origin from recurrent series production
- Points show more divergent negative patterns than convergent patterns. This is good evidence that the majority of points are constructed by modification and not by confection during the reduction process (classical Levallois points are not preferred for tools with a tip)

- Despite the high morphological diversity of bifacial objects on blanks, they are all made inside the framework of a quite standardised production concept
- The blanks show that nearly the entire production of them could have been made on-site (with the exception of singular objects)
- Despite the fact that there is some evidence for bulb reduction on blanks, the number of Janus flakes is very low
- The ratio of flakes and blades of GH 3 ist 1889:121=15,6
- FAS is the preferred RM (ratio of 5.66:1 to all other lithic raw materials)
- Most of the blanks are made from fine-grained raw materials
- The ratio of hard and soft hammer technique is 9:1
- N=405 modified blanks show n=442 modifications
- Multiple modified blanks are mostly Levallois blanks
- In regard to the total blanks assemblage the number of crested or *débordant* blanks, as well as core tablet is quite low
- Most of the analysed blanks had to be classified as simple blanks

Concerning the spatial distribution of bifacial objects there are also some general observations to be listed:

- Bifacial objects are always situated in the upper half of GH 3
- The upper half of GH 3 contains way more blades than the lower half
- The same is observable for the distribution of objects made from chert and quartzite
- If modified and unmodified blanks are spatially compared it is visible that both are randomly scattered in the entire volume of GH 3
- Most of the blanks have a maximum length between 20 and 60 mm

VII.13 Blank modification

VII.13.1 Introduction

In GH 3, n=394 blanks show a subsequent modification after production. As discussed in chapter V.2.3, modification reflects an intentional action. They reflect 17.87% of the analyzed n=2205 blanks. If only complete blanks are taken into account, the percentage of modification is 18.53% for n=144 modified, complete blanks (see also tab. 222).

	Unmodified blanks	Modified blanks	Percentage of modified blanks
All analysed blanks	1811	394	17,87
All complete blanks	633	144	18,53

Tab. 222 - Percentage of modified blanks from GH 3

The ratio between all cores and modified blanks is 247/394=0.63:1. This would mean if all n=394 were made from these 247 cores, every core could have had produced 1.6 blanks that were modified afterwards. This hypothetical consideration can go further, if cores that are considered to have not been used to produce such blanks, such as tested raw-pieces, cores-of-hammerstones, cores-of-anvils, bifacial objects and core-debris are excluded. In this way a total of n=125 cores could have produced these blanks. This would result in 3.15 modified blanks per potential core.

If length and width of complete, modified blanks are compared to the length and width of reduction surfaces of these potential cores (see fig. 277), it is visible that the dimension of the reduction surfaces is in mean larger than the dimensions of these modified blanks. This is also consistent if FAS or chert alone is compared (because these raw materials contain blanks, and cores).

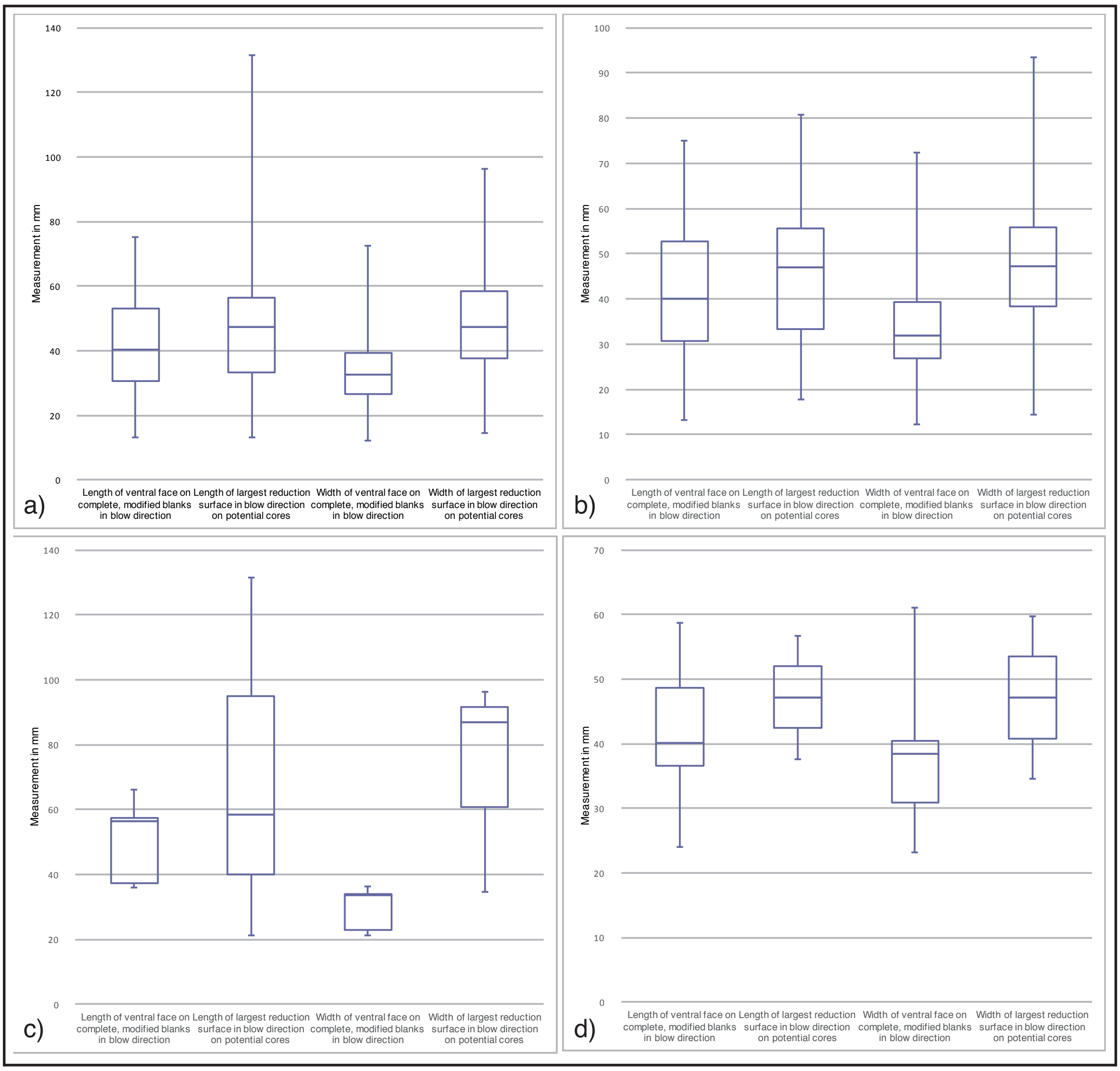

Fig. 277 - Comparison of length and width of complete, modified blanks from GH 3 with length and width of reduction surfaces on potential cores. a) All lithic raw materials, b) Only FAS, c) Only chert and d) Only unknown flint

The number and ratio of modified blanks suggest that the working step of modification, and therefore implied re-tooling, was a quite important component of the tasks realized on-site (or simply discarded on site, if individual objects are taken into account, see also chapter X.3).

VII.13.2 Dimension of modified blanks

Fig. 278 shows the dimension range of these modified blanks, separated by blank type (flakes in violet and blades in red). There is a clearly visible overlap of both blanks types, because fragments and complete blanks are plotted. Most of the modified blanks are located in the center and the majority of them is in the dimensional range of flakes. In regard to thickness, modified blanks reach the complete thickness span of blanks.

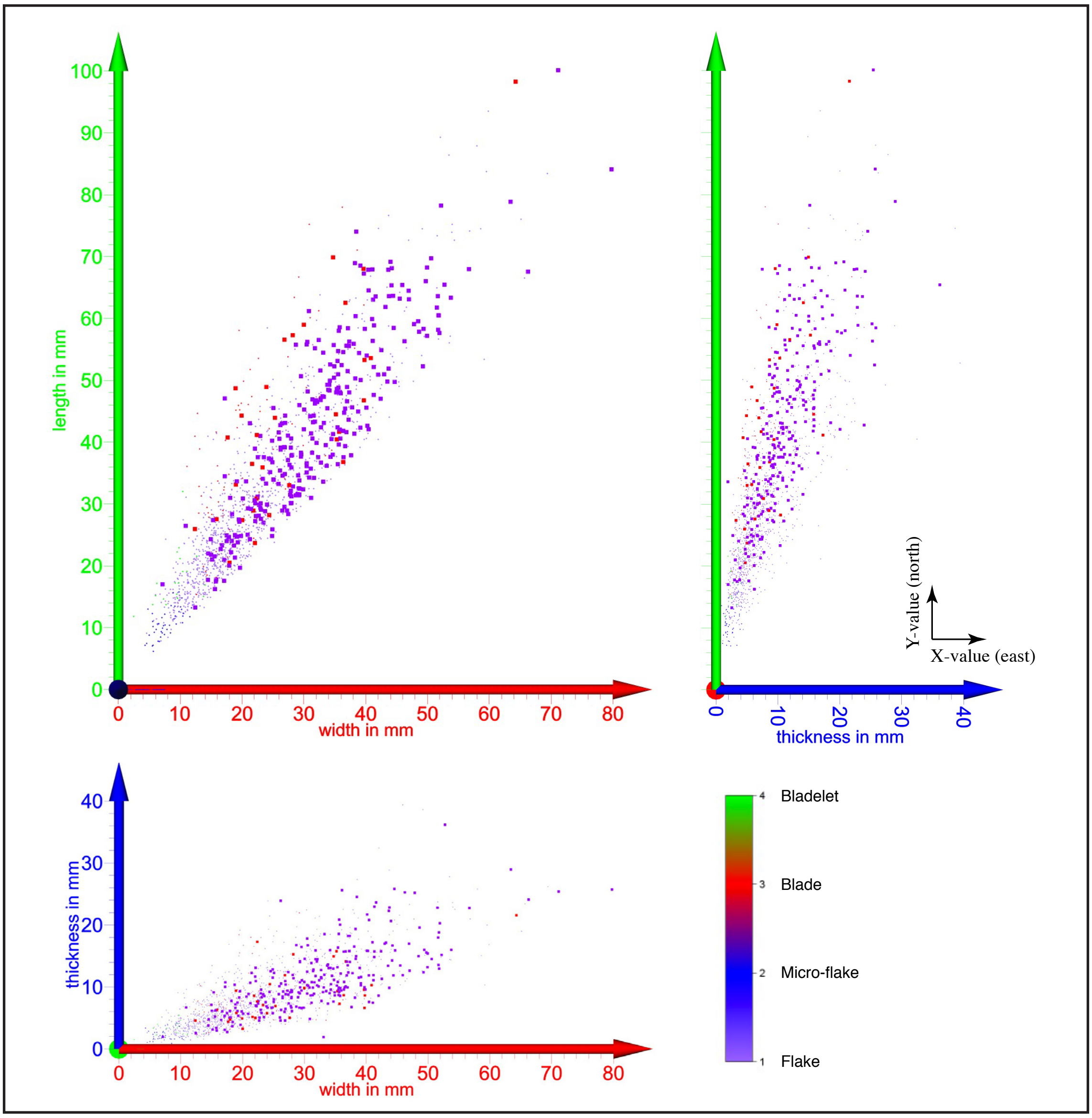

Fig. 278 - Dimensions of modified blanks from GH 3. Flakes in violet (big dots are modified flakes, small diamonds are unmodified flakes) and blades in red (big dots are modified blades, small diamonds are unmodified blades)

In dimension, the average of flakes and blades is quite close to each other (see fig. 278). Lengths of both blank types are comparable. However, widths and thickness differ significantly. The dimensional values are displayed in the following tab. 223:

Dimension	Total			Flake			Blade		
Values	Length	Width	Thickness	Length	Width	Thickness	Length	Width	Thickness
Minimum	13.3	7.1	1.9	13.3	7.1	1.9	20.5	12.4	3.2
Q1	31.5	23.5	7.2	31.5	24.7	7.4	32.1	20.0	5.6
Median	41.0	30.6	9.9	41.0	31.1	10.0	41.0	24.9	7.9
Q3	52.2	37.1	13.5	52.2	37.3	13.7	50.6	35.2	10.0
Maximum	100.1	79.8	36.2	100.1	79.8	36.2	98.3	64.3	21.6

Tab. 223 - Boxplot values for modified flakes and blades from GH 3

Fig. 279 displays the dimension of complete, modified flakes and blanks and shows that the dimensional range of flakes is in all dimension bigger than for blades.

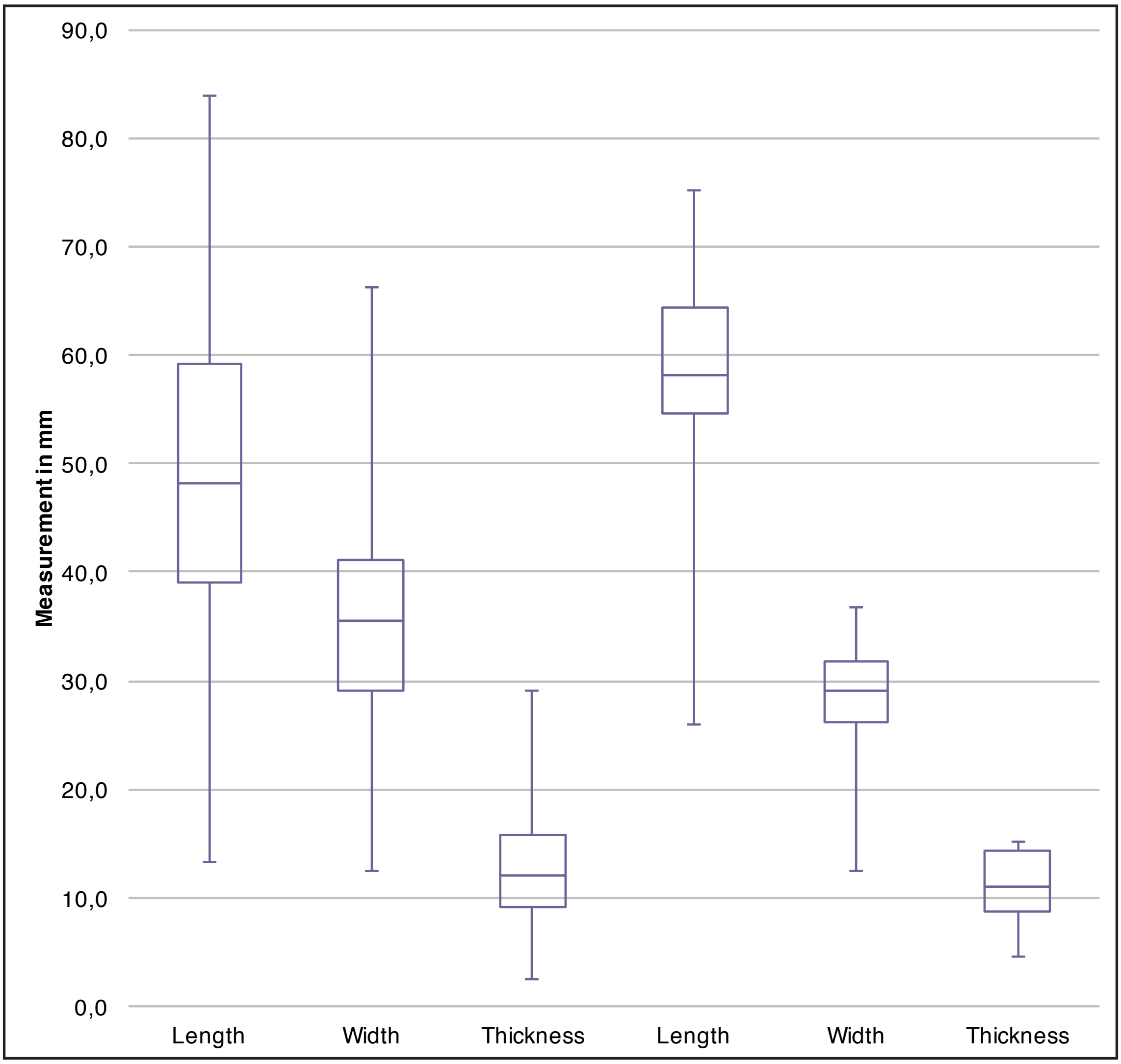

Fig. 279 - Dimensional comparison of complete, modified flakes (left) and blades (right) from GH 3

VII.13.3 Distribution of modified blanks

In displaying the distribution of modified blanks in categories (listed in the next paragraph, see tab. 224) of modification, there is no clear pattern of each category visible (fig. 280).

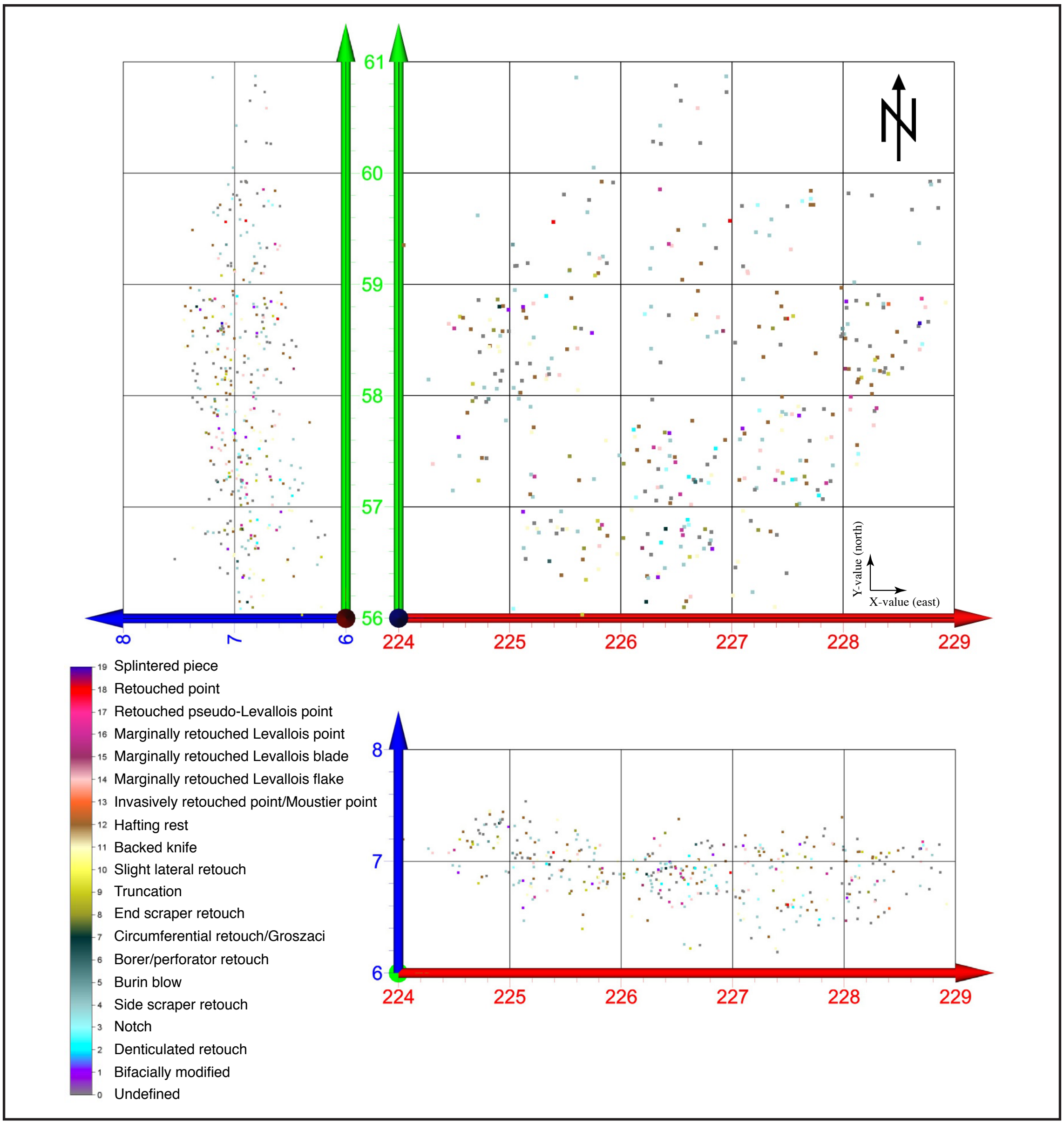

Fig. 280 - Distribution of modified blanks separated into 20 types of modification from GH 3

Therefore the approach here is to display only some types at once to see if a distributional pattern is visible or not. The first comparison use very commonly described modified blanks, namely bifacial objects, denticulates, notches and side scrapers (see fig. 281). They are almost randomly distributed allover the excavated area of GH 3. Side scrapers are everywhere present. Denticulates and notches are situated in the middle and eastern part. Bifacial objects are present in the middle and southern part. In regard to depth, the most obvious observation is that bifacial objects, denticulates and notches are much more distributed in the upper half.

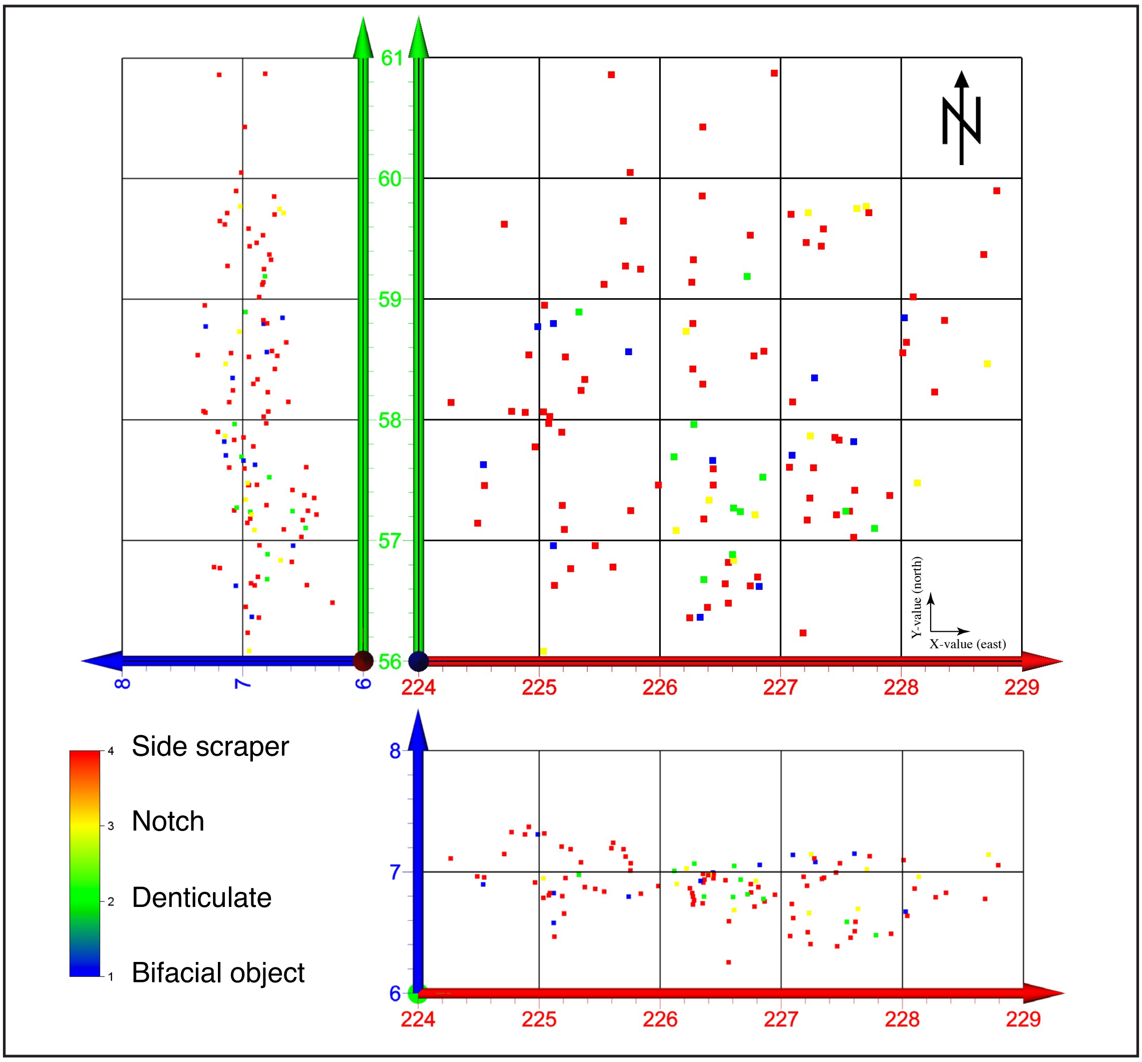

Fig. 281 - Spatial distribution of bifacial objects (blue dots), denticulates (green dots), notches (yellow dots) and side scrapers (red dots) from GH 3

VII.13.4 Comparison of surface and edge modification on ventral and dorsal surfaces

In the database the modification on blanks is separated into four types:

- Modification that influence the surface of the ventral face
- Modification that influence the edge on the ventral face
- Modification that influence the surface of the dorsal face
- Modification that influence the edge on the dorsal face

The modification of the ventral face mostly affected the bulb region. There is evidence for n=17 objects for a removed bulb. For n=5 of them this happen during the detachment of the matrix-blank. On n=12 blanks the bulb was intentionally removed. In total on n=40 blanks modification influenced the surface of the ventral face. In addition to the removal of the bulb region, thinning processes produced up to n=24 negatives on a ventral face. Most of the objects with ventral face modification are made on FAS (n=34), three are from an unknown flint, two are made from chert, and one blanks from quartz show also such modification. If we exclude bifacial objects on blanks (n=13), another n=27 objects are to discuss here. All, except of one blade, are flakes. The denomination of them is listed in the following tab. 224:

Blank type	Blank class	Modification on ventral face	Number
Flake	Simple flake	3 times intensional removal of the bulb, 5 times thinning of the surface, 5 times thinning of surface parts	**14**
	Raw piece cap	2 times intensional removal of the bulb, 2 times thinning of surface parts	**4**
	Surface correction blank	Large negative on left lateral	**1**
	Éclat débordant	One time intensional removal of the bulb and one time a large negative tinned the surface	**2**
	Levallois blank	2 times intensional removal of the bulb, 2 times negative on ventral face	**4**
	Ventral blank	One negative visible	**1**
Blade	Lame débordant	Tranchet blow negative influence the ventral face	**1**
Total			**27**

Tab. 224 - Blanks with modification than influence the ventral face from GH 3

The dorsal face is affected on n=37 objects (n=9 are bifacial objects). With the exception of two from chert, all are made from FAS. The spectrum contains raw piece caps, simple blanks, edge correction blanks, Levallois blanks and a ventral flake. They are listed in tab. 225.

Blank type	Blank class	Modification on dorsal face	Number
Flake	Raw piece cap	Retouch influenced the surface	**5**
	Simple flake	Splintered piece with a highly transformed dorsal face, the rest contain thinning and retouch that massively influenced the surface	**11**
	Éclat débordant	One time thinning from the butt onto the surface, one time retouch influenced the surface	**2**
	Edge correction blank	Thinning of the surface	**1**
	Levallois blank	Thinning of the surface, retouch influenced the surface	**8**
	Ventral flake	Tranchet-blow negative on terminal and influenced the surface	**1**
Total			**28**

Tab. 225 - Blanks with modification than influence the dorsal face from GH 3

Modifications on edges are discussed in the following.

VII.13.5 Type of modification

In general, blank modification is done by using a vast range of retouch techniques. In a typological view, the most common type of modification is related to hafting purposes on the lateral edges of terminal fragments (n=106, see chapter X.9). It is followed by (invasive) scrapers modification (n=85) and (marginal) lateral retouch (n=46). The following tab. 226 lists all types of modification (please not that some blanks have more than one kind and position of modification):

Type of modification	Number	Explanation
Undetermined retouch	**39**	Retouch on parts of edges that could not be further specified
Bifacial modification	**19**	Bifacial objects, such as Keilmesser, bifaces, etc. on blanks
Denticulated, toothed	**17**	More than one adjacent notch on the edge
Notch	**14**	One or more non-adjacent notches
Side scraper	**85**	Quite steep retouch, used in a transversal way, mostly >60°
Burin	**3**	Object, showing a burin removal on an edge
Borer	**5**	Pointed retouch, it that way that it cannot be used for perforation
Groszak	**3**	Circumferential retouch on a small round flake
End scraper	**25**	Clear convex retouch on the terminal end
Truncation	**16**	Clear straight retouch on the terminal end
Lateral retouch	**46**	Slight retouch on one of the lateral edges, mostly <60°
Backed knife	**41**	Blank with a triangular cross-section and confected back
Hafting rest	**106**	(Mostly basal fragments) showing lateral retouch that can be used to fix the object in a haft (direct and inverse retouch, sometimes also notched or toothed)
Moustier point	**2**	Intensive modified blanks with retouch on both lateral edges formed a point (intensively constructed point)
Retouched point	**6**	Marginal modified blank with retouch on both lateral edges formed a point (retouch emphasize the point character)
Tranchet-blow	**5**	Tranchet-blow for the formation of a straight cutting edge, also named para-burin
Splintered pieces	**1**	Opposing damage that should be the result of using the object as wedge for splitting
Total	**433**	

Tab. 226 - List of all modifications on blanks from GH 3

Remarkable in this context is that there are n=393 blanks showing n=433 modifications. The reason for that is simply that some blanks own more than one particular type of retouch. It is conscious that this classification approach is far from being finished. A much more objective approach would be to separate all edge modification into categories of production (how are they made?), morphology (how do they appear? Shape, angle, etc.) and function (use wear and hypothesis for what the modification was made for). Unfortunately, this splitting must be related to further research and is not part of this discussion. Blanks with more than one kind of modification (n=36) have the following combinations (tab. 227):

Combination of modification	Note	Number
Truncation and borer retouch	Surface correction blank with truncation on break and borer retouch	**1**
Lateral retouch and truncation	Edge correction blanks with slight lateral retouch and truncation	**2**
End scraper and hafting rest	Convex end scarper retouch and toothed retouch on the terminal part of the lateral edges	**1**

End scraper and lateral retouch	Convex end scarper retouch and slight toothed lateral retouch	**1**
Lateral retouch and backing	One lateral edge with a marginal retouch, the other with backing	**2**
Lateral retouch and scraper retouch	One lateral edge with a marginal retouch, the other with an intensive retouch	**4**
Lateral retouch and hafting rest	One lateral edge with marginal retouch, retouch on the terminal part of the lateral edges	**1**
Levallois flake with toothed retouch and side scraper retouch	Levallois flake with toothed retouch on one lateral edge and the other with an invasive side scraper retouch	**1**
Levallois flake with end scraper retouch and hafting rest	Levallois flake with convex end scraper retouch and retouch on the terminal part of the lateral edges	**1**
Levallois flake with truncation and lateral retouch	Levallois flake with truncation and marginal lateral retouch	**2**
Levallois flake with lateral retouch and knife backing	Levallois flake with marginal lateral retouch and the other edge with backing	**1**
Levallois flake with lateral retouch and hafting rest	Levallois flake with marginal lateral edge retouch and retouch on the terminal part of the lateral edges	**3**
Levallois flake with side scraper retouch and hafting rest	Levallois flake with side scraper retouch on a lateral edge and retouch on the terminal part of the lateral edges	**2**
Levallois blade with lateral retouch and hafting rest	Levallois blade with marginal lateral retouch and retouch on the terminal part of the lateral edges	**1**
Levallois blade with backing and hafting rest	Levallois blade with backing on one lateral edge and retouch on the terminal part of the lateral edges	**1**
Levallois point with lateral retouch, pointing	Levallois point with marginal lateral retouch, formation of a pointed end	**1**
Levallois point with lateral retouch and hafting rest	Levallois point with marginal lateral retouch and retouch on the terminal part of the lateral edges	**3**
Retouched point and side scraper retouch	Flake, retouched to a point, one lateral show an invasive side scraper retouch	**1**
Retouched point and hafting rest	One Flake and one blade, retouched to a point and retouch on the terminal part of the lateral edges	**2**
Side scraper retouch, tranchet-blow and hafting rest	Flake with invasive side scraper retouch, a tranchet-blow and retouch on the terminal part of the lateral edges	**1**
Side scraper retouch and hafting rest	Flake with invasive side scraper retouch and retouch on the terminal part of the lateral edges	**2**
Side scraper retouch and burin	Flake with invasive side scraper retouch and a burin blow	**1**
Borer and undefined retouch	Flake with some small retouched parts of the edge and the formation of a borer point	**1**
Total		**36**

Tab. 227 - Blanks from GH 3 showing more than one kind of modification

Some of these blanks show a chronological succession of these modification with different degrees of patination, which are indications for a time gap between. In the course of this work we mention this circumstance but the particular analysis of this phenomenon (recycling) is reserved for future work and not explicitly part here. The following paragraphs discuss the total of the modified blanks in more detail. So called hafting rests are discussed in chapter X.9 and bifacial objects are discussed in chapter VII.14.

VII.13.6 Comparison between blanks class and modification

This section discusses the relation between blank classes and modification. It shows which blanks class was modified in which way. The following tab. 228 shows numbers of unmodified and modified blanks per blank class:

Modification Blank class	Unmodified	Modified	Total	Percentage of modified blanks
Simple blank	868	187	**1055**	17.73
Raw-piece cap	200	28	**228**	12.28
Blank of surface correction	340	39	**379**	10.29
Blank of edge correction	204	15	**219**	6.85
Crested blanks	4	2	**6**	33.33
Éclat débordant* and *lame débordant	35	15	**50**	30
Core tablet	1	1	**2**	50
Levallois blank	58	98	**156**	62.82
Kombewa flake	11	2	**13**	15.38
Tranchet-blow blank	9	0	**9**	0
Bifacial objects on blank	0	19	**19**	100
Blank deriving from retouch	68	1	**69**	1.45
Total	**1798**	**407**	**2205**	**18.46**

Tab. 228 - Unmodified and modified blanks from GH 3, per blank class

There are n=187 simple blanks with modification (blanks where the production concept could not be evaluated), followed by n=98 modified Levallois blanks. All other modified blanks are n=122. As the tab. 228 clearly shows nearly all blank classes contain blanks that were modified after production (the only exception are tranchet-blow blanks). A first implication of this is that all blanks have the potential (in the mind of the producers) to be used and to be integrated in further modification processes. For a better overview the percentages of modified blanks are listed in the following fig. 282.

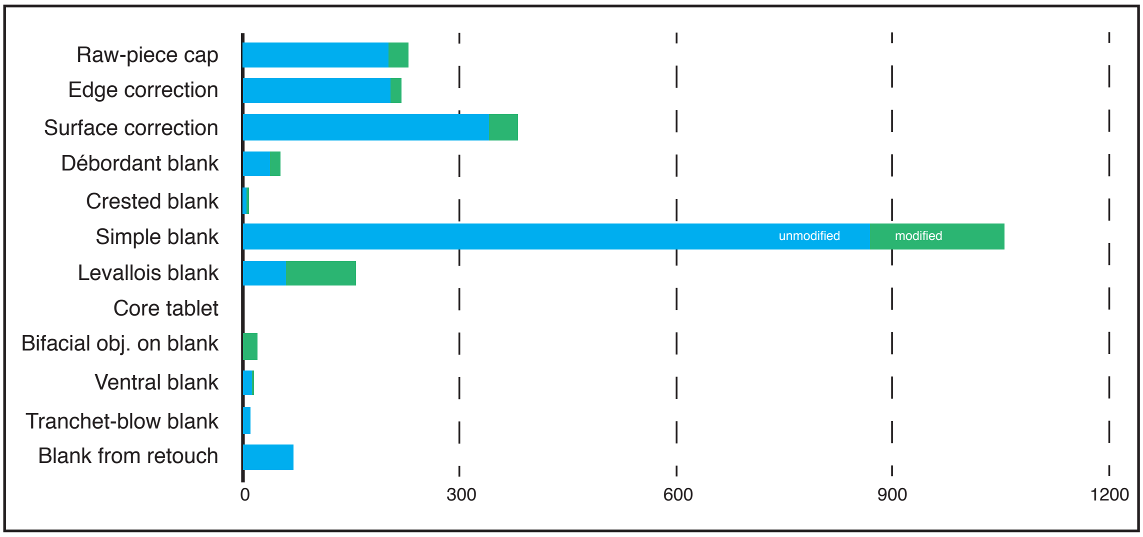

Fig. 282 - Comparison of unmodified and modified blanks per blank class from GH 3 as bar graph

The following sections elucidate and discuss the detected types of modification on blanks.

VII.13.7 Side scraper modification

In the following section side scraper modification (n=85) is discussed, including their blank production and the modification of these blanks, as well. As there are so many definitions what a side scraper is (e.g., Brézillon 1971; Debénath & Dibble 1994), we summarize simply that a side scraper modification is a regular, quite steep retouch (which is not a backing but larger than 60°) that seems to be used in a transversal way (in regard of the retouch, see fig. 23) in pushing motion (whittling) or pulling motion (scraping). Bordes' (1961: 25) definition is very general: „[...] *an object made on a flake or blade, Levallois or not, with continuous retouch that is flat or abrupt, scaled or not, on one or more margins, in order to produce a more or less cutting edge which is straight, convex, or concave, with no deliberate notching or denticulation*." (Debénath & Dibble 1994: 70).

In total, n=72 of the objects showing a side scraper retouch are made on FAS. Chert is the raw material for n=5, unknown flint and unknown silicious raw material are present with n=4, each. Additional to them, one lacustrine flint with scarper retouch is also present. In regard of fragmentation, there are n=44 complete blanks, n=14 basal, n=7 medial and n=15 terminal blank fragments, as well as n=4 left lateral and n=1 right lateral fragment. From all of these n=85 blanks with a side scraper retouch, there are n=25 blanks attributed to Levallois reduction. Tab. 229 summarizes objects with a scraper retouch in regard to fragmentation and production concept for the initial blank.

Fragmentation Reduction	Complete	Basal	Medial	Terminal	Left lateral	Right lateral	Total
Levallois	18	3	1	2	1	0	**25**
Laminar	1	1	0	1	0	0	**3**
Quina	1	0	1	0	0	0	**2**
Ventral (Kombewa)	0	0	0	1	0	0	**1**
Unknown	24	10	5	11	3	1	**54**
Total	**44**	**14**	**7**	**15**	**4**	**1**	**85**

Tab. 229 - Fragmentation in regard to reduction for side scrapers from GH 3

The majority of side scrapers are made on blanks from non-determined production sequences (n=54). The majority of a determined production sequence derives from Levallois production (n=25). In addition to these both there are n=3 laminar blanks, n=2 Quina-like blanks and one ventral blank (see fig. 283). The position of the retouch negatives is not always situated on the blank's dorsal face as the following tab. 230 lists:

Position of the retouch	Total
Solely on dorsal face	**57**
Solely on ventral face	**7**
On both faces	**13**
Undetermined	**8**
Total	**85**

Tab. 230 - Position of the retouch on blanks with scraper modification

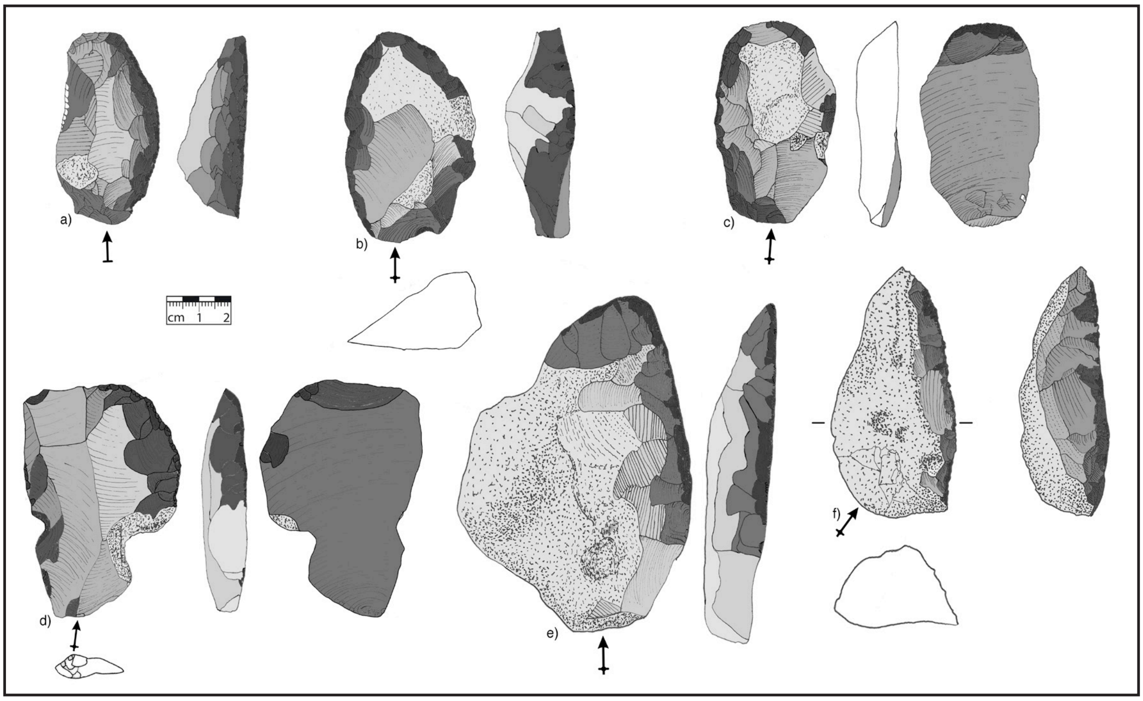

Fig. 283 - Examples of blanks modified with a scraper retouch from GH 3. a) Highly invasive (Quina) retouch (GER10.226-058.89); b) Circumferential retouch on cortical flake (GER10.226-059.245); c) Circumferential retouch on dorsal face and Kostenki-like retouch on the terminal end on the ventral face (GER10.226-059.248); d) Convex retouch on dorsal face and large negative on the terminal end on the ventral face (also Kostenki-like), with a natural and an intentionally retouched notch (hafting purposes?) (GER10.226-060.221); e) Large cortical flake with flat but intensive circumferential retouch (GER10.228-058.216) and f) Cortical flake with highly intensive (Quina) retouch (GER12.226-057.294)

For n=20 blanks, there is evidence for a ventral-face retouch (see tab. 230). If the outline of a blank is divided into 8 segments, these blanks altogether show n=22 segments with retouch (two blanks show retouch on two segments, see fig. 284):

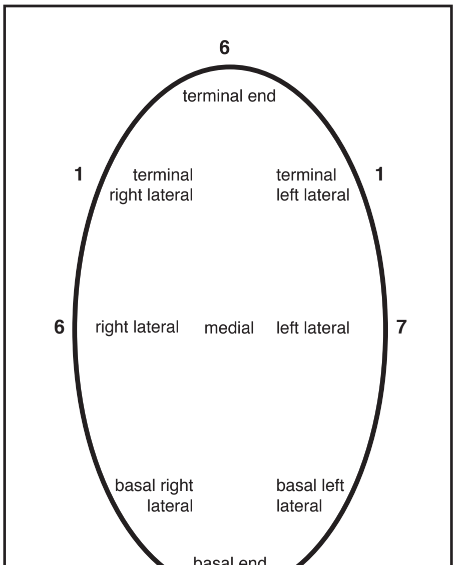

Fig. 284 - Display of the position of retouch on ventral faces (right and left is interchanged, because lateral edges are named after their (top) dorsal view) on blanks with scraper modification from GH 3

Only n=7 of these modified blank show their retouch only on the ventral face (see tab. 231 and examples in fig. 285).

Find-number	Blank class	Position of the modification with ventral-face negatives
GER09.227-060.153.1	Surface correction flake	Right lateral
GER10.226-058.201	Simple flake	Left lateral
GER10.226-059.148	Simple flake	Terminal
GER10.226-059.217	Simple flake	Left lateral and terminal
GER10.227-058.275	Simple flake	Left lateral
GER10.227-058.338	*Éclat débordant*	Left lateral
GER13.228-057.415	Surface correction flake	Right lateral
Total	**7**	**8**

Tab. 231 - Modified blanks with solely ventral-face negatives interpreted as scraper retouch from GH 3

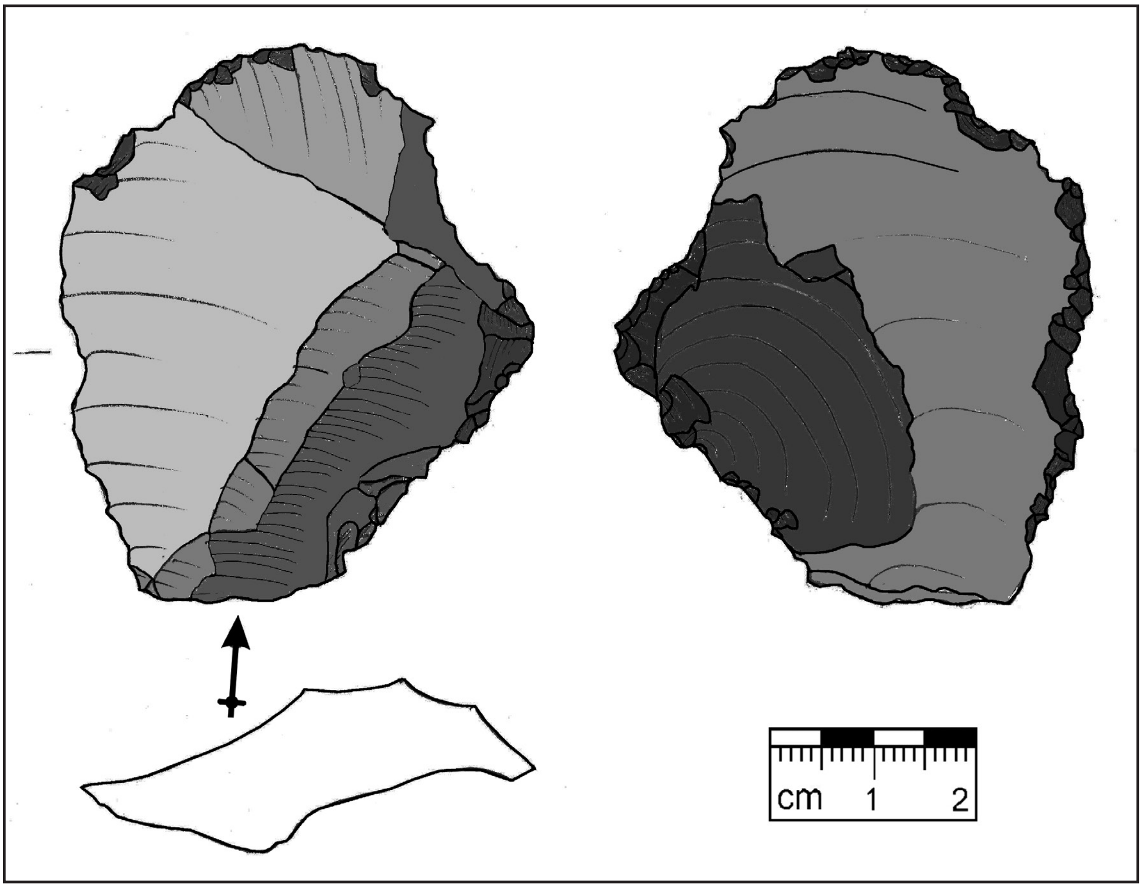

Fig. 285 - Example of a modified blank with solely ventral-face negatives interpreted as scraper retouch from GH 3 (GER13.228-057.415)

Another n=13 modified blanks are retouched on ventral and dorsal face (see tab. 232 and fig. 286).

Find-number	Blank class	Modification with dorsal-face negatives	Modification with ventral-face negatives
GER09.227-059.120.1	Levallois flake	Left lateral and terminal retouch	Basal retouch
GER09.227-059.144.1	Simple flake	Terminal left-lateral retouch	Terminal left lateral retouch
GER09.227-060.134.1	Simple blade	Left and right lateral retouch	Left lateral retouch
GER09.227-060.145.3	Surface correction flake	Left lateral retouch	Left and right lateral retouch

GER10.226-058.102	Simple flake	Left and right lateral retouch	Terminal right lateral retouch
GER10.226-059.290	Simple flake	Left lateral and terminal retouch	Terminal retouch
GER10.226-060.215	Levallois flake	Left lateral retouch	Left lateral and terminal retouch
GER10.227-058.221	Levallois flake	Right lateral retouch	Right lateral retouch
GER10.228-058.400	Simple flake	Left and right lateral retouch	Terminal retouch
GER11.225-059.275	Simple flake	Left lateral retouch	Left lateral retouch
GER12.227-057.689	Simple flake	Right lateral retouch and two tranchet-blows	Right lateral retouch
GER12.229-058.304	Levallois flake	Terminal retouch	Terminal retouch
GER13.227-057.1263	Levallois flake	Left lateral retouch	Right lateral retouch
Total	**13**	**20**	**15**

Tab. 232 - Modified blanks with ventral and dorsal-face negatives interpreted as scraper retouch from GH 3

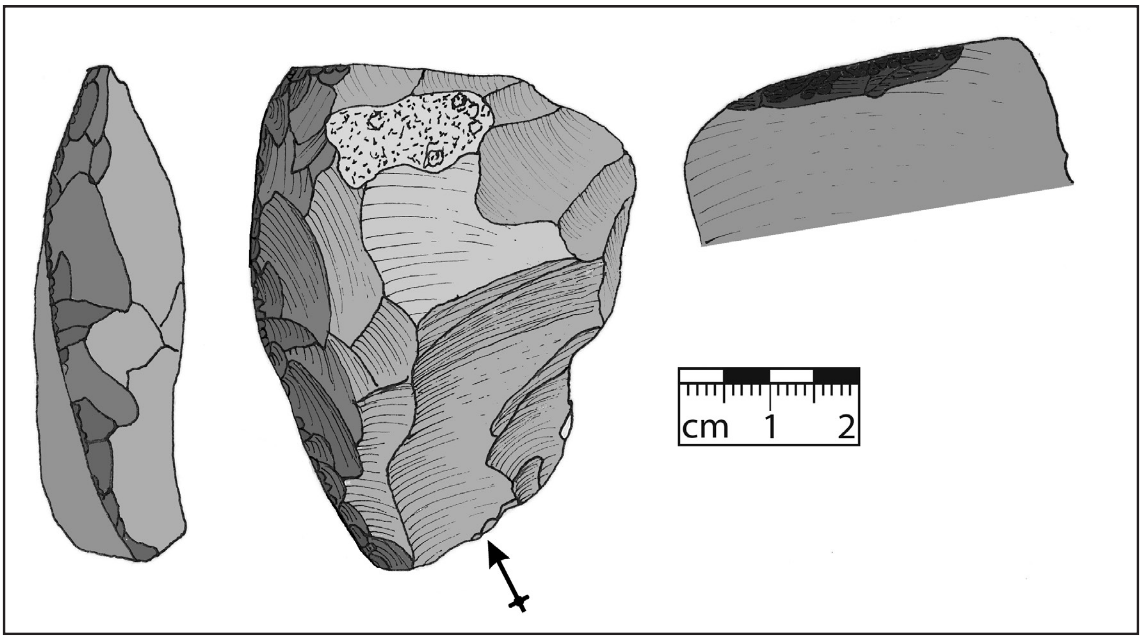

Fig. 286 - Example of a modified blank with ventral and dorsal-face negatives interpreted as scraper retouch from GH 3 (GER10.226-059.290)

Solely dorsal-face retouch negatives are visible on n=57 blanks. The following tab. 233 shows their blanks classes and tab. 234 the position of the retouch:

Blank class	**Number**
Raw-piece cap	**2**
Simple blanks	**48**
Surface correction	**2**
Éclat débordant	**1**
Levallois blank	**4**
Total	**57**

Tab. 233 - Blank classes of solely dorsal-face retouched blanks from GH 3

Position of the retouch	Number
Terminal	**20**
Right lateral terminal	**3**
Left lateral terminal	**2**
Right lateral	**17**
Left lateral	**29**
Right lateral basal	**2**
Left lateral basal	**2**
Basal	**2**
Total	**77**

Tab. 234 - Position of the retouch of solely dorsal-face retouched blanks from GH 3

Altogether, these n=57 blanks show n=77 positions of retouch. Terminal, left and right lateral position seems to be preferred, but this should be an illusion because right and left lateral, as well as right and left basal position is only registered, if the retouch is short. There are n=31 blanks with only one dorsal position of retouch, n=20 with two positions and n=6 with three positions of the retouch.

The amount of left and lateral retouch for blank with only one retouch position equals almost (see tab. 235). Examples of these single scrapers are displayed in fig. 283, above.

Position of the retouch	Number
Terminal	4
Right lateral terminal	0
Left lateral terminal	0
Right lateral	11
Left lateral	13
Right lateral basal	2
Left lateral basal	0
Basal	1
Total	**31**

Tab. 235 - Position of retouch of blanks that show only one retouch on their dorsal face from GH 3

The masses and dimensions of all side scrapers are displayed in fig. 287 as box-plot. The medians of the side scrapers are 23.7 g for mass, 53.8 mm for length, 36.5 mm for width and 13.9 mm for thickness. As the figure shows, a normalization in mass or dimension for side scrapers are not given (a high normalization would be displayed in a very small range of the 50% box).

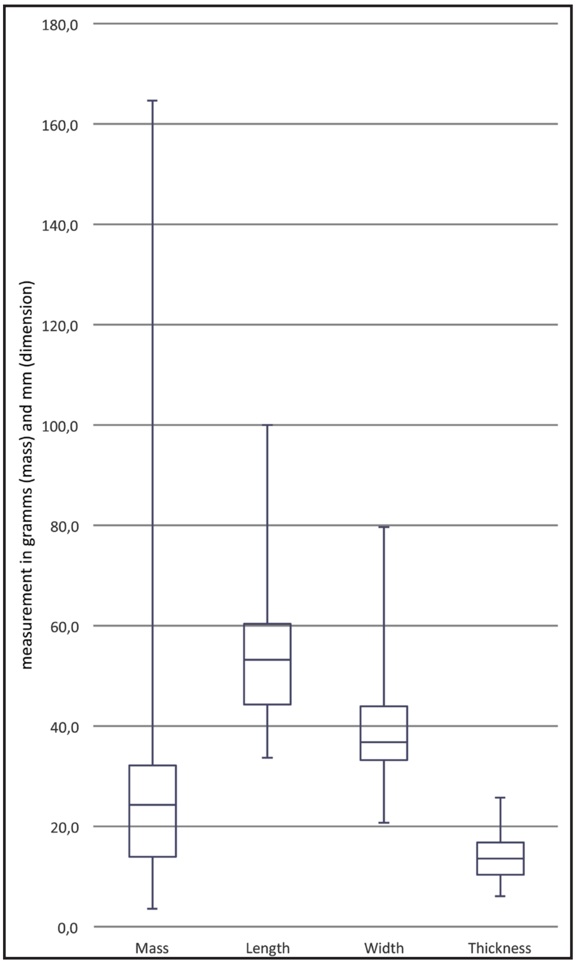

Fig. 287 - Masses and dimensions of all side scrapers from GH 3, displayed as boxplot

Platform dimensions of these side scrapers vary much more in width than in thickness (see fig. 288). The median lays at 19.8 mm for width and 9.0 mm for thickness. The position of modification of these blanks that show a scraper modification is in total quite diverse. At least, there are n=9 combinations of retouch position (see tab. 236). The masses of these combinations are displayed in fig. 289 and 293 as box-plots. They show clearly that the mass of blanks with two dorsal modifications has the highest diversity.

Number of side-scraper modification	Dorsal or ventral position of retouch	Number
One side-scrapers modification	One dorsal	**31**
	One ventral	**6**
Two side-scraper modifications	Two dorsal	**20**
	Two ventral	**1**
	One dorsal and one ventral	**7**
Three side-scraper modifications	One dorsal and two ventral	**1**
	Two dorsal and one ventral	**4**
	Three dorsal	**6**
Four side-scraper modifications	Three dorsal and one ventral	**1**
Undefined		**8**
Total		**85**

Tab. 236 - Combinations and numbers of scraper modifications from GH 3

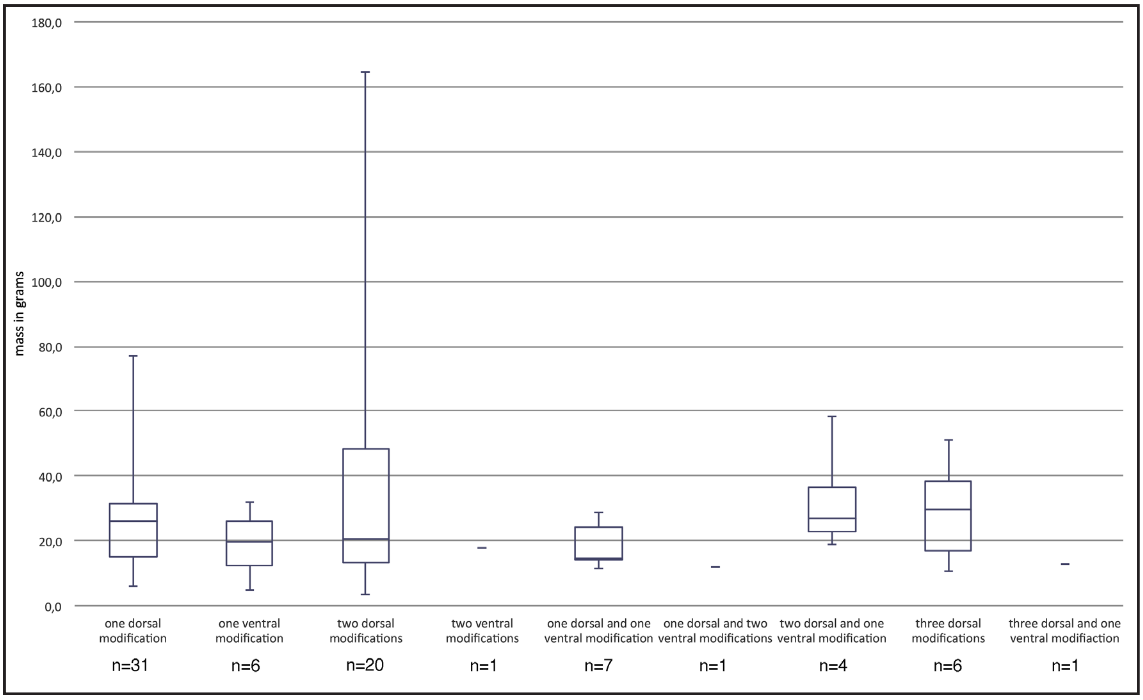

Fig. 288 - Boxplot of masses of the nine combinations of scraper-modifications from GH 3

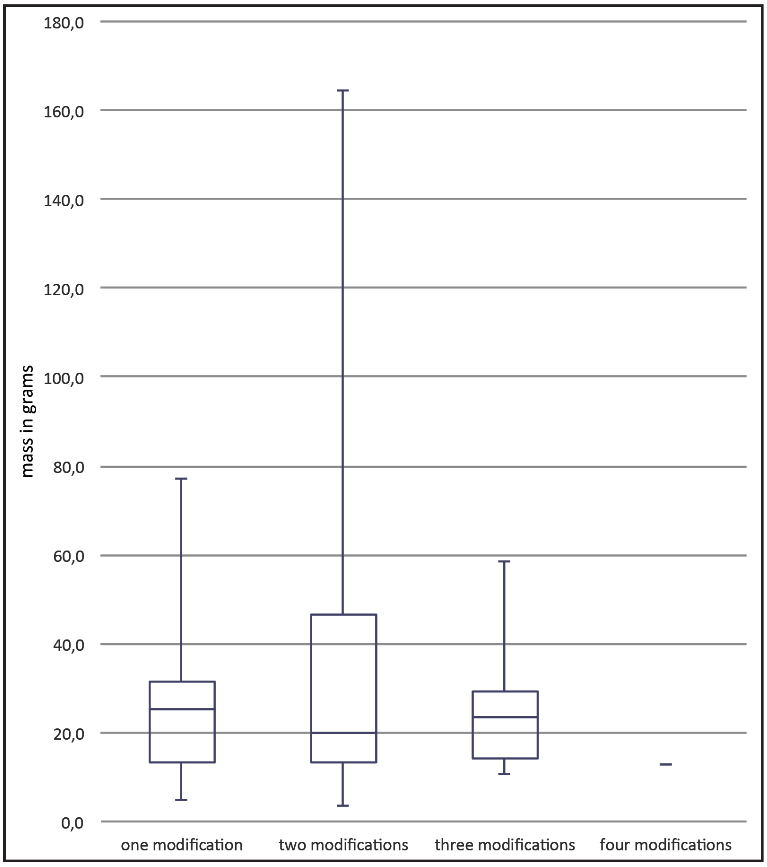

Fig. 289 - Boxplot of masses of the one to four numbers of combinations of scraper-modifications from GH 3

The intensity and multiphase system or retouch (repeated retouch) is not part of this discussion and is reserved for further analysis about lithic artifacts from the site (see chapter X.11). For the moment, there is evidence of at least n=11 blanks with multiphase retouch, which are listed in the following tab. 237 and displayed in fig. 290.

Find-number	Blank class	Note
GER10.226-058.201	Simple flake	Left lateral step multiphase retouch on ventral face with steps
GER10.226-059.245	Simple flake	Dorsal left lateral simple retouch, dorsal right lateral multiphase retouch
GER10.226-060.77	Simple flake	Dorsal left lateral simple retouch, dorsal terminal multiphase retouch
GER10.226-060.84	Simple flake	Dorsal left lateral multiphase retouch
GER10.228-058.216	Simple flake	Dorsal left lateral and basal multiphase retouch
GER10.228-058.421	Raw piece cap	Dorsal right lateral multiphase retouch
GER11.225-060.55	Levallois flake	Dorsal right lateral multiphase retouch, Quina-like
GER12.227-057.689	Simple flake	Dorsal right lateral two tranchet-blow negatives and multiphase retouch
GER12.229-059.635	Raw piece cap	Dorsal right lateral multiphase retouch
GER13.225-058.869	Simple flake	Dorsal terminal multiphase retouch
GER13.225-058.863	Simple flake	Dorsal right lateral multiphase retouch
total	**11**	

Tab. 237 - Modified blanks showing multiphase retouch from GH 3

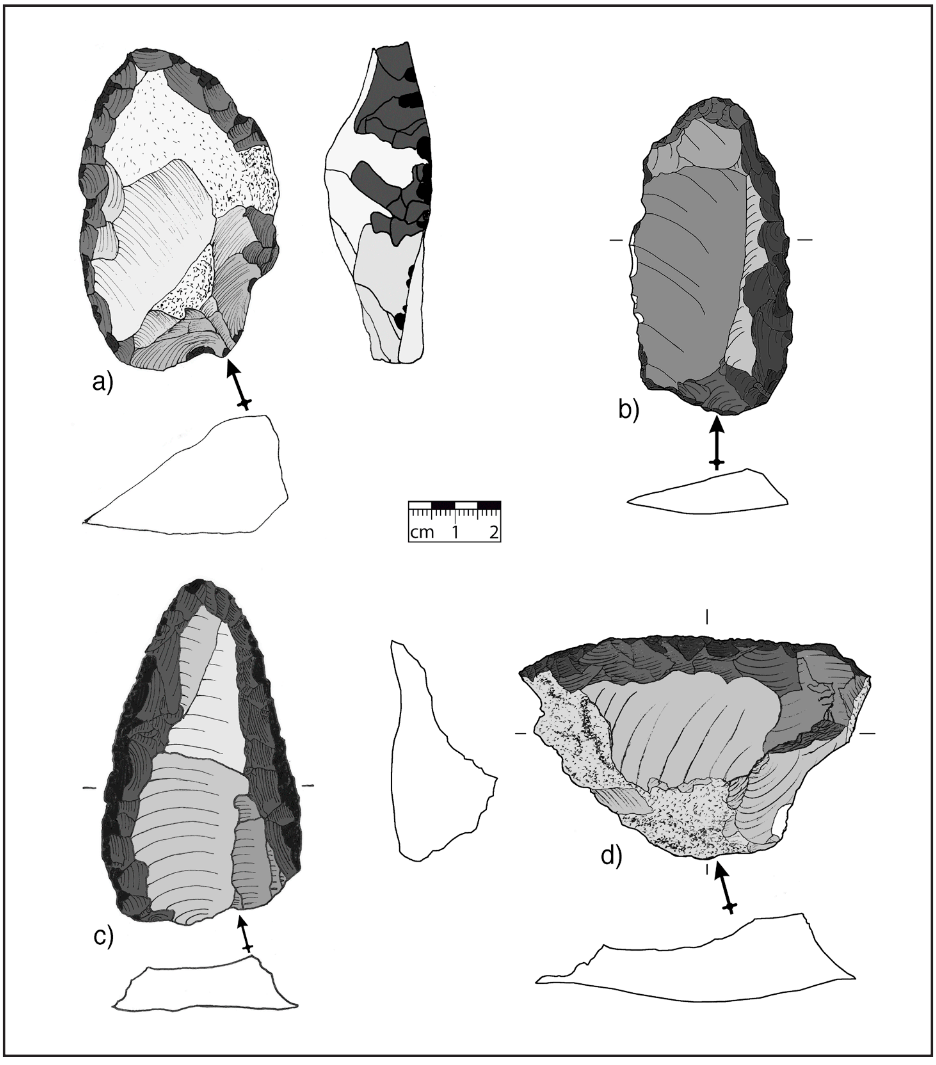

Fig. 290 - Blanks modified with multiphase retouch from GH 3. a) Cortical blanks with circumferential retouch (GER10.226-059.245); b) Levallois flake with right lateral retouch (GER11.225-060.55); c) Moustier point (GER12.229-059.637) and d) Simple blank with terminal retouch (GER13.225-058.869)

VII.13.8 Modified points and points constructed by modification

There is evidence for n=22 blanks that are confected as points. The confection can be part of the core configuration and production (for example resulting in a Levallois point), or the confection can be done by modification after the production (the term confection is used in the sense of Boëda 2013).

The majority of them are classified as Levallois blanks (n=14). Two other modified points are classified as pseudo-Levallois point (symmetry axis does not equal the blow direction). The other n=6 can be classified as constructed points. For n=13 of all of these modified points, there is good evidence that retouch was also performed for hafting purposes.

There are n=10 basal fragments, n=3 terminal fragments and n=9 complete points. The majority of these points is made on FAS (n=18). Another n=3 are made on chert and one is made from an unknown flint.

Examples of these points are displayed in fig. 291 and tab. 238 summarizes them. All n=22 points have retouch on their dorsal face, and n=6 of them also have retouch on the ventral face.

Find-number	Blank class	Note
GER09.227-060.132.1	Simple flake	Triangular right lateral fragment with a stepped retouch
GER09.227-060.153.2	Levallois point	Trapezoid basal fragment with ventrally and dorsally lateral retouch (multiphase, for hafting?)
GER09.227-060.153.3	Simple flake	Complete rectangular flake with lateral retouch (for cutting edge and hafting), impact?
GER09.227-060.158.1	Pseudo-Levallois point	Complete triangular flake with (ventrally and dorsally) lateral retouch
GER09.227-060.158.3	Levallois point	Basal fragment (parallelogram) of a Levallois point with retouch on left lateral and terminal
GER09.228-059.137.3	Simple flake	Complete flake in the shape of a parallelogram with right lateral retouch
GER10.226-058.239	Levallois point	Basal fragment (oval) of a Levallois point with lateral retouch
GER10.226-060.108	Simple flake	Complete triangular flake with ventrally left lateral and dorsally right lateral retouch,
GER10.227-058.174	Levallois point	Basal fragment (oval) of a Levallois point with ventrally and dorsally lateral retouch
GER10.227-058.294	Levallois point	Complete triangular Levallois point with lateral retouch
GER10.227-058.308	Levallois point	Basal fragment (pentagonal) of a Levallois point with lateral retouch
GER10.228-058.145	Levallois point	Basal fragment (trapezoid) of a Levallois point with marginal retouch
GER10.228-058.368	Levallois point	Basal fragment (trapezoid) of a Levallois point with lateral retouch
GER12.226-057.423	Levallois point	Complete triangular Levallois point with lateral retouch

GER12.227-057.695	Levallois point	Basal fragment (oval) of a Levallois point with marginal retouch
GER12.227-057.731	Levallois point	Complete trapezoid Levallois point with vent-rally and dorsally lateral retouch
GER12.229-058.201	Levallois point	Basal fragment (oval) of a Levallois point with lateral retouch
GER12.229-058.298	Levallois point	Basal fragment (oval) of a Levallois point with marginal retouch and impact?
GER12.229-059.637	Levallois flake	Complete triangular Levallois flake with lateral retouch (multiphase)
GER13.225-059.1041	Levallois point	Complete (hexagonal) Levallois point with ventrally right lateral retouch and dorsally left lateral retouch
GER13.228-057.334	Simple flake	Terminal fragment (hexagonal) of a simple pointed flake, with lateral retouch
GER14.229-059.676	Pseudo-Levallois point	Basal fragment of a triangular flake with lateral retouch
total	**22**	

Tab. 238 - Modified points from GH 3

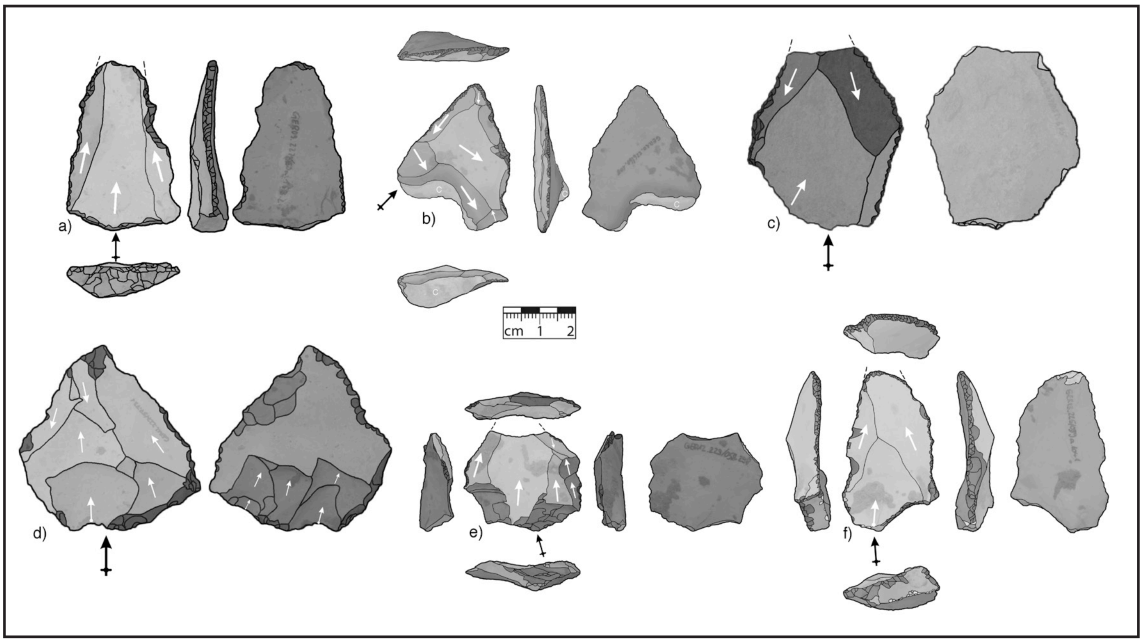

Fig. 291 - Examples of modified points from GH 3. a) Production point (unidirectional-convergent negatives, slight lateral retouch, tip broken, notches for hafting, GER09.227-060.153.2); b) Constructed point (centripetal negatives, slight lateral retouch, notches for hafting, GER10.226-060.108); c) Production point (bidirectional-divergent negatives, slight lateral retouch, tip broken, GER12.227-057.695), tip could be refitted (GER09.227-060.118.1); d) Production and constructed point (bidirectional negatives, removed bulb, bifacial retouch for pointing, GER12.227-057.731); e) Production point (unidirectional-convergent) with slightly constructed pointing, broken tip (GER12.229-058.298); f) Production and constructed point (unidirectional-convergent negatives, lateral retouch, broken tip and re-modified terminal end, GER13.225-059.1041)

If we compare the complete modified points in regard to size (see box-plot in fig. 292), we see diversity for length and width, whereas thickness is clustered. The box-plot values of these complete modified points are displayed in tab. 239. The „ideal“ or „standard“ dimensions of a modified point from GH 3 would be 42.5 mm in length, 32.8 mm in width, with a thickness of 9,3 mm and a mass of 8.9 grams.

Values	Length	Width	Thickness	Mass
Minimum	21,4	19,7	5,5	1,5
Q1	37,8	26,8	7,6	6,0
Median	42,5	32,8	9,3	8,9
Q3	49,9	38,0	10,1	15,5
Maximum	68,5	49,3	12,4	21,8

Tab. 239 - Box-plot values for dimension of complete modified points from GH 3

For n=18 of these modified points data about the butt is available. The width and thickness of them are displayed in fig. 293 as box-plot. The small range of platform thickness corresponds with the total thickness of the modified points. In hard-hammer technique, the butt thickness is related to the morphology of the reduction surface. Of course, a thick butt is related to a thick blank. But a thin butt is not always related to a thin blank. A good example is the chapeau de gendarme-shape of platforms (see fig. 294a). Here, the thickness of the butt does not correspond to the thickness of the blank (also different measurement can be taken for butt thickness). Another example is a previous hinge that lowers the platform thickness but does not have to be related to the total length or thickness of the blank (fig. 294b).

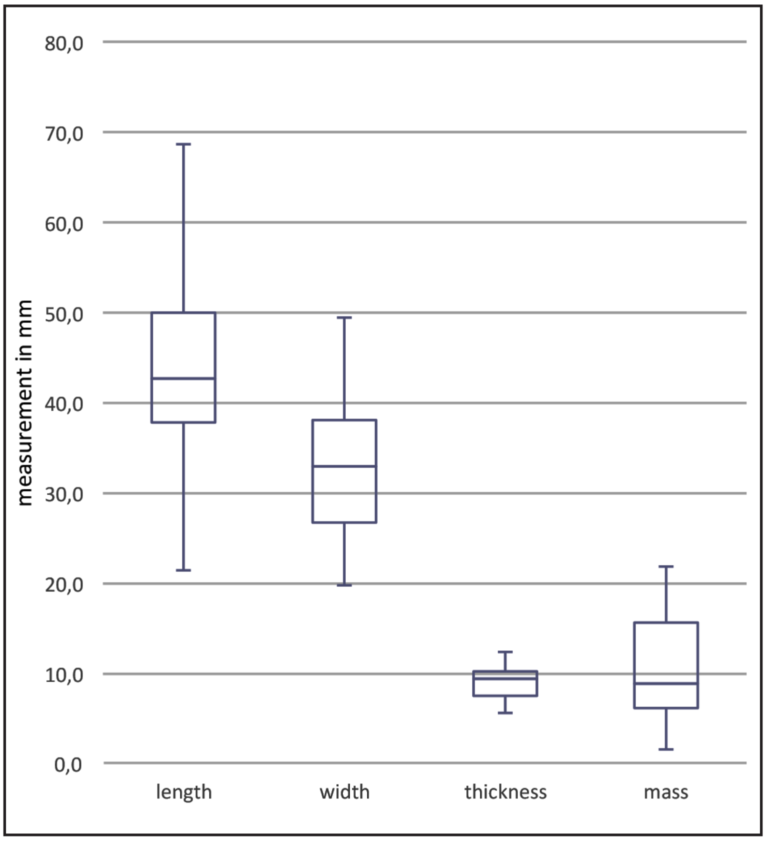

Fig. 292 - Boxplot of length, width, thickness and mass of complete modified points from GH 3

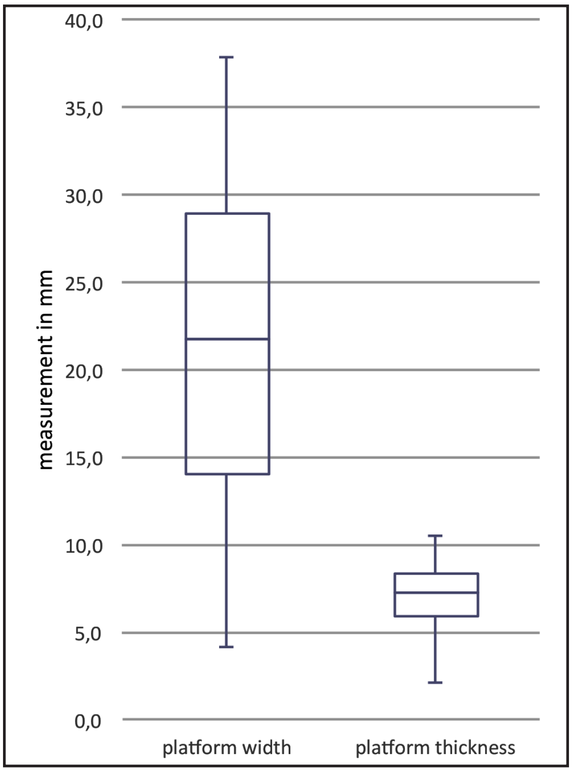

Fig. 293 - Boxplot of platform dimension of n=18 modified points from GH 3

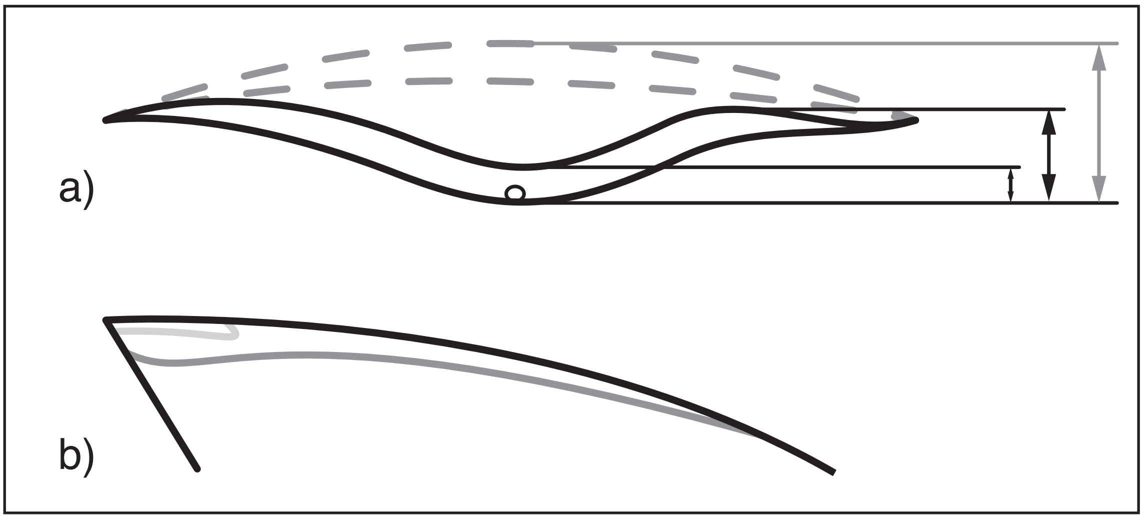

Fig. 294 - Two possibilities for the mis-correlation of butt thickness and total thickness. a) Chapeau de gendarme -shape lowers the thickness of the butt massively, but lowers the total thickness in a smaller content and b) A hinge can lower the butt thickness but does not have to be related to the total length and thickness of the blank

VII.13.9 Toothed and notched modification

In GH 3, n=31 blanks show a toothed or notched retouch (n=17 toothed and n=14 notched). All of them are made on FAS. With the exception of two blades, all are made from flakes. Examples of these artifact are displayed in fig. 295. They are made on raw-piece caps (n=7), on surface correction blanks (n=6), on Levallois blanks (n=5), on *éclats débordants* (n=3), on edge correction blanks (n=2) and on simple blanks (n=8).

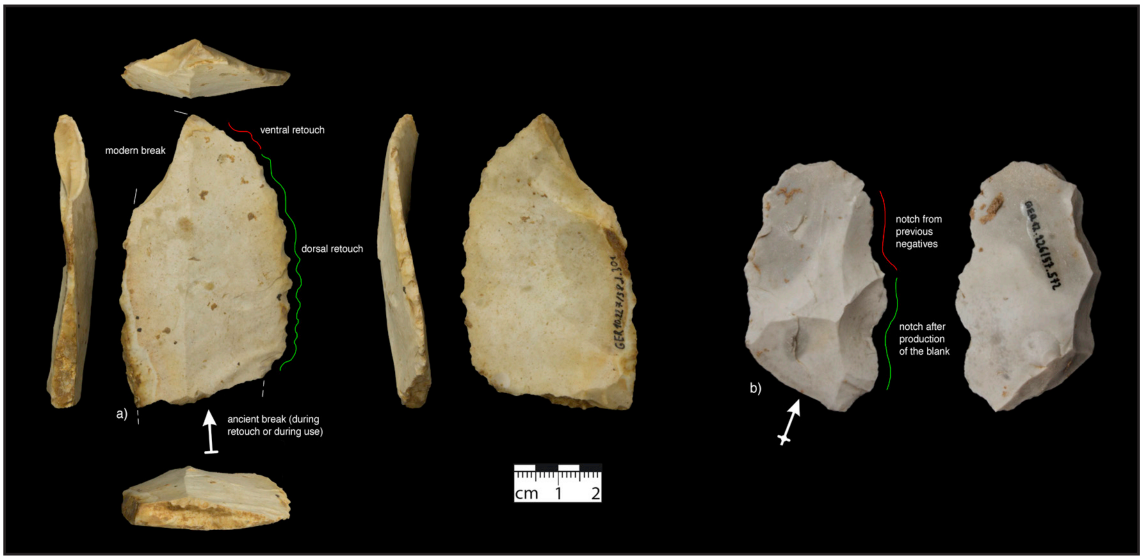

Fig. 295 - Examples of blanks with teeth and notches from GH 3. Left - blank with teeth retouched after blank production (GER10.227-058.301) and right - blank with two notches (one derives from previous negatives of the reduction surface, the other was retouched after production (GER12.226-057.572)

The following fig. 296 is showing the masses and dimensions of all denticulates and notches from GH 3 as box-plot.

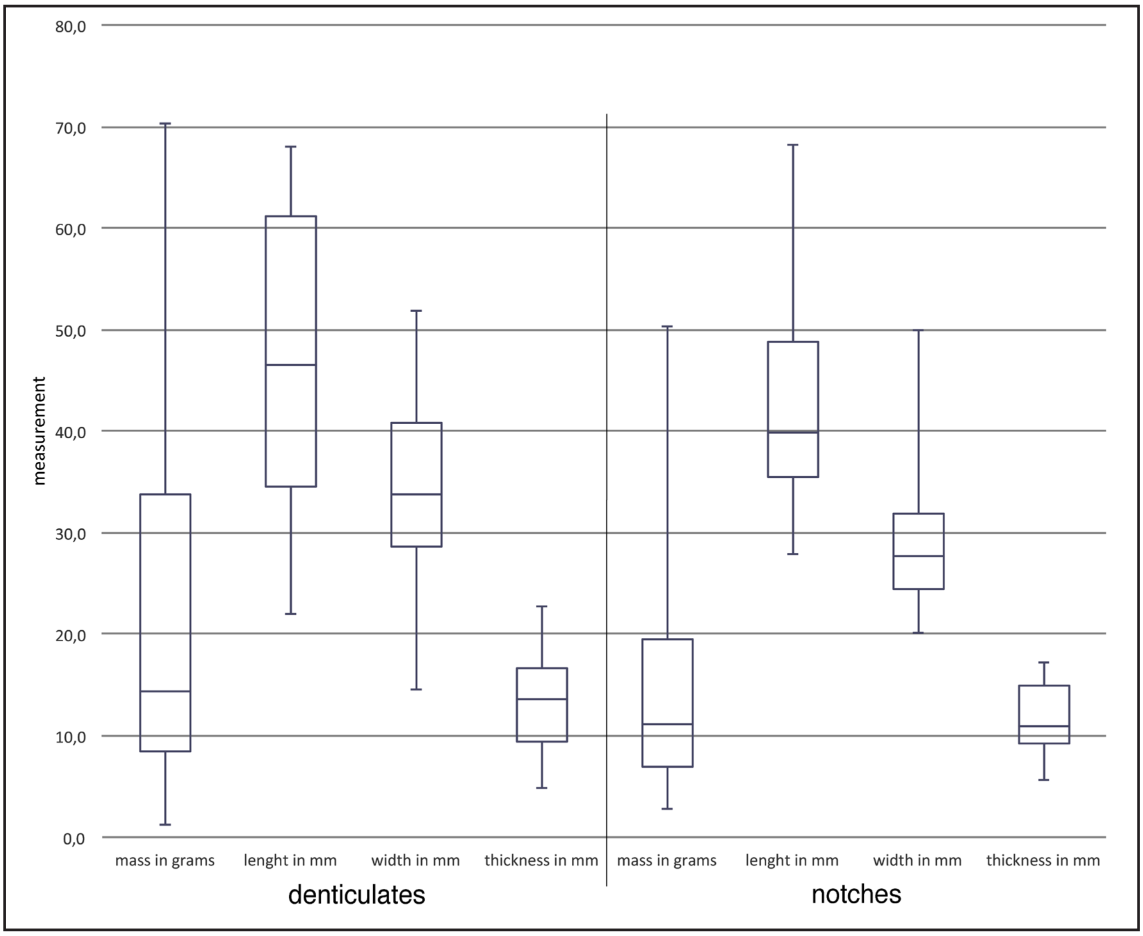

Fig. 296 - Masses and dimensions of all denticulates and notches from GH 3, displayed as boxplot

As implied in the section above about scraper modification, some of the objects that show denticulates and notches can also be hafting rests. But in addition to them, there is clear evidence for a performance of teeth and notches on these pieces after the production (see fig. 295a for a denticulated blank and 295b for a notched blank).

By plotting dimensions of denticulates (black) and notches (red), we can see that they share the same range and are not separated by their total blank dimension (see fig. 297)

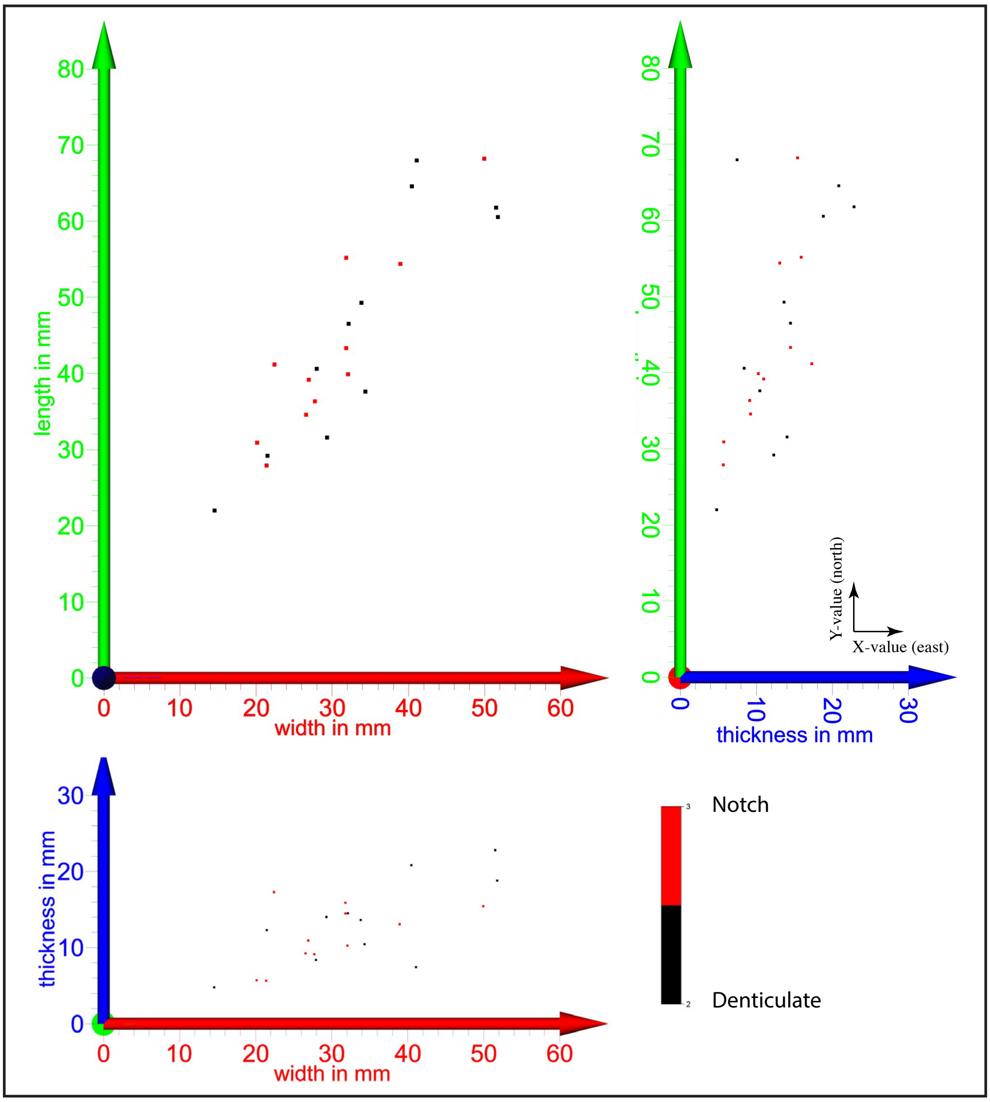

Fig. 297 - Dimensions of denticulates (black) and notches (red) from GH 3

All n=17 objects with teethed retouch carry them on n=25 positions (this circumstance is best displayed in fig. 298). There is more retouch on the left lateral edge that on the right.

