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Virtual Windows to the Past: Reconstructing the 'Ceramics Workshop' at Zominthos, Crete

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The reconstruction of the 'Ceramics Workshop' at Zominthos, Crete is an ideal example of the contribution of computer graphics to the interpretation of archaeological data. Room 13 has been interpreted as a ceramics workshop without taking into account the peculiar absence of windows. A virtual reconstruction and illumination analysis of this area helped to identify its plausible uses, while several alternative models enabled a comprehensive approach to the simulation of lighting. This paper will discuss the decision making process based on the archaeological evidence, and will address all the possible readings of this ambiguous dataset by explicitly examining the various structural and lighting models produced, while trying to understand how people perceive the environment and interact with it.

Keywords: Minoan Crete, Virtual Archaeology, Lighting Analysis.

1. Introduction

Houses, working spaces, open areas, religious buildings and other facilities, are all distinctively lit, showing that the involvement of light in architecture is a complex phenomenon that allows everyday practices and rituals. As indicated in numerous finds from Archaic and Classical Greece, the role of the illumination in ancient structures was of great concern. People were producing terracotta lamps, either to use them in everyday practices or various rituals. In addition, sunlight had an integral role in these practices. Although the range of uses are well documented in ancient sources, the understanding of illumination in prehistoric times is more complicated, as the physical remains are found in far less quantity, and the preservation is problematic in comparison to subsequent eras. As well, written sources do not exist to provide an indication of people's intentions. The loss of data, such as the materials used for the construction of the walls, the roofing techniques, and the exact size of structures leave room for several hypotheses. To overcome these constraints the present is used, often inappropriately, as a correlation to ancient environments, and as a consequence, the archaeological interpretations produced do not take into account the special conditions that existed in prehistory. A virtual simulation of a prehistoric environment helps to test different hypotheses and overcome these constraints.

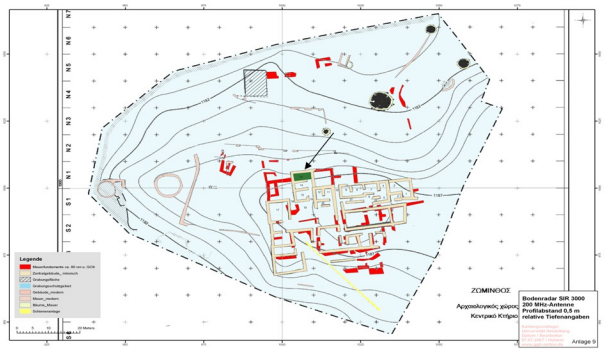

Figure 1: *The Plan of Zominthos Central Building. The location of the 'Ceramics Workshop' is specified by the arrow. Red colour indicates the structures revealed by the geomagnetic prospection (© Zominthos project).*

Zominthos is located in the mountains of central Crete, the largest of the Greek islands and the fifth-largest island in the Mediterranean Sea. The site was discovered in 1982 by Professor Yannis Sakellarakis and the excavation is still in progress. It has revealed a monumental Central Building (fig. 1) that covers an area of 1,600 square metres, built from the 17th century BC onward (SAKELLARAKIS and PANAGIOTOPOULOS, 2006). Although only the ground floor is visible today, the archaeological evidence suggests that the Central Building had at least two floors built of large blocks of local stone, some

coated with white plaster and decorated with frescoes. Only 10 of at least 45 rooms have been partly or fully explored up to now, and the finds mainly consist of pottery, concentrations of animal bones, numerous fragments of carbonized wood, and several small artefacts.

2. The 'Ceramics Workshop': Theoretical Aspects

At the northwest corner of the so-called Central Building, Room 13, which has been characterised as a Ceramics Workshop was unearthed in 1989 (fig. 2). It is a 15-square-meter area with more than 250 vessels for everyday use, some bronze and stone tools, a basin in the middle of the room and a potter's wheel. Ceramics had been placed on two benches running along the northern and southern walls, some of which were found in situ. Some of them may have been positioned on wooden shelves along the walls, as indicated by the great quantity of unearthed carbonised wood (fig. 3). Along with Rooms 14 and 15, it is an annex to the Central Building.

Figure 2: *Aerial View of the 'Ceramics Workshop' (© Zominthos project).*

Several areas, which have been characterized as ceramics workshops, have been found in Minoan Crete (MICHAELIDIS, 1993). However, they are not architecturally distinct, and the only way to identify them is to reveal artefacts or installations which are related to the production of pottery (EVELY, 2000). Room 13 actually presented all the characteristics that could safely classify this area as a workshop; benches, tools, hundreds of pots and a wheel. However, there are two peculiar features which need further investigation: 1. Although the walls are preserved to a significant height, no window was revealed, as are the cases of the adjacent rooms 14 and 15, as well as rooms 8 and 9 at the façade of the building. 2. The basin in the middle of the room is an extraordinary find.

