Between reconstruction and reproduction. The role of virtual models in archaeological research

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Introduction

Over the last five years the interest and attention focused on issues regarding virtual archaeology has produced a wide body of literature, which has investigated technical, theoretical and methodological matters. Two main directions are recognizable. One concerns the impact of VR within the educational context, such as the museum environment or the archaeological site, with VR employed as a didactic tool and a means to popularize archaeology and illustrate cultural heritage (Roussou 2002). The other direction has led to the development of new epistemological approaches in the field of archaeological research (Reilly 1990, Forte and Beltrami 2000). Two different goals, two different ways of developing 3D reconstructions. To simplify this statement, it may be said that, in the first case, i.e. within the public framework, the product is meaningful only in its final realization. The purpose of the virtual restoration of a monument, usually monumental architecture, is principally the aesthetic and/or educational impact on the public at large or on the student, and it results in indistinct interpretations. In the second case, i.e. within the research framework, the chief aim of VR is to analyze the different processes, which allow us to reach the final result. It represents "…*the manipulation of an archaeological interpretation*" (Barcelò 2000).

In this paper we will discuss the use of VR as a research tool in archaeology by examining the distinction between two different underlying processes, virtual Reconstruction and virtual Reproduction.

Virtual Reconstruction

Virtual may be taken to mean "… *something that can act as surrogate or replacement for an original* (Barcelò, Forte and Sanders 2000) ,"...*the representation of some (not necessarily all) features of a concrete or abstract entity*", (Barcelò 2000) or basically the re-creation of what cannot be visible in reality.

Reconstruction can be interpreted as the integration of entities not present, totally or partially, in the archaeological scenario, moving beyond the archaeological reality to produce a possible scenario, following a deductive process:

Start from presumed objective archaeological data (what is seen, recognized and documented);

Proceed on the basis of different assumptions (for example the estimation of certain parameters like the height of a wall by the evaluation of the collapsed construction material);

Arrive at interpretations that will determine the integrations (adding a second floor to the analyzed structure if the walls reach a certain supposed height).

The model can be read as a synthesis of these various processes.

Virtual Reproduction

I mean by Reproduction that process which leads to the modelling of what is present in the archaeological scenario.

In the prehistoric context, for example, often the lack of standing elements, posts, walls etc, as well as the general lack of "monumentality", restricts our ability to reach the reconstruction stage since any further interpretation of the structural features would tend to be artificially contrived especially when the data is not sufficient or since the data *manipulation* is not necessary .

In this case, we may take virtual to mean that what is seen and modelled represents the complexity of the entire state of the archaeological findings: what, during the different phases of digging was achieved partially is now visible in all its complexity.

We may define Virtual Reproduction as the overlay of the different excavation layers, the re-composition of all the elements, for example the stratigraphy referring to one living area over a period of time, is never seen contemporaneously during the field investigation because excavations by their very nature, destructive, constitute an unrepeatable experience.

Therefore the possibility of reiterating the exploration virtually, not as a digging simulation, (since by virtue of documentary constraints, absolute integrity is effectively impossible to maintain), but as a bringing to light of the different steps of the excavation, allows us to improve the interpretation process and to carry on different experimentations.

By means of the analysis of two case studies the distinction between the two experiences may be clarified.

Case study

The virtual reconstruction of Hut A in Maccarese Le Cerquete Fianello (Rome)

Within the sphere of a larger project, promoted by the Italian Institute of Pre-history and Protohistory, entitled "Computational analysis and data-treatment of habitation structures of the prehistory and protohistory in Italy" approved and financed by M.U.R.S.T (2000-2001), the analysis and the reconstruction of hut A in the Calcolithic site of Maccarese, *Le cerquete Fianello*, was performed ((Manfredini et al. in print, VVAA 2002).

The postholes found in the village of Maccarese and easily recognizable as pertaining to human habitation, fuelled an interest in the modelling of the foundation floor of Hut A in order to enhance the bi-dimensional graphics of the archaeological data acquired in the excavation phase and to further enhance in 3D the surface profile of the ground and the morphology of the single holes that held the structural supports of the dwelling.

The attempt to recreate this structure was made possible through the use of different data sources: the 2D traditional documentation (plans and contour lines), photographic documentation, ethnographic data and photos, anthrocological data, spatial analyses. The re-composition of all this data produced the reconstruction and provided us with hints on how to experiment with several elaboration to restore virtually the upper parts of the hut in different ways. The position of the post-holes is quite clear and gives us the shape of the hut itself: it is regularly ovular (fig.1).