For objects with notches (n=14) the picture is a bit different. There are n=16 position registered. The bigger amount of retouched notches are present on the left side (see fig. 299).

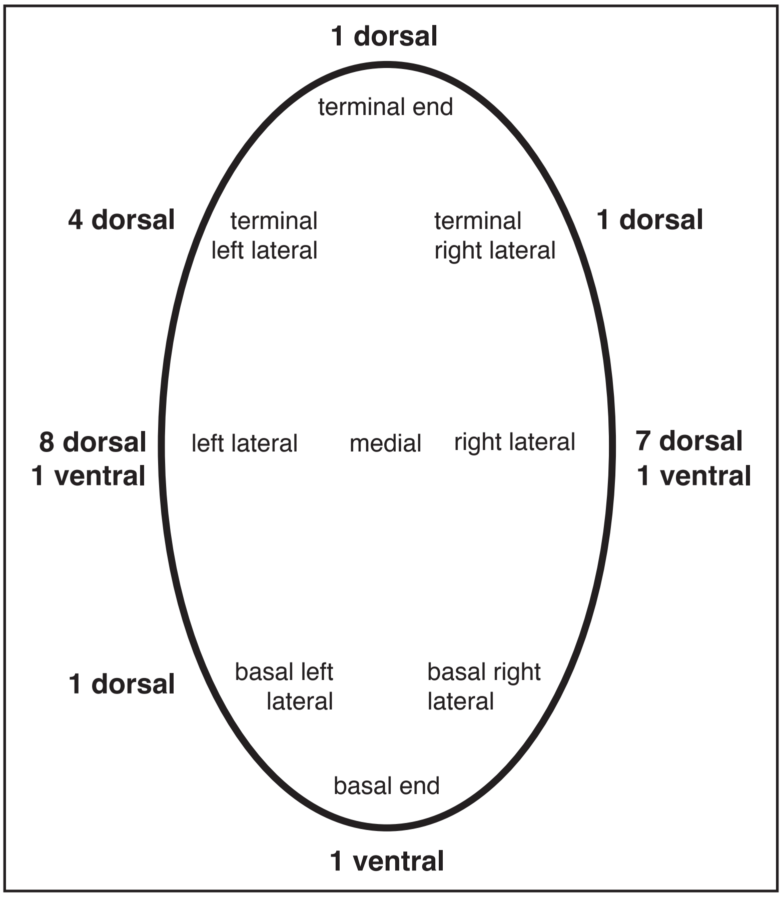

Fig. 298 - Positions of the denticulated retouch on denticulates from GH 3

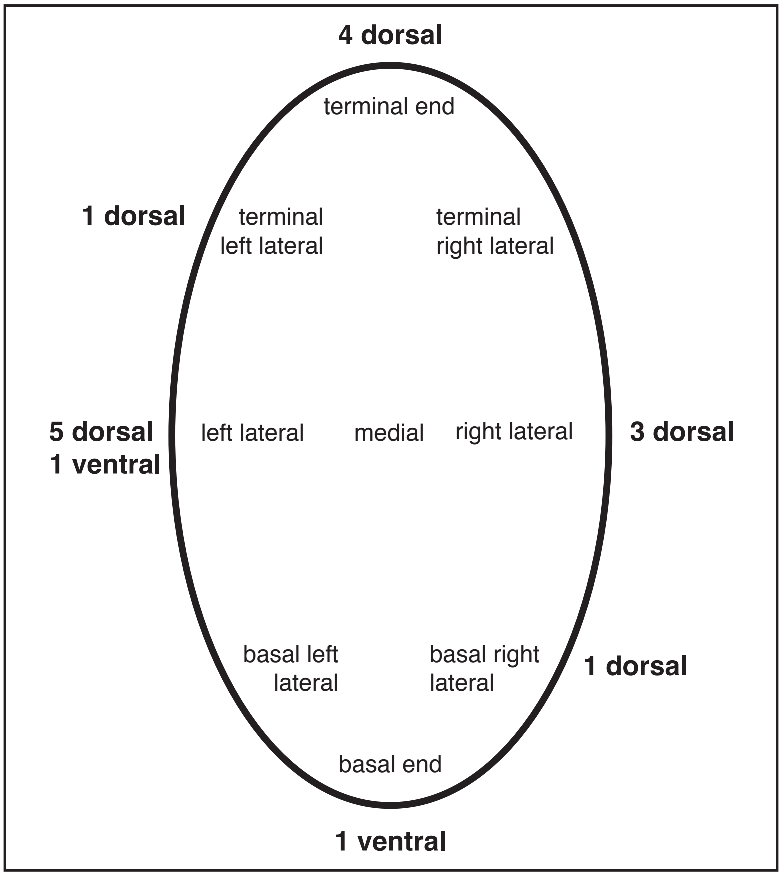

Fig. 299 - Positions of the retouched notch on notches from GH 3

Another observation in regard to denticulates and notches is shape. A geometric outline approximation was defined for top view (view on the dorsal face), sideview (view on the right lateral edge) and cross-section (view on the terminal edge) as it is described in chapter V.2.2. The following tab. 240 and 241 show the geometric outlines for objects carrying denticulates resp. notches:

Geometric outline approximation	Geometric outline in top view	Geometric outline in sideview	Geometric outline in cross-section	Total
Triangle	1	0	5	**6**
D-shape	1	3	4	**8**
Parallelogram	0	1	1	**2**
Rectangular	3	1	0	**4**
Trapez	2	8	2	**12**
Lenticular	0	1	4	**5**
Oval	2	0	0	**2**
Pentagon	5	1	0	**6**
Arch	1	2	0	**3**
Polygon	2	0	1	**3**
Total	**17**	**17**	**17**	**51**

Tab. 240 - Geometrical outline approximation for the blanks of denticulates from GH 3

Geometric outline approximation	Geometric outline in top view	Geometric outline in sideview	Geometric outline in cross-section	Total
Triangle	0	1	6	**7**
D-shape	0	2	2	**4**
Parallelogram	0	1	1	**2**
Rectangular	1	1	0	**2**
Trapez	2	0	2	**4**
Lenticular	0	3	1	**4**
Oval	6	0	0	**6**
Sinus-shaped	0	1	0	**1**
Pentagon	2	4	2	**8**
Arch	1	1	0	**2**
Hexagon	1	0	0	**1**
Polygon	1	0	0	**1**
Total	**14**	**14**	**14**	**42**

Tab. 241 - Geometrical outline approximation for the blanks of notches from GH 3

The outline of the cross section refers to the position in core reduction (using one or more crests or a convexity) for the blank production. In a reduction sequence, a triangular shaped objects must be removed before a trapezoid or pentagonal shaped object can be removed. For the denticulates (tab. 240) we see that after triangular shaped cross sections (n=5), D-shaped (n=4), trapezoid (n=2) and lenticular (n=4) are alike represented. A parallelogram as cross section (n=1) can refer to an edge removal.

For notches, the amount is slightly different (tab. 241). Most of the shape in cross section is triangular (n=6), followed by D-shape (n=2), trapezoid (n=2) and pentagon (n=2). Here, also one is in the shape of a parallelogram. Blanks that are modified with teeth and notches cannot be seen as a closed assemblage. The diversity in regard to the blank shape is high (see above). One striking observation is that the retouch in teeth and notch shape is mostly performed that the negatives are visible on the dorsal face (direct retouch).

VII.13.10 Modification with a burin blow

There is only little evidence for the performance of a burin blow on blanks. Only three examples were found and all three examples look as the performance of a burin blow was not on purpose but just happened (see fig. 300). Therefore we avoid to discuss them intensively. Two of them are made on fragments and another on a complete blade-sized surface correction blank. They are listed in tab. 242.

Find-number	Note
GER10.226-060.113	Terminal fragments of a simple blanks, burin blow in terminal end
GER12.225-058.496	Medial fragment of a simple flake, left lateral edge shows some retouch, the burin blow is situated on the basal breaking surface
GER12.228-059.215	Complete surface correction blanks with a burin blow on the left lateral
total	**n=3**

Tab. 242 - Blanks with burin-blow modification

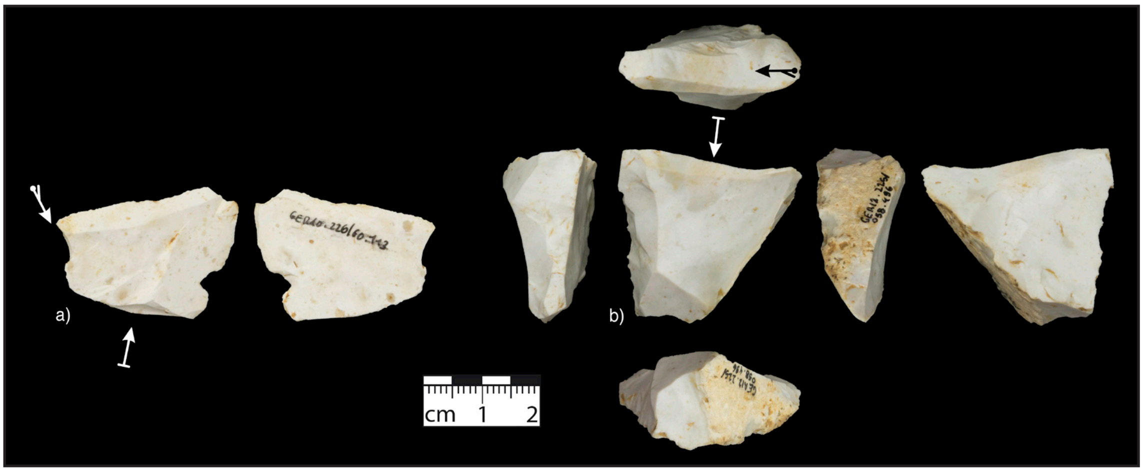

Fig. 300 - Blanks with burin-blow modification. a) Burin blow on the left lateral edge, the right lateral edge possesses a retouched notch for (another?) burin blow (GER10.226.060.113) and b) Burin blow on breaking surface (GER12.225-058.496)

VII.13.11 Modification as perforator (borer)

The performance of a borer retouch is as seldom as described for burin blows. Here also, only three artifacts were detected that fit into this category (they are listed in tab. 243 and displayed in fig. 301).

Find-number	Note
GER09.228-059.116.3	A complete simple flake with a pointed terminal end
GER10.227-058.195	A basal fragment of a simple flake with a pointed terminal end
GER12.226-057.437	A complete simple blade with a pointed end and (hafting?) retouch left and right lateral basal
total	**3**

Tab. 243 - Blanks with perforator modification

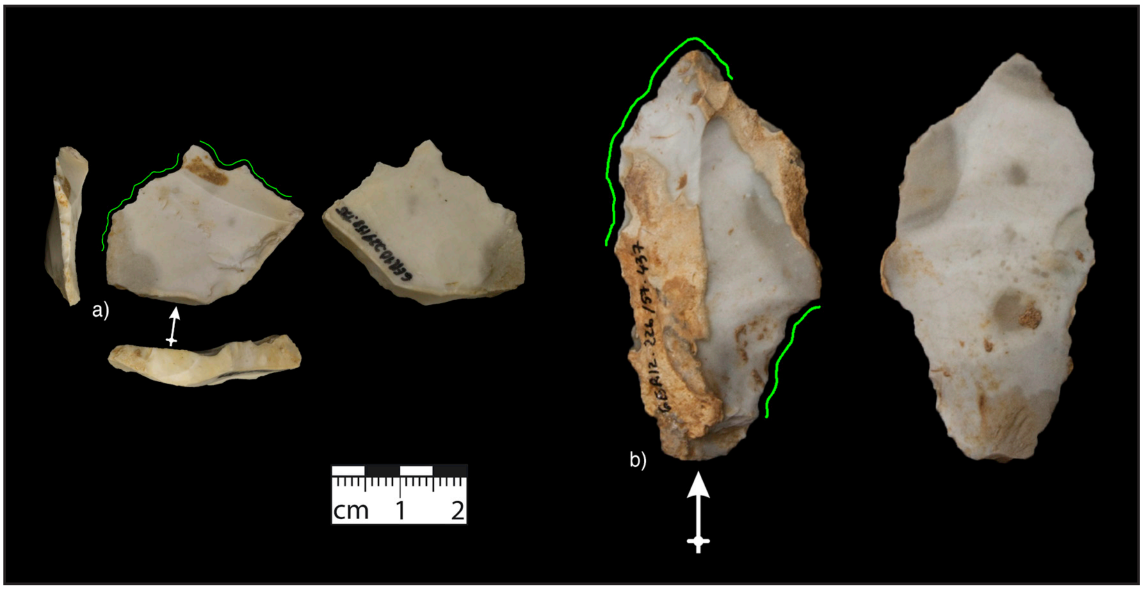

Fig. 301 - Blanks with perforator modification. a) GER10.227-058.195 and b) GER12.226-057.437

VII.13.12 Circumferential modification (*Groszak*)

As for the both above described artifact categories, only a small number of *Groszak*-like blanks were detected (n=3). They are all made from flakes and are circumferentially retouched (see fig. 302). This particular modification is described as a kind of an index fossil for the Micoquian. Bosinski (1967) described them as „*Typ Heidenschiede*“: „*Hinzuweisen ist auf eine Anzahl kleiner flacher, annähernd runder Abschläge mit umlaufend perlretuschierte Kante* [...]“. (Bosinski 1967: 50). The name *Groszak* was established by Krukowski (1939-1948) and Hillgruber (2007), for instance, describes them as a dominant element in the assemblage of the Kleine Feldhofer Grotte in the Neanderthal, where n=67 were found (excavations in 1997 and 2000).

They are all made from small round blanks and have a circumferential retouch. One of them have a circumferential, denticulated retouch (GER12.227-057.521). The following fig. 303 shows the dimension of them as box-plot and illustrate that the range of the measurement are quite close to each other. They are listed in tab. 244.

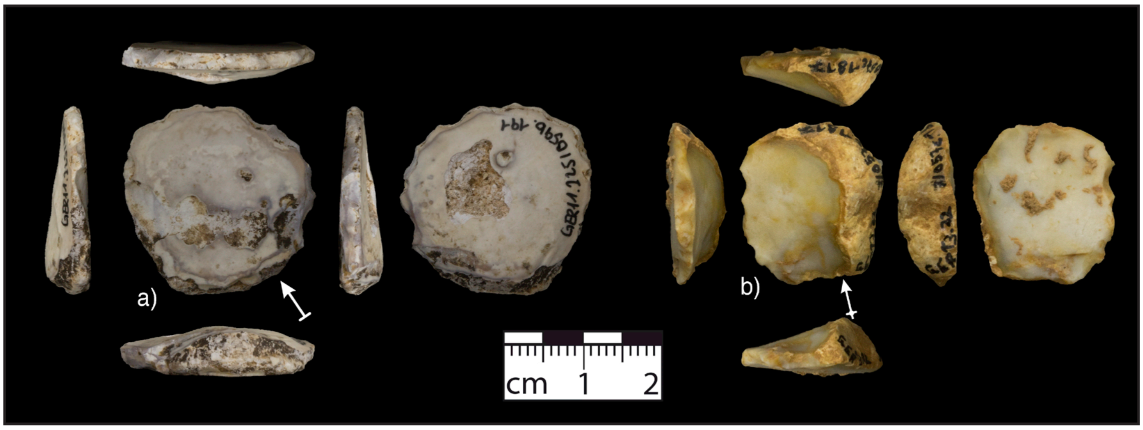

Fig. 302 - Groszak-like blanks from GH 3. a) GER11.225-059.191 and b) GER13.227-057.1817

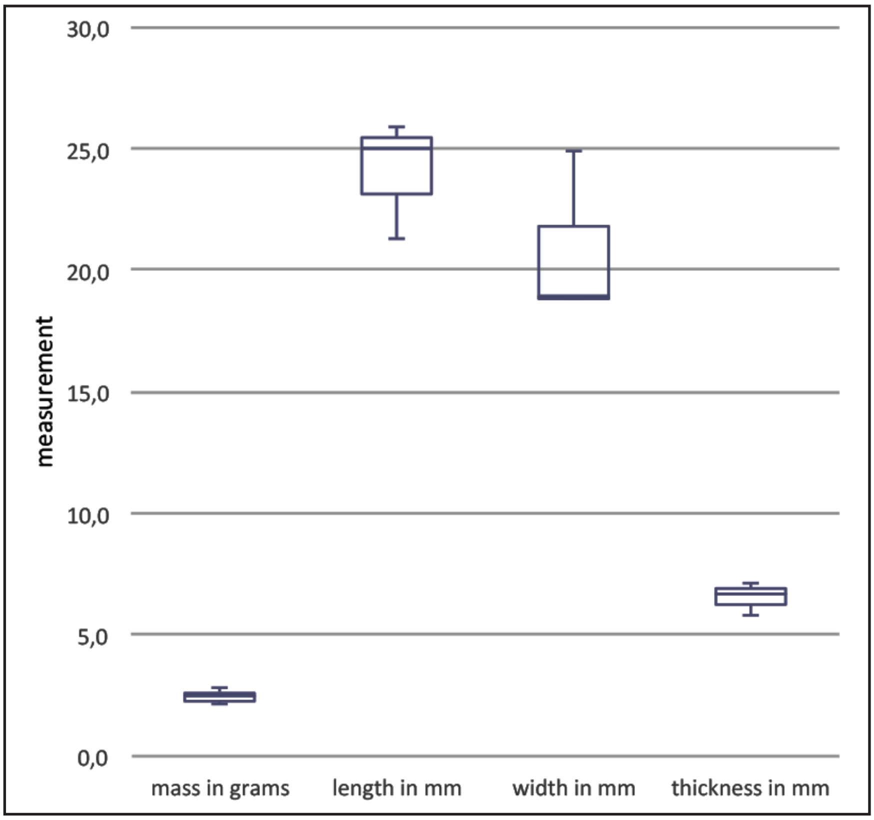

Fig. 303 - Boxplot of mass and dimension of these Groszak-like blanks from GH 3

Find-number	Note
GER11.225-059.191	Small, oval flake with a circumferential retouch, made from an unknown flint
GER12.227-057.521	Small, quite oval flake with circumferential denticulated retouch, made from FAS
GER13.227-057.1817	Small, oval flake with a circumferential retouch, made from FAS
Total	3

Tab. 244 - Groszak-like blanks from GH 3

VII.13.13 End-scraper modification

Another category of modified blanks are such with a rounded retouch edge on their terminal end (end scraper). This kind of modification was detected 25 times. Overall, there are made on Levallois flakes (n=6), on raw-piece caps (n=4), on one surface correction blank and on n=13 simple blanks (see examples in fig. 304 and list in tab. 245). Almost none of them can be described as being typical, in the sense of an index fossil as they are visible in the Upper Paleolithic record (e.g., Demars & Laurent 1989).

Find-number	Blank class	Note
GER09.227-059.137.4	Raw-piece cap	Complete oval raw-piece cap with sinus-shaped retouch on left lateral terminal
GER09.227-060.131.1	Simple flake	Pentagonal, terminal fragment of a simple flakes with convex retouch on the terminal end
GER09.228-059.134.1	Raw-piece cap	Pentagonal, left lateral fragment of a raw-piece cap with sinus-shaped retouch on the terminal end
GER09.228-059.141.2	Raw-piece cap	Complete pentagonal, simple flakes with sinus-shaped retouch on the terminal end
GER09.228-059.142.5	Simple flake	Complete oval raw-piece cap with convex retouch on the terminal end
GER10.226-058.134	Levallois flake	D-shaped, basal fragment of a Levallois flake with sinus-shaped retouch on terminal end
GER10.226-059.116	Simple flake	Oval, terminal fragment of a simple flake with straight terminal retouch
GER10.226-059.181	Levallois flake	Complete, heptagonal Levallois flake with sinus-shaped terminal retouch
GER10.226-060.138	Simple flake	Oval, left lateral fragment of a simple flake with convex terminal retouch
GER10.227-058.167	Simple flake	Rectangular, terminal fragment of a simple flake convex terminal retouch
GER10.227-058.346	Simple blade	Complete oval simple flake with convex terminal retouch
GER10.228-058.279	Simple flake	Oval, terminal fragment of a simple flake with convex terminal retouch
GER10.228-058.318	Levallois flake	L-shaped, terminal fragment of a Levallois flake with terminal slightly pointed retouch
GER11.225-059.259	Simple flake	Hexagonal, complete simple flake with convex terminal retouch
GER12.225-058.430	Simple flake	Hexagonal, terminal fragment of simple flake with sinus-shaped terminal retouch
GER12.225-059.701	Simple flake	Complete D-shaped simple flake with sinus-shaped terminal retouch
GER12.226-057.422	Raw-piece cap	Complete oval raw-piece cap with terminal slightly pointed retouch
GER12.226-057.692	Simple flake	Pentagonal, terminal fragment of a simple flake with convex terminal retouch
GER12.227-057.448.5	Levallois flake	Trapezoid, basal fragment of a Levallois flake with straight terminal retouch
GER12.227-057.675	Simple flake	Complete oval simple flake with sinus-shaped terminal retouch
GER12.229-059.520	Simple blade	Trapezoid, terminal fragment of a simple flake with sinus-shaped terminal retouch
GER13.225-059.975	Levallois flake	Complete pentagonal Levallois flake with convex terminal retouch

GER13.227-057.1912	Levallois flake	Complete hexagonal Levallois flake with convex terminal retouch
GER13.227-057.1924	Raw-piece cap	Oval, medial fragment of a raw-piece cap with convex terminal retouch
GER13.228-057.212	Surface correction blank	Complete oval surface-correction blank with convex terminal retouch
Total	**n=25**	

Tab. 245 - Blanks with end-scraper modification from GH 3

These objects are quite divers in regard to size (see box-plot in fig. 305) and shape (see fig. 304). This picture change if we make two groups (big pieces and small pieces), which is an easy task, because two pieces are much heavier and thicker as the rest (see the box-plot in fig. 306).

Fig. 304 - Examples of blanks with end-scraper modification from GH 3. a) Raw-piece cap with sinus-shaped retouch (GER09.227-059.137.4); b) Simple flake with convex retouch (GER12.227-057.675); c) Levalloid flake detached from a neocortex surface with convex retouch (GER12.227-057.675) and d) Surface correction blank with convex retouch, two opposed notches (for hafting?) and small break terminally (GER12.228-057.212)

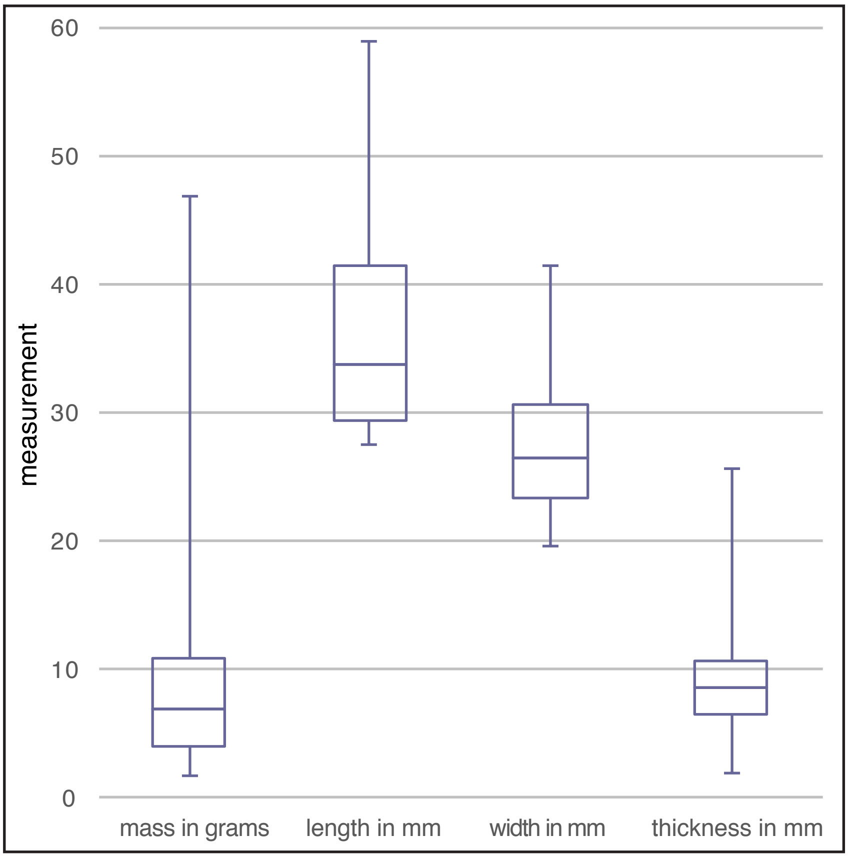

Fig. 305 - Boxplot of the dimension of all blanks with end-scraper modification from GH 3

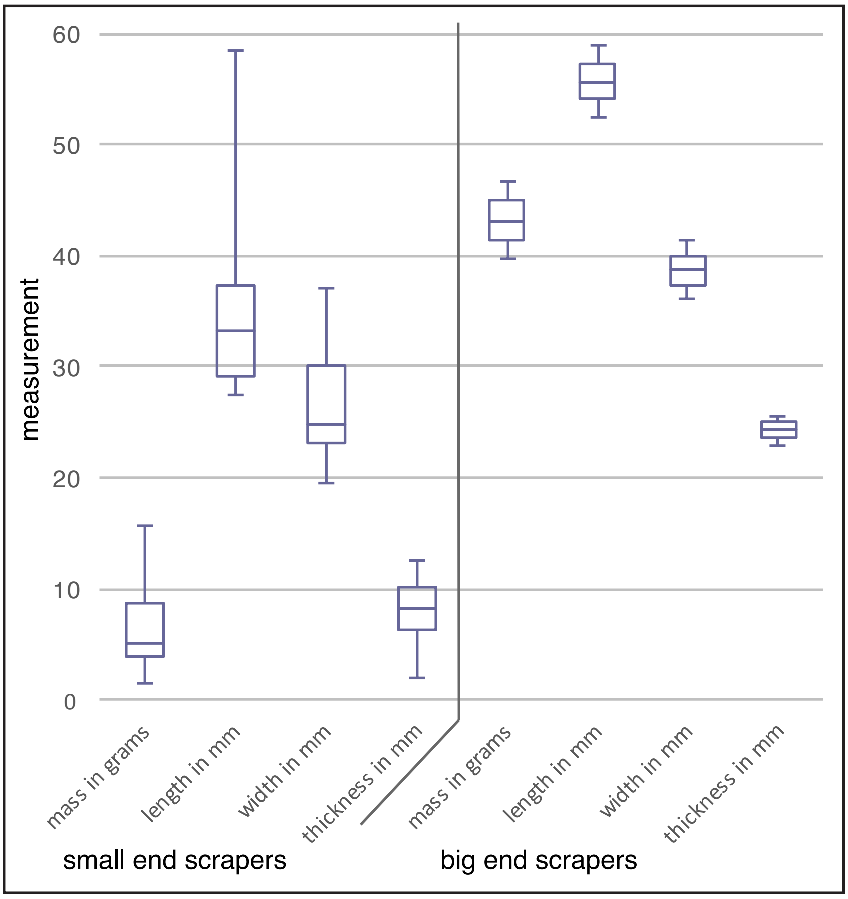

Fig. 306 - Boxplot of the dimension of blanks with end-scraper modification from GH 3, separated in small and big pieces)

In a classical sense, only three of these pieces would find place in typological descriptions about end-scrapers (GER13.225-059.975, GER13.227-057.1924 and GER13.228-057.212, see fig. 304), because of the explicitly rounded retouch on the terminal end.

VII.13.14 Truncated modification

There are n=16 blanks from GH 3 showing a truncated modification (see tab. 247 and examples in fig. 309). Such a modification is quite close to an end-scraper modification but straight. The size and shape of the blanks with a truncated modification is diverse. Only n=7 of them are complete blanks. The dimensional range is displayed in fig. 307 and 308, and shows that these complete blanks are scattered over the entire range and frame the fragments. The increase in thickness corresponds to the increase in length and width. The box-plot values of the dimensions can be seen in tab. 246.

Values	Mass	Length	Width	Thickness
Minimum	0,4	13,3	12,4	2,5
Q1	3,4	28,0	22,7	6,9
Median	5,9	34,6	27,9	8,6
Q3	14,6	44,1	34,8	11,9
Maximum	26,1	63,7	44,4	15,3

Tab. 246 - Boxplot values of the dimensional range of blanks with truncated modification, from GH 3

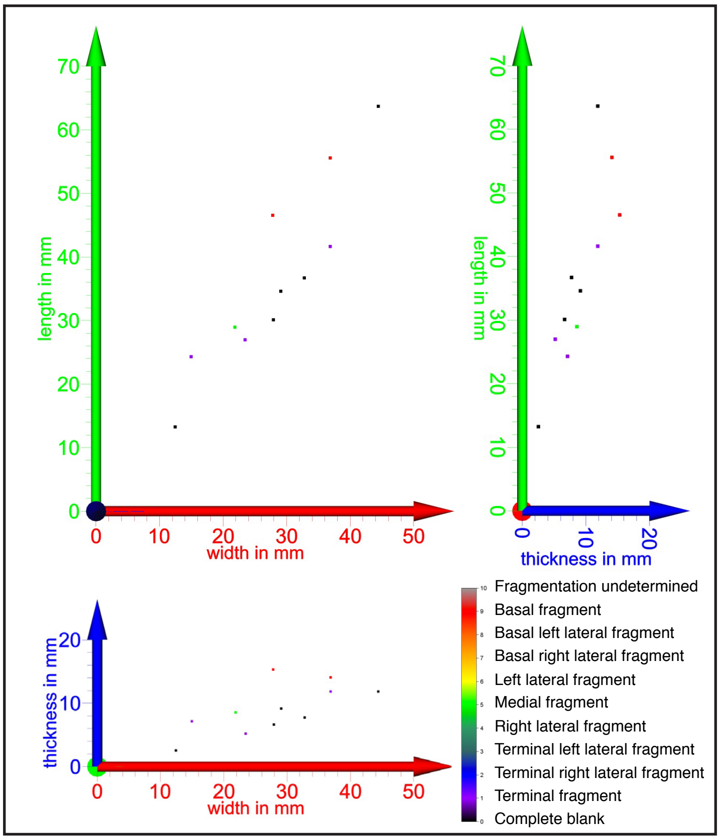

Fig. 307 - Scatterplot of the dimensional range of blanks with truncated modification, from GH 3

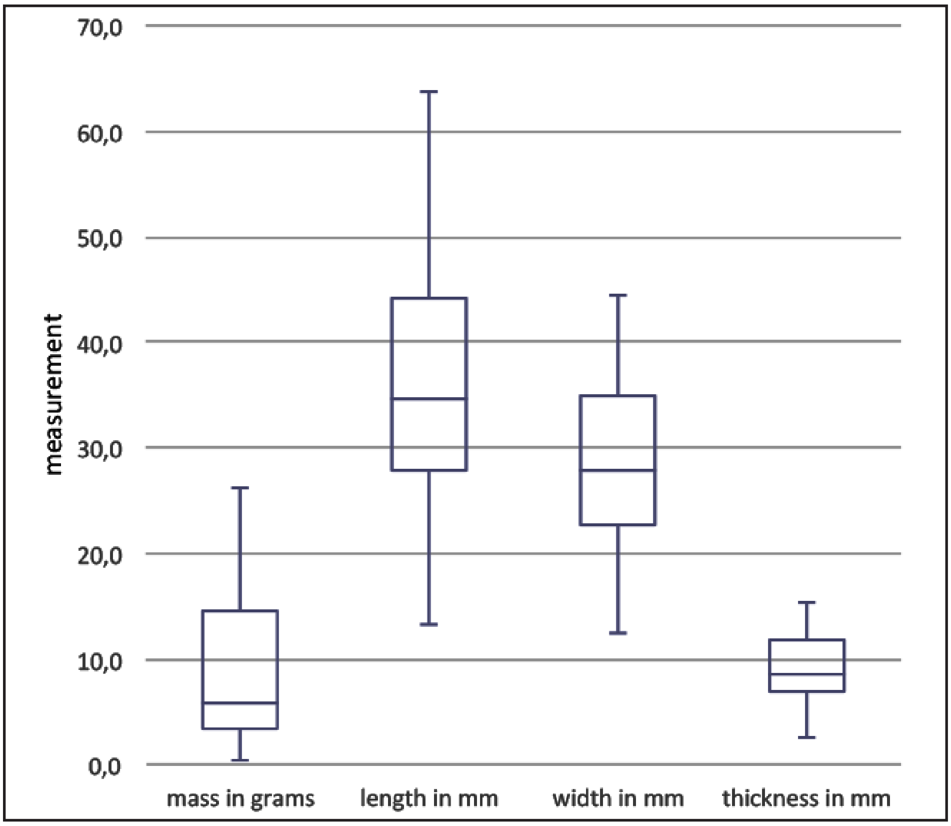

Fig. 308 - Boxplot of the dimensional range of blanks with truncated modification, from GH 3

Find-number	Blank class	Note
GER09.227-058.17.2	Surface correction blank	Pointed-oval, basal fragment on a surface correction blank with straight but pointed retouch
GER09.228-059.136.1	*Éclat débordant*	Trapezoid, basal fragment of an éclat débordant with terminal pointed retouch
GER09.228-060.77.1	Levallois flake	Oval, complete Levallois flake with terminal pointed retouch and lateral retouch
GER09.228-060.92.1	*Éclat débordant*	Parallelogram, complete éclat débordant with terminal buckled retouch
GER10.226-060.128	Simple flake	Rectangular, terminal fragment of a simple flake with terminal straight retouch
GER10.226-061.116	Levallois flake	Rectangular, terminal fragment of a Levallois flake with terminal sinus-shaped retouch and lateral retouch
GER10.226-061.124	Simple flake	Pentagonal, basal fragment of a simple flake with terminal straight retouch
GER10.227-058.192	Edge correction flake	Oval, complete edge correction flake with terminal buckled retouch
GER10.228-058.101.1	Edge correction flake	Rectangular, complete edge correction flake with terminal convex retouch
GER10.228-058.308	Edge correction flake	Parallelogram, basal fragment with terminal convex retouch
GER12.225-059.672	Simple blade	Trapezoid, medial fragment of a simple flake with terminal straight retouch and lateral retouch
GER12.225-059.743	Simple flake	Rectangular, terminal fragment of a simple flake with terminal straight retouch

GER12.229-058.303	Edge correction flake	Pentagonal, complete edge correction flake with terminal straight retouch
GER12.229-059.179	Edge correction flake	Trapezoid, complete edge correction flake with terminal slightly convex retouch
GER12.229-059.620	Surface correction blank	Pentagonal, medial surface correction blank with terminal buckled retouch
GER13.225-058.706	Levallois flake	Oval, complete Levallois fake with terminal buckled retouch
total	**11**	

Tab. 247 - Blanks from GH 3 with truncated modification

The shape of the truncation is (in top view) between straight and concave, but never convex (see fig. 309). The retouch for the truncation produced always negatives on the dorsal face (direct retouch). As it is written in tab. 247 the truncation is sometimes associated with lateral retouch (GER09.228-060.77.1, GER10.226-061.116 and GER12.225-059.672).

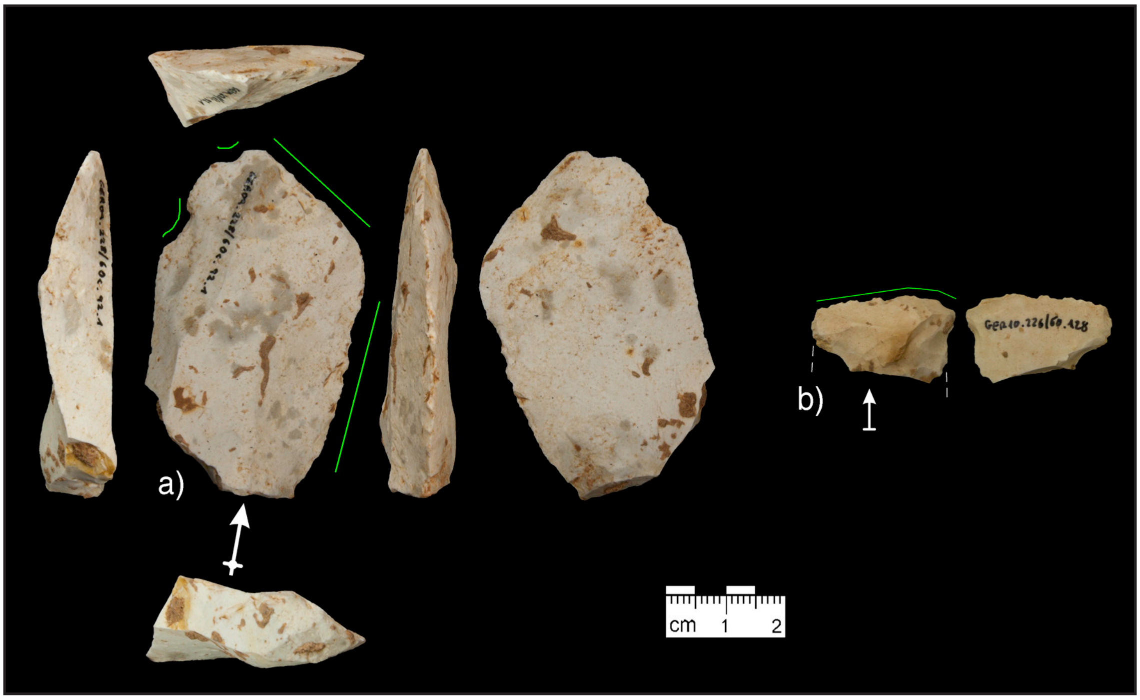

Fig. 309 - Examples of blanks with truncated modification, from GH 3. a) Complete éclat débordant with truncation and two notches (GER09.228-060.92.1) and b) Terminal fragment of a simple flake with irregular truncation (GER10.226-060.128)

VII.13.15 Lateral modification

Overall, n=46 blanks show a marginal lateral modification (examples are displayed in fig. 310). Four of these artifact were also classified as having scraper retouch. The differentiation between both kinds of retouch is as follows: A lateral retouch is not invasive and just regulates the edge, and the retouch only slightly influences the shape of the blank.

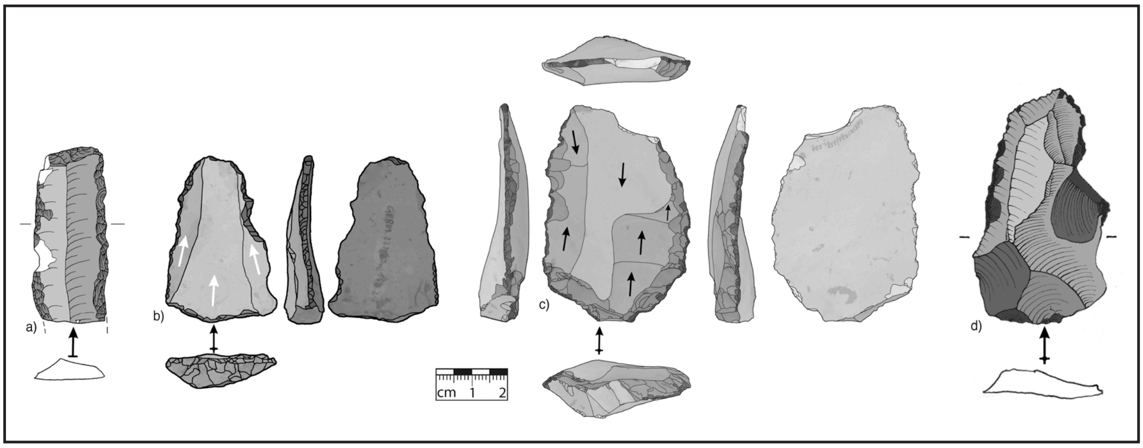

Fig. 310 - Examples of blanks with lateral modification from GH 3. a) Blade with lateral retouch and truncation (GER09.227-060.145.1); b) Levallois point with lateral retouch (GER09.227-060.153.2); c) Constructed point of Levallois flake with lateral retouch (GER10.226-058.239) and d) Éclat débordant with lateral retouch (GER12.229-058.203)

Lateral retouch was performed on Levallois blanks (n=15), on one *éclat débordant*, one *lame débordante*, on a pseudo-Levallois point, on n=2 raw-piece caps, on n=2 surface correction blanks, on n=4 edge correction blanks and on n=20 simple blanks. The following fig. 311 shows the sizes of the blanks modified with lateral retouch and is a good example for the comparison of complete blanks and fragments. It shows clearly that complete blanks are in the dimensional range of fragmented blanks. This is a hint for a quite vast size range of formerly complete blanks. The box-plot values are displayed in tab. 248.

	Complete blanks with lateral modification				Blank fragments with lateral modification			
Values	Mass	Length	Width	Thickness	Mass	Length	Width	Thickness
Minimum	1,8	20,1	17,9	6,1	1,1	16,3	15,6	3,2
Q1	9,6	38,4	31,5	9,3	4,2	33,9	24,0	7,1
Median	14,8	51,4	34,2	10,4	10,2	42,4	33,2	9,3
Q3	20,9	56,1	36,4	12,5	21,1	53,0	40,8	11,7
Maximum	33,3	67,3	39,7	18,6	53,9	68,1	46,9	23,6

Tab. 248 - Boxplot values of blanks modified with lateral retouch from GH 3 (separated into complete blanks - left and fragments - right)

VII.13.16 Backed knifes and backing

In total, there are n=41 blanks with a confected back (see fig. 312 for examples). As a list of 41 entries would be to long, the features will be reported in a condensed way. Only three blanks show ventral retouch (GER12.225-059.569 which is an *éclat débordant* with a convex, right lateral ventral retouch; GER09.227-060.158.2 which is a surface correction flake with a flattened bulb and GER10.226-058.80 which is a Levallois flake with terminal ventral retouch). The entire range of blank classes were used to make backed knifes. There are n=19 complete ones and n=22 fragments (see tab. 249).

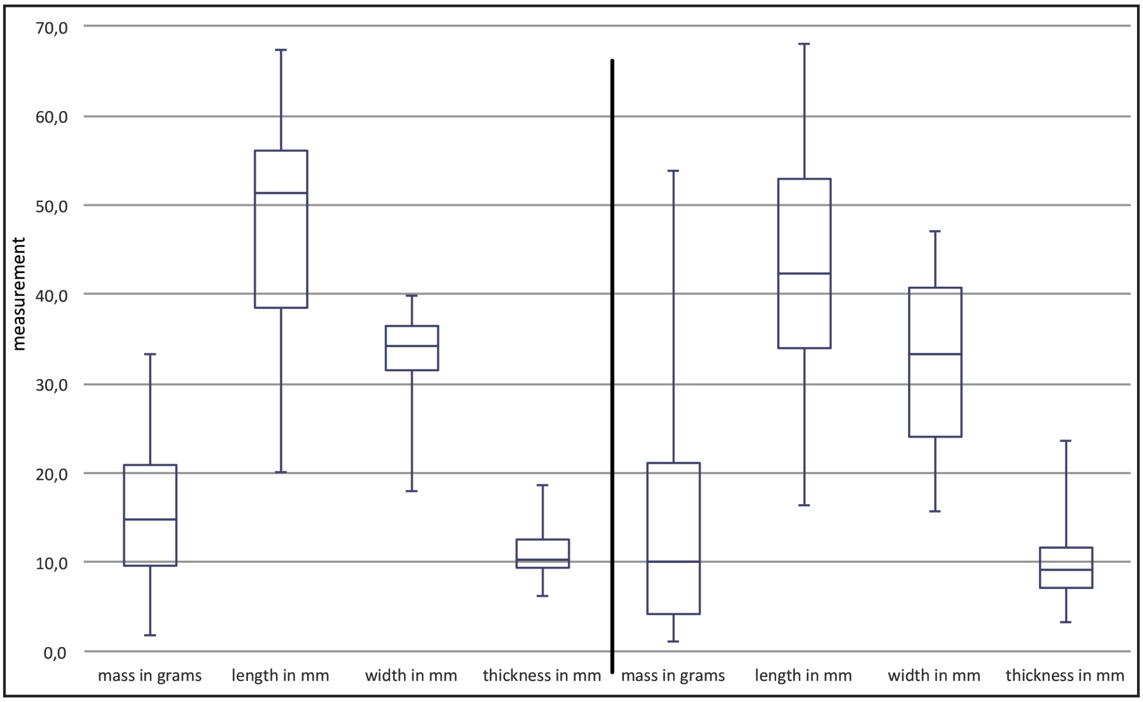

Fig. 311 - Boxplot of blanks modified with lateral retouch from GH 3 (separated into complete blanks, left and fragments, right)

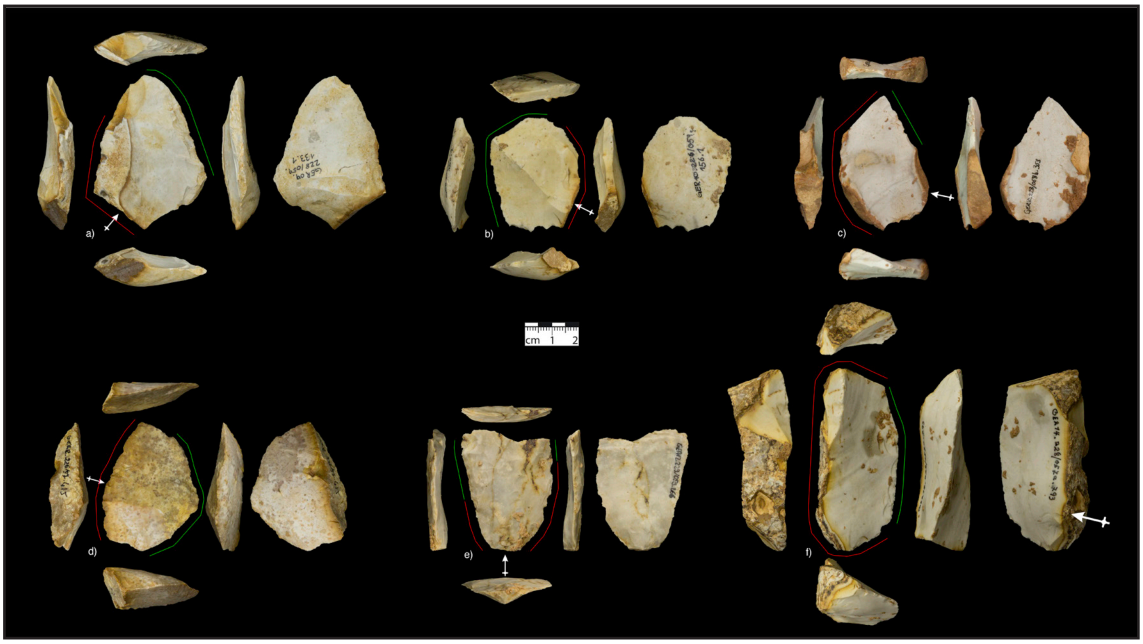

Fig. 312 - Examples of backed knifes from GH 3. a) Simple blank with cortical back and retouched narrow angle on the active edge (GER09.228-059.133.1); b) Levallois flake with cortical butt as back, hafting notches and circumferential active edge (GER10.226-059.156.1); c) Quina-like blank with cortical back and slightly retouched active edge (so to speak a unifacially retouched variety of a Keilmesser-shaped lithic object, GER10.228-058.353); d) Surface correction blank with terminally a slight retouch and cortical butt as back (GER12.226-057.415); e) Levallois blade with surface invasive retouch, hafting notches and possibly two lateral active edges (GER12.229-059.266) and f) Triangular flake with slight retouch on the active edge and cortical back (GER14.228-057.793)

Fragmentation Blank class	Complete	Basal	Medial	Right lateral	Terminal	Undetermined	Total
Éclat débordant	2	0	1	0	0	0	**3**
Surface correction flake	7	3	0	0	2	0	**12**
Crested blade	0	0	0	0	1	0	**1**
Edge correction blade	0	0	0	0	0	0	**0**
Simple flake	7	0	1	1	2	2	**13**
Simple blade	0	1	1	0	0	0	**2**
Levallois flake	3	1	0	0	1	1	**6**
Levallois blade	0	1	0	0	0	0	**1**
Quina-like flake	0	1	0	0	0	0	**1**
Raw-piece cap	0	1	1	0	0	0	**2**
Total	**19**	**8**	**4**	**1**	**6**	**3**	**41**

Tab. 249 - Blank classes of backed knifes from GH 3

The dimensional range of these modified blanks is illustrated as box-plot for fragmentation (fig. 313), the box-plot values (tab. 250) and a scatter plot by blank class (fig. 314). It is visible that fragments are clustered in size and mostly smaller than complete backed knifes.

	All backed knifes				**Complete blanks**				**Blank fragments**			
Values	Mass	Length	Width	Thick-ness	Mass	Length	Width	Thick-ness	Mass	Length	Width	Thick-ness
Minimum	3.1	25.7	17.2	5.0	3.1	32.1	19.1	5.0	3.1	25.7	17.2	5.8
Q1	4.9	36.8	26.3	8.1	9.0	41.0	29.8	9.0	4.4	34.8	22.6	7.0
Median	10.7	43.8	32.3	10.4	12.4	46.5	35.6	10.8	7.7	39.7	29.5	9.5
Q3	15.4	48.7	36.4	12.5	19.2	59.1	41.6	14.4	14.1	46.9	34.4	11.5
Maximum	128.8	83.8	63.4	29.0	128.8	83.8	63.4	29.0	18.2	54.6	39.7	13.9

Tab. 250 - Boxplot values of backed knifes from GH 3 by fragmentation (Left - All backed knifes, mid - Complete blanks, right - Fragments)

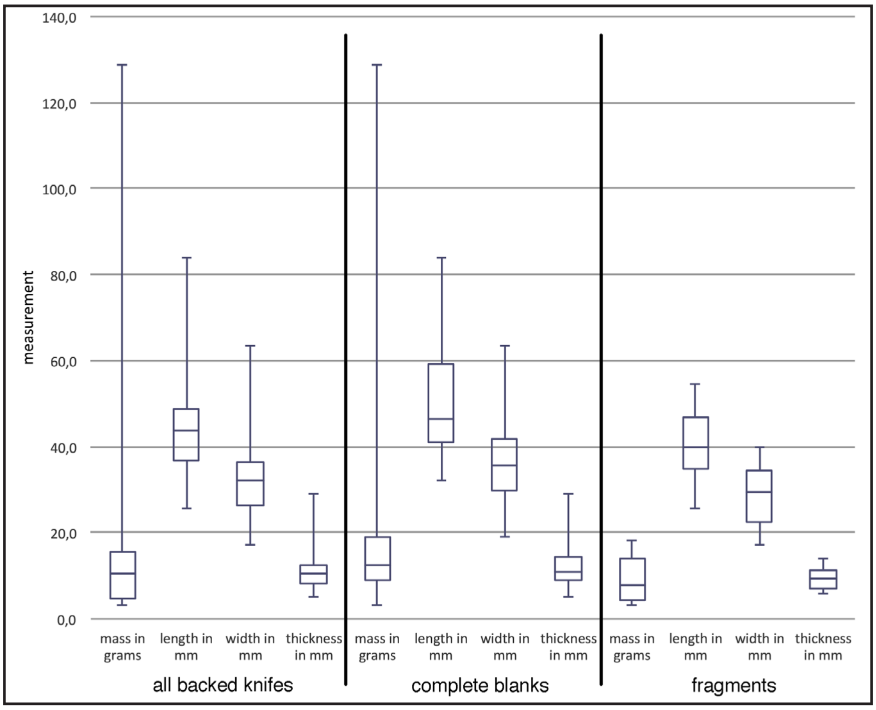

Fig. 313 - Boxplot of backed knifes from GH 3 by fragmentation (Left - All backed knifes, mid - Complete blanks, right - Fragments)

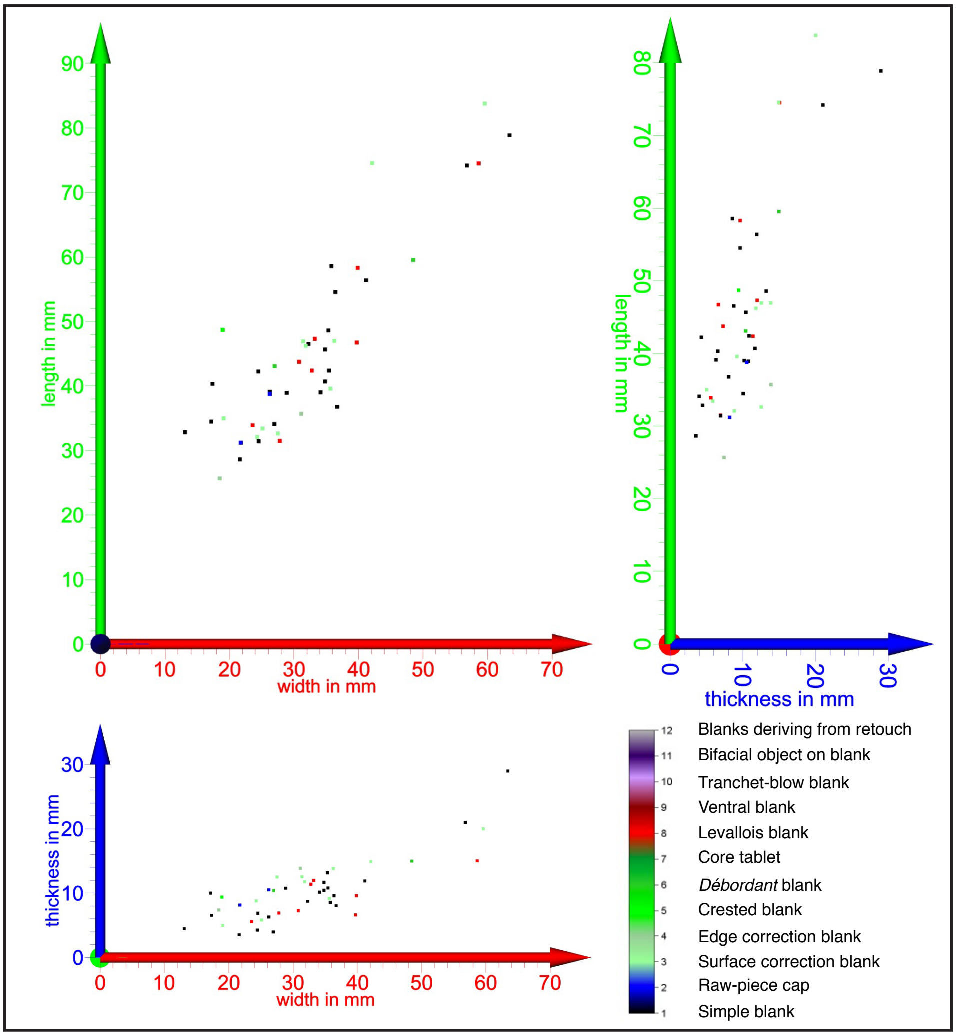

Fig. 314 - Dimensional scatter plot of backed knifes from GH 3 by blank class

VII.13.17 Bulbs removal

There is evidence of complete or partly bulb removal on n=17 blanks (they are listed in tab. 251). Examples are displayed on fig. 315. On the two bifacial objects, the bulb removal is integrated into surface modification and bifacial shaping. For the other blanks, the removal of the build was probably performed to flatten the ventral face (for hafting purposes?).

Find-number	Description of the blank	Description of bulb removal	Other modifications
GER09.227-058.19.8	Surface correction flake	Bulb removed during blow (one negative)	Non
GER09.227-059.143.1	Simple flake	Bulb and platform was removed after production (three negatives, centripetal)	Left and right lateral and terminal a dorsal retouch
GER09.228-059.116.8	Bifacially worked object	Bulb was removed after production (three negatives, centripetal)	Dorsal face modified, left lateral ventral retouch
GER09.228-060.98.1	Simple flake	Half of the bulb removed during blow (three negative, unidirectional)	Non
GER10.226-059.185	*Éclat débordant*	Bulb was removed after production (six negatives, centripetal)	Non

GER10.226-059.245	Simple flake	Most of the bulb removed during blow (twelve negatives, centripetal)	Left and right lateral dorsal multiphase retouch
GER10.226-060.84	Simple flake	Bulb removed during blow (five negatives, unidirectional)	Left lateral a dorsal multiphase retouch
GER10.228-058.276	Simple flake	Bulb was removed after production (two negatives)	Left lateral a dorsal tranchet-blow negative
GER10.228-058.365	Raw-piece cap	Bulb was removed after production (four negatives)	Non
GER10.228-058.369	Simple flake	Bulb and platform was removed after production (three negatives, centripetal)	Denticulated retouch on basal ventral
GER11.225-058.43	Simple flake	Bulb was removed after production (four negatives, orthogonal)	Non
GER11.227-057.91.1	Levallois flake	Bulb was removed after production (four negatives, bidirectional)	Non
GER12.227-057.731	Levallois point	Bulb was removed after production (three negatives, bidirectional)	Left and right lateral and terminal a dorsal retouch
GER12.229-059.352	Simple flake	Half of the bulb removed during blow (one negative)	Non
GER12.229-059.635	Raw-piece cap	Bulb was removed after production (one negative)	Right lateral a dorsal multiphase retouch
GER12.229-059.637	Levallois flake	Bulb was removed after production (two negatives bidirectional)	Non
GER13.227-057.1790	Small symmetrical biface with plane-to-convex surfaces	Bulb was removed after production (eight negatives)	Left lateral terminal a ventral retouch, left lateral terminal a dorsal retouch, terminal a dorsal retouch and right lateral terminal a dorsal retouch
total (n=17)			

Tab. 251 - List of blanks with evidence for bulb removal from GH 3

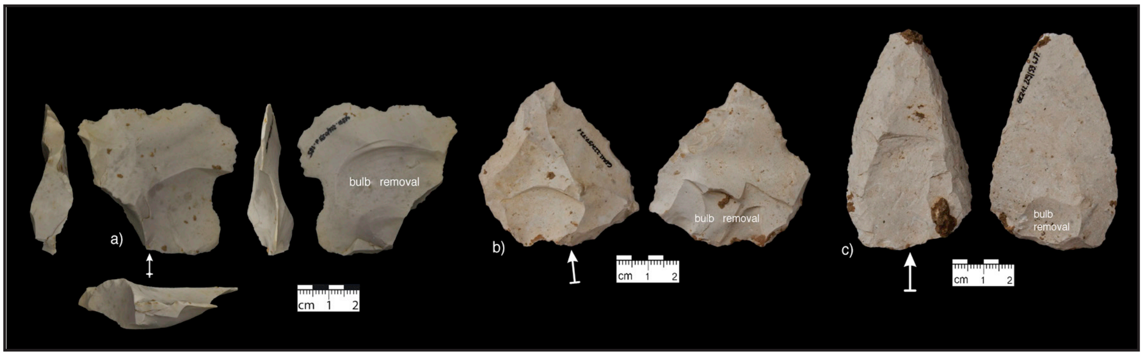

Fig. 315 - Examples of blanks with evidence for bulb removal from GH 3. a) Éclat débordant (GER10.226-059.185); b) Constructed point from Levallois flake (GER12.227-057.731) and c) Moustier point (GER12.229-059.637)

VII.13.18 Invasive ventral face modification

In addition to the modification on surfaces on bifacial objects, some blanks show intensive and invasive surface modification on either the ventral or dorsal face. There is evidence for n=27 blanks from GH 3 with invasive modification of the ventral face (see examples in fig. 316). On n=11 of them in addition the bulb was also removed. In most of the times only some negatives are visible on the ventral face, but the habit of the surface (and therefore the volume of the object) was massively influenced. This modification is always related to other modifications on the edges of the blank. For instance, in n=6 times it is related to side scraper retouch.

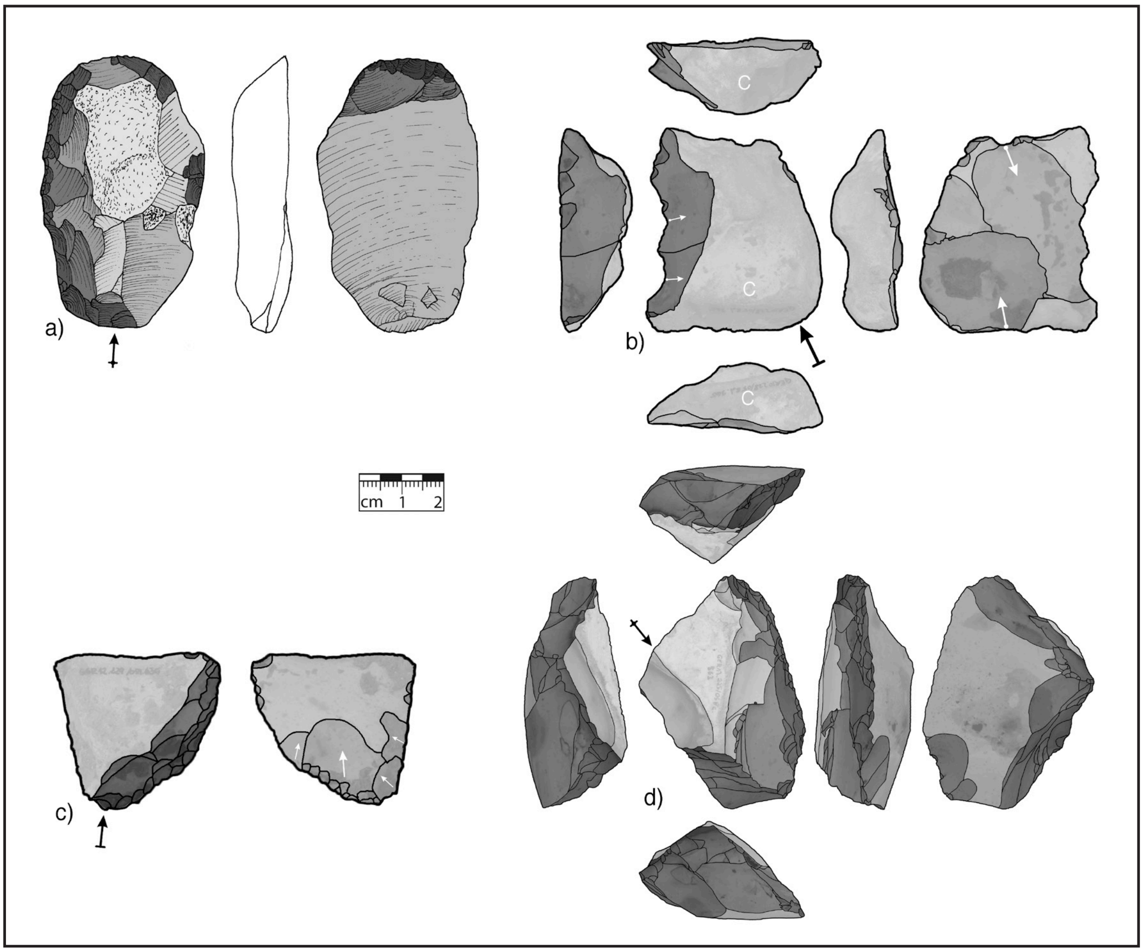

Fig. 316 - Examples of blank with ventral face modification from GH 3. a) Simple blank with rests of cortex, scraper retouch and ventral reduction on the terminal end (GER10.226-059.248); b) Raw-piece cap with ventral face modification on nearly the entire face and backing, a preform of a Keilmesser? (GER10.228-058.365); c) Raw-piece cap with removed bulb zone and scraper retouch (GER12.229-059.635) and d) Simple blank with rests of cortex, intensive backing and scraper retouch (GER13.225-058.863)

VII.13.19 Objects with multiphase retouch

Inside GH 3 there are n=11 objects showing a multiphase retouch. This very intensive kind of modification changed the morphology of the objects massively. Most of them can be described as scrapers and seem to be singular objects. Maybe they all are imported in their condition and brought as primary or basic equipment (*équipment de base* of Leroi-Gourhan & Brézillon 1966) to the site. FAS is the raw material from n=9 of them. The other two are made on chert and unknown flint. Two of them are made on Levallois flakes, the other (with the exception of one blade) are made on simple flakes. Four of them are complete, the others are fragments (n=4 terminal, n=2 basal and one medial fragment). They are listed in the following tab. 252 and some examples are displayed in fig. 290:

Find-number	Raw material	Description
GER09.227-060.153.3	FAS	Complete blade, lateral multiphase retouch to form a point, in the basal part of the lateral edges retouch and damage for hafting
GER09.228-059.135.1	FAS	Small medial fragment, terminal multiphase retouch, a transversal scraper?
GER10.226-059.245	FAS	Terminal fragment of a big flake, dorsal face has some cortex left, Left right lateral edge retouched in at least three phases, right terminal edge retouched in at least two phases, double scraper, both retouched edges are separated by a small patch of terminal cortex
GER10.226-060.77	FAS	Small basal flake-fragment, with left lateral convex multiphase scraper retouch and terminal straight multiphase scraper retouch that reduced the flake massively
GER10.226-060.84	FAS	Basal fragment of a flake containing a bit of cortex, Left lateral a convex and intensive multiphase retouch
GER10.228-058.216	FAS	Terminal fragment of a big raw piece cap, vast difference in patination on dorsal (retouch is white) and ventral face (beige-brown, stained), terminal end, butt and bulb region completely reduced, formation of a circumferential straight (lateral) and convex (basal) retouch, produced in at least three phases of retouch
GER10.228-058.421	FAS	Complete raw-piece cap with a stepped convex retouch on the terminal end, the right lateral edge is only slightly retouched, from some notches in the basal part of the laterals hafting is probable
GER11.225-060.55	Unknown flint	Complete Levallois fake with intensive, steep retouch on the right lateral edge, the terminal end is rounded by retoucher, too
GER12.227-057.689	FAS	Complete raw-piece cap with right lateral a cortex back, the left lateral edge is modified in the basal end by a notch, the terminal end is modified by a tranchet-blow and a subsequent retouch
GER12.229-059.635	FAS	Terminal fragment of a raw-piece caps with intensive convex retouch on the basal and right lateral edge, the bulb was removed, too
GER12.229-059.637	Chert	Levallois flake, intensively modified on the lateral edge for the formation of a pointed end, bulb removal and a kind of fluting on the dorsal face (very likely after the production of the flake itself)
Total	**n=11**	

Tab. 252 - Objects with multiphase modification from GH 3

VII.14 Bifacial objects

VII.14.1 Introduction

The excavated part of GH 3 yielded n=26 bifacial objects in total. The assemblage of bifaces-on-cores are discussed in chapter VII.10.15 and bifaces-on-blanks are discussed in chapter VII.11.13. This chapter summarizes both sections and show analysis about morphological features from both matrices of bifacial objects. The classification and grouping of the bifacial elements (bifacial objects and tranchet-blow blanks) from VP I and II are also discussed in detail in Frick & Floss (in press). The bifacial objects are grouped into six clusters of morphological features (see tab. 253). Each group contains objects with specific features regarding backing, symmetry, position of the active edge, shape of individual surfaces and the constellation of surface to each other.

Bifacial object	Number
Asymmetrical biface with small restricted backing	5
Small symmetrical biface with plane-to-convex surfaces	2
Asymmetrically bifacially backed knife	4
Asymmetrically bifacially backed knife with tranchet blow	2
Bifacially worked object	5
Bifacial preform	8
Total	26

Tab. 253 - Groups of bifacial objects from GH 3

Criteria for the grouping are listed in tab. 254. It combines morphological criteria, such as symmetry in top view and cross section, shape of the cross section, present of backing, regularization and confection of edges and surfaces, shape of the active edge, invasiveness of shaping and the production sequence.

Criterion	Description	Asymmetric biface with small restricted backing	Small symmetrical biface with plane-to-convex surfaces (Fäustel)	Asymmetrically bifacially backed knife (simple Keilmesser)	Asymmetrical bifacially backed knife with tranchet blow (Keilmesser with tranchet blow)	Bifacially worked objects	Preforms
Regularization and confection	Can we see a regular or irregular outline? Is the outline shaped specifically? Is it possible to distinguish techno-functional units of the outline?	yes	yes	yes	yes	yes	no
Active edge	Is there a (convex or straight) active edge?	yes	yes	yes	yes	yes	no
Passive part (back)	Is there a back for grasping visible?	yes	no	yes	yes	yes and no	yes and no
Passive part (base)	Is there a base for grasping visible?	yes	yes	yes	yes	yes	yes and no
Systematized production sequence	Is it possible to replicate the objects by following strict production steps?	yes	yes	yes	yes	yes	no
Invasiveness of surface and edge working	is only the edge worked?	no	no	no	no	yes	no
Top-side symmetry	Is the top view symmetric? What kind of symmetry?	yes and no	yes and no	no	no	no	no
Cross-section symmetry	is the cross section symmetric?	no	no	no	no	no	no
Cross section	Plan-convex on thicker or thinner object, bi-convex on thicker or thinner object, plan-convex to plan, plan-convex on both sides.	plano-convex	plano-convex	mostly plane-to-convex on both sides	mostly plane-to-convex on both sides	mostly plane-to-convex on both sides	diverse

Tab. 254 - Criteria for grouping of bifacial objects from GH 3, see also Frick & Floss (in press, tab. 5)

The following chapters discuss each group of bifacial objects in detail. They discuss the morphology of the objects, the production sequence, as well as their dimensional and distributional patterns. After detailed description these groups are compared to each other. Formally described bifacial objects (without preforms) are illustrated in the following fig. 321.

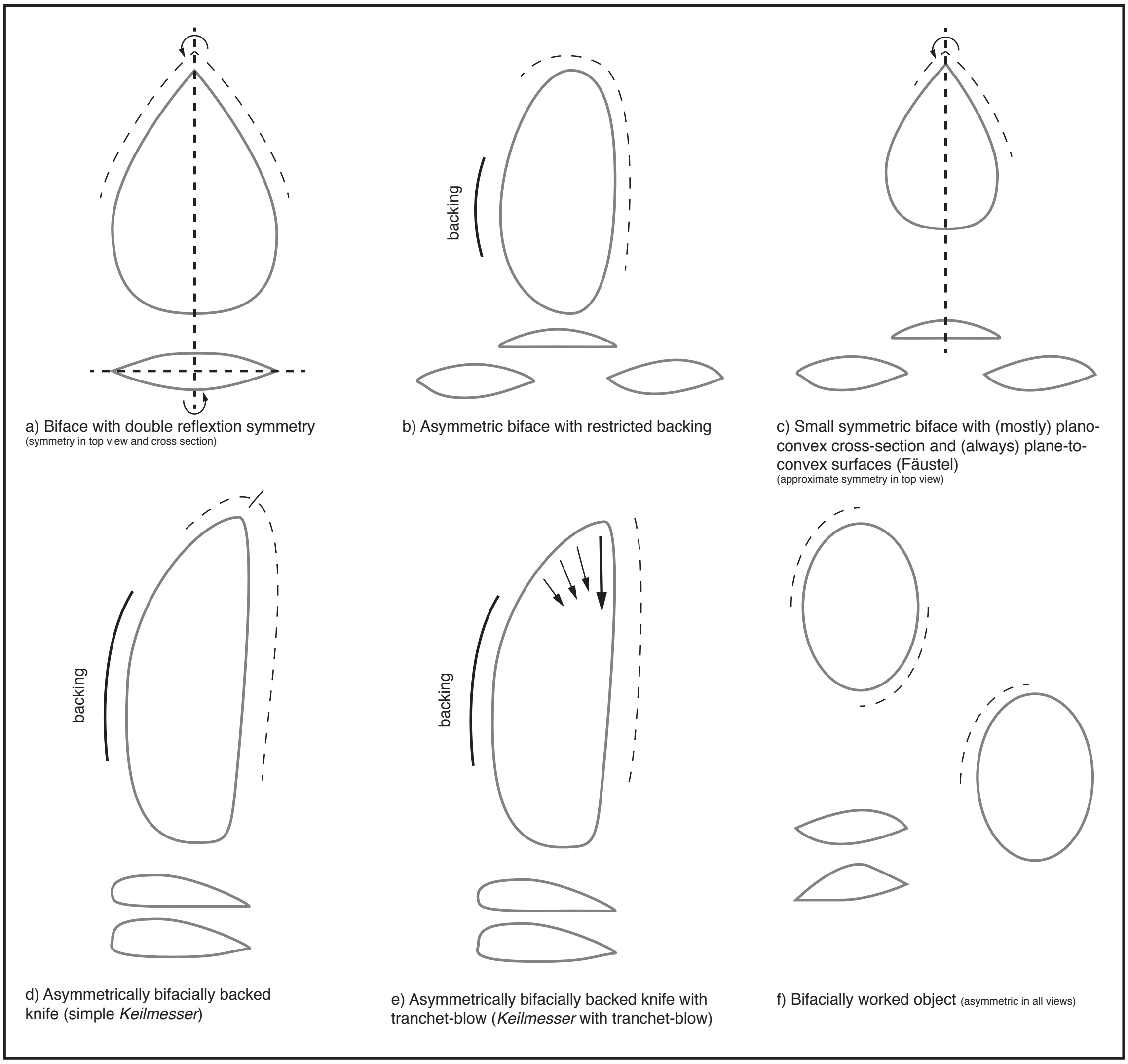

Fig. 317 - Schematic representation of bifacial objects detected at VP I & II. a) Biface with double reflexion symmetry (symmetrical by turning along the long axis and in cross section); b) Asymmetric biface with restricted backing; c) Small symmetric biface with plane-to-convex surfaces (Fäustel); d) Asymmetrically bifacially backed knife (simple Keilmesser); e) Asymmetrically bifacially backed knife with tranchet-blow (Keilmesser with tranchet-blow) and f) Bifacially worked object

VII.14.2 Production analysis

Introduction

The method of analysis for bifacial objects combines approaches of different „schools". It combines methods of cross-section and top view analysis, the constellation of surfaces to each other, the shaping and morphology of edges, the handling during production and the succession of production steps.

Symmetry

Symmetrical features of bifacial objects are visible in cross-section and top view. The main axis for observations is the axis of the longest dimension that correspond with the reference plane dividing the top side from the bottom side (see fig. 317, see the schematic representation above).

Cross section and constellation of surfaces

In general, surfaces of bifacial objects can be flat or convex. However a surface can combine flat and convex parts. Boëda (1995a, c) described observable variations in cross-section for bifacial objects from Kůlna cave, Moravia. The combination of a flat and convex surface is called plano-convex (the more plane surface is called bottom side, the more convex surface is called top side, see fig. 90, chapter V.2.3). If a surface of itself combines plane and convex parts this is called plane-to-convex (one part of the surface is plane, the other is convex). These combinations are displayed in fig. 90 (see also Frick & Floss in press; fig. 14). The term of plano-convex can also be used for the constellation of surfaces on edges (how surfaces meet each other on edges, see fig. 89).

Rotating and turning

Rotation of bifacial objects is a necessary process in the production of bifacial object, independent if surfaces or edges are shaped. Weißmüller (1995; fig. 37) illustrated this using rotating (*wenden*) and turning (*klappen*) concerning the alternating unidirectional edge regularization (*wechselseitig-gleichgerichtete Kantenbearbeitung*) as it was described by G. Bosinski in many publications (e.g. Bosinski 1967, 1969; Wetzel & Bosinski 1969).

We defined turning (t) as rotation along the long axis (changing the top side with the bottom side in plane view) and rotating (r) as rotation along one vertical axis (side is the same, but topsy-turvy; like the rotation of a propeller or rotor on a propeller-driven airplane). As it is for three-dimensional objects there is the option of a third way of rotation along main axes (rotation along transversal axis). All three variations are illustrated in fig. 318 (but beware only two are used for description) and listed in tab. 255:

Rotation	Axis	Resulting effect
Turning	Longitudinal axis or roll axis	Top side and bottom side are interchanged, base and terminal end stay
	Transverse axis or pitch axis	Top side and bottom side are interchanged, base and terminal are interchanged
Rotating	Vertical axis or yaw axis	Base and terminal end are interchanged, top side and bottom side stay

Tab. 255 - Rotation, rotation axis and resolution effect for bifacial objects

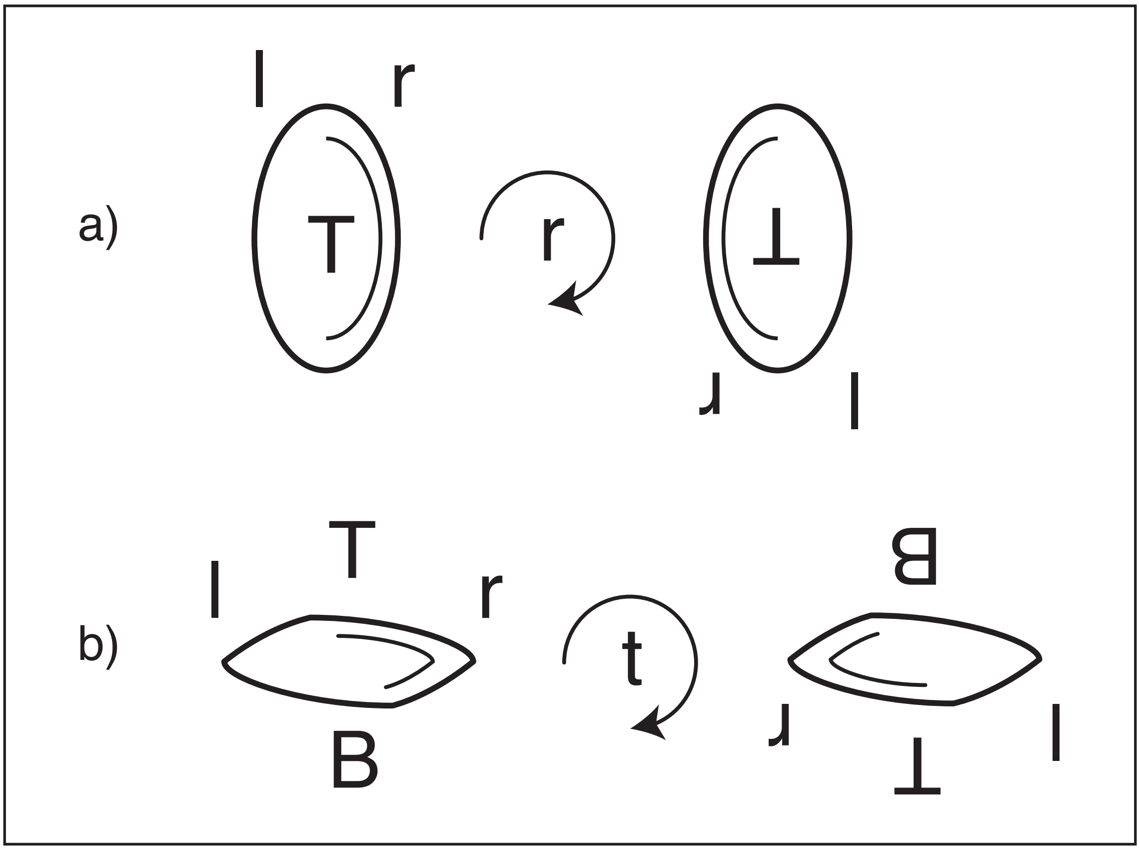

Fig. 318 - Illustration of a) Rotation and b) Turning on bifacial objects for the production of surfaces and edges

Alternating unidirectional edge regularization

Alternating unidirectional edge regularization (*wechselseitig-gleichgerichtete Kantenbearbeitung*) was first described by Bosinski for bifacial objects from Western Germany (e.g. Bosinski 1967, 1969; Wetzel & Bosinski 1969). It describes a specific succession of working steps for the production of bifacial objects and results in straight and regularized edges, as it is illustrated in fig. 319.

Succession of production steps

The succession of production steps is illustrated in this context using drawings with gray-shaded surface parts. Scars and negatives that are assumed as related to each other are painted in the same gray-shade. Older working steps are brighter and younger working steps are darker.

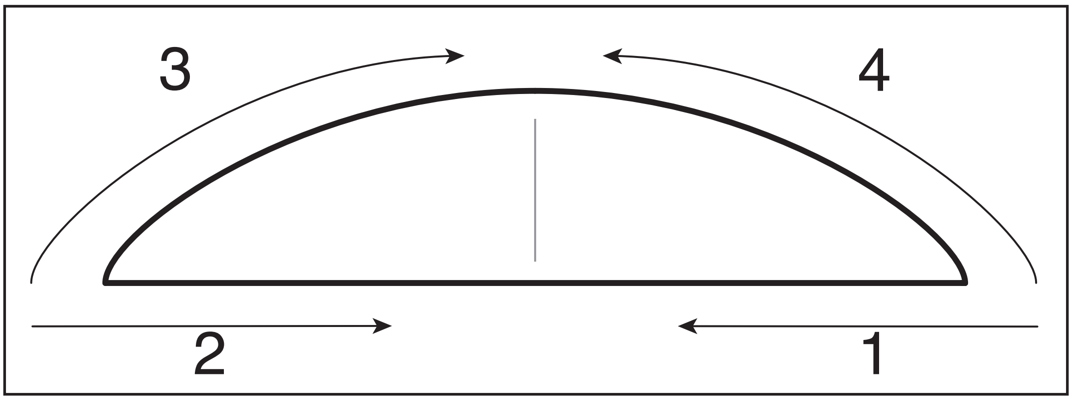

Fig. 319 - Illustration of alternating unidirectional edge regularization (AUER), as described by Bosinski (1967)

The succession of production steps can be illustrated using different shades on surfaces. Another, but related approach is to use Harris matrices (see for example Jöris 2001). The approach here is to use a code to illustrate the working steps (tab. 256):

Code	Meaning
T	Top side is worked
B	Bottom side is worked
Tr	Right side of the top side is worked
Tl	Left side of the top side is worked
Tb	Basal part of the top side is worked
Tt	Terminal part of the top side is worked
Br	Right side of the bottom side is worked
Bl	Left side of the bottom side is worked
Bb	Basal part of the bottom side is worked
Bt	Terminal part of the bottom side is worked
r	Rotating, same side is worked but different edge
t	Turning, different side is worked but same edge

Tab. 256 - Code for the description of the reduction of bifacial objects

VII.14.3 Asymmetric bifaces with small restricted backing

The reason for a slight asymmetry in top view (also known as plan view) of these bifaces is the small restricted backing of the outline. The active edge is always situated circumferential of the terminal end. The shape of the cross section depends on its position and vary between plano-convex and plane-to-convex.

Bifaces of this group derive from the 2011 to 2013 excavation campaigns. With the exception of one (made on an unknown flint) all are made of FAS (fig. 268, chapter VII.11.13). They are listed in tab. 257:

Find-Number	Matrix	Description	Production steps	production stages as code
GER11.225-059.222	Flake	Alternating unidirectional edge reduction for the production of bifacial edges, probably a tip of a big biface that was reworked and used again	The matrix is not visible anymore, only guessed, production of a back on the left edge, flattening of the bottom side, regularization of the right lateral and the tip edge on top side, regularization of the left lateral edge on the bottom side, probably break off of this tip, rework of the base	Tl - t - Br - r - Bl - t - Tr - t - Bl - r - Br - t - r - Tr -r - Tb - t - Bb
GER12.226-057.385	Flake		Flattening the ventral face, shaping the dorsal face, regularization of the left lateral edge	
GER12.227-057.141.1	Flake	Very similar to GER11.225-059.222 but much smaller	The matrix is not visible anymore, only guessed, flattening of the bottom side, production of a back on the left edge, regularization of the edges on the top side, break off of this tip, no rework	Tl - t - Br - r - Bl - t - Tl - r - Tr
GER12.227-057.457	Flake	Plano-convex flake with a natural cortex back, all surfaces are intensively shaped, top side is convex, bottom side is, the edge where the cortex is, was secondarily (recycling) modified	The matrix is a plano-convex flake, flattening the ventral face, backing of the center of the right lateral edge, shaping the dorsal face, regularization of the left lateral edge on top side, regularization of the base on top side	Bl - r - Br - t - Tb- r - Tr - r - Tl - Tt - t - Bl

GER13.228-057.474	Flake	Broken tip of a bigger biface	Flattening of the ventral face, backing of parts of the left lateral edge, regularization of the right lateral edge and the terminal end, breaking-off of the tip	Br- r - Bl - t - Tl - r - Tr - t - Bl - r - Br
Total		**5**		

Tab. 257 - Listed asymmetric bifaces with small restricted backing from GH 3

VII.14.4 Small symmetrical bifaces with plane-to-convex surfaces

Both examples in this category from GH 3 are more or less symmetrical in plane view. Both show the combination of a more plane and a more convex surface, but the surfaces for itself are plane-to-convex shaped. The small one is made from FAS and the bigger one from an unknown flint variety. The turning and rotating processes during production are well visible on both objects. They are listed in tab. 258 and displayed in fig. 269, chapter VII.11.13).

Find-Number	Matrix	Description	Production steps	production stages as code
GER12.227-057.420	Flake	Very small bifacial object, made from a cortical flake, production steps are performed in an alternating unidirectional edge reduction way, Made from FAS	Selection of a small cortical flake, decortication of dorsal face, intensive reduction on ventral face for shaping the tip, ventral face forms the top side, edge regularization on left part of the top side, edge regularization on left side of the bottom side	Br - r - Bl - t - - r- Tl - r - Tr - t - r - Bl - t - Tl
GER13.227-057.1790	Flake	Small bifacial object, made from a cortical flake, production steps are performed in an alternating, unidirectional edge reduction way, Made from unknown flint	Selection of a small cortical flake, flatting the ventral face by removing the bulb, production of a convexity on dorsal face, edge regularization on left edge of the ventral face, edge regularization on the right edge of the dorsal face, edge regularization on the left edge of the dorsal face	Bt - t - r - Tt - t - Br - t - Tr - r - Tl

Tab. 258 - List of small bifaces with plane-to-convex surfaces

VII.14.5 Asymmetrically bifacially backed knives or *Keilmesser*

A *Keilmesser* is a bifacially worked lithic object with one active edge (cutting edge). This edge is mostly formed by bifacial retouch using **A**lternating **U**nidirectional **E**dge **R**egularization (AUER, *wechselseitig-gleichgerichtete Kantenbearbeitung* after Bosinski 1967). Opposing to this active edge (mostly on the other lateral edge, primary active edge) the *Keilmesser* possess an unworked or roughly worked back that is often shaped first. Sometimes, the terminal part of the *Keilmesser* can also possess a sharp edge (secondary active edge). If both active edges are present they meet in an angle (forming a tip) or blend into each other. The German name *Keilmesser* derives from its triangular wedge-shaped cross section. Such *Keilmesser* in generally interpreted as cutting knifes. The general morphology and function of *Keilmesser* is extensively described by Jöris (e.g., Jöris 1993, 2001, 2006a, 2012).

Examples of *Keilmesser* are known from Southwestern Europe (e.g. Galeria Pesada in Portugal, Marks et al. 2002) to Western Asia (e.g., Upper Desna River Basin in Russia, Ocherednoi 2010).

A challenging task for *Keilmesser* (KM) or asymmetrically bifacially backed knifes (ABBK) is denomination. The following presents an in-exhausted list of names for such objects (tab. 259):

Name	English expresion	Literature
Faustkeilschaber	Hand-axe side-scraper	Müller-Beck 1956
Biface à dos	Backed biface	Bordes 1961
Biface-racloir	Hand-axe side-scraper	Bordes 1961
Prądnik	Prondnik, Pradnik	Krukowski 1939-48 Migal & Urbanowski 2006
Pradnik knife	Pradnik knife	Migal & Urbanowski 2006
Asymmetrical backed knife	Asymmetrical backed knife	Migal & Urbanowski 2006
Racloir-couteau du type Prondnik	Side-scraper knife of the Prondnik type	Desbrosse et al. 1976
Keilmesser	Wedge knife	Jacob-Friesen 1949 Bosinski 1967

Tab. 259 - Denomination of Keilmesser

There are n=4 objects categorized as asymmetrically bifacially backed knives or simple *Keilmesser* in GH 3. Three of them are made on flakes and one could be made on a flakes or frost fragment. They are listed in the following tab. 260 and displayed in fig. 320.

