A 3D Perspective in the Interpretation of Living-floor Morphologies: Intrasite Analysis of Prehistoric Contexts

Giovanna PIZZIOLO[1] – Sabina VITI[2]

[1]Dipartimento di Archeologia e Storia delle Arti, Università di Siena (Italy)
[2]Dipartimento di Scienze dell'Antichità "G. Pasquali", Università di Firenze (Italy)
[1]pizziolo@unisi.it
[2]sabina.viti@gmail.com

Abstract

In writing this paper our intention has been to illustrate the refi nements in methodology in contextualising and interpreting prehistoric evidence discovered in the Sesto Fiorentino plain (Florence, Italy) from the Neolithic to the Bronze Age. To create this process we have used a 3D and GIS framework at an intrasite level.

We have experimented with the potentialities of 3D visualisation to investigate intrasite settlement strategies characterised by complex settings. Therefore, by clarifying issues previously embedded in traditional 2D documentation, we have been able to propose some innovative approaches to improve our knowledge of prehistoric settlements in this specific area.

Keywords

intrasite analysis, 3D visualisation, prehistoric settlements

1. Introduction

The aim of this paper[1] is to offer some new archaeological interpretations through the use of a 3D approach in exploring prehistoric living-floors, from the Neolithic to the Early Bronze Age, in the Florentine area of Sesto Fiorentino.

Many prehistoric sites have come to light since 1982 in this area through rescue excavations carried out by the University of Siena and the University of Firenze in collaboration with the Soprintendenza ai Beni Archeologici della Toscana. Our research is part of a broader project, called the "Progetto Sesto" (The Sesto Project), begun 25 years ago by the Universities of Siena and Florence, with the intention of studying the prehistoric evidence and the peopling process of the Sesto Fiorentino area (Sarti and Martini 1993). In recent years, this project has acquired archaeological data in a GIS system and has implemented the reading of prehistoric contexts through GIS analysis and 3D visualization (Pizziolo and Sarti 2005; Pizziolo and Sarti 2006).

The creation of visual models was mainly undertaken to achieve the contextual reading of these living-floors in their spatial relationships and to compare prehistoric contexts that are culturally and spatially related.

We chose to work in this manner because of the specific nature of Sesto Fiorentino, because of various constraints that impacted significantly on past settlement strategies and, by extension, our research.

Thus we will proceed as follows: we will start with a general overview of the archaeological context focussing on the characteristics of the studied area, in particular the environmental and anthropic biases. Following this, we will describe, by means of some significant case-studies, how logistical constraints and settlement typology have influenced our methodological choices with significant emphasis on the creation and use of visual models.

2. The study area

The study area corresponds to the Municipality of Sesto Fiorentino, a town located on the north-western side of Florence (Italy) at the foothills of Mount Morello. This area is part of the larger system of the Firenze-Prato-Pistoia alluvial plain, which originated on a lacustrine basin and developed along a tectonic depression after the Late Pleistocene Era (Conedera and Ercoli 1973; Ghinassi and Tangocci 2008). The main watercourse, the Arno River, gradually drained the basin covering the lacustrine sedimentation,

[1] The authors equally contributed to this work.

and its tributaries created alluvial fans along the margins.

The lacustrine sedimentation has been covered by recent alluvial deposits. The Middle-Late Holocene sedimentary succession of the Sesto Fiorentino area consists of 1 to 4 meters of thick alluvial deposits, which run from muddy to gravelly, overlaying a well-developed soil capping the Pleistocene palustrine clay. The old town is located on the largest of the three alluvial fans along the foothills. The different reclamation activities (i.e. the draining of territory with a natural wetland predisposition, which was undertaken from Roman times until the last century) have given the area its present appearance.

In the last twenty-five years the urban expansion of Sesto Fiorentino, now stretching across the Florentine plain, has enabled archaeologists to discover a substantial body of evidence and to identify a wide temporal and spatial range of archaeological contexts through systematic preliminary archaeological test pits within the building or infrastructure construction areas. These specific monitoring conditions have allowed archaeologists to carry out several rescue excavations.

Due to these existing circumstances, the thick clusters of small trenches (with an average dimension of 1x3x3m.) are disseminated irregularly in the study area and have led to more than 250 positive test pits. In an area of 20km, 50 systematic excavations have revealed prehistoric contexts (Sarti *et al.* 2008) (*Fig. 1*).

Unfortunately, since our rescue field activities are severely limited by the rules and regulations of the municipality and its infrastructure, and consequently by the dimensions and the plan of the buildings to be constructed, it is not feasible for us to investigate the sites in their totality, i.e. in relation to their surroundings, and in most cases it is even impossible to determine their extent (Pizziolo and Sarti 2005; 2008). Moreover, urban expansion and the direction it follows, governs the allocation of the excavated areas as well as the authorization to dig test pits and preliminary trenches.