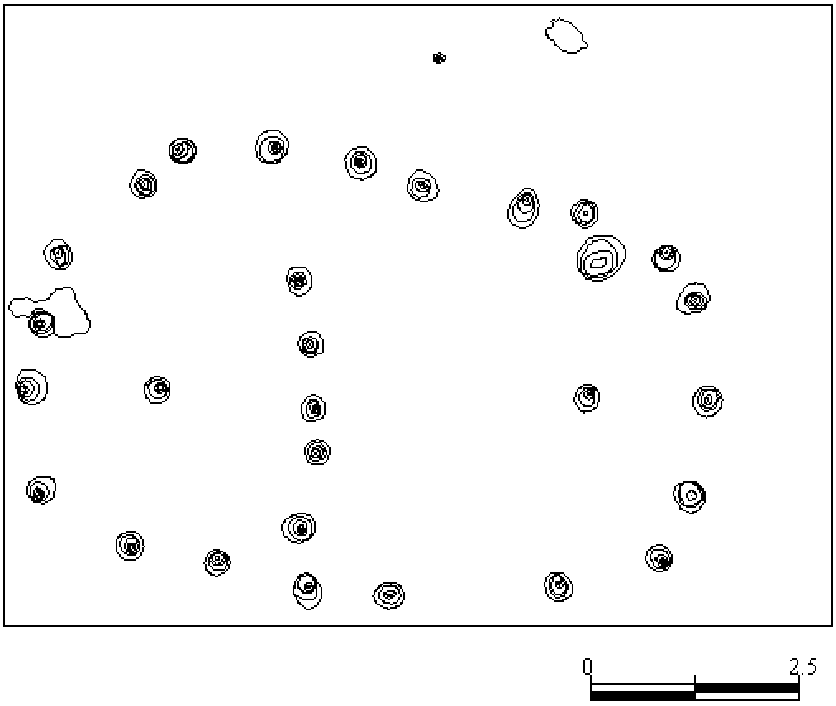

Fig.1 The 2D documentation: Contour-lines of Hut A Maccarese Le Cerquete (Rome).

The surface modelling, based on the interpolation of the contour-lines (Surfer 6), was performed to analyze more precisely the morphology of the post-holes, allowing us to visualize them from any vantage point (fig.2-3).

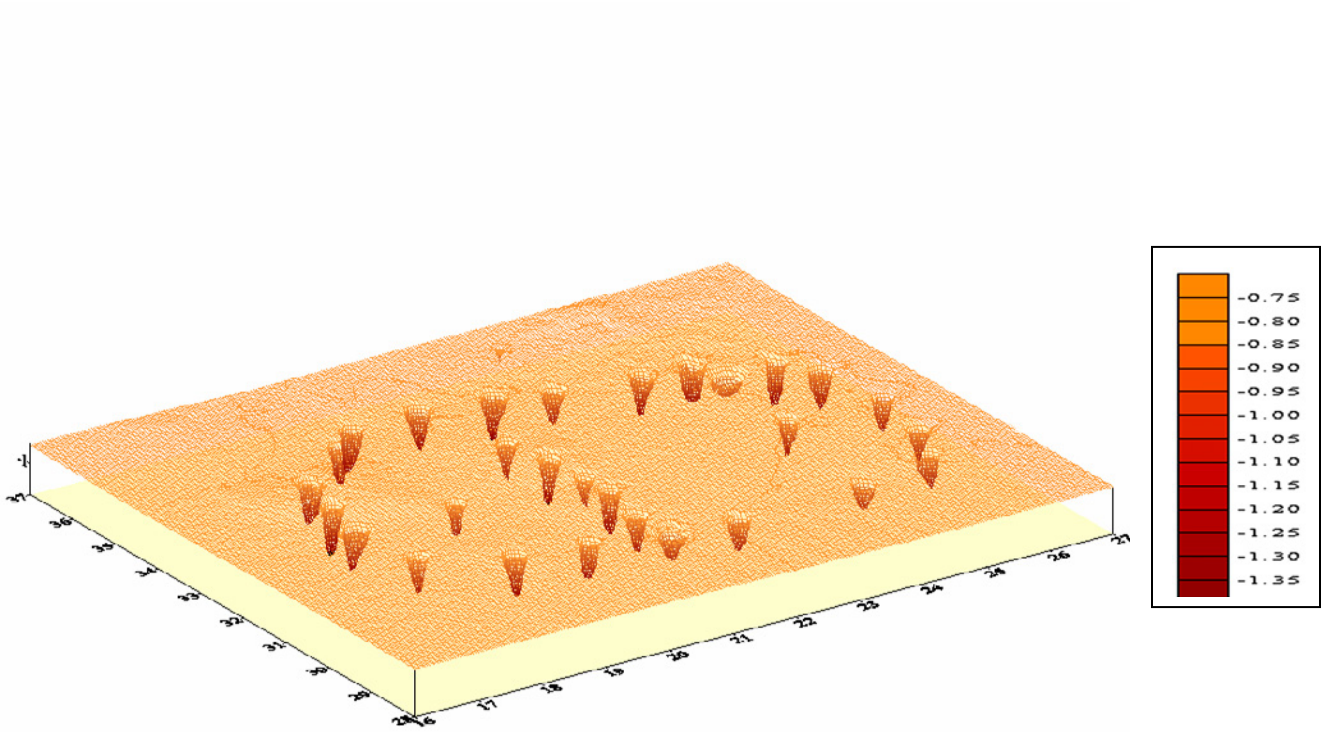

Fig.2 The 3D model of the surface of Hut A Maccarese Le Cerquete (Rome) .