Find-Number	Matrix	Description	Production steps	production stages as code
GER13.225-058.913	Flake	Flake with bifacially regularized lateral edge	Production steps are backing, reworking of the ventral face, reworking of the dorsal face and finishing the cutting edge by bifacial regularization	Br - r - Bl - t - Tl - r - Tr
GER10.226-059.155	Cortical flake or frost fragment	Flat and wide cortical flake or frost shard, broken active edge	Selection of a flat matrix, flattening the bottom side, regularization of the back, shaping the active edge on the ventral face (bottom side), shaping the active edge on dorsal face (top side), regularization of the active edge on the top side, use and break, re-regularization of the active edge on bottom side	Bl - r - Br - t - Tr - r - Tt - t - Bt
GER10.226-059.301	Flake	Flake with cortex rests (maybe an éclat débordant), bifacially regularized right lateral edge	Selection of a flake, regularization of the back with some negatives, shaping of the active edge dorsally and ventrally	Tl - r - Tr - t - Bl
GER12.229-059.533	Flake	Dorsally shaped flake with steep back, terminally highly modified and edge regularization	Selection of a flake, dorsally surface shaped, backing on the right lateral edge on dorsal face,	

Tab. 260 - Asymmetrically bifacially backed knives from GH 3

VII.14.6 Asymmetrically bifacially backed knives with tranchet blow

There are n=2 *Keilmesser* showing a tranchet-blow modification in GH 3 (fig. 321). Both are from the 2012 campaign (an additional showed up in the 2015 campaign, but is not part of this discussion) and made from FAS. Both are different in size. The bigger one (GER12.229-059.428) is completely surface modified and the tranchet-blow was not the last working step (after it edges were regularized). The small one (GER12.226-057.1227) shows only coarse edge regularization. It can also be assumed that the tranchet-blow was not for finishing the object. It could be part of the shaping of edges and surfaces.

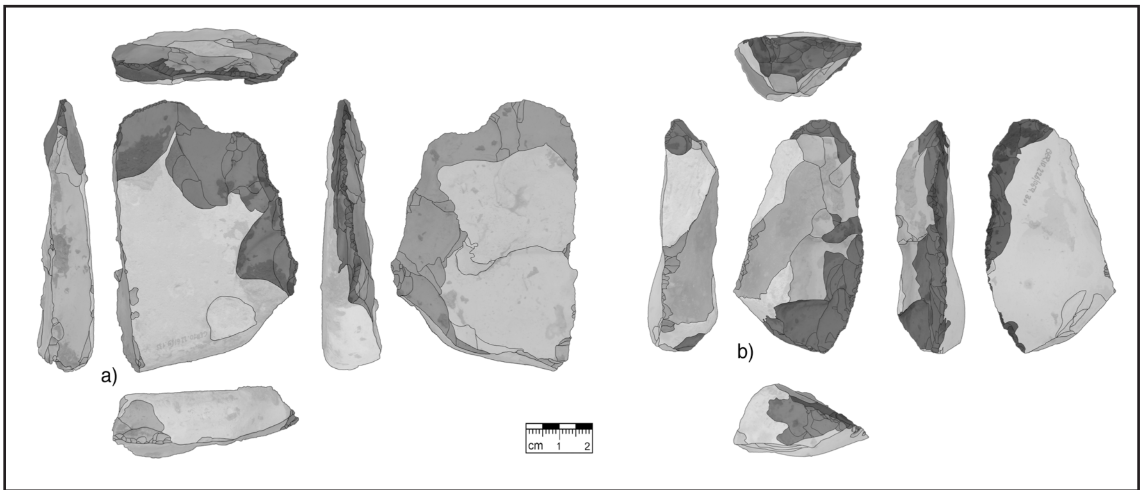

Fig. 320 - Asymmetrically bifacially backed knives from GH 3. a) GER10.226-059.155 and b) GER10.226-059.301

It seems that the formation and function of a tranchet-blow negative was known, but seem to be not important (or necessary), or (as is looks) the skills to produce an adequate tranchet-blow negative (as they are known from the neighboring VP I) were not perfected. Both *Keilmesser* with tranchet-blows are listed in tab. 261:

Find-Number	Matrix	Description	Production steps	Production stages as code
GER12.226-057.1227	Flake	Ventral and dorsal faces are shaped with bigger negatives, the tranchet-blow is situated on the right lateral edge	Selection of a small flake, backing on the basal end, shaping of the ventral face, edge regularization on the terminal end of the dorsal face, tranchet-blow negative on the right lateral edge of the ventral face (bottom side)	Tb - t- Br - r - Bl - t - Tt - t - Br
GER12.229-059.428	Raw piece	Flat nodule (disc-shaped), complete surface shaped, tranchet blow on left lateral edge of the top side	Selection of a flat raw piece, flattening of bottom side, flattening of top side, edge regularization on right edge of bottom side, edge regularization of left edge of top side, tranchet blow in left lateral edge of the top side, edge regularization on the right lateral edge of the bottom side, edge regularization on the terminal end of the top side	Br - r - Bl - t - Tr - r - Tl - t - Br - t - Tr - r - Tl - t - Br - t - Tt

Tab. 261 - Asymmetrically bifacially backed knifes with tranchet-blow from GH 3

VII.14.7 Bifacially worked objects

Bifacially worked objects are diverse in shape and size. They show mostly only a minimal modification in that way that one edge is bifacially regularized or one edge is ventrally and the other is dorsally modified. The result is that the surfaces are both in a plane-to-convex shape. There are n=5 object named as bifacially worked object. Three of them are made of FAS and two are made from an unknown flint. Four are made on flakes, and another is made on a flat nodule. All five are listed in the following tab. 262 and examples are displayed in fig. 267, chapter VII.11.13.

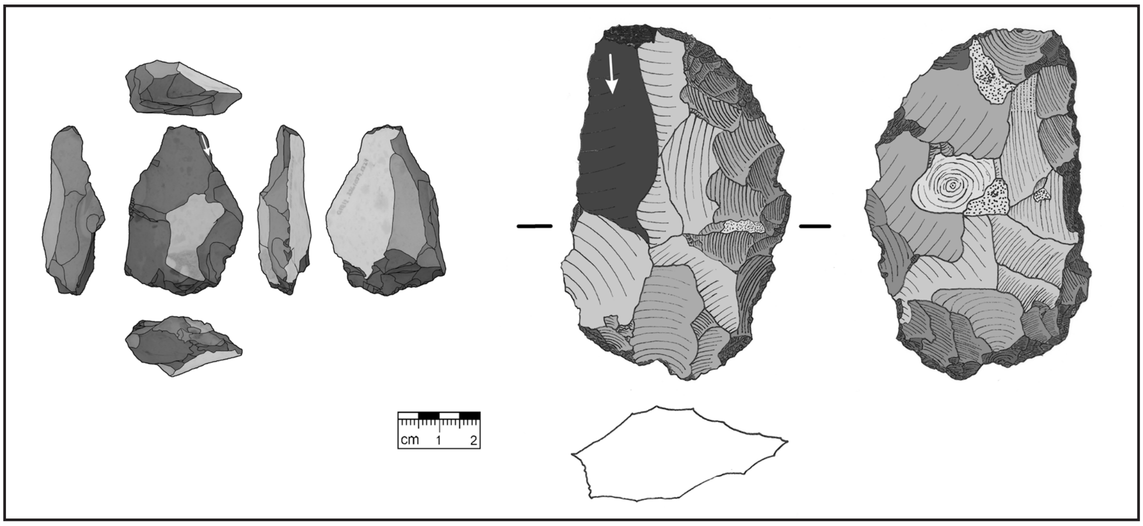

Fig. 321 - Asymmetrically bifacially backed knifes with tranchet-blow from GH 3. left) GER12.226-057.1227 and right) GER12.229-059.428

Find-Number	Matrix	Description	Production steps	production stages as code
GER09.228-059.116.8	Flake	Small flake showing surface shaping on both sides, one edge show and additional regularization	Selection of a small flake, minimal surface shaping on ventral face, edge regularization (backing) on the right lateral edge of the dorsal face, edge regularization on the right lateral edge of the ventral face	Bb - r - Bt - t - Tr - t - Br
GER10.226-059.196	Flake	Bigger flake with backing and regularization on the terminal end and on one lateral edge, both retouched edges are independent from each other	Selection of a bigger flake, backing on the right lateral edge of the dorsal face, edge regularization on terminal end of the dorsal face, bulb removal and shaping of the right lateral edge of the ventral face	Tr - r - Tt - t - Bb - Br
GER10.227-058.219	Flake	Bigger flake showing a direct retouch on the right lateral edge and inverse retouch on the other edge	Selection of a bigger flake, edge regularization on the right lateral edge of the dorsal face, edge regularization on the right lateral edge of the ventral face	Tr - t - Br
GER10.228-058.58	Flake	Tip of a bigger flake showing bifacially retouch on the right lateral side	Selection of a bigger flake, regularization of the right lateral edge of the dorsal face, edge regularization of the left lateral edge of the ventral face	Tr - t - Br
GER10.228-058.200	Flat nodule	Flat nodule showing bigger removals on the ventral face and shaping of the dorsal face, edge regularization on the right lateral edge of the dorsal face	Selection of a flake, some bigger removals on the ventral face (centripetal), thinning of the dorsal face and edge regularization on the right lateral edge of the dorsal face	Bl - r - Bb - r - Br - t - Tl - r - Tb - r - Tr

Tab. 262 - Bifacially worked objects from GH 3

VII.14.8 Bifacial preforms

Bifacial preforms are unfinished products (they can also be named pre-products or semi-finished products). These objects show partial bifacial reduction but lack a clear edge and surface regularization. Often they show only some removals on either side and knapping mistakes are often visible (a possible reason for discarded prior to finishing). Each object show an own reduction sequence. Three of them are made on frost shards, three on flake and two on raw pieces, but all are made from local FAS. They are listed in the following tab. 263 and examples are displayed in fig. 322.

Find-Number	Matrix	Description	Production steps	production stages as code
GER09.228-058.7.1	Frost shard	Frost shard showing some edge working on „ventral“ and „dorsal“ face	Retouch on „ventral“ face and retouch on „dorsal“ face, no edge regularization visible	B - t - T
GER09.228-059.116.5	Raw piece	Flat raw piece showing bifacial removing on either side	Selection of a flat and small raw piece, flattening of bottom side, removal of cortex on top side and marginal edge regularization, edge working on bottom side	Bl - t - Tr - r - Tl - t - Br
GER10.226-060.146	Frost shard	Frost shard showing some removals on either side	Selection of a small frost shard, removing of cortex on „dorsal“ face (top side), flattening on the „ventral“ face (bottom side)	Tb - t - Bb
GER10.228-058.252	Flake	Flake showing bifacially modification on its left lateral edge	Selection of a flake, some removal on left lateral edge ventral and dorsally	B - t - T
GER12.226-057.723	Frost shard	Frost shard showing some, quite flat removals on either side	Flattern of the bottom side, beginning of retouch on the top side, on edge regularization visible	B - t - T
GER12.226-057.861	Flake	Flake showing removal of the bulb part, edge working on dorsal face, edge working on ventral face	Removal of the bulb region of a cortical flake, circumferential edge working on the dorsal face, flattening of the ventral face, on edge regularization visible	Bb - t - T - t - B
GER12.229-059.124	Raw piece	Convex surface shaping on either side of a flat nodule	Removal of cortex from a flat nodule on either side, no edge regularization visible	T - t - B
GER12.225-059.702	Flake	Cortical flake showing flattening on ventral face and beginning of backing	Selection of a cortical flake, flattening the ventral face (bottom side), beginning of the production of a back	Bl - t - Tl

Tab. 263 - Bifacial preforms from GH 3.

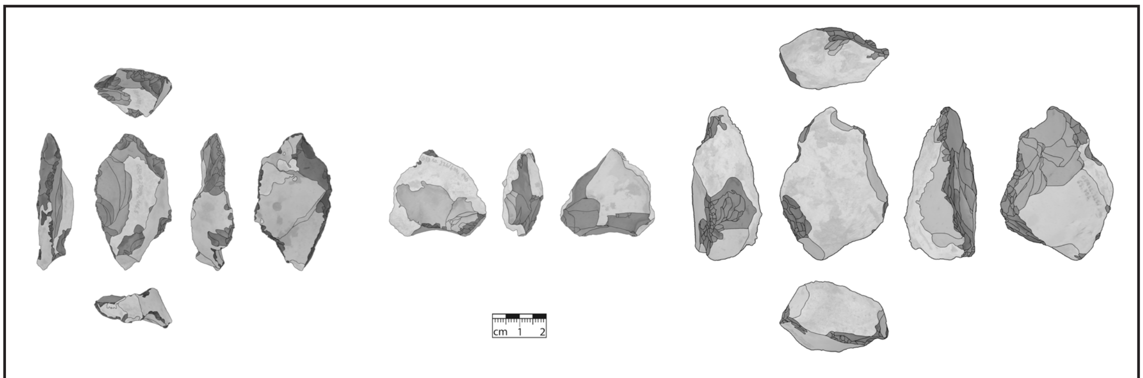

Fig. 322 - Bifacial preforms from GH 3. a) GER09.228-059.116.5; b) GER10.226-060.146 and c) GER12.225-059.702

VII.14.9 Comparison of the bifacial objects

Introduction

Inside the lithic assemblage of GH 3 six groups of bifacial objects were morphologically separated. However, if preforms are disregarded, the bifacial objects of the resting five groups show some common features in regard to morphology, production steps and techno-functionality. In the following these groups of bifacial objects from GH 3 are compared with each other.

Symmetry

The most obvious morphological feature of the bifacial objects from GH 3 is a lack of more than one symmetry. A symmetry is only visible in the top view of small symmetrical bifaces with plane-to-convex surfaces. All other outlines in top view, side view or cross section are asymmetric.

Roughing-out, thinning and shaping, and finishing

Among cortical flakes and flakes without cortex, raw pieces (assumed, but present as cores with some rests of cortex) and even frost shards are used as matrices for the production of bifacial objects. The percentage of flakes with and without cortex equals almost. This is also true for raw pieces and frost shards (see fig. 323).

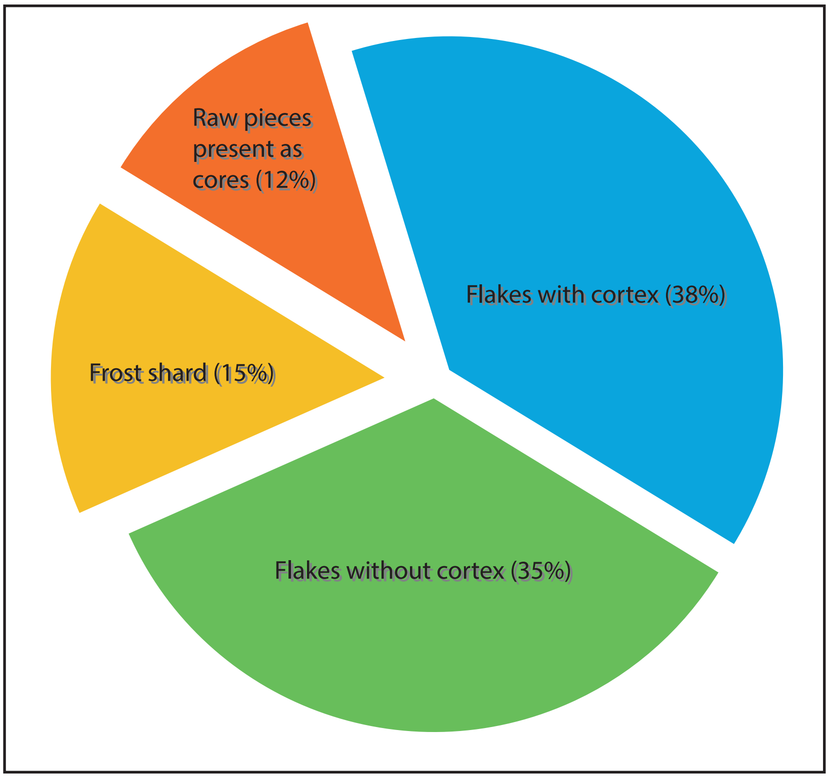

Fig. 323 - Matrices used for bifacial objects from GH 3

In most of the cases the shaping followed specific and independent steps. At the beginning the more flat surface (bottom side) is shaped (see fig. 324a) or a back is formed (fig. 324b). The more convex surface is shaped after. For surfaces that posses a plane and convex part, the process is turned. Here the convex part is shaped first and the plane part is following (see fig. 324c).

The finishing of edges (the regularization) is always done in a unidirectional manner (fig. 324d). In non of the cases an edge is shaped using a method were the object is turned after every blow (which results in a sinus-shapes edge line). It is possible that on highly modified and shape-transformed bifacial-objects this technique was used in the beginning (first stage, roughing-out, *sensu* Newcomer 1971). The advantage of this shaping method is to get a sinus-shaped edge line

that connects both sides of a flat preform or nodule in the middle of both surfaces. This results in a similar edge angle to either side if the resulting reference plane is seen as base (fig. 324e). The opposing case of AUER results in a reference plane that is shifted to one side (very often the bottom side), resulting in an asymmetric cross section of the shaped object (fig. 324a to d). Here, the resulting edge is in its final shape unifacially retouched, and straight in side view (fig. 324d).
It seems this unidirectional method for shaping bifacial objects is used on all bifacial objects for the thinning and shaping (second stage, thinning and shaping, sensu Newcomer 1971), as well as the final stage, the finishing. This shaping is a strong argument for placing the bifacial objects into a Micoquian context with strong connections to Central European assemblages of the *Keilmessergruppen*.

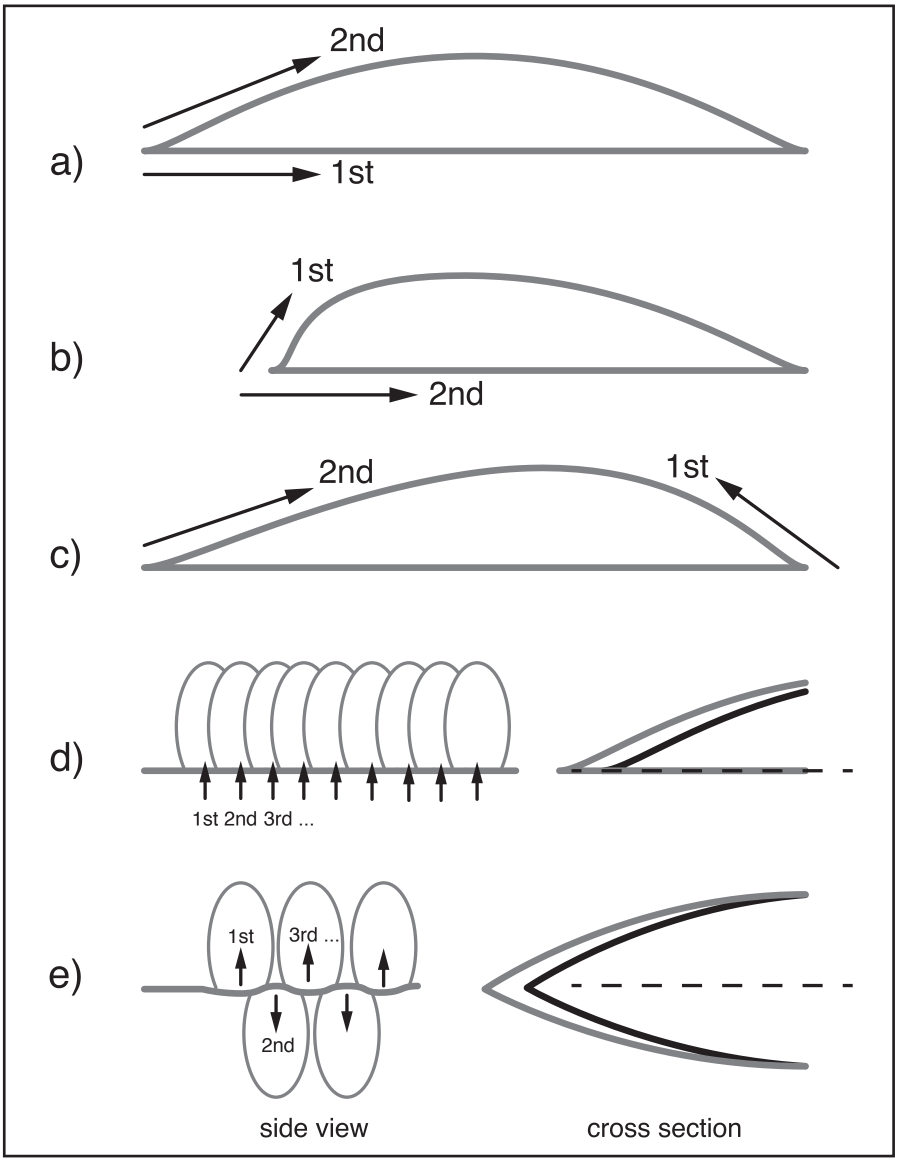

Fig. 324 - Alternating unidirectional edge and surface regularization for shaping bifacial objects. a) Plano-convex cross section (first the plane surface, and second the convex surface); b) Plano-convex cross section (first the formation of a back and second the plane surface); c) If a surface is plane and convex, the convex part is first shaped and at second the plane part of the surface; d) Unidirectional edge regularization and e) Bidirectional edge regularization

Joining of surfaces on edges

In general, there are n=7 morphological possibilities for joining surfaces on edges (viewed in cross section). It seems that at VP II (especially in the time of GH 3), the combination that contain one plane surface was preferred, and especially the convex-straight variation. This is in opposition to the edge regularization of Quina side-scrapers, where the surfaces meet in a concave-straight way (Verjux & Rousseau 1986) using a particular technique for the production with tangential drawn-away moving-direction (see fig. 16f and Baena Preysler & Carrión Santafé 2003; Bourguignon 2001; Romagnoli et al. in press).

Dimension of bifacial objects

If bifacial objects are dimensionally plotted by their group affiliation there is no obvious cluster visible. But the ratio in two dimensions at a time display some patterns for all objects. In regard to length and width, bifacial objects are always situated in a ratio between L=W and L=W/2. This pattern becomes soft if thickness is incorporated. In regard to thickness and width bifacial objects are situated between T=W and T=4W. By comparing length and thickness they are situated between L=T/1.5 and L=T/6 (see fig. 325).

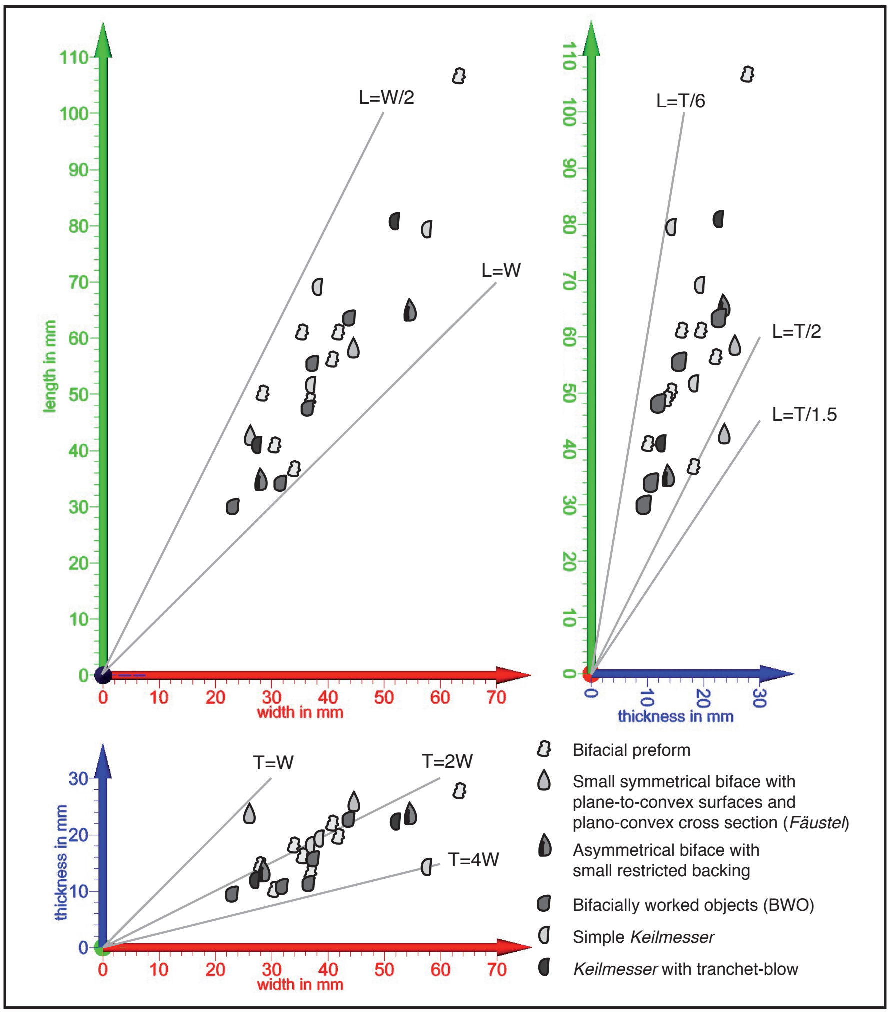

Fig. 325 - Dimension of bifacial objects from GH 3

Mass of bifacial objects

In fig. 326 the masses of bifacial objects per group are listed as box plot. Preforms scatter at most. The bandwidth of all other bifaces is much smaller. In average, bifacially worked objects have the lowest mass and *Keilmesser* with tranchet blows the highest.

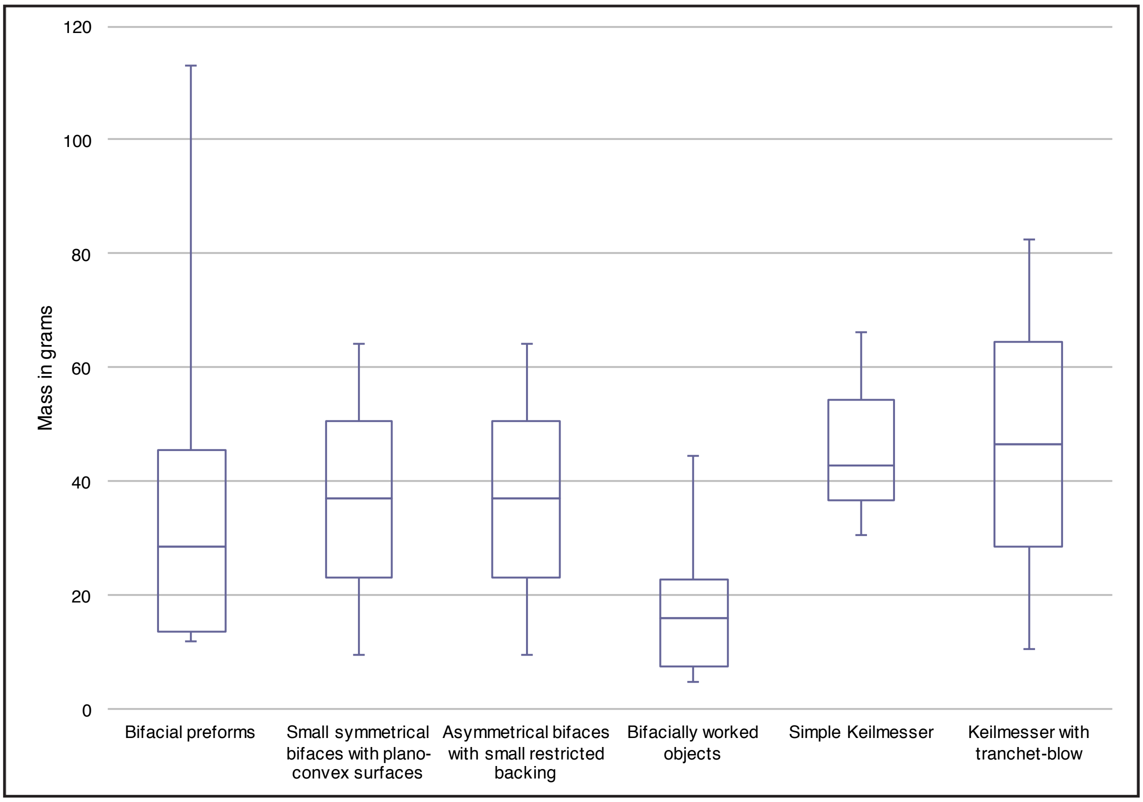

Fig. 326 - Masses of bifacial objects as boxplot

Allometry of bifacial objects

The question of this section is, if the morphology of bifacial objects is related to their size. In this case the formed groups of bifacial objects are compared to each other to see if some rules can be derived (in the context of the question if physical or cultural constrains are responsible for the observation). On fig. 325 (above) there is no clear and striking pattern visible. We see that bifacial preforms are mostly situated in the size of all other (finished) bifacial objects. The ratio of length-to-width for all bifacial objects equals always between L=W and L=W/2 (flake dimension). The ratio of length-to-thickness or thickness-to-width is more scattered. BWO and *Fäustel* are always small in length and width, but thick.

An assumption could be that *Keilmesser* without tranchet blow are normally bigger in size than Keilmesser with tranchet blow, because a tranchet blow (and associated negative on the arch of a *Keilmesser*) could be a modification in the meaning of restoration a former tool. But the sample size is too small to find significance and both are present as big and small examples.

All three dimensions increase in relation to each other for asymmetrical bifaces with small restricted backing, as well as Keilmesser with and without tranchet blow. This gives a hint that the idea behind these objects is related to specific relations of theses dimensions. Or if these objects are integrated in maintenance processes the dimensional relation of these objects need to stay constant in regard to handling or in regard to their recognition to be of the same kind of tool.

VII.15 Comparison of features of educts and products

VII.15.1 Introduction

The following chapters show comparisons of educts (raw pieces and cores) and products (blanks). Each chapter compares at first each other in general and then for particular groups.

VII.15.2 Comparison of educts and blanks

In a more or less closed assemblage raw pieces and in a smaller degree cores should have in general a bigger dimension than resulting blanks. If the maximum length of raw pieces, cores and blanks of FAS and chert are compared (see fig. 327), this is visible for GH 3 (measurements of n=17 raw pieces, n=189 cores and n=2161 blanks). Blanks are in mean smaller than raw pieces and cores.

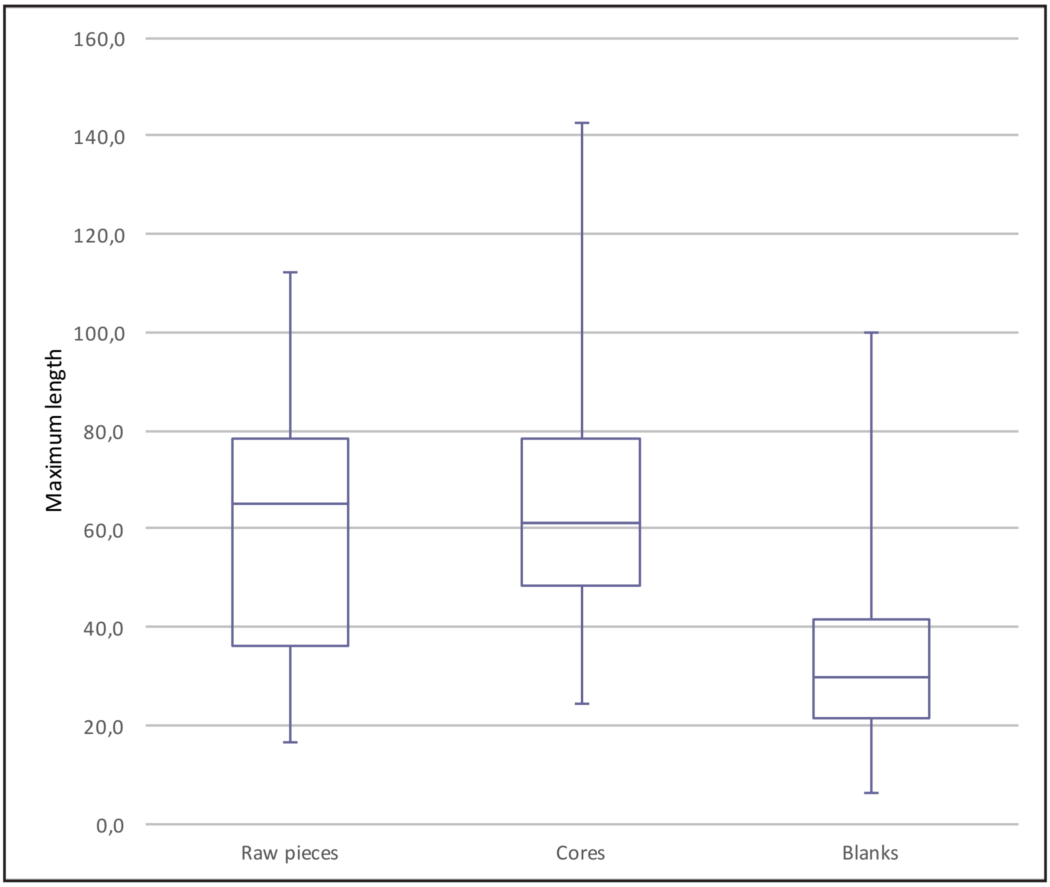

Fig. 327 - Comparison of the maximum length of raw pieces, cores and blanks of FAS and chert from GH 3, displayed as boxplot

VII.15.3 Comparison of reduction surfaces on cores and size of blanks

On n=126 cores (regardless of its lithic raw material) the dimension of the largest reduction surface and the dimension in knapping direction of n=1458 blanks from GH 3 were measured. If both are plotted as histogram in the same scale it shows that length and width of reduction surfaces are always larger than length and width of the ventral face of blanks in knapping direction (see fig. 328 and 329). In regard to length the highest frequency for reduction surfaces are around 46 to 60 mm and for blanks between 10 and 28. This is similar for width of the reduction surface (around 37 to 55 mm) and the ventral face of blanks (around 10 to 33). This correlation shows that the bandwidth of blanks fall into the spectrum of cores. This can be seen as another aspect that (only in regard to dimension) blanks from GH 3 were detached on-site because blanks fit into the spectrum of cores.

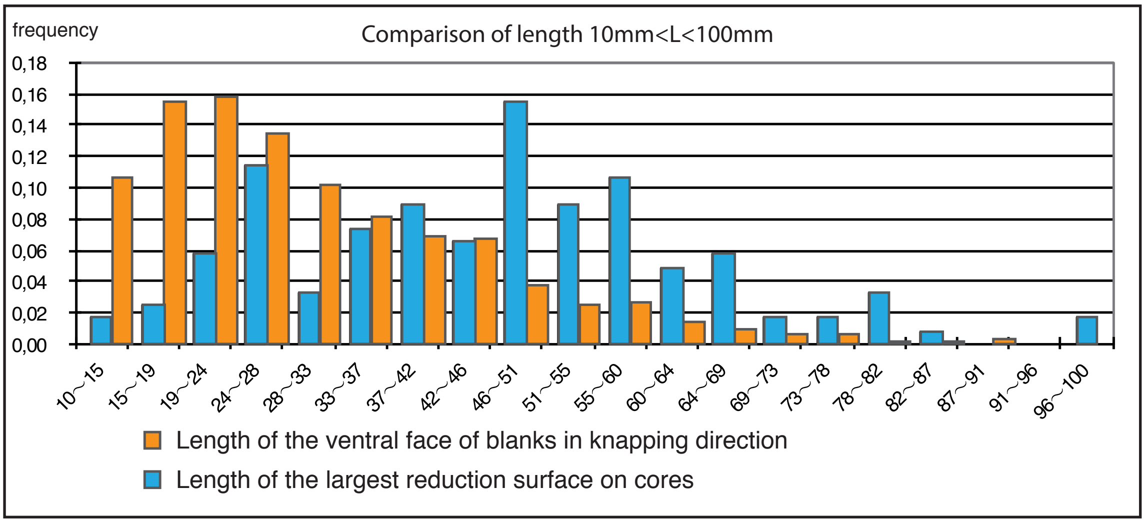

Fig. 328 - Length of the largest reduction surface on cores and length of the ventral face of blanks in knapping direction from GH 3

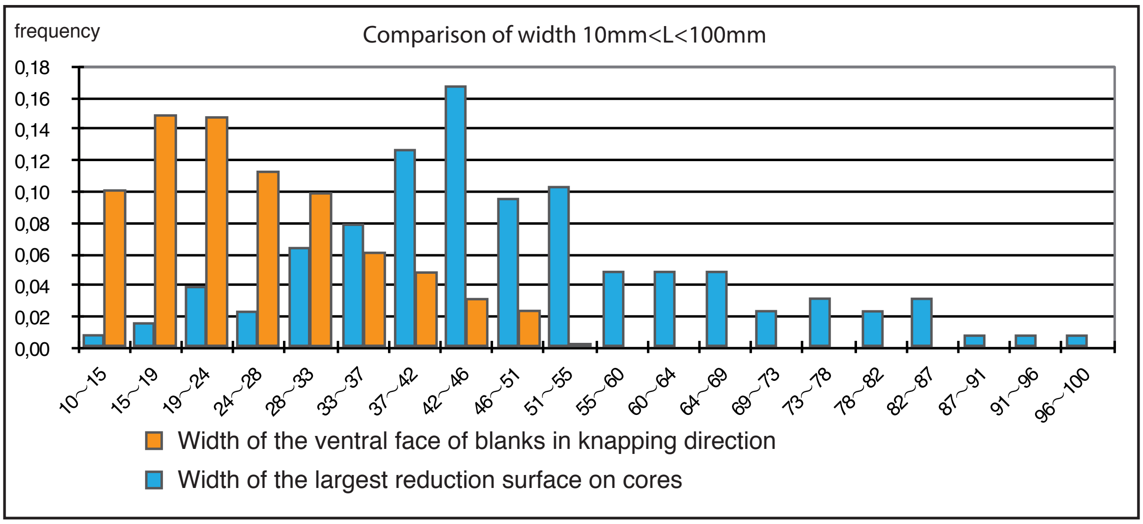

Fig. 329 - Width of the largest reduction surface on cores and width of the ventral face of blanks in knapping direction from GH 3

VII.15.4 Comparison of reduction surfaces and blanks from Levallois reduction

Introduction

As Richter (1997) mentioned, a close correlation between cores and blanks is only possible for Levallois cores and blanks, as well as Kombewa cores and blanks. The following compares reduction surfaces of Levallois cores and Levallois blanks.

The negative constellation on the reduction surface of n=21 Levallois cores (see chapter VII.10.17) is confronted (see tab. 264) with negative constellations on dorsal faces of n=48 complete Levallois flakes (see chapter VII.11.10):

Negative pattern	Number of cores showing this pattern for target blanks on the reduction surface	Number of blanks showing this pattern on the dorsal face
preferential (uni-directional)	5	0
uni-directional, parallel	4	27
uni-directional, convergent	0	20
uni-directional, divergent	0	12
bi-directional, parallel	4	13
bidirectional, orthogonal	2	9
bidirectional, convergent	0	7
centripetal	6	24
Total	**21**	**112**

Tab. 264 - Comparison of negative patterns of reduction surfaces of Levallois cores and negative patterns on dorsal faces of Levallois blanks

At first sight, there are similarities. There are more cores, as well as blanks showing a uni-directional pattern. But, both patterns of negatives are not directly comparable. The main reason is that the pattern on the reduction surface of a core show both, negatives of target and configuration removals. This can also be visible on dorsal faces of blanks. The difficulty here is now to find rules to separate these negatives from each other to find plausible arguments for the kind of reduction and patterns for correlation of cores and blanks. In this moment, we have to keep in mind that direct evidence of physical refits are not available.

Levallois blanks of first, second and third series

The correlation of Levallois blanks with the scheme of Boëda (1988b: 22, fig. 6) for Levallois blanks of the first, second and third series, shows this different order (see fig. 330). Blanks with a uni-directional negative pattern on the dorsal face are seen as blanks of the third series. Orthogonal negative patterns as blanks of the second series and centripetal patterns as first series.

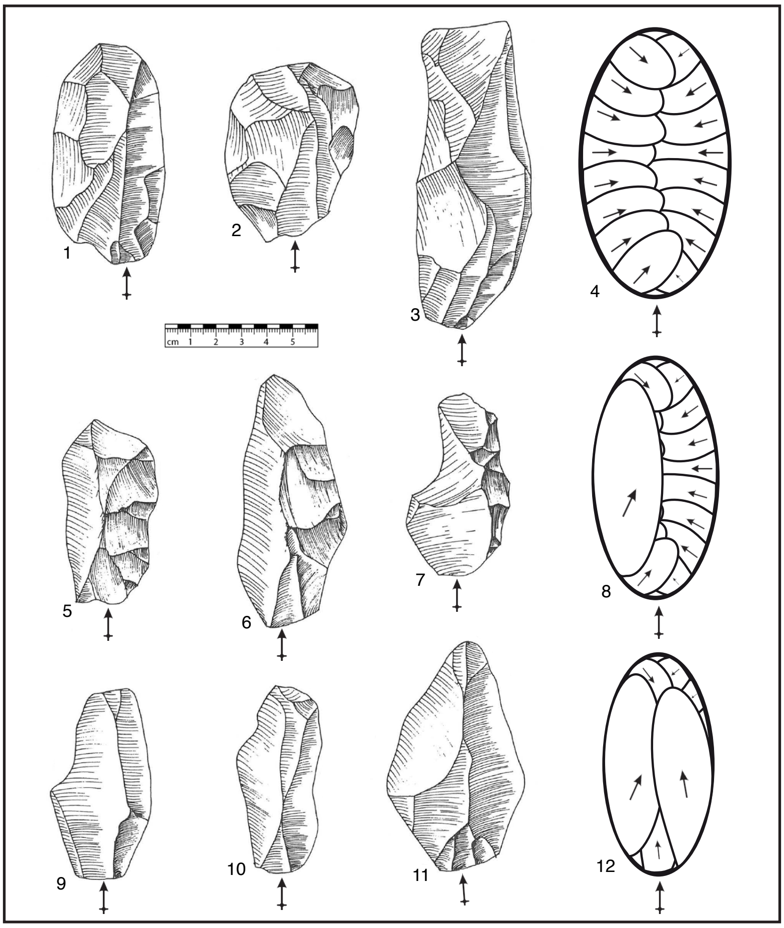

Fig. 330 - Levallois blanks from successive series of removals. 1) to 4) First series; 5) to 8) Second series; 9) to 12) Third series. 1 to 3, 5 to 7 and 9 to 11 are drawings of blanks from Biache-Saint-Vaast, niveau IIa, adopted from Boëda (1988b: 22, fig. 6)

By using the data from tab. 264 (above) for blanks, the following correlation for Levallois blanks from GH 3 is shown (tab. 265):

Successive series of Levallois removals, after Boëda (1988: 22, fig. 6)	Negative pattern	Number of blanks showing this pattern on the dorsal face
first series	centripetal	24
second series	bidirectional, orthogonal	9
third series	bi-directional, parallel	13
third series	bidirectional, convergent	7
third series	uni-directional, parallel	27
third series	uni-directional, convergent	20
third series	uni-directional, divergent	12
Total		**112**

Tab. 265 - Correlation of dorsal negative pattern of Levallois blanks from GH 3 with the theme of Boëda (1988b: 22, fig. 6)

The correlation of dorsal negative pattern of Levallois blanks from GH 3 with the theme of Boëda (1988b: 22, fig. 6) shows that the second series of Levallois blanks is underrepresented. One interpretation of this observation might be that Levallois cores were prevalently reduced in another way. For example, by removing only correction blanks in a centripetal manner after the first removal. Another possibility would be that the first removed blank made a negative on nearly the entire reduction surface. In this way, the second series (if removed in the same or opposed direction as the first) would also show only parallel negatives on the reduction surface. This hypothetical reflection is visible on Levallois cores from GH 3. The best example for this is a Levallois core made on a cortical blanks (GER10.227-058.235, see fig. 331). There, nearly the entire reduction surface (former ventral face) was used to get a blank. The second (nearly) quadratic blank was removed in the same direction as the first one, and should have at least one negative of the first blank on its dorsal face.

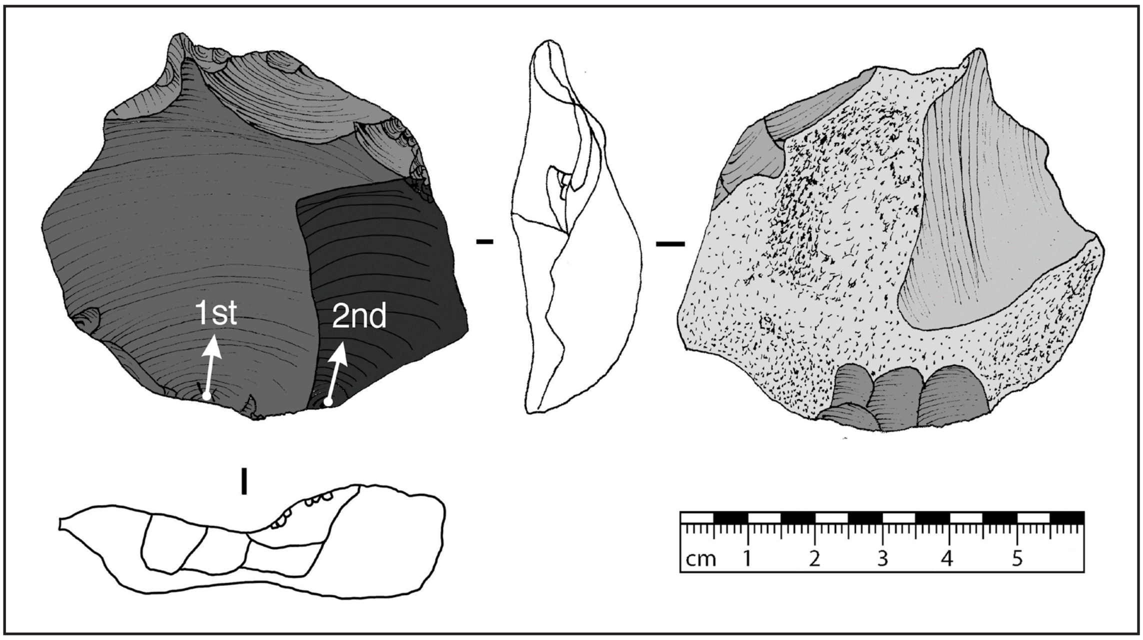

Fig. 331 - Levallois core made of a cortical blank showing a big removal on the former ventral face and a second one parallel in the same direction (GER10.227-058.235)

Another hint for skipping the second series is given by a recurrent Levallois core (GER10.226-059.143.1). On the reduction is visible that after a preferential (quadratic) flake was removed, the convexity was restored from the opposed direction. The next removals were stuck from two opposed platforms (bi-directional). Now, it was tried to restore the convexity again, but this process was stopped. As last step, small removals on the edges were removed (see fig. 332).

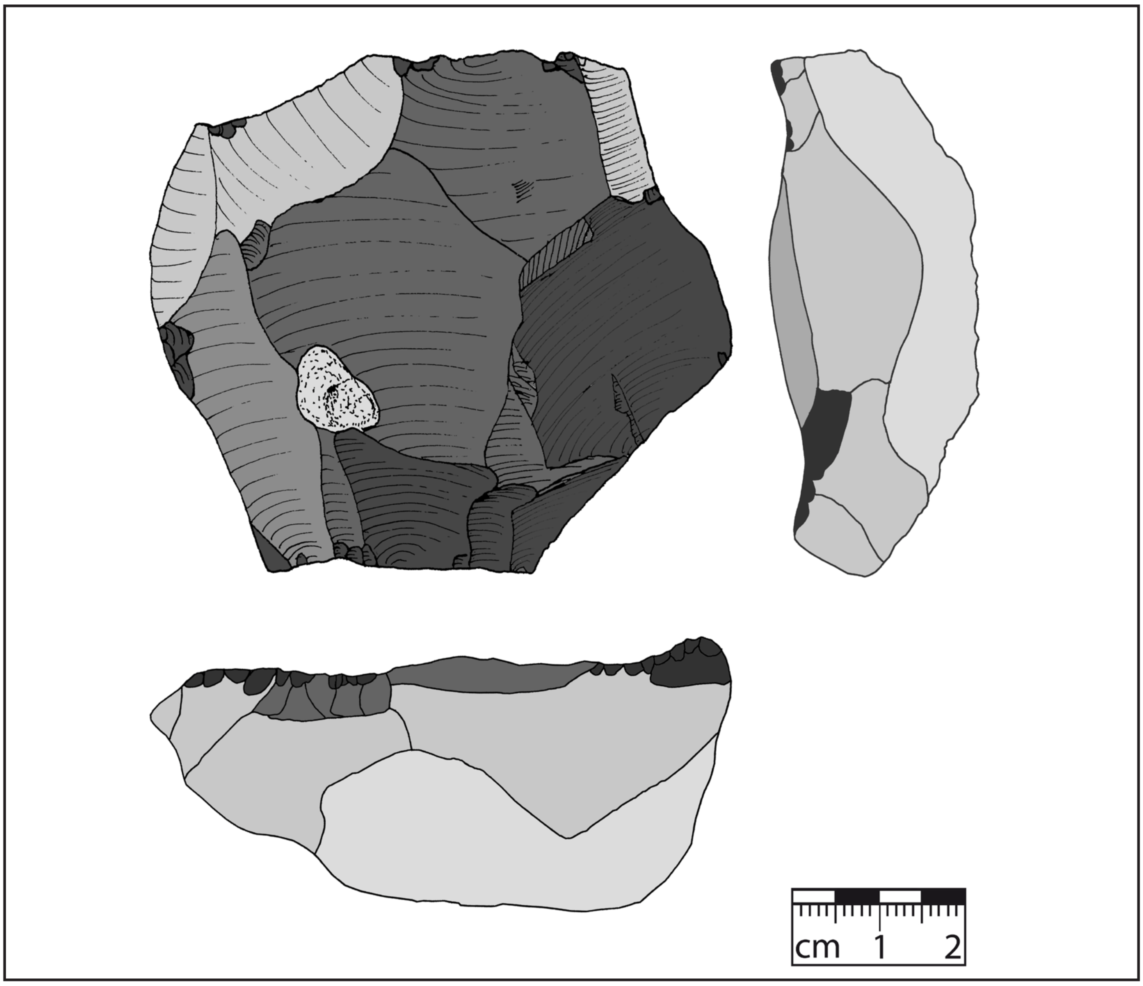

Fig. 332 - Recurrent Levallois core showing the removal of a preferential, quadratic flake and bi-directional removals (GER10.226-059.143.1)

Levallois points and corresponding cores

Objects classified as Levallois points (n=24) show some distinctive negative pattern on the dorsal face (listed in tab. 266). The majority possesses a unidirectional-convergent pattern on previous detachments on the dorsal face, but there are also examples of points with a bidirectional pattern (illustrated in fig. 333).

Direction and constellation of negatives	Number of Levallois points showing this pattern on the dorsal face	Number of Levallois cores showing this pattern on the reduction surface
Unidirectional-parallel	4	0
Unidirectional-convergent	11	3
Unidirectional-divergent	2	0
Bidirectional-parallel	2	0
Bidirectional-convergent	2	0
Centripetal	3	0
Total	**24**	**3**

Tab. 266 - Comparison of negative patterns (direction and constellation) on dorsal faces of Levallois points and on reduction surfaces of Levallois cores for points from GH 3

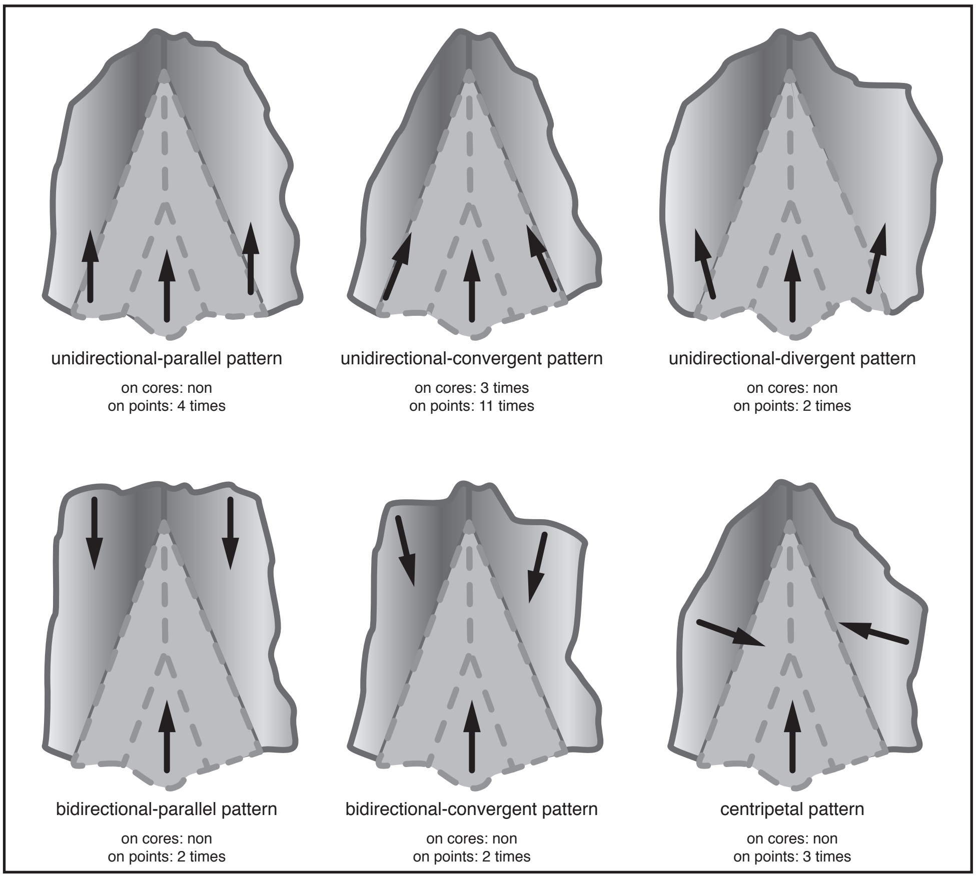

Fig. 333 - Illustration of negative patterns on dorsal faces of Levallois points and on reduction surfaces of Levallois cores for points from GH 3

Additionally to these n=24 blanks classified as Levallois points, there are only three cores from GH 3 classified as Levallois cores for points (GER13.225-058.679, GER12.226-057.688 and GER14.229-060.1315). These cores are slightly different to cores described by Boëda (1982) or Bordes (1980: 46, fig. 1) for the detachment of Levallois points. The cores and the points for themselves can serve to give a hint how triangular, pointed and convergent blanks were produced.

There is one preform of a core (GER13.225-058.679, see fig. 334 left) showing two convergent removal negatives on the reduction surface. This core offer two explanatory models. On the one hand, the constellation of tectiform and convergent surfaces was used to produce pointed and triangular blanks (as they were removed on the core). And on the other hand, these two negatives on the reduction surface created a (in this case unused) crest that might be used to create a pointed blank. Another core show a similar but slightly different concept for pointed blanks. There the terminal end of the core was pre-shaped that a resulting triangular blanks has a pointed end (GER12.226-057.688, see fig. 334 right). But there are two other possibilities left for the production of pointed blanks. The first is that point production was integrated in the regular reduction of Levallois core (maybe in the way as described) and in second and following series the strategy of core reduction was changed. This would result in cores that display more or less no evidence for point production. The second way is the construction of points. There are examples that points were constructed from other blanks (see fig. 335). The displayed bandwidth shows that both constructed and predetermined points exist in GH 3.

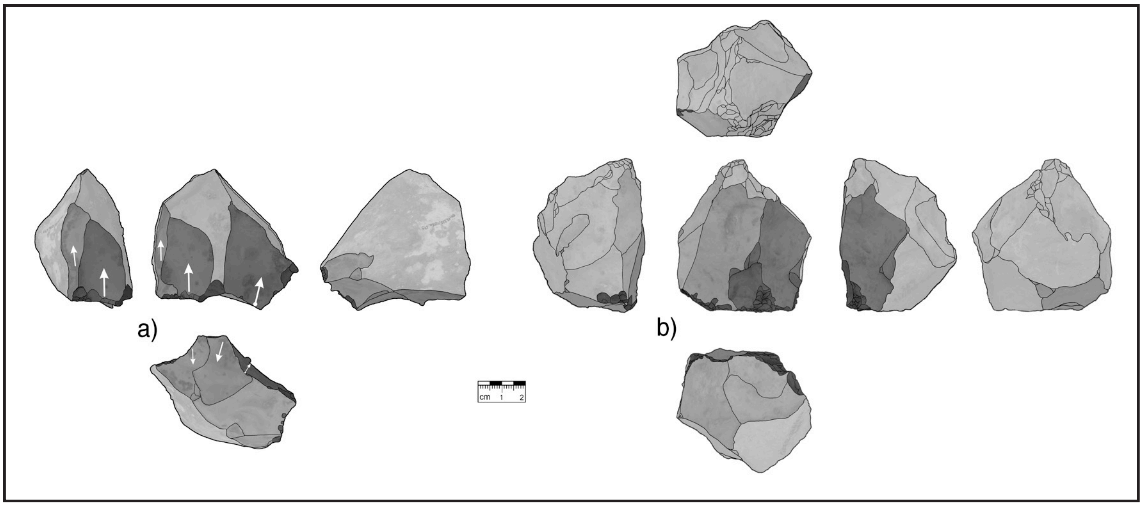

Fig. 334 - Levallois cores for points from GH 3. Left) GER13.225-058.679 and right) GER12.226-057.688

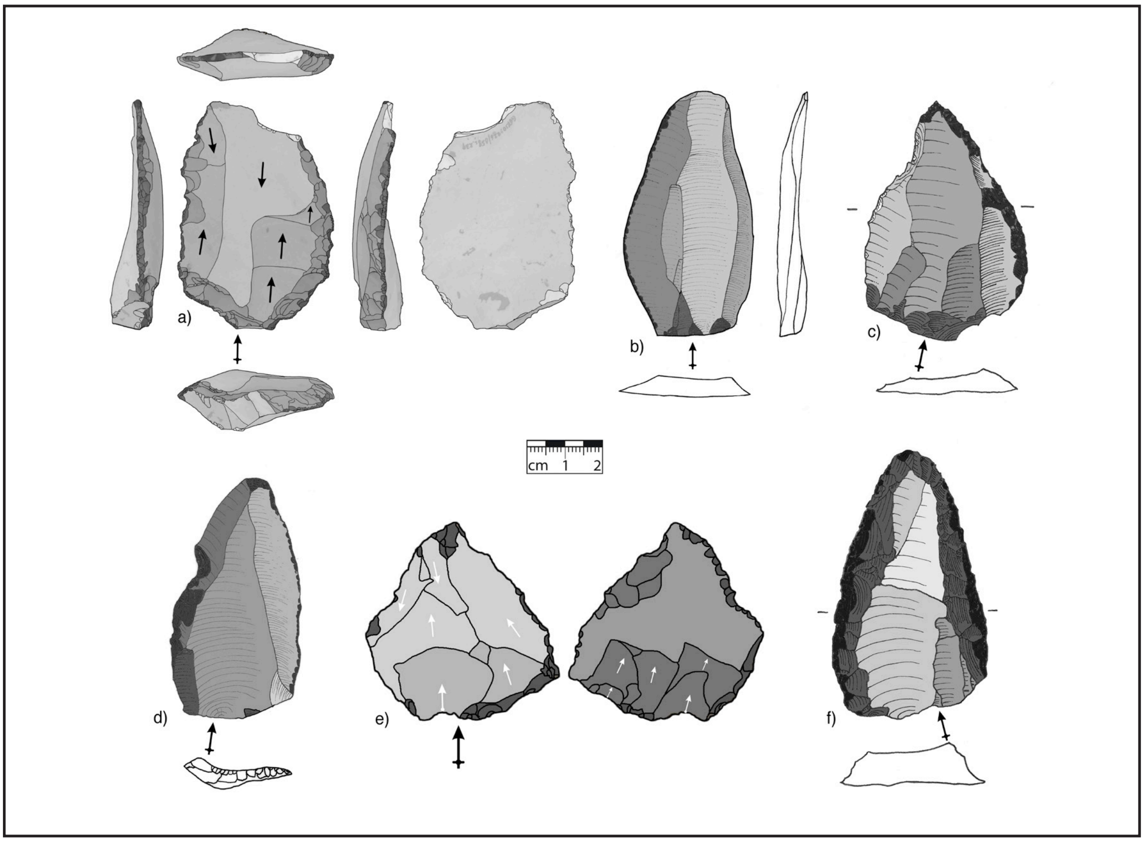

Fig. 335 - Levallois points from GH 3. a) Constructed point on (oval) Levallois flake with broken tip (GER10.226-058.239); b) Levallois point with rounded tip and marginal retouch on the left lateral edge; c) Constructed point on Levallois flake (GER12.226-057.1200); d) Levallois point with intensive (left lateral edge) and marginal (right lateral edge) retouch (GER10.226-059.261); e) Retouched Levallois point with removed bulb part (GER12.227-057.731) and f) Constructed point of Levallois flake with heavily invasive retouch on either lateral edge and the tip (GER12.229-059.637)

VII.15.5 Comparison of transported and processed entities

Discarded mass

The volume of GH 3 excavated between 2009 and 2014 contain around 79 kg of lithic raw materials (see tab. 267 and fig. 336). In regard to this mass, the majority remained as cores (47%), followed by raw pieces (32%), blanks (16%) and debris (5%).

Objects	Mass (in kg, rounded)	Mass (%)
Raw pieces (used and unused)	25	32
Cores	37	47
Blanks	13	16
Debris (heat debris, frost shards, debris from breaking and knapping)	4	5
Total	**79**	**100**

Tab. 267 - Rounded mass of all weighted lithic objects from GH 3 in kilograms and percentage

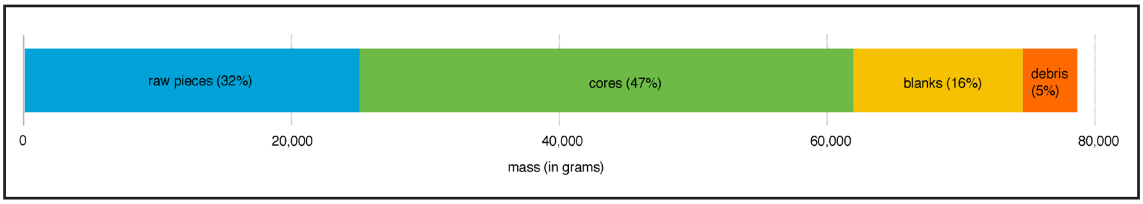

Fig. 336 - Bargraph of mass of all weighted lithic objects from GH 3

As explained in chapter VI, all lithic raw material must have bee imported into the site, because the on-site geology contains no silicious and silicate raw material. Therefore, nearly 80 kg of stones had to be transported to the site (with the option that maybe another 5 kg of debris and other small pieces are hidden in unanalysed collective finds). From the condition of the assemblage it is very unlikely that all was transported in one procurement tour. The spatial distribution of lithic objects in GH3 indicate that many occupation events are accumulated in the homogeneous sediments of GH 3. There is evidence that suggest this, but without (for the moment) clear sign that would allow to separate the assemblage of GH 3 into distinctive sub-assemblages (attempts are collected in chapter X.15).

Used mass

GH 3 contains lithic objects that were brought to site, but where not used (in the sense of knapping). These objects (n=179 with 4,474.7 grams) are n=26 unused raw-pieces with 3075 grams, n=98 unmodified frost-shards with 1057.7 grams, and n=55 heat debris with 342 grams (if only objects are taken into account that were weighted). All other objects were integrated in knapping processes (making products and modifying).

Chapter VIII: Lithic assemblage of GH 4x

“Never take life seriously. Nobody gets out alive anyway.” (Sydney J. Harris)

or:
„Someone told me once never take life seriously, always take yourself seriously. Or was it, never take yourself seriously, always take life seriously?“ (Terrill 1999: 495)

VIII.1 Introduction

The assemblage of GH 4x contains n=27 lithic objects. It is irrational to describe this assemblage in the same intensity as the assemblage of GH 3. GH 4x is nearly complete excavated (only small rests are left in square meter 225-057, but this square-meter block has to be untouched as witness). The following tab. 268 gives a first overview on the assemblage:

Lithic object	Number	Raw material
Raw piece used as hammerstone	1	Quarzitic sandstone
Raw piece used as anvil	1	Quarzitic sandstone
Core-from-anvil	2	One from FAS and one from quartzite
Tested raw-piece	4	All are made from FAS
Levallois core	1	FAS
Core-debris	1	FAS
Simple flake	3	One is made from quartzite, two are from FAS
Edge-correction flake	1	FAS
Surface-correction flake	8	All are made from FAS
Levallois flake	1	FAS
Tranchet-blow blank	1	Unknown flint
Blade with hafting-rest traces	1	FAS
Frost shard	2	FAS
Total	**27**	

Tab. 268 - Assemblage of lithic objects from GH 4x

There are n=22 objects made from FAS, n=2 from quartzitic sandstone, n=2 from quartzite and one from unknown flint. Unfortunately, a refitting attempt in 2015 was unsuccessful and indicate that the assemblage is not complete. This incompleteness is also indicated for example that tested raw pieces are present, but no raw piece caps (the assumption is here that if raw pieces or tested raw pieces are brought to the site they should be reduced further).

The spatial position of this GH (see chapter IV.9.3) offers different hypotheses about the origin of this small assemblage. The assemblage derives from sediments situated directly on top of weathering sediments on limestone blocks. On the one hand, the assemblage could belong to the assemblage of GH 3 (which is above GH 4x) and the sediment was altered differently to other parts from GH 3. Another possibility is that the assemblage is in association to the assemblage of GH 4, as it was suggested in 2010 as part of the material was found. Another possibility is that the sediment of GH 4x is a spot of dumped material from other places (for example from the main occupation area).

Nevertheless, some statements can be made about the reduction processes visible in the assemblage.

VIII.2 Mass and dimension

The lithic assemblage of GH 4 has a mass of 2,177.2 grams (displayed as boxplot in fig. 337). Hammerstone and anvils are the heaviest objects. The tested raw-pieces are small (compared to material from GH 3 or 4).

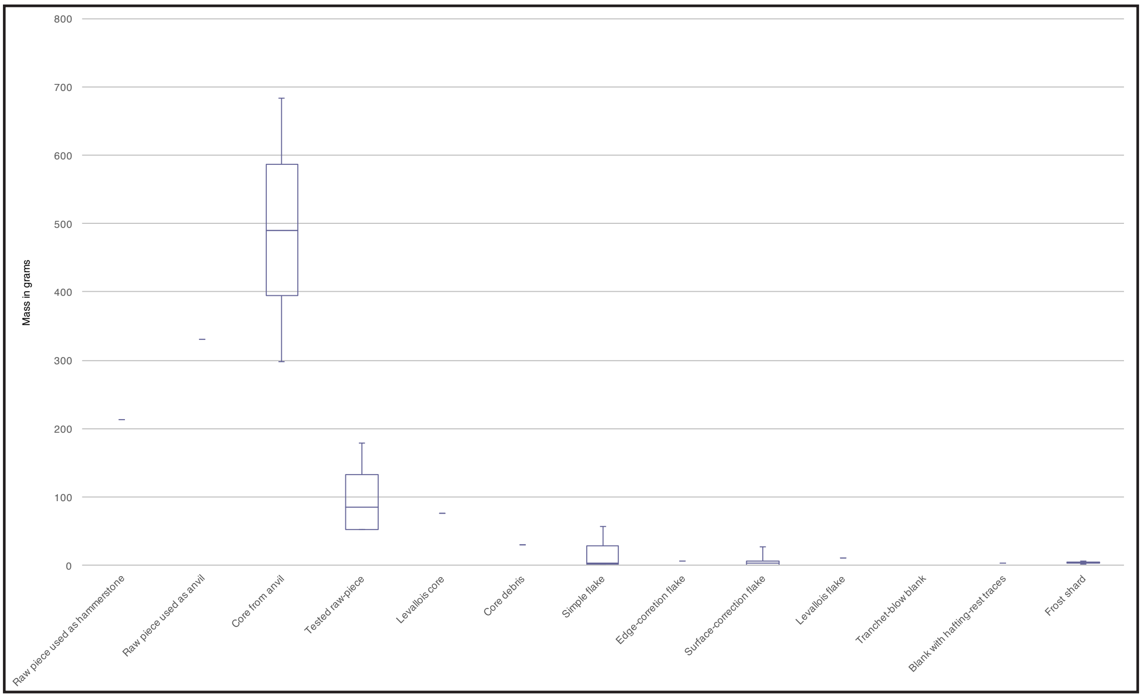

Fig. 337 - Mass of assemblage components from GH 4x, as box-plot

Length, width and thickness of the lithic objects from GH 4x are displayed in fig. 338.

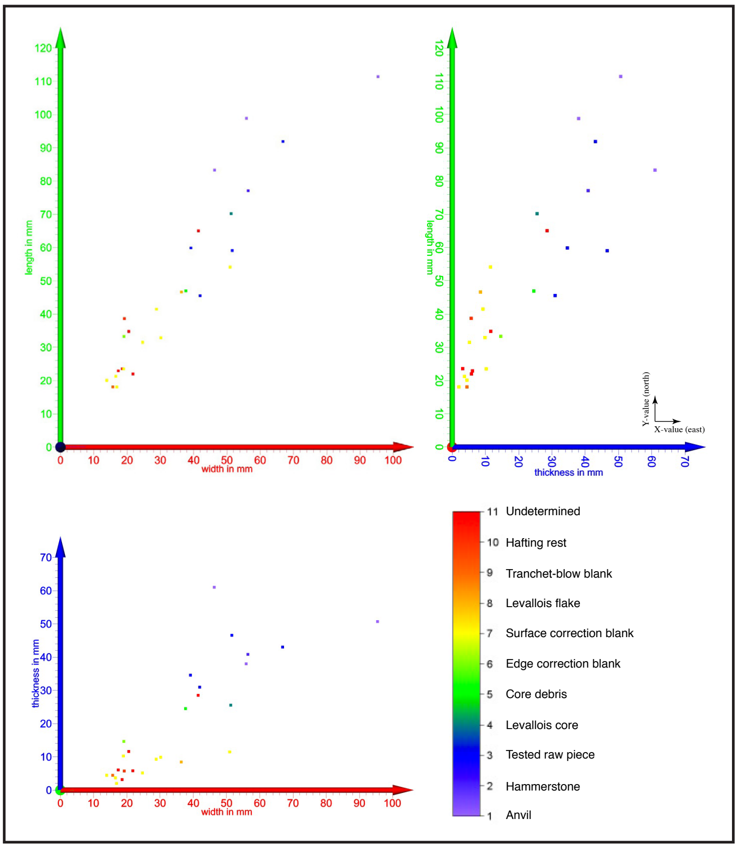

Fig. 338 - Dimensional scatter-plot of lithic objects from GH 4x

VIII.3 Hammerstones and anvils

GH 4x yielded n=5 objects classified as hammerstones and anvils. Concerned here are n=2 raw pieces, two cores and one flake. These objects are made from quartzitic sandstone and quartzite. Two of them are displayed in fig. 339. The flake is made from quartzite and quite thick. The blow that detached this flakes split the bulb region away. The plane surfaces of the flake fit well into the spectrum we know from this raw material.

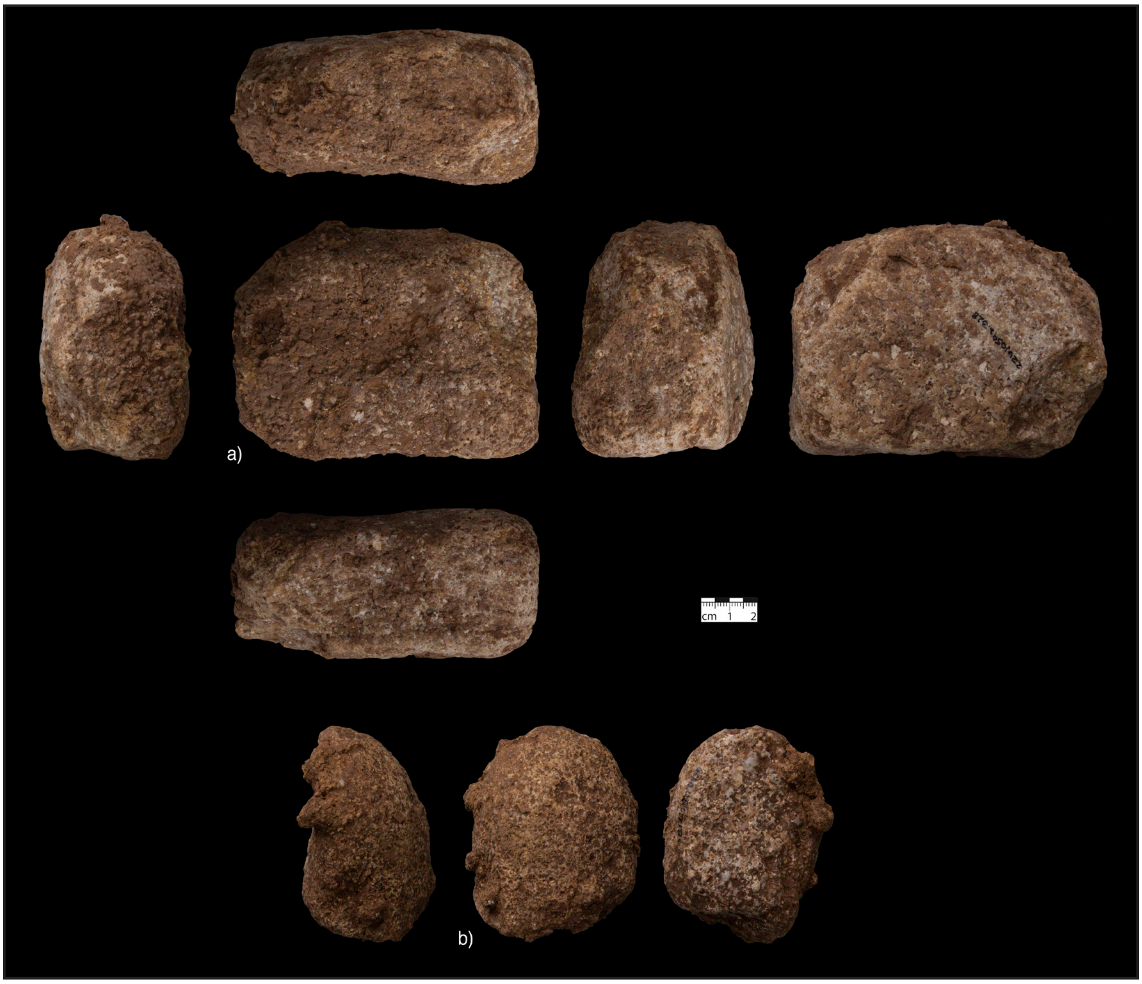

Fig. 339 - Core-of-anvil (GER10.226-059.328) and raw piece as hammerstone (GER13.225-058.1325) from GH 4x. Both are made from quartzitic sandstone

VIII.4 Tested raw pieces

There are n=4 tested raw pieces from GH 4x. All are made from FAS. Two of them are displayed in fig. 340. Both displayed objects are made from round nodules. The other both are made from irregular shaped nodules.

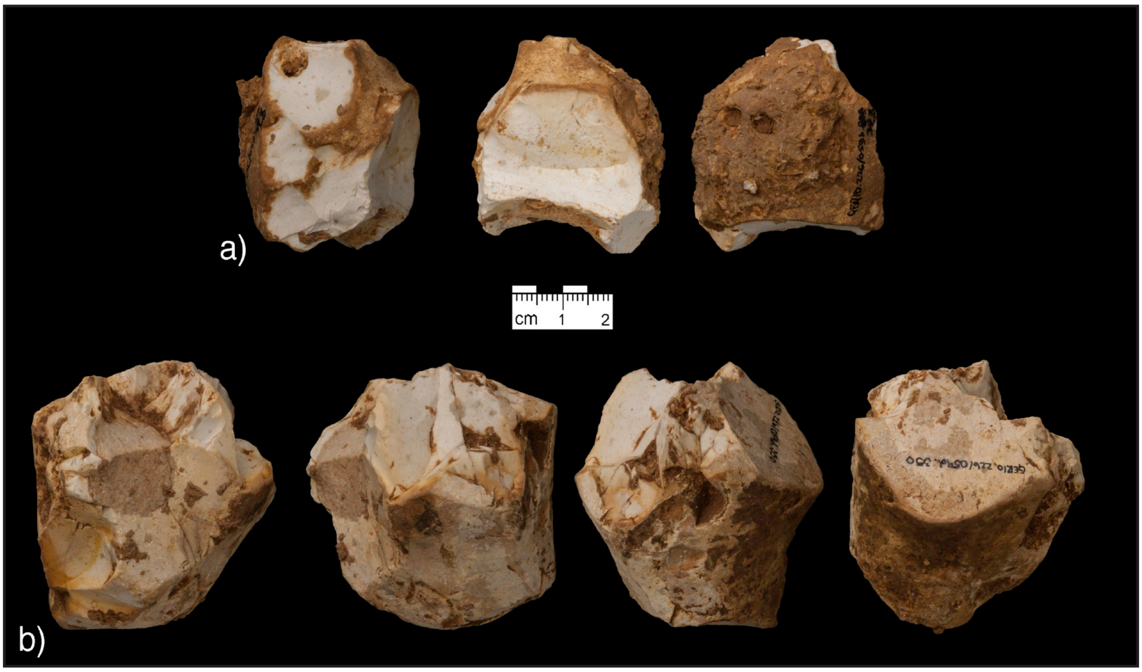

Fig. 340 - Tested raw pieces made on round nodules of FAS, from GH 4x. a) GER10.226-059.323 and b) GER10.226-059.350

VIII.5 Levallois core

There is one core from GH 4x classified as levalloid. The core is made from a cortical flake and the ventral face served as reduction surface. It is recurrently, unidirectionally reduced in a parallel manner. The reduction surface has evidence for seven detached flakes, removed in two series. The produced flakes (as indicated by their negatives) are polygonal or oval. An intensive configuration is not visible. It is likely that the bulb was that prominent that the reduction started immediately after changing the inclination of the platform part. The first flake to be removed from the reduction surface respectively the ventral face should have been a Janus-like flake, but there is no evidence from the GH 4x assemblage of this. The core is displayed in fig. 341.

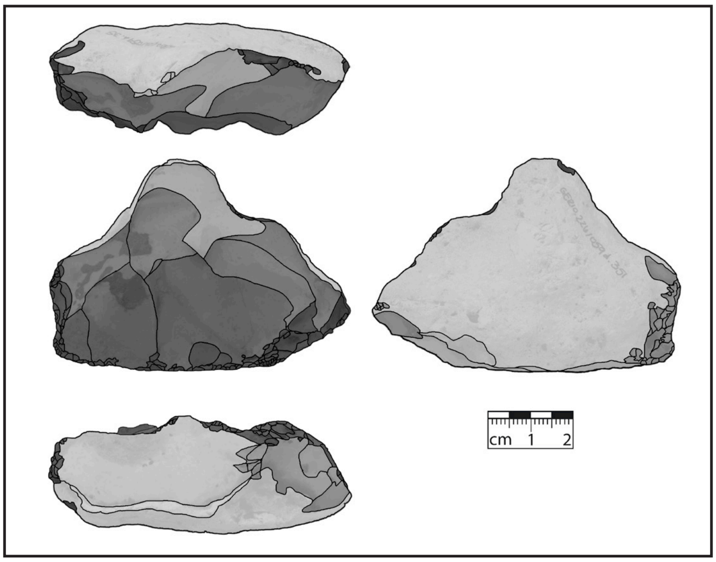

Fig. 341 - Levallois-like core from GH 4x (GER10.226-059.351)

VIII.6 Blanks from GH 4x

There are n=15 blanks from GH 4x. One made from quartzite was discussed in chapter VIII.3. There are n=5 complete flakes, two terminal fragments of flakes, five medial fragments of flakes, as well as tow basal fragments of a flake and a blade. All of them (with the expectance of one tranchet-blow blank from unknown flint) are made from FAS. The Levallois flake (unfortunately no picture available) is a medial fragment of an oval flake without cortex and centripetal negatives on the dorsal face. The tranchet-blow blank is described in Frick and Floss (in press) and is a medial fragment showing a tectiform dorsal face with to main negatives and two surfaces on the ventral face. Fig. 342 gives an overview of the blanks from GH 4.

Fig. 342 - Blanks from GH 4x. a) Surface-correction flake made with soft-hammer technique (GER10.226-059.334); b) Terminal fragment of a surface-correction flake (GER10.226-059.324); c) Medial fragment of a blade-like flake with marginally lateral retouch (GER10.226-059.325); d) Mid row: surface-correction flake (GER10.226-059.320); e) Basal fragment of a blade with lateral retouch for hafting (GER10.226-059.242); f) Surface-correction flake showing traces of use on the left lateral edge and on the terminal concave edge (GER10.226-059.338) and g) Medial fragment of a tranchet-blow blank (GER10.226-059.321)

VIII.7 Summary of the study of lithic objects from GH 4x

With a total of just n=27 lithic objects the assemblage of GH 4x is small. Remaining sediments of this GH are visible in square meter 225-057 (square meter remains as witness). Attempts of making refits inside were unsuccessful. But the available material demonstrate that different tasks are preserved. Hammerstones and anvils are evidence for knapping or splitting processes. The Levallois core, as well as the correction flakes demonstrate reduction processes on site. Additionally, tested raw pieces show that raw material units (as complete raw pieces or tested) were imported. The assemblage is far from being complete and speculations about its origin are appropriate. On the one hand, the assemblage could derive from unearthed parts from surface cleaning processes. Another possibility is that slightly altered sedimentation processes formatted GH 4x and the assemblage is part of GH 3. Further and intensified refitting attempt can have the potential to solve this problem.

Chapter IX: Lithic assemblage of GH 4

„In Anbetracht der Tatsache, dass verfahrene Situationen nur mittels, oder besser auf Grund einer Vielzahl an Lösungsvorschlägen von der Seite - aus der Hüfte heraus - betrachtet werden können, sollten wir hierbei massiv innehalten und überdenken, ob es durchaus ratsam sein könnte, auch in diesem Falle, über eine Umstrukturierung des Gesagten nachzudenken, was durchaus, aber nur unter beträchtlichen Vorbehalten angebracht erscheinen mag.“ (In view of the fact that messy situations can only be viewed by means of, or rather by, a large number of suggested solutions from the side - from the hip - we should stop and think about whether it would be advisable, also in this case, to think about a restructuring of what has been said, which may seem appropriate, but only with considerable reservations. J.A. Frick, April, 25, 2016)

IX.1 Introduction

The assemblage of GH 4 contain n=211 lithic objects. In consequence of its position below GH 3, the excavation of GH 4 have not progressed as far as GH 3. At this time, this circumstance is seen as responsible for the small assemblage. In regard of the profiles, GH 4 is definitely extending into north-eastern direction. The general distribution of this GH is described in chapter IV.9.3. In nearly all excavated square meters of GH 4, there was a clear detectable connection between big, nearly complete long bones and lithic objects. The lithic objects that are part of this discussion all derive from the campaigns 2009, 2010 and 2014 (in the years 2011 to 2013 this GH was not further excavated). The assemblage of GH 4 is listed in tab. 269 (in regard to raw material and lithic object):

Raw material Lithic object	FAS	Chert	Unknown flint	Granite	Quartzite	Quartz	Quartzitic sandstone	Standstone	Unknown raw material	Total
Raw piece without use traces	0	1	0	0	0	0	0	2	2	5
Raw piece used as hammerstone	0	0	0	1	1	0	1	0	1	4
Raw piece used as anvil	0	1	0	0	0	0	0	0	0	1
Core from hammerstone	0	0	0	0	4	1	0	0	0	5
Opportunistic flake-core	7	0	0	0	0	0	0	0	3	10
Levallois core	5	0	0	0	0	0	0	0	0	5
Quina-like core	1	0	0	0	0	0	0	0	0	1
Ventral core	2	0	0	0	0	0	0	0	0	2
Bifacial-worked-object on flake	1	0	0	0	0	0	0	0	1	2
Flake	96	3	0	0	0	0	0	0	21	120
Blade	6	0	0	0	0	0	0	0	2	8
Micro-flake	1	0	0	0	0	0	0	0	0	1
Bladelet	3	0	0	0	0	0	0	0	0	3
Frost shard	6	0	0	0	0	0	0	0	1	7
Heat debris	4	0	0	0	0	0	0	0	0	4
Debris from knapping and breaking	14	2	1	1	1	2	0	6	6	33
Total	**146**	**7**	**1**	**2**	**6**	**3**	**1**	**8**	**37**	**211**

Tab. 269 - Assemblage of GH 4 in regard to raw material and lithic object (empty fields are red shaded)

Five raw pieces show no traces of use and another five were used as hammerstones and anvils. There are n=5 types of cores present (cores-from-hammerstones, opportunistic flake-cores, Levallois-cores, a Quina-like core and ventral cores). The assemblage also contains n=132 blanks, n=7 frost shards, n=4 heat debris fragments and n=33 fragments from knapping and breaking debris (see fig. 343).

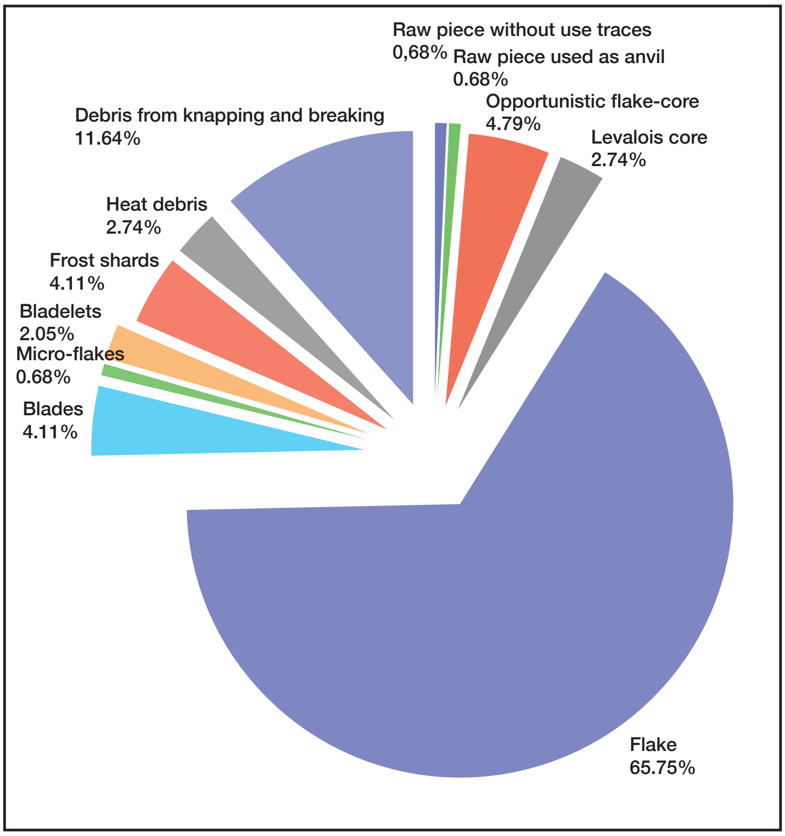

Fig. 343 - Pie chart of the lithic assemblage of GH 4

The majority of objects are made from FAS (n=146), followed unknown raw material (n=37) and sandstone (n=8). The other objects are made from chert (n=7), quartzite (n=6), quartz (n=3), granite (n=2), unknown flint (n=1) and quartzitic sandstone (n=1, displayed also in fig. 344 as bar graph).

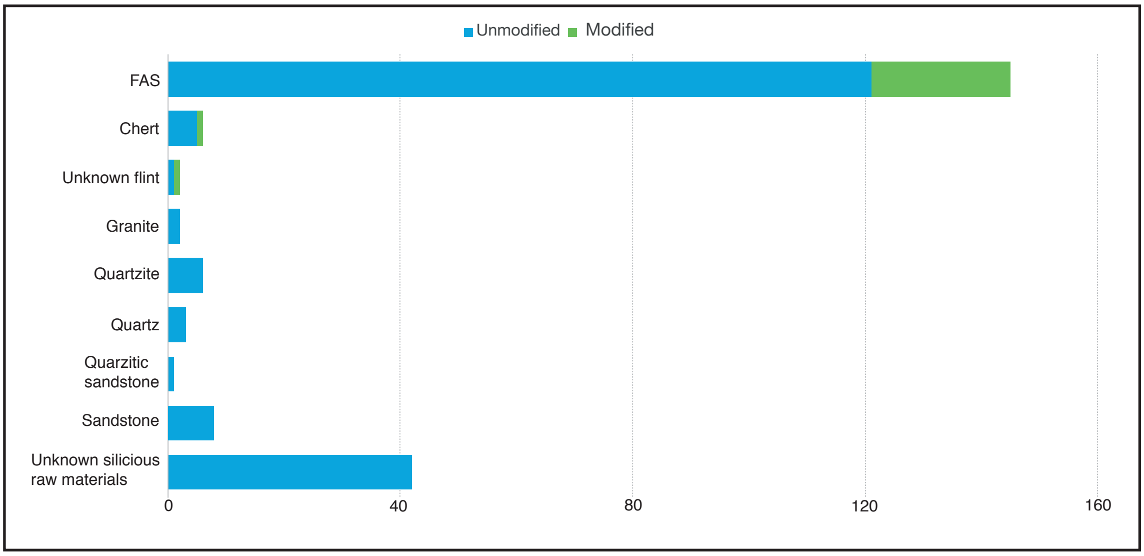

Fig. 344 - Bar graph of the lithic assemblage of GH 4, in regard to modified and unmodified lithic object of each raw material

GH 4 yield n=26 modified objects or 12.44% of the assemblage (see also Fig. 344, above). The majority of modified objects are made from FAS, but also objects from chert and unknown flint are modified. As for GH 3, modified objects are made on a vast range of objects (n=1 frost shard, n=2 raw piece caps, but also on n=11 correction blanks and n=5 Levallois blanks and n=7 simple blanks).