After the Ceramics Workshop was discoverd, the excavator thought that the confirmed absence of windows was plausible, since clay can become very fragile when there is not a stable environment during the whole production process. Also, the existence of two large windows, in the adjacent rooms 14 and 15, made him believe that the workshop received sufficient indirect illumination, so as to facilitate the potter's work, but not adversely affect the clay.

However, having worked on similar archaeological contexts modelling the ways that light behaves in specific environments, I was quite distrustful of this scenario. Thus, it was decided that it might be useful to apply some computer methodologies, and analyse all the possible perspectives. The initial thought, that it is impossible to have a workshop without windows, was also embraced by a young potter from a neighbouring village. He also argued that the production of a vessel in complete or partial darkness is improbable, since the potter should have direct visual contact with the clay.

The results of this research were an amalgamation of computer applications, archaeological and ethnographic research. Several interviews were conducted with traditional and modern potters, many of them came on-site to observe the actual structures and lastly, the authors visited traditional workshops in nearby villages, all of them presenting large openings (fig. 4).

Figure 3: *3D reconstruction of the 'Ceramics Workshop' (© Papadopoulos, C.).*

As far as the basin is concerned, there is only one known archaeological comparator, at the farmstead at Zou, that is also closely related to the production of pottery (PLATON, 1956). However, 50 years after its excavation this site remains unpublished and no more information is available. Although there are pits, vessels or curved rocks with similar uses in several ethnographic comparasons with strong traditions in the production of pottery (fig. 5), there is no such structure in the interior of these buildings. The fact that fine-grained soil was found at the bottom of this basin at Zominthos, and that two potters managed to make pots by using this clay, led the excavator to believe that this was a structure for the purification of the clay. Clay is gathered from natural resources, and needs to be prepared through various steps in order to be suitable for the production of pottery. Its plasticity is one of the most important factors, and thus, flotation and levigation is applied. The purified clay needs to remain a couple of

days in a deposit until the water evaporates with the help of the air and the sun. The latter means that such a process, assuming that the basin was used for purification, could not have occurred in the interior, as all the comparisons suggest.

Figure 4: *Traditional ceramic workshops in Rethymno, Crete, preserving large openings (© Papadopoulos, C.).*

Figure 5: *Structures and objects for the purification of the clay. Left: carved rock, top right: built basin, bottom right: ceramic vessels (© Papadopoulos, C.).*

3. Reconstruction Process

The creation of several structural models (fig. 6) gave the only chance - apart from a future physical reconstruction - to provide a reliable illumination study, which accounts for the impact that this unusual absence of windows may have had. Firstly, a window was modelled in the west wall, similar to the ones in rooms 14 and 15. Another alternative is the existence of a window in the north side of the room, similar to the ones in the façade of the building. However, the fact that the wall at this side is preserved up to 2 metres may only suggest one or two small oblong openings at the upper courses of the wall. The scene was also rendered with an internal window at the partition wall between rooms 13 and 14. Also, an opening at the east side and without windows, which was the initial suggestion, was also included. Last of all, alternative constructions were rendered with a combination of these features (e.g. one window at each side), and with the partition wall not reaching the roof. The archaeological data provided strongevidence ofthe existence of an upper storey for the whole workshop complex, and thus, an opening at the roof, which would have been a solution to the problem, is not plausible.

Figure 6: *Alternative structural models of the 'Ceramics Workshop'. From top left to bottom right: window in the west wall, window in the north wall, no windows, window in the east wall, lower partition wall, window in the partition wall, windows in the north, south, east walls, opening at roof (© Papadopoulos, C.).*

The thorough study of the field notes provided a well-founded estimation of the form, number, and initial position of the various finds (fig. 7). The stratigraphical sequence, the numerous fragments of carbonised wood, and the great number of ceramic finds, suggested that wooden shelves were positioned along the walls to facilitate the placement of the artefacts. The two benches were also modelled after carefully considering the available evidence regarding their structure, materials and approximate dimensions.