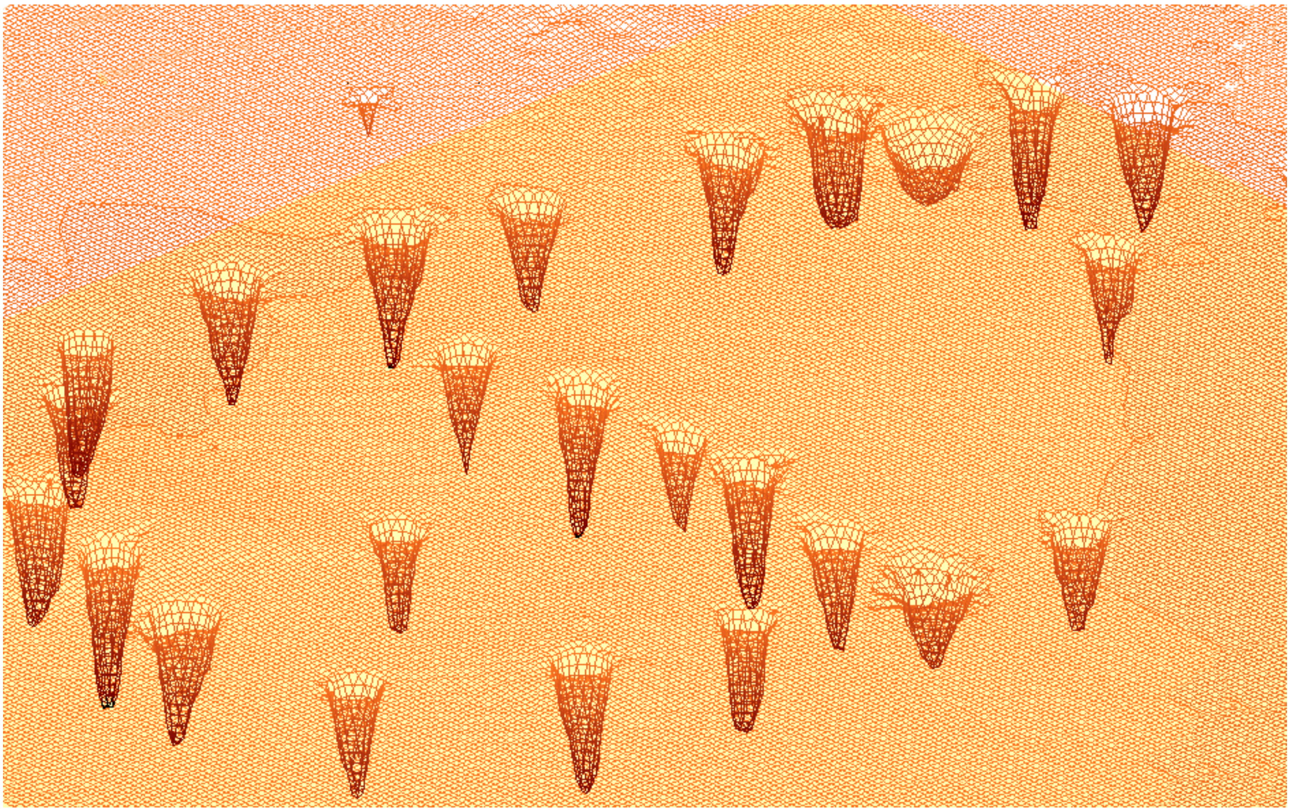

Fig.3 A zooming of the modeled surface. The morphology of the post-holes in evidence.

Several observations were made once the modelling was done; even though this information was embedded in the 2d documentation it didn't have the same impact. In order to model the posts to their approximate dimensions, the calculation of the diameter was based on the measurements of the medium slice that cuts through the post-holes. Once the plans were acquired and vectorialised in a Cad program (AutoCad2002), the further steps were performed by the use of 3D StudioMax4.

The height (4.5/5 m), and the general aspect of the rough straw clusters of the hut was extrapolated by analyzing early twentieth century photos from the photographic archive of the area of Maccarese.. Keeping in mind the limitations of an exact correlation between these structures, we recognize some interesting similarities: same plan, disposition of the posts, same soil and similar environment (fig.4).

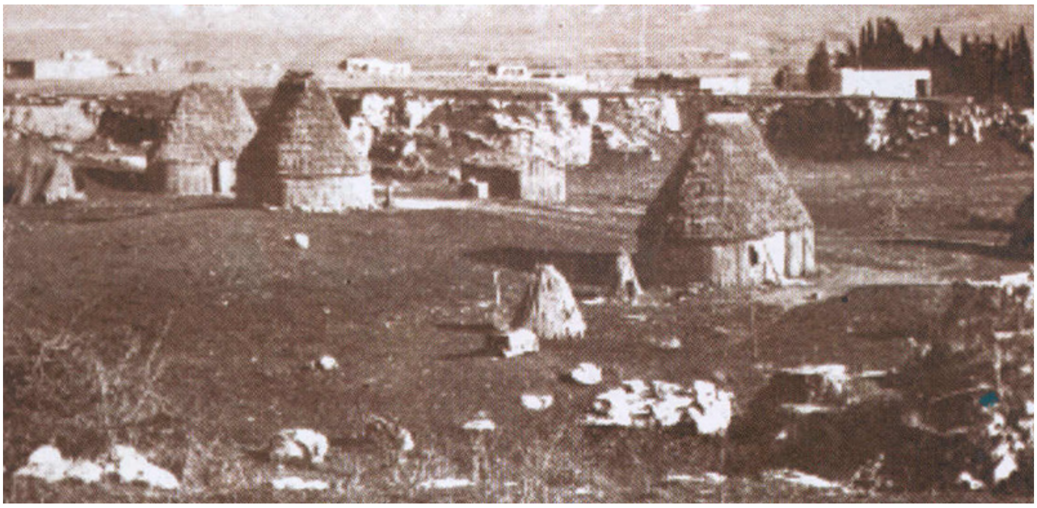

Fig.4 A photo of the early twentieth century of the area of Maccarese.