IX.2 Distribution

In the campaigns 2009 to 20014, lithic artifacts attributed to GH 4 were excavated in n=6 square meters (227-059, 227-060, 228-057, 228-058, 228-059 and 228-060). They are homogeneous scattered in these square meters (see fig. 345). Only for frost shard, heat debris, and knapping and breaking debris a clustering is visible (see fig. 346).

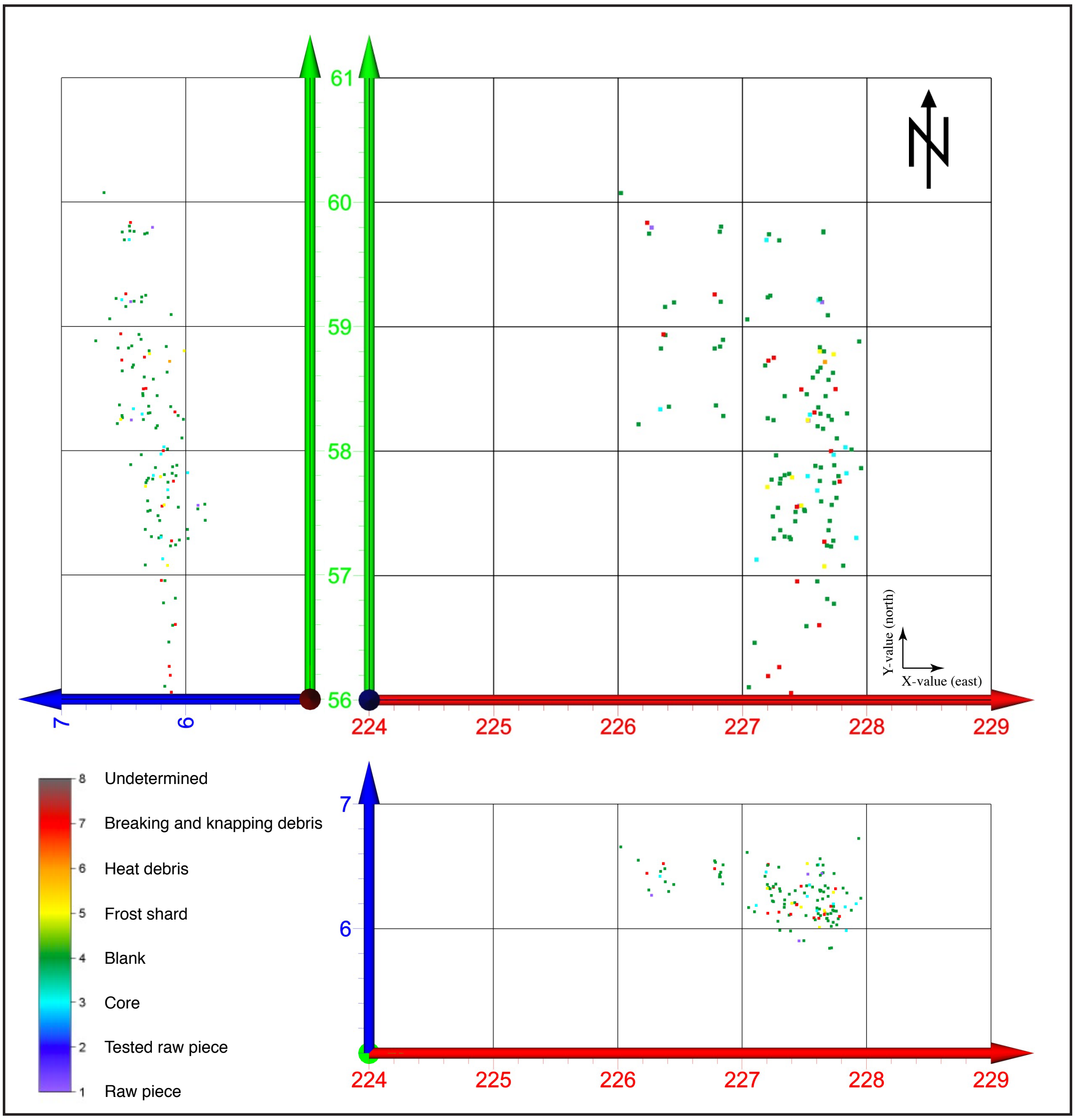

Fig. 345 - Scatterplot of the spatial distribution of lithic artifacts in GH 4

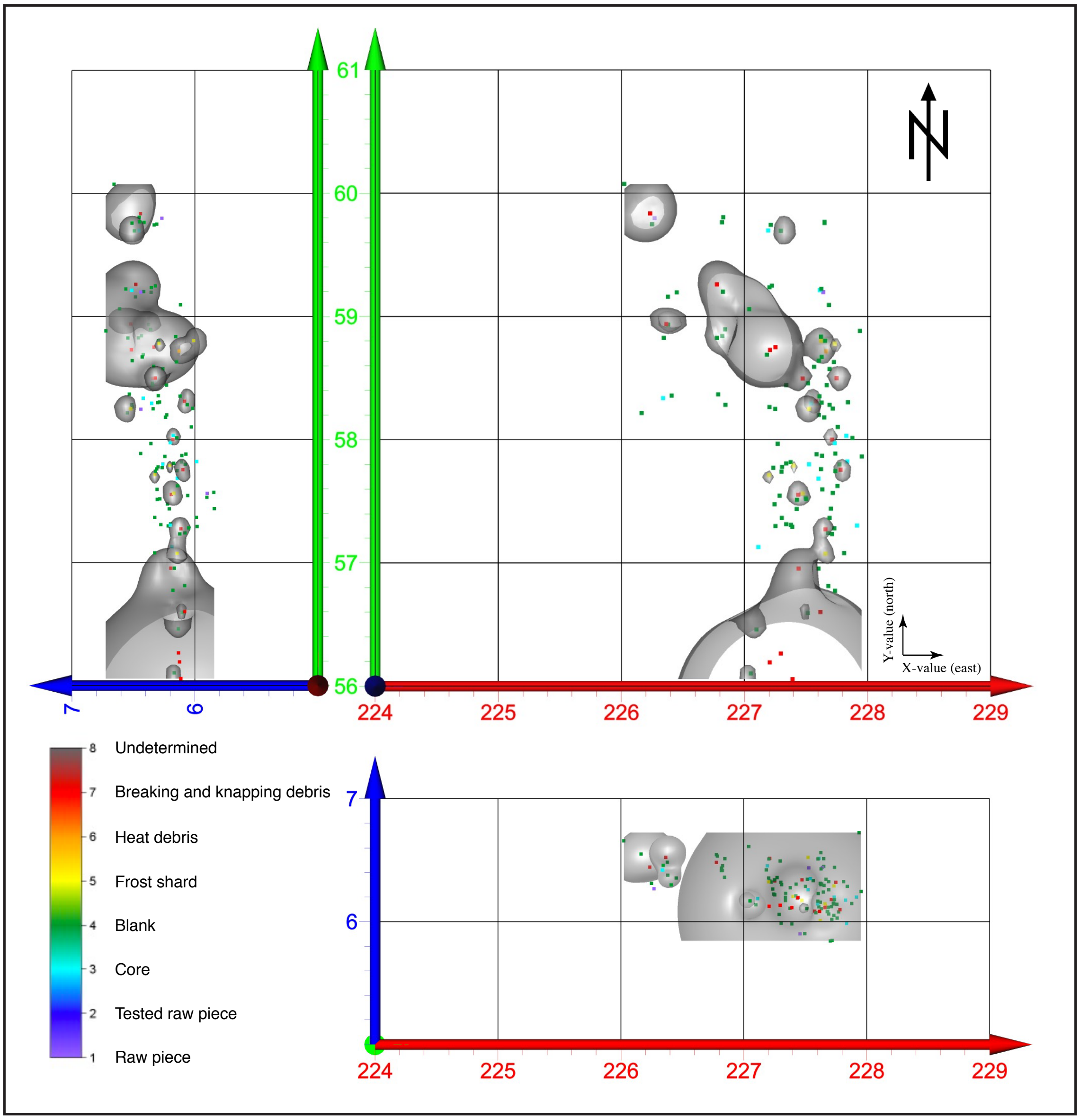

Fig. 346 - Scatterplot of the spatial distribution of lithic artifacts in GH 4. Isosurface separating frost shards, heat debris, and knapping and breaking debris from raw pieces, cores and blanks

The three dimensional scatter of lithic artifacts in this GH shows (by rotation the scatter-plot) some evidence for a possible separation of the lithic assemblage into two clusters in regard to depth. Lithic object below Z=6.15 might belong to sediments that filled the space beside the first rock collapse. In 2009 and 2010 this scatter was seen as a canal filling, but the ongoing excavation could evaluate that the sediment continue into eastern and northeastern direction. The second cluster of lithic object is situated on top of the first lithic scatter and spread also on top of the first rock collapse. These circumstances are displayed in fig. 347, where the approximated volume on the first rock collapse counted and lithic objects of GH 4 are scattered. The appearance of the assemblage makes it very challenging to divide the assemblage of GH 4 into two sub-units. For the moment this has to stay a suggestion.

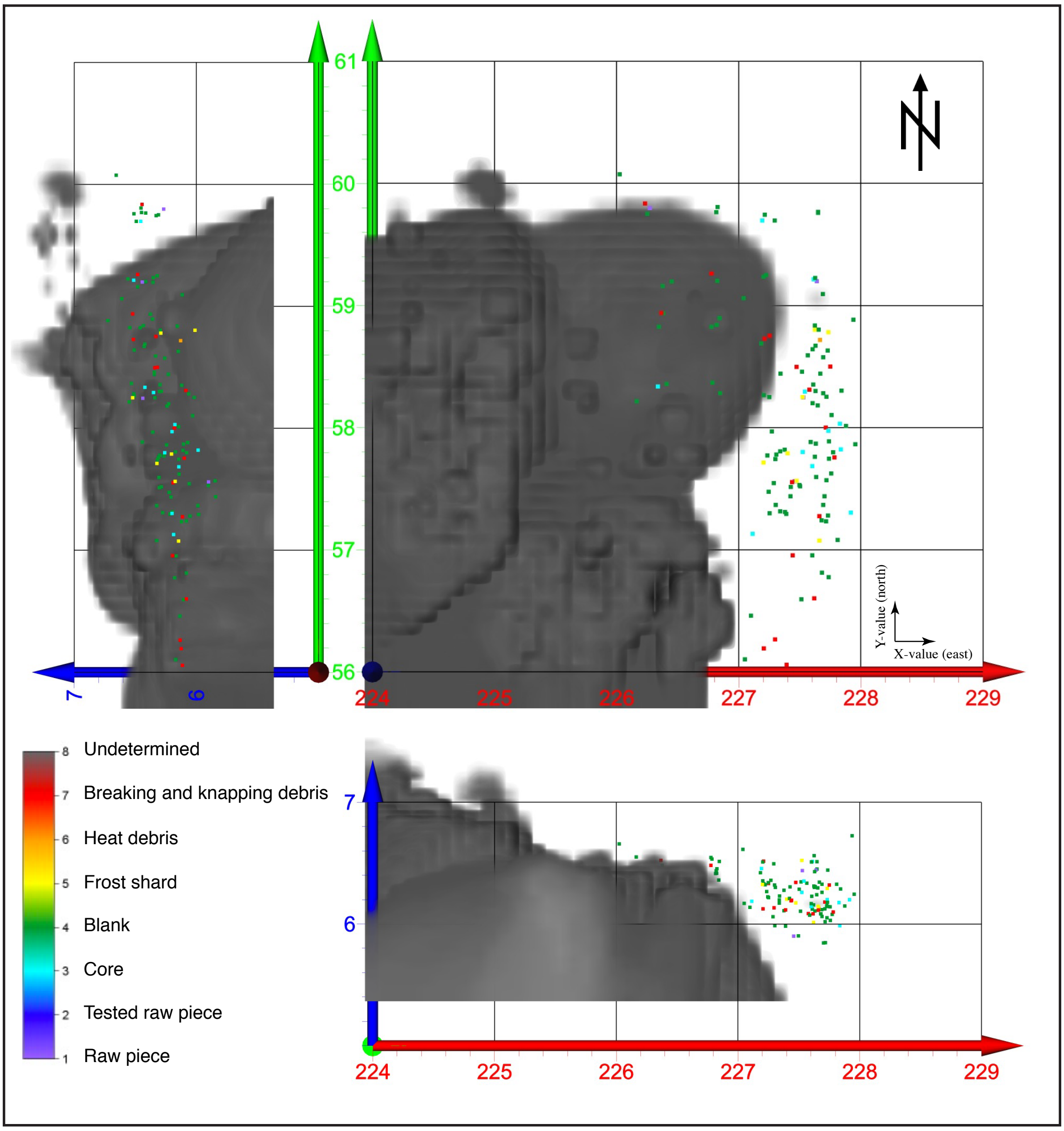

Fig. 347 - Volume render (as far as it was measured) of the first rock collapse (gray) and scatter of lithic objects from GH 4 (colored dots)

IX.3 Dimension and mass

Dimension and mass was measured on n=162 of these n=211 lithic objects from GH 4. It shows that the majority are small, but there are some exceptions (mostly in mass, see fig. 348).

The dimensional scatter plot (fig. 349) demonstrates that cores (cyan) and raw pieces (violet) are generally bigger than blanks and all kind of debris. It also shows that no micro-flakes are integrated in dimensional measuring. This reason of this circumstance is simply that only a small amount of collective finds from GH 4 are finally processed and therefore the fine-fraction is not available for analysis. Blanks are in majority present in flake-dimension.

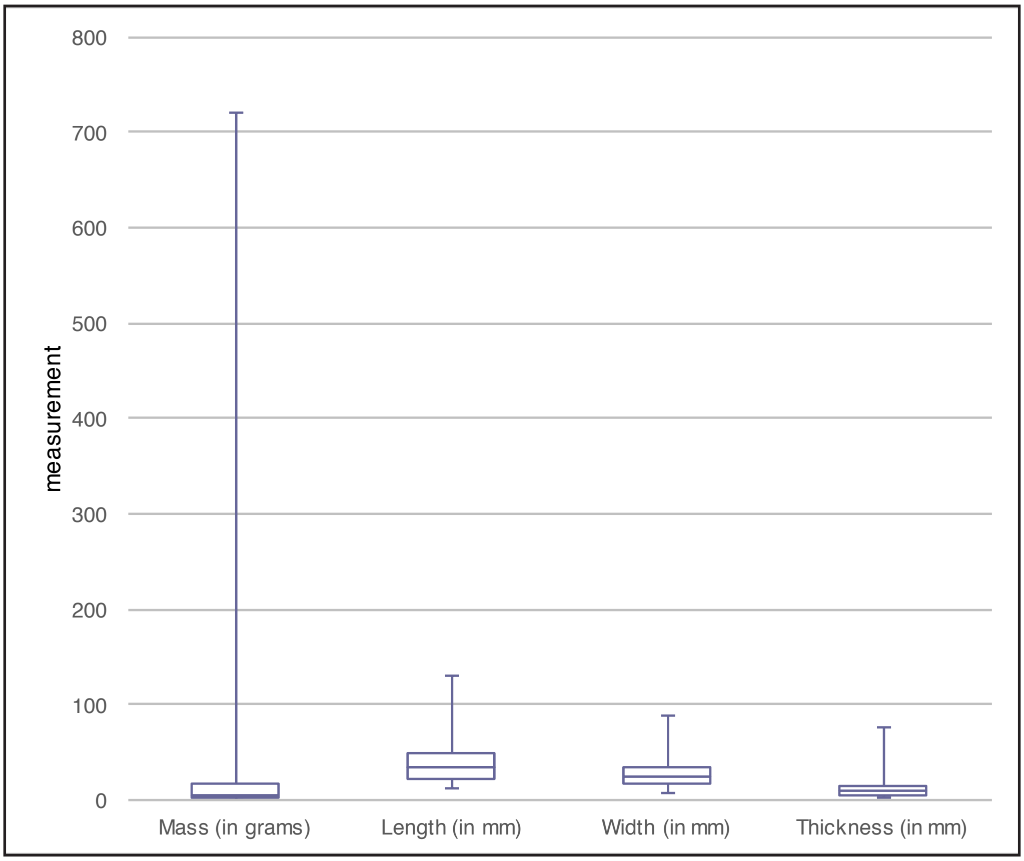

Fig. 348 - Mass and dimension of all measured lithic objects from GH 4, displayed as box-plot

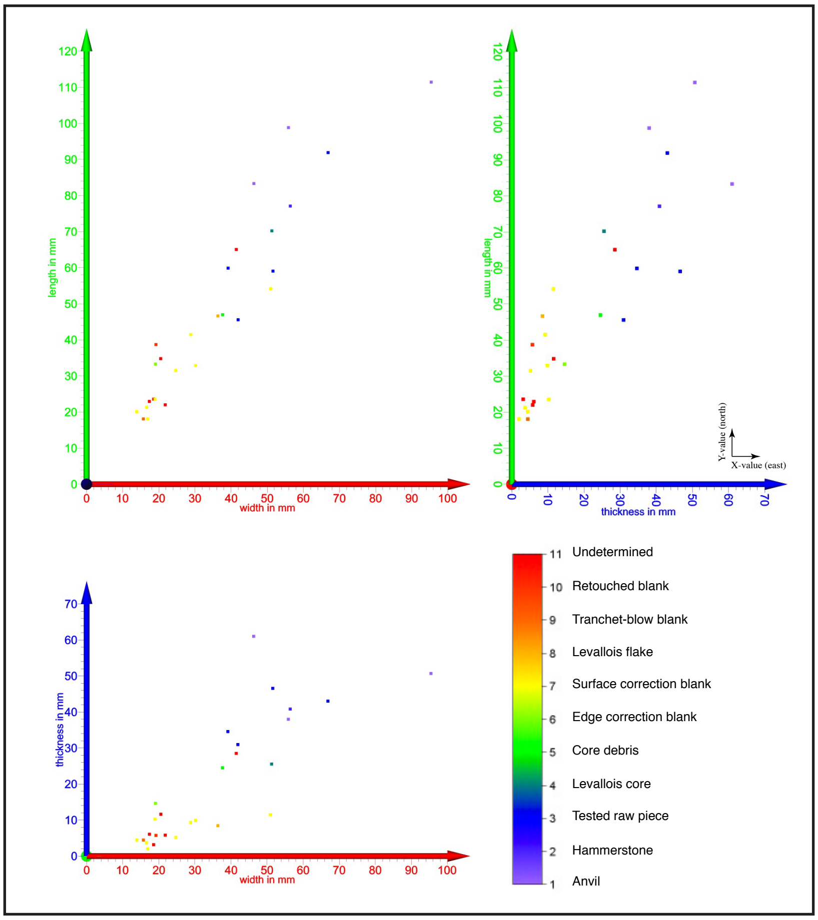

Fig. 349 - Dimensional scatter plot of lithic objects from GH 4

IX.4 Raw pieces

GH 4 contain n=10 raw pieces. Five of them have no traces of use, another one is classified as anvil and n=4 as hammerstones. The raw pieces are listed in regard to type and raw material in the following tab. 270:

Raw material / Type	Chert	Granite	Quartzite	Quartzitic sandstone	Sandstone	Unknown raw material	Total
Raw piece without traces of use	1	0	0	0	2	2	5
Raw piece used as anvil	1	0	0	0	0	0	1
Raw piece used as hammerstone	0	1	2	1	0	0	4
Total	**2**	**1**	**2**	**1**	**2**	**2**	**10**

Tab. 270 - Correlation between type of raw piece and raw material from GH 4

Despite the small amount of raw pieces, they are made from n=6 raw materials. FAS is not the raw material of raw pieces, but other fine-grained raw material were used (chert and unknown raw material). As example, on fig. 350 a hammerstone (quartzite) is displayed showing three crushed zones (GER10.228-058.577).

Fig. 350 - Hammerstone on raw piece showing three crushed zones (GER10.228-058.577)

Raw pieces are quite different in size, as the box plot of mass and dimension shows (fig. 351). The immense peak in mass is mostly due to the hammerstone displayed in fig. 348 above, which is the biggest chunk of the raw pieces.

For n=9 the raw piece is in the shape or rounded nodules and one is in the shape of a plate (one of the chert raw-pieces, GER09.227-059.160.1). One of the sandstone raw pieces has traces of heat (GER09.228-059.145.1).

For the hammerstones a binary division can be made. On the one hand, two big hammerstones made out of quartzite (GER10.228-058.577.1, see fig. 350, above and GER09.228-060.131.1, see fig. 353). On the other hand, two small hammerstones from granite (GER09.228-060.116.2) and quartzitic sandstone (GER09.227-060.175.1). Mass and dimension of these four hammerstones is displayed in fig. 352.

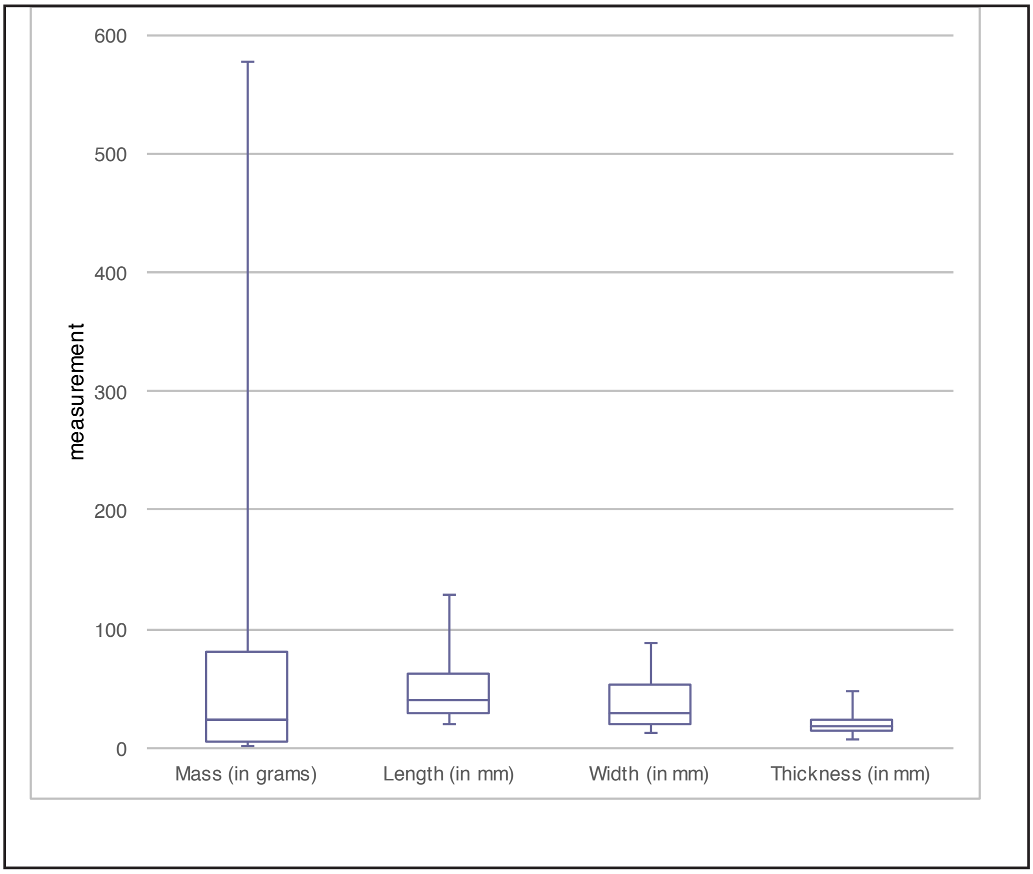

Fig. 351 - Boxplot of mass and dimension of raw pieces from GH 4

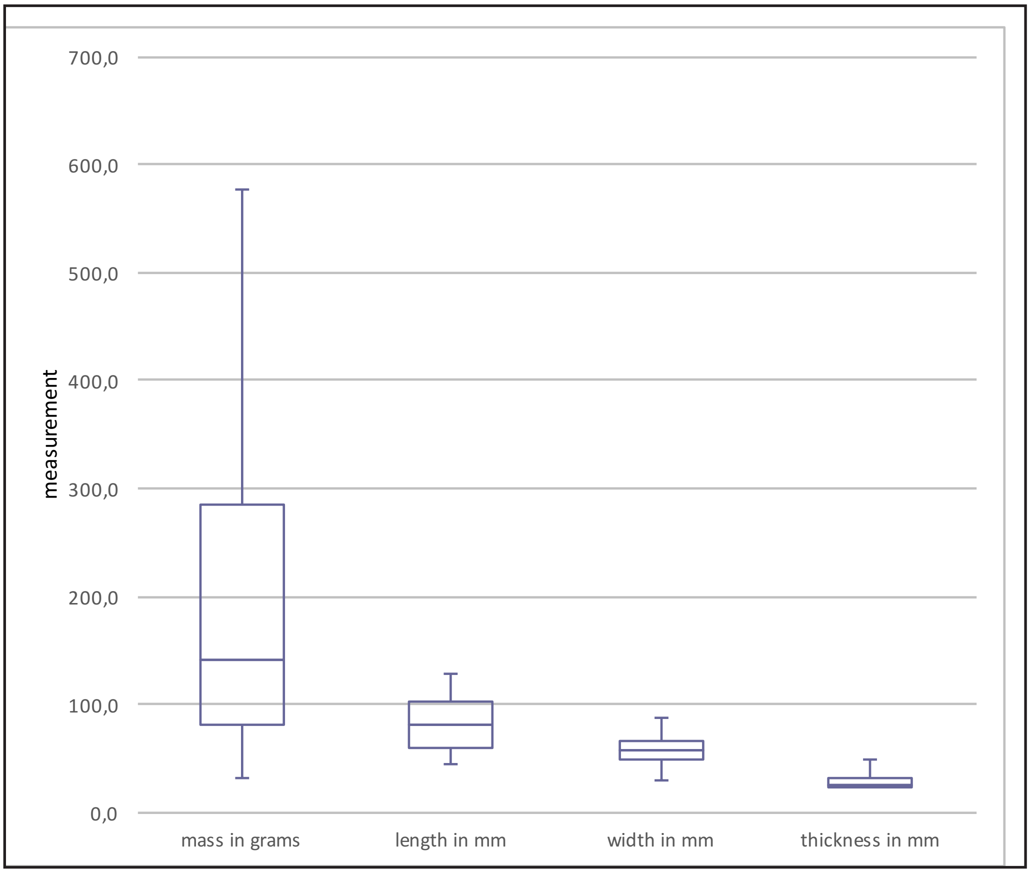

Fig. 352 - Mass and dimension of the hammerstones from GH 4, displayed as box-plot

Fig. 353 - Hammerstone from quartzite with two crushed zones (GER09.228-060.131.1)

One object is classified as anvil (a small plate from chert) and one of the surfaces shows two concavities. The denomination of these two concavities is challenging (see fig. 354). Even with the aid of a binocular (because of the porous raw material), there are three options: 1. two negatives of frost shards; 2. two rotary grinding surfaces and 3. negatives of two detached flakes.

Fig. 354 - Raw piece with two undetermined concavities (GER09.227-059.160.1)

IX.5 Cores

IX.5.1 Introduction

GH 4 yielded n=23 cores (objects with at least one negative of detachment). This GH 4 has no evidence for tested raw pieces, but yielded n=10 opportunistic cores, n=5 Levallois cores, one Quina-like core, n=2 ventral cores on raw-piece caps and n=5 cores-of-hammerstones. These objects are made from FAS (n=15), unknown raw material (n=3), quartzite (n=4) and quartz (n=1). The correlation between core class and raw material is displayed in tab. 271:

Core class	FAS	Unknown raw material	Quartzite	Quartz	Total
Tested raw piece	1	0	0	0	**1**
Opportunistic core	6	3	0	0	**9**
Levallois core	5	0	0	0	**5**
Quina-like core	1	0	0	0	**1**
Ventral core	2	0	0	0	**2**
Core-of-hammerstone	0	0	4	1	**5**
Total	**15**	**3**	**4**	**1**	**23**

Tab. 271 - Correlation between core class and raw material

N=19 of these n=23 cores are measured and weighted (see box-plot in fig. 355). Mass is showing a large range and the range of dimensions is condensed. In regard to the specific density of the lithic material (the average specific density of silica is around 2.65 g/cm3) this makes sense. Most of the lengths are under 100 mm.

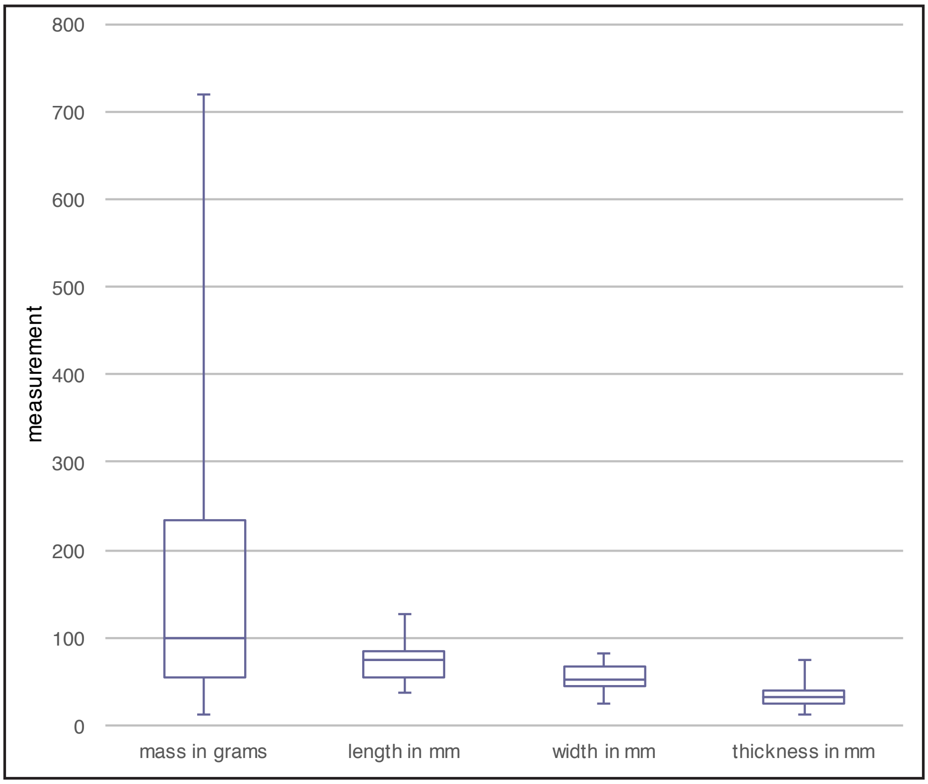

Fig. 355 - Box plot of mass and dimension of n=19 cores from GH 4

The cores from GH 4 are scattered in almost all square meters where lithic objects from GH 4 are distributed (square meters 227-059, 227-060, 228-058, 228-059, 228-060 and 228-061). In top view, the square meters 228-058 and 228-059 yield a concentration of cores. If all cores are taken into account, a binary division is not clearly visible, but likely (see fig. 356).

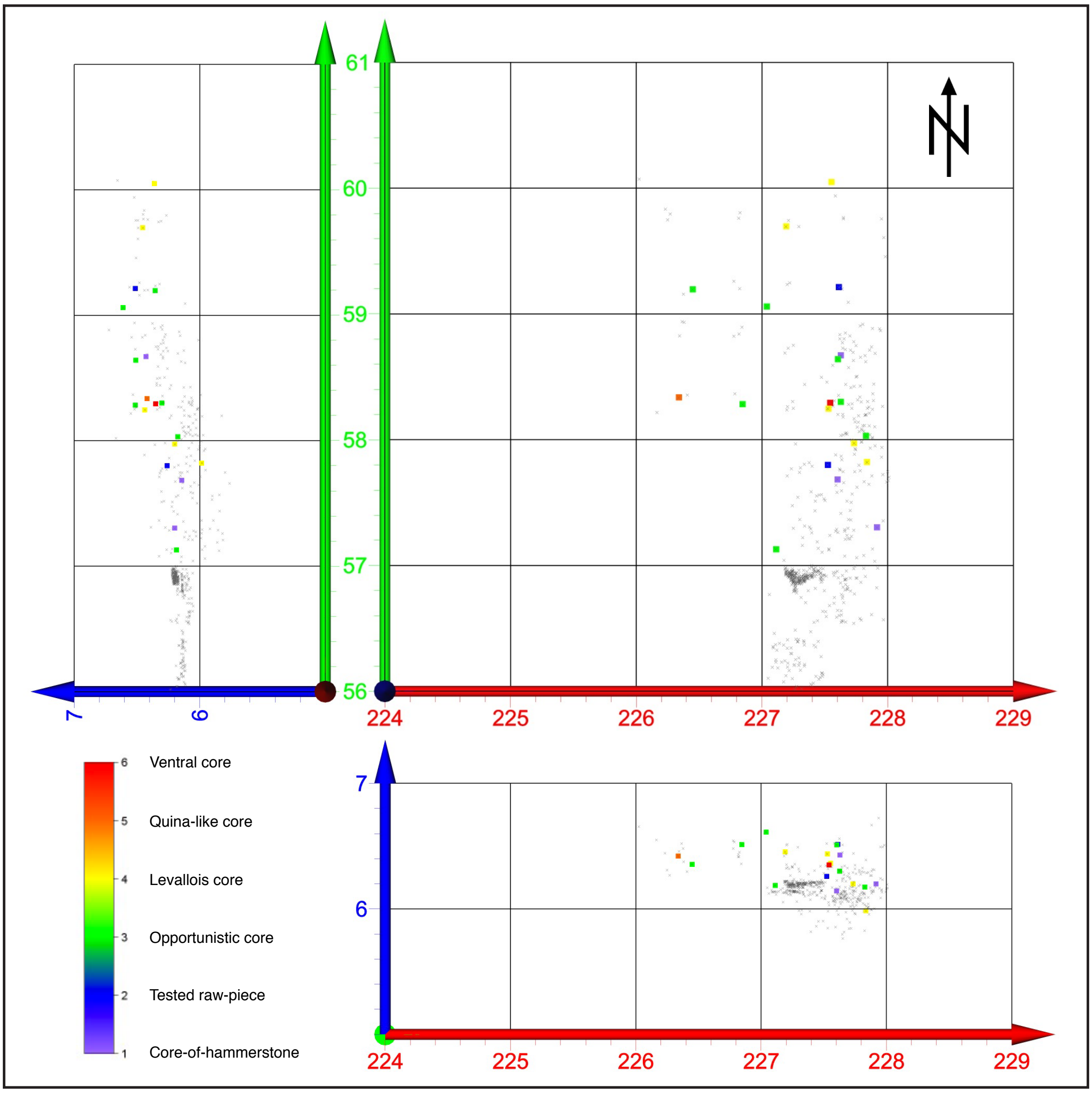

Fig. 356 - Spatial distribution of all cores in the scatter of lithic objects from GH 4

IX.5.2 Tested raw-piece

GH 4 yielded one tested raw piece (GER09.228-060.119.1, see fig. 357). It is made from FAS and shows some marginal traces of heat influence. The temperature did not invade much into the nodule. From the appearance on negatives, the nodule was heated before it was knapped. One edge shows fine-grained good knappable raw material, but was not further exploited. Other parts of the nodule show more evidence for the interruption of the knapping process. These parts are more coarse-grained and have fissures and micro-cracks.

The tested raw-piece is big (mass = 719.1 g, length = 126.16 mm, width = 70.58 mm and thickness = 75.75 mm) and corresponds from its size to the spectrum of FAS raw pieces known from other assemblages of VP II.

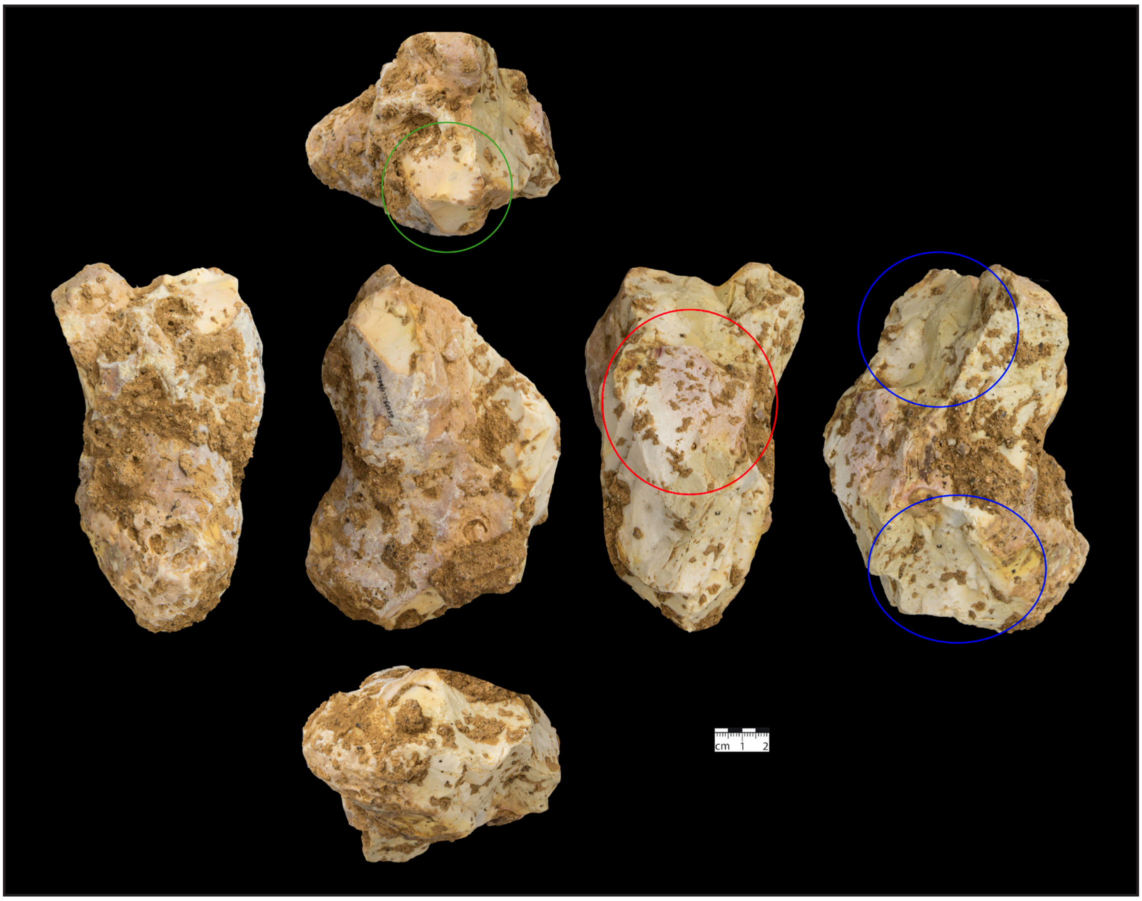

Fig. 357 - Tested raw piece from GH 4 (GER09.228-060.119.1). Indicated are one edge with fined-grained raw material (green ellipse), two parts with a combination of coarse-grained material and fissure (blue ellipse) and remnants of cortex with traces of heat influence (red ellipse)

IX.5.3 Opportunistic cores

There are n=9 cores classified as opportunistic cores. FAS was the preferred raw material (n=6) and three cores are made from an unknown raw material. They are made out of n=2 flakes and n=7 raw pieces in nodule-shape. One of the cores show traces of heat (before knapping). For n=5 of these cores fine-scale information and measurements are available. Mass and dimension of these cores are displayed in fig. 358. The mass of these cores is quite variable. This is also true for dimension.

One of these cores is of particular interest, because it is a small nodule with influence of heat (fig. 359). This object was knapped after the heat exposure. The platform and two auxiliary surfaces show irregularities and fissures. The core seems to have produced one cortical flake.

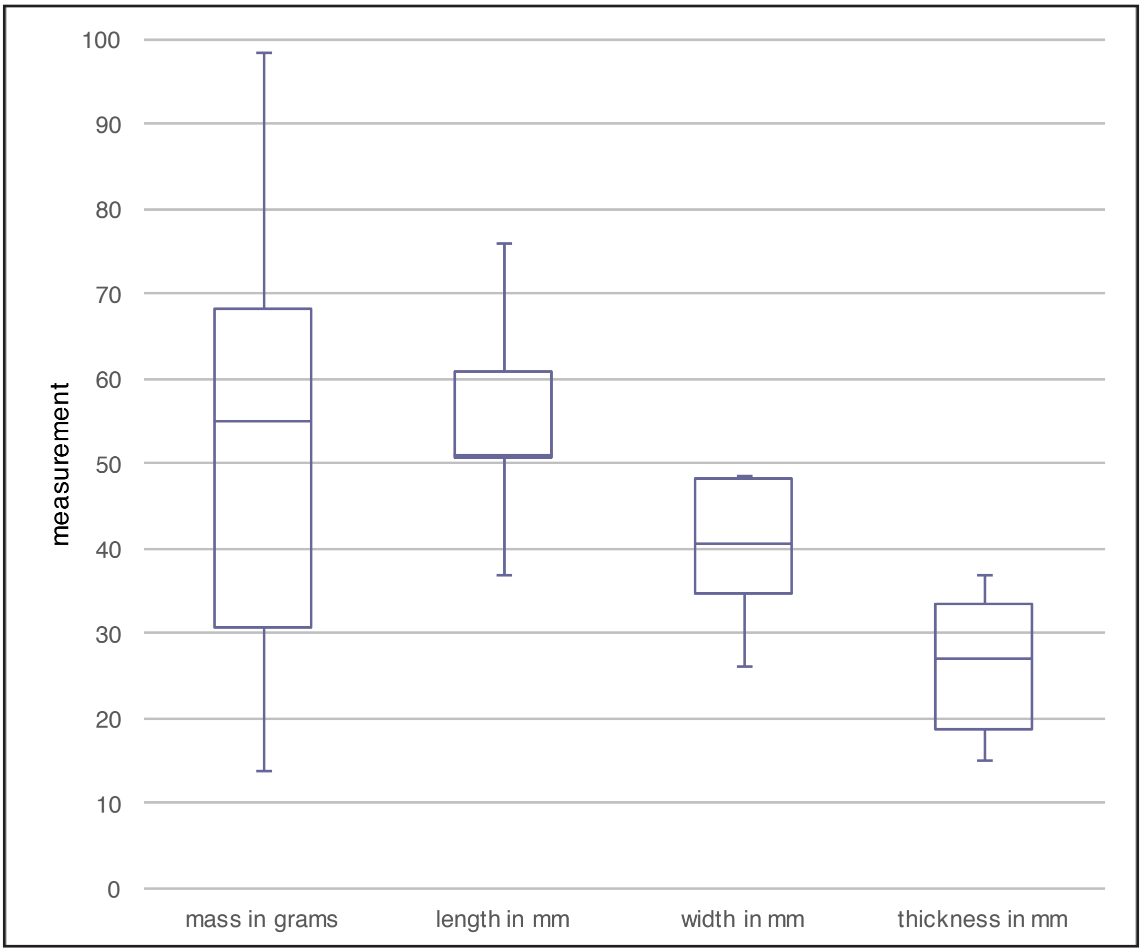

Fig. 358 - Mass and dimension of opportunistic cores from GH 4

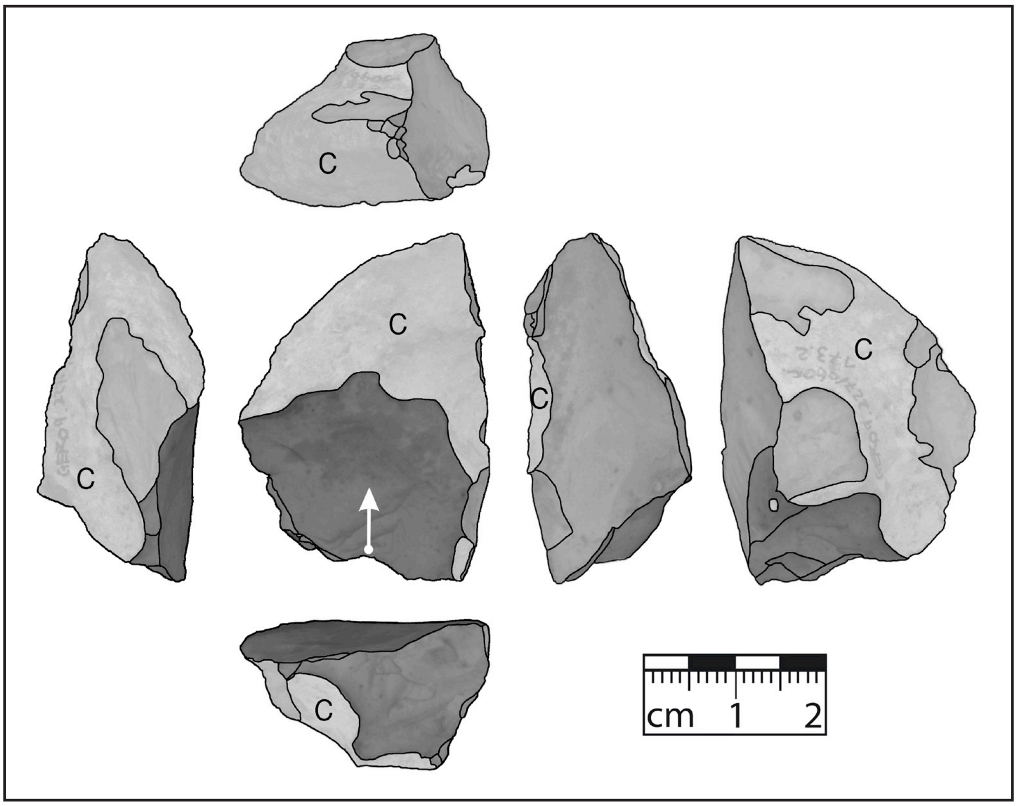

Fig. 359 - Opportunistic core on a nodule that was exposed to heat (GER09.227-060.173.2)

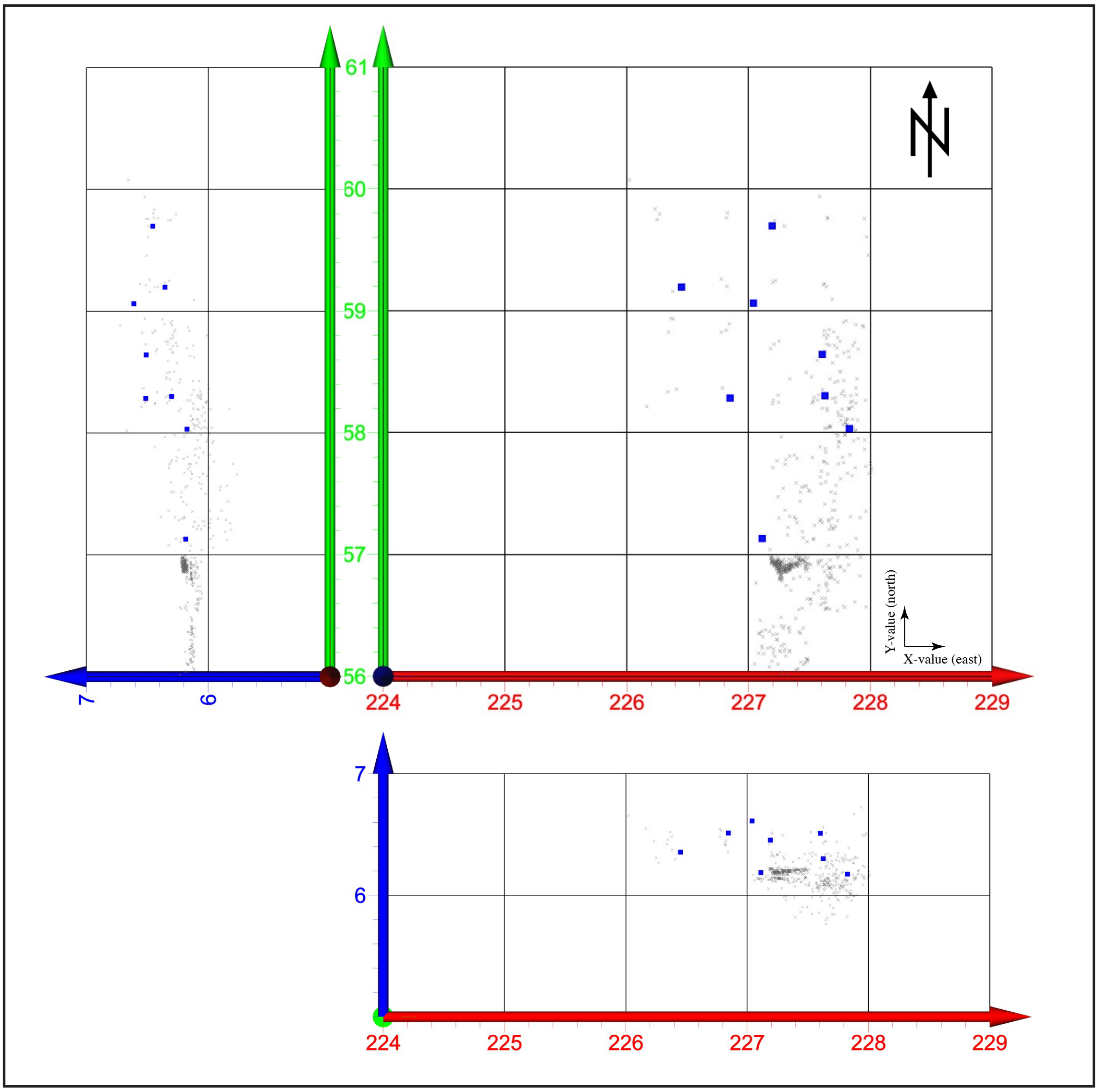

Fig. 360 - Spatial distribution of opportunistic cores in the scatter of lithic objects from GH 4

The circumstance of a knapped object after exposure to heat is seldom in VP II. All opportunistic cores produced some blanks in flake format and show the use of available angles and convexities for getting blanks. In all of this cores a conceptual frame cannot be recognized. The number of reduction surface vary from one to three. The common feature that justify to classified these cores into one group is that after testing the raw piece, a small amount of blanks were retouched that have the possibility to serve as matrix for further purposes.

In top view, the opportunistic cores are randomly scattered in GH 4 (see fig. 360). In side-view instead, they are situated in the upper parts of GH 4. This might be another evidence for a proposed binary division of the objects from this GH.

IX.5.4 Levallois cores

GH 4 yielded n=5 Levallois cores made from FAS. They are displayed in fig. 361. The cores are in different conditions. Two of them are made on blanks. The other three are made on raw-pieces. The first, GER09.228-059.154.1 (fig. 361a) is an exhausted and very flat core made on a blank. A little remnant of the ventral face is left on the reduction surface, but is to small to indicate the knapping direction of the blank. The minimal inclination between the reduction surface and the remnant of the ventral face indicate that very likely only one series of blanks were removed. GER09.228-060.166.2 (fig. 361b) is also a blank, but shows some knapping mistakes (hinges) on the proposed reduction surface. The platform for the initial detachment of a central blank is not installed. GER10.228-058.468 (fig. 361c) is a reduced core made from a nodule. The core shows a unidirectional-parallel pattern on the reduction surface. It seems the nodule had a good shape to start immediately the reduction after installation of a platform. The core is not exhausted, the reduction of another series can immediately start again. GER10.228-058.536 (fig. 361d) is another preform of a core. On this core a typical beginner mistake is visible. The negatives serving as platforms for the configuration of the reduction surface are to steep to shape an intended, convex reduction surface. With such a platform inclination, the reduction surface will get too flat. The whole core would need a complete shape restoration to serve as core for planimetric reduction. GER09.228-060.116.1 (fig. 361e) is an exhausted bidirectionally reduced core (maybe also a blank as matrix).

The production analysis show that in every case, the side opposed the reduction surface is shaped first. Secondly, the platform is shaped (on reduced cores). The last removals are mostly situated on the reduction surface (see gray shades in fig. 361). Mass and dimension of these five Levallois cores are displayed in fig. 362 and show a linear correlation between mass, length, width and thickness of the cores. The biggest and smallest core are the preforms (b and d). The both exhausted cores are in the lower range.

The Levallois cores are scattered in a row of four square meters (228-058, 228-059, 228-060 and 228-061) and form two clusters in top view (see fig. 363). In regard to Z-value they are scattered from around 6 to 6.4.

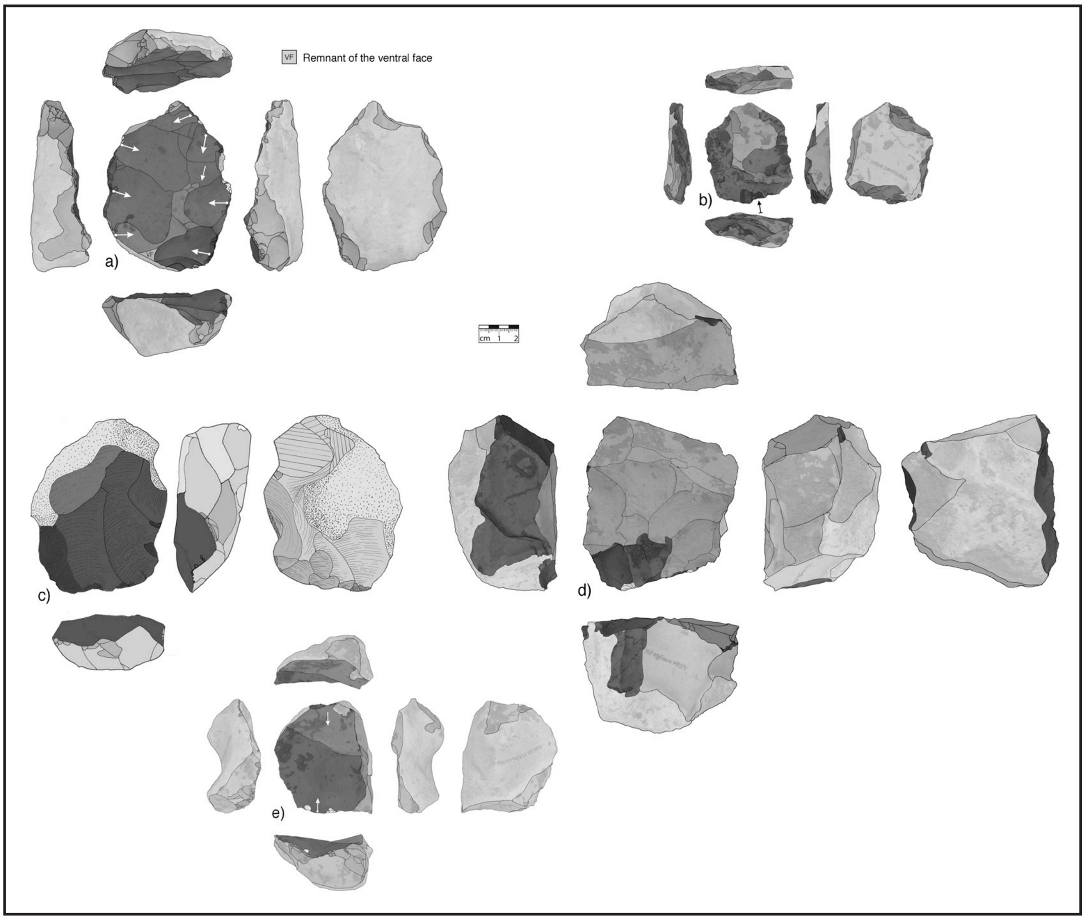

Fig. 361 - Four Levallois cores from GH 4. a) Exhausted and flattened centripetal core on cortical blank (GER09.228-059.154.1); b) Preform of a core mad from a blank(GER09.228-060.166.2), c) Unidirectional core made from a raw piece (GER10.228-058.468), d) Preform of a core (GER10.228-058.536) and e) Bidirectional core (GER09.228-060.116.1)

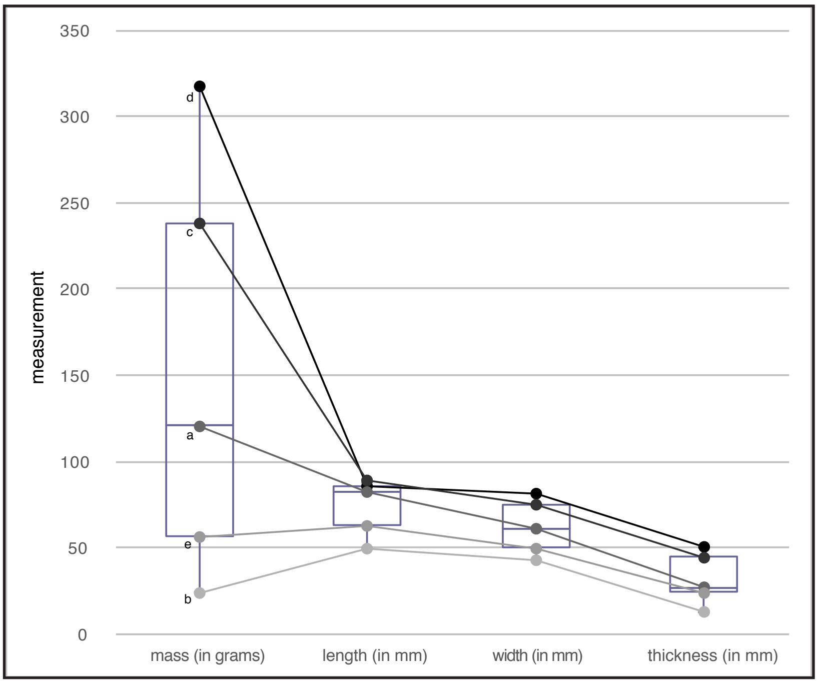

Fig. 362 - Mass and dimension of Levallois cores from GH 4, displayed as box plot. The letters in the illustration corresponds with the letters in fig. 361

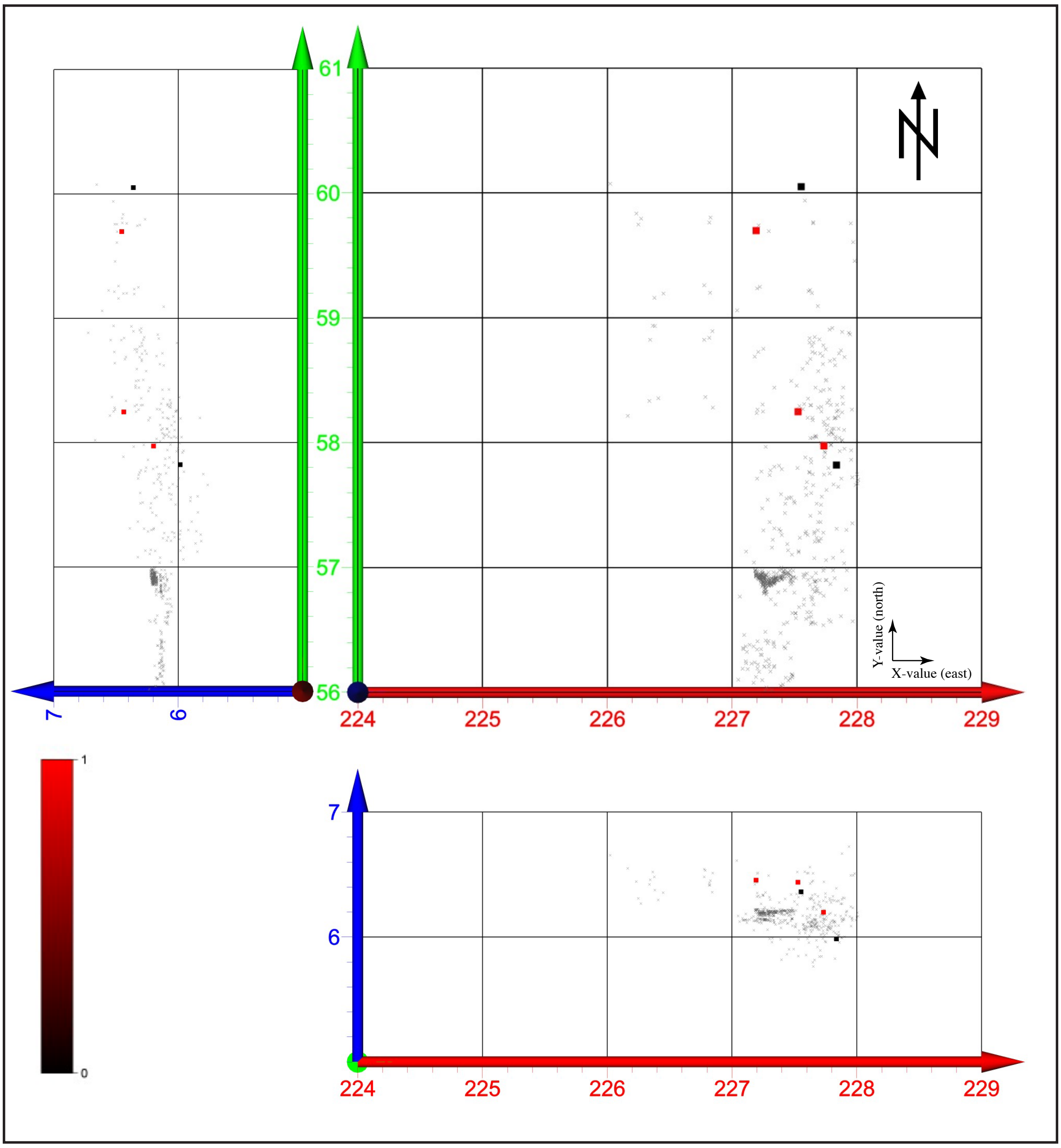

Fig. 363 - Spatial distribution of Levallois cores in the scatter of lithic artifacts from GH 4

IX.5.5 Cores-of-hammerstones

There is evidence for n=5 cores-of hammerstones from GH 4 (see fig. 364). The raw material of them is quartzite (n=4) and quartz (n=1). The use of them is demonstrated by negatives of detachment. The hammerstones were tuned or rotated for the use. On all hammerstone more that one contact zone (crushed zones in combination with detachment negatives) is visible.

Despite a span in mass (133.6 grams to 350.6 grams), dimension differences are quite narrow, in special regard to length (see fig. 365). They are nearly congruent in size.

Fig. 364 - Two cores-of-hammerstones from GH 4. Negatives of detachment by use are indicated as black lines. Left) hammerstone from quartzite showing four negatives (GER10.228-058.463) and right) hammerstone from quartz showing two negatives (GER10.228-058.507)

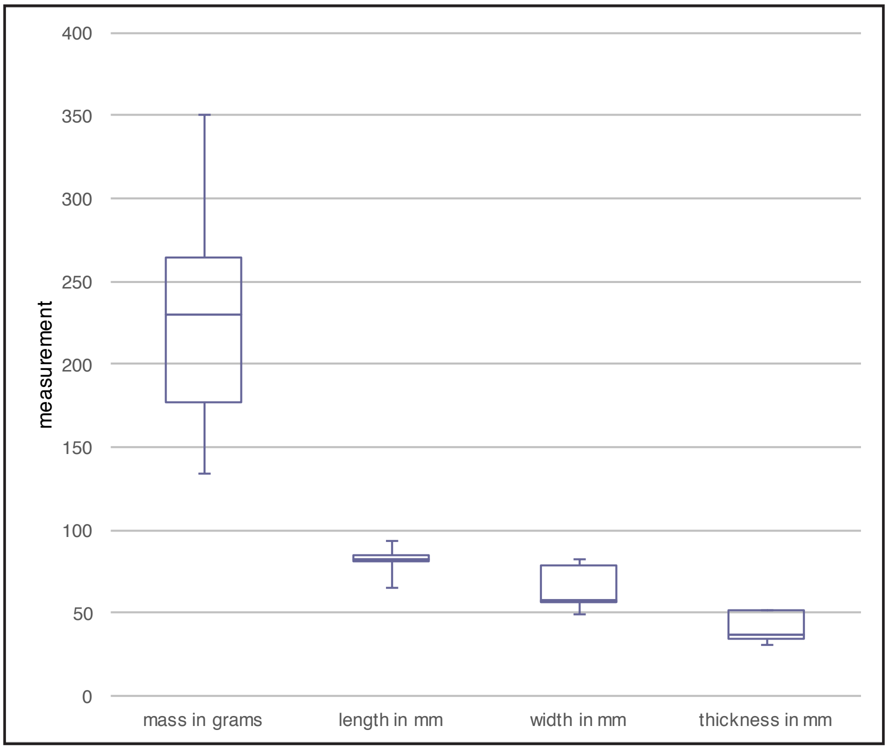

Fig. 365 - Mass and dimension of all five cores-of-hammerstones from GH 4, displayed as box plot

IX.5.6 Other cores

In addition to cores-of-hammerstones from coarse-grained material or fine-grained cores, such as Levallois or opportunistic cores, there are n=3 other cores to be mentioned. One is reduced along two corresponding planes (therefore it is called Quina-like core, GER09.227-059.161.1) and two cortical flakes (GER09.228-059.155.1 and GER09.228-059.157.7) showing detachment negatives on their ventral face. All three are made from FAS and their mass and dimension are displayed in fig. 366. They are scattered in neighboring square meters and relatively close in regard to their Z-value (see orange and red dots in fig. 365, above).

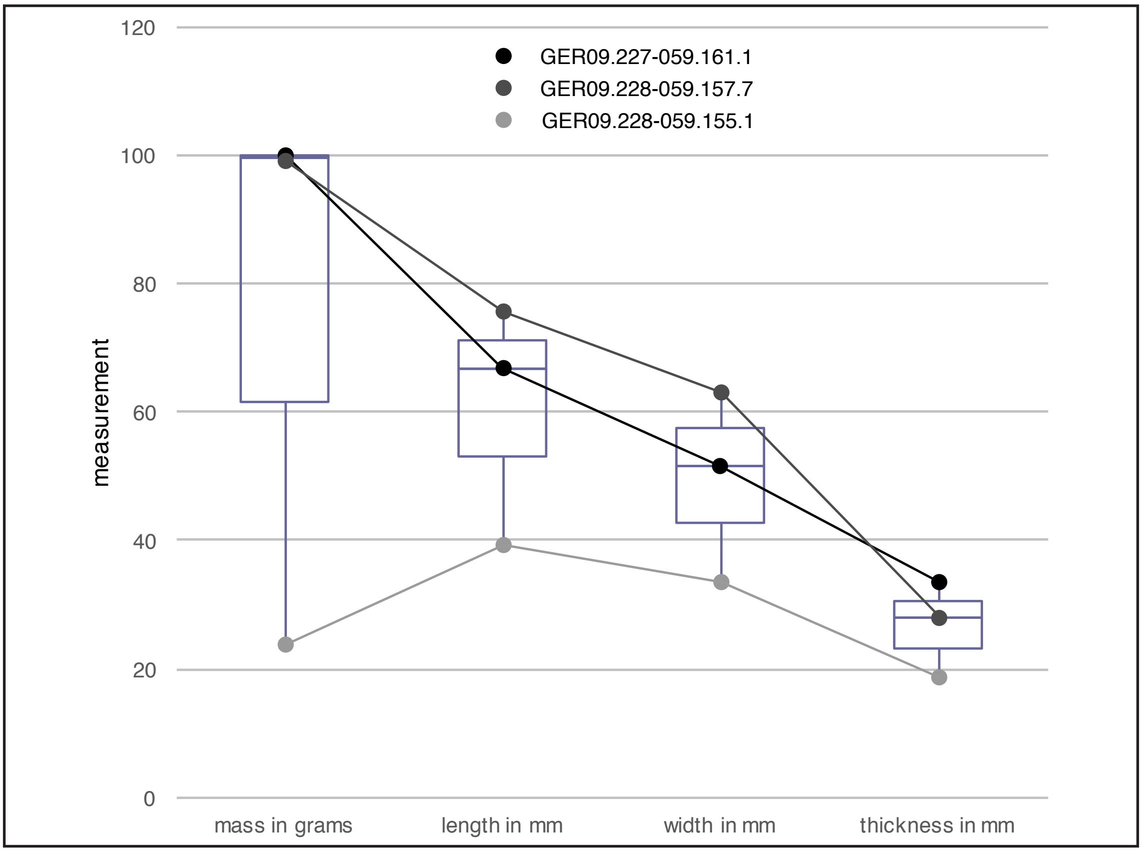

Fig. 366 - Mass and dimension of addition cores from FAS from GH 4

IX.6 Blanks

IX.6.1 Introduction

GH 4 yielded n=134 blanks (if cores-on-blanks are ignored). They are made from n=4 different raw materials (listed in tab. 272). The majority of blanks is made from FAS, followed by an unknown raw material. Chert and unknown flint are present in only some pieces.

Raw material	Total
FAS	107
Chert	3
Unknown flint	1
Unknown raw material	23
Total	134

Tab. 272 - Raw materials of blanks from GH 4

The blanks are classified into n=11 groups and the following tab. 273 lists them as overview. The majority of blanks are classified as surface correction blanks and simple blanks. Levallois blanks are only present in n=11 pieces. Fine-scale information is present for n=102.

Number / Blank	Number of unmodified blanks	Number of modified blanks	Total
Raw-piece cap	5	2	**7**
Surface correction blank	33	7	**40**
Edge correction blank	19	4	**23**
Éclat and lame débrodant	3	0	**3**
Core tablet	1	0	**1**
Levallois blank	5	6	**11**
Ventral blank	2	0	**2**
Bifacial object made on blank	0	2	**2**
Blank deriving from retouch	2	0	**2**
Simple blank	37	5	**42**
Burin blank	1	0	**1**
Total	**108**	**26**	**134**

Tab. 273 - Unmodified and modified blanks from GH 4

Mass and dimension of all measured blanks (n=102) are displayed in fig. 367 and show clearly differences in size and weight. The dimensional scatter plot show that the majority of blanks are situated in the flake dimensional range (fig. 368). An isosurface that separates initial and configuration blanks from other blanks show some interesting patterns that need explanation. At first, it shows that target blanks from Levallois reduction (dull green) are clustered in the mid (with a trend to be quite long to their width). Simple blanks (dark gray), blanks from retouch (red) and burin blanks (bright gray) are quite small in dimension. Bifacial objects are situated in the medium range (orange). Raw piece caps (black) are clustered between the last both described patterns. Correction blanks (violet, blue, dark green and bright green) are scattered from small to large.

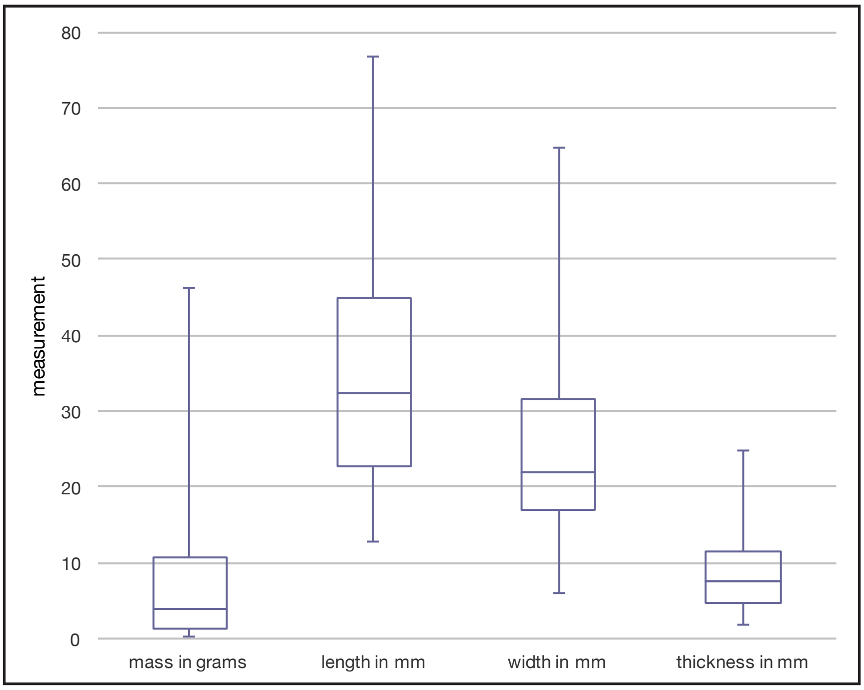

Fig. 367 - Mass and dimension of blanks from GH 4, displayed as boxplot

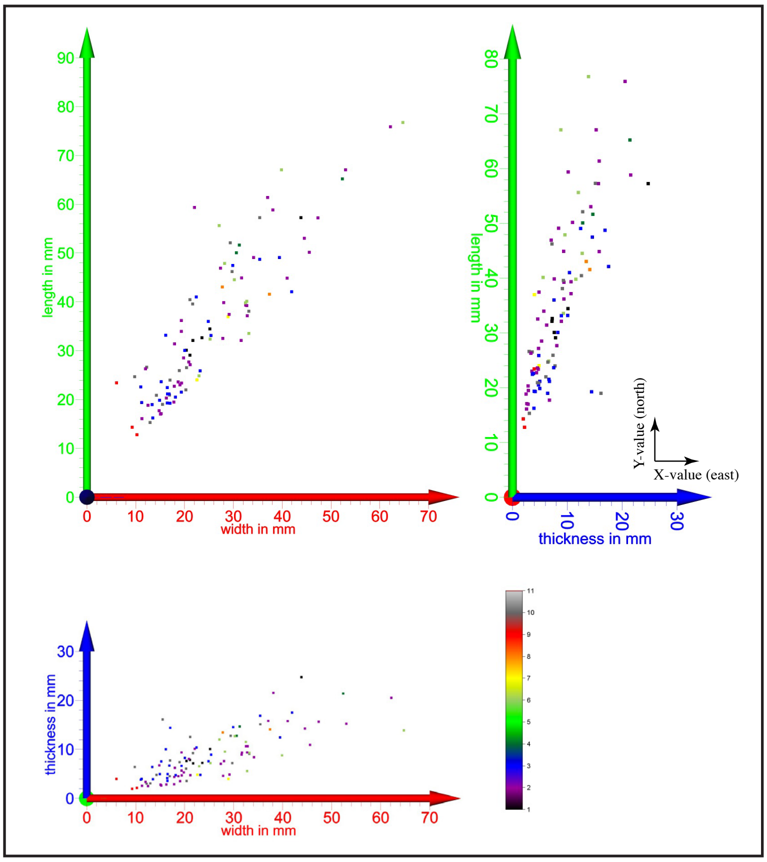

Fig. 368 - Dimensional scatter plot of blanks from GH 4

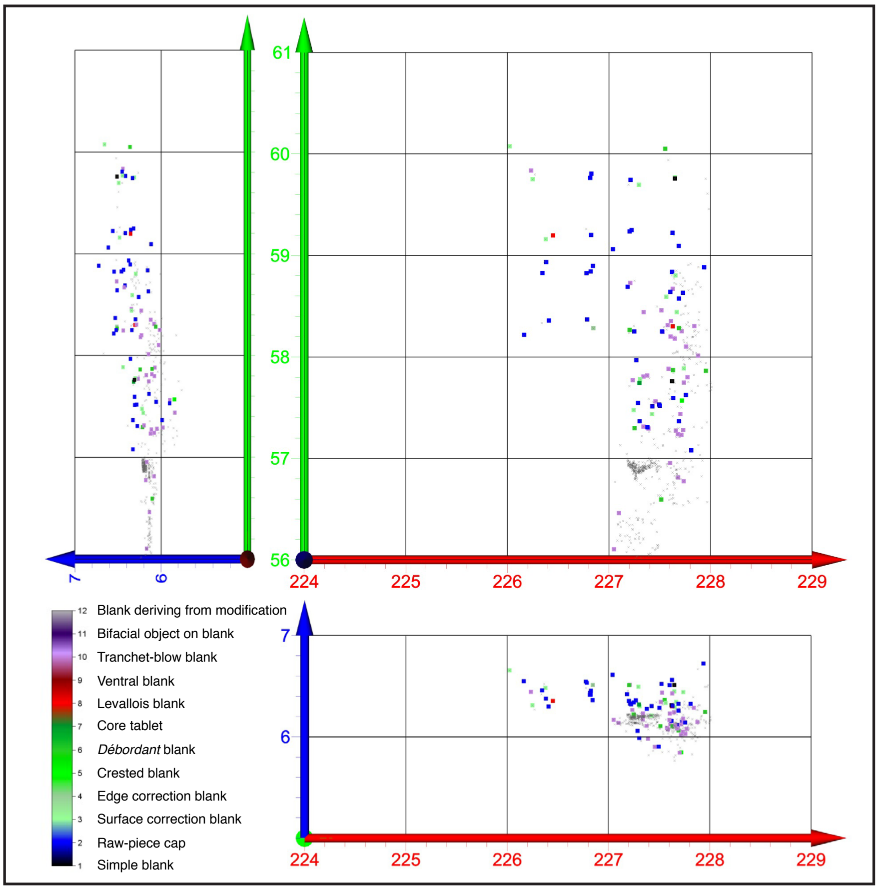

Fig. 369 - Distribution of blanks from GH 4

Blanks are distributed in all square meters were GH 4 was excavated (fig. 369). From the overview there is not clear distribution pattern visible. Only the distribution of initial and configuration blanks is clustered.

IX.6.2 Blanks removed for initialization and correction purposes

The umbrella term of initialization and correction blanks includes raw-piece caps (n=7), surface (n=40) and edge (n=23) correction blanks, *éclats débordants* and l*ames débordantes* (n=3) and a core tablet (n=1). In core reduction they are removed for the formation of angles and convexities on these cores, but as tab. 273 (above) shows, some of them were also modified after their production. Ranges of mass and dimensions for these blanks are displayed in fig. 367. The differences between edge-correction blanks on the one hand and *éclats débordants* and *lames débordantes* on the other hand are clearly visible. In mean surface correction blanks are bigger than edge correction blanks. Raw-piece caps are situated in the mid. Unfortunately, the core tablet is not measured in its dimension. One example of a surface correction blank is displayed in fig. 370.

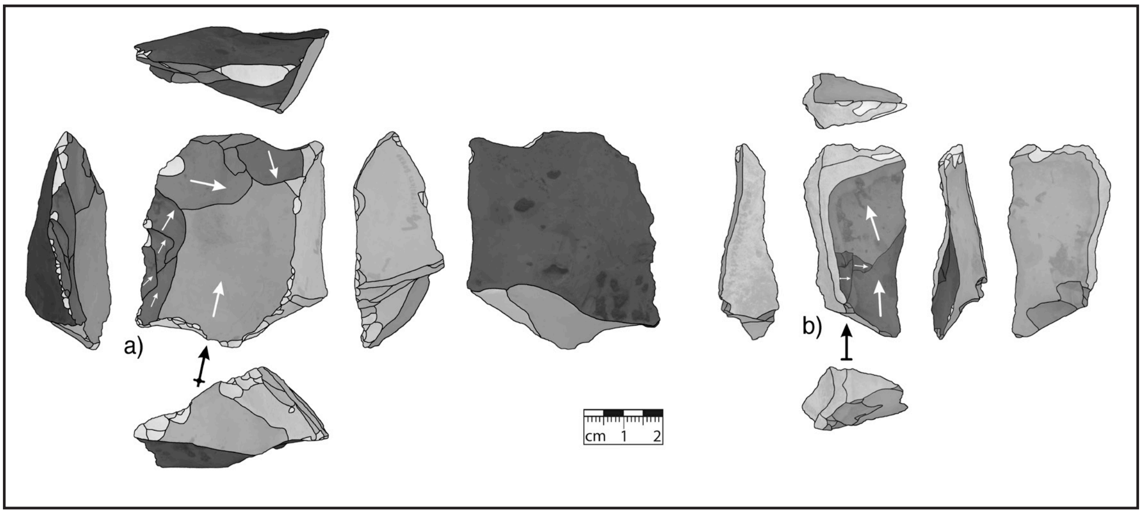

Fig. 370 - Éclat débordants from GH 4. a) GER09.227-059.162.1 and b) GER09.227-060.173.4

IX.6.3 Levallois blanks

GH 4 contain n=11 Levallois blanks. In a typological view they are separated into n=5 Levallois flakes, n=2 Levallois blades and n=4 Levallois points. They are distributed in nearly all square meters where GH 4 was excavated and show in top view no significant distribution pattern (see fig. 371). In regard to Z-value the proposed binary division is here also visible (in particular in view to west).

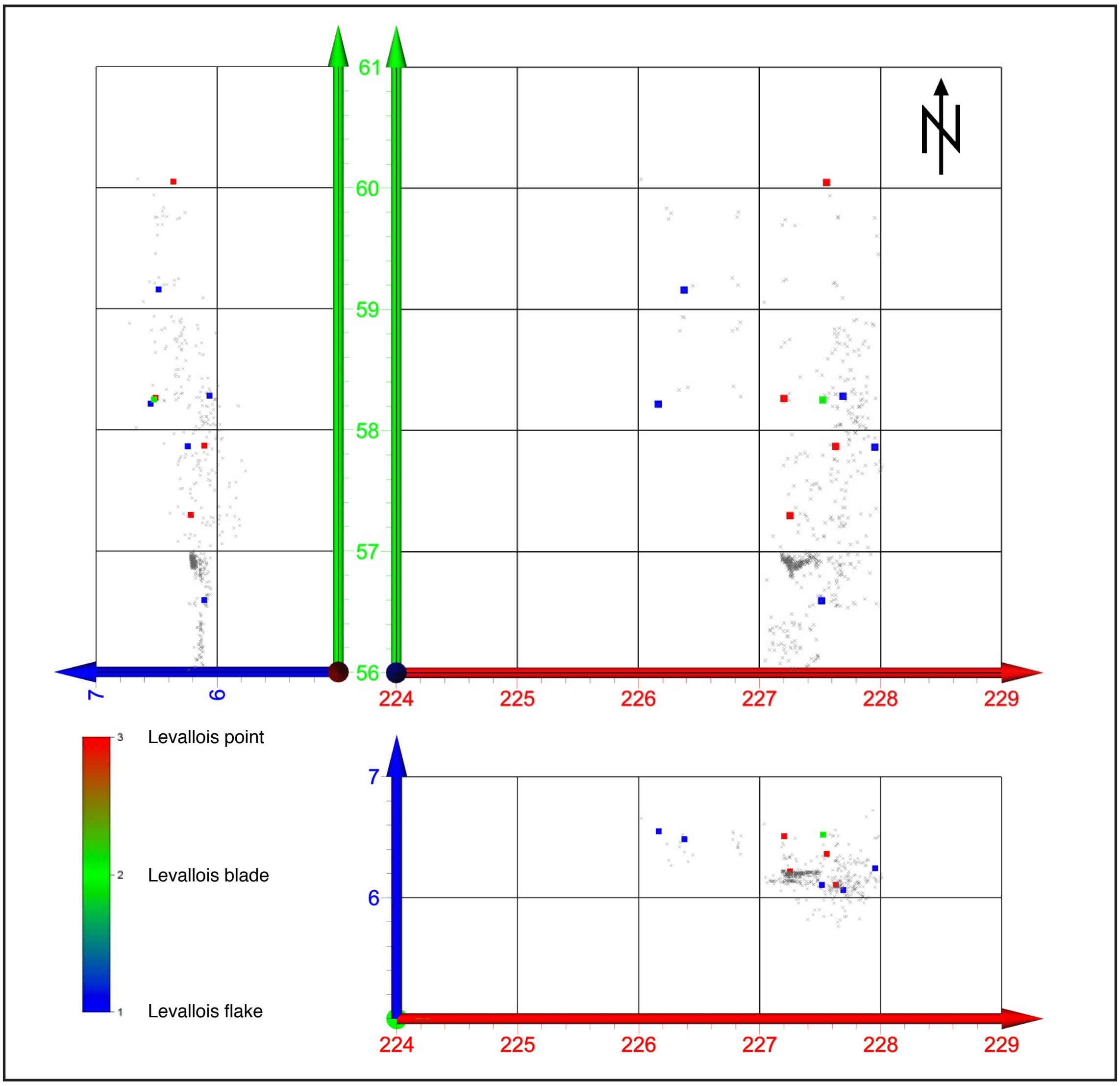

Fig. 371 - Spatial distribution of Levallois blanks (typologically separated) from GH 4 in the scatter of all lithic objects

Ten of these blanks are measured and weighted. FAS (n=8) and chert (n=3) were used as raw material. The metric range of Levallois blanks is quite large. In regard to mass, they can be separated into three groups: The first is a group of small and light objects under a mass of 5 grams. The second group is a group of medium objects between 6.9 and 15.9 grams and the third group contains one extra large object of 39.3 grams (see also fig. 256, chapter VII.11.10).

Only six of them are complete. The others are present as n=2 terminal fragments, a basal fragment, a right lateral fragment and one terminal left lateral fragment. Complete Levallois blanks scatter also in dimension and mass, as visible in fig. 372. Only in regard to thickness, the dimensional range is quite small.

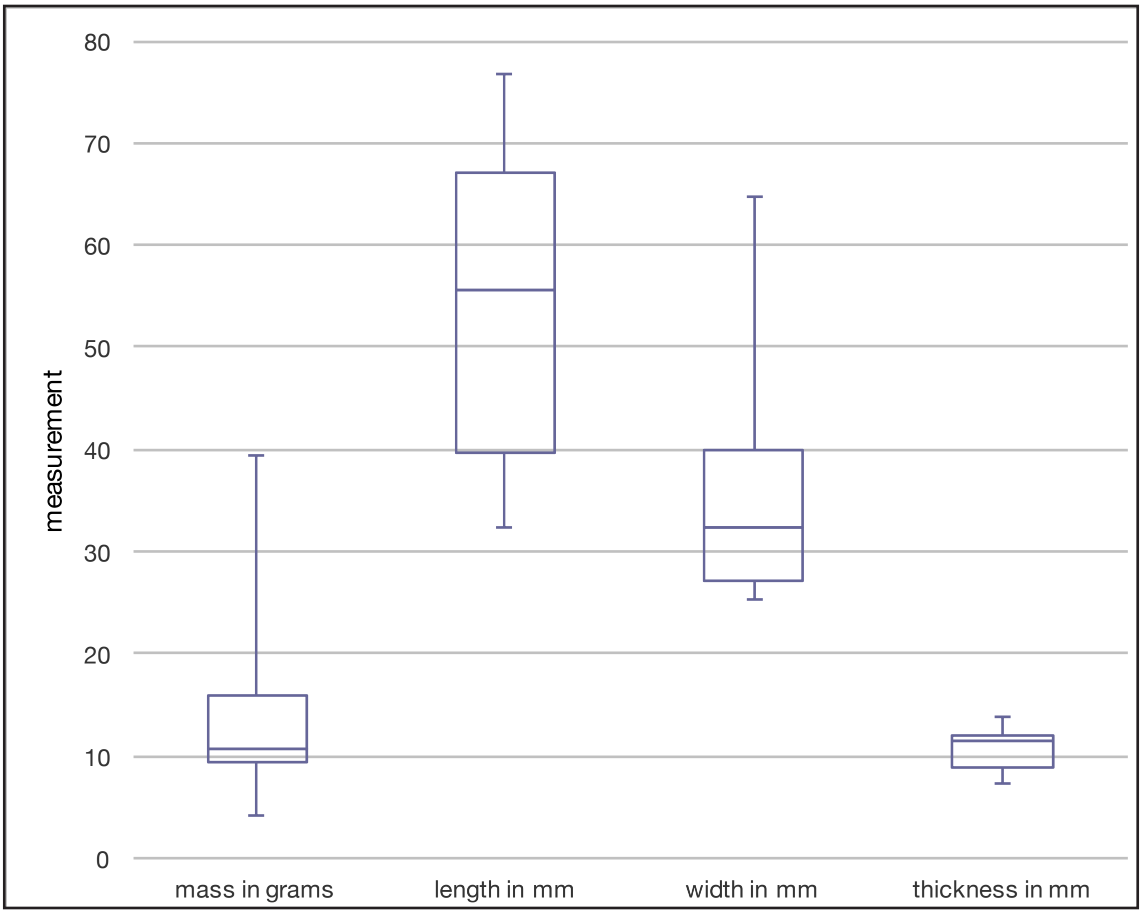

Fig. 372 - Mass and dimension of complete Levallois blanks from GH 4

The n=11 Levallois blanks show n=5 different negative pattern on their dorsal face. There are n=5 blanks with a centripetal pattern, n=2 with a unidirectional-parallel, n=2 with a bidirectional-parallel, one with a unidirectional-orthogonal and one with a bidirectional-convergent pattern (see also tab. 274). The variability in shape is displayed in fig. 373.