Thus to summarise: this alluvial plain is characterised by a wetland environment in which palaeostreams and alluvial fans have left traces and have dynamically modified the surface settings. These environmental characteristics forced the communities to take advantage from this context at the outset of their occupation by modifying the natural setting. From an archaeological point of view the pedogenesis – and in particular the effect of the rise and fall of the water table level – and the anthropic post-depositional events during historic and modern times have reduced our ability to identify respectively the stratigraphies and the previous prehistoric occupations of the land. In addition, we needed to take into account the above-mentioned logistic constraints, i.e. the rules of rescue excavation.

3. Intra site analysis in Sesto Fiorentino: using visual models

The sites examined testify to a continuity of use of the same area and in several cases even of the same morphology. The different cultural phases are often defined by thin layers as a result of either an intensive erosion action or a specific typology of occupation, i.e. provisional and temporary.

Furthermore, the complexity of these multi-stratified contexts is due to the fact that the palimpsests are unclear because of lack of evident structures except for several pits and post-holes (*Fig. 2*).

The study of prehistoric settlements has to consider the presence of latent structures that frequently can be revealed only with post-processing analyses, even though spatial patterning of archaeological remains may not reflect the spatial patterning of past

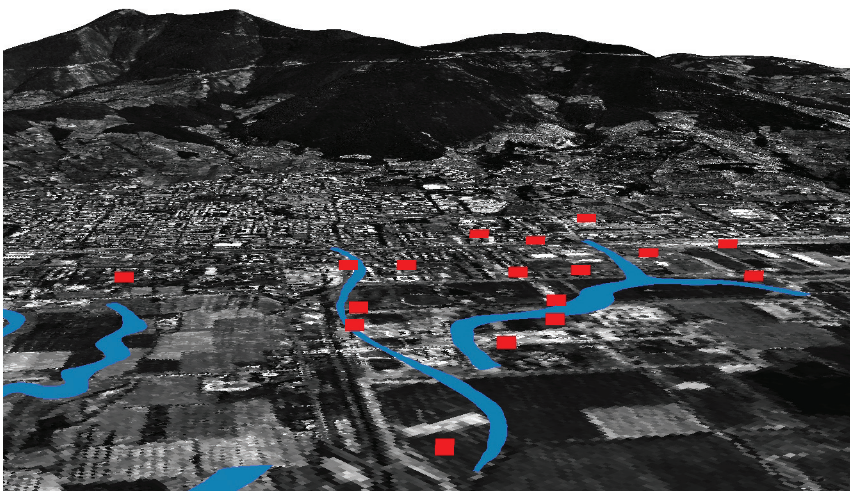

Fig. 1. Prehistoric site (black points) and palaeorivers (in grey) on the aerial photo of Sesto Fiorentino draped on the DEM.