The study of the anthracological remains encountered in the interior of the structure revealed the presence of various tree species, most especially the oak (*Quercus* sp.)and the elm (*Ulmus* sp). If we compare other findings (Bietti Sestieri et al. 1998), it is reasonable to believe that the perimeter walls were made of oak and that the covering was constructed from lighter material such as elm. For this reason, a texture like that of oak bark was chosen for the manufacture of the support posts and a wood possessing the coloration of elm was used for the sloping posts of the roof, taking into account that some form of humidity resistance treatment of the wood altered its original texture.

The 2 different interpretations that are presented were tested. Even though there are many variables such as the humidity, the ecological constraints etc., the principles of static rules were taken under consideration. Several other variations were tried once the basic model was built up and the one shown seems to be the most feasible (fig.5-6).

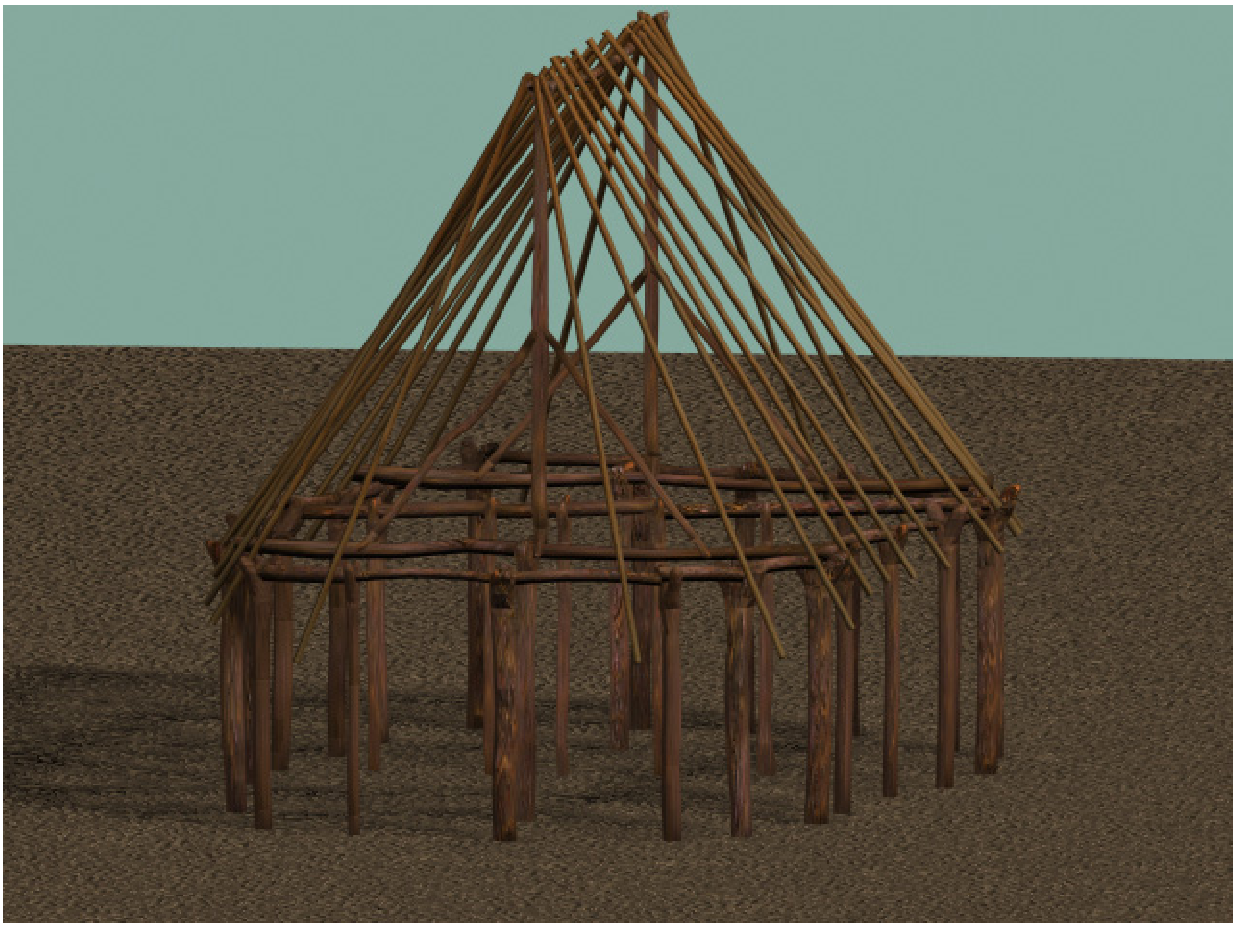

Fig.5 First hypothesis of reconstruction.