Dorsal negative pattern	**Number**
Unidirectional-parallel	**2**
Uni-directional-orthogonal	**1**
Bidirectional-parallel	**2**
Bidirectional-convergent	**1**
Centripetal	**5**
Total	**11**

Tab. 274 - Dorsal negative pattern on Levallois blanks from GH 4

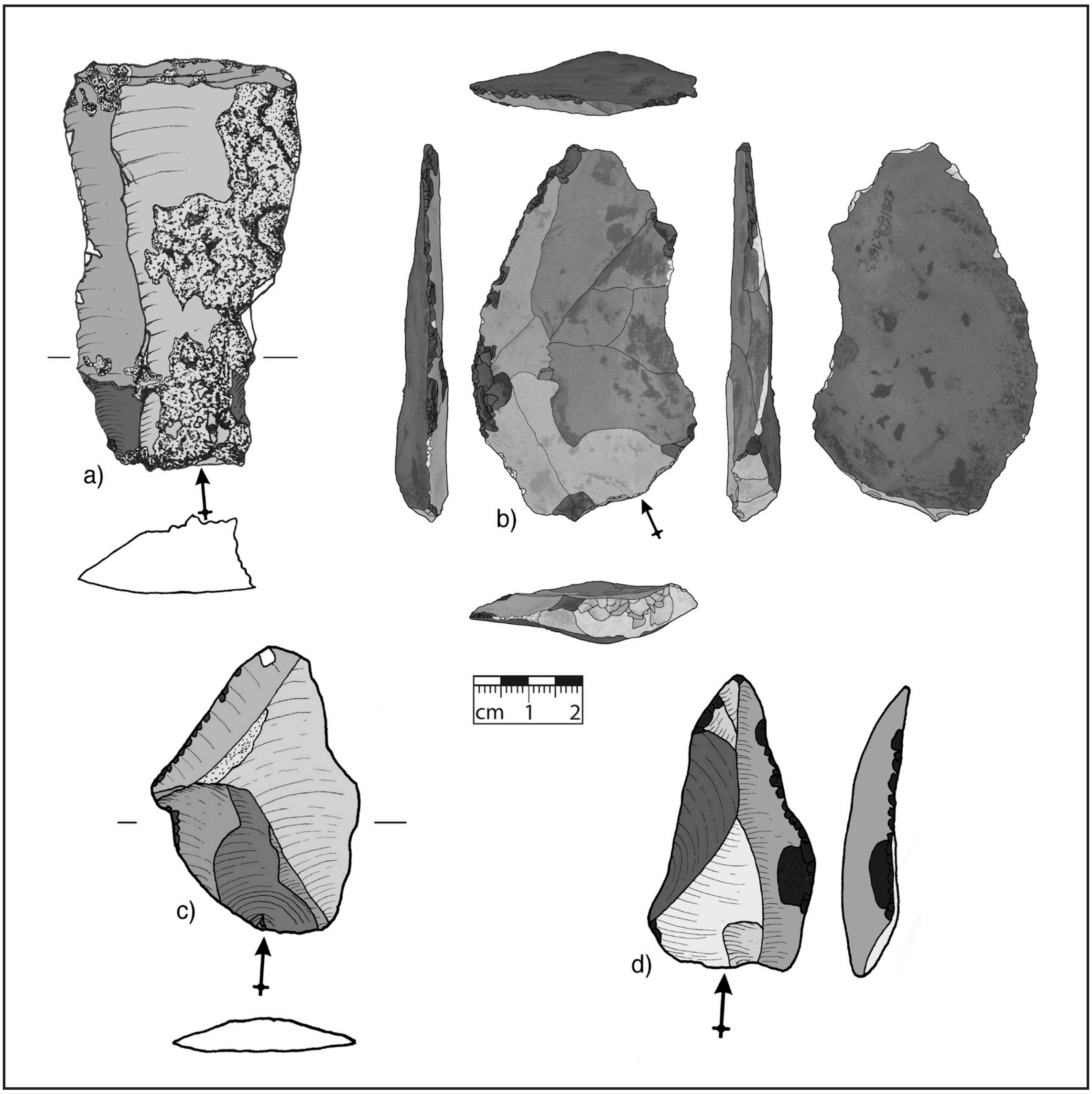

Fig. 373 - Examples of Levallois blanks from GH 4. a) Levallois blade made from FAS that broke during production and shows desilicification on the ventral face (GER09.228-059.153.1); b) Constructed Levallois point made from chert (GER09.228-060.166.3); c) Predetermining flake for shaping the convexity of a Levallois core (GER10.228-058.447, classified as surface-correction blank) and d) Retouched Levallois point (GER10.228-058.525)

Concerning the spatial distribution of these different negative patterns (see fig. 374), both clusters contain objects with a centripetal pattern. The only real difference between both clusters is that the upper contain both objects with the unidirectional-parallel pattern (they are situated at the same position, because they are from collective finds).

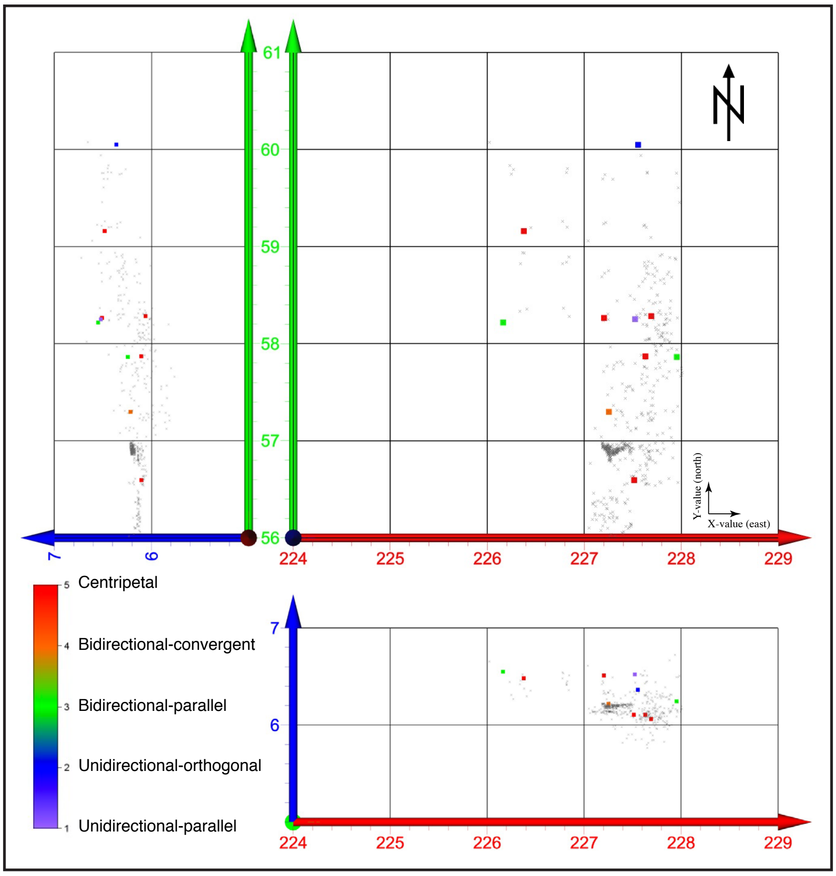

Fig. 374 - Spatial distribution of Levallois blanks from GH 4 in regard to their negative pattern on the dorsal face, situated in the scatter of all lithic objects from GH 4

IX.6.4 Ventral blanks

GH 4 contains n=2 ventral blanks. Both are made from FAS and are fragments. One is a terminal (GER09.227-060.169.2, see fig. 375), the other is a left lateral fragment (GER10.228-058.449).

Fig. 375 - Terminal fragment of a ventral blank from GH 4 (GER09.227-060.169.2)

Both are quite small (see box plot in fig. 376), one belongs to the upper half of GH 4 (GER09.227-060.169.2) and the other to the lower half (GER10.228-058.449) of the GH (see fig. 345, above).

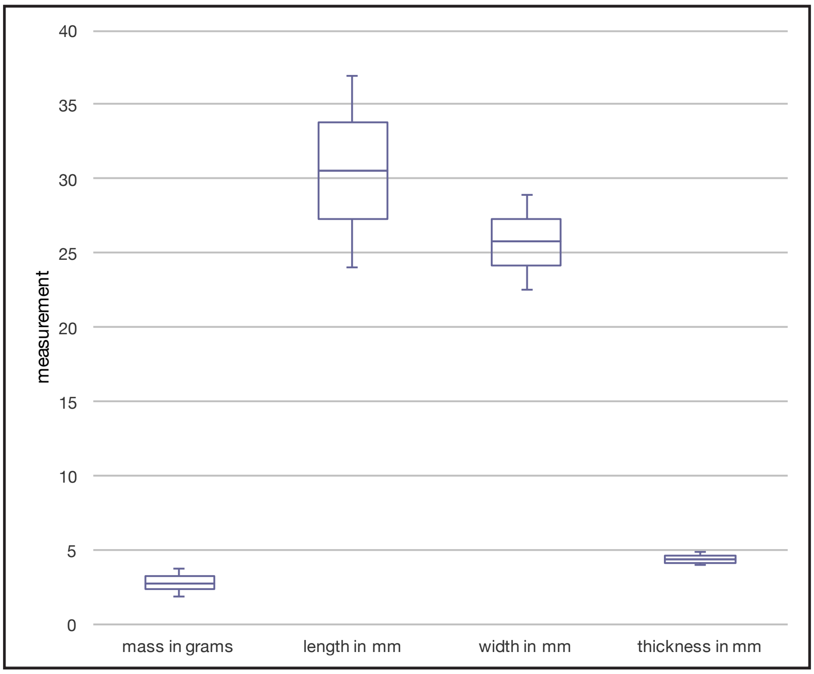

Fig. 376 - Box plot of mass and dimension of ventral blanks from GH 4

IX.6.5 Bifacial objects

There is evidence of two bifacial objects from this GH. Both are not discussed in Frick & Floss (in press). One is a bifacially worked object (GER09.227-060.173.3, see fig. 377a) and the other an asymmetric variety of a *Fäustel* (GER09.228-059.209.1, see fig. 377b). Both are made from blanks, but the first is made from FAS, the second from an unknown brown flint.

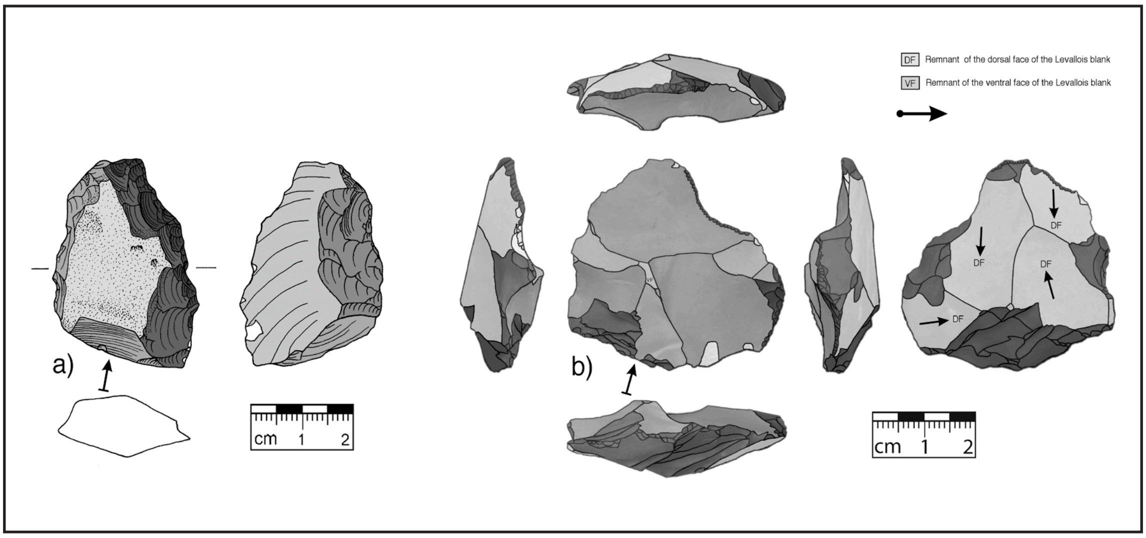

Fig. 377 - Bifacial objects from GH 4. a) Bifacially worked object (GER09.227-060.173.3) and b) Asymmetric variety of a Fäustel (GER09.228-059.209.1)

The first bifacial objects is a terminal fragment of a bifacially worked object and has a bifacially confected back, as well as a unifacially worked active edge. Both sides are not surface shaped. The top side has cortex left and the bottom side shows the ventral face of the flake. It probably broke during use and was re-confected on the active edge. The rhythm of production is: 1. shaping the back on the ventral face; 2. shaping the back on the dorsal face; 3. shaping the active edge on the dorsal face (Br- t-Tl-r-Tr).

The second bifacial object was very likely made from a Levallois blanks with a centripetal dorsal negative pattern. Only a tiny spot on the top side is the remnant of the ventral face. The object is nearly completely surface shaped on the top side. The bottom side was only shaped on the edges and on its base. The active edge is circumferential around the tip. At first the surface of the top side (former ventral face) was shaped, followed a reconnection of the bottom side (the former dorsal face) on the edges. As last step the active edges were unidirectionally retouched. The shape of this bifacial object has parallels in one from GH 3 (GER09.228-059.116.9, see fig. 268a). The plane surface of the plano-convex cross-section of the tip of both was formed by a bigger negative that ended in a hinge.

Mass and dimension of both objects are listed in the following tab. 275. Both objects are quite small and are distributed in the upper half of the GH 4 (see also fig. 345, above).

Find-number	Denomination	Mass (in grams)	Length (in mm)	Width (in mm)	Thickness (in mm)
GER09.227-060.173.3	Bifacially worked object	13.5	43.05	27.75	25.33
GER09.228-059.209.1	Asymmetric *Fäustel*	17.4	41.56	37.41	33.09
Total		**30.9**	**84.61**	**65.16**	**58.42**

Tab. 275 - Mass and dimension of both bifacial objects from GH 4

IX.6.6 Other blanks

Three groups of blanks from GH 3 are left and are discussed in the following. It is a matter of blanks deriving from retouch, simple blanks and one burin blank.

Blanks deriving from retouch

The blanks deriving from retouch are characterized by remnants of a retouched edge that was produces before the detachment. If these objects were removed during a retouch procedure or much later for restoration purposes is questionable. Both objects are the only clear evidence for reshaping of edges on-site during GH 4. One of these belongs to the upper part of GH 4 and the other to the lower part (see also fig. 345, above). Both are small, have a mass of 0.2 grams (see tab. 276) and are made from FAS.

Find-number	Mass (in grams)	Length (in mm)	Width (in mm)	Thickness (in mm)
GER09.227-059.156.5	0.2	12.79	10.22	2.18
GER09.228-059.203.1	0.2	14.32	9.26	7.41
Total	**0.4**	**27.11**	**19.48**	**9.59**

Tab. 276 - Mass and dimension of blanks deriving from retouch from GH 4

Simple blanks

They are n=42 blanks showing no specific feature and are classified as simple blanks. Possibly, further research will find specific denominations (e.g., by refitting). They are made from FAS (n=20) and (yet) unknown raw material (n=22). Mass and dimensional measurements is only available for n=16 of these blanks. There is evidence for n=5 modified simple blanks (GER09.228-059.159.1 is displayed in fig. 378). The spatial distribution of these blanks is displayed in fig. 345, above).

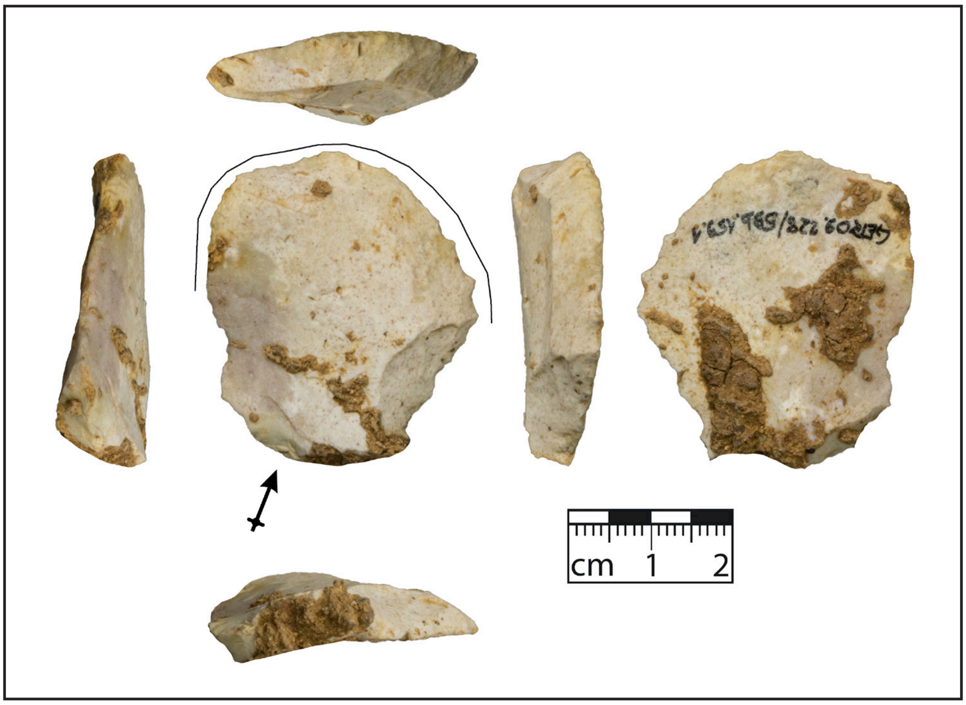

Fig. 378 - Simple blank that was invasively reduced in length by retouch (GER09.228-059.159.1)

IX.7 Reconstructing reduction sequences

IX.7.1 Introduction

The reconstructed reduction sequences for material from GH 4 is illustrated in different figures, separated by raw-material. Each includes all objects from a specific raw material and are explained in the following (fig. 378 to 382).

IX.7.2 Reduction sequences for FAS

The reconstructed reduction sequences for objects from FAS shows that the assemblage is not complete. The objects arrived the site in different conditions. Also some objects must have been removed from the site. The ratio of cores to blanks for n=8 cores on raw-pieces, n=6 cores on blanks and n=107 blanks (14/107) equals 7.6. The correlation between raw pieces, cores and blanks is illustrated in fig. 379. It shows that for a complete assemblage some objects are missing. The number of raw-piece caps is much to low. This results in the assumption that cores were imported as initialized or configured cores. But the tested raw piece demonstrate that at least one complete nodule or this tested one was imported. The number of retouched objects and corresponding retouch blanks cannot be correlated. There are n=23 retouched objects and only n=2 blanks from retouch. This is an evidence for the import of finished modified objects on-site. If the amount of Levallois cores and blanks would be complete, these n=5 cores would have produced n=8 Levallois blanks.

There is evidence for n=6 cores-on-blanks and n=2 bifacial objects-on-blanks. But the number of ventral blanks (Janus flakes) is very low (n=2). This is another evidence that the most of the blanks that served as matrices for cores were produces of-site. The presence of surface and edge correction blanks, as well as éclat and lame débordant(e) demonstrate clearly that the configuration of some cores take place on-site.

IX.7.3 Reduction sequences for chert

The reduction sequence of chert is very sketchy (see fig. 380). Only complete raw pieces (n=2), Levallois blanks (n=3) and n=2 debris fragments are present. There is no evidence for cores, correction blanks or blanks that derive from retouch. Of course, further excavation can change this picture radically. For now, we have to argue that in the excavated parts of GH 4 is no evidence for the reduction of objects made from chert and the Levallois blanks were imported in their finished condition.

IX.7.4 Reduction sequences for unknown flint

The evidence from unknown flint are even more sketchier as for chert (see fig. 381). There is only evidence for n=2 objects from this material, a bifacial object and a debris fragment. The debris might be evidence that in unearthed parts of this GH are other objects that were reduced on-site. The bifacial object has to be seen as single object that was imported in its present condition.

IX.7.5 Reduction sequences for unknown raw material

There are n=35 objects from unknown silicious raw material (see fig. 382). There is evidence for n=2 raw pieces, n=3 cores, n=23 blanks and some debris (n=7). As raw material at least five objects could have been imported (the raw pieces and the (unreduced) cores). As there are no refits available, no further statements of transformation on- or off-site can be made.

IX.7.6 Reduction sequences for coarse-grained raw materials

Coarse-grained raw materials are present as unused and used raw-pieces, cores-from hammerstones and debris (fig. 383). The conditions of the objects are evidence that they were used for knapping purposes on-site. Nevertheless, some objects are missing. The cores-from-hammerstones show bigger negatives from detachments and these blanks are not present on-site (or at least in the excavated parts of GH 4).

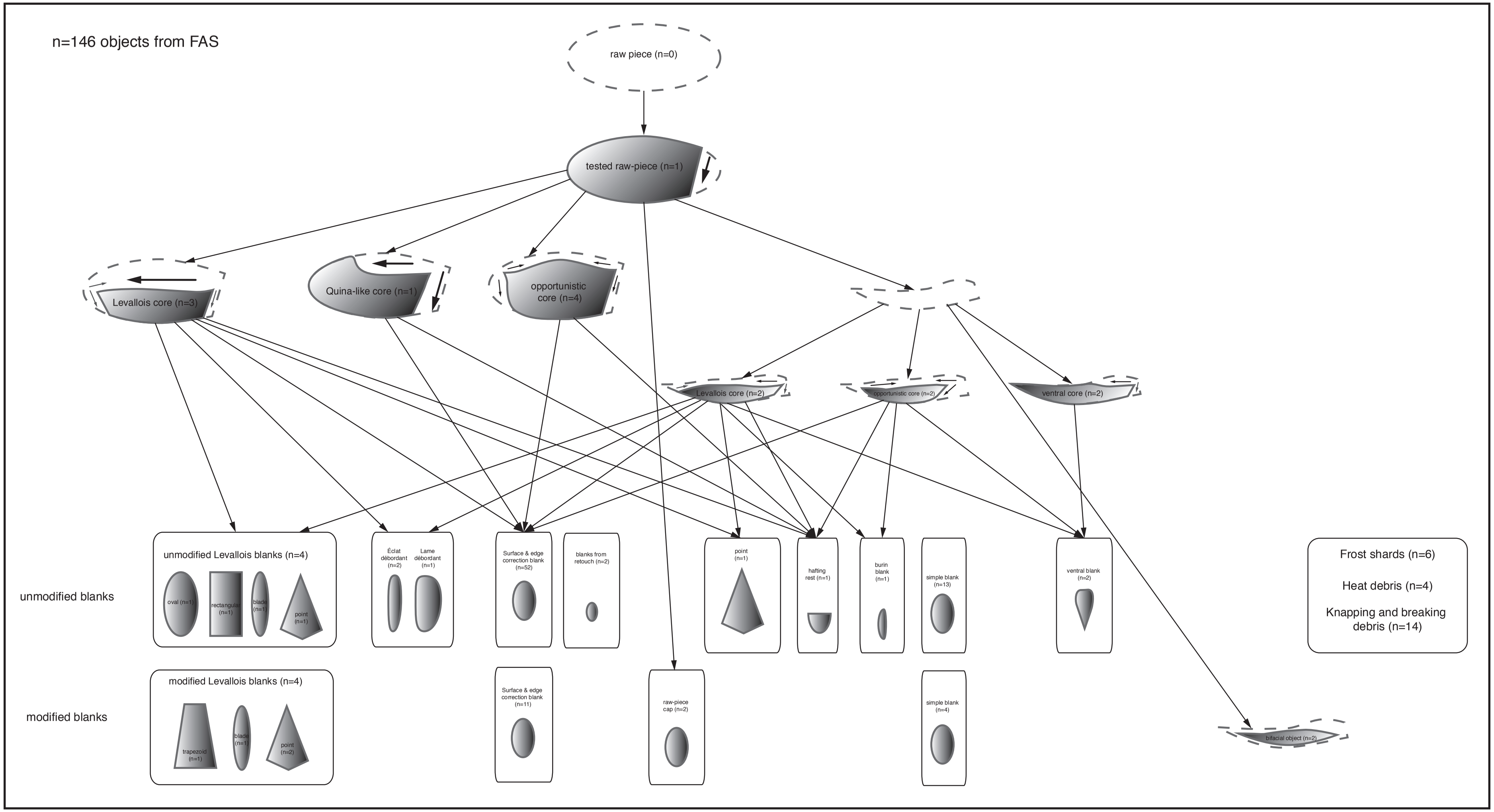

Fig. 379 - Reconstructed reduction sequence for objects made from FAS

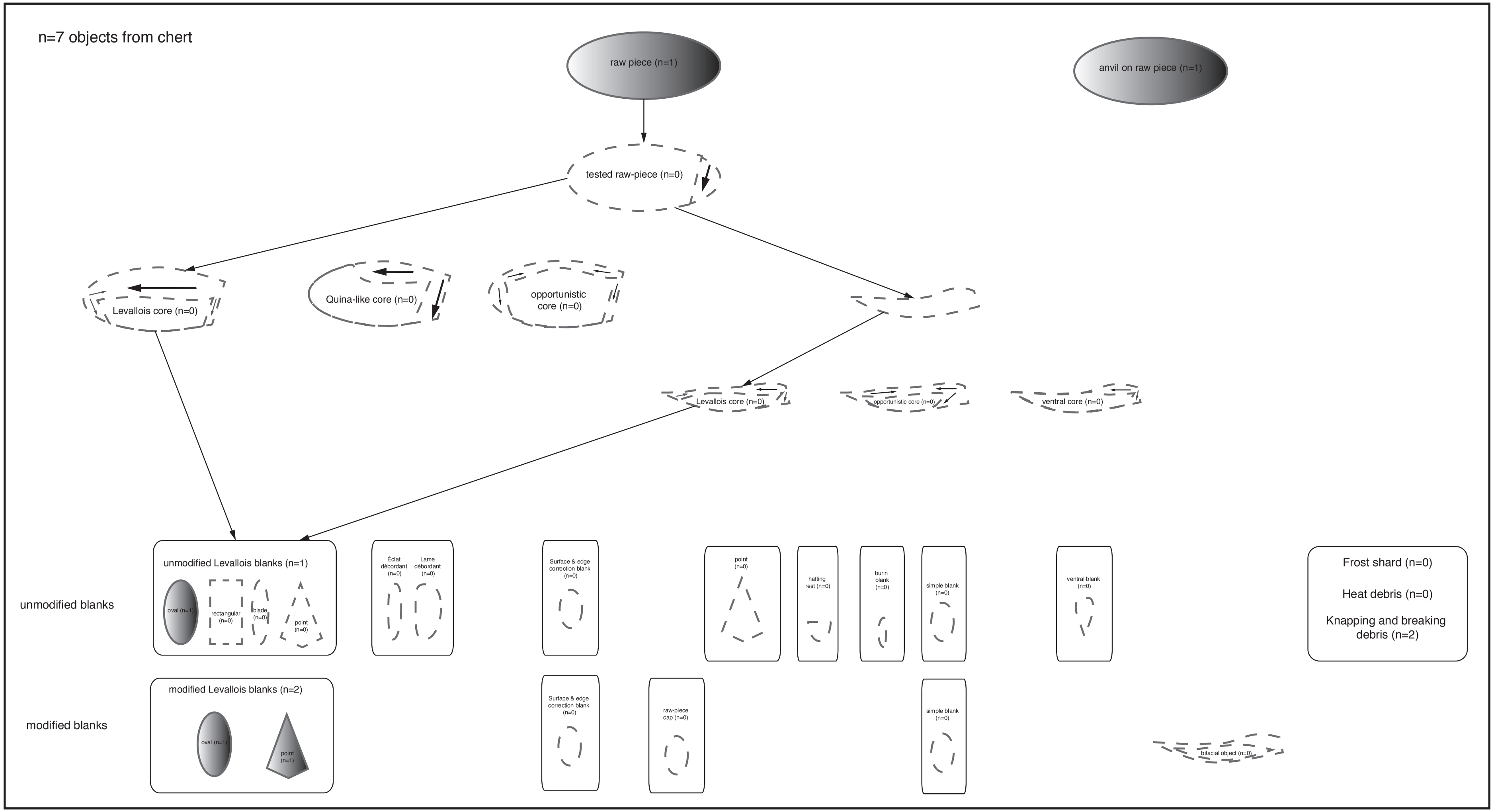

Fig. 380 - Reconstructed reduction sequence for objects made from chert

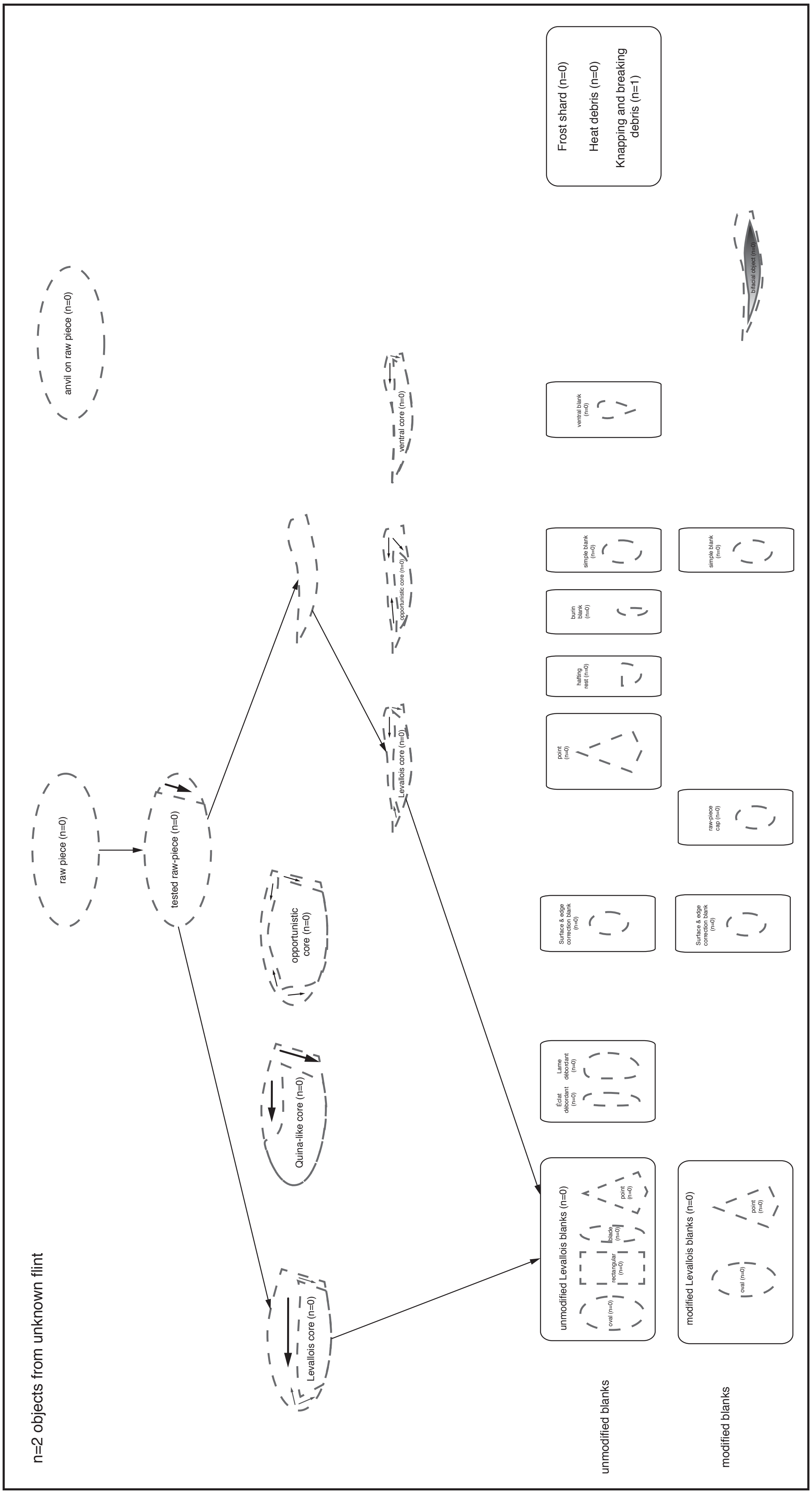

Fig. 381- Reconstructed reduction sequence for objects made from unknown flint

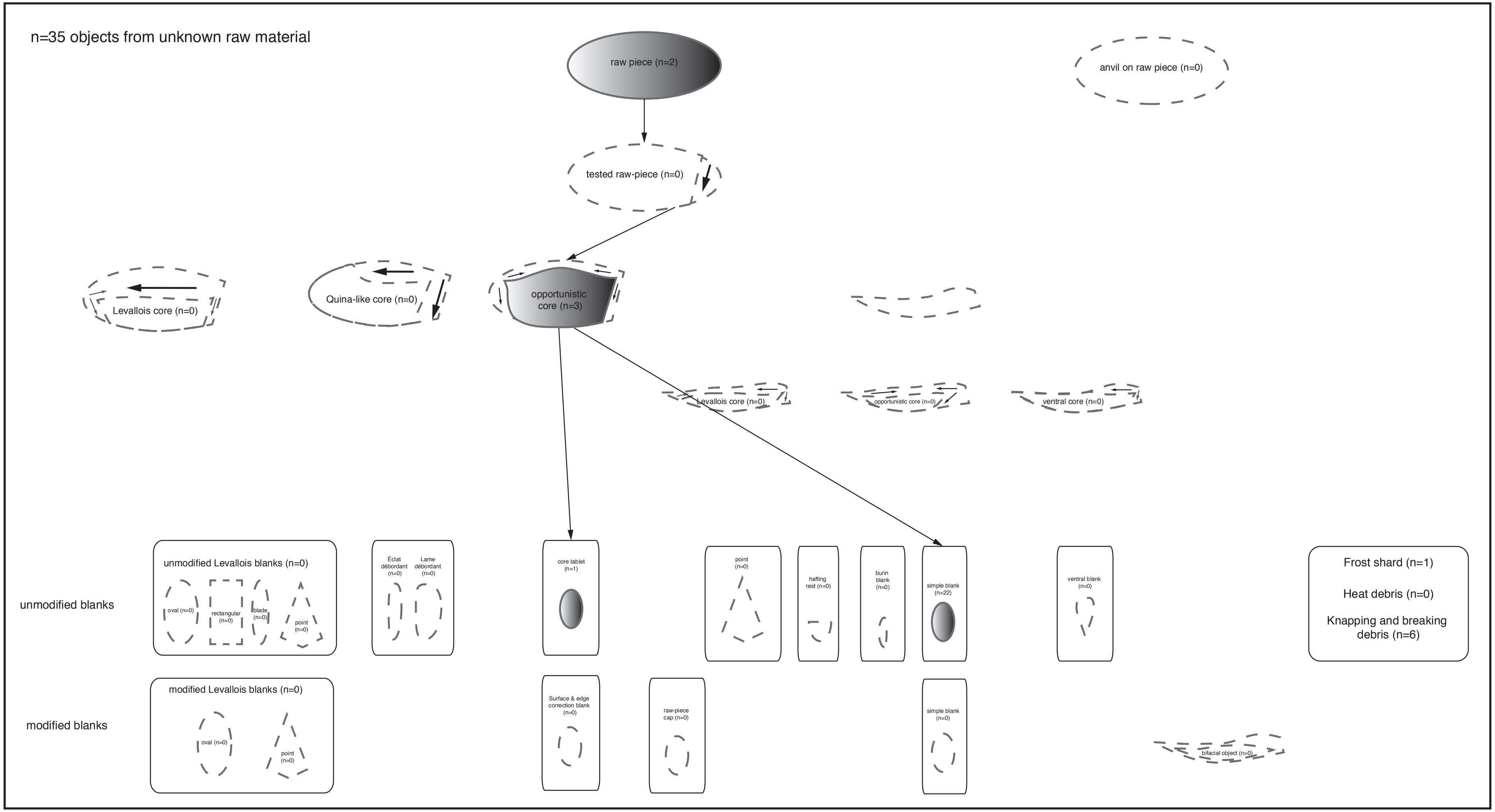

Fig. 382 - Reconstructed reduction sequence for objects made from unknown raw material

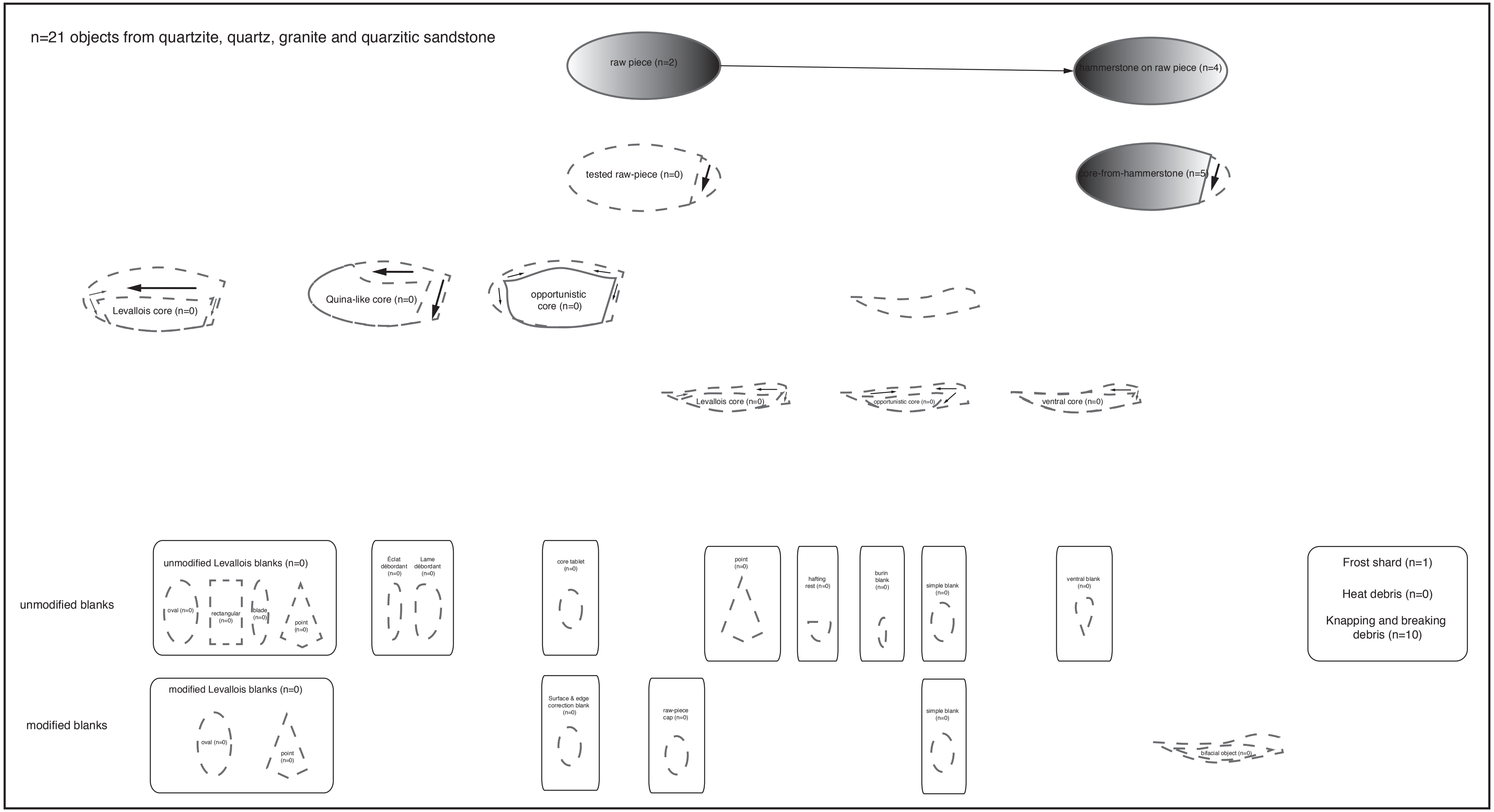

Fig. 383 - Reconstructed reduction sequence for objects made from coarse-grained raw materials

Chapter X: Idiosyncrasies and preferences

"When your head is about to explode, you shouldn't dare call in a psychiatrist because you're about bringing new ideas to world that will later label you a freak." (Michael Bassey Johnson)

X.1 Introduction

The paramount task of this chapter is to describe objects or groups of objects that are „out of the ordinary". In this chapter a combination of object description and interpretative thoughts is used. It combines interpretations about production sequences, possible function, the „spirit" of an objects, the purposes of production and use, as well as the outstanding character.
At first the combination of blank-production concepts is discussed (sometimes also called ramification), followed by observations about import, workpieces, breakage mechanics, hafting and double patination. After that, sections follow that discuss hammerstones, anvils, containers and de-conceptualized cores.

X.2 Combination of blank-production concepts

X.2.1 Overview

If blank-production concepts are seen as mental templates that contain a combination of intrinsic and extrinsic factors for obtaining blanks in a wanted morphology. These concepts can be sorted hierarchically in a chronological order. A concepts using blanks as matrix can only be performed if blanks are obtained. But concepts that change the morphology of the matrix for shaping the core nearly completely, such as Levallois, can be performed on different matrices. Here, a remarkable issue is the use of ventral faces on blanks for planimetric reduction to fulfill the Levallois concept. In using blanks as matrix, the shaping of complete surfaces of the blanks is not necessary. A cortical and convex dorsal face, or the bulb region of the ventral face are usable as existing convexities. These convexities can be extended and enlarged.
The use of blanks as matrix for Levallois cores is known from many other Middle Paleolithic assemblages and was for example described by Boëda (1994) for cores from the assemblages of Corbehem. He also describes the „*initialisation de type Kombewa*" as possible solution for the use of a volume for core reduction (Boëda 2013: 115) and describes ventral reduction of blanks from Barbas C'3 (core of the type D1). Later on (Boëda 2013: 146ff), he describes the used reduction on Levallois cores, but without clearly demonstrate the matrix used for cores (from the pictures, some of the displayed cores can have a blank as matrix).
Other examples are described from El Esquilleu, Cantabria (Cuartero et al. 2015). They describe for instance a Levallois-like core made from a quartzite blank (Esquilleu'01 - Niv XVII - JIOB - no 403) showing a cortical dorsal face and some removal negatives on the ventral face. Arzarello et al. (2012: 571, fig. 3.5) display a flake detached from the ventral face of a blank to configure the reduction surface of a Levallois core-on-blank (see fig. 384).

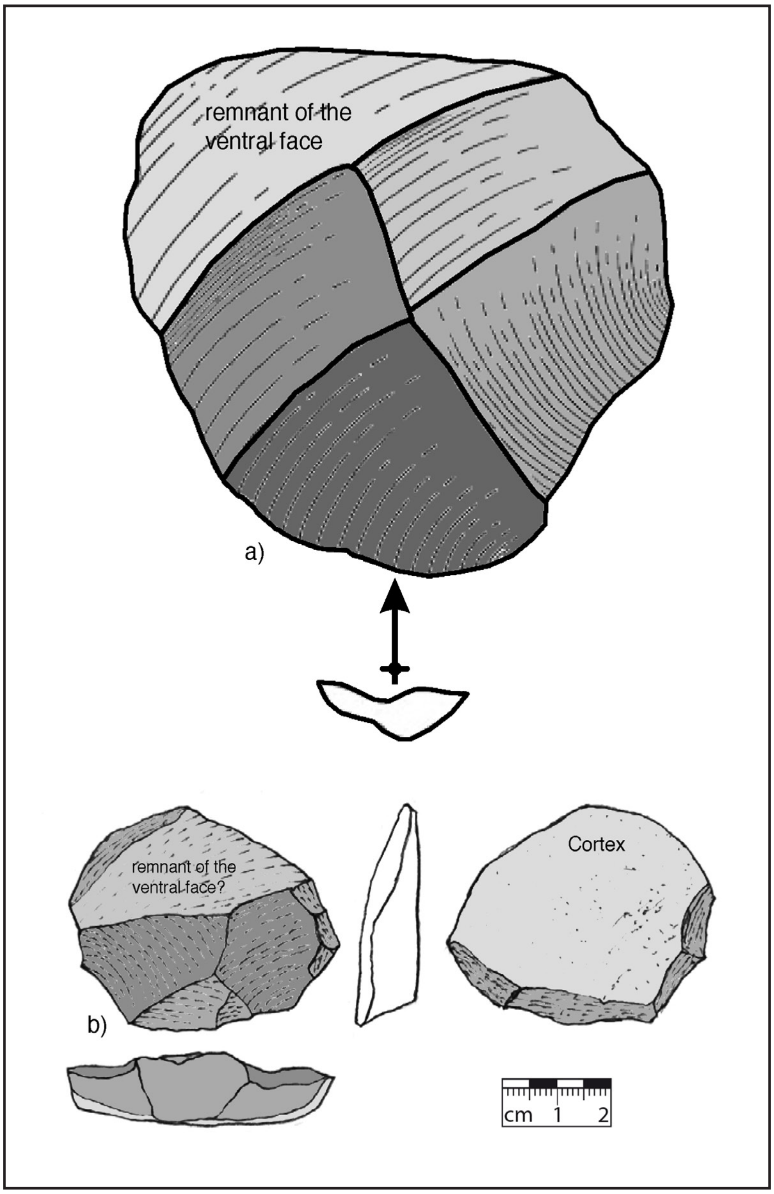

Fig. 384 - Flake and core showing the combination of Ventral reduction and Levallois. a) „Levallois-Kombewa" flake from surface configuration, redrawn from Arzarello et al. (2012: 571, fig. 3.5) and b) Levallois-like core made from quartzite from El Esquilleu (Esquilleu'01 - Niv XVII - JIOB - no 403), redrawn from Cuartero et al. (2015: 119, fig. 6F)

X.2.2 Configuration of blanks to fulfill the requirements of the Levallois concept

In GH 3 and 4 there are n=11 cases for using a blanks as matrix for Levallois reduction (on the other hand, on n=31 the matrix is a raw-piece). On 80% of the Levallois cores made on blanks for GH 3 and 4 the dorsal face possesses remnants of cortex and mostly only the edges are freed from cortex.

This is good evidence for reflections about the way of configuring these blanks. The ideal way would be to select a cortical blank (maybe a raw-piece cap) possessing a completely convex cortical dorsal face (fig. 385a). The initialization step removes cortex on the edges to form platforms from the configuration of the ventral face (fig. 385b). Now, the reduction surface-to-be is configured centripetally, circumferential around the bulb, for extending the convexity given by the bulb (fig. 385c). After this one or more platform(s) is/are formed; a nearly circumferential for centripetal reduction or one or more spots for other reduction schemes (fig. 385d). Now, the production of wanted blanks can start. At first, for example, the removal of a central (preferential) flake that use nearly the entire convexity (fig. 385e), followed by lateral removals in different schemes (fig. 385f).

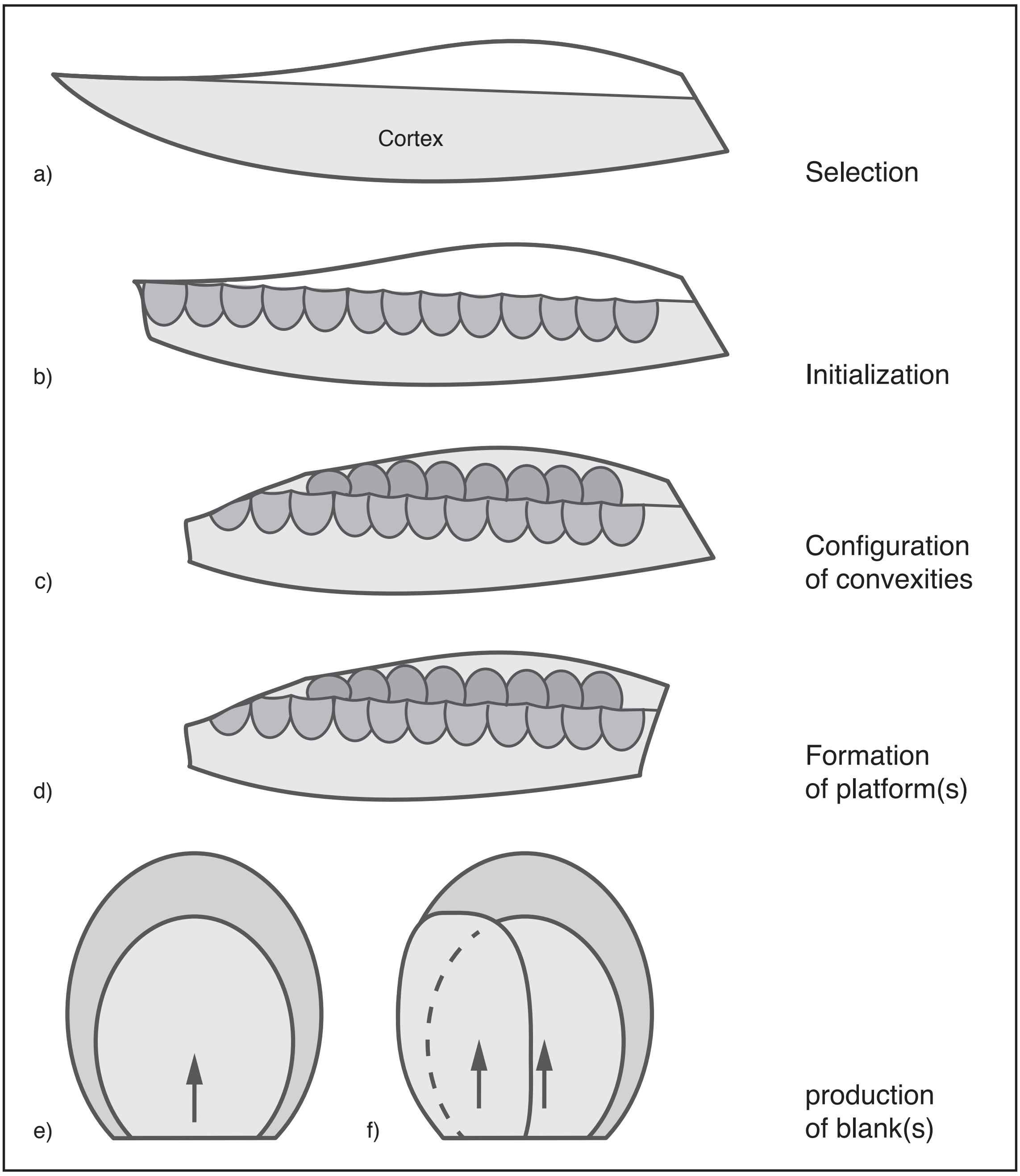

Fig. 385 - Idealized scheme for initialization, configuration and reduction of blanks from the ventral face of a blank following the Levallois concept. a) Selection of a cortical blank with convex dorsal face; b) Initialization: formation of platforms for configuration; c) Centripetal configuration of the convexity of the reduction surface-to-be; d) Formation of platform(s) for reduction; e) Removal of a central blank and f) Removal of a subsequent blank (a to d - Side view, e and f - Top view)

Interestingly, the amount of ventral blanks (in particular Janus flakes) is very low at VP II. GH 3 and 4 yielded only n=14 flakes that can be clearly denominated as ventral blanks (n=12 from GH 3 and n=2 from GH 4). One reason for that might be that the blanks that removed the bulb region were highly modified and therefore the original dorsal face is not visible anymore.

X.3 Import of individual objects (single pieces)

X.3.1 Overview

Individual objects are lithic pieces without counterparts in the respective assemblage. In the context of the transformation analysis, these pieces are called single pieces (Uthmeier 2004b). Main criteria for the separation are raw-material specifics, as well as the completeness of objects. Concerning the second criteria (completeness), this is true for raw-pieces that show no detachments. The first criterium (raw material specifics) is used for blanks.
In the assemblages of GH 3, 4x and 4, there is evidence for at least n=190 individual objects, including n=174 from GH 3, n=2 from GH 4x and n=14 from GH 4. Only GH 3 and GH 4 yielded blanks that are classified as individual objects (GH 3 with n=61 and GH 4 with n=4, see tab. 278). The refitting attempts from 2010, 2013 and 2015 could not find counterparts for this blanks. The blanks are made from FAS, chert, lacustrine flint, unknown flint and unknown raw material.
The biggest difficulty in finding individual objects is patination. On the majority of lithic objects from GH 3, 4x and 4 the patination is developed in such a way, that the „interior“ cannot be seen. Only in some cases, the interior is viewable. In most of the cases the patination is so dense that only big clusters of whitish, beige and grayish patinated objects could have been formed. These extracted blanks are individual for example in regard to a specific banding under the cortex, the smoothness of the surface, their homogeneity, dots and impregnation. The following tab. 277 gives an overview to these blank in regard to raw-material group:

GH	Raw material	Number
GH 3	FAS	**30**
	Chert	**10**
	Unknown flint	**15**
	Lacustrine flint	**4**
	Unknown raw-material	**2**
Total, GH 3		**61**
GH 4	FAS	**1**
	Chert	**3**
Total, GH 4		**4**
Total, GH 3 and 4		**65**

Tab. 277 - Blanks from GH 3 and 4, classified as individual objects (single pieces)

X.3.2 Individual objects from GH 3

There is evidence of n=174 individual objects from GH 3, including n=91 raw pieces, n=64 blanks, n=18 cores (tested raw pieces) and n=4 debris. The individual character of raw pieces is clear. For the tested raw pieces, no specific counterparts could have been found. The individualized debris includes, one frost shard, a piece of pyrolusite and two debris fragments from a volcanic material. The blanks with individual character are discussed in the following.

Spatiality of individual objects

If all individual objects are plotted (fig. 386), there is no specific spatial cluster visible (the isosurface separates fine-grained and coarse grained raw materials). Individual objects are scattered in all excavated square meters of GH 3, only coarse-grained raw materials (colors of light green to red, see legend in fig. 386) are more clustered than fine-grained materials. This is also visible in side-view. For the moment, it seems that no real distribution pattern of individual objects are present.

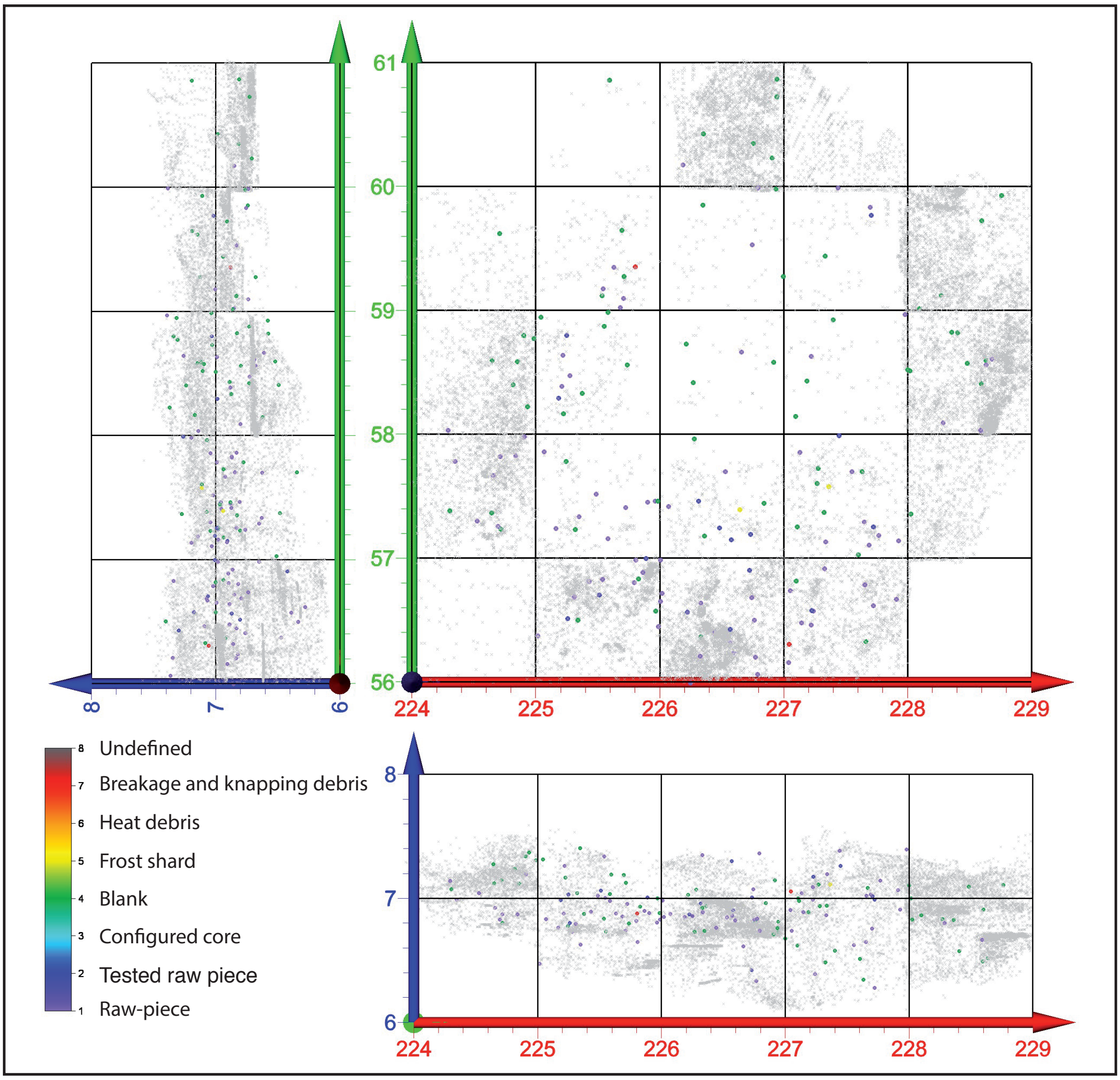

Fig. 386 - Spatial distribution of all individual objects from GH 3

Individual blanks from chert

There are n=10 objects from chert without any overlap in raw-material specifics. Six of them are complete flakes, three are basal fragments and one is a terminal fragment. Eight of these objects are modified after production. There are n=6 Levallois blanks, one bifacial object, one simple flake, one edge correction blanks and one flake with a scraper retouch (the objects are listed in tab. 278 and fig. 387).

Find-number	Matrix	Morphological description	Raw-material description
GER09.228-060.107.1	Flake	Simple flake (unmodified)	Bright brown, many tiny dark-brown points, without cortex
GER10.226-058.66	Flake	Levallois flake with scarper retouch	Gray-green, without cortex
GER10.226-060.215	Flake	Levallois flake with scarper retouch	Bright gray, without cortex
GER10.228-058.176.1	Flake	Surface correction flake (unmodified)	Brown with a dark-grown spot, without cortex
GER11.226-057.95	Flake	Simple flake with scraper retouch	Similar in color to Bergerac flint, without cortex
GER12.226-057.423	Flake	Levallois point with traces of hafting	Bright gray with a calcedony vein, without cortex
GER12.229-059.637	Flake	Levallois flake, Moustier point	Bright gray with micro-fossils, without cortex
GER13.225-059.965	Flake	Levallois flake with traces of hafting	Bright gray, coarse-grained, without cortex
GER13.227-057.1790	Flake	Bifacial object, Fäustel	Bright brown and gray, without thick cortex
GER13.228-057.304	Flake	Levallois point with traces of hafting	Gray with small beige points, without cortex
Total, n=10			

Tab. 278 - List of individual blanks made from chert from GH 3

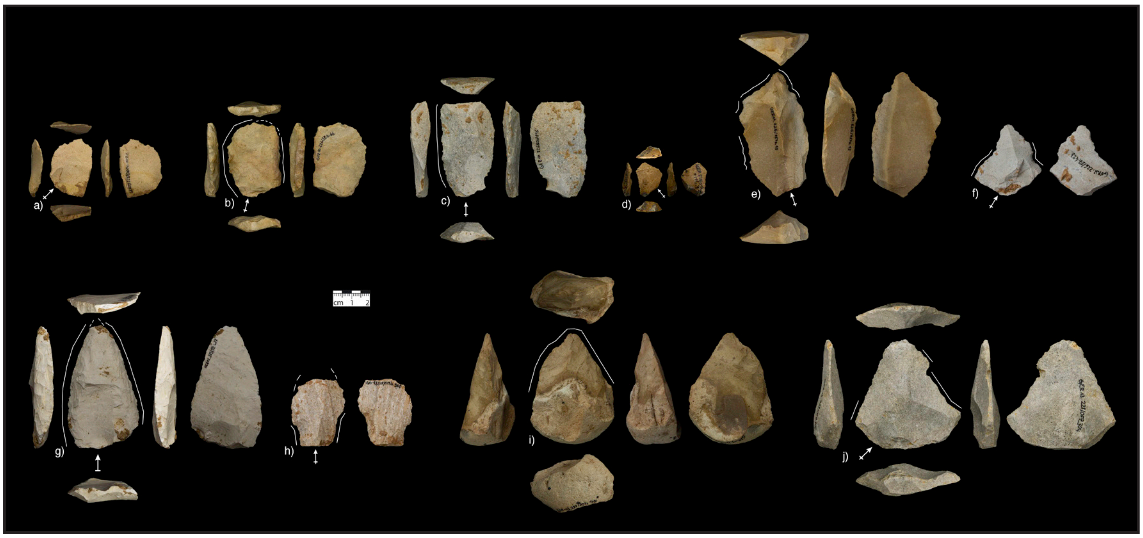

Fig. 387- Individual chert blanks from GH 3. a) Unmodified simple flake (GER09.228-060.107.1); b) Ovaloid Levallois flake with slightly denticulated scraper retouch and backing (GER10.226-058.66); c) Rectangular Levallois flake with scraper retouch (GER10.226-060.215); d) Unmodified surface correction flake (GER10.228-058.176.1); e) Simple flake with pointed tip, concave scraper retouch and possibly traces of hafting (GER11.226-057.95); f) Small Levallois point with possible traces of hafting (GER12.226-057.423); g) Levallois flake with convergent multiphase retouch, removed bulb and dorsally a fluting-like removal negative (GER12.229-059.637); h) Levallois flake with arrowhead-like shouldered hafting possibilities (GER13.225-059.965); i) Bifacial object, small symmetric biface with plano-convex cross-section and plane-to-convex surfaces (Fäustel, GER13.227-057.1790) and j) Levallois point with hafting traces (GER13.228-057.304)

The following fig. 388 shows assumed conditions during import and discard, as well as on-site and off-site activities for individual objects from chert from GH 3.

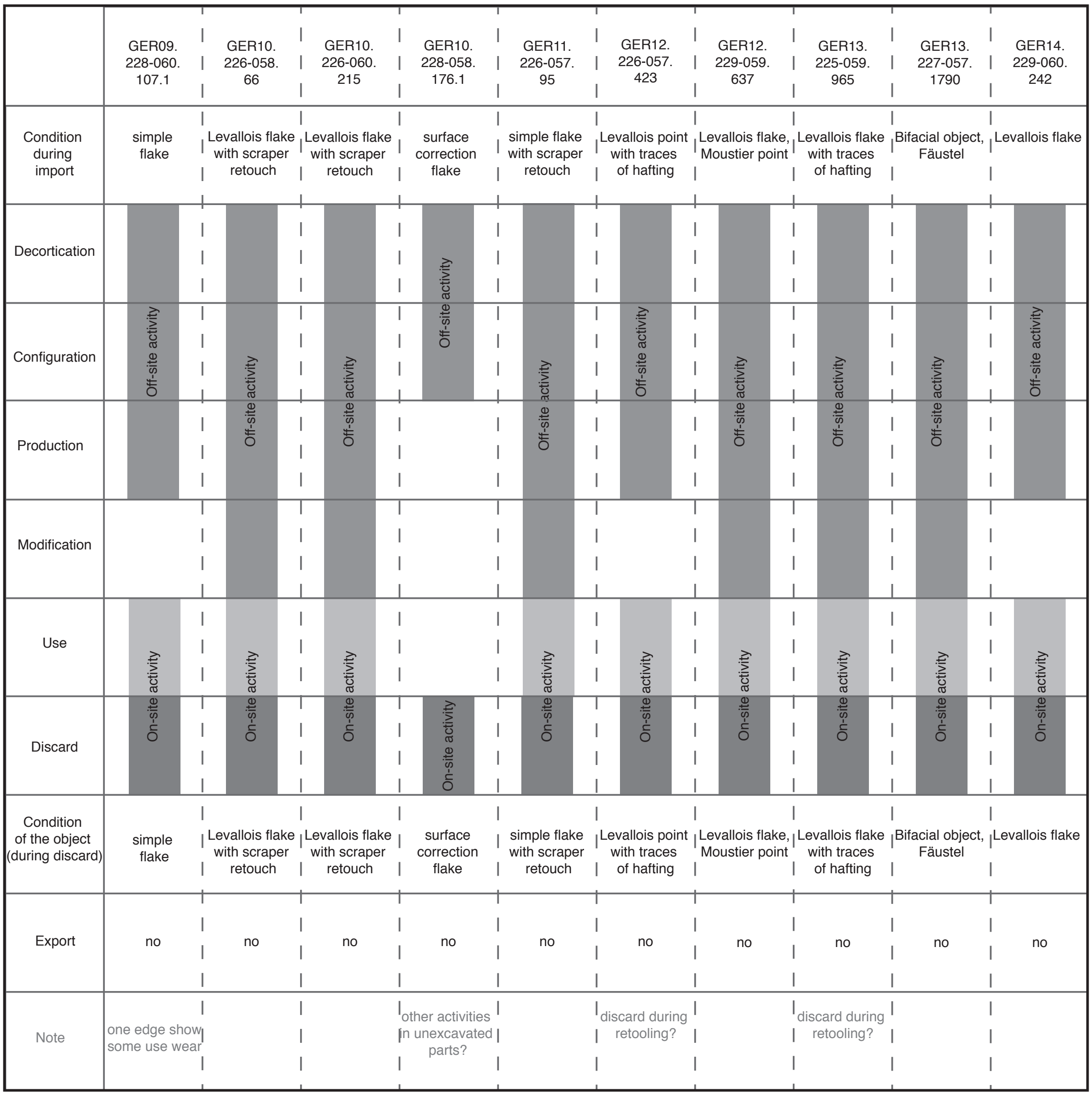

Fig. 388 - Assumed conditions during import and discard, as well as on-site and off-site activities for individual blanks from chert from GH 3

Individual blanks from FAS

In total, n=30 individual blanks made from FAS were detected. There are n=9 complete flakes, n=6 terminal fragments, n=10 basal fragments, one left lateral fragments, one medial fragment and n=3 indeterminate fragments. The bandwidth of blanks is much larger that for chert. It contains one raw-piece cap without a counterpart, n=4 surface correction blanks, n=11 Levallois blanks, n=12 simple blanks (with and without modification), one ventral core with scraper retouch and a citrus-shaped flake with scraper retouch. Over all, n=8 are unmodified and n=22 have modification. Examples of these individual blanks (single pieces) from GH 3 made from FAS are listed in the following tab. 279 and fig. 389.

Find-number	Matrix	Morphological description	Raw-material description
GER12.226-057.415	Flake	Surface correction flake with a slight retouch on terminal left lateral	Ventral face whitish, one big gray spot, many gray points; dorsal face beige with many light brown dots
GER13.225-059.975	Flake	Simple flake with end-scraper retouch	Ventral face is light gray with one dark gray spot; dorsal face is rust-colored (two different patinations)
GER10.226-060.84	Flake	Simple flake with scraper retouch	Brown banding directly under the cortex, ventral face shows a long druse, completely beige impregnated
GER13.225-058.1035	Blade	Terminal fragment of a simple blade with intensive lateral retouch	Three degrees of patination; very smooth cortex, dorsal face show translucent patina and whitish patina; ventral face shows beige impregantion
GER12.229-059.266	Blade	Basal fragment of a Levallois blade with intensive lateral retouch, hafting rest	Gray patination with light gray and dark gray zones
GER10.228-058.134	Flake	Basal fragment of a big Levallois flake, inverse retouch on both lateral edges, hafting rest	Gray patination with light gray and dark gray zones, beige impregnated
GER10.226-060.77	Flake	Basal fragment of a simple flake, terminal with intensive retouch	Beige bandings, some gray-green dots
Total, n=7			

Tab. 279 - Examples of individual blanks (single pieces) made from FAS, from GH 3

Fig. 389 - Examples of individual blanks (single pieces) made from FAS, from GH 3. a) Backed knife (GER12.226-057.415); b) End-scraper (GER13.225-059.975); c) Blank with multiphase retouch (transversal scarper, GER10.226-060.84); d) Blade with concave and denticulated lateral retouch (GER13.225-058.1035); e) Thin Levallois blade with lateral retouch (hafting rest, GER12.229-059.266); f) Thick Levallois flake with lateral retouch (hafting rest, GER10.228-058.134) and g) Basal fragment of a flake with intensive retouch on the terminal end and on the left lateral edge (GER10.226-060.77)

The assumed conditions during import and discard, as well as on-site and off-site activities for examples of individual blanks from FAS from GH 3 are displayed in fig. 390. As no corresponding objects to these blanks were detected, it is assumed that the production and modification of these pieces were conducted off-site. It is also assumed that all of these objects were used for transforming other materials and were possibly discarded during retooling processes.

	GER12. 226-057. 415	GER13. 225-059. 975	GER10. 226-060. 84	GER13. 225-058. 1035	GER12. 229-059. 266	GER10. 228-058. 134	GER10. 226-060. 77
Condition during import	backed knife	simple flake with end-scraper retouch	simple flake with scraper retouch	simple blade with lateral retouch	Levallois blade with lateral retouch and traces of hafting	Levallois flake with lateral retouch and traces of hafting	simple flake with terminal retouch
Decortication							
Configuration	Off-site activity	Off-site activity	Off-site activity	Off-site activity	Off-site activity	Off-site activity	Off-site activity
Production							
Modification							
Use	On-site activity	On-site activity	On-site activity	On-site activity	On-site activity	On-site activity	On-site activity
Discard							
Condition of the object (during discard)	backed knife	simple flake with end-scraper retouch	simple flake with scraper retouch	simple blade with lateral retouch	Levallois blade with lateral retouch and traces of hafting	Levallois flake with lateral retouch and traces of hafting	Levallois flake with lateral retouch and traces of hafting
Export	no	no	no	no	no	no	no
Note		three degrees of patination, made from discarded core?		a tip of a tool, other activities in unexcavated parts? discard during retooling?	discard during retooling?	discard during retooling?	

Fig. 390 - Assumed conditions during import and discard, as well as on-site and off-site activities for examples of individual blanks from FAS from GH 3

Individual blanks from lacustrine flint

There are four blanks classified as lacustrine flint, that probably derive from the northern margin of the Bresse basin (see tab. 280). Interestingly, only one object (GER14.229-060.1316) is intensively modified. The presence of another piece (GER14.229-060.1375) is a clear evidence for surface shaping using soft hammer techniques on this material on site and therefore for production on-site using this „exotic" raw material (see fig. 391). If they all derive from this far distance, the content of imported material from this lacustrine flint could have been much higher and is probably to be found in unearthed parts (or it was exported).

Find-number	Matrix	Morphological description	Raw-material description
GER09.228-059.144.1	Flake	Complete surface correction blank (unmodified)	Fine brown banding
GER14.229-060.138	Flake	Basal fragment of a simple blank (unmodified)	Small fragment with bright and dark streaks
GER14.229-060.1316	Flake	Simple flake with scraper retouch	The raw material of the entire object is intensively banded in bright and dark beige and gray, the bright beige cortex at the butt of the blank is very similar to cortex known on pieces from FAS
GER14.229-060.1375	Flake	Basal fragment of a surface correction blank (unmodified), excellent example of the use of a soft hammer technique	This objects shows a bright beige banding of coarser grains, and darker beige banding with fine brighter banding, the cortex is also very similar to FAS, object is definitely made using soft hammer techniques
Total, n=4			

Tab. 280 - Individual blanks (single pieces) made from lacustrine flint, all from GH 3

Fig. 391 - Individual blanks (single pieces) made from lacustrine flint, from GH 3. a) Simple flake with scraper retouch (GER14.229-060.1316); b) d) Unmodified basal fragment of a (soft hammer) surface correction blank (GER14.229-060.1375) and c) Unmodified basal fragment of a simple blank (GER14.229-060.138)

Individual blanks from unknown flint

There is evidence for at least n=15 individual blanks from unknown flint varieties in GH 3. The blanks are listed in tab. 281 and a selection of them is displayed in fig. 393. As for the other raw material, there are no corresponding feature in regard to raw material. In focusing on three of these objects (fig. 392), the material is fine-grained and homogeneous, but does not correspond to FAS. The tranchet-blow (GER10.226-058.164.2) has in raw-material appearance no correspondence of objects possessing a tranchet-blow negative (therefore no refitting was possible). The Groszak (GER11.225-059.191) show traces of resolution of the raw material, but the circumferential retouch is clearly visible. The Levallois flake was retouched in at least two phases on its terminal end. The raw material (very smooth in the white part and coarser in the yellowish parts, with dots) is absolutely unique, there are no similarities in the entire site. The reconstructed conditions of the blanks is illustrated in fig. 391.

Find-number	Matrix	Morphological description	Raw-material description
GER09.227-059.118.2	Flake	Terminal fragment of a simple flake (unmodified), it could be a tip of a tool	Fine-grained, caramel-brown, opaque, uni-color
GER09.227-059.143.3	Flake	Levallois flake (unmodified)	Beige, brown and ocker, gray dots
GER10.226-058.164.2	Flake	Tranchet-blow blank	Dark-beige, milky
GER10.226-058.220	Flake	Edge correction flake (unmodified)	Bright beige and fine-grained on the lateral edges, the rest is darker and a bit coarser
GER10.226-059.161	Flake	Surface correction flake (unmodified)	Bright beige and white, milky
GER10.227-058.275	Blade	Surface correction flake with scraper retouch	Bright beige
GER10.228-058.423.1	Blade	Simple flake (unmodified)	Dark-gray
GER11.225-059.157	Flake	Simple flake with undefined retouch	Bright-brown and beige, white schlieren and gray dots
GER11.225-059.191	Flake	Groszak	Gray, gray schlieren, milky
GER11.225-060.55	Flake	Levallois flake with scraper retouch	Bright beige, milky, rusty dots
GER12.225-058.108	Flake	Surface correction flake (unmodified)	Greenish-gray, milky, rusty dots, white
GER12.229-059.387	Flake	Simple flake with scraper retouch	Beige-brown and gray edges
GER13.225-058.706	Flake	Levallois flake with end-scraper retouch	White and yellowish-beige with dots, milky
GER13.228-057.254.1	Flake	Edge correction flake (unmodified)	
GER14.227-060.220	Flake	Simple flake (unmodified)	White as porcelain
GER14.227-061.1407	Flake	Simple flake with marginal retouch and borer retouch	Ocher-brown, very smooth
GER14.229-059.3845	Flake	Simple flake (unmodified)	Gray-brown and beige
Total, n=17			

Tab. 281 - Individual blanks (single pieces) made from unknown flint varieties, from GH 3

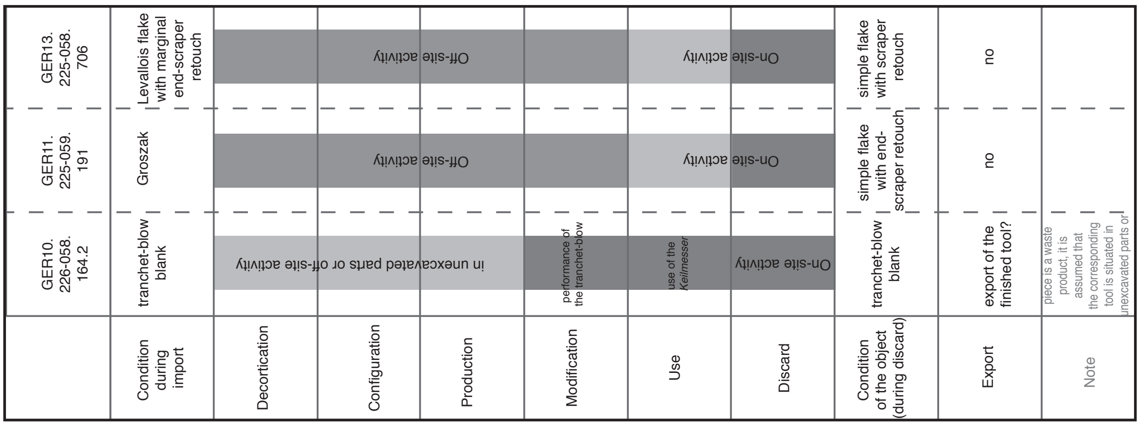

Fig. 392 - Assumed conditions during import and discard, as well as on-site and off-site activities for examples of individual blanks from unknown flint varieties from GH 3

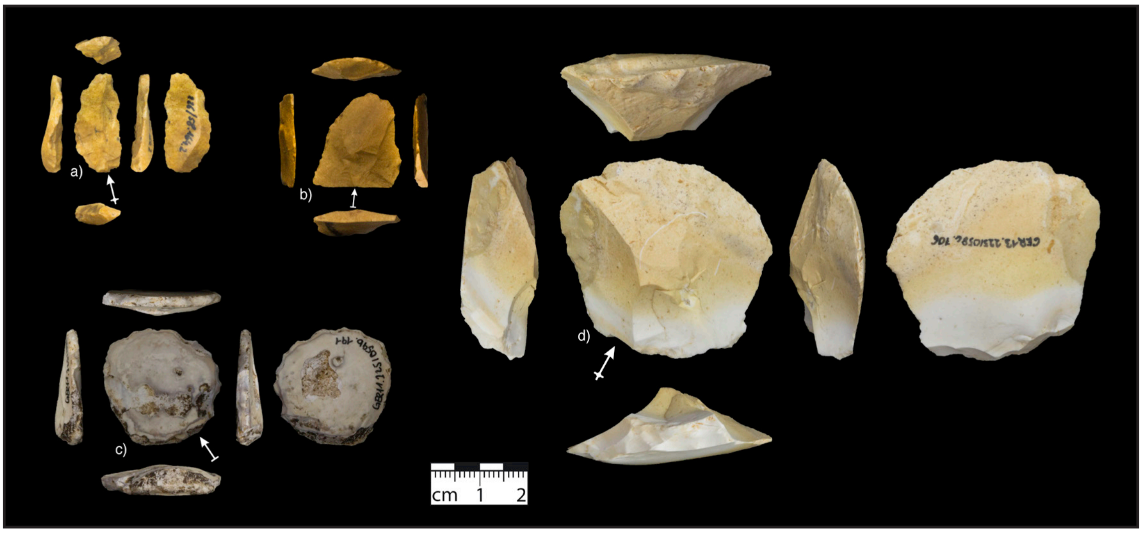

Fig. 393 - Examples of individual blanks made from unknown flint varieties, from GH 3. a) Tranchet-blow blank (GER10.226-058.164.2); b) Terminal fragment of a blank, possibly a tip of a tool (GER09.227-059.118.2); c) Groszak (GER11.225-059.191) and d) Levallois flake with marginal end-scraper retouch (GER13.225-058.706)

Individual blanks from unknown raw material

There are n=3 blanks from a yet unknown raw material that show a distinctive and individual character. The first (GER09.228-059.124.1 , fig. 394a) is flat, trapezoid and show features of soft hammer knapping. It is characterized as surface correction blanks (probably from surface shaping of a bifacial object). The patination is intensive and the surface is smooth and show desilicification. The blank broke during excavation and is also in the interior completely patinated. The second one (GER10.228-058.404, fig. 394b) is also classified as surface correction blank. As modern breaks on the edges show, the objects is also totally patinated. Ventral and dorsal face show banding of white and gray in almost the entire surface. One big negative on the dorsal face is has no banding. The rest of cortex on the but is very similar in appearance to cortex-features of FAS. It is possible that it is a completely patinated and desilicified blanks from FAS.

Fig. 394 - Individual blanks made from unknown raw material. a) Surface correction blank (GER09.228-059.124.1) and b) Surface correction blanks (GER10.228-058.404)

Both blanks posses no modification, such as retouch and are blanks deriving from configuration of cores or from flattening of bifaces. Therefore it is supposed that corresponding blanks are to be found in un-excavated parts, as this blanks represent blanks that are seen as waste products.

X.3.3 Individual blanks from GH 4

There are four blanks that were separated as individuals blanks from GH 4 and all four are Levallois blanks (see tab. 282). Three of them are made from chert and one is from FAS. Fig. 395 shows two of these individual blanks from GH 4. As explained in other chapters, the excavated volume is (compared to GH 3) meager and it is supposed that the entire material from GH 4 is far from being complete. For the moment, these objects must be seen as individual object, but with the background knowledge that only a small part of GH 4 is excavated and the remaining volume might yield corresponding objects.

Find-number	Matrix	Morphological description	Raw-material description
GER09.227-060.169.3	Flake	Right lateral fragment of an oval Levallois flake	Chert, beige, one edge is reddish
GER09.228-060.166.3	Flake	Levallois point	Chert, white and red
GER10.228-059.266.1	Flake	Oval Levallois flake	Chert, green-gray
GER14.228-057.1519	Flake	Oval Levallois flake	FAS, cream-white with gray spots
Total, n=4			

Tab. 282 - Individual blanks from GH 4

Fig. 395 - Individual blanks from GH 4

X.4 Mental workpieces (blanks deriving probably from the same raw piece) from GH 3

X.4.1 Introduction

The formation of workpieces (Uthmeier 2004b) collects data about shared features of lithic objects, with the assumption that the objects should derive from one raw piece (see chapter V.5.6).

X.4.2 Mental workpieces from FAS

The major lithic raw material (FAS) at VP II makes this attempt to find workpieces very challenging. The major reason is the high degree of patination of the pieces. As unintentional breaks of objects demonstrate (almost all derive from the test pit excavation in 2009), the patination hides many features of the raw material appearance and therefore the interior (the fresh material) differs vastly from the exterior (the patination). In general two big clusters of objects from FAS can be made, one with more grayish patination and one with more beige patination. As this probably reflects post-depositional processes we have to disregard many objects from reflexions about workpieces.

At least there are three mental workpieces made from FAS that are left to discuss (refitted workpieces are discussed in the next chapter). One contain four objects, the other three objects that share raw-material features.

Fig. 396 - Mental workpiece 1 from FAS containing four blanks. a) Backed knife (GER09.228-059.133.1); b) Blank with straight scraper-retouch (GER09.228-060.83.3); c) Edge correction blank (GER10.226-058.219) and d) Backed knife from a levalloid blank (GER10.226-059.156.1)

Mental workpiece 1 (mWP1) from FAS

This mentally refitted workpiece contains four blanks. The shared feature of all four is a dark banding directly under the cortex and an orange corona of this banding inside. The patination of all four blanks is not completely the same, but this kind of banding is unique (see fig. 396). Three of the blanks are retouched. All buts are cortical and suggest that all four blanks (if they are made from the raw piece) were detached in an early stage of the reduction process.

Mental workpiece 2 (mWP2) from FAS

The shared feature of these three objects is a doted cortex (see fig. 397). The base of the cortex is dark brown and carry bright beige-whitish dots (mostly in small concavities). This mental workpiece contains two raw-piece caps and a *lame débordante*. The convexity and size of the both raw-piece caps suggest that the raw piece was larger (possibly with a maximum dimension of around 100 mm). The *lame débordante* suggests that the raw piece was configured to a Levallois core. All three pieces are classified as waste products, therefore the rest of the reduction sequence (at least other decortication products) should be present on-site. The cortical features allow to classified them all into a mental workpiece, but no physical connections between them are possible.

Fig. 397 - Mental workpiece 2 from FAS containing three blanks. a) Raw-piece cap (GER12.229-059.356); b) Raw-piece cap (GER13.228-057.443) and c) Lame débordante (GER13.228-057.513)

Mental workpiece 3 (mWP 3) from FAS

The next workpiece contains two blanks wich high similarities in regard to cortex (fig. 398). The cortex is smooth, rolled and has three layers. The exterior layer is bright beige, followed by a medium brown layer and the interior is of darker brown. The pieces could not be refitted. From their morphology at least one blanks should be between both. The first (GER10.226-059.216) is a basal fragment of a blade-like flake possessing cortex on the right lateral edge. The second one (GER10.228-058.353) is also basal fragment and possesses cortex on either lateral edge.

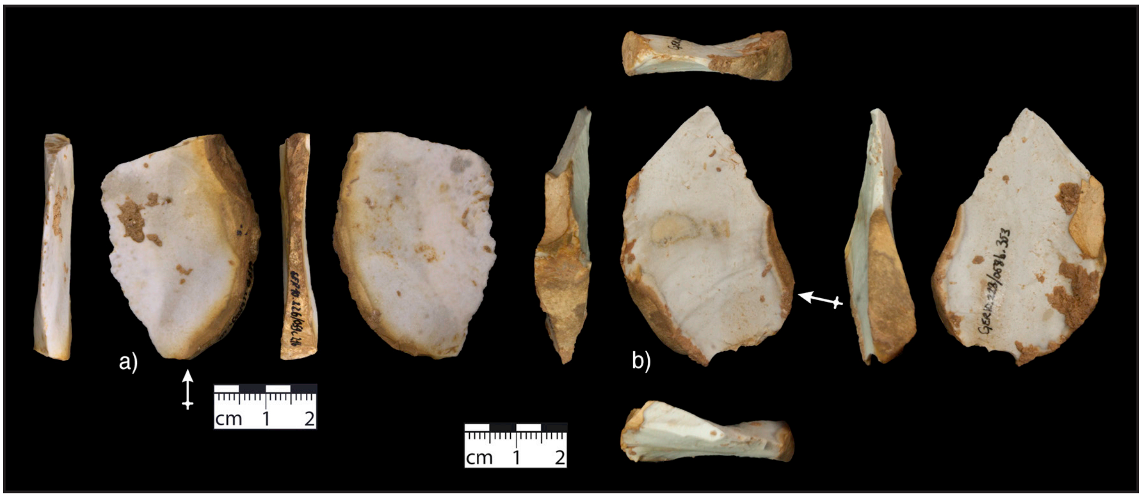

Fig. 398 - Mental workpiece 3 from FAS containing two blanks.a) Basal fragment of a blade-like flake (GER10.226-059.216) and b) Basal fragment of a flake (GER10.228-058.353)

X.4.3 Mental workpieces from chert

Objects made from chert are highly characteristic concerning texture, grain size and abrupt change in color. The formation of workpieces is much easier as for FAS. The total amount of objects from chert is meager and the entire bandwidth of this material in regard to color change or cortex thickness is yet only little known. This lack on knowledge about the bandwidth of this raw material contain the possibility that the mental refitted objects belong to different raw pieces. For that reason, the workpieces of chert are insecure.

Mental workpiece 4 (mWP 4) from chert

The first workpiece of chert contains five blank fragments. The overlap is related to grain size and an abrupt change in color, from gray-green to red (see fig. 399). This workpiece contains two fragments that could be refitted in 2015. The pieces are listed in tab. 283:

Find-number	Matrix	Morphological description	Raw-material description
GER09.227-060.118.1	Flake	Terminal fragment of a Levallois flake, denominated as tip of a tool (refitted to GER12.227-057.695)	Medium grain-size, color change from in gray-green to red
GER10.226-059.214.1	Flake	Terminal fragment of a blank	Medium grain-size, color change from in gray-green to red
GER10.226-059.223.1	Flake	Basal fragment of a blank, the dorsal face is very flat and possesses only one negative	Medium grain-size, color change from in gray-green to red
GER10.227-058.281.1	Flake	Terminal fragment of a blank	Medium grain-size, color change from in gray-green to red
GER12.227-057.695	flake	Basal fragment of a Levallois point (refitted to GER09.227-060.118.1)	Medium grain-size, color change from in gray-green to red
Total, n=5			

Tab. 283 - Objects that belong to mental workpiece 4, made from a gray-green to red chert, from GH 3

The workpiece contains two refitted pieces. The raw material of the other three pieces possesses the same raw material features, but no refits were possible. We would think as they are break-offs (basal and terminal fragments) its is still possible that other pieces of this workpiece are situated in unearthed parts of GH 3. As the biggest blank (GER12.227-057.695) suggests this workpiece is related to Levallois reduction and the non-refitted fragments could belong to blanks of other reductions series of the same core. As no smaller fragments of this characteristic material were found (it is questionable if very small fragments can that clearly referred to this material) it is possible that all (in complete) four blanks are imported as finished ones. Four of the objects belonging to this workpiece are displayed in fig. 399.