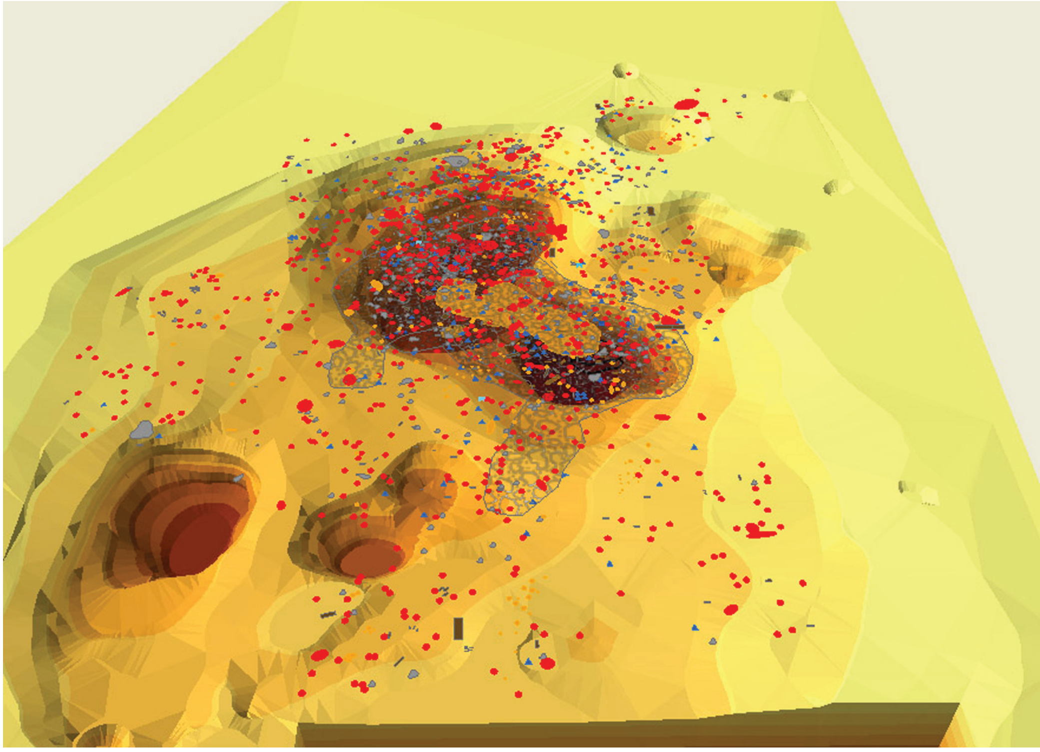

Fig. 2. An example of a 3D elaboration of a Neolithic living floor.

activities. In fact it is usually difficult to determine the degree of distortion of the data set caused by formation processes, cultural and non-cultural (Shiffer 1972).

Even though the application of quantitative analysis has been limited by the nature of the documentation it still offers probabilistic distributional trends and delivers relevant information on spatial data structures for behavioural interpretation (Blankholm 1991).

The density of artefacts has been analysed on a square meter basis, showing in some cases functional or specific areas of use (Fenu *et al.* 2003). The integration of different levels of analysis leads to a more comprehensive reading of the use of the space and of the organisation of the living-floors; nevertheless in this paper we are focussing on 3D visualisation potential.

In addition to the above-mentioned factors that have influenced the direction and flow of our research analysis – environmental conditions, logistic constraints and the typology of settlements – we should point out that the documentation that we are dealing with was acquired in a traditional bi-dimensional way without foreseeing digital post-processing.

In particular, since the original archive mostly consists of 1x1m distribution plans at 1:10 scale (producing a huge amount of fragmented data), in order to achieve an all-encompassing view of the area, we needed to recompose this corpus in an analytical model (*Fig. 3*). We needed to develop different procedures that revealed the potentiality of the data acquired bi-dimensionally but in which the *z* value has been widely registered: the features (distribution maps), the Stratigraphic Units (US) and the contour lines.

The acquisition of this information, first in a CAD and then in a GIS environment, has produced a new set of documentation that allows us to achieve a dynamic and interrelated view of the living plans and the archaeological remains.

Through intrasite analysis, we would like to distinguish post-depositional events, to investigate the spatial organisation of these areas, and to determine the strategies of occupation in each defined site. In our archaeological context this means to considering the relationship between anthropic settings and natural morphologies.

Obviously the core of the analysis is the exploration of dwelling strategies connecting shapes to human behaviours.

Beyond the ability to describe a scenario as a preliminary step of any interpretative process, with visual models we clarify problems and finally we formulate questions. These are made explicit through qualitative analysis of the model that can subsequently and continually be validated (Frischer

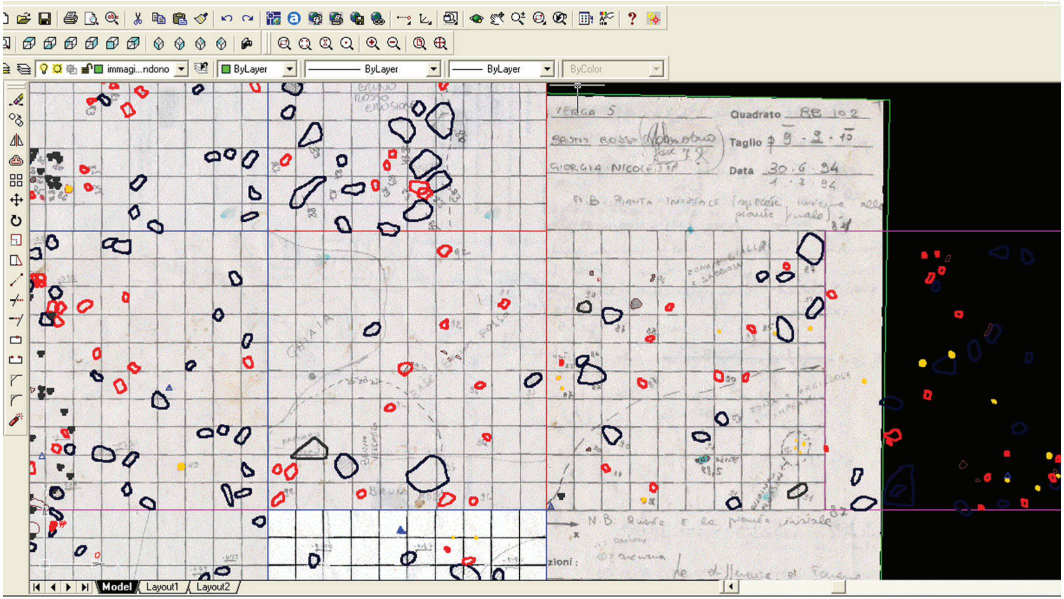

Fig. 3. 1x1m distribution plans at 1:10 scale recomposed and vectorialised in a CAD environment.

et al. 2000). This stage of explanation becomes part of our visualisation process, the steps of which can be retraced at any time (Gardin and Peebles 1992).