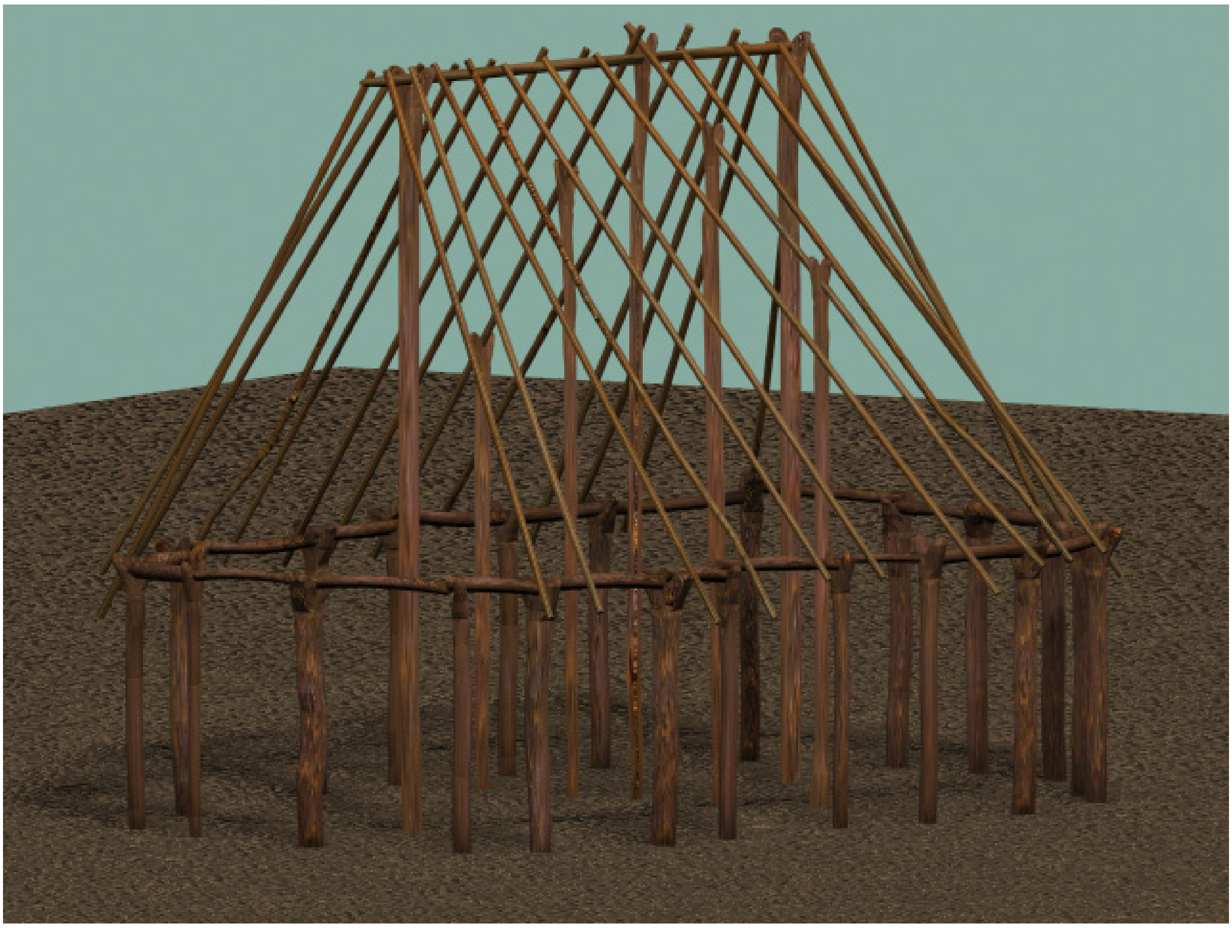

Fig.6 Second hypothesis of reconstruction.

In order to avoid " …the difficulty for the end user to distinguish the model's realism and the archaeological reality…" (Kanter 2000) and to create for this reason a transparent model (Ryan 2001),

the rendering of the roughing was left opaque (medium transparency) to underline in a more evident way the uncertainty of the interpretation (Fig.7).