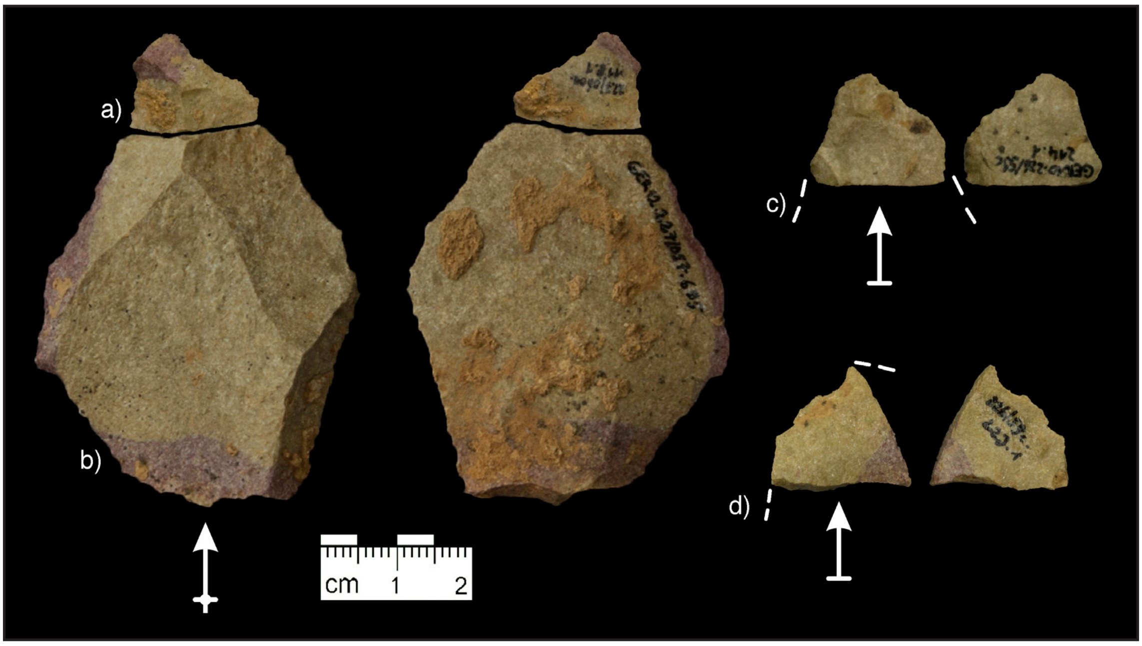

Fig. 399 - Mental workpiece 4 from chert containing five blanks (four are displayed). a) Basal fragment of a flake (GER09.227-060.118.1); b) Basal fragment of a Levallois point (GER12.227-057.695); c) Terminal fragment of a blank (GER10.226-059.214.1) and d) Terminal left lateral fragment of a blank (GER10.226-059.223.1)

Mental workpiece 5 (mWP 5) from chert

The workpiece 5 contains three blanks. The raw material is beige-gray and fine-grained. One blanks possesses a rest of cortex. The pieces could not be refitted. They are displayed in fig. 400 and listed in tab. 284.

Find-number	Matrix	Morphological description	Raw-material description
GER09.227-060.134.4	Flake	Medial fragment of a flake, shapes as a shouldered point, circumferentially retouch	Beige-gray and fine-grained
GER10.226-059.257	Flake	Medial fragment of a flake, left lateral edge is slightly retouched	Beige-gray and fine-grained
GER10.226-060.189	Flake	Terminal fragment of a flake, terminal rest of cortex, one dorsal negative is a fissure surface	Beige-gray and fine-grained
Total, n=3			

Tab. 284 - Objects that belong to mental workpiece 5, made from a beige-gray chert, from GH 3

The series of object is to small to contemplate about related reduction sequences. Interestingly, one piece is complete edge retouched (GER09.227-060.134.4) and it is shape close to a shouldered point.

Fig. 400 - Mental workpiece 5 from chert containing three blanks (unfortunately, only one is displayed (GER09.227-060.134.4)

X.4.4 Mental workpiece 6 (mWP 6) from unknown flint

The first workpiece from an unknown flint variety contains two blanks. The raw material is homogeneous and bright beige and on both very similar to each other, but no refitting was possible. The bigger blank (GER09.227-059.143.3) has a levalloid character and is displayed in fig. 401. The smaller piece is a terminal end of a surface correction blank (GER13.225-058.946)

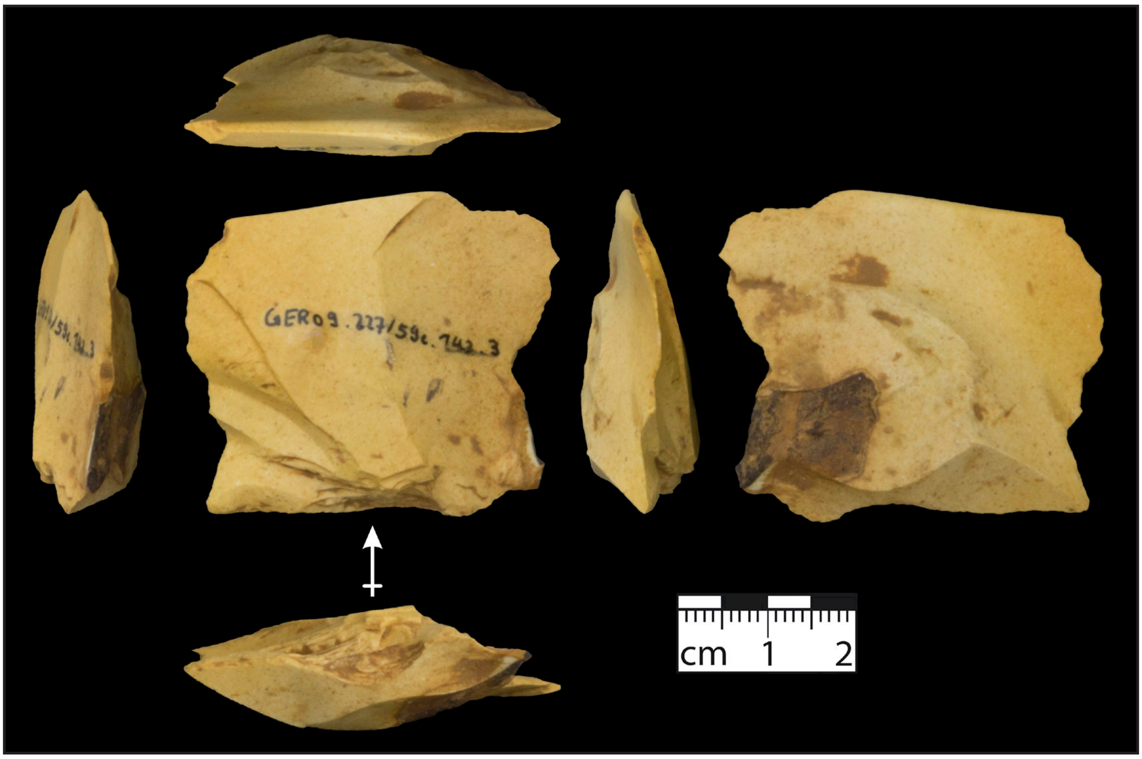

Fig. 401 - Mental workpiece 6 from unknown flint containing two blanks (unfortunately, only one is displayed (GER09.227-059.143.3)

X.5 Physically refitted workpieces

X.5.1 Introduction

GH 1 to 4 contain n=41 lithic objects that could be refitted. Refitting attempt were undertaken in 2010, 2013, 2014, 2015 and 2016. The refitting session of 2010 (student class of 10 times for 4 hours) was the longest. In average around 5 people tried to refit the material from GH 3 and 4 from the campaigns 2009 and 2010. The attempts of 2013 and 2014 were short-time for some hours. The session in 2015 was undertaken by 2 people for 3 weeks (5 hours a day). During excavation, obvious refitting of spatial close objects was done immediately.

There was a quite low success of all these refitting sessions. There is evidence for n=41 lithic objects integrated in proofed lithic refits, from a total of n=7.122 databased lithics from all GHs. These reflect only 0.57% of the assemblage.

The following text describes the important refits of all of these sessions in total (excluding recent breaks) and the following tab. 285 lists all five possibilities (including recent breaks) of refits:

Refit type	Description	Number of this refit type	Literature
Refit of objects from a production-sequence (production sequence refit)	Refitting of core and corresponding blanks, or blanks in succession	**9**	Cziesla 1990, Schurmans 2007
Refit of broken objects (break refit)	Refitting of breaks, such as trampling, sediment movement, or use	**5**	Cziesla 1990, Schurmans 2007
Refit from modification (modification or resharpening refit)	Refitting of a modification blanks on the correspon-ding tool, such as burin and burin spall	**0**	Cziesla 1990, Schurmans 2007
Refit of recent breaks	Refitting of breaks that happened recently, such as during the excavation	**5**	
Refit of thermal fracturing (thermal refit)	Refitting of fragments that broke apart because of thermic influence, such as heat debris or frost shards	**1**	De la Torre et al. 2012
Total, n=5		**16**	

Tab. 285 - Refit types and number of refits from all GHs at VP II

All refits from production sequence, breaks and thermal fracturing are listed in the following tab. 286.

Number of the physical workpiece (phWP)	Raw material	Type of refit	involved objects
1	FAS	Production sequence refit	GH3, GER10.226-059.224 (raw-piece cap) GH3, GER10.228-058.255 (raw-piece cap)
2	FAS	Production sequence refit	GH3, GER09.228-060.80.2 (raw-piece cap) GH3, GER09.228-060.80.4 (raw-piece cap)
3	Quartzite	Break refit	GH3, GER10.226-058.126 (core-of-hammerstone) GH3, GER10.226-058.127 (flake-from-hammerstone)

4	Chert	Production sequence refit	GH3, GER10.226-059.203 (Levallois core) GH2, GER10.226-060.52 (Levallois blade)
5	Chert	Production sequence refit	GH3, GER12.225-059.911 (tested raw piece) GH3, GER12.229-058.234 (raw-piece cap)
6	Quartzite	Break refit	GH3, GER12.225-059.892 (core-of-hammerstone) GH3, GER12.225-059.893.1 (flake-from-hammerstone) GH3, GER12.225-059.893.2 (flake-from-hammerstone)
7	Chert	Break refit	GH1, GER10.225-059.2.5 (left lateral fragment of a Levallois flake) GH1, GER10.225-060.23.2 (right lateral fragment of a Levallois flake)
8	Chert	Break refit	GH 3, GER09.227-060.134.1 (terminal fragment of a blade) GH 3, GER09.227-060.134.2 (basal fragment of a blade)
9	Chert	Break refit	GH 3, GER09.227-060.118.1 (terminal fragment of a Levallois point) GH 3, GER12.227-057.695 (basal fragment of a Levallois point)
10	FAS	Thermal refit	GH 4, GER09.228-059.153.6 (frost shard) GH 3, GER10.226-060.207 (debris)
11	FAS	Production sequence refit	GH 3, GER12.227-057.535 (raw-piece cap) GH 3, GER12.227-057.541 (opportunistic core)
12	FAS	Production sequence refit	GH 2, GER10.225-060.20.1 (opportunistic core) GH 1, GER10.228-058.17.1 (raw-piece cap)
13	FAS	Production sequence refit	GH 3, GER15.229-060.1687 (debris) GH 3, GER15.229-060.1688 (terminal fragment of a flake)
14	FAS	Production sequence refit	GH 3, GER09.228-060.80.5 (raw-piece cap) GH 3, GER10.226-060.87 (basal fragment of a flake)
15	FAS	Production sequence refit	GH 3, GER12.229-059.181 (basal fragment of a Levallois flake) GH 3, GER12.229-059.182 (right lateral fragment of a flake)
Total, n=15			

Tab. 286 - List of all production sequence, breaks and thermal fracturing refits from GH 1 to 4 from VP II

X.5.2 Physically refitted workpiece 1 (phWP 1) from GH 3

The first described refitted objects derive from a production sequence (see fig. 402a). It contains two blanks from FAS. The bigger one (GER10.226-059.224) is a raw-piece cap with one old neocortical negative and one negative of a former small former removal. The punctuated platform might be an evidence that this blanks was removed quite early in the reduction sequence (non-installed platform on a core). The second blank is much smaller than the first, but the terminal end possesses rest of cortex. From the position of the cortex (end of the core) and the size of the blank, this might be evidence for being detached from a small and exhausted core and therefore the raw piece should have been small.

X.5.3 Physically refitted workpiece 2 (phWP 2) from GH 3

This refit also derives from a production sequence (fig. 402b). Two raw-piece caps from FAS were refitted (GER09.228-060.80.4 and GER.228-060.80.2) and derives from a bigger raw piece. Both platforms are free of cortex, therefore they are not the first removed blanks in the decortication process. Both blanks are part of the same collective find. This suggests that their spatial position was very close to each other.

X.5.4 Physically refitted workpiece 3 (phWP 3) from GH 3

The next workpiece contains a core-of-hammerstone (GER10.226-058.126) and the corresponding flake (GER10.226-058.127) made from quartzite (fig. 402c). This refit was named as part of a reduction sequence, because from the position of the flake, it should have been detached intensionally. The core-of-hammerstone shows use-wear from knapping and abrasion. Although the raw material is coarse-grained, the bulb and the corresponding negative is clearly visible.

X.5.5 Physically refitted workpiece 4 (phWP 4) from GH 3

This workpiece is exceptional (see fig. 402d). It is a production sequence and contains two pieces, a flat core (GER10.226-059.203) and a corresponding blade (GER10.226-060.52.1) from a chert variety. After the detachment of the blade, the core was reduced in length. The raw material of these both pieces is very unique, but other objects of this material could not be detected.

X.5.6 Physically refitted workpiece 5 (phWP 5) from GH 3

This workpiece (see fig. 402e) contains a core (tested raw piece) from a small nodule of FAS (GER12.225-059.911) and a corresponding basal fragment of a raw-piece cap (GER12.229-058.234). This refits shows that decortication took place on-site. The cortex of both pieces is rolled and signals a fluvial source for the raw-piece (the creek nearby?).

X.5.7 Physically refitted workpiece 6 (phWP 6) from GH 3

The next refitted workpiece (fig. 402f) is a core-of-hammerstone (GER12.225-059.892) and two corresponding flakes (GER12.225-059.893.1 and GER12.225-059.893.2). As the negative on the core suggests another flake is missing.

X.5.8 Physically refitted workpiece 7 (phWP 7) from GH 1

This refits consists of two flake fragments from chert (fig. 403a). Both probably broke during knapping in an axial way (Siret break, GER10.225-060.23.2 and GER10.225-059.2.5). On the original flake another additional flake fragment is missing.

X.5.9 Physically refitted workpiece 8 (phWP 8) from GH 3

This workpiece consists of a basal (GER09.227-060.134.2) and terminal (GER09.227-060.134.1) fragment of a chert blade (fig. 403b). There are no corresponding objects of this specific variety of chert.

X.5.10 Physically refitted workpiece 9 (phWP 9) from GH 3

The workpiece 9 is also part of the mentally refitted workpiece 4. Here, a terminal fragment (tool tip, GER09.227-060.118.1) and a corresponding Levallois point (GER12.227-057.695) are refitted (fig. 403c). The break-off of the tip happened probably during use

X.5.11 Physically refitted workpiece 10 (phWP 10) from GH 3

This workpiece is refitted from two thermic fragments (fig. 403d, frost shards, GER09.228-059.153.6 and GER10.226-060.207). They broke because of a druse. These two refitted objects are the only one (up to now) with a big difference in Z-value (6.88 to 6.52) that contradicts the hypothesis of a layered sedimentation in GH 3. But is has to keep in mind that one piece was regularly excavated (GER10.226-060.207) and the other derives from the test pit excavation in 2009 (GER09.228-059.153.6). The test pit excavation was fast dug and therefore a certain degree of sediment mixture is not impossible.

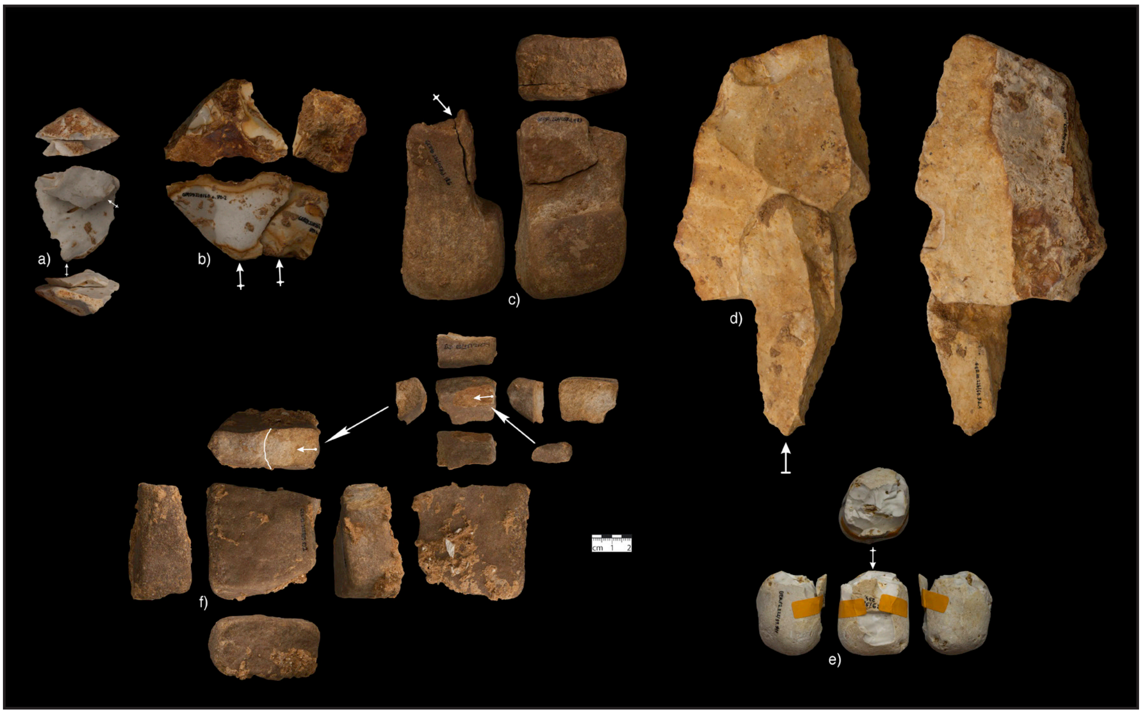

Fig. 402 - Physically refitted objects from production-sequences (blank-on-core or blank-on-blank) from GH 3. a) phWP 1, production-sequence refit (GER10.226-059.224 and GER10.228-058.255); b) phWP 2, production-sequence refit (GER09.228-060.80.4 and GER.228-060.80.2); c) phWP 3, core-of-hammerstone and corresponding flake (GER10.226-058.126 and GER10.226-058.127); d) phWP 4, core and corresponding blade (GER10.226-059.203 and GER10.226-060.52.1); e) phWP 6, core-of-hammerstone and two corresponding flakes (GER12.225-059.892, GER12.225-059.893.1 and GER12.225-059.893.2) and f) phWP 5, tested raw-piece and raw-piece cap (GER12.225-059.911 and GER12.229-058.234)

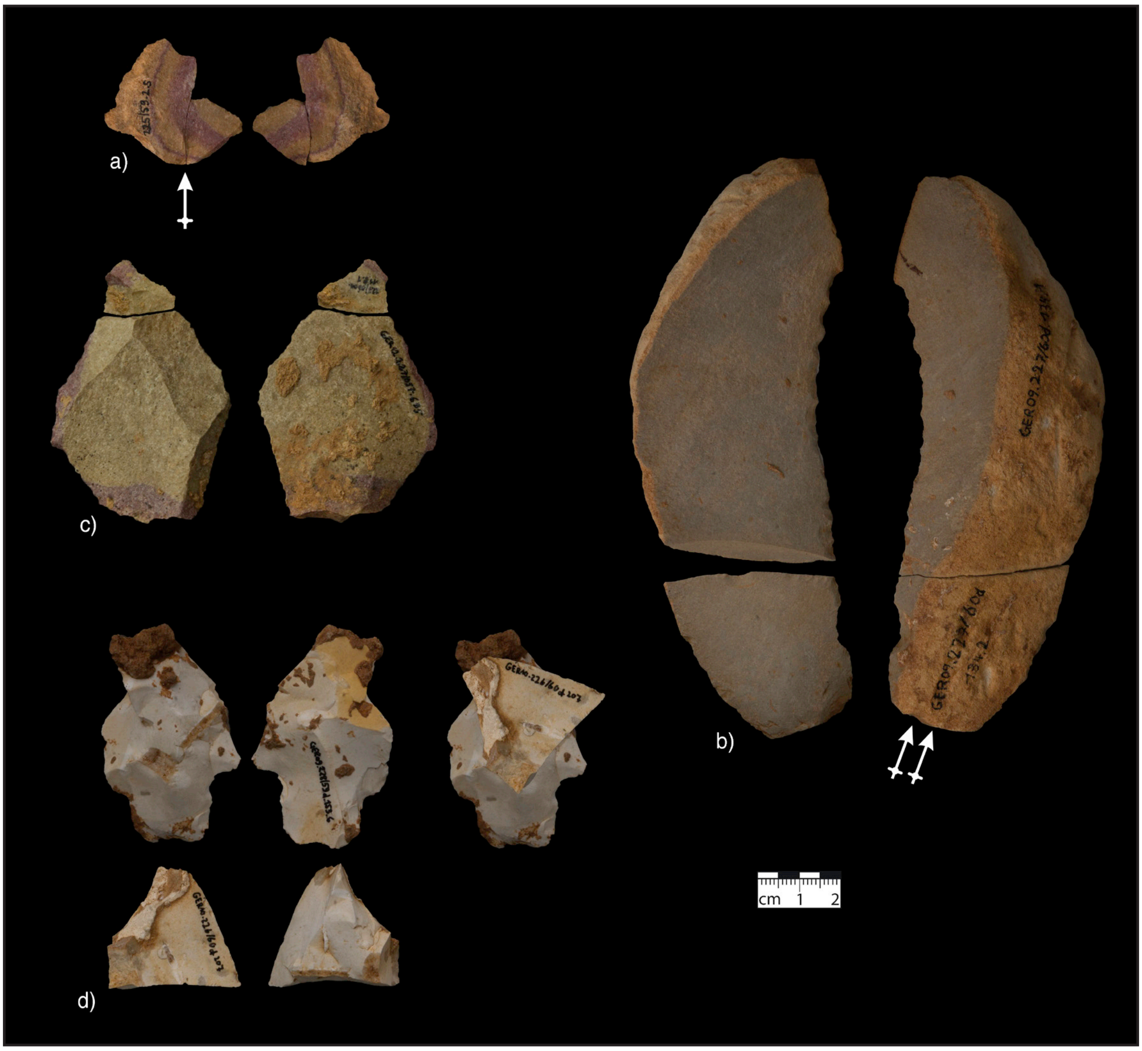

Fig. 403 - Physically refitted objects from ancient breaks (refits of fragments) from GH 3. a) Refit of Siret break (GER10.225-060.23.2 and GER10.225-059.2.5); b) Refit of break (GER09.227-060.134.1 and GER09.227-060.134.2) and c) Refit of a tool tip and a Levallois point (GER09.227-060.118.1 and GER12.227-057.695) and d) Refit of frost shards (GER09.228-059.153.6 and GER10.226-060.207)

X.6 Spatial distribution of the workpieces from GH 1 to 4

The majority of mentally or physically refitted objects is situated in GH 3, but some pieces could be refitted between GHs (see fig. 404). These objects demonstrate diverse aspects. Connections between objects from GH 1 and 2 are due to the mixed character of both GHs. The singular connection between an object from GH 2 and 3 demonstrate that parts of the GH 3 are reworked by animal activities (nominated as GH 2), as it was detected during excavation. The refit between two pieces from GH 3 and 4 is very like due to the fast excavation of the test pit from 2009. The corresponding object from GH 3 was excavated in 2010.

The objects (mentally and physically) refitted from GH 3 demonstrate the affiliation inside this GH. Some spatial observations can be made. On the one hand, most of the workpieces are connected in a horizontal manner. This is more due for the physically refitted objects than for the mentally refitted. In a view to the

North, a slight inclination (higher in the West and lower in the East) is visible. This inclination is not as clear in a view to the West perspective. The top view shows that there are some close-range connection, as well as distances up to 4 meters.

The spatial distribution of mentally refitted objects is in regard to Z-value not free of critique. They scatter in hight much more than physically refitted pieces.

Some aspects might help to make the spatiality of the workpieces much clearer. On the hand, much more intensive refitting attempts to find more connections between pieces (but is has to keep in mind that still only a quarter of the actually volume of e.g. GH 3 is excavated) to establish a much more clearer signal. On the other hand, the interaction between the minor fluviatile and the major aeolian part of the sediment can have led to mixture processes that are far from clearly been understood.

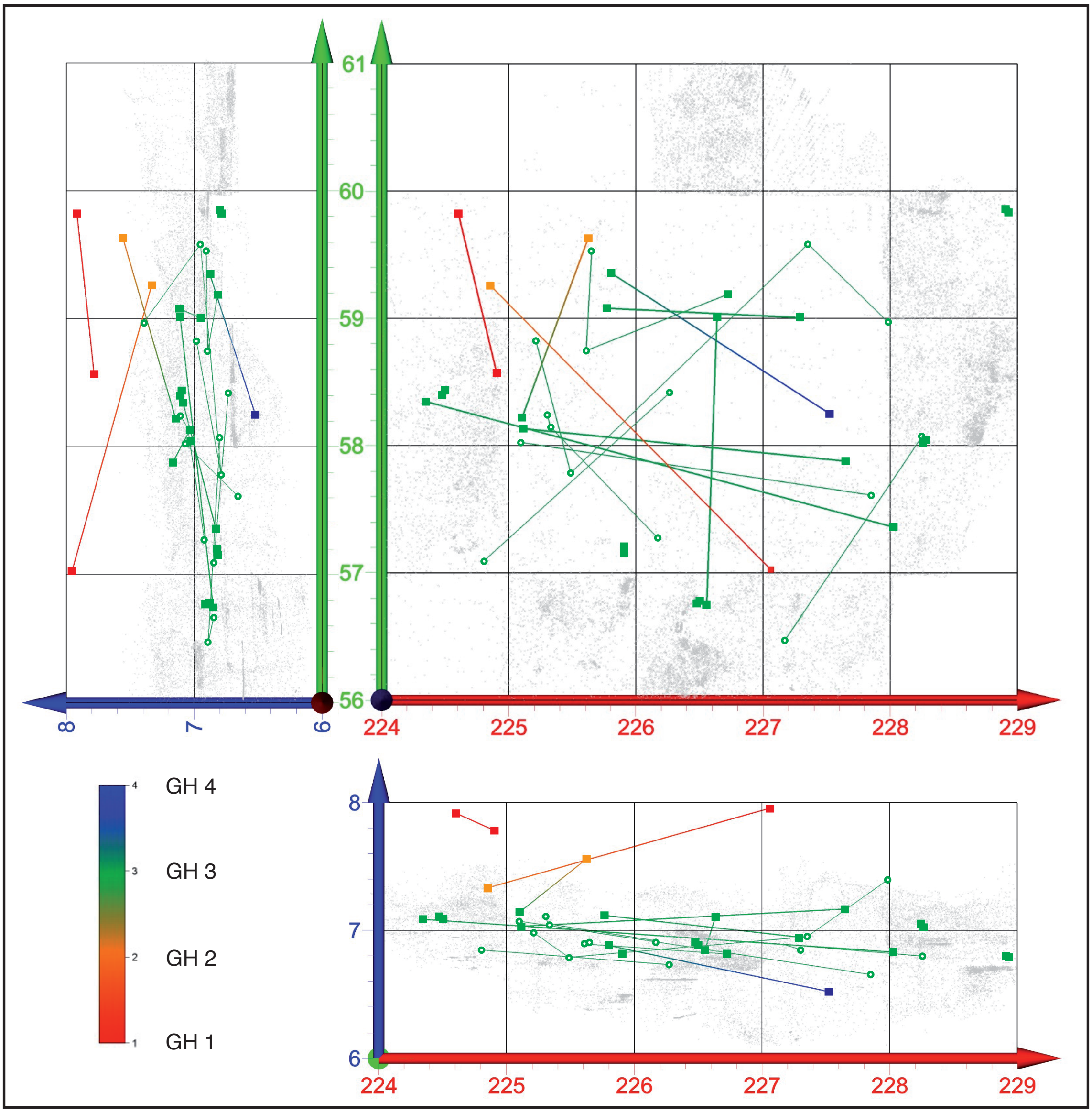

Fig. 404 - Spatiality of workpieces from GH 1 to 4. Circle lines are mentally refitted workpieces, connected with a slim line. Filled squares are physically refitted workpieces, connected with a thick line.

X.7 Import and distances to raw-material sources

X.7.1 Introduction

Geological observations on the site and the close surrounding clearly demonstrate that all lithic raw materials were imported to the site. The distances of transportation differ between different raw material. The difficulty in reliable correlations between nowadays known sources and the presence of specific raw materials on-site is related to the knowledge that the source of some raw material is not punctuated. For instance FAS is almost omnipresent in the surrounding of the site. The source areas of other raw materials instead are much more punctuated.

X.7.2 Distances to raw-material sources

The evaluation of distances between raw material sources and VP II shows four patterns (see fig. 405). The source of lacustrine flint (Mont-les-Étrelles type) has a distance of around 110 km (beeline) in northeastern direction. This material is only present in individual objects (n=4). The Mid-range distances for specific chert types is around 15 km (gray fine-grained chert from Saint-Vallerin, present in one piece, GER09.226-057.423) and 20 km (middle coarse-grained chert with white-banded dots from Culles-les-Roches, present in one piece, GER13.225-059.965). In a distance of around 3 km, there is evidence for different chert varieties in Saint-Martin-sous-Montaigu (coarse-grained, red and beige chert; coarse-grained with red banding and dark-gray with thick cortex). Quartzite and quartz is present in the Orbize creek (distance of around 120 m) and in the Vallée des Vaux (distance of around 4 km). In the direct surrounding of the site, FAS and quartzite and quartz is present.

FAS and quartzite and quartz can be seen as autochthone raw material from the direct surrounding (r < 1 km), chert from Saint-Martin-sous-Montaigu as local raw material from the extended surrounding of the site (1 < r < 5 km). Chert from Saint-Vallerin and Culles-les-Roches is a territorial raw material from the daily foraging radius (5 < r < 20 km). The lacustrine flint from the Mont-les-Étrelles type is an external raw material from outside of the territory. For the moment there is no evidence of allochthonous raw material from in a mid-range distance (20 < r < 40 km). The classification of distances and raw material was taken from Floss (1994) and is displayed for a better overview in the following tab. 287 and in fig. 405:

Distance between VP II and raw-material source	Raw-material type	Raw materials	Territory
Less than 1 km	Autochthone raw material	FAS, quartzite and quartz	Direct surrounding
Between 1 and 5 km	Local raw material	Chert from Saint-Martin-sous-Montaigu	Extended surrounding
Between 5 and 20 km	Territorial raw material	Chert from Saint-Vallerin and Culles-les-Roches	Daily foraging area or territory
Between 20 and 40 km	Allochthonous raw material	No evidence	Extended daily foraging area if auxiliary camps are present
More than 40 km	External raw material	Lacustrine flint of the Mont-les-Etrelles type	Outside the territory

Tab. 287 - Distances between raw-material sources and VP II, type of raw material, raw material of this type and denomination of the territorial area

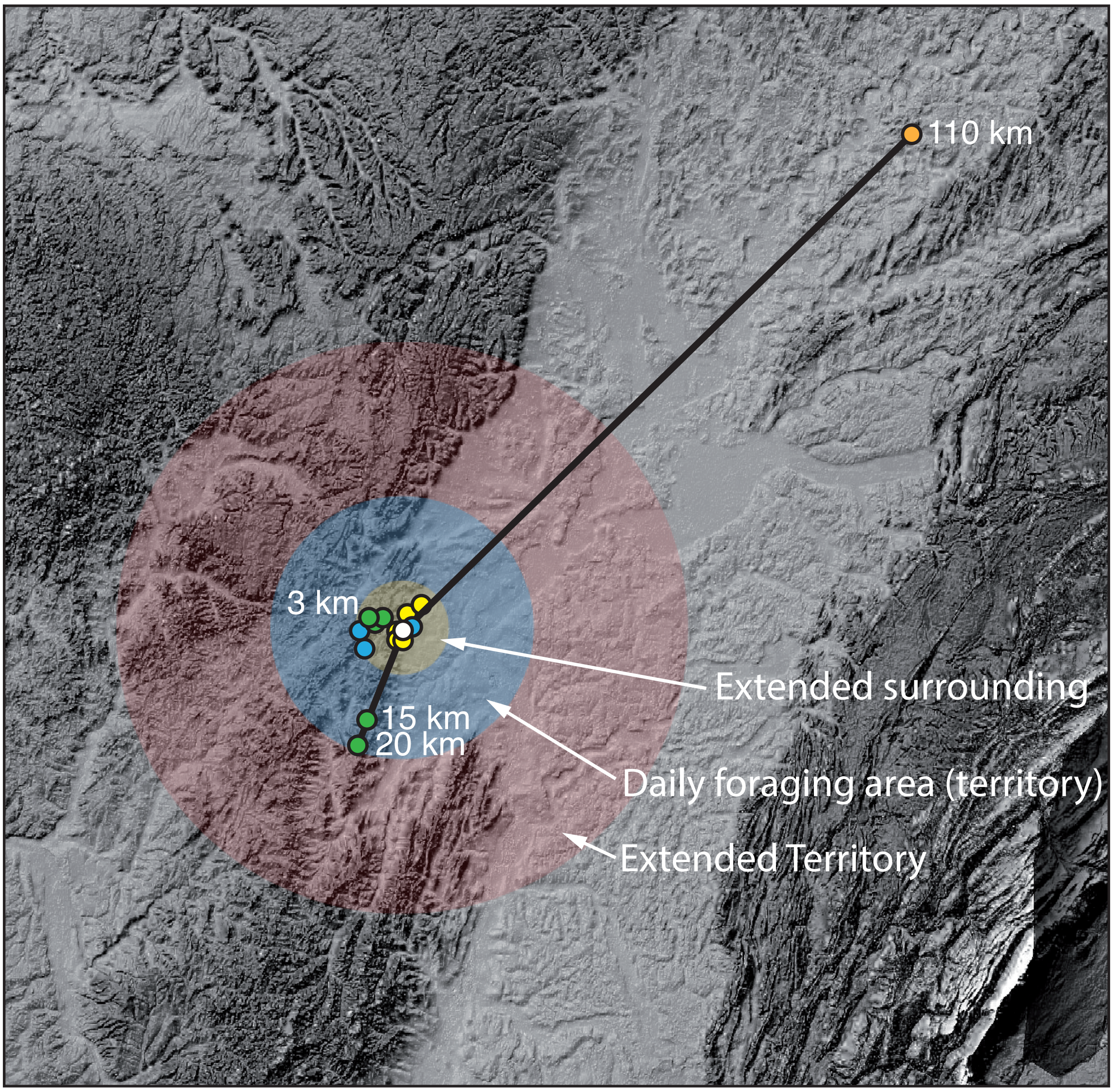

Fig. 405 - Distances between VP II and sources of used raw materials. Base maps: NASA, SRTM 2000

X.7.3 Import of raw pieces

The stratified assemblages of VP II do not derive from one single knapping event. They contain objects that were imported in different reduction stages and some objects could also have been exported. The following section tries to formulated hypotheses about the import, on-site processes and export stages of groups of objects and individual objects. The approach here is guided by works of Floss (1994), Weißmüller (1995), Richter (1997), Uthmeier (2004b), Richter (2005). The previous chapters are the base for interpretations of import processes. Initially, all present objects from silicious lithic raw materials were imported to the site. The following section speculated about the conditions how these objects arrived the site.

The presence of n=114 raw pieces in GH 3, 4x and 4 clearly demonstrates that they were imported without any reduction step before. There is evidence for raw pieces from a vast range of raw materials (e.g., FAS, chert varieties, quartzite, quartz, sandstone). The amount of raw pieces of these three GHs is displayed in fig. 406.

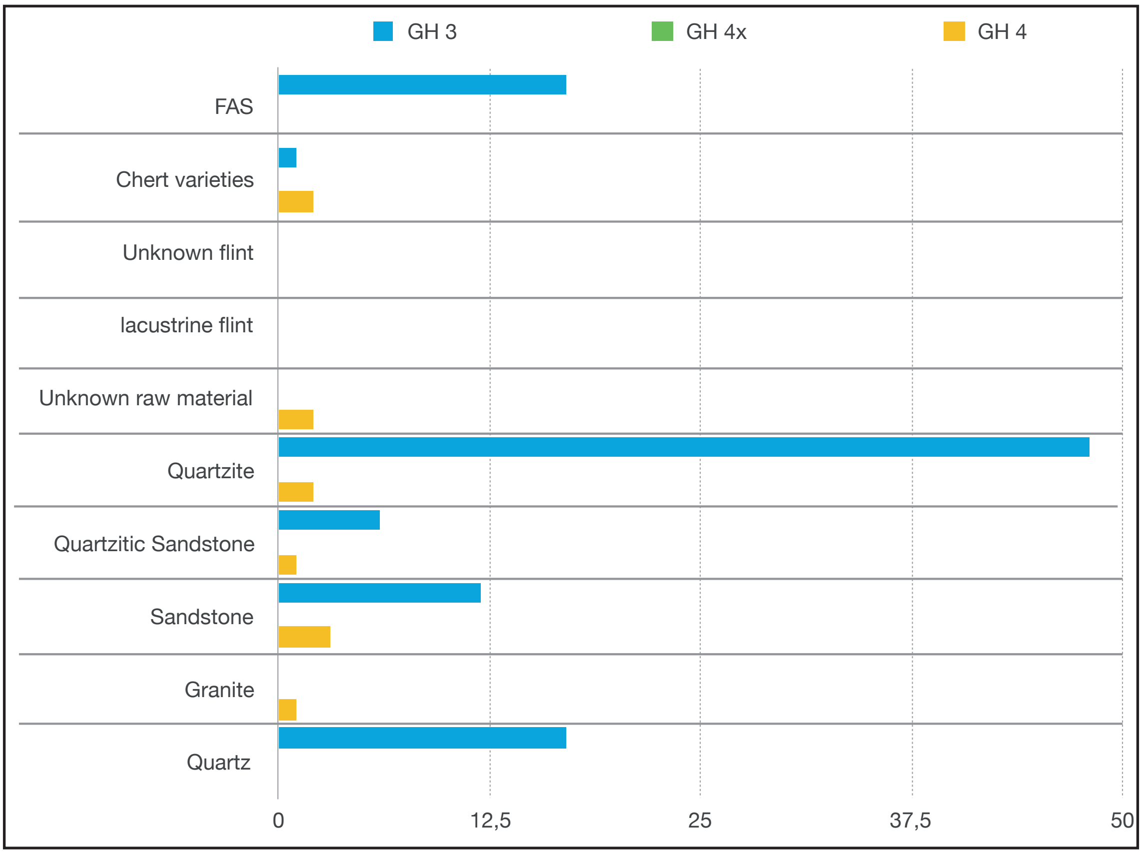

Fig. 406 - Number of raw pieces of each raw material in GH 3, 4x and 4

X.7.4 Import of tested raw pieces

There is evidence for decortication processes on site. At least the n=266 raw-piece caps (from GHs 3, 4x and 4) demonstrate that raw-pieces or tested raw-pieces arrived the site in such a condition that enough cortical parts were left (on tested raw-pieces) to detach these raw-piece caps. There is also evidence from at least n=1507 lithic objects carrying cortex on their surface. Unfortunately, the best example that raw-pieces were tested and decorticated derives from a refit from GH

1 and 2. The following fig. 407 shows that the majority of tested raw-pieces and raw-piece caps derives from the autochthone FAS. Object from chert and lacustrine flint are never present as raw-piece caps or tested raw-pieces. This suggest that objects from this material were imported at least as initialized cores or as finished blanks.

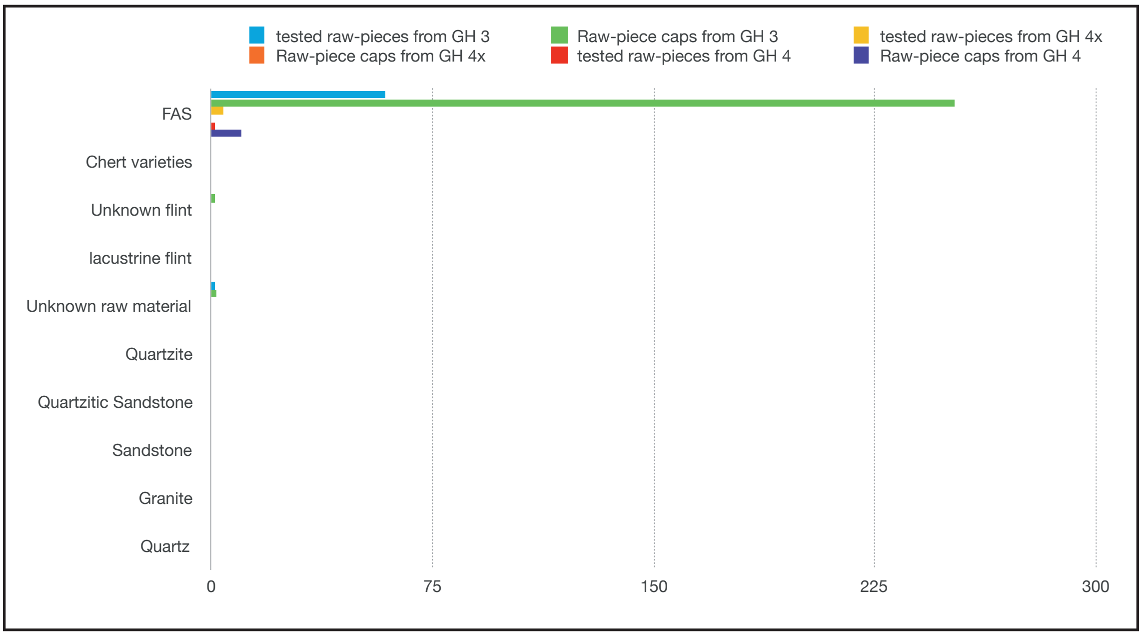

Fig. 407 - Numbers of tested raw-pieces and raw-piece caps from GH 3, 4x and 4

X.7.5 Import of cores after their initialization

GH 3 yield one example of a Levallois core (GER12.227-057.448.2, fig. 408) from an unknown flint that has specific raw-material features and was therefore classified as individual object, as no corresponding blanks were found of this material. This core must be imported as individual object (at least from unearthed parts of GH 3), but without using the core on-site for blank production (the scars are also rolled and rounded). It seems therefore that the core was only imported and discarded. Further evidence for the import of cores that passed the initialization stage is hard to find, because of intensive patination of the majority of lithic objects. Only major campaigns of refitting attempts can give more direct evidence about the correspondence of cores and flakes, as well as between flakes.

X.7.6 Import, use and discard of hammerstones

GH 3, 4x and 4 yielded n=107 objects classified as hammerstones. There are n=54 without detachments (hammerstones on raw pieces) and n=53 with detachment negatives (cores-of-hammerstones). Fig. 409 illustrated the differences in the GHs. GH 3 has the larges bandwidth of raw materials used as hammerstones, and yielded also flakes of this materials that possibly derive from knapping (some might also derive from anvils). The discard of broken hammerstones is comprehensible.

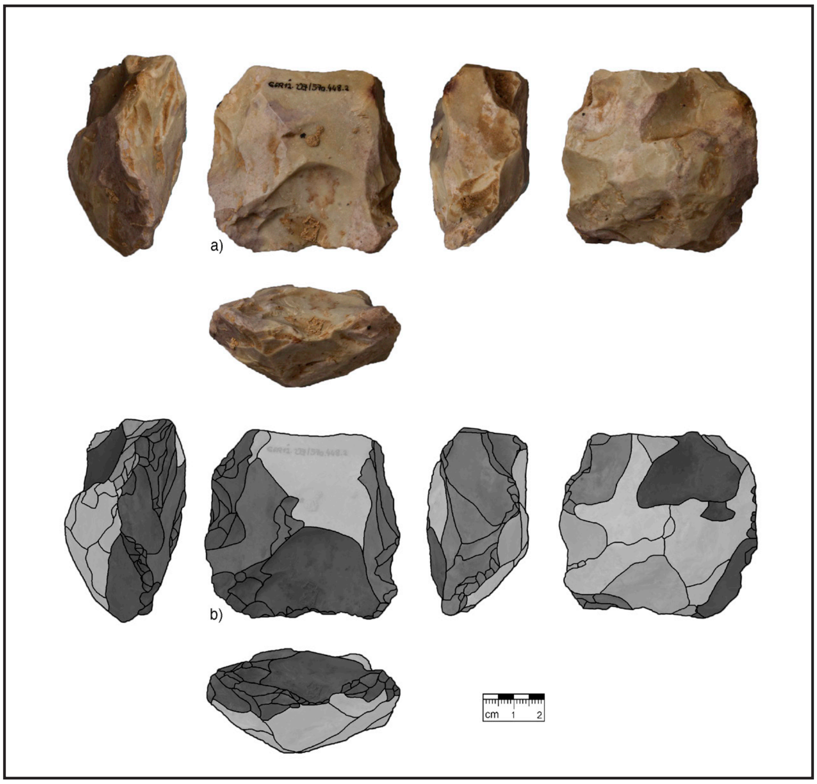

Fig. 408 - Imported and unused discarded Levallois core from GH 3 (GER12.227-057.448.2)

The presence of complete and broken hammerstones, as well as corresponding flakes (including two refittings of flakes on hammerstones from GH 3) is good evidence for the performance of knapping processes directly on-site. The band-width of raw materials (and therefore different features in regard to knapping) illustrates that different knapping techniques were used on site (as it was also illustrated for knapping technique features on blanks).

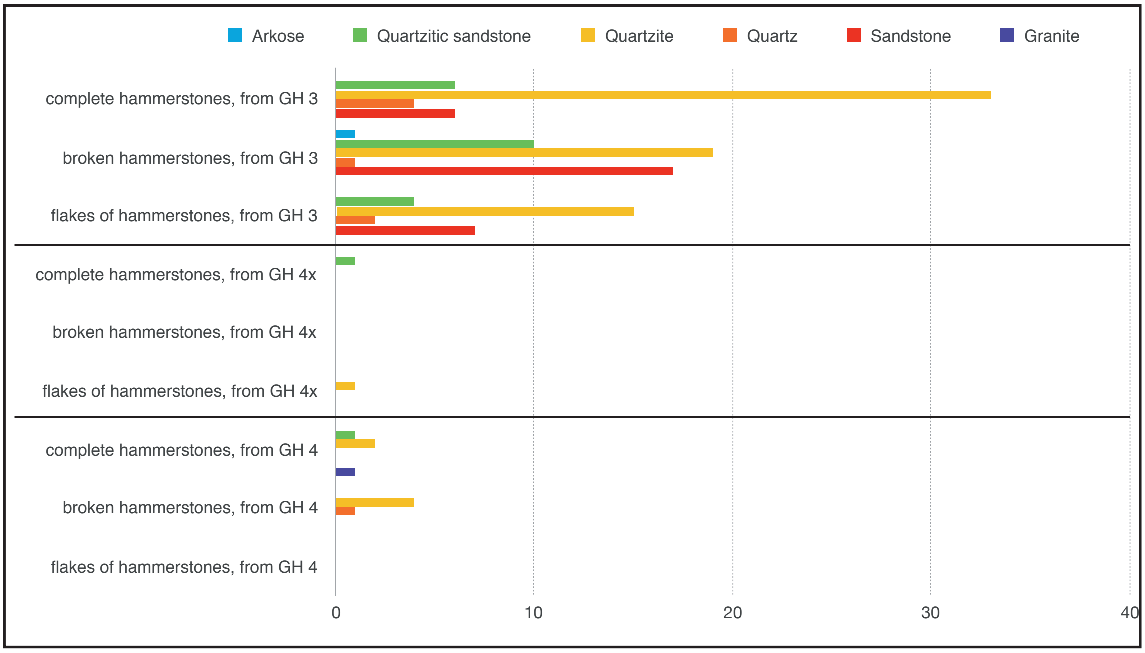

Fig. 409 - Numbers of complete and broken hammerstones, as well as flakes-from-hammerstones from GH 3, 4x and 4

X.7.7 Import of individual blanks

GH 3 yielded n=64 blanks whiteout any corresponding in regard to raw material specifics

Spatial distribution of individual blanks in GH 3

In total, individual blanks are situated in the entire volume of GH 3, but the upper part of GH 3 contains much more of these objects. The majority of these blanks is made from FAS and distributed in the entire excavated volume of GH 3 (see fig. 410a), but with higher density in the western parts of the GH. Individual blanks from chert are much more scattered. The other three materials (unknown flint, lacustrine flint and unknown raw material) are significantly clustered. In regard to blank type, the pattern change. Levallois and ventral blanks are significantly clustered (fig. 410b), as well as raw-piece caps and simple blanks. Correction blanks are situated in the western part and in a spot in the East. Concerning the distribution of modified and unmodified blanks, a binary division is visible (see fig. 410c). Modified objects are present in the western part of GH 3 and in a spot in the central eastern part.

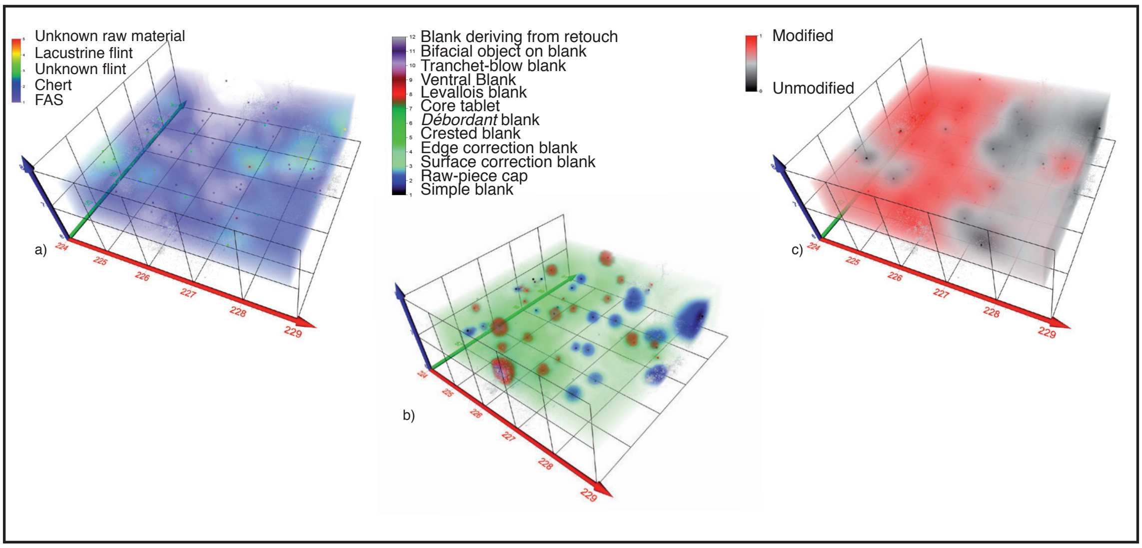

Fig. 410 - Distribution of individual blanks from GH 3. a) Distribution in regard to raw material; b) Distribution in regard to blank type and c) Distribution of modified and unmodified blanks

Fragmentation of individual blanks

There are complete individual blanks and fragmented with individual raw material specifics. They are listed in tab. 288 for GH 3, 4x and 4.

Number / Fragmentation	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Complete	26	0	3	**29**
Basal	21	0	1	**22**
Medial	3	1	0	**4**
Left lateral	1	0	0	**1**
Right lateral	0	0	1	**1**

Terminal	7	0	0	**7**
Undetermined	6	0	0	**6**
Total	**64**	**1**	**5**	**70**

Tab. 288 - Fragmentation of individual blanks from GH 3, 4x and 4

X.8 Observations on constraints in regard to breakage mechanics

X.8.1 Introduction

The analysed lithic material from VP II shows some idiosyncrasies in regard to breakage mechanics and the knowledge of the knappers about it. This section is majorly focusing on the aspects of grain size differences of the raw material and knapping features.

Different grain sizes on FAS and zones with low silicification (rests of calcite are present) possesses different break resistance. Personal knapping attempts with FAS material could demonstrate this observation. The finer and more homogeneous a raw material is the better the knapping quality and the break resistance is reduces compared to coarse-grained material (see fig. 411).

Fig. 411 - Differences in raw material quality on FAS collected west of the Chateau de Germolles (see fig. 5 in Frick et al. 2012)

X.8.2 Coarse-grained zones and „swallow“ of energy

Coarse-grained zones and zones with low silicification „swallow“ energy during the knapping process. The resulting surfaces (negatives on cores and ventral faces on blanks) are much more irregular that on fine-grained material. If a reduction surface has fine-grained and coarse-grained zones, a knapper has to find the right position and the right amount of energy to detach a blank. On some core negative patterns, it is good visible that the resulting negative ended in a hing because of this alteration in raw material. If such a coarse-grained zone is situated on the platform of the core, much more energy is necessary to initialize the break. There are some examples of blanks with more than one ring crack on this difficult zones.

One possibility in knapping to detach a blank from a surface possessing such different grain-sizes is to use more energy for the blow to let the break pass the zone where coarse-grained and fine-grained material meets. To prevent an overshot, the knapper has to place the holding fingers on the position where the blanks is supposed to have its terminal end. If the material connection between coarse-grained and fine-grained material is strong enough the resulting blanks can be used for further purposes. If it is not strong enough the blank will break there.

Fig. 412 - Example of a cortical butt of a blanks with a lip (GER13.227-057.2742)

X.8.3 Cortical butts and lips

The „swallow“ of energy is known for cortex as well. Normally, cortex is much softer than the interior of the raw material. In knapping the cortex becomes compressed and a small amount of energy is left to initialize the break. Therefore, break features on such a blank can differ from known features (e.g. Kerkhof & Müller-Beck 1969; Pelegrin 2000; Roussel 2005). An example for a cortical butt of a blanks with a lip is displayed in fig. 412.

X.8.4 Multiple impact points on blank butts

There is evidence for multiple attempts to detach a blank. As example, GH 3 yielded n=136 blanks showing more that one impact point of the butt (see chapter VII.11.5). Multiple tries of blank detaching are related to divers reasons. Some are listed in the following (non-exhaustive):

- No optimal angle between platform and reduction surface
- Previous face battering
- Blow without the required force
- Coarse-grained zone „swallows“ the energy
- Wrong knapping angle

GH 3 yield evidence of n=11 examples where four impact points on blank butts are visible (one example is displayed in fig. 413). Sometimes a successful blow exposed a previous (non-clastogenic) Hertzian cone.

Fig. 413 - Example of a blank possessing four impact points (GER09.227-059.146.1)

X.8.5 Holding criteria for a successful break

In addition to constraints in regard to raw material, there are some important criteria for a successful Hertzian cone break. We are aware that the following are speculations, but the observation origin from own knapping attempts and are explained using aspects from the literature. As Bertouille (1989a) explains the shock introduced by the hammer produce a compressive spheric wave that transform into a plane wave. The introduced energy is reflexed on the surface of the core as well, if the difference in specific density between core and surrounding is big enough. A knapper can lower this difference in pressing the core on the thigh or holding it in the hand (as well as fixation in a device). On the specific position a part of the energy is not reflexed but continuous into the other medium. This is perceptible by a shock in e.g. the holding hand. The position of this energy loss can be chosen. An example shall demonstrate this. If a blade should be detached and the holding hand holds the core in the middle of the reduction surface, a part of the introduced energy left the core on this specific position. The result is for instance a hinge on this position, or a broken blank. High speed records could show for pressure flaking that a blank detaches first in the terminal part (Tixier 2012). And in such a way, if the holding hand presses the blank on the core, it will result in a break. A knapper considers this circumstances in holding the core in that way that the basal part of the reduction surface is pressed, or the whole surface. But a knapper can use this circumstances also to control the length of blanks in pressing the core where the blanks is supposed to end.

X.8.6 Plane and facetted butts preferred

On n=1040 blanks from the GHs 3, 4x and 4 the number of negatives were counted (fig. 414 illustrate them as bar graph and tab. 289 lists them). If the numbers of negatives on butts are compared, all three analysed assemblages show the same tendencies. On the one hand, the majority of butts possesses one negative. On the other hand, there are many butts with more than ten negatives. These tendencies are present for all three assemblages.

Number / Butt surface	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Completely cortical	82	2	10	**94**
1 negative	355	2	35	**392**
2 negatives	67	0	6	**73**
3 negatives	83	0	8	**91**
4 negatives	56	0	4	**60**
5 negatives	61	1	2	**64**
6 negatives	38	1	3	**42**
7 negatives	43	0	1	**44**
8 negatives	20	0	1	**21**

9 negatives	15	1	1	**17**
10 negatives	23	0	0	**23**
>10 negatives	115	1	3	**119**
Total	**958**	**8**	**74**	**1040**

Tab. 289 - Amount of negatives on blank butts from GH 3, 4x and 4

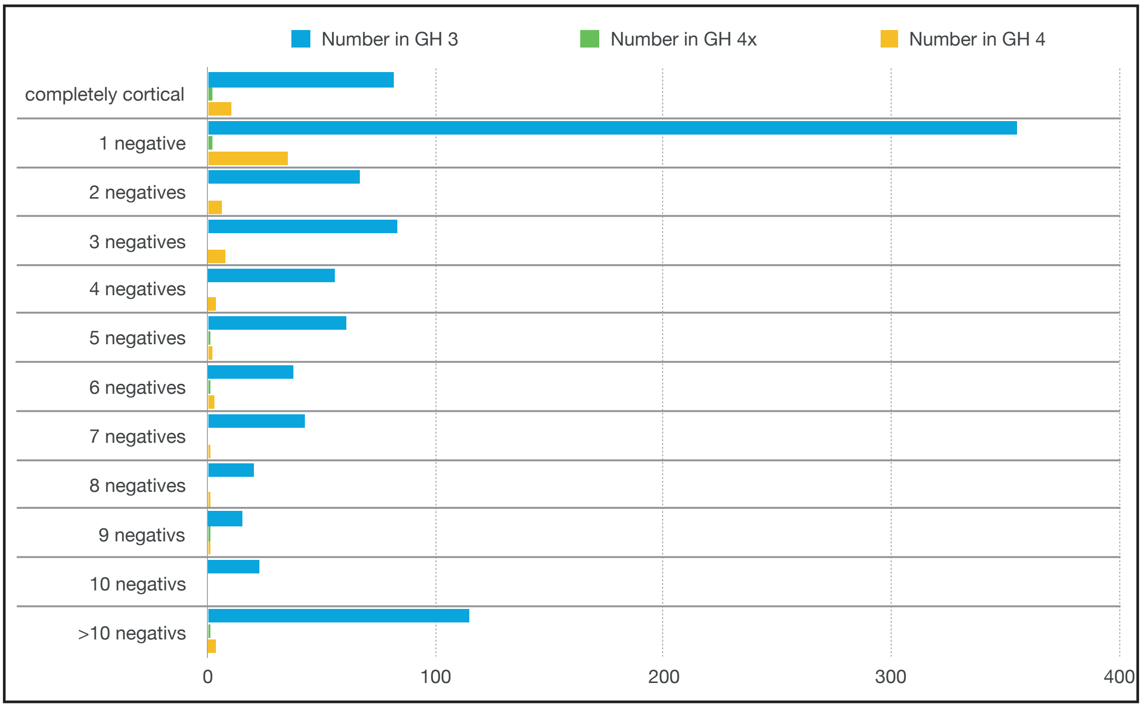

Fig. 414 - Amount of negatives on blank butts from GH 3, 4x and 4

Faceting on butts

Faceting on butts can be defined as an intensive retouch on core edges for shaping the platform (the part that is reserved for the impact). The result of the faceting is to pronounce the platform that the blow will hit exactly the wanted point. As the literature does not provide exact number of negatives that can be seen as faceting, in the following more than 10 negatives on butts are defined as faceting (independently if these negatives derive from the general shaping of the platform or if they are installed afterwards). There is evidence for n=115 blanks butts from GH 3 with more then 10 negatives, as well as n=1 from GH 4x and n=4 from GH 4. The following tab. 290 list blanks types with more then ten blank-butt negatives.

Number Blank class	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Raw-piece cap	6	0	0	**6**
Surface correction blank	35	1	1	**37**
Edge correction blank	11	0	0	**11**
Débordant blank	4	0	0	**4**
Levallois blank	33	0	2	**35**
Tranchet-blow blank	2	0	0	**2**
Bifacial preform	1	0	0	**1**
Ventral blank	1	0	0	**1**

Simple blank	15	0	0	**15**
Blank from retouch	7	0	0	**7**
Total	**115**	**1**	**3**	**119**

Tab. 290 - Blank butts possessing more then ten negatives from GH 3, 4x and 4

The majority of blanks with more then ten butt negatives are blanks from surface shaping, as well as target blanks from Levallois reduction. But also other blank types have evidence for faceting (see tab. 289).

Surface shaping using organic blow devices

There is evidence for parallelized surface shaping with soft hammer techniques. GH 3 yielded at least n=60 surface correction blanks with indices for soft hammer techniques for flattening surfaces (GH 4 n=1 and GH 4x n=1). The following fig. 415 displays two of them. These blanks can be seen as evidence for surface shaping (thinning) processes on (probably bifacial) objects on-site.

Fig. 415 - Surface shaping blanks produced using soft hammer techniques. a) Flat and trapezoid blank from FAS that ended in a hinge (GER13.225-059.1176) and b) Flat and trapezoid blanks from unknown raw material (broken during test-pit excavation, GER09.228-059.124.1)

X.9 Macro-morphological evidence for hafting

X.9.1 Introduction

VP II yield evidence for re-tooling processes on-site. On the one hand there is evidence from blanks that probably broke during their use (fixed in a haft). On the other hand there are tips of tools present on-site that broke-off during use. The following chapter describes these objects detailed and show their morphological similarities.

From GH 3, 4x and 4 there is evidence of n=269 objects possessing macro-morphological traces that are interpreted as hafting traces. Additionally to fragments of blanks (n=226) there is evidence from n=43 complete blanks. The following sections discuss these fragments that are supposed to be stuck in a haft (hafting rest) or broke-off during use (tool tip).

X.9.2 Definition for hafting rest and tool tip

Hafting rests are defined here as lithic objects (mostly modified blanks) that show macroscopical evidence of being a formerly hafted and broken blank while fixed in a haft. The hafting rest is the fragment that stuck in the haft (the rest of the hafting part of the hafted blank). In lack of a better term, we use hafting rest as the name for a fragment of a lithic object that was formerly probably hafted, used and broke during use. A tool tip (*Werkzeugende*, after Weißmüller 1995) is the corresponding part of the formerly hafted, used and broken tool. A tool tip can also be a small (terminal) fragment (as part of the active part of the tool) and the tool where a tool tip broke-off can also be handheld. A tool tip is evidence for tool use on-site. A hafting rest is evidence that a used and broken blank was discarded on-site (with the option of so called retooling, the process of replacing a used and often broken tool), see also fig. 416.

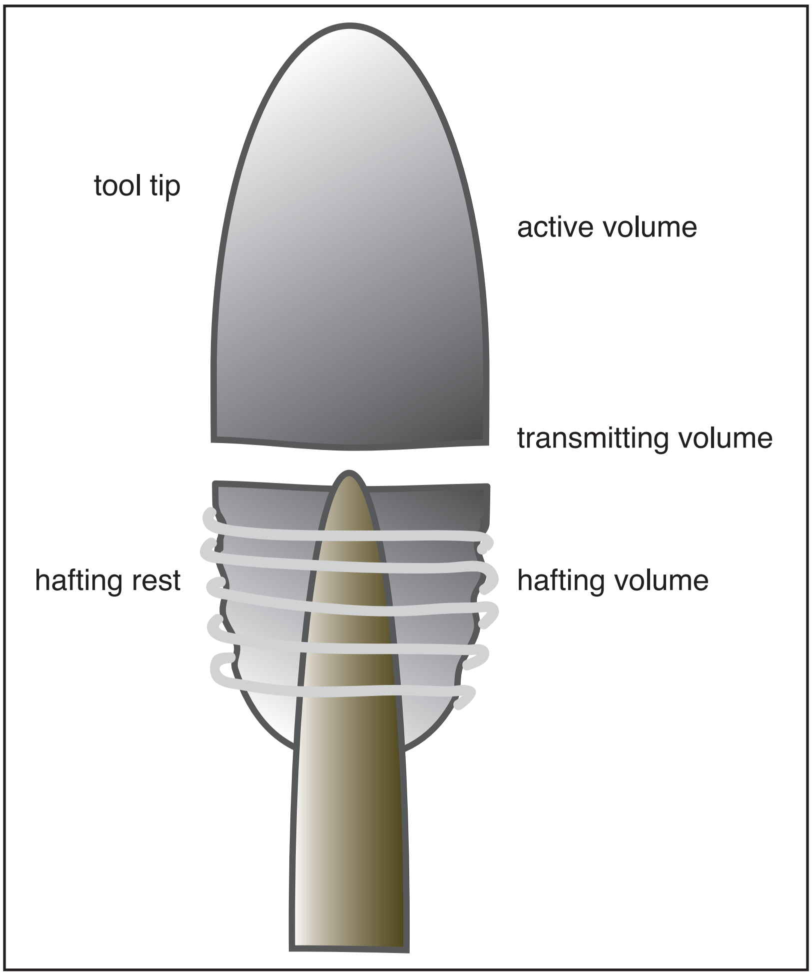

Fig. 416 - Display of an idealized hafting rest and tool tip

X.9.3 Quantity and dimension of hafting rests

The lithic analysis of GH 3, 4x and 4 rendered evidence of blanks that could have been fixed in a haft and broke while being fixed. In total, there are at least n=148 blanks showing such traces (examples are displayed in fig. 417). The range of blank classes of these pieces is displayed in tab. 291.

Number / Blank class	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Raw-piece cap	3	0	0	**3**
Surface correction blank	11	0	3	**14**
Edge correction blank	1	0	0	**1**
Éclat débordant	2	0	0	**2**
Levallois blank	68	0	1	**69**
Simple blank	54	2	3	**59**
Total	**139**	**2**	**7**	**148**

Tab. 291 - Blank classes and numbers of hafting rests from GH 3, 4x and 4

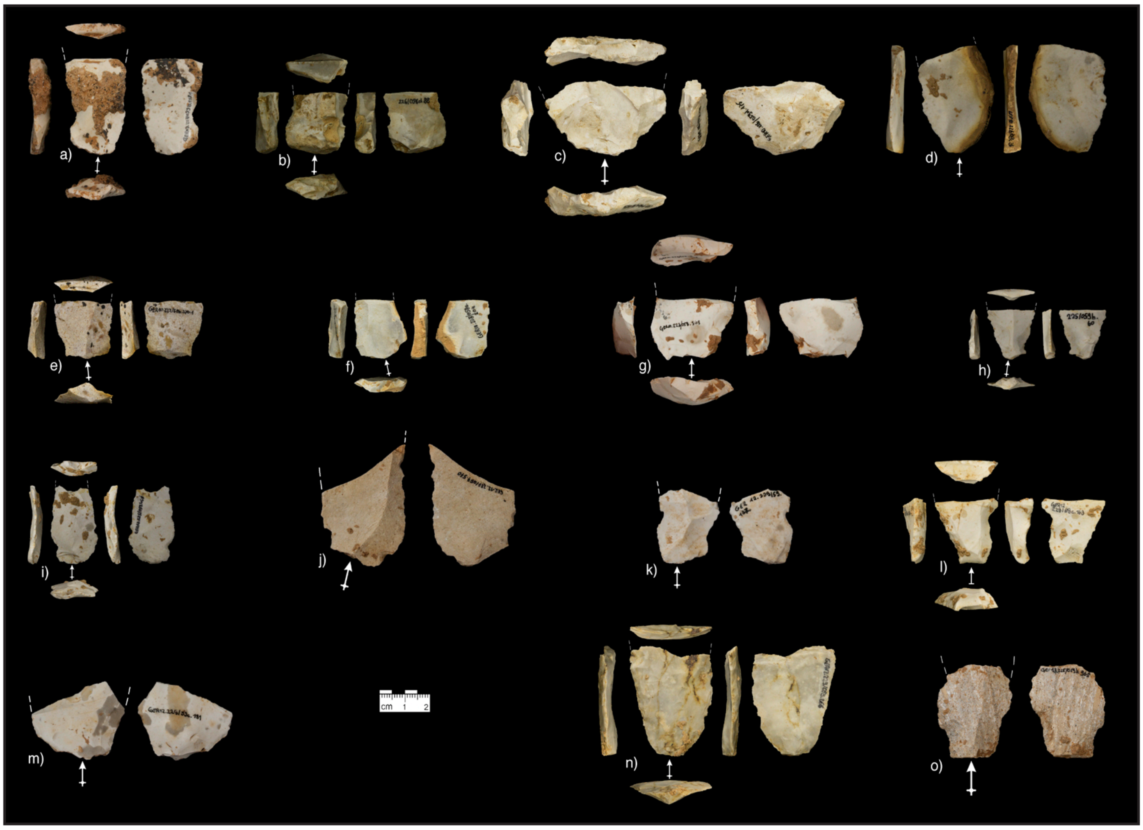

Fig. 417 - Examples of hafting rests from GH 3. a) Hafting rest with retouched lateral notches, made from FAS (GER 09.227-059.118.1); b) Hafting rest made from a cortical FAS flake with retouched lateral teeth (GER10.226-058.88); c) Hafting rest with lateral break-offs, made from FAS (GER10.226-059.175); d) Hafting rest made from a FAS flake with cortical back (GER10.226-059.216); e) Hafting rest made from a chert flake with lateral retouch (GER10.227-058.270.1); f) Hafting rest made from a FAS flake with cortical back (GER10.228-058.204); g) Hafting rest with lateral retouch on FAS flake (GER 10.228-058.363); h) Hafting rest with lateral retouch on FAS flake (GER11.225-059.60); i) Hafting rest made from a FAS blade with retouched lateral notches (GER12.225-059.468); j) Hafting rest made from a chert blade (GER 12.227-057.570); k) Hafting rest made from a FAS blade with retouched lateral notches (GER 12.229-059.137); l) Hafting rest with lateral retouch on FAS flake (GER12.229-059.163); m) Hafting rest with lateral retouch on FAS flake (GER 12.229-059.181); n) Hafting rest made from a FAS blade with lateral retouch (GER12.229-059.266) and o) Hafting rest made from a chert flake with lateral retouch (GER 13.225-059.965)

For n=148 of these pieces, mass and dimension are measured (displayed in fig. 418 as box plot). In regard to GH 3, 50% of the hafting rests have lengths between 30 and 45 mm, widths between 23 and 38 and thicknesses between 6 and 10 mm. The singular piece from GH 4x in not representative. The small contingent from GH 4 show lengths between 25 and 40 mm, widths between 20 and 30 mm and thicknesses between 5 and 9 mm. If the pieces as representative convolute are displayed as dimensional scatterplot with volume rendering, two clusters appear. Levallois blanks (red) show a dense cluster in the midrange and simple blanks (black) another in the small range. These clusters are visible in all three dimensions (see fig. 419).

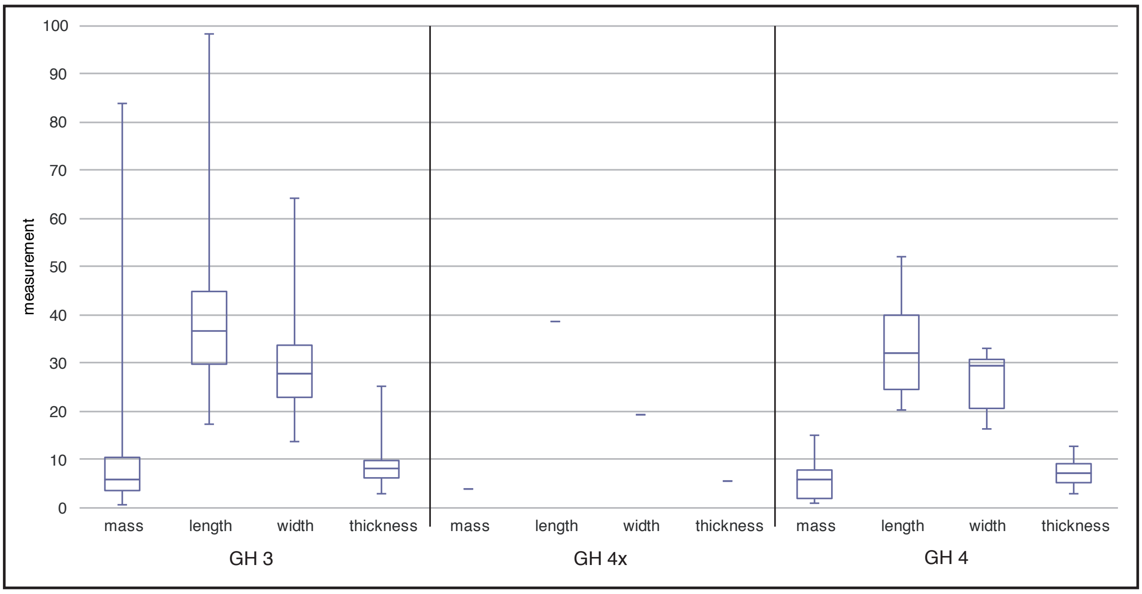

Fig. 418 - Mass and dimension of hafting rests from GH 3, 4x and 4, displayed as box-plot

The majority of hafting rests are basal blank fragments (see tab. 292). Additionally, there are other fragments showing these particular combination of features. The reason here is related to fragmentation. A hafted blank can also be fragmented in more than two pieces.

Number Fragment	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Basal	119	1	6	**126**
Basal left lateral	1	0	0	**1**
Medial	13	1	1	**15**
Left lateral	3	0	0	**3**
Right lateral	3	0	0	**3**
Total	**139**	**2**	**7**	**148**

Tab. 292 - Fragmentation of hafting rests from GH 3

X.9.4 Quantity and dimension of tool tips

GH 3 and 4 yielded together n=74 tool tips (n=68 in GH 3 and n=6 in GH 4, examples are displayed in fig. 420). Here again, tip of tools broke off from tool made from different blank classes (see tab. 293). The vast majority of blanks had to be classified as simple blanks, because a tool tip does not offer always enough features to make a more reliable classification.

Number Blank class	Number in GH 3	Number in GH 4	Total
Raw-piece cap	4	1	**5**
Surface correction blank	6	1	**7**
Edge correction blank	0	0	**0**
Crested blade	1	0	**1**
Éclat débordant	0	0	**0**
Core tablet	1	0	**1**
Levallois blank	7	2	**9**
Ventral blank	1	0	**1**
Ventral core	1	0	**1**
Bifacial object	3	1	**4**
Simple blank	44	1	**45**
Total	**68**	**6**	**74**

Tab. 293 - Blank classes of tool tips from GH 3 and 4

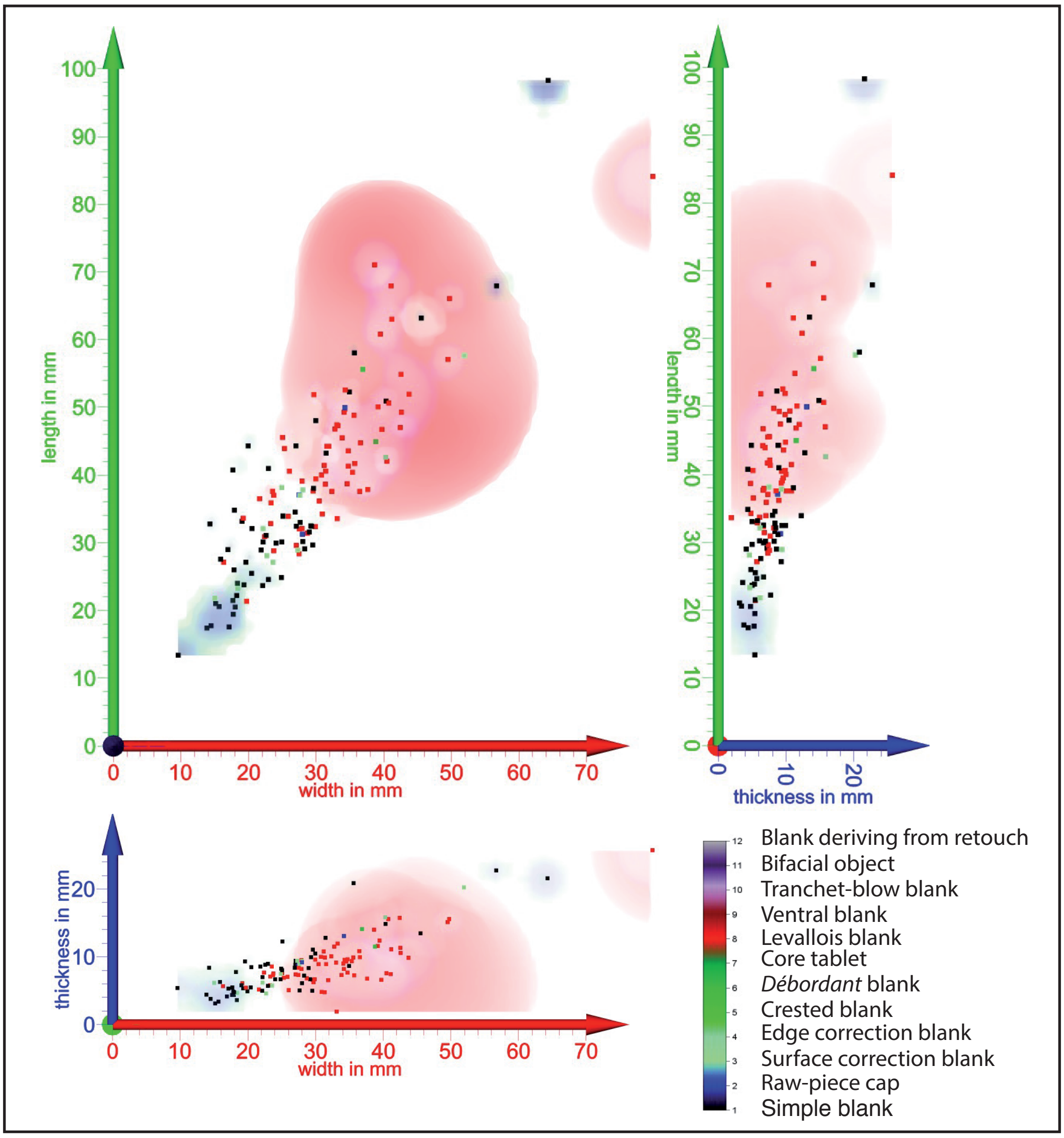

Fig. 419 - Dimensions of hafting rests from GH 3 as scatterplot with volume rendering

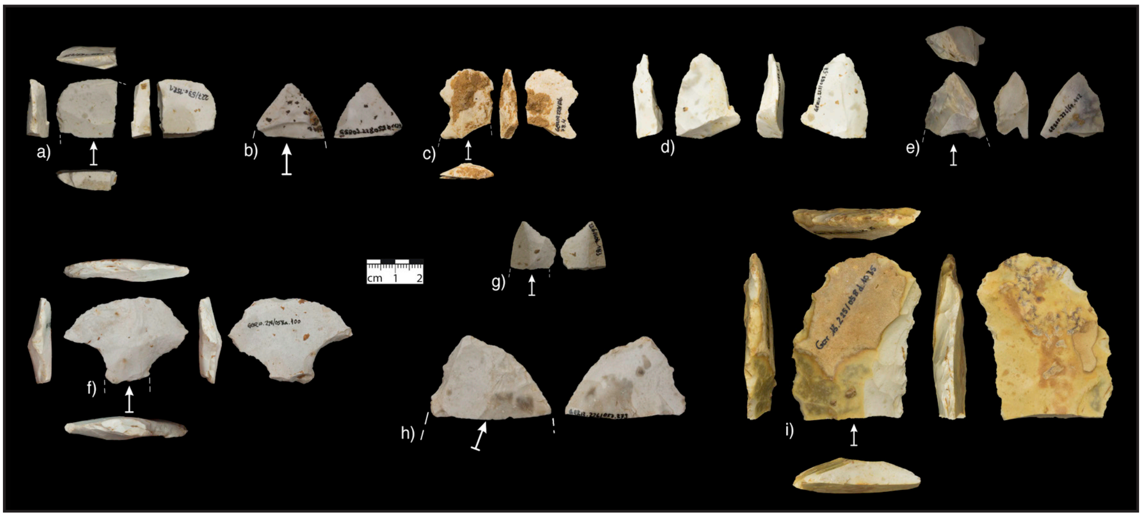

Fig. 420 - Examples of tool tips. a) Terminal left lateral fragment of a convex retouched tool (GER09.227-059.158); b) Terminal pointed tip of a tool (GER09.228-059.113.4); c) Terminal fragment of a round retouched tool with lateral notches (GER09.228-060.78.4); d) Terminal end of a bifacial object with burin-like negative (impact?) (GER10.228-058.58); e) Terminal fragment of a surface retouched blank maybe a secondary crested blank with subsequent retouch (GER10.226-060.112); f) Shouldered and previously hafted end-scraper? (GER10.228-058.400); g) Marginally retouched tool tip (GER10.226-060.183); h) Terminal fragment of a tool with left lateral backing (GER12.226-057.273) and i) Terminal fragment of a blade with denticulated lateral retouch (GER13.225-058.1035)

Measurements are available for n=65 (GH 3 n=60 and GH 4 n=5) of these n=74 tool tips. A box plot of mass and dimension shows similar relations for objects from GH 3 and GH 4, with the exception that 25% of the objects from GH 3 are bigger than objects from GH 4 (see fig. 421).

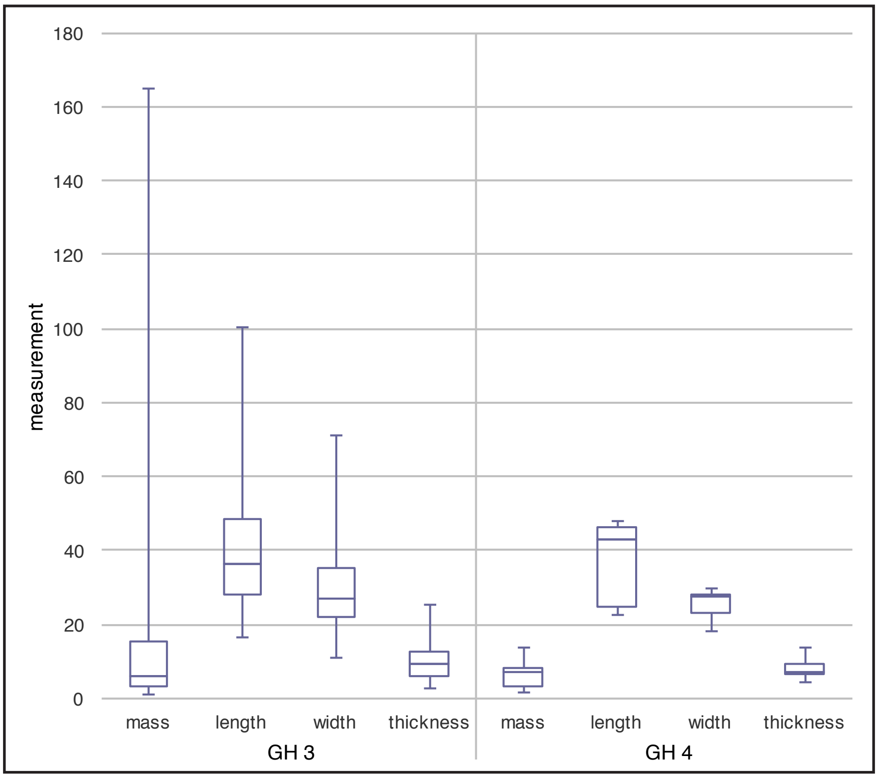

Fig. 421 - Boxplot of mass and dimension of tool tips from GH 3 and 4

A dimensional scatter plot of tool tips from GH 3 show some clusters in size. Tool tips from simple blanks are either big or small. Correction blanks and Levallois blanks are situated in the mid-range. This pattern is visible in length-to-width and length-to-thickness (see fig. 422).

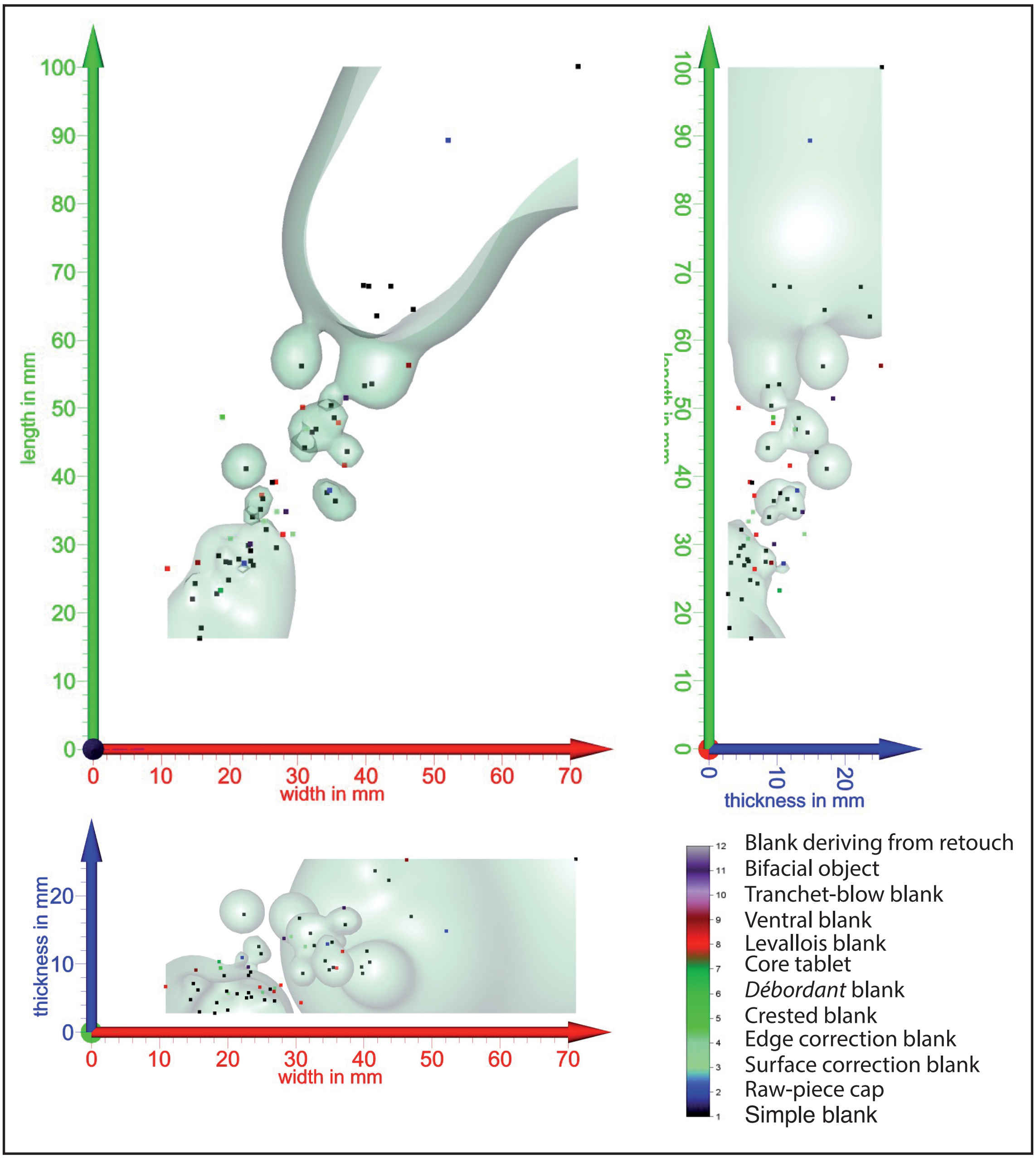

Fig. 422 - Dimensional scatter plot of tool tips from GH 3. Isosurface at 2.5, separating simple blanks and raw-piece caps from other blank classes

X.9.5 Spatiality of hafting rests, tool tips and complete blanks with hafting traces

The comparison of spatial distribution of hafting rests (red dots), tool tips (green dots) and complete blanks with hafting traces (black) shows that all three kinds are scattered in the entirety of the excavated GH 3 (see fig. 423). Analysis using isosurfaces and volume rendering offers some patterns.

The spatial density of hafting rest is higher in direction of the northeastern corner. The density of tool tips and complete blanks is higher in the rest of the volume of GH 3. There is no visible separation in Z-value.