In this sense the 3D models are used as a tool to dynamically explore the archaeological scenario and verify the consistency of data. The representation of the different features by means of a visual model allows us not only to formally present all the components and their spatial positions, but also to identify their relationships (Barcelò 2001).

Furthermore, in our archaeological context the visual model provides us with a greater opportunity to culturally and spatially compare similar prehistoric contexts in a manner which was not previously possible. This analogical procedure can help us to analyse and detect the archaeological variables that finally appear in a more "transparent" and univocal manner.

Using a model as a spatial representation we visually manipulate the information, thus allowing us to manage the uncertainty.

For example, in the case of the Neolithic site of Neto Via Verga (Viti 2006; Sarti and Volante 2002), several difficulties arose while digging and trying to interpret the stratigraphy; thus the sequence during the excavation was determined by typology observations of the pottery and by the identification of the profile of the stone levels. The natural action, mostly erosive, has determined a lack of separation between layers affected by a intense pedogenesis.

The overlay of the different layers, the re-composition of all the elements referring to a living area over a period of time, was never seen contemporaneously during the field investigation not only because excavations by their very nature are destructive, but also because of the difficulty in recognizing the layers themselves. In other words

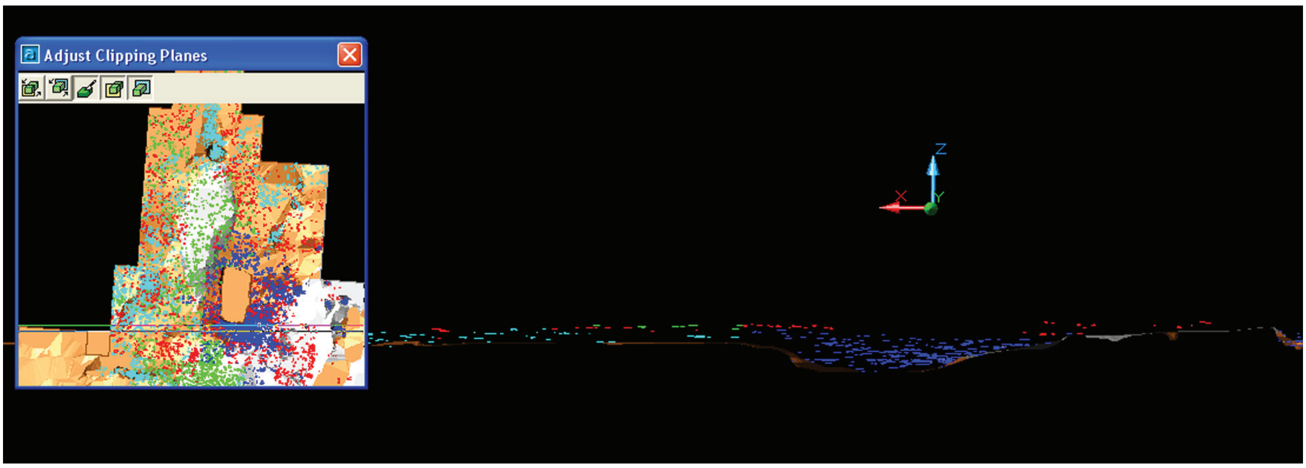

Fig. 4. A cross section view: a snapshot of interactive exploration. Each colour correspond to defined cultural phase.

what we originally see in its fragmented state becomes reconstructed virtually into a coherent form.

In this case we performed an interactive cross-section throughout the site and we assigned a different colour to each identified layer. In this way we were able to recognize the profiles (corresponding to different cultural phases) and their topology as recorded in the field. The fact that in certain points the profiles where congruent leads us to analyse in detail the typology of significant artefacts and confirm or not previous interpretations (*Fig. 4*). In this sense a precise visualization of the uncertainties driven further studies of the data set.

This procedure has also been applied to other sites with more "structured" living-floor but in which the function of the pits is unclear. By the visual analysis of the fillings we tried to inspect the deposition process (*Fig. 5*).

In certain cases cross-sections of pit fillings, in which the soil appeared homogeneous, revealed a possible re-use of the pit, exposing, from different points of view, the particular distribution of the artefacts or – on the contrary – they provide evidence forthe natural deposition process that determinate a particular setting. With such observations we can better define abandonment events, the presence of different occupations during a period of time, non-cultural events, etc.