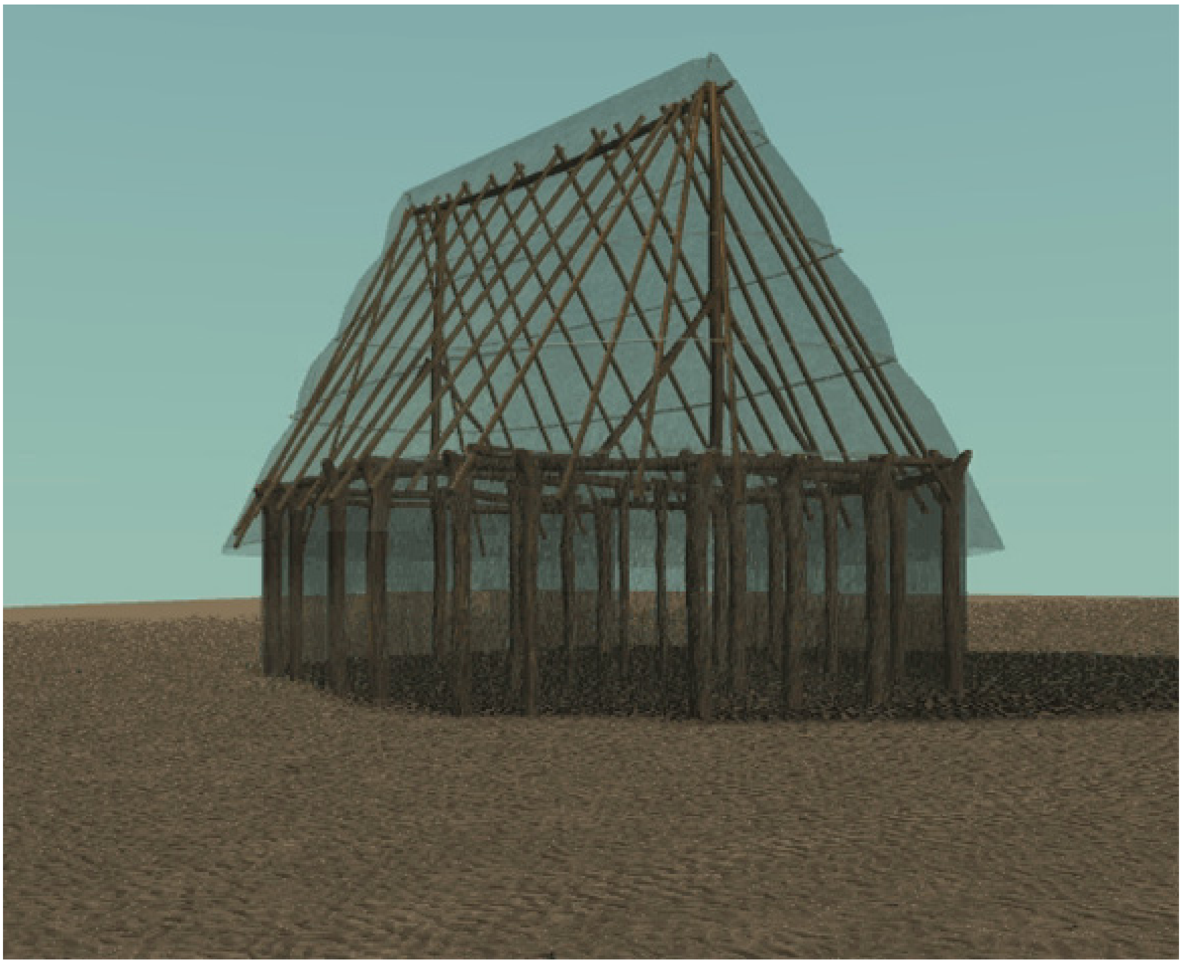

Fig.7 The roofing of the hut is rendered with a high opacity in order to keep the model transparent and underline the uncertainty of the interpretation.

The production of an animation allows us to show and visually explain as well, with minimal artifice (the lighting of the post inside the perimeter of the hut), where it is thought and verified, by effecting a spatial analysis of the general distribution of the archaeological material, that a passage existed between the two living areas recognizable in the structure. The process, which produced this animation, clarified certain points and during the construction it was possible to formulate different interpretations in a concrete way. From all the data collected we produce a graphic representation and the final animation represents the synthesis of all the accrued data and its interpretation (see the Maccaresehut.avi file).

It is important to point out that the interaction of the modeller with the model during the different steps of the creation process represents the topic phase of the research. Many complicated concerns are in fact dealt while the model is being created, (e.g. the calculation of the diameter of the posts, the problems related to the issue of statics, the entries, the alignment of the beams etc.) ultimately making reconstruction viable. Thus it could be said that the model not only represents the ultimate result of the archaeological interpretation, but may also constitute the means to understanding the data itself.

Case study

4.2 The virtual reproduction of grave 7 in Romito Cave (Papasidero, Cosenza)

The Epi-gravettian grave in Romito cave, (Martini et al. in print) is a good example by which to illustrate the concept of virtual reproduction (Fig.8).

In this case, the model was created through the use of different data sources. The contour lines permitted the modelling of the pit (AutoCad 2002) and by the acquisition of different cross sections of the stones, we performed their modelling (Rhino1.0). The photographic documentation provided the textures in order to achieve a photo realistic result and was also used to have a more precise view of the conservation state of the bones. The modelling of the skeleton is still on going and was carried out by the acquisition of the 2D documentation, the photos and anthropological data (3DstudioMax4).

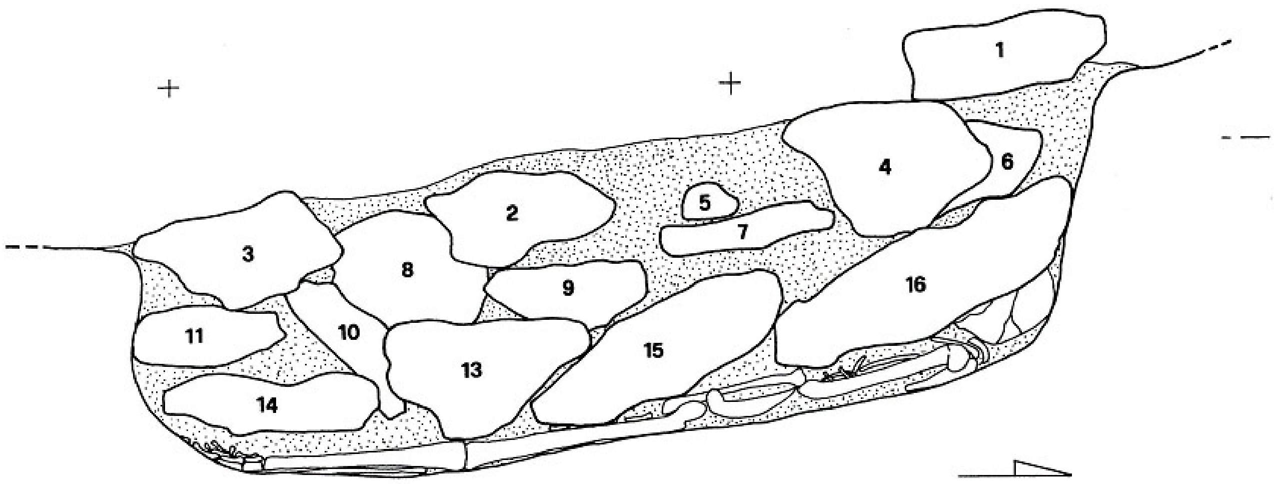

Fig.8 A cross-section of the grave 7 in Romito Cave (Papasidero, Cosenza). The 2D original documentation.