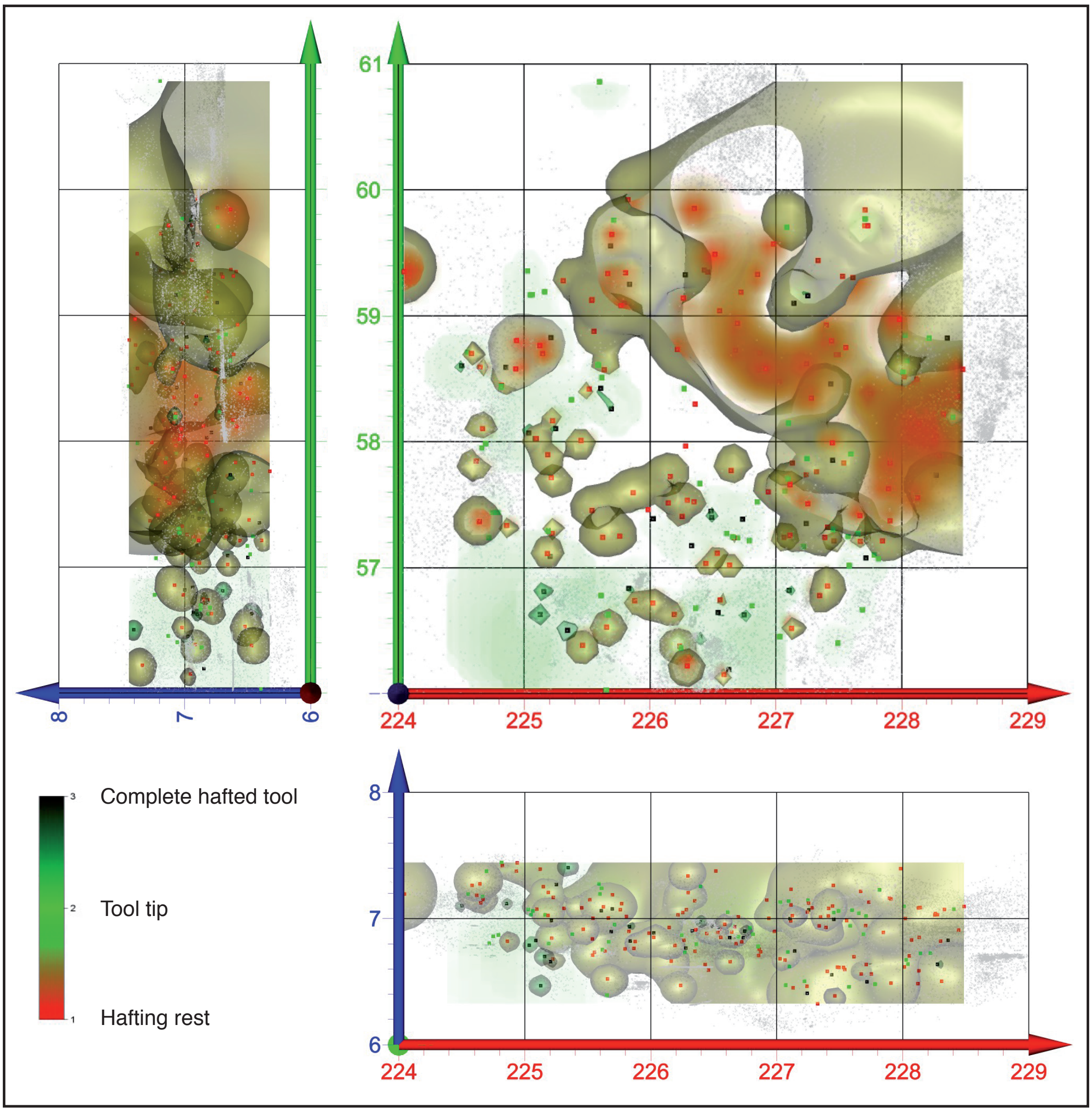

Fig. 423 - Spatial distribution of hafting rests (red dots), tool tips (green dots) and complete blanks with hafting traces (black dots). One isosurface separates hafting rest and tool tips (yellowish green) and another separates tool tips from complete blanks (green). The density of the hafting rest is highlighted by a red cloud

X.9.6 Techno-morphological description of hafting rests

Tool tips and complete hafted blanks are morphological diverse. On the contrary, hafting rest show some particular, common features (listed in tab. 294). These commonalities allow to group these objects.

Feature	Meaning
Basal fragments of probably longer blanks	In most of the cases, the terminal part is broken off
Quite thin	Width-to-thickness ration
The terminal end shows mostly a bending fracture	This fracture happened after production
The lateral edges show dorsal and ventral damage	Is this damage from binding?
One or both lateral edges show retouch, very often in an alternating manner	Retouch support or produce a specific shape of the edges
The lateral edges can have teeth or notches, which are often retouched	Retouch support or produce a specific shape of the edges
The lateral edges show sometimes polished parts	Polish from rubbing of the fixation?
Combination of features reveal an interpretation as blank fragments stuck in a haft	All active (transformative) parts are removed by the break, left is the passiv part that stuck in a haft

Tab. 294 - Common features of hafting rests in the assemblage of GH 3

The width-to-thickness ratio of these pieces equals 3.4 (as it is displayed in fig. 424).

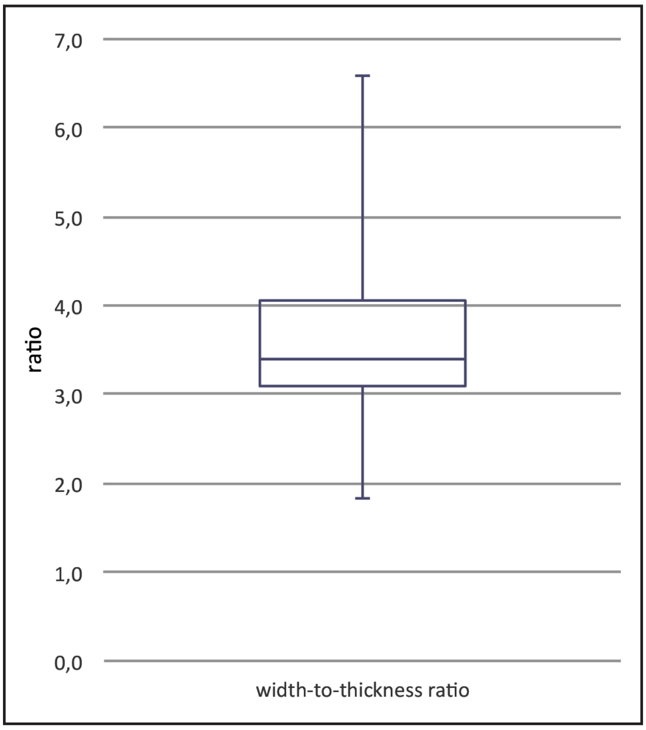

Fig. 424 - Boxplot of the width-to-thickness ratio of all hafting rests

An idealized hafting rest is displayed in fig. 425, showing lateral retouch and the terminal fracture.

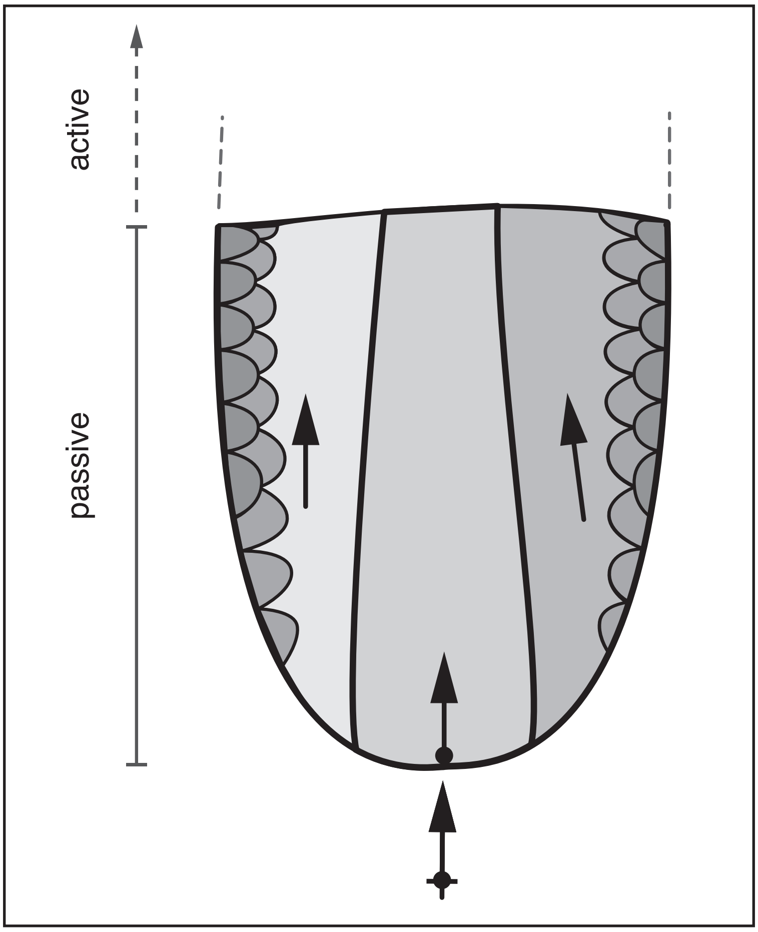

Fig. 425 - Idealized hafting rest showing lateral retouch and the terminal fracture

X.9.7 Assumptions about the production concept

The majority of objects defined as hafting rest has unidirectional negative directions on the dorsal face (see tab. 295). From these hafting rests n=44 show rests of cortex (all from GH 3), but the amount of left cortex is very low (in majority under 10%). This is an evidence that the majority of hafting rest were blanks deriving from production stages that followed after the removal of cortex.

Number Direction and constellation of negatives on the dorsal face	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Unidirectional-parallel	61	1	2	**64**
Unidirectional-convergent	25	0	1	**26**
Unidirectional-divergent	3	0	0	**3**
Unidirectional-orthogonal	8	0	2	**10**
Bidirectional-parallel	17	1	0	**18**
Bidirectional-convergent	4	0	0	**4**
Centripetal	12	0	2	**14**
Only cortex	2	0	0	**2**
Undefined	7	0	0	**7**
Total	**139**	**2**	**7**	**148**

Tab. 295 - Direction and constellation of negatives on the dorsal face of hafting rests from GH 3, 4x and 4

The evidential features for evaluation the production sequence of these objects are listed in the following:

- 17.6% of the blanks have a faceted butt
- The morphological axis is in almost all cases equal to the technological knapping axis
- Only n=7 objects show signs of soft hammer techniques, the rest possess ring cracks, bulbs and points clearly to the use of hard hammer techniques
- The directions of the negatives on the dorsal face are mostly uni-directional and in the same direction as the technological knapping axis of the piece
- The majority of objects possess no cortex and place these objects in production stages were no cortex are left

X.9.8 Operational production sequence

The features of these pieces suggest a specific production sequence. On the one hand, parallel lateral edges are preferred that were often confectioned with retouch. During the production the parallelism of the lateral edges was attained by the configuration of the flaking surface. After the production these blanks were confected by retouch on their lateral edges in different ways (ventral, dorsal, alternating, straight, toothed, notched).

We suggest the following operational chain for these pieces:

- Blank production using a concept that produce uni-directional parallel negative on dorsal faces and produce quite thin pieces with hard-hammer technique
- Modification of the lateral edges for hafting (the possibility of modification on active or transmitting parts is given)
- Fixation of the lithic object in a haft, it is supposed that they are fixed in a juxtaposed hafting system with a transversal winding of sinew or leather
- Use of the composite tool in longitudinal (maybe also transversal direction)
- Possible re-confection (reshaping or remoulding) of the active parts for the extension of the use life
- Second use in a same or other manner
- Breakage of the inserted lithic object in the haft (the fragmentation took part directly terminal of the hafting area)
- Removal of the broken piece and possible re-tooling of the haft by another lithic object
- Discard of the broken object

X.9.9 Lateral modification

The sense and purpose of modification on the lateral edges is to shape these for the hafting process in such a way that the binding material is not cut-off and that the blanks will be stable fixed in the haft in a proper way. There are many combinations of edge modification visible. In the following these are listed (tab. 296) and discussed afterwards:

Edge / Modification	Left lateral edge	Right lateral edge	Total
Regular dorsal retouch	42	44	**86**
Concave dorsal retouch	3	2	**5**
Denticulated dorsal retouch	3	3	**6**
Notched dorsal retouch	6	3	**9**
Regular straight ventral retouch	16	15	**31**
Concave ventral retouch	2	3	**5**
Denticulated ventral retouch	2	3	**5**
Notched ventral retouch	6	4	**10**
Edge crushing by pressure (binding?)	84	86	**170**
Total	**164**	**163**	**327**

Tab. 296 - Detected edge modification by retouch and crushing on hafting rests

X.9.10 Meaning

As suggested above there are lines of macroscopical evidence that these pieces are fragments of formerly hafted lithic artifacts that broke off and remained inside the haft. It is suggested that the intensive patination of lithic objects from GH 3 struggle use-wear analysis to prove this hypothesis.

The slight thickness of these pieces, the bending fractures at the terminal end, and very similar lateral modifications characterize these object into a cluster and suggest also that they could have been used in a very similar manner. We would expect this activity was one that needed a hafted lithic object with a slight thickness and was used in such an activity that it had to break with a bending fracture. There are different ways how a bending fracture at a hafted lithic object can occur (not exhausted list):

- The object was compressed because it was used as part of a missile (longitudinal motion)
- The object was compressed because it was used as thrusted knife (longitudinal motion)
- The object was used as a knife (longitudinal motion) and slid sidewards
- The object was used for scraping or scratching (transversal motion) and slid sidewards

It seems more unlikely that these pieces were use as projectiles because there are other triangular and deltoid objects in the assemblage (some of them show breakage at the terminal end).

X.10 Residues and appositions

Some lithic objects (n=256) show black dots on their surfaces. During data collection these dots were ascribed as manganese oxide precipitation as it can be seen on and in calcite rocks (e.g., dendritic structures). While reading a publication about Inden-Altdorf (Pawlik & Thissen 2011) were optical very similar structures were described, I was not sure anymore if these structures are really and exclusively manganese oxide precipitations. Another suggestion would be residues such as birch bark tar. Further analyses are necessary to solve this problem (e.g., high power microscopy or chemical analysis done by specialists) and cannot be part of this thesis.

X.11 Multiple patination, recycling and reuse

There is evidence of different degrees of patination on at least n=15 objects (the analysis set a minor focus on this aspect, therefore at least). Different patination is good evidence for a time gap between two working steps and a sign for resumption of discarded objects. Additionally, the modification of cores, multiphase retouch on tools or changes in the reduction concept is also evidence for resumption of objects. Cuartero et al. (2015) describe three relevant cases of lithic recycling: 1. Tools on cores (TOC), 2. Cores on tools (COT) and 3. Cores on flakes (COF). Romagnoli (2015) describe four ways to identify the discard phase between two knapping events: 1. Tool made on patinated blanks (differences in patination between the retouch and the rest of the blank), 2. Transformation of a core into a tool (modified cores or retouched cores), 3. Blanks (also modified blanks) that were modified into a core and 4. Retouched cutting edges on broken tools (in Grotta di Cavallo made from shell). All of these cases can be separated by the presence of differences in patination and therefore in the length of the time gap between to phases. The following describes n=15 cases of multiple patination on lithic objects from GH 3. There is evidence on n=5 cores and n=10 blanks (listed in the following tab. 297). Examples of these objects are displayed in fig. 426.

Recycled object	Number	Description
Tested raw piece	**3**	One tested raw piece with four tested positions and another highly patinated negative; one tested raw piece with one tested position and another with a different patination; one tested raw piece with two different patination on tested positions
Preform of a Levallois core	**1**	Core with two phases (separated by different patination) of configuration but without target removals
Ventral core	**1**	Blank with a removed bulb and two patinations
Surface correction blank	**2**	Retouch of these both objects has a different patination
Surface correction blank	**1**	Shows two negatives on the ventral face with different patination
Surface correction blank	**1**	Dorsal face posses old patination, blank was removed from a different patinated reduction surface on a core
Surface correction blank	**1**	Dorsal phase possesses to kinds of patination

Tool tip of a laterally retouched simple blank	1	Retouch has different patination
Levallois blank with denticulated retouch	1	Retouch has different patination
Broken raw-piece cap	1	Breakage surface posses a different patination (no recycling but break long after detachment)
Simple blank with retouch	2	Retouch of these both objects has a different patination
Total	15	

Tab. 297 - Objects from GH 3 showing more than one degree of patination

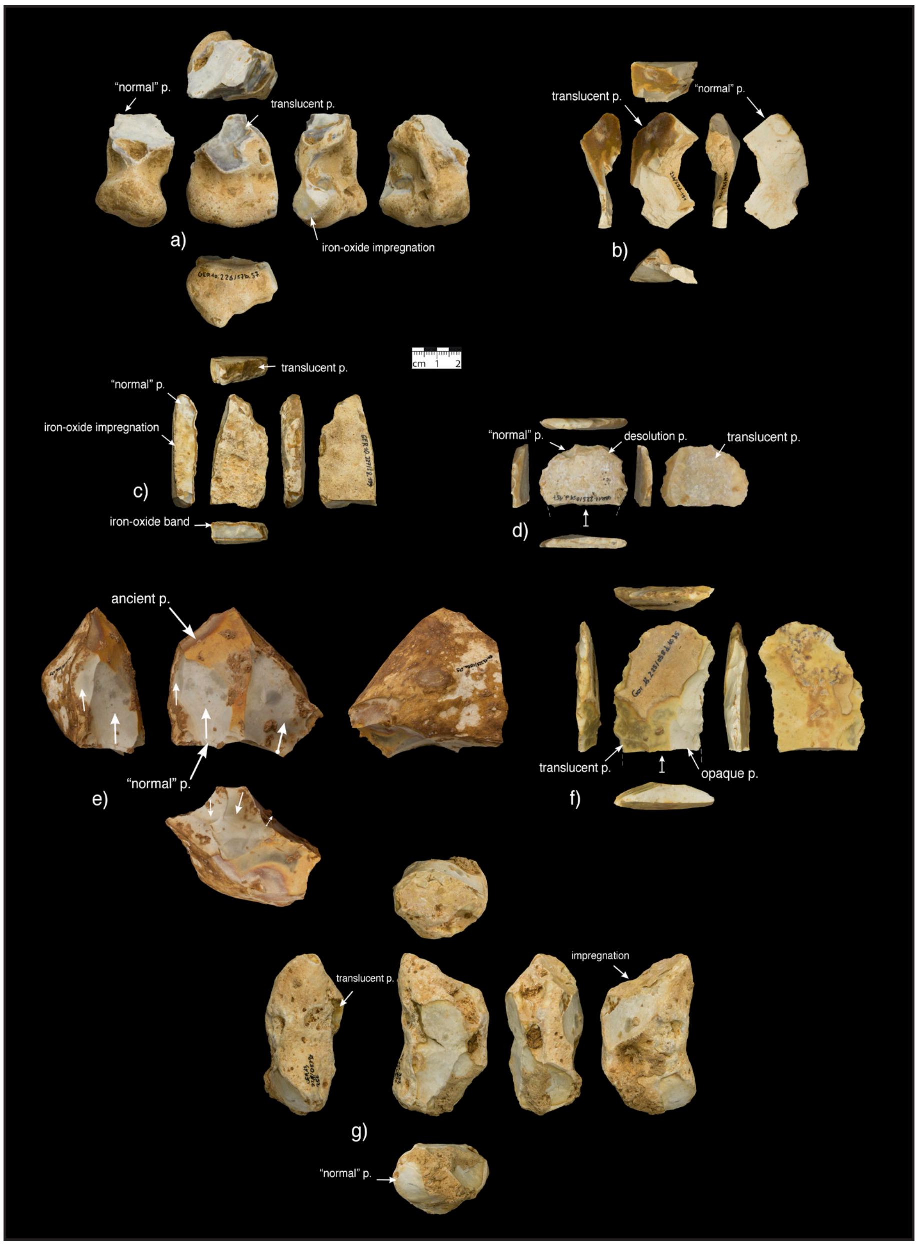

Fig. 426 - Examples of objects from GH 3 showing more than one degree of patination. a) Tested raw piece with three degrees of patination (GER10.226-057.57); b) Edge correction blank with two degrees of patination (GER10.226-059.191); c) Tested raw piece with three degrees of patination and an iron-ixid band under the cortex (GER10.227-058.199); d) Tool tip with three degrees of patination (GER11.225-059.157); e) Preform of a Levallois core for points with two patination degrees (GER13.225-058.679); f) Tool tip with two degrees of patination (GER13.225-058.1035) and g) Tested raw piece with three degrees of patination (GER13.228-057.255)

Objects with multiple patination are scattered in majority in the southern half of the excavated GH 3 and are situated mostly in the upper half of GH 3 (see fig. 427).

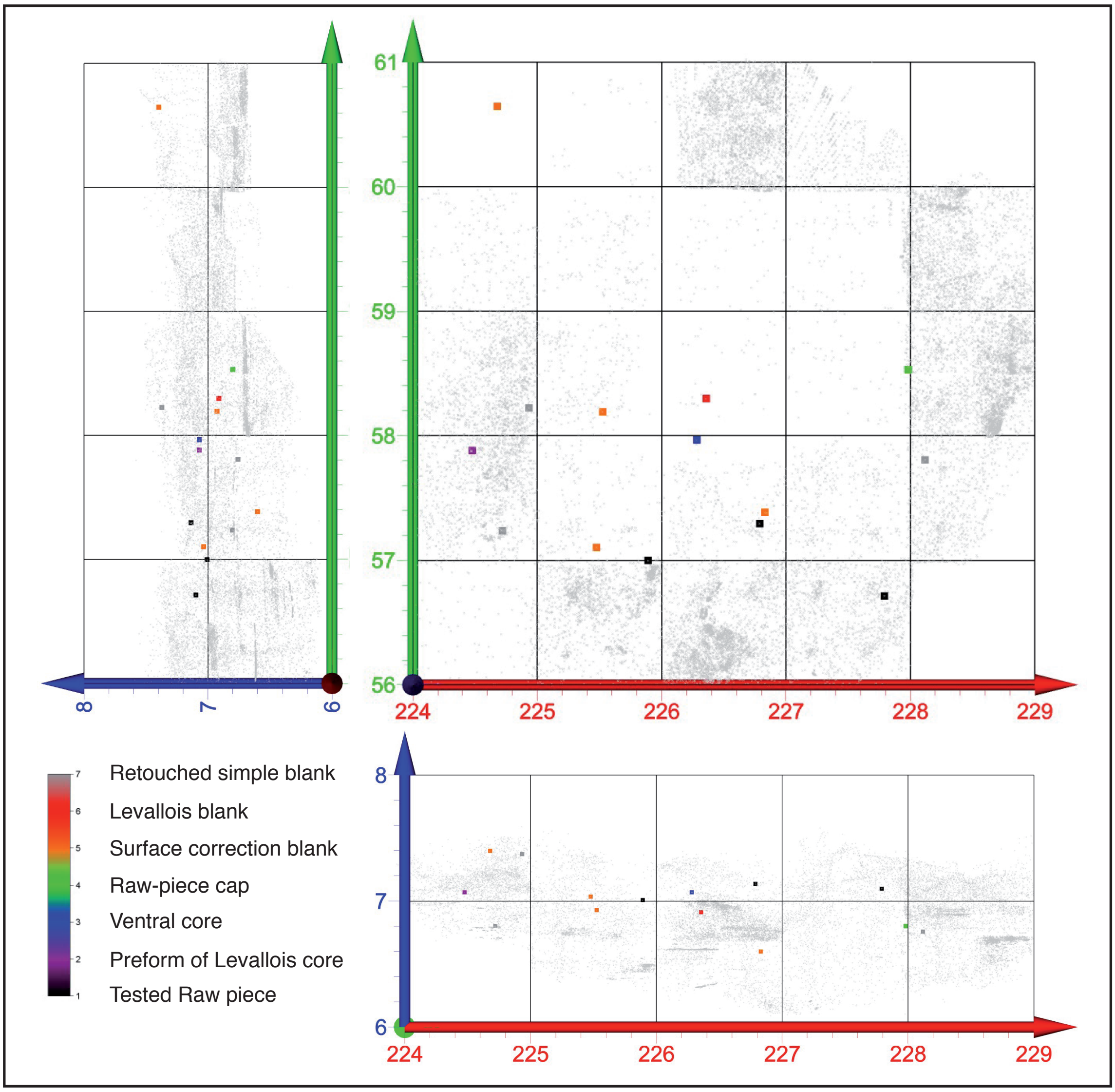

Fig. 427 - Spatial distribution of objects from GH 3 showing more than one degree of patination

The question remains open wether this is an indication for slower sedimentation processes and a longer exposure of artifacts on the surface to be elevated from there to be reworked (second use life or second archeological biography).

GH 3 yielded n=10 cores showing reuse as tool but without differences in the patination of surfaces (they are discussed in chapter VII.10.18). They are good evidence for a renewal of discarded objects but without a vast gap in time.

X.12 Hammerstones and anvils

X.12.1 Introduction

So called nonflint stone tools (name adopted from Beaune 1993a) can be used for a wide range of tasks. The following tab. 298 combines Tab. 1, 2 and 3 from Beaune (1993a) and her description in Nonflint Stone Tools of the Early Upper Paleolithic for an overview how such lithic objects can be used .

Denomination	**Active (green) or passiv (red) or both (yellow)**	**Mode of percussion**	***Performed task***	**Kind of contact**	**Function**	**Identification criteria from form and size**	**Traces of manufacture**	**Traces of use**
Hammerstone	Active	Thrusting	*Knapping*	Punctiform	Flint débitage and retouch	Cobble or other stone with regular spherical or ovoid form	*Mostly rounded cobbles are used as hammerstones, sometimes exhausted cores are also used*	Marks of blows or crushing on surfaces, extremities or ridges
Anvil	Passiv	Thrusting	*Knapping or pressing*	Punctiform	Flint débitage and retouch	Large stone with more or less flat, horizontal, or convex superior surface	Sometimes trimmed to reduce size	Traces of impact on superior surface
Retoucher	Active	Thrusting	*Knapping or pressing*	Punctiform	Flint débitage and retouch	Globular cobble or stone, smaller than hammerstone		Traces of crushing from contact against an edge or surface
Abrasion stone	*Active*	*Thrusting*	*Abrading*	*Diffuse*	*Flint débitage and retouch*	*Similar to hammerstones, often with one flat surface or concavities because of use*		*Abrasion and striae*
Mallet	Active	Thrusting		Punctiform	Bone and ivory shaping	Straight, elongate cobble with depressions near one or both extremities		Traces of repeated packing abutting a depression
Nutting stone (pitted block)	Passiv	Thrusting	*Crushing*	Diffuse or multipunctiform	Food preparation	Stone with one or more circular depressions		Pitted, regular circular depressions produced by use
Crushing muller	Active	Thrusting	*Crushing*	Diffuse or multipunctiform	Food preparation	Cobble with flat extremities	Surface may be hammered or polished	Flat or slightly convex extremities with traces of pecking
Mortar	Passiv	Thrusting	*Crushing and grinding*	Diffuse	Food preparation	Container with a depth of at least 10 em	Pitted; sometimes polished	Traces of percussion and crushing In the cavity

Pestle	Active	Thrusting	*Crushing and grinding*	Diffuse	Food preparation	Elongated, cylindrical or tri-conical cobble	Natural, pecked or sometimes polished	Traces of percussion and used facets on one or both extremities
Grindstone-mortar	Passiv	Thrusting and posed	*Crushing and grinding*	Diffuse	Food preparation	Container with a depth of 5-10 cm.	Pitted; sometimes polished.	Traces of percussion and polish
Pestle-grinder	Active	Thrusting and posed	*Crushing and grinding*	Diffuse	Food preparation	Oblong cobble with circular, triangular or oval section		Use polish on surfaces and extremities, sometimes traces of percussion
Seed-grindstone	Passiv	Posed	*Crushing and grinding*	Diffuse	Food preparation	Large block with plano-concave superior surface (max. depth of 4-5 cm)	Surface sometimes prepared by roughening and trimming	Traces of hammering on superior surface, concavity formed by use
Grinder	Active	Posed	*Crushing and grinding*	Diffuse	Food preparation	Oblong cobble with circular, triangular or oval section	Obtained by hammering and trimming by roughening to make the surfaces abrasive	Surfaces flattened by use, the rest of the piece retains some traces of hammering
Vegetal grindstone	Passiv	Posed	*Crushing and grinding*	Diffuse	Food preparation	Superior surface slightly concave from use wear	Roughened during manufacture (never trimmed)	Surface completely formed by use
Mulling stone	Active	Posed	*Crushing and grinding*	Diffuse	Food preparation	Squat cobble, often circular	Sometimes roughened, traces later obliterated by use polish	Use-polish on the surfaces and extremities
Palette	Passiv	Posed	*Providing*	Diffuse	Pigment preparation	Flat superior surface		Surlace completely or partially polished; traces partially polished; traces
Color grinder	Active	Posed	*Crushing and grinding*	Diffuse	Pigment preparation			*Abrasion of grinding, traces of color*
Ocher bowl	Passiv	Containing	*Providing*	Non	Pigment preparation	Bowl-shaped	Natural or produced by pecking and polishing	Traces of colorant; sometimes traces of scraping produced while mixing colors
Smoothing-tool	Active	Posed	*Abrading*	Diffuse	Leather and hide work	Cobble of hard atone	Cobble of hard atone obliterated by traces of use	Surfaces and extremities smoothed, lustrous, shiny

Polisher	Passiv	Posed	*Abrading*	Diffuse	Stone, bone and ivory polishing	Block with abrasive qualities		Imprint of the polished object (groove, depression); Imprint has a polished appearance
Whetstone	Passiv	Posed	*Abrading*	Diffuse	Stone, bone and ivory polishing	Block with abrasive qualities		Small flat facets or long grooves with a polished appearance
Container	Passiv	Containing	*Providing*	Non	Storage	Bowl-shaped	Natural or produced by pecking and polishing	*Residues of the contained material*
Lamp	Passiv	Containing	*Providing*	Non	Lightning	Bowl-shaped or plaquette-like	Plaquette-like	Traces produced by fire (carbon and/or reddening)
Centrally pitted cobble	Active and passiv	Thrusting	*Unknown*	Punctiform	Unknown function			
Pitted block	Passiv	Thrusting	*Unknown*	Diffuse or multipunctiform	Unknown function			
Total (n=24)	10 x active, 13 x passive, and 1 x active/passiv	10 x thrusting, 8 x posed, 2 x thrusting/posed and 2 x containing		5 x punctiform, 13 x diffuse, 3 x diffuse or multipunctiform and 3 x non	3 x flint débitage and retouch, 1 x bone and ivory shaping, 10 x food preparation, 3 x pigment preparation, 1 x leather and hide work, 2 x stone, bone and ivory polishing, 1 x storage, 1 x lightning and 2 x unknown function			

Tab. 298 - Combination of three tables of Nonflint Stone Tools as described by Beaune (1993b: tab. 1 to 3). Italics are supplemented by the author

The resampled list of Beaune (1993b: tab. 1 to 3) is quite long. In GH 3, 4x and 4 there is evidence for three of these functions of nonflint stone tools. As the following shows the term nonflint stone tools is not the best choice. Examples can demonstrate this very clearly. On instance, hammerstones are often made from nonflint lithic material, but sometimes old, exhausted cores from fine-grained raw materials or rounded flint nodules are uses as hammerstones. Another example is discussed in the next section, a container made from FAS (flint from the argiles à silex). In the following all hammerstones, anvils and a supposed container are discussed.

X.12.2 Hammerstones

Objects classified as hammerstones are present in two varieties. On the one hand complete hammerstones that show characteristic crushed or damaged zones from use. On the other hand, there is evidence of broken hammerstones. These broken hammerstones are classified as cores-from-hammerstones because they show at least one negative of detachment. Complete hammerstones are discussed in chapter VII.9.6 and cores-from hammerstones are discussed in chapter VII.10.8. This section gives an overview of all of them from GH 3, 4x and 4.

These three GHs yielded n=107 lithic objects classified as hammerstones. The following list presents them (tab. 299).

Number Hammerstone	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Complete hammerstone (hammerstone-on-raw piece)	49	1	4	**54**
Broken hammerstone (core-from-hammerstone)	48	0	5	**53**
Total	**97**	**1**	**9**	**107**

Tab. 299 - Complete and broken hammerstones from GH 3, 4x and 4

The number of complete and broken hammerstones equals in most of the cases, but their spatiality differs. As fig. 428 shows, broken hammerstones (red) are much more clustered than complete (black) hammerstones (for GH 3). This pattern is clearly visible in top view, but not as clear side view. Complete hammerstones are mostly situated in the upper half of GH 3.

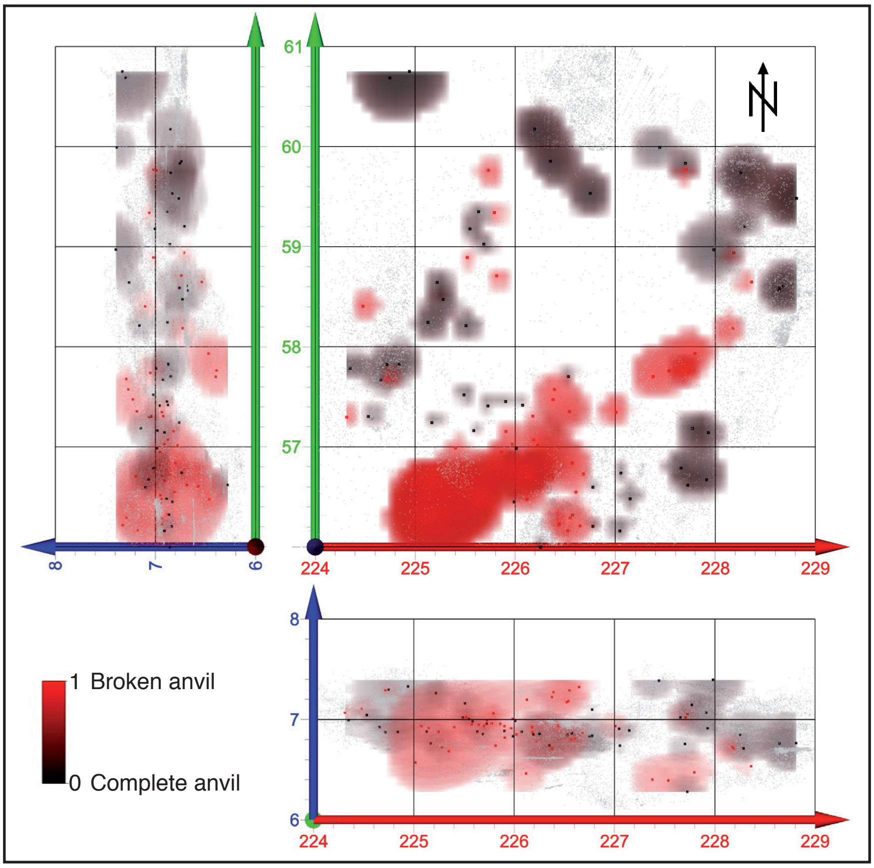

Fig. 428 - Spatial distribution of complete and broken hammerstones from GH 3

X.12.3 Anvils

As for hammerstones, anvils can be complete (anvil-on raw piece) or broken (core-from-anvil). There is evidence of n=27 anvils from GHs 3, 4x and 4 (see tab. 300).

Anvil	Number	Number in GH 3	Number in GH 4x	Number in GH 4	Total
Complete anvil (anvil-on-raw piece)		15	1	1	17
Broken anvil (core-from-anvil)		8	2	0	10
Total		23	3	1	27

Tab. 300 - Complete and broken anvils from GH 3, 4x and 4

Here the number of broken and complete anvils differ. The spatial distribution is clustered. Complete anvils (blue) and broken anvils (green) are visibly clustered in top view. In regard to Z-value this cluster is not as clear visible (fig. 429).

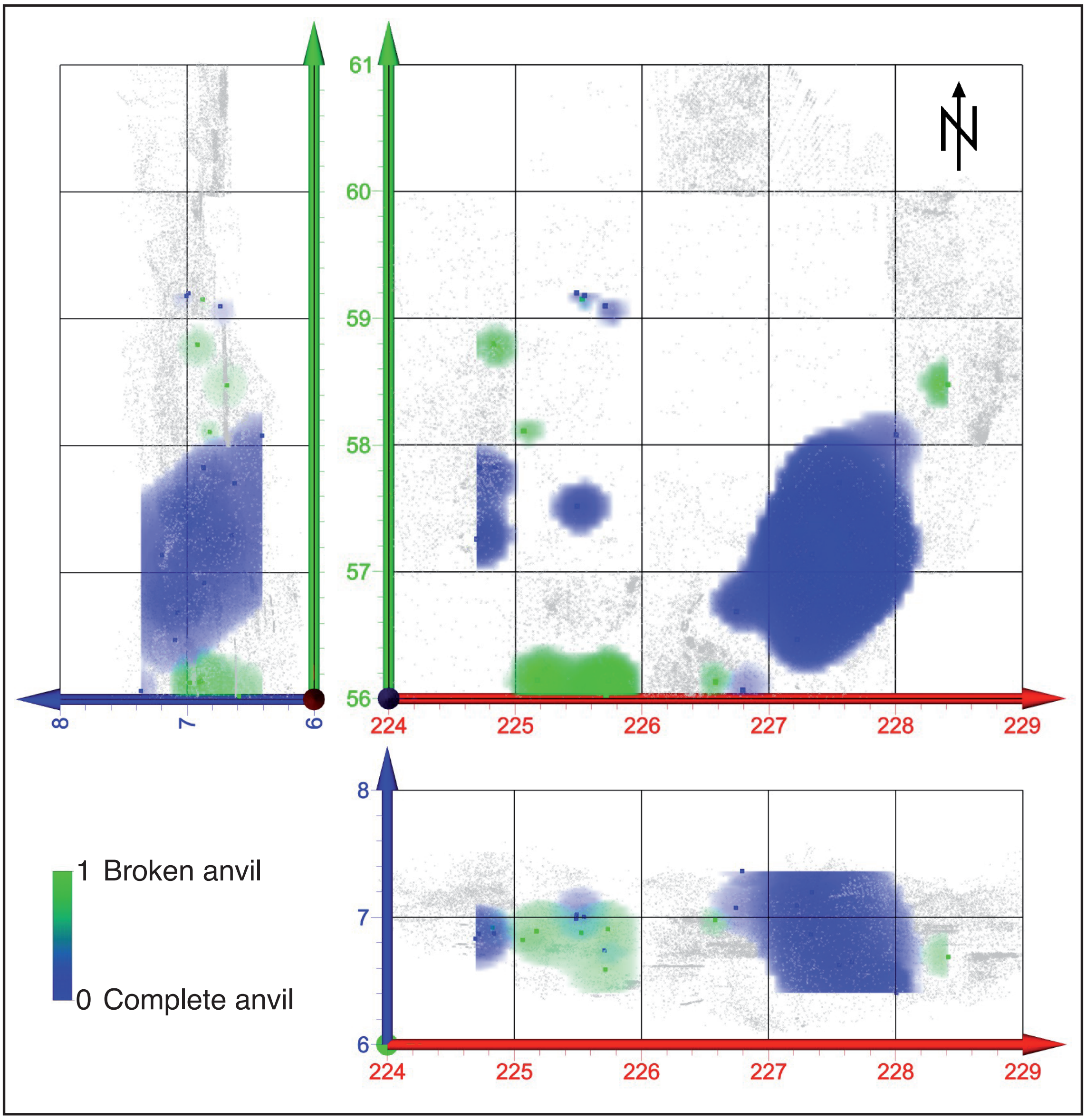

Fig. 429 - Spatial distribution of complete and broken anvils from GH 3

X.12.4 Spatial distribution of hammerstones and anvils compared

If both patterns of clustering for hammerstones and anvils are displayed in one picture (fig. 430) . The different spatial situation of all four categories are clearly visible. There are only slightly overlaps between the spatial distribution of them. The only clear overlap is visible in the southeastern corner for complete anvils (blue) and broken hammerstones (red).

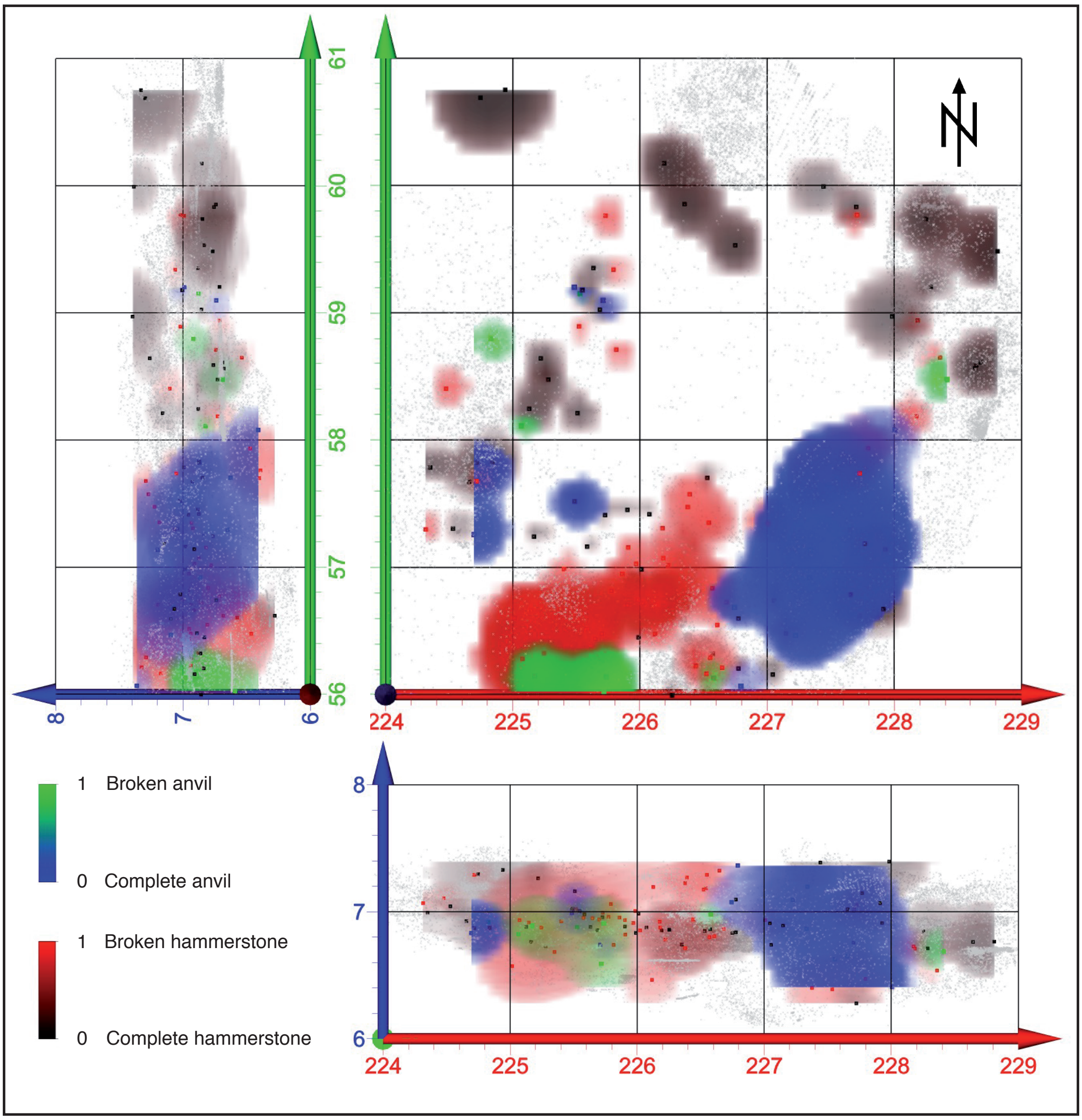

Fig. 430 - Spatial distribution of complete (blue) and broken (green) anvils, as well as complete (black) and broken (red) hammerstones from GH 3

X.13 Container

GH 3 yielded one highly particular lithic object from FAS (see fig. 431). It is classified as opportunistic core that was used as a bowl with a handle containing a black, yet unknown substance (qualitative XRF analysis suggests that it is manganese oxide, pers. comm. H. Floss, April, 29, 2016). The speculation reached from inorganic (manganese oxide) to organic (bitumen or birch-bark tar). Qualitative chemical analyses are suggested and could show, if this object is not only particular from its morphology but also from the substance in the concavity. Without speculating to much, the presence of an organic material that can be used for clueing haft and hafted objects together would add clear evidence for intentional use of material that is extremely complicate in its production. Other evidence for the use of organic clues (bitumen) are known from Umm el Tlel (Boëda et al. 2008a, b; 1996). The use of birch-bark tar is known for example from Königsaue (Koller et al. 2001).

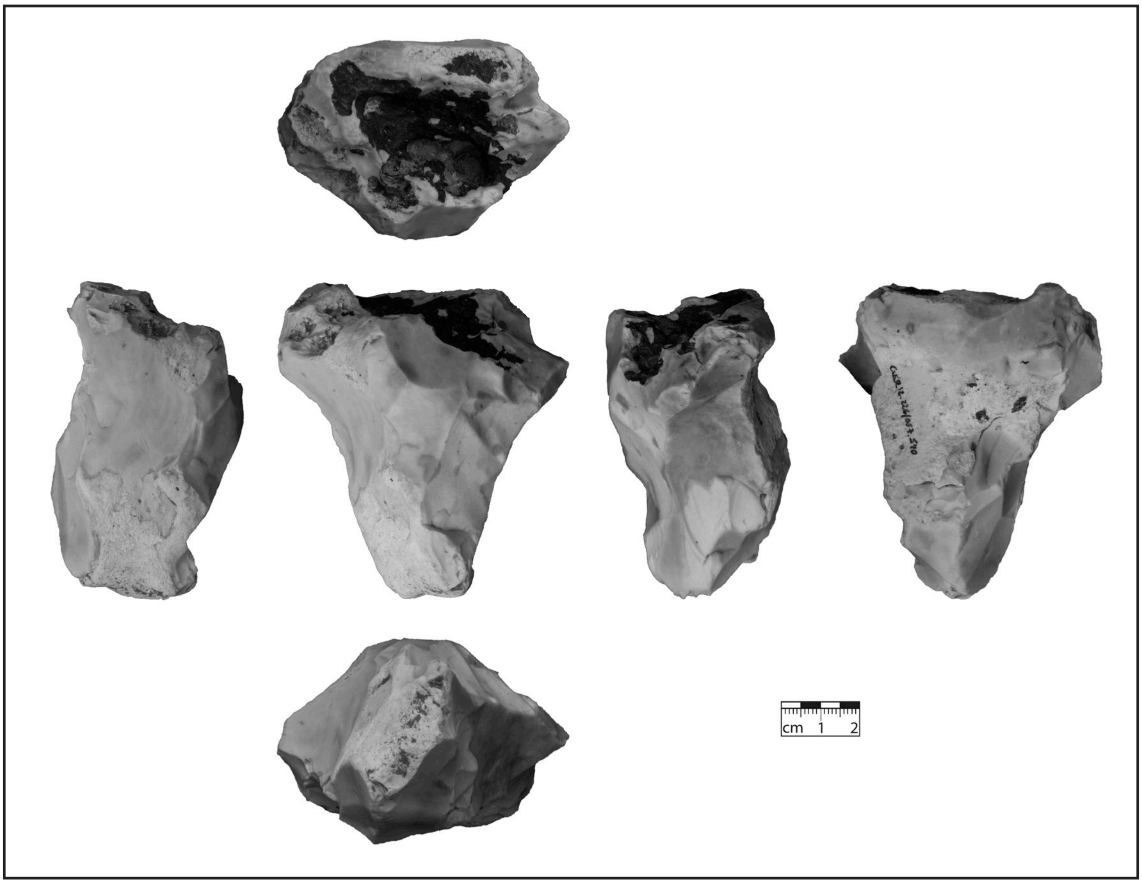

Fig. 431 - Bowl with a handle containing a black (unknown) substance from GH 3 (GER12.226-057.540)

X.14 De-conceptualization of cores

X.14.1 Introduction

GH 3 yielded some evidence of cores that show signs of de-conceptualization. These cores were in the beginning produced and reduced in the framework of a lithic reduction concept, but have features of subsequent irregular reduction that led to destruction (no possibility of further targeted reduction).

Richter (1997) described this phenomenon in the course of Levallois reduction from Sesselfelsgrotte G-complex. There, in continuous reduction of the reduction surface and as the core gets smaller the negative pattern tents to a centripetal and much more opportunistic pattern. The predetermining character of the convexities of the reduction surface is lowered and the resulting small flakes are more opportunistic in morphology. After regular reduction, the core is reduced on positions were it is still possible. It is a continuous reduction without considering the Levallois criteria. A former Levallois core can tend to be disc-shaped as exhausted core (Richter 2012a) or to be totally flattened. The de-conceptualization can result in the impossibility of an unambiguous classification.

X.14.2 Example of a de-conceptualized core

Some de-conceptualized cores are possibly invisible, because the former reduction concept is complete removed. There are some examples of cores in the lithic assemblage of GH 3 that show irregular reduction, but without any signs of a probably former regular reduction. Mostly, such cores are classified as opportunistic cores. The presented example for a de-conceptualized core (GER10.227-058.165, see fig. 432) has two phases of reduction. At first, the decortication was performed in producing regular negatives. The second phase produced hinges and steps resulting in a destruction of the core. The re-configuration would need to remove a big volume for providing adequate angles and convexities for further regular reduction.

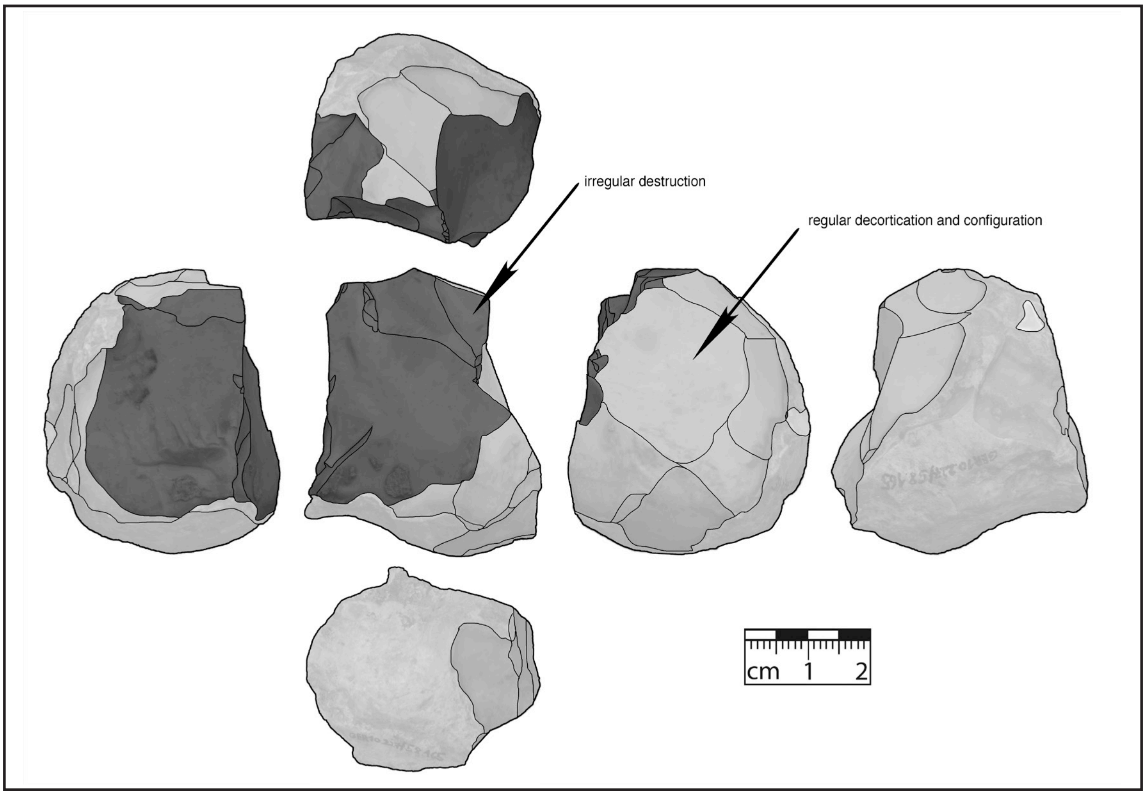

Fig. 432 - Example of a de-conceptualized core from GH 3 (GER10.227-058.165). The two phases are marked in gray shades (bright gray - regular decortication and dark gray - negatives with hinges and steps resulting in destruction)

X.15 Summary of observations from spatial distribution of lithic objects

X.15.1 Introduction

Individual spatial distribution of lithic objects can contribute to the evaluation of sub-layers in geological units, as well as actions and tasks on site. It can also offer ideas about things to find in non-excavated parts (such as the volume under the remaining collapsed rocks). The following summarize evidence of these three aspects, beginning with subdivision of geological layers in regard to spatial distribution of lithic artifacts, followed by an evaluation of actions and task occurred on-site and a collection of ideas what to find in non-excavated parts of the site.

X.15.2 Subdivision of geological layers

The spatial observations of lithic objects could not find clear evidence for grouping of lithic objects in stratified distinctive sub-layers. But a range of observations give hints or tendencies for possible subdivision. Several spatial observations were published in Frick (2016) in regard of finding evidence for spatial division inside homogeneous sediments, exemplified on GH 3.

At first, evidence from the study of microfaunal remains by Jeannet (2014) demonstrated that almost no movement after sedimentation occurred in the western part of the Upper GH 3, as well as micromorphological observations showed only little bioturbation processes (small root channels) in GH 3 and 4 (Wißing 2012). In addition, unearthed lithic objects have in majority sharp edges. Another argument for vertical subdivision derives from refitting attempt (fig. 404 in chapter X.5), because of minor vertical differences of refitted objects. The majority of refits derive from objects close to each other. Far-distance refits are almost horizontally oriented and may indicate a slight inclination of sub-layers.

Vertical subdivision in sub-layers inside GH 3

The strongest evidence for a vertical subdivision derives from the distribution of charcoal fragments from GH 3 (see fig. 433). The distribution in distinctive lenses strongly suggest the presence of a nearly horizontal separation in sub-units. Unfortunately, the careful spatial measurement of charcoal remains started in 2011 and are therefore only available for square meters around which were excavated in 2009 and 2010. But these U-shape arranged square meters clearly indicate that charcoal remains are present in clearly distinctive lenses on different levels inside the geological unit. The addition of combustion features such as burnt sediment and other remains would indicate the presence of fire places but objects with fire features cannot be directly directed to the distribution of charcoal remains. The most obvious explanation of these pattern is that light and heavier objects are

discarded by different actions. On the one hand the light material (namely charcoal fragments) could have been discarded by aeolian transport from the main occupation zone (possessing the original fire place) and the heavier were discarded by hand (dumping zone from cleaning processes).
In addition, the upper half of GH 3 contains a much higher diversity of artifacts as the lower part. Likewise, particular objects are predominantly distributed in the upper half, namely bifacial objects (see fig. 273 in chapter VII.14) and objects from quartzite (see fig. 130 in chapter VI.5.3).
Apart from lithic objects there is evidence from faunal remains to be prevalently situated in the upper half of GH 3. The highest density of faunal remains (mostly bone fragments) is present on the southwestern corner of the excavated area of GH 3. On the other hand lithic object are prevalently present in all other excavated parts (see fig. 434). In regard to vertical distribution it is possible that differences in site-use are responsible for this pattern. In the lower half of GH 3 the site could be mainly used as lithic workshop in the upper sedimentation phase of GH 3 a shift toward the use as central base camp could have happened (including cleaning of butchery zones and clearing out of fire places).The comparison of the vertical distribution of limestone and charcoal fragments may indicate a shift in climate conditions during the sedimentation of GH 3 (see fig. 435). Limestone fragments are mainly present in the upper part of GH 3. Also, charcoal fragments and limestone fragments are mutually exclusive in their distribution. Rock fall from the ceiling in the southwestern corner and rock fall as part of the rock-shelter collapse in the northeastern corner could have happened easier during ice melting processes (e.g., the shift from OIS 4 to 3, Dansgard-Oeschger-events during OIS 3 or simply in spring). Aeolian blow of charcoal fragments under a rock shelter or into a cave tunnel needs dry conditions (that are often coupled with cold and harsh climates). The aeolian transportation is also indicated by the presence of quartz, feldspar and mica in sand size in GH 3 and 4 (micromorphological evidence from Wißing 2012).
Vertical subdivision in sub-layers inside GH 4
A vertically binary-division tendency is also visible for the entirety of lithic objects from GH 4. One volume is present on top of the sintered rocks of GH 7 and 8 (first rock collapse), and another unit is situated eastwards of these rocks (see fig. 348 in chapter IX.2). As this GH and its finds are only excavated in parts were it was available (after removal of the overlaying GH 3), this tendency will vary by further excavation work.

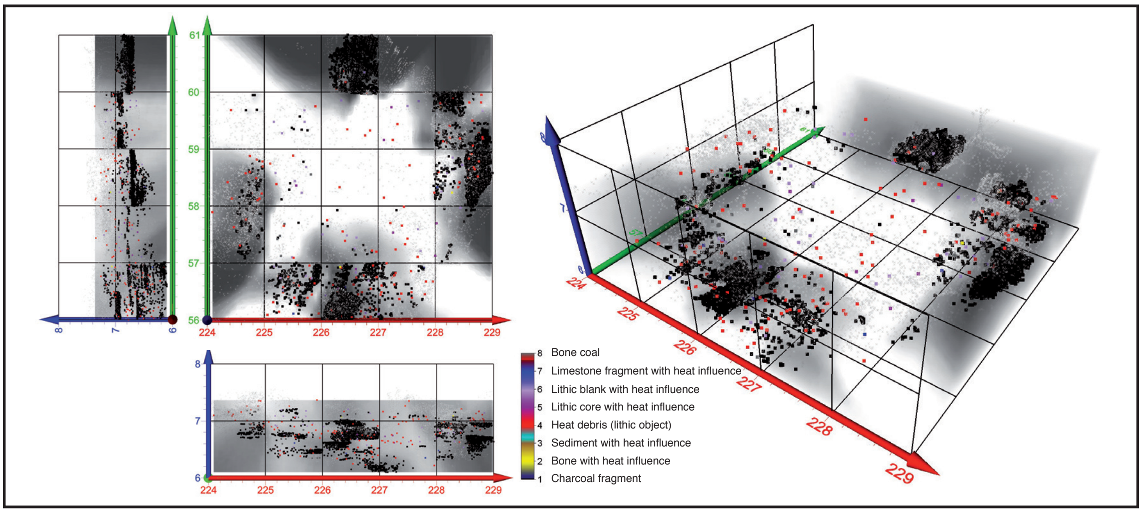

Fig. 433 - Spatial distribution of objects with heat influence from GH 3 in four different views. Above left - view to west, above mid - top view, below mid, view to north and right - oblique view. The volume render (dark gray cloud) indicates the density of charcoal fragments

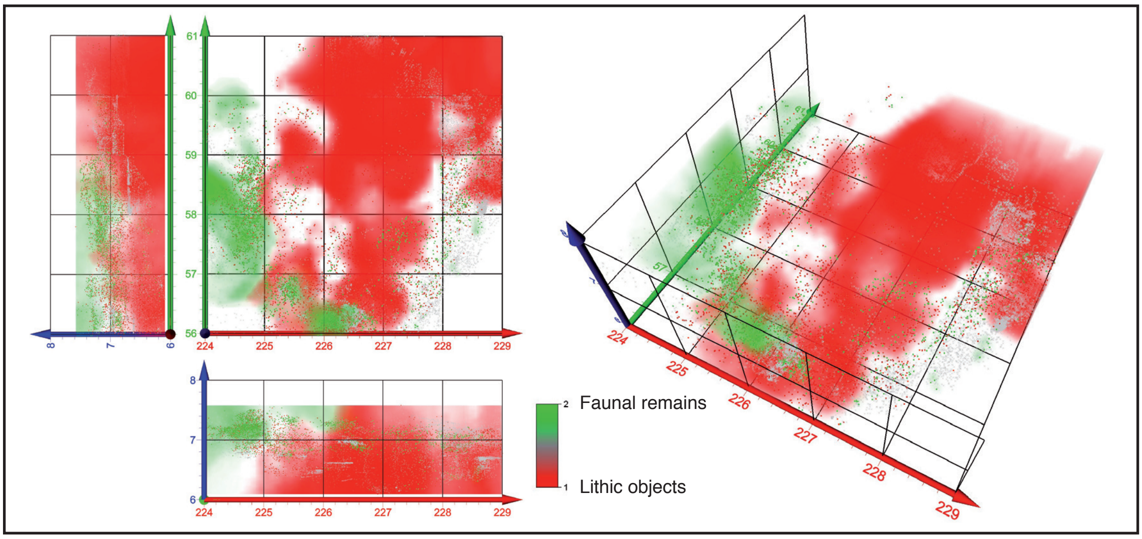

Fig. 434 - Comparison of the spatial distribution of faunal remains (green dots) and lithic objects (red dots) in GH 3 in four different views. Above left - view to west, above mid - top view, below mid, view to north and right - oblique view. Green volume render indicates higher density of faunal remains and the red volume render indicates higher density of lithic objects

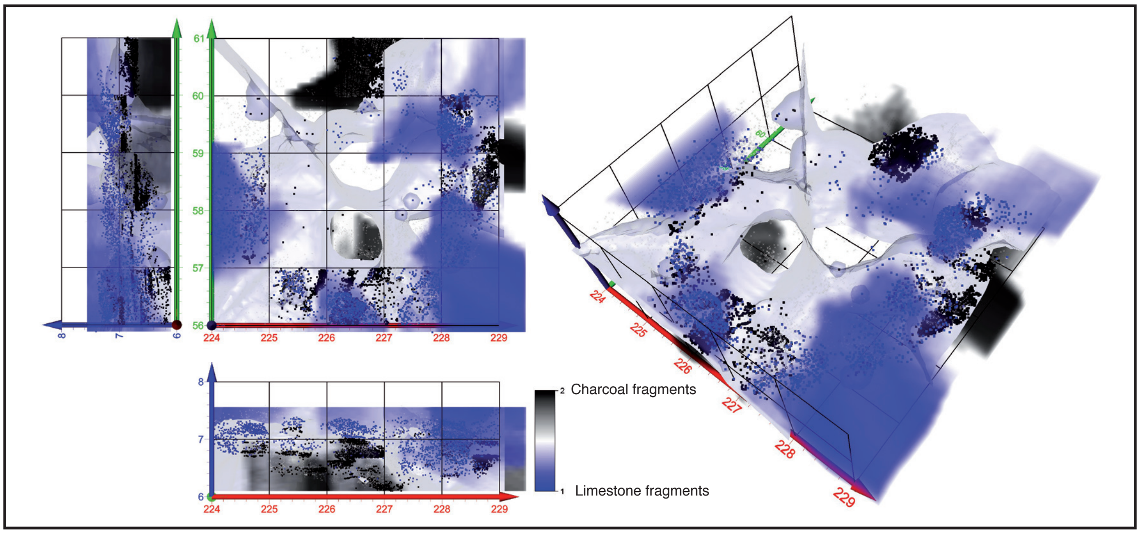

Fig. 435 - Comparison of the spatial distribution of limestone fragments (blue dots) and charcoal fragments (black dots) in GH 3 in four different views. Above left - view to west, above mid - top view, below mid, view to north and right - oblique view. Blue volume render indicates higher density of limestone fragments and the dark gray volume render indicates higher density of charcoal fragments.

X.15.2 Horizontal distribution, concentrations, tasks and actions in GH 3

Introduction

The spatial distribution of objects from GH 3 offers evidence for particular spatial patters. Some of these patterns are just visible vertically, other are visible horizontally as well. This section discusses pattern visible in horizontal distribution and their meaning.

Dumping zone in the interior of the cave tunnel?

The spatial comparison of faunal remains and lithic objects (see section above and fig. 434 therein) indicate high concentrations of faunal remains in the interior of the cave tunnel and much lower densities in direction of the opening of the rock shelter in the upper half of GH 3. Two possible explanations come into mind. On the one hand it could indicate a specific task of paleolithic cave and rock-shelter dwellers using the area in the back (behind the fire place) as dumping area for food debris to keep carnivores away, as it is exemplified for Kebara cave, level X (Speth et al. 2012) or at level J of Abric Romaní (Carbonell 2012). Another explanation of this pattern is related to chemical processes that could have led to disintegrate faunal remains under the opening of the rock shelter. In this case the chemical alteration was only present in a minor degree in the interior of the cave tunnel. The solving of this question is clearly related to intensified study of the faunal remains of the site and to spatial studies of the results.

Workstations in GH 3?

The spatial distribution of lithic objects shows evidence for the assumption of workstations for particular tasks.

At first the clearest proof comes from the distribution of quartzite. If the distribution of this material is separated into categories of hammerstones, anvils, blanks and debris a specific pattern is indicated (see fig. 430 in chapter VI.5.3). Breaking and knapping debris is prevalently situated in the northeastern corner and in a little spot in the South. On the other hand complete hammerstones and anvils, as well as broken ones (cores) are situated in the opposing southwestern corner. This pattern is visible (again) for the upper part of GH 3. In the lower parts almost no big pieces (such as hammerstones and anvils) of this material is present. The question is now, what the reason for this pattern is. On the one hand the combination of bones and big chunks of quartzite in the southwestern corner speaks for a place for breaking and splitting bones to get access to marrow. On the other hand this pattern could also be related to cleaning processes in getting rid of bigger chunks in the front and a dumping zone inside the cave tunnel. This would also speak for a more randomly scattered distribution of objects in the lower half of GH 3.

But if the specific distribution of quartzite objects is compared to that of other material the picture get blurry. Interestingly, for lithic objects from FAS another specific distribution lead to other interpretations about workstations. The upper hand of GH 3 is clearly dominated from blanks that are distributed in nearly the entire volume (green volume render). The density of blanks in the South is much lower than in other parts. Bigger chunks are situated (as of for quartzite) in its majority also in the South (darker green-blue spots). Lower entities of the GH 3 volume contain higher densities of debris (orange and red volume render). For the interpretation of these described patterns, one has to bear in mind that from the material from 2009 and 2010 there are many collective finds left to be analysed and these could contain many small pieces that create this specific pattern in the south of the excavated volume of GH 3. But nevertheless, in the southern row (excavated in 2011 to 2014) a considerable binary division is present for materials from FAS (see fig. 436).

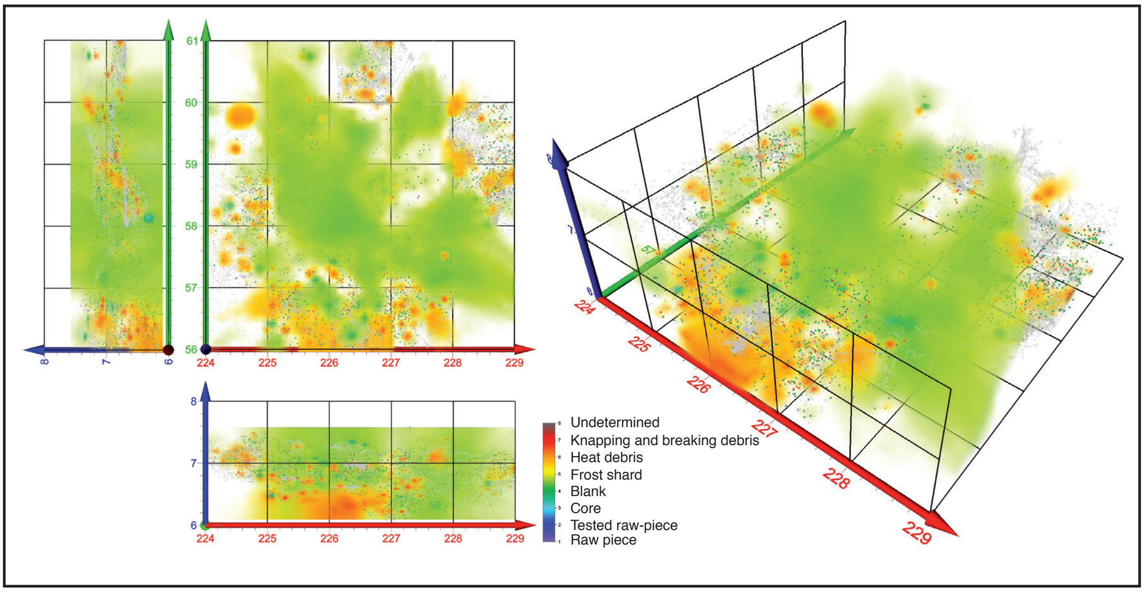

Fig. 436 - Spatial distribution of lithic objects made from FAS (flint of the argiles à silex). Above left - view to west, above mid - top view, below mid, view to north and right - oblique view. Green volume render indicates higher density of blanks, dark green-blue volume render indicates cores and raw pieces (bigger chunks) and red-orange-yellow volume render indicates debris of every kind. Gray crosses represent the scatter of alle measurement points from GH 3

General object densities in GH 3

Previous sections summarized evidence about spatiality of objects from stratified sediment units at VP II. The best evidence for a division of a geological unit in at least two entities (volumes) derives from GH 3 and prevalently bases on evidence from distribution tendencies summarized from three-dimensional plotting of single finds and general density of these objects. The following focusses on some aspects to summarize evidence for a binary division of GH 3.

The upper volume of GH 3 (fig. 437a) possesses the highest diversity. It shows zones with a high density of complete hammerstones and anvils, as well as others with quartzite debris. FAS cores and blanks are also separated in regard to their density of distribution.
The lower volume of GH 3 (fig. 437b) draws a completely different picture. Here, also induced by the underground of the first rock collapse. The densities are all present in the eastern half of the excavated area.

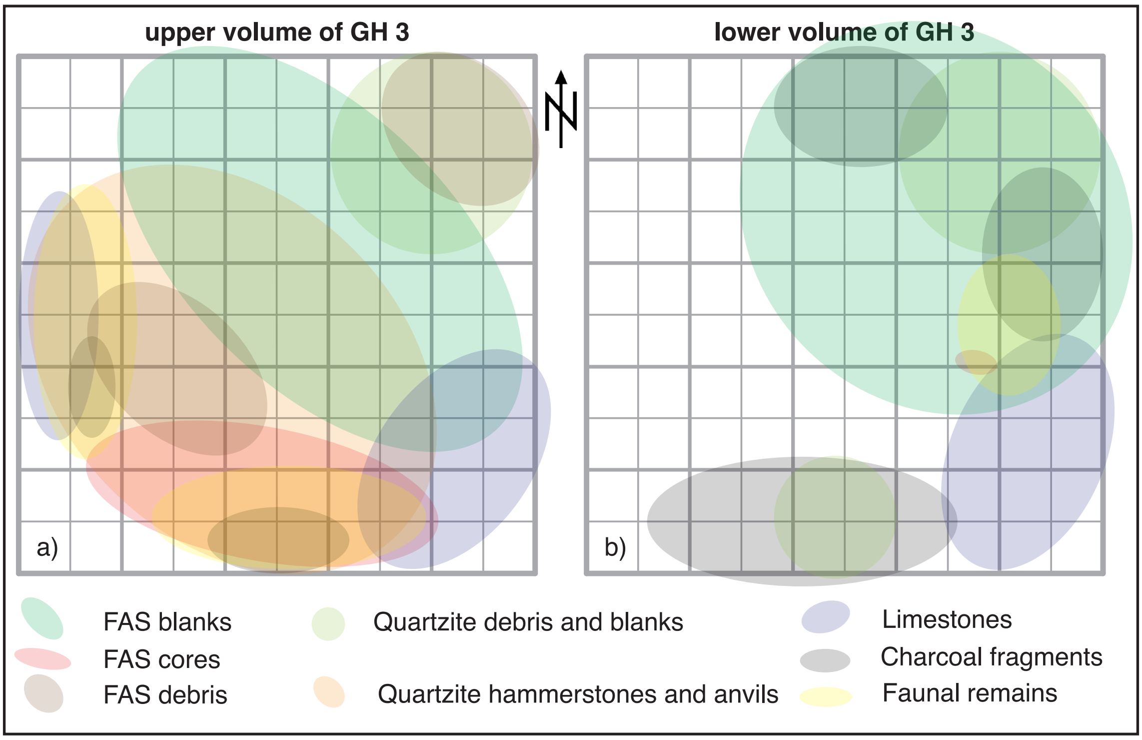

Fig. 437 - Comparison of evidence from object densities in the upper and lower volume of GH 3 demonstrating a binary division of GH 3

Chapter XI: Inter-site comparison of Grottes de la Verpillière I & II

„Now logic is a wonderful thing but it has, as the processes of evolution discovered, certain drawbacks. Anything that thinks logically can be fooled by something else which thinks at least as logically as it does.“ (Adams 2009a: 51)

XI.1 Introduction

Additional to similarities of both Grottes de la Verpillière, such as the position on the same hill slope and commonalities in the assemblages, there are major differences between both archeological sites.

XI.1.1 Time of discovery or: 1868 versus 2006

Grotte de la Verpillière I (VP I) was discovered in 1868 during road construction and was subsequently excavated the first time in the same year by Ch. Méray and team (Chabas 1876; Méray 1869, 1876). The discovery of Grotte de la Verpillière II (VP II) took place 138 years later during excavations at VP I (Floss 2006; Frick & Floss 2015). The most surprising fact here is that in the 1950s and 60s the complete hill slope at the subdistrict Verpillière was cleared from vegetation (picture of J. Combier from the April, 24, 1963, see fig. 66, chapter IV.4.5) and some of the collapsed limestone blocks of VP II are visible on the picture. Fortunately, no excavation started here, maybe because the cave tunnel was complete invisible because of the immense rock collapse and no artifacts were visible on the surface of the badger den.

XI.1.2 Verifiable cultural entities

At VP I there is evidence for occupations in Middle Paleolithic, Châtelperronian, Aurignacian and Gravettian times, but there is some evidence for Neolithic and maybe Medieval occupations as well (Dutkiewicz 2011; Dutkiewicz & Floss 2015; Floss et al. 2012). On the other hand at VP II, the main occupation took place in the Middle Paleolithic. The evidence for a Châtelperronian, Upper Paleolithic, Neolithic and Medieval occupation are poor but present.

XI.2 Comparison of the early Upper Paleolithic occupation

The Upper Paleolithic artifacts (here, including the Châtelperronian points) from VP II (material excavated between 2006 and 2012) were analysed in the course of the Bachelor thesis of Th. Götz (2013).

The analysis of the Upper Paleolithic artifacts from VP I is ongoing, however first results are available for Aurignacian artifacts (Floss et al. 2015). At VP I the Upper Paleolithic presence is striking. Artifacts from VP I were used by Breuil (1911) in the *Bataille aurignacienne* (for the history of this, see Dubois & Bon 2006) to argue for the presence of a distinct early Upper Paleolithic phase (called Aurignacien after Abri d'Aurignac). The range of artifacts includes aurignacoid blades and bladelets (only some Dufour-Bladelets are present, n=7), as well as carinated pieces and burins. Kremmer (2015) analyzed n=1371 bladelets from GH 1 at VP I and could extract aurignacoid (proto-, early and late), gravettoid and Mesolithic types. These are nearly the same chronological stages as Dutkiewicz (2011), Frick et al. (2011) and Floss et al. (2012) could extract from the ancient collections and from preliminary analysis of recently excavated material.

At VP II, there are only minor amounts of diagnostic lithic objects that can be placed in an Upper Paleolithic context. Preliminary analysis from Floss et al. (2012; 2013a), as well as Götz (2013) could demonstrate the presence of artifacts attributed to the Aurignacian, or generally into an Upper Paleolithic context. The following tab. 301 summarizes the artifacts listed by Götz (2013) from collective finds of GH 1 and 2 (2006 to 2012 excavation).

Lithic object	Number
Châtelperronian point	2
Blade	143
Unretouched bladelet	30
Retouched bladelet	9
Burin	6
Burin spall	1
Splintered piece	2
Borer	1
End scraper	3
Kostenki knife (dorsal core)	1
Bladelet core (carinated piece)	3
Blade core	3
Other core	10
Total	214

Tab. 301 - Listed lithic objects with Upper Paleolithic character from GH 1 and 2 (2006 to 2012 excavation) as described by Götz (2013)

These objects with an Upper Paleolithic character are in majority aurignacoid, but as well as the Châtelperronian points situated on top of the collapsed rock shelter. The position of all of these objects — above the rock shelter — might speak for an Upper Paleolithic occupation on top of the plateau after the collapse. Unfortunately, the remaining sediment cover on the plateau is very low (as GPR analysis demonstrated; Leach 2014). Analysis in 2012 and 2013 on the plateau could not detect further artifacts.

In conclusion, it is demonstrated that artifacts with Upper Paleolithic character are present at VP II. They all derive from mixed sediments on top of the collapsed rock shelter. It is very likely that the sediment (including the Upper Paleolithic artifact, but also post-paleolithic artifacts) has its origin on the plateau and accumulated via land-slide on top of the rock collapse. However, the sediment contains also Middle Paleolithic artifacts that can derive from stratified parts under the rock collapse (animal activity) or from another Middle Paleolithic occupation on the plateau, as well.

The foregoing shows that the intensity of the Upper Paleolithic occupation (or accumulation of objects from this time period) differs between both sites.

On VP I, extended and intensive occupation events during the Aurignacian (proto-, early and late), Gravettian and possibly Solutrean (Dutkiewicz 2011) took place under and in front of the rock shelter, as it was demonstrated again in extensive mechanic excavations on the terrace of VP I in 2015 (Hoyer & Floss 2016; Hoyer et al. 2016).

XI.2 Comparison of the Châtelperronian

The Châtelperronian is present in both sites in form of Châtelperronian points and probably blade cores for the production of matrices for Châtelperronian points (Würschem 2015). At VP I, there is evidence from n=33 Châtelperronian points and n=9 cores with reduction features that tends to Châtelperronian strategies. The presence of Châtelperronian points at VP II is limited to two finds from the 2007 excavation in GH 1 (GER07.230-061.12.2 and GER07.230-062.38.1, see fig. 438).

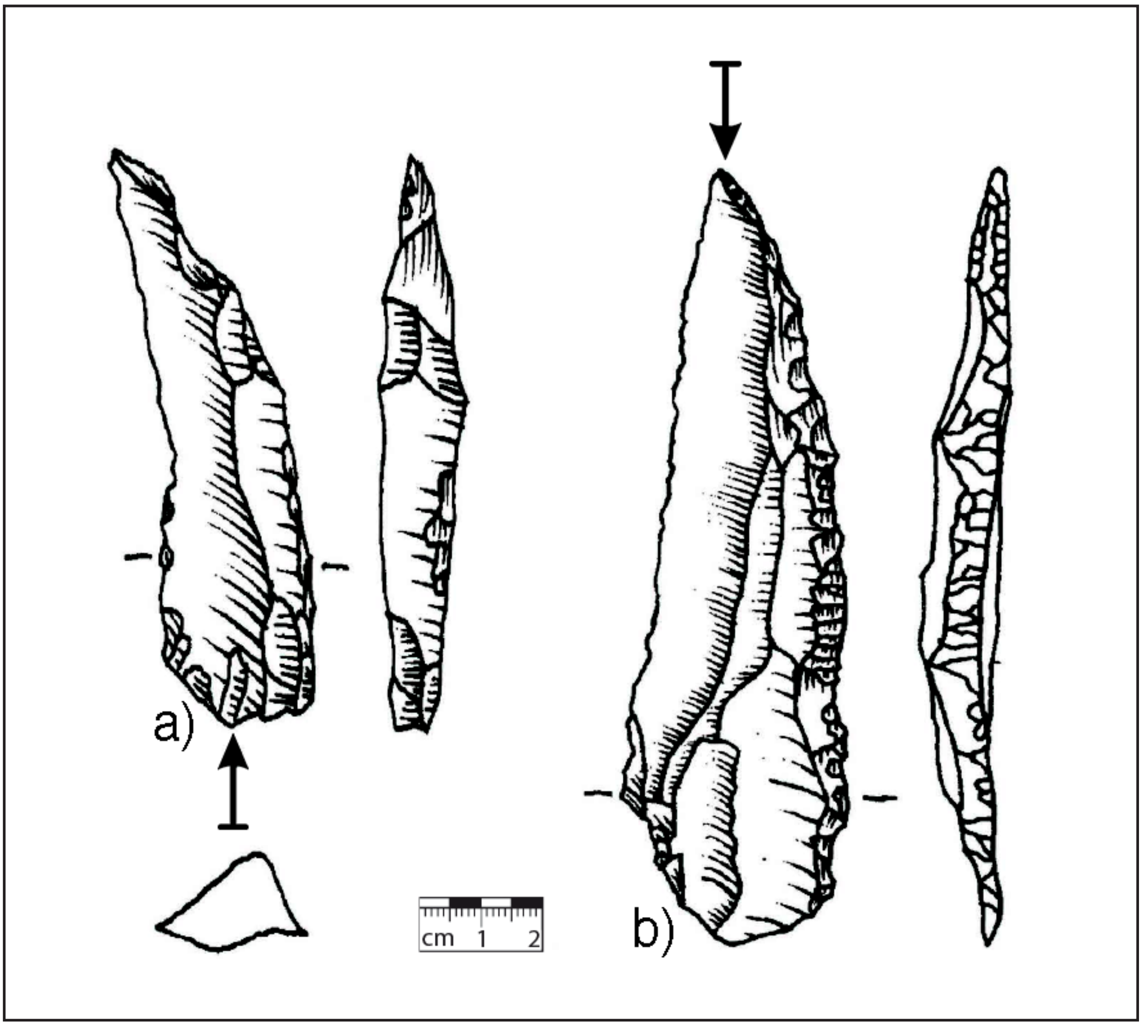

Fig. 438 - Châtelperron points from GH 1 at VP II (adopted from Götz (2013: 30, fig. 15), scale and arrows are added). a) GER07.230-061.12.2 and b) GER07.230-062.38.1

From the presence of these two points, VP II is the easternmost Châtelperronian site (around 5 m more eastern than VP I) to date.

A real comparison is challenging because of the sparse presents of diagnostic artifacts. At VP I it is likely that the occupation during Châtelperronian times took place under the rock shelter. A small spot of sediment (GH 40) that yielded such a point was found in 2014. Unfortunately, the ultrafiltrated AMS 14C date from Th. Higham (Oxford) of 49.600±3.900 on bone (GER14.195-096.34) from this GH has a large standard deviation (Heckel et al. 2016), but definitely dates into the OIS 3. At VP II, if any occupation in Châtelperronian times took place on the site, it occurred on top of the collapsed rock shelter, because it crushed at the end of the Late Middle Paleolithic occupation (directly after the sedimentation of GH 3, see chapter IV.6). In this case, it is much more likely that the Châtelperronian points (both from GH 1) derive from on top of the plateau and were washed (together with Upper Paleolithic and post-Paleolithic finds) down hill.

XI.3 Comparison of the late Middle Paleolithic occupation

XI.3.1 Introduction

The Middle Paleolithic is due to stratified (partly dated) sediment layers and artifacts present at both sites. The lithic industries of both sites shows striking similarities in regard to blank production, the presence of bifacial elements, as well as resharpening processes using tranchet blows. Méray (1876: 266, fig. 18) displayed one Keilmesser with tranchet blow and described it as a small shaped nodule: „*Les casse-têtes formés d'un rognon de silex, dont un côte a été taillé en biseau* […]" (Méray 1876: 263)

In the 1970s, Desbrosse et al. (1976) analysed the material from an ancient collection from the Méray excavation in 1868 (coll. Jeannin) and described the *Keilmesser* (Prondniks) from VP I in detail. The analysis found comparisons in the material from Ciemna (Poland) and Buhlen (BRD) concerning shape and the use of tranchet blows for resharpening processes of the cutting edge.

The analysis of all known ancient collections of VP I last until this century. Dutkiewicz (2011) collected all available information about ancient excavations and collections of the site and undertook preliminary analysis of the lithic industries in the course of her Magister's thesis. The available Middle Paleolithic artifacts from the old collections, as well as the excavations between 2006 and 2009 were analysed in the course of the author's Magister's thesis (Frick 2010). Both, the ancient collections and the material from the actual excavations contain evidence for levalloid blank reduction, bifacial elements and resharpening processes using tranchet blows. In addition to this general accordance between the Middle Paleolithic industries from VP I and VP II, there are particularities.

XI.3.2 Bifacial elements

In focusing on bifacial elements (bifacial objects and tranchet-blow blanks), bifacially worked objects (BWOs) are only present in VP II and bifaces with double reflection symmetry are only present in VP I. All other kinds of bifacial objects are present on both sites (see tab. 302). The vast amount of bifacial elements is present in GH 3 (at VP II).

If bifacially worked objects are seen as objects that use the morphology of the blanks with a simply created bifacial cuting edge or an alternated edge modification, the option is given that they are reused (or with a gap in time, recycled) blanks.

In contrary to VP II, bifaces with double reflection symmetry are present at VP I. They are in majority known from ancient collections, but also from recent excavations (n=1 from 2008) and a new one from a mechanical test pit in 2015 (northern part of the VP I terrace, see fig. 439). The stratigraphic position of the newest biface (near the valley ground, down hill, lowest part of the stratigraphy) might be a hint for another chronological phase (older than the KMG) of the Middle Paleolithic at VP I. As example, in the Senonais (Dept. Yonne), there is evidence for symmetrical bifaces from the early OIS 5 (Deloze et al. 1994).