The use of visualization in this sense produces a new and re-elaborated set of data that gives a considerable inputs to the forthcoming studies of the site.

Another typology of visual observation can be related to Bell Beaker sites which show a peculiar settlement strategy (Sarti 1998). In fact, in Sesto Fiorentino, at the end of the third millenium BC Bell Beaker people started to exploit palaeo-river beds, using them as drainage structures inside which they settled.

In particular, the top of the drainage layer of the bed formed by gravel deposits was exploited and partially modified to constitute the palaeo-surface on which the inhabitants lived.

Some artificial enlargements of the dry river bed banks have been recognized. The post-holes are generally dug into the natural very compact gravel.

As a case study, we analysed the excavation areas of Querciola and Semitella, two Bell Beaker palaeo-surfaces located inside two segments of palaeo-riverbeds (Pizziolo and Sarti 2008) (*Fig. 6*).

Given the position of the two excavations, it becomes interesting to hypothesize whether or not we are dealing with the same ancient stream or dealing with contexts that originated through similar environmental conditions.

A major general comparison between the geometries of the riverbeds has concentrated on the analysis of the profiles of the banks and the depths created by the action of the waters; the visual analysis leads us to observe that the banks are very similar, and we can suppose that the two incisions were generated by the same hydraulic conditions. Such observation gave the impetus to calculate the degree of slope in order to perform a quantitative comparison.

The analysis, carried out in a GIS 3D application, suggests the hypothesis of an opportunistic use of the shapes of the riverbed as support for the creation of light covering.

In previous studies, the exploitation of river bed drainage and gravel deposits was recognized, but by modelling the surface we can better observe the morphologies of the banks and recognise possibly functional shapes, (i.e. for the support of structures or dwelling spaces). The spatial disposition of post-holes shows a preference for using the upper part of the bank, choosing the side in front of the steepest edge (*Figs 7* and *8*).

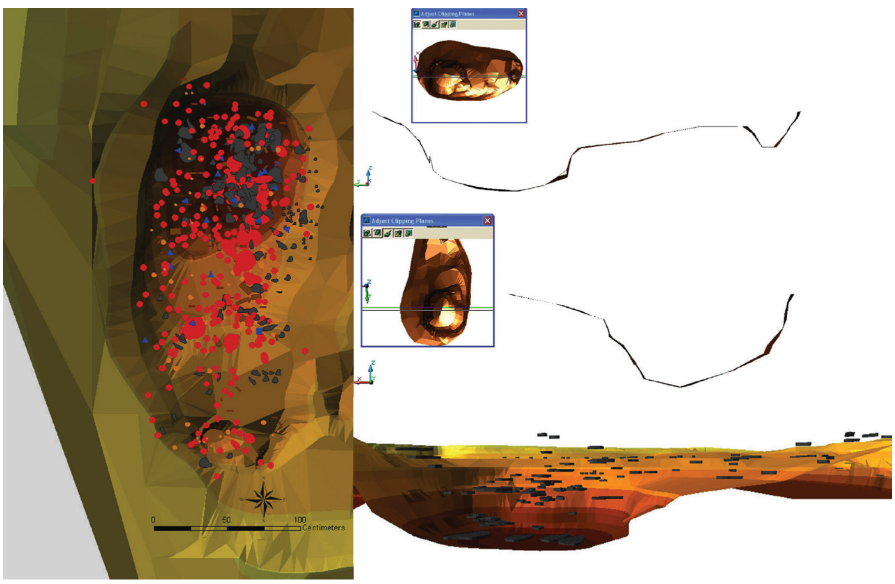

Fig. 5. A 3D elaboration of a Neolithic pit: analysis of morphology and fillings.