In this instance it is not necessary to undertake a restoration of any missing feature because the grave appears in its integrity. The 3D reproduction of the pit and the filling in of the depression, including the covering architectural stone complex, allows us to reconstruct and underscore the dynamic anthropological events that generated the burial formation process: the excavation of the grave (Fig.9), the deposition of the body(Fig.10), the stone covering in its architectural complexity (Fig.11-12).

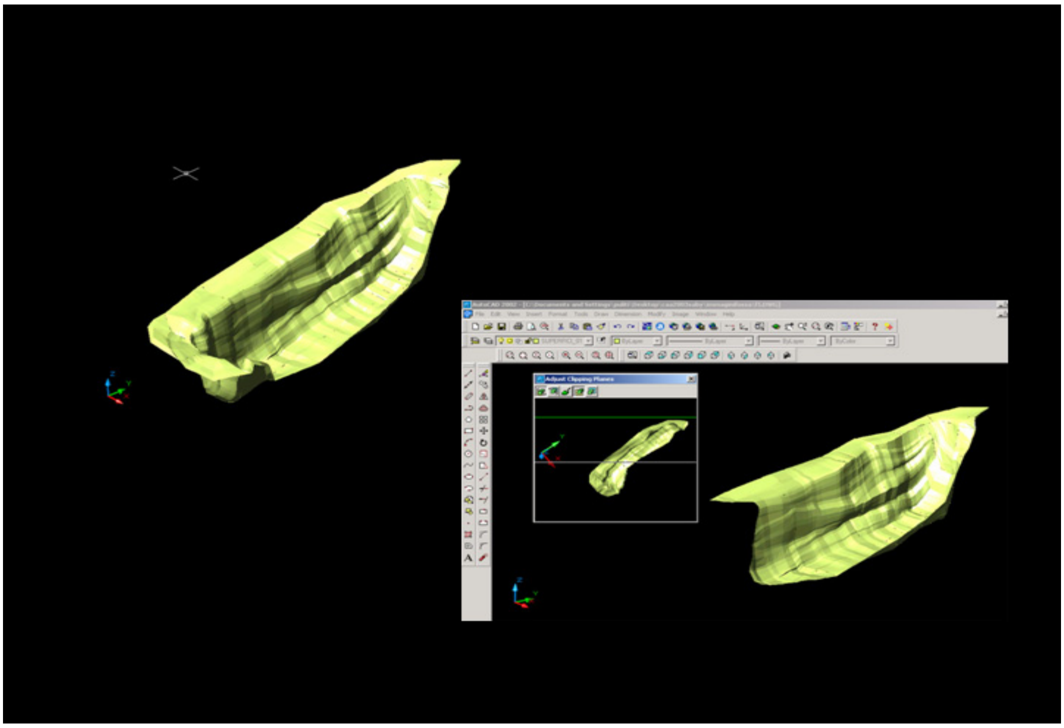

Fig.9 An isometric view of the 3D modelling of the pit in shading mode. The 3D model allows by clipping planes to create interactive cross-sections.

Fig.10 The left view of the pit and part of the skeleton bones rendered

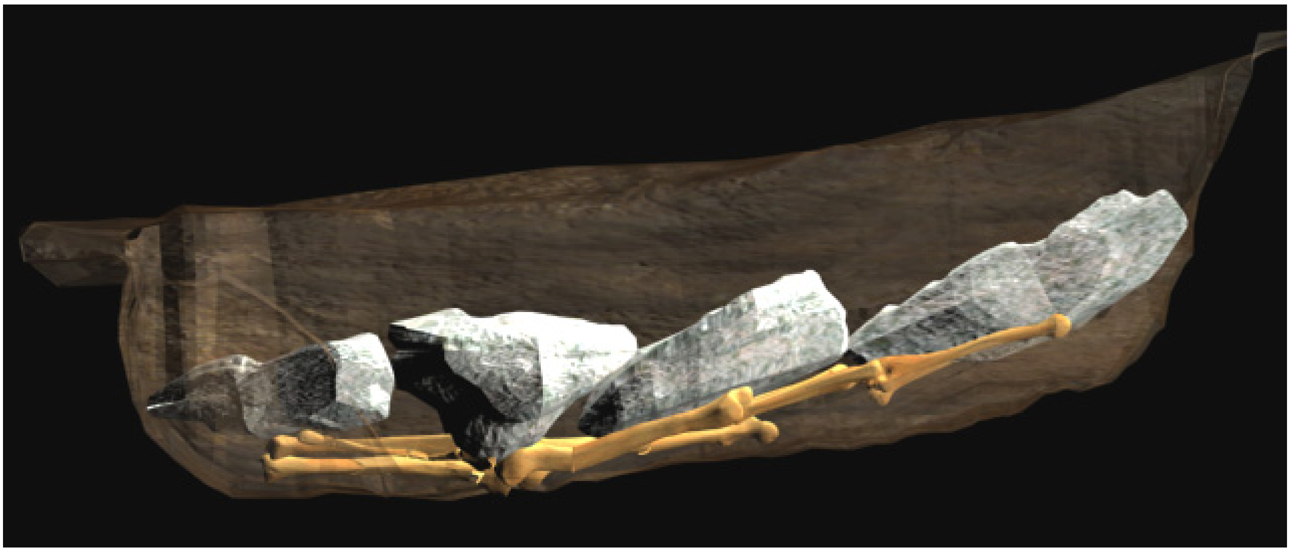

Fig.11 The pit, the skeleton, the direct overlapping of the stones

Fig.12 The pit, the skeleton, the complete covering of the stones

The model provides us with the opportunity to visualize the burial-place with all its composite characteristics, even where it was not possible to appreciate it in the archaeological scenario;

Fig.13 The photo taken by the left view. The grave before the digging.