Site / Bifacial element	VP I (1868 to 2014)		VP II (2006 to 2014)					Total number
	Ancient collections	New excavations (2006 to 2014)	GH 1	GH 2	GH 3	GH 4x	GH 4	
Biface with double reflection symmetry	9	1	0	0	0	0	0	10
Asymmetric biface with small back	8	5	1	3	5	0	0	22
Symmetrical biface with plane-to-convex surfaces and plano-convex cross section (Fäustel)	4	1	1	0	2	0	1	9
Asymmetrically bifacially backed knife (simple Keilmesser)	6	4	1	0	4	0	0	15
Asymmetrically bifacially backed knife with tranchet blow (Keilmesser with tranchet-blow)	17	1	0	0	3	0	0	21
Bifacially worked object (bifacial scraper)	0	0	0	0	5	0	1	6
Bifacial preform	23	9	2	0	8	0	0	42
Tranchet-blow blank	9	0	0	0	9	1	0	19
Total number, each	**76**	**21**	**5**	**3**	**36**	**1**	**2**	**144**
Total number, per site	**97**		**47**					**144**

Tab. 302 - List of all bifacial elements from VP I and II (empty fields are red shaded)

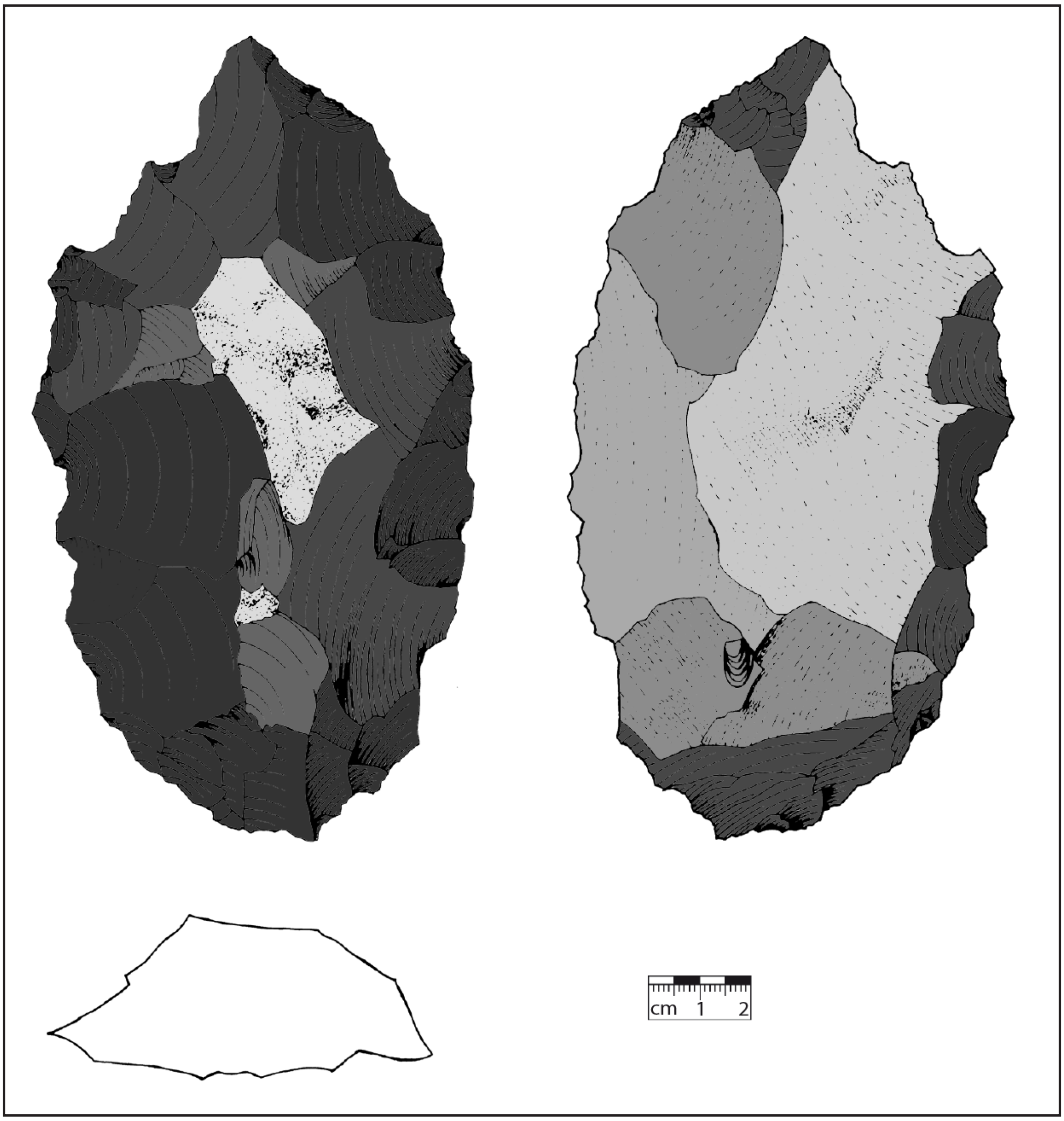

Fig. 439 - Bifacial preform of a probably double symmetric biface from the test pit in the norther part of the terrace at VP I, adopted from Hoyer et al. (2016: 53, fig. 34)

XI.3.3 Levallois cores

Preliminary analysis of the assemblage of the stratified GH 16 at VP I (Litzenberg 2015) demonstrated the presence of an exhausted bi-directional parallel Levallois core (GER11.192-099.431, see fig. 440), as well as one bifacial preform (GER11.192-099.428, see fig. 441 and tab. 293). This GH (only rests are present in twelve square meters) is left on an actual area of around 3 square meters (the rest was affected by ancient excavations) and is attributed as Middle Paleolithic „living floor" (Floss 2010; Floss et al. 2013b). Preliminary dating attempts (ESR - U/Th) of Richard et al. (Richard et al. 2016) on horse teeth from GH 15 (situated on top of GH 16 and a clear mixture of Middle Paleolithic and early Upper Paleolithic objects, own observation, see also Floss et al. 2013b) give datings of 34±2 (VPI-744); 48±3 and 51±3 ka

(VPI-398). Therefore, for the first, GH 16 can bee seen as a Middle Paleolithic layer of 50 ka or older with the presence of Levallois and bifacial objects. As the area of this GH is meagre — as well as the assemblage size — it is attributed to a Middle Paleolithic with Levallois and bifacial objects. A clear attribution of a space-time-unit of the Middle Paleolithic has to stay open, but for the presence of Levallois and bifacial object the option of an attribution to the KMG is disputable, as well.
The analysis of old collections and the excavated material from mixed layers (2006 to 2009) of VP I that are attributable to the Middle Paleolithic (Frick 2010) demonstrated clearly that the majorly used lithic reduction concept is Levallois. Discoidal and Quina-like cores are very rare. The blank production follows the Levallois concept.

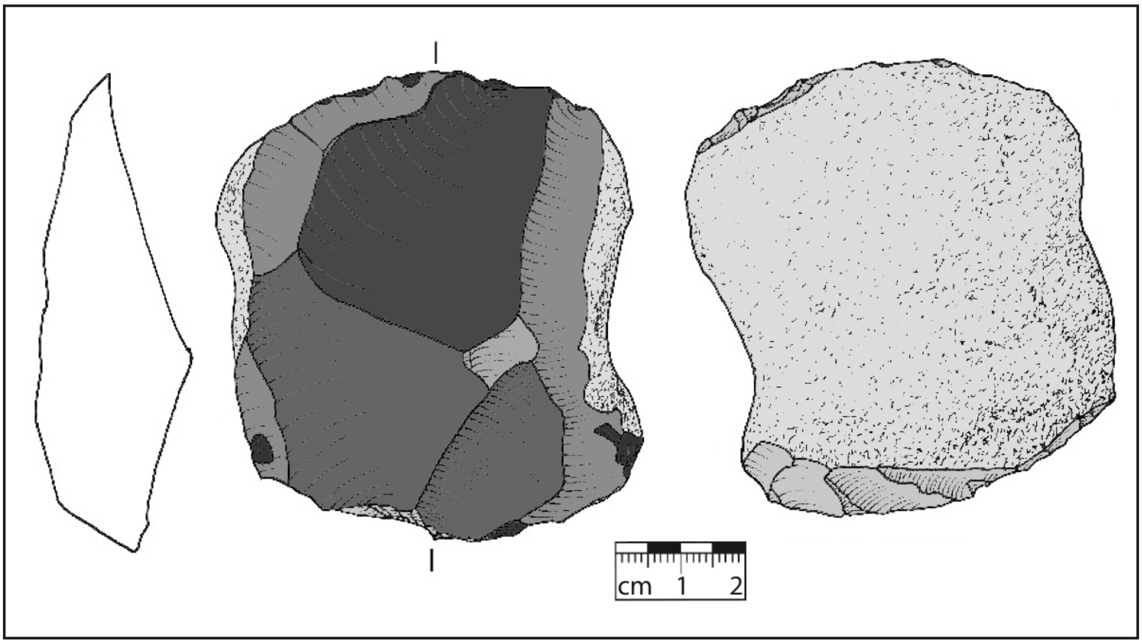

Fig. 440 - Exhausted bi-directional parallel Levallois core from GH 16 at VP I (GER11.192-099.431), adopted from Litzenberg (2015: 34, fig. 25) and modified

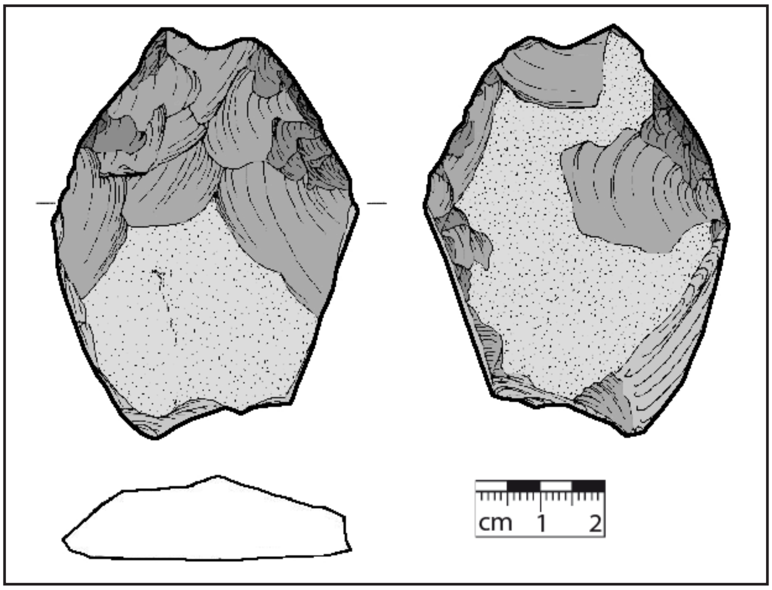

Fig. 441 - Bifacial preform from GH 16 at VP I (GER11.192-099.428), adopted from Litzenberg (2015: 35, fig. 26), and modified

XI.3.4 Conclusion of comparison

The assemblages of VP I and II that are attributed to the Middle Paleolithic demonstrate clearly the high dominance of Levallois reduction for the production of wanted blanks. Levallois at both sites is a highly variable way of blanks production. The majority of cores are exhausted, flattened and smaller than 60 mm in diameter. Additionally, a great morphological range of bifacial objects are present at both sites. The most extraordinary bifacially modified objects are Keilmesser that are present in GH 3 at VP II, the mixed covering layers at VP II, as well as old collections from VP I and their mixed covering layers (foremost GH 1). The originality of these objects resides not only through the presence of tranchet-blow blanks, but also through corresponding negative on some of these *Keilmesser*. In opposition to VP II (from the status of excavation), VP I yield evidence for another kind of Middle Paleolithic unit that contains bifaces with double reflection symmetry (up-to-now in small numbers from old collections, mixed layers, as well as from a test trench from 2015 (see fig. 438, above). Without clear, reliable evidence, we attribute them to the OIS 5 because of parallels from the Sennonais, Yonne (see Deloze et al. 1994), e.g., from the open-air site of Le Grand Chanteloup in Molinons (sites nearby such as Charbonnières in the Mâconnais are unfortunately undated).

Chapter XII: Comparison of VP II and further Middle Paleolithic assemblages in the Côte chalonnaise

"I cook with wine, sometimes I even add it to the food." (W. C. Fields, in Lendler 2005)

XII.1 Introduction

This chapter applies the knowledge gained from the study of the lithic record of VP II and surrounding sites, as well as the summarized knowledge of influencing factors and classification systems. It gives a broader image and framework of the site of Grotte de la Verpillière in its Paleolithic context.

The chapter gives an overview of the research in the „*Kontextareal*" (Weißmüller 1995: 51-57) of VP II. Richter et al. (2012: 7) define such contextual areas „*as the systemic environment of prehistoric humans comprising an array of adaptive relationships between natural and socio-cultural factors within a human habitat. The extension of the same habitat is defined by natural and chronological boundaries (definition according to the description given by Weissmüller, 1995).*"

The research at VP II and surrounding Middle Paleolithic sites offers a background for making observations to formulate a particular space-time unit (STU, see also chapter I.4.2, II.1.1 and V.4.3). And therefore, „[t]*he objective of either approach is to associate, for two or more sites, all aspects of material culture in a shared space-time matrix so that a sequence of regional events can be discerned and social processes inferred.*" (Blackham 1999: 2)

XII.2 Early research history

The beginning of Paleolithic research in the Côte chalonnaise is marked by first excavations from E. Perrault at Grotte de Mère-Grand à Rully in 1877 (de Mortillet 1883) and from Ch. Méray at Grotte de la Verpillière in 1868 (Méray 1869). On both sites the present of a Moustérien following the classification system of de Mortillet (1873) has been attested.

The research of Ch. Méray (1869, 1876) and F. Chabas (1876) at Grotte de la Verpillière was later used by Breuil (1911) to find additional arguments for the establishment of a paleo-chronological stage, called Aurignacien.

Grotte de la Verpillière was undergone the most intensive excavation work on a Paleolithic site in the Côte chalonnaise. Dutkiewicz (2011) collected evidence for more than 20 excavations there (from 1868 till today). Nevertheless, the vast majority of sites with Paleolithic artifacts are known via surface collections and not from documented excavations.

Well-known persons such as H. Delporte and J. Combier conducted excavations in the 1950s in the Côte chalonnaise and are listed in the following tab. 303 (definitely non-exhaustive):

Researcher	Year of excavation	Excavated site	Note	Literature
H. Delporte	1953-1955	Grotte de la Verpillière I	long trench on the terrace of VP I and small test pits in the entrance area	Delporte 1953-1955 Delporte 1955
J. Combier	1956-1957	Grotte de Mère grand à Rully		Combier 1956-1957
J. Combier	1959	Grotte de la Verpillière I	small test pit in the interior of VP I	unpublished Dutkiewicz 2011 Dutkiewicz & Floss 2015

Tab. 303 - Known paleolithic excavations in the 1950s in the Côte chalonnaise

Gros (1958) in using ancient collections from the Méray excavation and others discusses evidence for the presence of *Acheuléen supérieur*, *Moustérien*, *Périgordien* and *Aurignacien* artifacts at VP I.

The early research was led by classification systems established by G. de Mortillet or F. Bordes. The research of the 1950s and 60s classified the Mousterian assemblages in the system of the Bordesian facies.

A chronological table in Combier & Thévenot (1976) displays Germolles (VP I) and Saint-Martin-sous-Montaigu in the column of the *Moustérien récent* and Rully in the *Moustérien ancien* for principal Middle Paleolithic sites in the Châlonnais. In the text, the site of Grotte de la Mère Grand à Rully was defined as *Micoquien final*.

XII.2 Recent research history

XII.2.1 Introduction

The 1970s mark a small revolution in the understanding of Middle Paleolithic assemblages from Côte chalonnaise. The analysis of R. Desbrosse of ancient collections, as well as surface collections from the Côte chalonnaise (Desbrosse 1979; Desbrosse et al. 1976; Desbrosse & Tavoso 1970; Desbrosse & Texier 1973a, b) and the research from C. Farizy (1985, 1986, 1988, 1995) at Champlost (Yonne) led to the recognition that the Bordesian typology does not work for a vast range of lithic objects from this region. The research of both demonstrated the search for appropriate classification systems of the Middle Paleolithic record of the region.

XII.2.2 La Roche à Saint-Martin-sous-Montaigu

Research of the 1980s were mainly led by typological approaches. On the one hand, Ch. Pouliquen (1982a, b, 1983b) studied ancient collections of Lènez from La Roche à Saint-Martin-sous-Montaigu in the course of her *Diplôme d'etude supériers* (similar to Master II?) and evaluated the presence of a *Moustérien de tradition acheuléenne* or a *Moustérien de facies Quina*. She discussed both possibilities with intension. The affiliation of the assemblage with the *Moustérien de facies*

Quina rhodanien (*Quina facies* of the Rhône valley as defined by Combier 1967) is due to the presence of side scrapers with Quina retouch. The affiliation to the *Moustérien de tradition acheuléenne* derives from the presence of bifacial objects and manifest for her a particular expression of the *Quina rhodanien*: *„Ce caractère particulier est peut-être l'expression d'une variation locale du Quina rhodanien, mais il est peut-être la manifestation ponctuelle d'un type Moustérien à vaste diffusion géographique proche du groupe d'Altmühl.“* (Pouliquen 1983b: 206). In discussing the bifacial objects from the site, she refers to the *Altmühl* group from Bavaria (she cites Freund 1954 in the bibliography but not in the text) because the bifacial objects from La Roche look for her intermediate to „real“ bifaces (*vrais bifaces*) and foliated pieces (*pièces foliacées bifaces*), as she noted it for the Schulerloch or the Obernederhöhle in Bavaria, BRD (Pouliquen 1983b: 205).

XII.2.3 Research in the upper Loire basin

Philibert (1982) studied and summarized the Paleolithic record from the Upper Loire basin and discussed also assemblage from Saône-et-Loire (research was conducted in the early 1970s). She found evidence for the presence of the facies of the *Moustérien de tradition acheuléenne* in Rosereuil à Igornay, based on the work of Creusaton and Desbrosse (1966, 1967). The *Moustérien charentien* is present for here in Bois de Ranches à Blanzy, Bois des Thiborins à Blanzy and La Fiolle à Blanzy, as well as in Les Minots-les Durands à Montoenis. In addition to these sites, she list many sites from Saône-et-Loire as *Paléolithique moyen indeterminé*. In majority she discusses sites from the western part of the Saône-et-Loire department and turns only briefly to sites from the *Côte chalonnaise*.

XII.2.4 Gouédo's (1999) approach for the Micoquian in Eastern France

J.-M. Gouédo (1999) discusses in the course of his dissertation about the „*technocomplexe Micoquien en Europe de l'ouest et centrale*“ three sites from the South-east of the Parisian basin (Vinneuf and Champlost, Yonne, as well as Verrières-le-Buisson, Essonne) and includes the sites of Grotte de la Verpillière I, Bissy-sur-Fley and Blanzy in the discussion. For him, the Micoquian develops from the Acheuléen at around 450 to 400 ka. He chronologically separates the Micoquian into three units (*Micoquien ancien*, *Micoquien rich en „bifaces pointus“* and *Micoquien rich en „bifaces non pointus“*) and distinguishes three groups (A, B and C), whereby group A and C belong to the *Micoquien ancien* and group B seems be situated technologically between the Micoquian and the MTA, that is what he is calling „*technocomplexe micoquien*“. In this group the bifaces are made from bifacial and trifacial matrices and not from bifacial tools. For him the relationship between the Micoquian and the MTA are unclear. Group A and C belongs to the OIS 10 to 8 and group B is situated in the last glacial period (OIS 5 to 3). Gouédo (1999) sees a separation of the Middle Paleolithic record in the last glacial period (*Micoquien rich en „bifaces non pointus“*) . On the one hand, assemblages from this time span are grouped as *Keilmessergruppen* and *Prondnik-Horizont*. On the other hand, there are industries without *Keilmesser*, but with MTA bifaces and bifacial pieces. He strictly separates his *technocomplexe micoquien* from the *technocomplexe moustérien* (*„Levalloisien“, M. Type Quina, M. à denticulés ind. Laminaires*). The following tab. 304 gives an overview of this clustering:

Cluster	Sites	Dating	Note
Micoquien de groupe A	La Garenne à Cagny, Cimetrière à Cagny, L'Épinette à Cagny, Carrière Tellier à Saint-Achéul, Soucy I, Verrière-le-Buisson, Vinneuf, Combe Grenal, La Micoque, Orgnac III, La Baume Bonne	Gouédo (1999, fig. 176): Pre-Saalian (OIS 10 to 9) Deloze et al. (1994) dated Vinneuf in OIS 5c (niveau 0 and 1) and OIS 5d (niveau 2) Gouédo (1999: 92) about the dating of Verrière-le-Buisson: *„Le Micoquien semble donc bien en position primaire à l'interface 13-12, lors du début de la mise en place des granules, c'est-à-dire au début de la phase climatique humide mar-quée par des ruissel-le-ments, postérieure à une phase d'érosion qui aurait tronqué un paléosol corrélé hypothétiquement avec l'Éémien.“* Gouédo (1999: 38) about the dating of Vinneuf: *„L'analyse micromorpho-logique permet donc une attribution des niveaux archéologiques N2, N1 et N 0 à une phase antérieure à un pléniglaciaire. Elle tendrait finalement à une attribution de ces niveaux à un Éémien au sens large et peut-être au début du Weichsélien ancien. Le niveau N3 est antérieur à la seconde pédogénèse interglaciaire repérée sur le site que l'on pourrait attribuer à l'Éémien.“*	Gouédo (1999: 229): *„Le Micoquien de groupe A est défini à partir des industries de Vinneuf et de Verrières. Il se caractérise par une chaîne opératoire de façonnage d'outils en position indépendante ou relativement indépendante par rapport au domaine du débitage (façonnage sur supports généralement non issus des chaînes opératoires de débitage). Ble vise la confection de deux familles d'outils (les „bifaces pointus“ et les „bifaces non pointus“) sur supports façonnés bifacialement (sans dos) ou trifacialement (avec dos). Le façonnage est conçu en opposant la zone dite „active“ de l'outil (ZA), de la zone que nous interprétons comme restant inerte car liée à l'emmanchement ou à la préhension de l'objet (ZEP). Une majorité de ces outils, sur l'ensemble de la zone étudiée, est façonnée de manière alterne sur les quatre bords par de courtes séries d'enlèvements tantôt laminaires, tantôt de type éclat, à directions variées. Cette méthode de façonnage correspond à ce que G. Bosinski (1967) a appelé „wechselseitig-gleichgerichtet“. Sa réalisation se traduit par un graphisme aisément reconnaissable et qui semble différent de celui des bifaces acheuléens (fig. 140). Le „biface pointu“ est typologiquement assimilable à une pointe moustérienne dont la retouche s'étend sur les bords pour passer insensiblement à un racloir convergent. Le „biface non pointu“ est souvent un racloir ou parfois un couteau ou un denticulé. Il peut être opposé à un dos, appelé biface à dos chez nous. Le terme de „Keilmesser“, utilisé outre-Rhin, regroupe des formes d'outils qui correspondent à nos deux notions de „bifaces pointus“ et de „bifaces non pointus“. Un usage en percussion perforante s'ajoutant au raclage/grattage est probable pour les „bifaces pointus“, ce qui expliquerait les nombreuses cassures transversales et orthogonales des extrémités apicales. Nous utilisons le mot biface entre guillemets pour montrer la différence avec le biface-outil ; outil caractéristique de l'Acheuléen ou, dans tous les cas, non caractéristique du Micoquien.“*

Micoquien de group B	Salzgitter-Lebenstedt, Lichtenberg, Königsaue, Balver Höhle, Buhlen, Rörshein, Becov, Schambach, Klausennische, Bockstein, Sesselfelsgrotte, Kulna, Wylotne, Zwoten, Okiennik, Piékary, Krakow-Wawel, Ciemna		Gouédo (1999: 261): „[…] *le groupe B (le MTA) est provisoire.*"Gouédo (1999: 188): „*Cette partie commune du concept de façonnage/ confection entre biface MTA et biface micoquien nous permet d'avancer l'hypothèse d'un second groupe de Micoquien (groupe B) et donc d'un „technocomplexe micoquien" qui regrouperait toutes les industries du Paléolithique moyen où le „biface" est conçu comme support bifacial ou trifacial d'outil de type Paléolithique moyen et non comme un outil bifacial. Dans cette optique, les relations entre le Micoquien et le „Moustérien de Tradition Acheuléenne" sont donc à éclaircir. Y a t-il filiation comme le pensait F. Bordes au début de ses travaux ou ancêtre commun ?*"
Micoquien de group C	Mont du Beuvrey à Béthune, Mesvin IV, Vallée du Muid à Gouzeaucourt, Longavesnes, La Cotte de Saint Brelade à Jersey, Champlost	Mesvin IV is dated around 250 ka (Ryssaert 2005, Cahen et al. 1984) Champlost is dated around 45 to 65 ka with ESR (Farizy 1992, Farizy 1995)	Gouédo (1999: 189): „*Nous nommons donc l'industrie de Champlost „Micoquien du groupe C". Ce „technocomplexe micoquien" se caractériserait donc par des industries lithiques avec une présence d'outils de type Paléolithique moyen sur supports façonnés (qu'ils aient été ou non au préalable débités) bifacialement et/ou trifacialement en parallèle à la présence d'outils de type Paléolithique moyen sur supports débités. Les supports sont de natures variées : anciens nucléus, produits de débitage, blocs, galets, plaquettes, éclats de gel, etc. Dans le domaine de la technologie lithique, le „technocomplexe micoquien" serait donc lié au stade de développement que représente le Paléolithique moyen. Il est donc important de chercher à mieux caractériser ce technocomplexe, de voir s'il apparaît et éventuellement disparaît en même temps que le Paléolithique moyen et qu'elles sont ses relations avec l'autre grand technocomplexe du Paléolithique moyen qu'est le Moustérien.*"
Micoquien de group B ou C	Vellèches à Fontmaure, Abri du Musée à Les Eyzies, Les Pâtis à Férebrianges		

Tab. 304 - Grouping of „Micoquian" sites by Gouédo (1999)

The grouping of „Micoquian" sites by Gouédo (1999) is somewhat peculiar. As tab. 295 demonstrates there are sites grouped together that have differences in age estimation of around 200 ka (e.g., in group C). For the author, this approach is incomprehensible. Even if the bifacial component of these assemblages show similarities in morphology or used technology, the time gap clearly demonstrates that they are independent from each other. Of course, there can be some analogies of these assemblages, but this observation is not enough evidence for establishing an evolutionary line between these assemblages.

Gouédo (1999) distinguishes two *„families"* of bifacial objects and sees them scattered chronological in different time spans. Pointed bifaces are in major present in OIS 8 to 6 and non-pointed bifaces are present in OIS 5 to 6:

- Tools with a transversal border between the active and passive zone (pointed bifaces)
- Tool with an oblique border between the active and passive zone (non-pointed biface)

The approach of Gouédo demonstrates clearly the tradition of french scholars of lumping together assemblages that are formerly attributed to be Micoquian to a — from the Mousterian separated — evolutionary development line, as it was proposed by Obermaier, Breuil or Bordes. According to Obermaier (1908), Breuil (1932a) and Bordes (e.g., 1961, 1984) the Micoquian is a late Lower Paleolithic industry containing typical asymmetrical and pointed bifaces. Impressive examples of such bifaces are known from the unfortunately undated layer 6/N at La Micoque near Les Eyzies, Dordogne (see Hauser 1916, Tafel V) or sites in the Paris basin (e.g., Blaser & Chaussé 2016). The term Micoquian is in use for industries dated to the OIS 6, 5, 4 and 3, as well as for sites from western (Bretagne, France) to eastern Europe (Crimean Peninsula, Black Sea).

XII.2.5 New analysis of surface collections from Côte chalonnaise

Middle Paleolithic assemblages from the Côte chalonnaise derive in major from ancient collections of surface collecting activities. From this collections the majority is homed in Musée Denon in Chalon-sur-Saône, but some other depots are also known (see tab. 305 and Herkert 2016; Herkert et al. 2015).

Site	Depot	Note	Number of lithic artifacts	Number of faunal remains	Total
Grotte de la Mère Grand à Rully	Musée Denon		306	67	373
	MAN	excavation of Perrault	38	2	40
	Musée Jean Régier à Mont-Saint-Vincent	excavation of Combier	0	62	62
	L. Slimak, Université Toulouse II	excavation of Combier, fauna analysed by Fabre 2009	unknown	1226	1226
	University of Tübingen	surveys by AG Floss	14	77	91
		Total	**358**	**1434**	**1792**
La Roche à Saint-Martin-sous-Montaigu	Musée Denon		3477	21	3498
	Musée des Ursulines		11	0	11
	Laboratoire de Géologie à Lyon		4	0	4
	Musée Rolin		60	0	60
	University of Tübingen	2014 survey by AG Floss	2172	0	2172
	University of Tübingen	2009 survey by AG Floss	33	0	33
	University of Tübingen	2007 surveys of AG Floss	63	1	64
		Total	**5820**	**22**	**5842**
En Roche à Germolles	Musée Denon		401	1	402
	private collection	B. Mascioszeczyk	126	1	127
	private collection	V. Donguy	238	0	238
	University of Tübingen	2014 survey by AG Floss	62	0	62
	University of Tübingen	2013 survey by AG Floss	42	0	42
	University of Tübingen	2011 survey by AG Floss	22	0	22
		Total	**891**	**2**	**893**

Champs de Fourches à Chenôves	Musée Denon		66	0	66
	University of Tübingen	2007 surveys of AG Floss	283	0	283
	University of Tübingen	2006 surveys of AG Floss	40	0	40
		Total	**389**	**0**	**389**
Grotte de la Folatière à Culles-les-Roches	Laboratoire de Géologie à Lyon		94	1	95
	Musée Denon		695	64	759
	Musée Rolin		2	0	2
		Total	**791**	**65**	**856**
Saint-Sulpice à Germolles	Musée Denon		352	0	352
Grotte de Teux-Blancs à Saint-Denis-de-Vaux	Laboratoire de Géologie à Lyon		98	4	102
Les Crays à Dracy-le-Fort	Musée Denon		128	0	128
Les Varennes à Dracy-le-Fort	Musée Denon		68	2	70
La Fosse de Vaulx	Musée Denon		631	0	631
Bissy-sur-Fley	Musée Denon		4306	0	4306
Rue Cataux à Chenôves	Musée Denon		716	8	724
Total		**Total**	**14548**	**1537**	**16085**

Tab. 305 - Paleolithic collections from Côte chalonnaise, analysed by Herkert (2016, in prep)

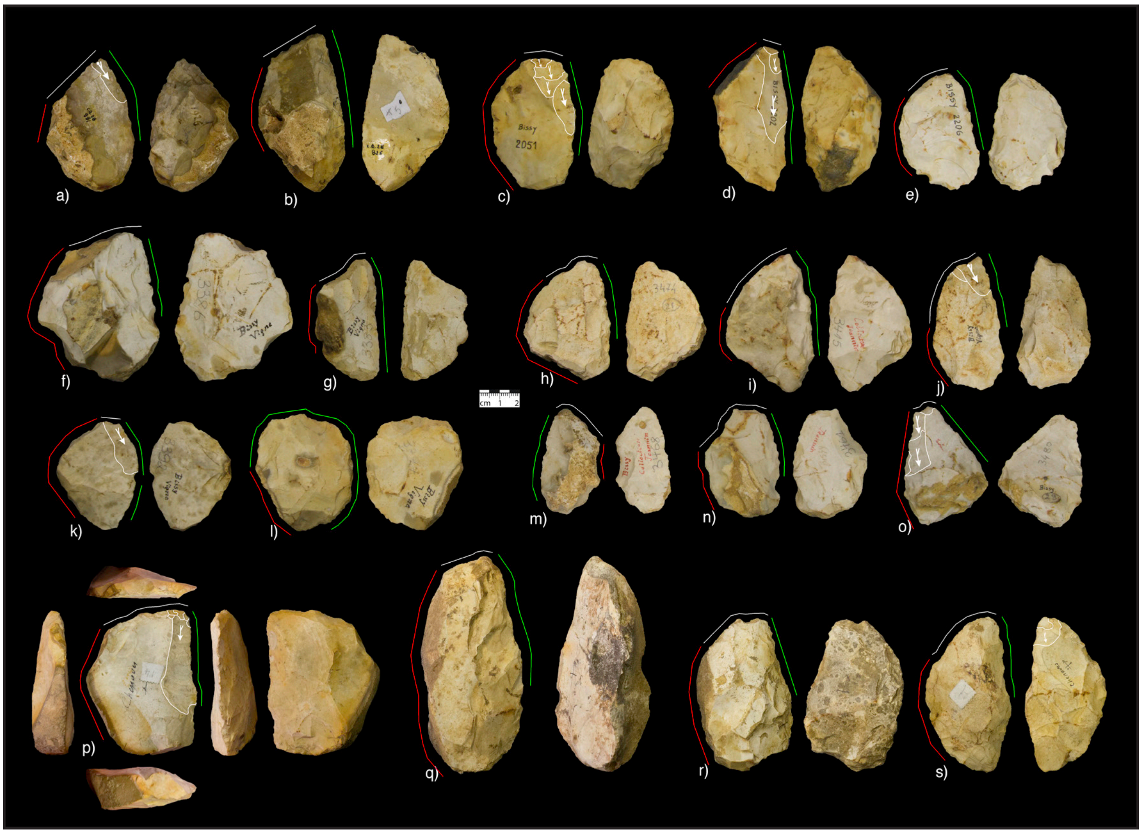

Fig. 442 - Keilmesser with and without tranchet blow from the Côte chalonnaise. a) and b) Saint-La Roche à Martin-sous-Montaigu; c) to o) Bissy-sur-Fley; p) to s) Rue Cateaux à Chenôves. Arrow indicates the tranchet blow, green line represents the active edge, white line on the outline shows the bow, white line in the interior outlines the tranchet-blow negative and red line indicates backing (photographs: working group Floss, drawings: J. A. Frick)

The analysis of this assemblages (tab. 296) is a major part of the dissertation work of Herkert (in prep). Preliminary analyses (Herkert 2014, 2016; Herkert et al. 2015) demonstrate that in assemblages affiliated to the Middle Paleolithic Levallois is the prevalent blank reduction concept. Sometimes ventral reduction methods are used to configure Levallois cores made from blanks (pers. comm. K. Herkert). Additionally, asymmetric bifacial objects (e.g., *Keilmesser*) are also present and Herkert et al. (2015) were able to extract around 30 Keilmesser from these assemblages. Some of them are also modified with a tranchet-blow. Examples of these Keilmesser are displayed in fig. 442 (above).

XII.3. Grotte de la Verpillière II as reference point for reflections

The excavation and analysis of Grotte de la Verpillière II offers now stratified and preliminary dated Middle Paleolithic assemblages as reference point for studies about ancient collection from excavations and surface collection (de-contextualized assemblages). VP II and in particular the lithic assemblage of GH 3 is used here as frame of reference for the classification of these de-contextualized assemblages.

GH 3 clearly shows a particular combination of artifacts and ways of lithic reduction, which are listed in the following:

- Presence of *Keilmesser* with and without tranchet blow modification
- Great diversity in the morphology of bifacial objects with preferences of asymmetrical morphologies
- The production of bifacial objects follows particular rules and lead to very straight edges (specific turning and rotation during production, the finishing is also known as *wechselseitig-gleichgerichtete Kantenbearbeitung*, Bosinski 1967) and plane-to-convex surfaces
- Prevalent use of Levallois reduction for a wide range of blank shapes (from oval to rectangular blanks, triangular and deltoid points and blades)
- Incidental presence of blades
- Minor presence of Groszaki
- Minor presence of dorsal reduction
- Use of ventral reduction on blanks for the configuration of Levallois cores and bulb reduction on tool
- Minor presence of Janus flakes
- Almost no evidence for other elaborated reduction concepts, such as Quina or Discoidal
- In addition to Levallois reduction there is evidence for opportunistic reduction processes to obtain blanks
- „Upper Paleolithic" tool types are more or less non-existent

- Tools can be made on blanks and cores, as well
- Blank tools are made from a wide range of blank morphologies, such as target, configuration and cortical blanks
- Major presence of evidence for hafting processes of a wide range of tools

The evaluated combination of umpteen Middle Paleolithic assemblages from the Côte chalonnaise (if the GH 3 assemblage from VP II is used as focal point) point clearly to industries that are prevalently present in central Europe and are described as Micoquian (*sensu* Bosinski) or *Keilmessergruppen* (KMG, *sensu* Jöris).
This assumption corresponds with studies from Desbrosse et al. (1976), Farizy (1995), Richter (1997b) or Jöris (2003) who affiliated the *Keilmesser* assemblage (from the ancient Jeannin collection from the Méray excavation in 1868) from Grotte de la Verpillière I to the Micoquian *sensu* Bosinski.

XII.4 *Keilmessergruppen* assemblages from the Côte chalonnaise

As this, new and forthcoming analyses propose (Frick in press; Frick & Floss in press; Frick et al. in prep.; Herkert in prep; Herkert et al. 2015) the Late Middle Paleolithic assemblages of the *Côte chalonnaise* and surrounding sites (e.g., from Baume de Gigny in the Dept. Jura) form a regional group with strong references to the *Keilmessergruppen* from central Europe.
The study of lithic artifacts attributed to the Middle Paleolithic of ancient collections (see tab. 296) and literature references create a homogeneous picture that allows to cluster around a dozen assemblages. The following tab. 306 list these sites:

Site	Dating and method	Specification	Notes on the lithic assemblages	Literature
Bissy-sur-Fley, Saône-et-Loire	Undated	Openair-site, surface collection	N=4306 lithic objects collected, Desbrosse & Texter (1973) used n=66 of them for the assemblage description. Levallois is present by n=26 blanks and one Levallois core. There are also n=12 bifacial objects (including n=4 Keilmesser and n=4 bifacial objects with back). N=16 retouched points (including n=4 heavily retouched Moustier points). Only one tranchet-blow negative on a blade visible. The Middle Paleolithic component of the assemblage consists of n=38 bifacial objects, n=219 side scrapers, n=409 Levallois objects and others (in complete n=863 diagnostic MP objects)	Parriat 1956 Desbrosse and Texier 1973
Rue Cateaux à Chenôves, Saône-et-Loire	Undated	Openair-site, surface collection	One *Keilmesser* with tranchet-blow, Guillard (1959) lists around 100 Levallois cores. In the collection in Musée Denon, there are n=27 bifacial objects (including n=4 Keilmesser, n=69 Levallois cores and n=204 Levallois blanks	Guillard 1959
Le Champ des Fourches à Chenôves, Saône-et-Loire	Undated	Openair-site surface collection	Around 800 pieces, but only n=21 clearly attributed to the Middle Paleolithic. Gros & Gros (2005: 124, fig. 74) displays three bifacial objects, but attribute all artifacts to the Neolithic. There are n=3 bifacial objects and n=17 Levallois blanks	Gros & Gros 2005
Grotte de Teux Blancs (ou Beurne aux Loups) à Saint-Denis-de-Vaux, Saône-et-Loire	Undated	Cave site, base camp?	Fast and uncontrolled excavation. Combier (1956: 51, fig. 3) displays one bifacial scraper and a double symmetric biface (1956: 54, fig. 4)	Mayet et al. 1920 Lènez 1935 Combier 1956

Grotte de la Mère Grand à Rully, Saône-et-Loire	Undated	Cave site, base camp?	Fast and uncontrolled excavation. Combier (1956-1957) displays in his excavation diary one quite symmetrical biface, a bifacial scraper, and two other bifacially retouched pieces and clear Levallois blanks from Niveau 1	Combier 1956-1957 Combier 1959 Desbrosse and Parriat 1975 Fabre 2009
Grottes de la Verpillière I à Mellecey Saône-et-Loire	Possibly between 40 and 50 ka (OIS 3) under the rock shelter (GH 16), possibility for also older sediments on the terrace	Rock shelter base camp?	Early fast and uncontrolled excavations. Recent excavations showed intricate stratigraphy. Occupation in front and under the rock shelter. Predominance of Levallois reduction. Blade production, Bifacial objects, including Keilmesser and tranchet-blow blanks Middle Paleolithic objects from ancient collections and from the excavations in mixed units from 2006 to 2008 were analysed by Frick (2010) in the course of the Magister's thesis GH16 (stratified Middle Paleolithic unit from the interior) was analysed in the course of the Bachelor thesis of Litzenberg (2015) Bifacial objects and tranchet-blow blank till 2014 are published in Frick & Floss (in press) In 2015 new find from the terrace (mixed layers), n=6 bifacial objects (including n=3 *Keilmesser*) and n=7 tranchet-blow blanks One big bifacial preform of a probably double symmetric biface was found in a trench northward of the entrance, this could be evidence for another (older) presence of a Middle Paleolithic (other than the LMG) at VP I and surrounding	Desbrosse et al. 1976 Floss 2006-2011 Floss et al. 2013, 2014, 2015, 2016 Frick 2010 Litzenberg 2015 Frick and Floss in press Hoyer et al. 2016 Richard et al. 2016
Grottes de la Verpillière II à Mellecey, Saône-et-Loire	GH 3 (45±4 IRSL ka, 33±2 ESR/U-Th EU ka, 36±3 ESR/U-Th RU, 38 ±4 ESR/U-Th) GH 4 (47±5 IRSL ka, 38±3 ESR/U-Th, 41±3 ESR/U-Th)	Rock shelter with corresponding cave tunnel base camp? recent excavation clear stratigraphy occupation unter the rock shelter and in the beginning of a cave tunnel GH 3 - Levallois, opportunistic reduction and bifacial elements GH 4 - Levallois and opportunistic reduction, only some bifacial objects	Analyses of VP II are described in this thesis!	Floss 2006-2011 Floss et al. 2013 Frick and Floss 2015 Frick and Floss in press Frick 2016 Frick submitted Richard et al. 2016 Zöller et al. 2016
Le Bois des Ranches & Thibourins à Blanzy, Saône-et-Loire	Unknown	Surface collection, openair-site	Short-term occupation in hunting camp? N=2335 lithic objects (including n=1125 tools and n=188 cores), core-to-blank ratio of 1:11, Desbrosse and Tavoso (1970) describe n=91 bifacial capers (possible from the drawings four more) and two foliated bifacial objects (one of them could be a *Keilmesser*), (also four of the cores are definitely Levallois cores)	Desbrosse and Tavoso 1970 Desbrosse 1979
La Roche à Saint-Martin-sous-Montaigu, Saône-et-Loire	Unknown	Surface collection, openair-site	Short-term occupation in hunting camp? There are some bifacial objects known (including *Keilmesser*, backed bifaces, *Fäustel* and bifacial scrapers) and Levallois cores present	Lènez 1926 Pouliquen 1982 Pouliquen 1982 Pouliquen 1983 Gros and Gros 2005
Grotte de Folatière à Culles-les-Roches, Saône-et-Loire	Unknown	Cave site, base camp?	Fast and uncontrolled excavation. There are only 61 Middle Paleolithic lithic objects known. Presence of n=9 bifacial objects and n=33 Levallois blanks	Bourdier 1947 Lafond 1947 Lafond 1957 Guillard 1959

La Baume de la Gigny à Gigny-sur-Suran, Jura	^{14}C of 28 to 30 ka, Oxygen Isotope correlation of OIS 5a to 3 (Navarro et al. 2004) level VIII (30 to 40 ka, OIS 3, betw. H3 and H4), level XV (around 55 ka, OIS 3), level XVI (around 60 ka, OIS 4), level XIX (between 70 and 80 ka, OIS 4 to 5), level XX (around 80 ka, MIS 5a), XXIa' -> Eem?)	Excavation of the entrance of a long tunnel cave, ^{14}C old dating and unreliable. OIS correlation seems to be a bit to young, especially for the upper levels	Micoquian biface and a *Fäustel* from niveau XXI Bifacial objects with and without tranchet-blow negatives from niveau XX, XIX, XII, XI, VIII	Campy et al. 1989 Navarro et al. 2004 Fabre 2010 Coudenneau 2005

Tab. 306 - Sites proposed to be forming a cluster of Keilmessergruppen sites in the Côte chalonnaise and surrounding

Additionally, some other known and analysed sites with Middle Paleolithic assemblages from the *Côte chalonnaise* are also dominated by Levallois reduction and contain bifacial objects, such as surface collections around Dracy-le-Fort or En Roche in Germolles (Herkert in prep). But the affiliation of these assemblages is yet not clear and need further investigation. If the assemblages from La Baume de Gigny are excluded, there are at least 350 bifacial objects that can serve as evidence in the Côte chalonnaise. The sites listed in tab. 297 are mapped in fig. 443.

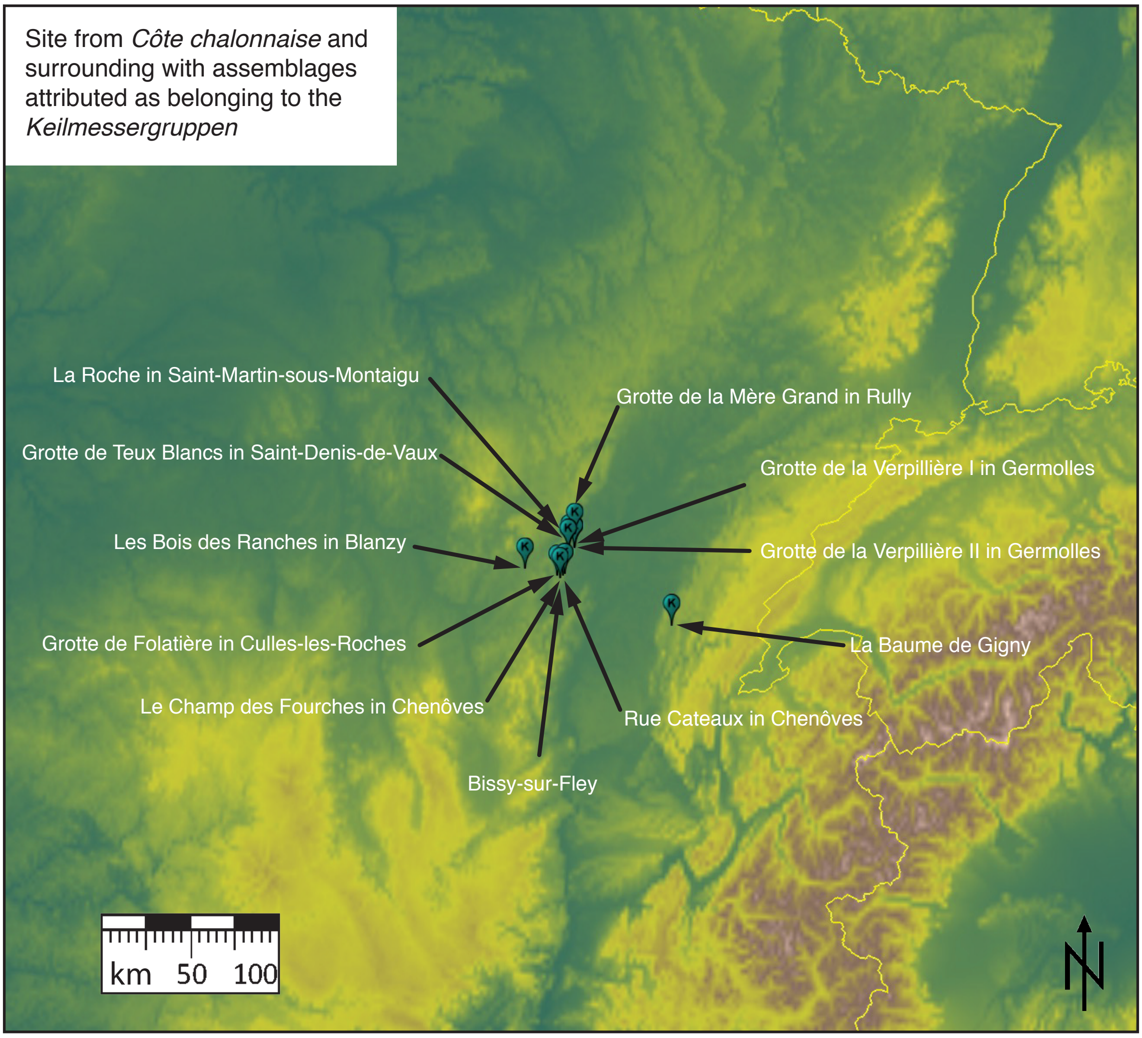

Fig. 443 - Middle Paleolithic sites from Côte chalonnaise and surrounding with assemblages attributed as Keilmessergruppen in the course of this study. Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

Chapter XIII: The Grotte de la Verpillière II in its European context

"A joker is a little fool who is different from everyone else. He's not a club, diamond, heart, or spade. He's not an eight or a nine, a king or a jack. He is an outsider. He is placed in the same pack as the other cards, but he doesn't belong there. Therefore, he can be removed without anybody missing him." (Gaarder 1996)

XIII.1 Introduction

As chapter XII demonstrated there are homological patterns visible in the Middle Paleolithic record of the Côte chalonnaise. The aim of this chapter is therefore to find arguments for explaining this cluster of congruent assemblages in this area. By doing so, the paleolithic record of surrounding areas has to be discussion.

XIII.2 Establishing a cluster of congruent assemblages

XII.2.1 Approaches for clustering the French and German record

Recent research of the Middle Paleolithic record of western Europe focusses inter alia on the finding of patterns in space and time. There are two excellent examples that give an overview of the Late Middle Paleolithic record and assemblage entities with a closer chronological fixation. On the one hand, Koehler (2009) resampled entities in western Europe (respectivly in France) such as the Quina and Rhodanian Mousterian in OIS 4, the MTA and *Charentien à influence micoquienne* (late OIS 4 and early OIS 3) and the technocomplexes of the *Néronien*, Denticulated Mousterian and the *Grand éclat Levallois Nord* in the OIS 3 (see also fig. 20 in chapter II). On the other hand, the research of Locht et al. (2016) summarized the INRAP work of the last 30 years in Northern France about the Middle Paleolithic and shows a great heterogeneity of assemblages. In focusing on MIS 4 to 3, there are contemporaneous unifacial and bifacial assemblage components visible that gives ideas about the Middle Paleolithic occupation of this area, but the research is far from being finished. For example during the MIS 5a there are divergent assemblages containing, preferential Levallois, or symmetrically bifacial objects or laminar reduction. Similar for sites at MIS 4 to 3, there are examples of discoidal and preferential Levallois, but the distribution of sites with preferential Levallois seems to be clustered in Nord-de-la-France. Other examples from the OIS 3 are clusters of sites with MTA-character or a final Mousterian with bifaces.

Another attempt for finding patterns in the chronological distribution of lithic reduction strategies was conducted in Southwestern France (Jaubert 2009, 2011, 2014; Jaubert et al. 2011b; Jaubert & Bordes 2008). There 35±5 lithic techno-complexes were identified on around 70 sites with Middle Paleolithic assemblages. An overview of chronological positions of these entities is given in fig. 444 and shows a provisional model for the archeo-sequence of this region. It demonstrates for example that Quina technology is present in the OIS 4, but also between 45 and 50 ka BP. Another interesting aspect is given by new stratigraphical observations in regard to the MTA. Synthesized, after the MTA two other entities are present there (Discoid-Denticulate Mousterian and Levallois Mousterian with large scrapers), see Jaubert et al. (2011a).

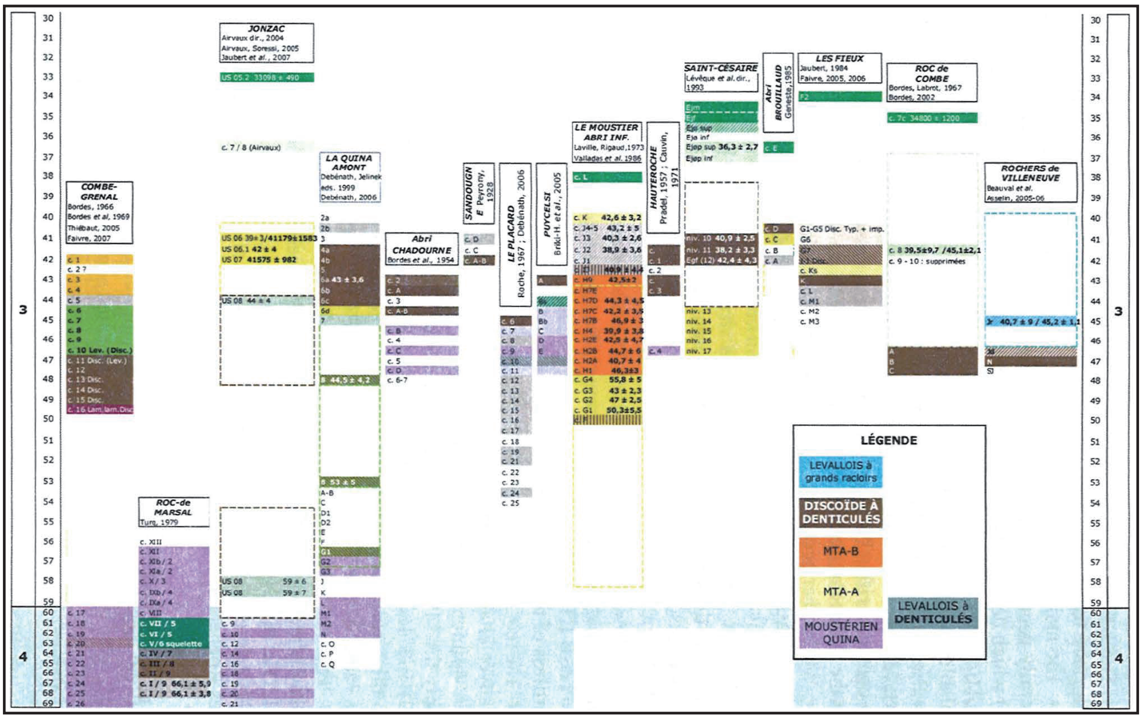

Fig. 444 - Provisional model of the Late Middle Paleolithic archeo-sequence (OIS 4 and 3) for the South-West France. Adopted from Jaubert (2014: 52, fig. 2)

German approaches of sorting the Middle Paleolithic record normally focusing on somewhat different aspects of assemblages as French approaches. Therefore a direct comparison is still challenging. On the one hand, studies such as Richter (1997) or Jöris (2003) focussed on the „Micoquian“ (Mousterian with Micoquian-Option, *Keilmessergruppen*, etc.). On the other hand, Conard and Fischer (2000) resembled different other entities, too. These approaches were discussed in chapter III.2.

A new summary of the Middle Paleolithic record in Germany is presented by Richter (2016) with using the record of the Sesselfelsgrotte as focal point. It demonstrates that the earlier stages of the Late Middle Paleolithic record in Germany contains mostly non-Levallois industries and the later stage mostly Levallois industries. This research is focussing on the Mousterian with Micoquian-Option (MMO) and highlights the dichotomy of unifacial and bifacial variants („Micoquian“, if classification is derived from „bifacial tools“ and Mousterian, if classification is based on unifacial tool counts, see Richter 2016: 118). The occupation of areas is described as cycles in regard to raw material patterns, typology and technology. „*The cycles start with small assemblages of broad spectrum raw material procurement* (Initialinventare)*. The cycles end with mostly larger assemblages* (Konsekutivinventare) *of more specialized raw material procurement confined to few resources. Initialinventare might originate from the beginning reconnaissance and exploitation of a region (f.e. the Altmühl valley).* Konsekutivinventare *document a more specialized exploitation of resources and might arise from a time when people had already been present in the region for weeks or months.*“ (Richter 2016: 118). In regard to bifacial objects, as present in many sites, they are tend to be more reduced in the *Konsekutivinventare*. All these and other aspects are summarized in the model of the MMO in fig. 445. It focuses on raw material diversity, the differentiation of the tool spectrum and on „Micoquian" tools with facial shaping. In short term occupation, the raw material diversity is high, the tool spectrum is not differentiated and there are almost no „Micoquian" tools (bifacial objects) present. At the end of the of the occupation cycle, the raw material diversity tends to be very low, the tool spectrum is differentiated and the amount of „Micoquian" tools is high.

As this approach mainly focusses on the assemblage of Sesselfelsgrotte G it remains still open if this approach can be used for other regions, such as southwestern France, Burgundy or Northern France, where bifacial objects are also very common in the Middle Paleolithic record. There is the possibility that the increase in bifacial objects (and also the more intensive reduction of these) and the other aspects are also observable.

If so, this model would present a general occupation scenario of Neanderthals in the Late Middle Paleolithic. Unfortunately, this model can only be tested by observing sites with the possibility of a good separation of stratified assemblages. For the moment, the Paleolithic record in our working area cannot provide such a high resolution. Therefore we cannot prove this model.

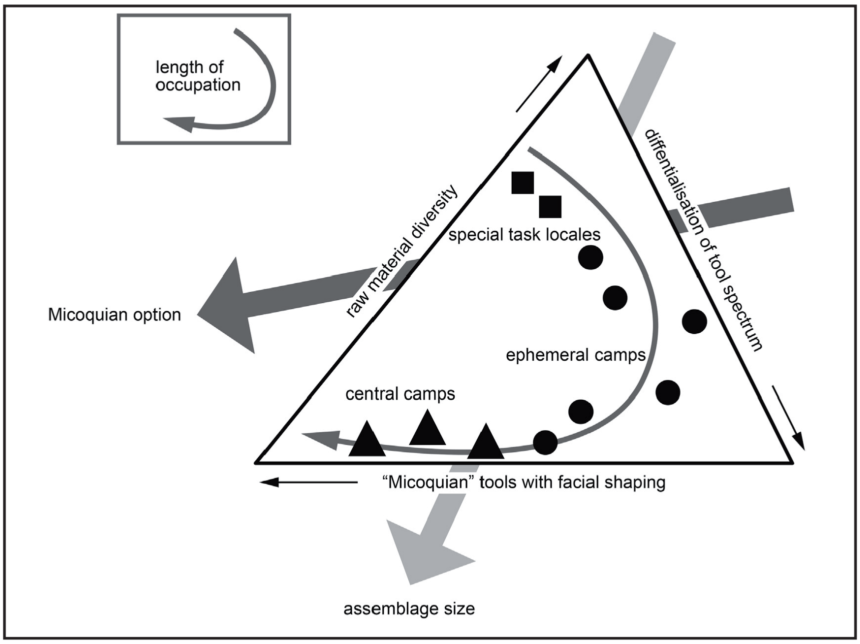

Fig. 445 - Model of the MMO assemblage formation of Sesselfelsgrotte G, adopted from Richter (2016: 120, fig. 6)

Another approach was proposed by Ruebens (2012, 2013, 2014) for the Late Middle Paleolithic in Western Europe, by observing a macro-regional tripartition in regard to bifacial objects that separated the record in the Mousterian of Acheulean Tradition (MTA, dominated by hand axes), *Keilmessergruppen* (KMG, typified by backed and leaf-shaped bifacial tools) and Mousterian with Bifacial Tools (MBT), geographically situated between these two major entities, and characterised by a

wider variety of bifacial tools (Ruebens 2013: 341). MTA and KMG are seen as two different cultural traditions. It is argued that the MBT is not a third cultural entity, but a „*transitional zone where influences from both the south and east were absorbed*“ (Ruebens 2013: 353). In the studies of Ruebens (2012, 2013, 2014) data provided by Frick (2010a) for the Middle Paleolithic of VP I were used. New research on VP I and VP II can now provide data with higher resolution and demonstrates that the majority of bifacial objects from either VP I or VP II are common elements of KMG assemblages (Micoquian *sensu* Bosinski). The formerly proposed high percentage of classical hand axes for the VP I assemblage (in 2009 only n=52 bifacial objects were studied) was relativized by new research (Frick & Floss in press) showing that only n=10 bifaces (with double reflection symmetry) are present (ancient collections and new excavations). In Frick (2010a) bifacial objects from VP I were separated into Keilmesser (n=15) and Bifaces (n=37). The group of bifaces contains preforms, triangular, cordiform, oval, and many more varieties. The new study evaluates that the majority of all observed bifacial objects from VP I are backed.
In 2010, before having good stratigraphical evidence or radiometric dating, it was considered if these bifacial object are formerly present in one stratigraphical unit (*Mittelpaläolithikum mit bifaziellen Objekten*) or if the assemblage contain two entities (MTA and Micoquian).

XIII.3 Assemblages directing to patterns known from central Europe

The observations from new assemblage studies in the Côte chalonnaise are mostly congruent to preliminary analyses of Desbrosse et al. (1976), Farizy (1995), Richter (1997) or Jöris (2003) who demonstrated a clear affinity of assemblages containing Keilmesser from Eastern France to assemblages from central Europe.
Farizy (1995) clustered sites such as Champlost, Vinneuf and Villeneuve-l'Archevéque in Yonne, Bissy-sur-Fley, Blanzy, Saint-Martin-sous-Montaigu and Verpillière I in Saône-et-Loire, Frettes from Haute-Saône, as well as Riencourt-lès-Bapaume and Beuvry à Bethune in Nord-Pas-de-Calais into the so called *Industries charentiennes à influences micoquiennes* (CIM, see fig. 446). And also, the former analysis of Desbrosse et al. (1976) evaluated strong affinities of *Keilmesser* (some with tranchet-blows) from VP I with ones from central European sites, such as Abri de Wylotne, Buhlen IIIb, Ciemna, Grotte du Docteur à Huccorgne, Kůlna 7a or Okiennik (see fig. 447).

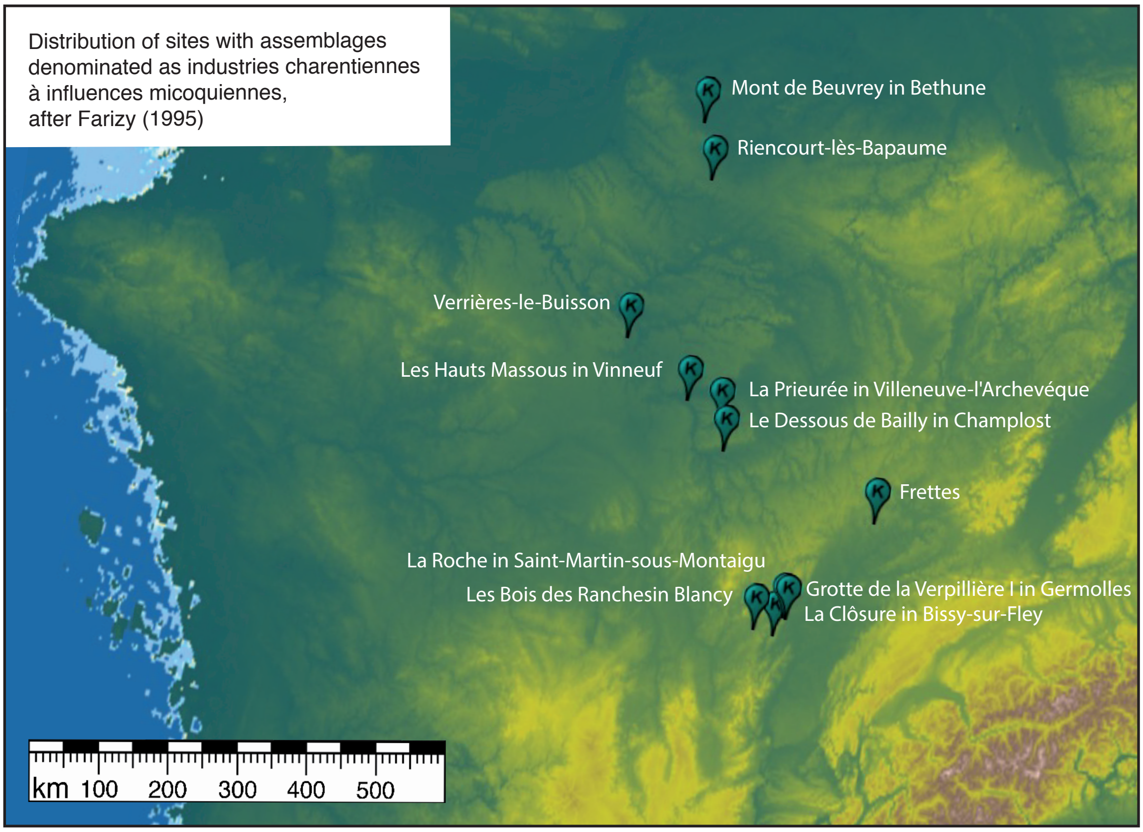

Fig. 446 - Sites of the Industries charentiennes à influences micoquiennes, after Farizy (1995), Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

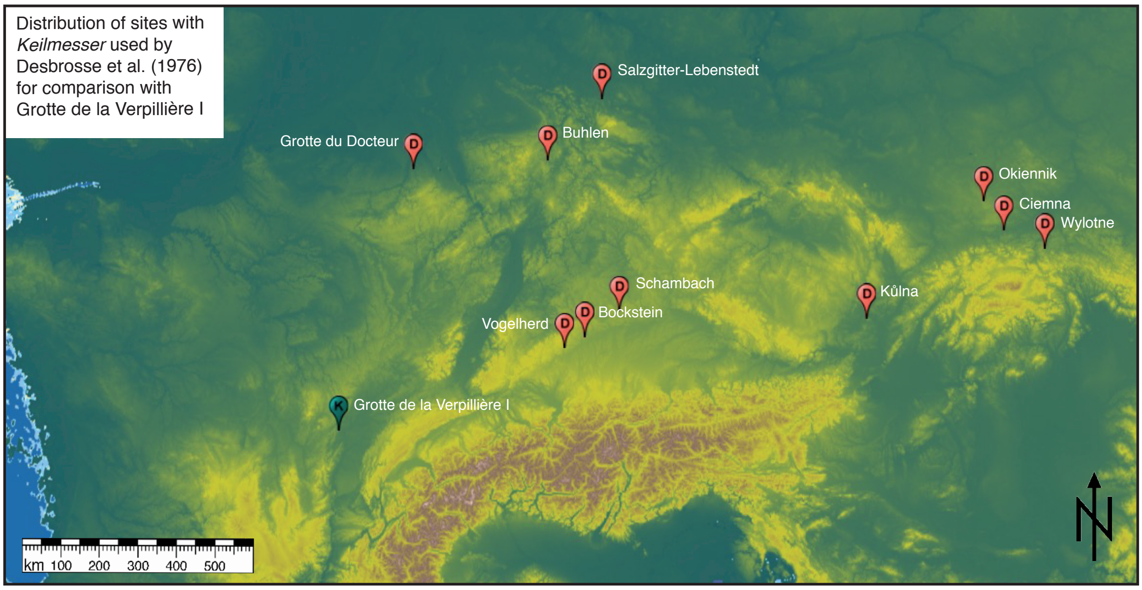

Fig. 447 - Sites used by Desbrosse et al. (1976) to make comparisons with Keilmesser from VP I. Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

In the 1960s, Bosinski (1969) defined the so called „*Pradnik-Horizont*" in the course of the excavations at Buhlen, because he saw in Buhlen a nearly identical assemblage to that from Ciemna. Jöris (1992) extended the „*Pradnik-Horizont*" by adding more sites where *Keilmesser* with tranchet-blows and corresponding tranchet-blow blanks were found. In that time the distribution of such sites reached from eastern France to the Crimean peninsula (see fig. 448).

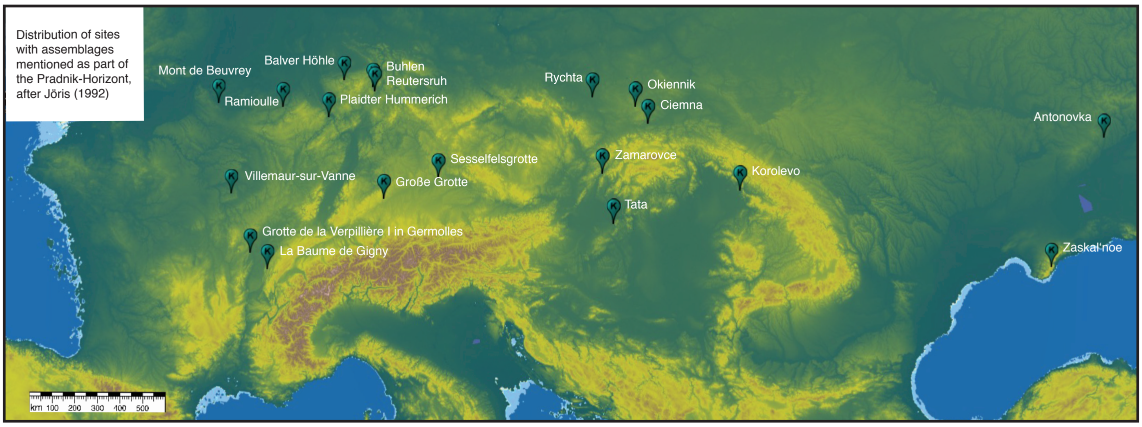

Fig. 448 - Distribution of sites containing Keilmesser with tranchet-blows („Pradnik-Horizont“) as mapped by Jöris (1992). Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

Richter (1997) proposed the term Moustérien mit Micoquien-Option (MMO) for consecutive assemblages that follow the Micoquian definition of Bosinski (e.g., 1967) using nearly the same sites as Jöris (1992). He proposed two chronological stages for the MMO. An older stage (MMO-A) for sites with non-Levallois reduction and a younger stage (MMO-B) for site with Levallois reduction (see fig. 449)

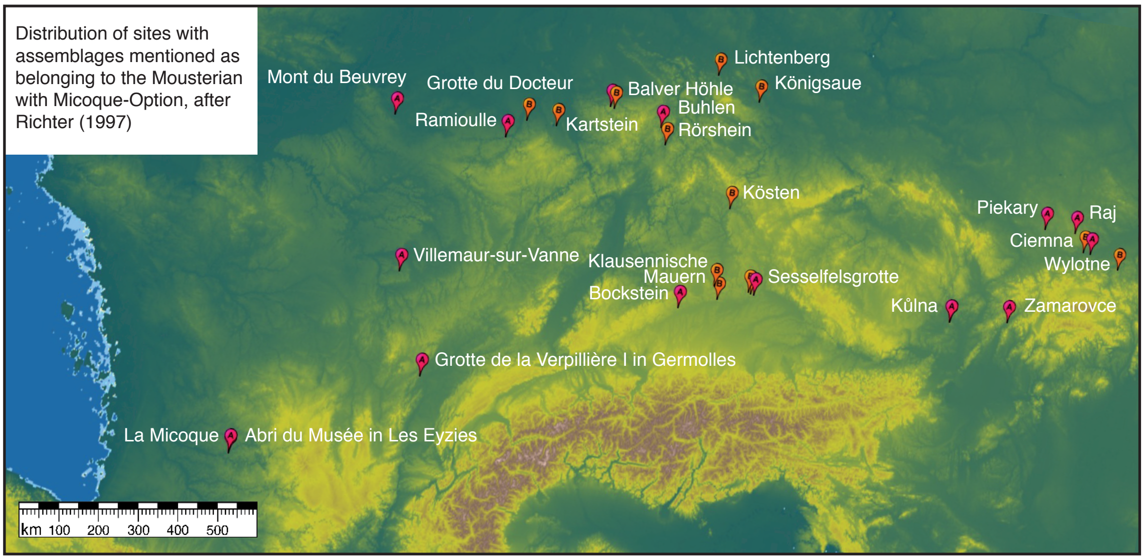

Fig. 449 - Distribution of sites of the MMO after the definition of Richter (1997). Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1.

But the new analysis of assemblage from the Côte chalonnaise demonstrates that Germolles (VP I) cannot belong to the MMO-A as proposed by Richter (1997), because it is also a Levallois assemblage with bifacial objects (containing also Keilmesser with tranchet-blow) and therefore should be placed in the MMO-B. The preliminary dating attempts at both Grottes de la Verpillière (Richard et al. 2016) support a young chronological position in the OIS 3 between 50 and 40 ka. On the other hand, Jöris (2003) proposed a spatial and chronological quartering of these sites (he prefers the term *Keilmessergruppen*) into KMG A, KMG B1, KMG

B2 and KMG C (see fig. 450). In this model Germolles (VP I) is placed into the KMG B2, a group that is not present in central Europe but contains *Keilmesser* with tranchet-blow. His definition of KMG B contains that Levallois reduction is nearby negligible, a systematical blank production is almost entirely absent and bifaces are rare and normally single pieces. *Keilmesser* possesses a bifacially retouched, bent back that reaches the active edge in a right angle and the active edge is always straight. Nearly all *Keilmesser* possesses tranchet-blow negatives and other *Leitformen* of Bosinski's definition are quite rare.
Here again, the new studies on Middle Paleolithic assemblages from the Côte chalonnaise draws a somewhat different picture. Contrary to Jöris and Richter, the Middle Paleolithic assemblages are mainly made using Levallois reduction. There is an intensive and systematical blank production visible (see chapter VII and following of this thesis). As the study of bifacial objects from VP I and II demonstrates there are different „types" of bifaces present on both sites and not really rare, but they are all made very individually, but by following specific production rules (see Frick & Floss in press, as well as chapter VII.14). In addition to *Keilmesser* with tranchet-blows there are quite different and distinctive bifacial objects present.

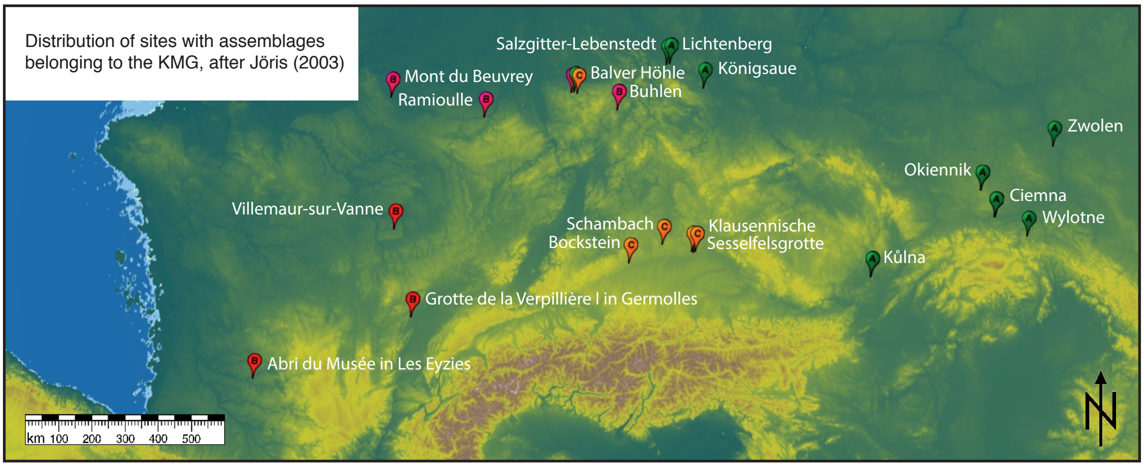

Fig. 450 - Distribution of sites of the Keilmessergruppen A, B1, B2 and C, after the definition of Jöris (2003). Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

In displaying all sites with assemblages mentioned in the literature to be „Micoquian" (see fig. 451), after Farizy (1995; *industries charentiennes à influences micoquiennes*), Stepanchuk et al. (in press; Eastern European Micoquian), Blaser & Chaussé (2016; Micoquian *sensu* Bordes or Bosinski), Gouédo (1999; *technocomplexe micoquien en Europe de l'ouest et centrale*); Weiß (2015; *Pradnik Kultur*, *Keilmessergruppen* oder *Moustérien mit Micoque-Option*), Jöris (1992; *Pradnik-Horizont*), Jöris (2003; *Keilmessergruppen*, *Micoquien sensu Bosinski*), Richter (1997; *Moustérien mit Micoquien-Option*), Bosinski (2000-2001; *Keilmessergruppen*) and Urbanowski

(2003; Micoquian) it is obvious that most of the sites are situated northwards of the alps (around N45° latitude).

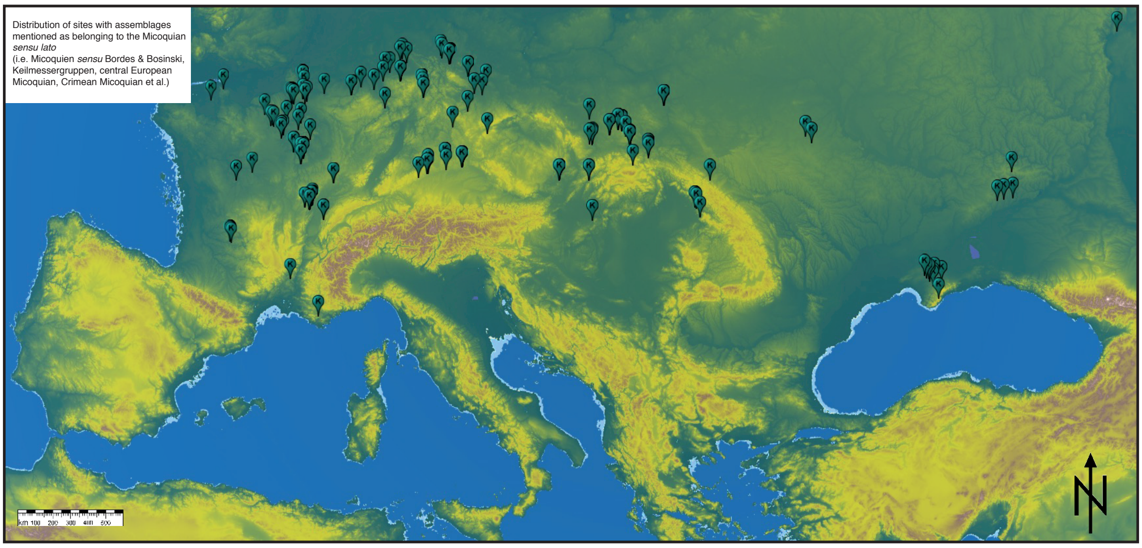

Fig. 451 - Distribution of sites containing assemblages that are mentioned to be „Micoquian" after Farizy (1995; industries charentiennes à influences micoquiennes), Stepanchuk et al. (in press; Eastern European Micoquian), Blaser & Chaussé (2016; Micoquian sensu Bordes or Bosinski), Gouédo (1999; technocomplexe micoquien en Europe de l'ouest et centrale); Weiß (2015; Pradnik Kultur, Keilmessergruppen oder Moustérien mit Micoque-Option), Jöris (1992; Pradnik-Horizont), Jöris (2003; Keilmessergruppen, Micoquien sensu Bosinski), Richter (1997; Moustérien mit Micoquien-Option), Bosinski (2000-2001; Keilmessergruppen) and Urbanowski (2003; Micoquian). Base map from TemporalMapping.org (80 meters below present day sea level), sites mapped with the aid of GoogleEarth Pro 7.1

For the moment, the dichotomy of approaches for the classification of Middle Paleolithic assemblages containing bifacial objects still exists. Ruebens (2012, 2013, 2014) approach in observing typological groups (classic, backed, leaf shaped, partial and bifacial scrapers) is a first step to get refined approaches about this subject. In this regard it would be a meritorious deed to conduct further studies about bifacial objects (technological and morphological) to define specific reduction sequences and shapes.

XIII.4 VP II in the context of sites circumferential of the Bresse basin

XIII.4.1 Regional patterns of the Middle Paleolithic record

As many studies show there are specific regional patterns (Bataille 2013; Cliquet 2001; Koehler 2009; Kozłowski 2014; Soressi 2002) of the Late Middle Paleolithic record visible. The research about the Middle Paleolithic of VP II and the surrounding area found also evidence for such a pattern.

The annual territorial approach of Richter (2014) using Voronoi cells (e.g., Aurenhammer 1991) calculates population density for the MTA (n=119 territories) and

MMO (n=63 territories) and propose a population density of 0.008 for the MTA and 0.003 individuals per km^2 for the MMO. An approach that is only suitable, if the short chronology of the MMO as proposed by Richter, as well as the dichotomy of MTA and MMO is used as basis. The approaches described in chapter II using physiological and psychological parameters of Neanderthals can also contribute to the understanding of small-scale regional patterns of the Middle Paleolithic record. On the other hand, as Bataille (2013) demonstrated there are many examples of Middle Paleolithic sites and occupation patterns that are congruent to patterns observable in Aurignacien sites. Also, there are observable patterns of landscape occupation strategies for high and low mobility, as well as landscapes with or without relief.

XIII.4.2 Sites on the northern margin of the Bresse basin

Another cluster of sites on the northern margin of the Bresse basin in Haute-Saône is studied by A. Lamotte. There is evidence for symmetrically and asymmetrically bifacial objects but without any reliable chronological data for these assemblages (Lamotte et al. 2012; Lamotte et al. in press; Lamotte et al. 2014; Lamotte et al. 2005). The chronological position is mainly observed by using typological comparisons of lithic objects. This is exemplified by so called *pièces et pointes foliacées* as serving as index fossile of the final Middle Paleolithic, as it can be seen in the Szeletian, Altmühlian or Jerzmanovician-Ranisian-Lincombian entities. The material from Montarlot, Frasne-le-Château and La Montbleuse is compared to leaf points (*Blattspitzen*) of the Szeletian from Hungary and the *Blattspitzenkomplex* of Southern Germany (in my opinion there are not similar in size and shape). The only *Blattspitze* close to the German-French border was found in Hoßklingenäcker in Mundelsheim (Lkr. Ludwigsburg). This example is similar in shape and size to Blattspitzen known from the Altmühlian in Bavaria (Wagner 1996).
Evidence from a Middle Paleolithic site with dating attempts are available from Point-de-Planches, Haute-Saône (Lamotte et al. 2012). There are two TL dating samples (from sondage 16) with dates of 47.3 ka +7.5/-6.2 ka BP (TL, PDP 52, above the occupation layer) and 52.1 ka +8.8/-7.1 ka BP (TL, PDP 51, below the occupation layer), indicating a site occupation in the early OIS 3 at this site. There are three asymmetrically bifacial objects displayed. One (Fig. 8.3) has tendencies to a terminal fragment of a *Keilmesser*. The other two (Fig. 8.1 and .2) are small and should be first denominated as *Fäustel*.
Here too, similarities of the assemblage to the Altmühlian (as prove Richter 2006b is cited) is referred (but Richter 2006 discusses the central European Micoquian, i.e., MMO). The circumstance of comparisons of eastern French bifacial objects with the Altmühlian was also observed in the study of Pouliquen (1982b, 1983b)

of bifacial objects from Saint-Martin-sous-Montaigu, but in neither case the displayed objects have morphological similarities to *Blattspitzen* from the *Blattspitzenkomplex* (Altmühlian), see for example Bolus (2004) or Kot (2013).

XIII.4.3 Sites on the western margin of the Bresse basin

The observed cluster of sites with evidence for belonging to a *Keilmessergruppen* context are prevalently situated on the western margin of the Bresse basin (see chapter XII) on the first and second hills of the Jurassic hill range. The exception from this „rule" is the site of Baume de la Gigny (Campy et al. 1989) which is situated on the eastern hill range on the other site of the Bresse basin.

The research of surface collections is still ongoing, but from the observations of Frick & Floss (in press), Herkert et al. (2015) and Frick (in press) a clear pattern of assemblage with *Keilmesser* (often with tranchet-blow) is visible (see also chapter VII). But there are some exceptions of ancient collection visible bearing Middle Paleolithic artifacts. For example the site of Saint-Sulpice in Germolles is directly situated on an outcrop of flint from the *argiles à silex*. A revision of the collections situated in Musée Denon (in 2015) could evaluate that the majority of lithic objects are Levallois cores (94 of 160, around 60%). However, in the collection there are also bifacial objects present (n=10). The assemblage of Saint-Sulpice could be of high interest for the study of the Middle Paleolithic in this area, because of the chance to study material from a workshop on a raw-material source.

Sites situated further in the west of the Saône-et-Loire department are not part of these reflections, because the last reconditioning of assemblages available from there dates back to the 1980s (Philibert 1982) using mostly the typological denominations from the literature for classifying lithic objects without a reliable chronological framework. Therefore this extensive work can serve as database for available ancient collections but without reliable denominations of lithic objects. For Saône-et-Loire, she lists n=129 paleolithic sites including n=91 sites with a Middle Paleolithic facies denomination. As an example, she lists n=59 assemblages as MTA (because these assemblages contain bifaces), but the site of Blanzy (Desbrosse & Tavoso 1970) containing n=91 bifacial objects is classified as *Moustérien de type Quina* because many of them are far from symmetrical in top view and therefore distinctive from known material from the „homeland" of MTA-biface sites (in this context, Blanzy is definitely integrated into the corpus of *Keilmesser*-bearing sites).

Chapter XIV: Summary

“Just believe everything I tell you, and it will all be very, very simple.’ Ah, well, I‘m not sure I believe that.” (Adams 2005: 15)

but also:
((1*2*3)-4+5)*6 = 42
913+613 = 9*6 = 54= 52+2 = 4*131+2+130 = 4213
1010102 = 1*25+0*24+1*23+0*22+1*21+0*20 = 32+0+8+0+2+0 = 42
(https://de.wikipedia.org/wiki/42_(Antwort))

Middle Paleolithic assemblages of Grotte de la Verpillière II

Based on lithic objects from GH 3, 4x and 4 this thesis is using technological, morphological and spatial analyses to describe the Middle Paleolithic assemblages (excavated between 2009 and 2014) of Grotte de la Verpillière II (VPII) in Germolles, Saône-et-Loire, France.

Simplified, all three assemblages yield evidence for Levallois blank production and the production of specific bifacial objects. All three assemblages are attributed to the *Keilmessergruppen*, a Late Middle Paleolithic entity foremost known from central Europe. This attribution is in congruence to studies of other scholars discussing ancient collections of Keilmesser from Grotte de la Verpillière I (only 50 m north of VP II), such as Desbrosse et al. (1976), Farizy (1995), Richter (1997), Jöris (2003), Floss (2005) or Frick (2010).

This study also presents data about spatial distribution of lithic objects inside the geological sediment units of the site of VP II that allow preliminary horizontally separation of them, showing that the highest diversity of forms, morphologies, raw materials and specifics is present in the upper part of GH 3.

The study of lithic raw materials from the assemblages of GH 3, 4x and 4 demonstrated that most of the material was procured from sources (primary, sub-primary and secondary) in the near surrounding of VP II. In addition to this, there is evidence from some pieces to be procured from farther raw-material sources. On the one hand up to 20 km in the South (in the distance of other KMG-sites of the surrounding) and on the other hand of around 110 km in the Northeast (in the direction of other KMG-sites in central Europe). It is still to early to attribute the assemblages of the site into the model of Richter (1997) of initial and consecutive assemblages, whereby the increase in diversity of lithic objects (including different raw materials and bifacial objects) from GH 4 (lower and upper part) , (GH4x in brackets because it is very small) and GH 3 (lower and upper part) is visible.

Following attributes (based on the material from GH 3) classify the assemblages studied: 1. *Keilmesser* with and without tranchet blow modification are often present; 2. Bifacial objects show a great diversity in their morphology and follows particular production rules concerning turning and rotation processes during production; 3. Levallois reduction is prevalently used for blank production providing a wide range of blank shapes (oval, rectangular, triangular, deltoid, long-narrow); 4. Incidental presence of blades; 5. Minor presence of Groszaki; 6. Minor presence of dorsal reduction; 7. Use of ventral reduction on blanks for configuration of Levallois cores and bulb reduction on tool; 8. Minor presence of Janus flakes; 9. Almost no evidence for other elaborated reduction concepts, such as Quina or Discoidal; 10. In addition to Levallois reduction there are evidence for opportunistic reduction processes to obtain blanks; 11. „Upper Paleolithic“

tool types are more or less non-existent; 12. Tools are made on blanks and cores; 13. Blank tools are made from target blanks, as well configuration and cortical blanks and 14. Major presence of evidence for hafting processes of a wide range of tools.

Comparison

These attributes are also present in a similar manner in surrounding site that are known from ancient collections (prevalently surface collections) and recent excavations (VP I). The observed similarities allows the formation of analogical clusters for classifying assemblages that lack chronological fixation. The analysis of Middle Paleolithic lithic assemblages at VP II is used as focal point for reflexions about further assemblages from the surrounding. The studies showed that analogies allow to cluster these sites together and attribute them to other *Keilmesser*-bearing assemblages that are highly present in central Europe and denominated as *Keilmessergruppen*.

Published aspects

Parallel to this thesis aspects of the lithic assemblages of GH 3, 4x and 4 are published or in the publication process. For instance an overview of bifacial elements from VP I and II (Frick & Floss in press), the analysis of the GH 3 lithic assemblage (Frick in press) and some spatial aspects of GH 3 (Frick 2016).

Influence of extrinsic and intrinsic parameters

The analysed assemblages demonstrate in a good way the complexity and particularity of lithic industries that are attributed to Neanderthals in the studied region. As VP II yielded no skeletal remains of Neanderthals the attribution of the assemblages to them base on analogies of similar assemblages (chapter III, XI to XIII) and the dating estimation (chapter IV). Factors assumed as influencing the expression of Neanderthal's assemblages (extrinsic and intrinsic parameters) are discussed in chapter II. The metabolism is assumed as having major influence on settlement patterns and therefore on the expression of the assemblages left behind. If the assumption is correct that Neanderthals had a higher energetic requirement for body maintenance (chapter II.2.6) this could have been led to close range settlement patterns, because the regrowing (subsistence) supplies of the surrounding landscape are faster exhausted (animals and plants). Short-distance transport of lithic raw material and the distribution of assemblages with very similar expressions are seen as aftereffects of this in lithic assemblages. The faunal record, as well, shout also provide information of these close range settlement patterns. In regard to the lithic assemblages there are good similarities visible in many sites of the studied region (see above) to support a regional pattern.

On the other hand, lithic assemblages are influenced by the abilities of the producers. Concerning the assemblages of GH 3, 4x and 4 they needed to know how to knapp with hard and soft-hammer techniques, to follow specific rules in core-reduction (Levallois) and in the production of bifacial objects (in regard to surface design, rotation and turning processes or edge regularization). They also needed to know how to deal with constrains of the lithic raw material, such as size of the raw pieces or fissures (see chapter X).

The surrounding landscape of the VP II provided enough lithic materials, but the examples of some chert and lacustrine flint objects show that material of distances of 20 or around 100 km are brought to site (chapter VI) . A first assumption of these facts could be that the material from distances to 20 km are in the territorial range (chapter XII) as indicated by the similarities (as listed above) found in the Côte chalonnaise assemblages that are attributed to the late Middle Paleolithic (*Keilmessergruppen* assemblages). The long-distance material (lacustrine flint) can serve as indication for a traveling route from central Europe as it was supposed by Jöris (2003) for the *Keilmessergruppen* (chapter XIII).

Chapter XV: Attachments

XV.1 List of figures

XV.2 List of tables

XV.3 Used abbreviations

The following tab. 308 summarizes used abbreviations (hopefully complete):

Abbreviation	Meaning
VP I	Grotte de la Verpillière I
VP II	Grotte de la Verpillière II
FAS	Flint of the *argiles à silex*
b2k	Before the year 2000 of our era
BP	Before present, normally the year 1950 of our era is used as present
ka	Lat. *kilo annum*, thousand years
CB	*Chaille bathonienne*, Bathonian chert
QT	Quartzite
QZ	Quartz
L	Length
W	Width
T or Th	Thickness
e.g.	Lat. *exempli gratia*, for example
i.e.	Lat. *it est*, it is, it means
IRSL	Infra-Red Stimulated Luminescence
TL	Thermoluminescence
ESR/U-Th	Electro-Spin Resonance/ Uranium-Thorium series
AMS ^{14}C	Accelerated mass spectrometry of radiocarbon
Hn	Homo neanderthalensis KING 1864
OIS	Oxygen Isotope Stage
LGM	Last Glacial Maximum, situated formerly at around 20 to 22 ka BP (1970s to 1980s), nowadays extended to the timespan between 26 and 21 ka BP (Chiverrell et al. 2010)
°C	degree Celsius

Tab. 307 - List of abbreviations used in the entire text

Chapter XVI: Extended table of contents

Chapter XVII: Bibliography

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End of thesis