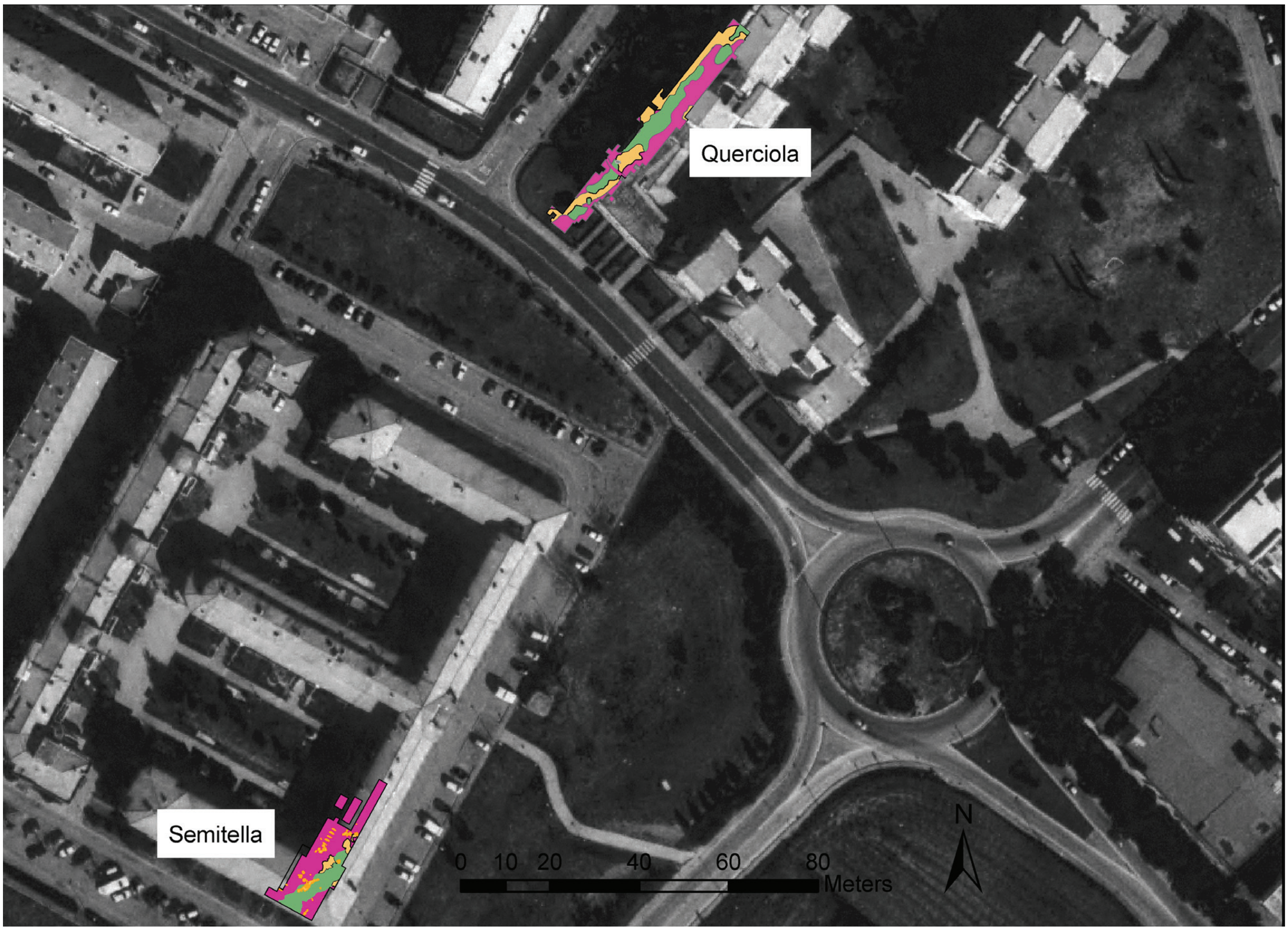

Fig. 6. Querciola and Semitella Bell Beaker excavation areas (in purple) showing the palaeorivers direction (in green).

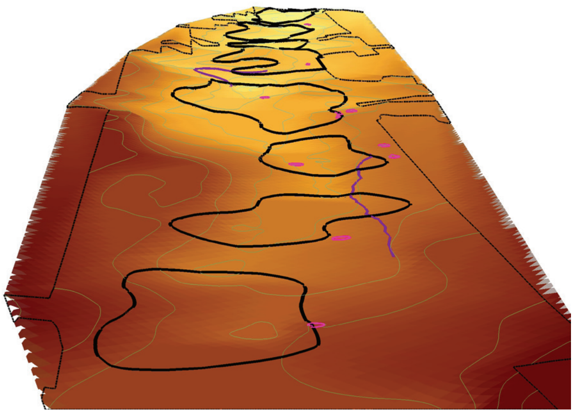

Fig. 7. A 3D elaboration of Querciola Bell Beaker excavation. Bank morpholgies are related to posthole, artificial cuts and to structures.

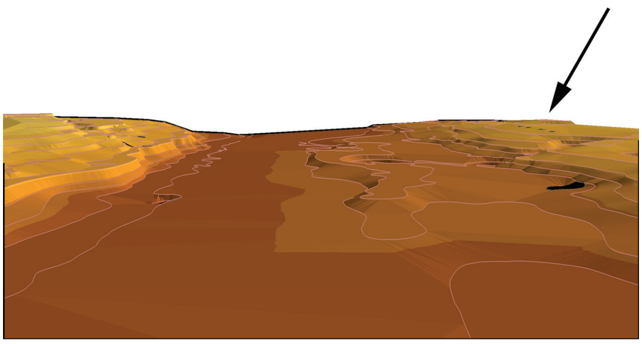

Fig. 8. A 3D elaboration of Semitella Bell Beaker excavation. Bank morpholgies are related to postholes (in black).