Fig 14 The photo taken by a top view . The stones overlapping the upper part of the skeleton

e.g. it is not possible to visually distinguish the respective position between the skeleton and the stones that directly cover it during the excavation stages, nor from the analysis of the traditional 2D documentation and the photos (Fig.13-14), whereas it lies within the scope of modelling to exploit various tactics to engineer visualization: the stones are rendered with a high opacity in such a way as to enable us to see the bones underneath and we can achieve a more comprehensible reading of their relationship (fig.15).

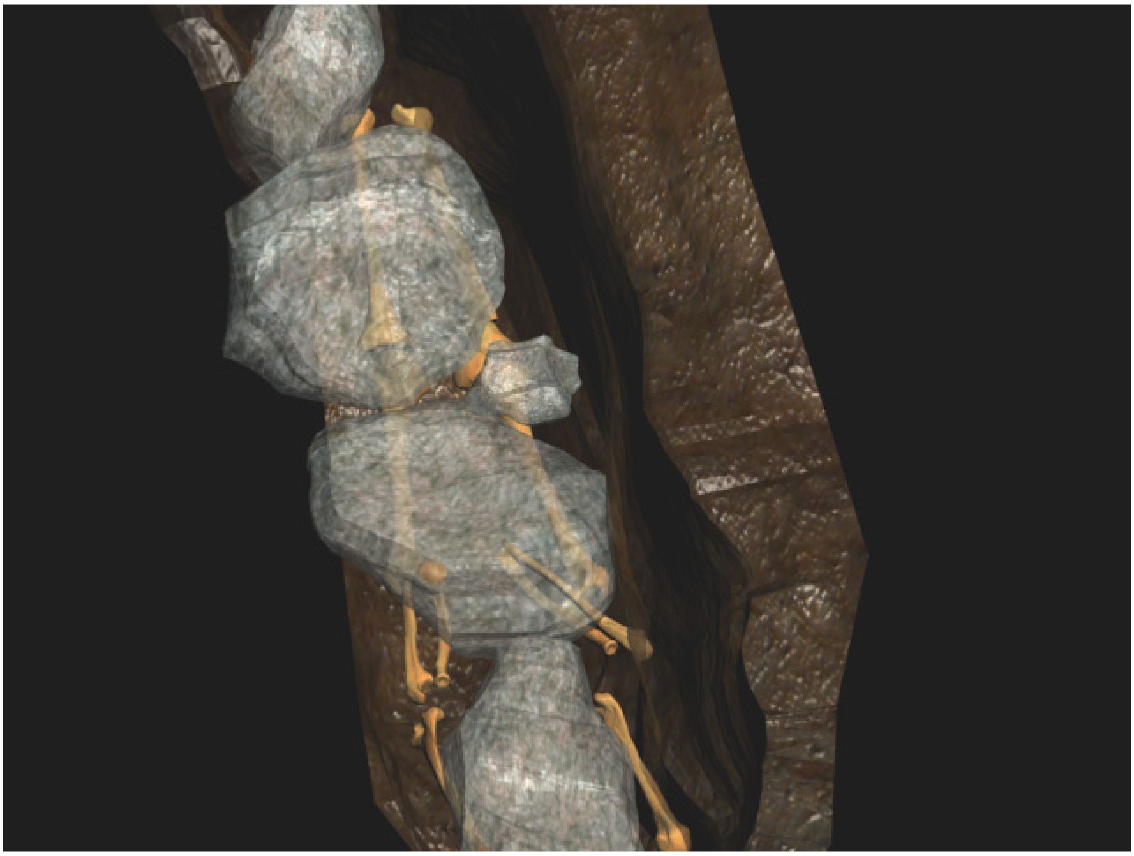

Fig.15 The top view of part of the grave with the stones overlapping the bones rendered with a high opacity.

It is possible to glean essential taphonomic data by observing the model. From the position and the rotation of the bones, it is feasible to determine in a significant way, how the overlapping stones acted upon the bones (as soon as the soft components of the interred body deteriorated) or how they splintered them (fig.16).

Fig16 Taphonomic analysis: the action of the stones on the bones.

The significance of this virtual reproduction is demonstrated via its capacity to explore iteratively the grave, the stone architecture, and the post-depositional events, and its value is confirmed in the power to provide this all-encompassing image not accessible previously to us solely by means of excavation.

Conclusion

When making a virtual reconstruction, all the interpretations developed during the modelling are represented graphically and explicitly. In the case illustrated here, the process being described may be defined as an action that extends from a specified perceived reality to a generalized conceived reality, in other words what we originally see in its fragmented state eventually becomes virtually reconstructed into a coherent meaningful form.

When a reconstruction is not possible or necessary, the virtual Reproduction helps and enhances the representation of the events that determined the archaeological state: for example, the post-depositional phenomena, or the stratigraphic relationships. In this instance, the process travels along a different route, one that begins with an diminished perception of reality and arrives at a more substantial or detailed reality. Such “virtuality” still needs to be further developed and exploited in archaeology or more specifically in prehistory research.

The goal of either process (Virtual Reconstruction and Virtual Reproduction) is to create a tool for a better understanding of the past in a visual way. The strategies to achieve this goal follow a parallel course. Where their paths diverge is in the final result and in the practical applications that may arise.

>> view the *avi

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