4. Intrasite – Intersite: the importance of a dynamic approach

We have already stressed the damage of a fragmented reading of a context discovered by single excavation units. In fact, the definition of the extension of the site is related to the limitations of rescue excavation, which do not always allow us to define the true extension of the prehistoric structures. Moreover, we cannot say that there is a correspondence between the number of excavated areas and the number of sites: different excavated areas may or may not correspond to either one or separate settlements. Furthermore, we are trying to find possible relationships between excavated areas proximally located and to evaluate the relationships of presumable contacts between different archaeological structures. Moreover, these difficulties are exponentially incremented due to the typology of these prehistoric sites, which are characterised by light and often latent structures or substructures. The analysis of the spatial, chronological and functional relationships between the settlement findings must, in fact, take into account a contextual approach.

In this research perspective, a great help in developing data contextualisation came from a dynamic shift in the scale of observation. We need to look in a more comprehensive way at data from an intrasite to intersite perspective within the same framework, and focus particularly on the connection between different excavated areas.

This means that the two scales of investigation follow a bi-univocal flow. Cultural observation at an intrasite level may provide useful information for intersite analysis and vice-versa.

In this sense the concept of "settlement units" (Pizziolo and Sarti 2008) provides a useful tool for exploring the archaeological landscape and the "places" of the past (Pizziolo and Sarti 2006).

By *Settlement Unit* we mean a large area in which the archaeological layers testify to a "spread" use of the surfaces associated with one event or to a sequence of occupations. This kind of scattered evidence, probably related to temporary but repeated activities, may be easily recognised as a settlement unit when it is investigated in its totality, but it is barely recognisable when partially investigated or tested along with separate adjacent excavations (Pizziolo and Sarti 2008, 44–45).

The ability to verify models in a 3D environment and to compare single excavations in a broader framework is very promising. In this unique environment the relative position of every entity is transformed into an absolute position and in this way we can compare similar contexts (*Fig. 9*).

Therefore it is crucial to analyse data at an intrasite level but we must also investigate evidence that has emerged in adjacent excavated areas in order to recompose the occupation sequence and determine the different behaviours.

Fig. 9. An example of a intrasite – intersite contextualisation.

5. Conclusion

This paper has concentrated on the advantages, in a intrasite analysis, of 3D visualisation and the potential of visual models, which exceeds the scope of previous traditional documentation methods. This intersite perspective may help us to better understand prehistoric dwelling activities.

To summarize, it may be said that by virtue of visual modelling at an intrasite scale, we exploited the opportunity to validate previous documentation and previous interpretations. Several issues were formalised and questions became more explicit by the creation and "manipulation" of visual models.

We explored the relationships between human occupation and natural morphologies, emphasizing how in this context this relationship is bi-univocal and not just a matter of human adaptation.

And finally, by shifting from an intrasite to an intersite perspective and vice-versa, we effectively endeavoured to compare features within the same archaeological contexts.

The visual comparison between living-floor morphologies within a defined geomorphological unit offers the possibility to identify not only the presence of a persistency of specific settlement strategies but also to connect different excavations in a site-entity. Moreover, such indications are valuable when analysing site distributions, providing significant hints for further research directions.

References

Barcelò, Juan A. (2001). Virtual reality and scientific visualisation. Working with models and hypoteses. *International Journal of Modern Physics C, 12, N°4*. 569–580

Blankholm, Hans Peter (1991). I*ntrasite spatial analysis in theory and practice*. Aarhus: Aarhus University Press.

Conedera, Claudio and Andrea Ercoli (1973). Elementi geomorfologici della piana di Firenze dedotti da fotointerpretazione". *L'Universo* 53, 255–262.

De Silva, Michele, Pino Fenu, Giovanna Pizziolo, Lucia Sarti and Sabina Viti (2001). Verso un sistema informativo geografico per lo studio dei contesti preistorici dell'area di Sesto Fiorentino (Firenze). Lo stato della ricerca. *Rivista di Scienze Preistoriche* LI, 471–482. Firenze.

Fenu, Pino, Giovanna Pizziolo, Lucia Sarti, Sabina Viti and Volante Nicoletta (2003). Elaborazioni ed analisi distributive del sito di Neto Via Verga: problemi e prospettive di ricerca di un contesto abitativo complesso. In: Carlo Peretto (ed.) *Analisi informatizzata e trattamento dei dati delle struttura di abitato della preistoria e protostoria italiana*. Origines IIPP. Pisa: Edizioni ETS, 159–174.

Frischer Bernard, Franco Niccolucci, Nick Ryan and Juan A. Barcelò (2000). From CVR to CVRO: the past present, and future of cultural virtual reality. In: Franco Niccolucci (ed.) *Proceedings of VAST 2000*. BAR 834, Oxford: Archaeopress, 7–18.

Gardin, Jean-Claude and Charlie Peebles (1992). *Representations in Archaeology*. Bloomington and Indianapolis: Indiana university Press.

Ghinassi, Massimiliano and Francesca Tangocci (2008). Middle-late Holocene deposits of the Sesto Fiorentino Area (Florence, Italy): preliminary data. In: Marco Baioni, Valentina Leonini, Domenico Lo Vetro, Fabio Martini, Poggiani Keller Raffaella and Sarti Lucia (eds.) *Bell Beaker in Every day life, Proceedings of the 10th Meeting "Archéologie et Gobelet" (Florence-Siena – Villanuova sul Clisi, May 12–15, 2006)* Firenze, 33–37.

Martini Fabio, Gabriella Poggesi and Lucia Sarti (1999). *Lunga memoria della piana*. L'area fiorentina dalla preistoria alla romanizzazione. Firenze.

Pizziolo, Giovanna and Lucia Sarti (2005). Landscape archaeology in Sesto Fiorentino: a GIS analysis for investigating settlement strategies in wetland area. In: J. F. Berger, F. Bertoncello, F. Braemer, G. Davtian, M. Gazenbeek (eds.) *Temps et espaces de l'homme en société, analyses et modèles spatiaux en archéologie*. XXV Rencontres Internationales D'archeologie et D'histoire D'antibe. Antibes: Editions APDCA, 443–452.

Pizziolo, Giovanna and Sarti, Lucia (2006). Exploring the archaeological landscape through a local perspective: spaces and places in the prehistory of the Florentine plain. In: Stefano Campana and Maurizio Forte (eds.) *From Space to Place, 2nd International Conference on Remote Sensing in Archaeology, Proceedings of the 2nd International Workshop, CNR,* *Rome, Italy, December 4–7, 2006*. Oxford: BAR International Series 1568, 261–269.

Pizziolo, Giovanna and Lucia Sarti (2008). Prehistoric Landscape. Peopling process and Bell Beaker settlements in the Florentine Area. In: Marco Baioni, Valentina Leonini, Domenico Lo Vetro, Fabio Martini, Poggiani Keller Raffaella and Sarti Lucia (eds.) *Bell Beaker in Every day life*, *Proceedings of the 10th Meeting "Archéologie et Gobelet" (Florence-Siena – Villanuova sul Clisi, May 12–15, 2006)* Firenze, 39–58.

Sarti, Lucia and Fabio Martini (1993). *Costruire la memoria*. *Archeologia preistorica a Sesto Fiorentino (1982–1992)*. Firenze.

Sarti, Lucia (1998). Aspetti insediativi del Campaniforme in Italia centrale. In: Franco Nicolis, Elisabetta Mottes (eds.) *Simbolo ed enigma*. *Il bicchiere campaniforme e l'Italia nella preistoria europea del III millennio a.C.*, Catalogo della mostra (Riva del Garda, 12 maggio–30 settembre 1998). Provincia Autonoma di Trento, 137–153.

Sarti, Lucia and Nicoletta Volante (2002). Neto-Via Verga (Firenze): le produzioni del Neolitico tardo e finale e del passaggio all'Eneolitico. In: Alessandro Ferrari, Paola Visentini (eds.) *Il declino del mondo neolitico*. *Ricerche in Italia centro-settentrionale fra aspetti peninsulari, occidentali e nord-alpini*. Atti del convegno (Pordenone 2001). Quaderni del Museo Archeologico del Friuli Occidentale, 4. Udine, 441–446.

Sarti, Lucia, Cristina Balducci, Prasildo Brilli, Pino Fenu, Valentina Leonini, Fabio Martini, Giovanna Pizziolo and Marco Zannoni (2008). Catalogue of Bell Beaker Settlements in Sesto Fiorentino, Florence. In: Marco Baioni, Valentina Leonini, Domenico Lo Vetro, Fabio Martini, Poggiani Keller Raffaella and Sarti Lucia (eds.) *Bell Beaker in Every day life*, *Proceedings of the 10th Meeting "Archéologie et Gobelet" (Florence-Siena – Villanuova sul Clisi, May 12–15, 2006)*. Firenze, 23–32.

Shiffer, Michael B. (1972). Archaeological context and systemic context. *American Antiquity* 37, n°2, 156–165.

Viti, Sabina (2006). Modalità insediative nella piana fiorentina nel Neolitico: analisi informatizzata e trattamento dei dati delle aree di frequentazione e delle strutture. Phd thesis, Università di Pisa, unpublished.