Figure 7: *3D models of ceramic vessels found in the 'Ceramics Workshop' (© Papadopoulos, C.).*

4. Technical Aspects

This project does not present any innovative components, unlike the author's project regarding the structural and lighting models for the Minoan cemetery at Phourni, Crete (PAPADOPOULOS 2010; PAPADOPOULOS and EARL, 2009). The three-dimensional models were produced in 3dsMax 2010, and Mental Ray (MENTAL IMAGES, 2010) was used as the render engine to achieve physically accurate results. The illumination analysis was undertaken in 3dsMax Design 2010, as it has specially designed tools for this task. The lighting analysis assistant points out all the parameters that need to be checked to result in a physically-based lighting calculation. Also, the lighting and material tabs allow to find invalid lights or materials in the scenes. After checking that all these components were compatible to Mental Ray, the lighting analysis was carried out via rendered image overlay (fig. 11), which prints the lighting values on top of the rendered image, and the values obtained were cross checked with pseudo-colour exposure control (fig. 10), which translates the photons of the scenes into colours taking into account their intensity. Since both are view-dependent, a light meter was also used to report incident lighting – illuminance – falling onto the scene (fig. 12), to check if there are any inconsistencies of the lighting values. Also, a Macbeth colour chart was rendered in the scenes (fig. 9) offering improved subjective comparison of colour bleed and variations in luminaire colour.

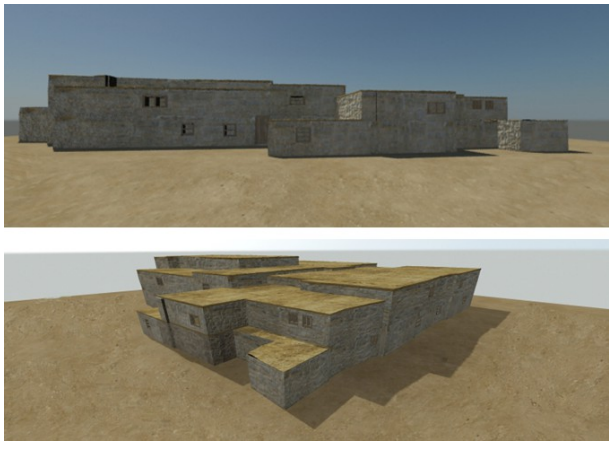

Figure 8: *Hypothetical reconstruction of Zominthos 'Central Building' (© Papadopoulos, C.).*

Figure 9: *Macbeth Colour Chart rendered in the 'Ceramics Workshop' (© Papadopoulos, C.).*

However, it should be taken into account that the resultant image is a depiction of how a camera exposes and captures a scene, without considering the human eye's adaptability in different lighting conditions (FERWERDA *et al.*, 1996; LEDDA *et al.*, 2004). A schematic view of the Central Building was produced (fig. 8) based on the available evidence and the detailed study that Palyvou has provided for the architecture of Akrotiri, Santorin (PALYVOU, 1999; 2005), in order to achieve physically accurate calculations of Global Illumination. Lastly, since there was no need to examine prehistoric dates, the various scenes were rendered with 3dsMax taking into account the latitude and longitude values for the Zominthos area at current date. Since the amount of polygons produced was extremely high for one workstation, distributed bucket rendering was used to speed up the process.

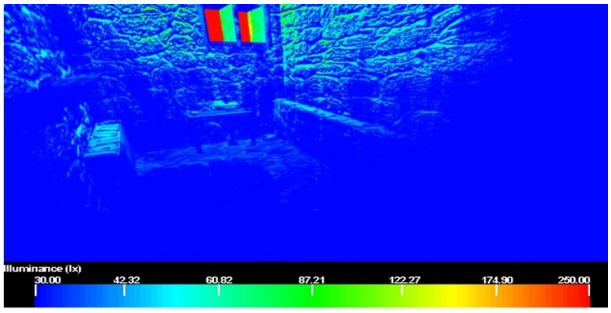

Figure 10: *Pseudo-colour Exposure Control of the 'Ceramics Workshop' with a window in the west wall. Illuminance in the scene does not exceed 60 lux in the area near the window (© Papadopoulos, C.).*

5. Results

The illumination analysis provided a comprehensive way to examine the contribution of light in the interior of room 13 through the various structural models produced. The archaeologist´s initial notion - that the windows of neighbouring buildings may have provided sufficient light and air for aiding the potters' work - should be decisively rejected. Our lighting analysis tools demonstrated that not enough light could enter the room through neighbouring openings, as the values obtained do not exceed 40-50 lux in spring and summer months. Light coming through the windows of rooms 14 and 15 and one possible opening at the end of the corridor linearly decreases, and only a small amount reaches Room 13. To have a reference for the values presented in this paper, western standards of the US Green Building Council were used, which suggests a minimum of 250 lux for working spaces, while for specific tasks, which need more visual acuity, the illuminance values required are much higher (HANCOCK, 1982). However, today levels are much higher than actually needed and people usually perform tasks under lower visual acuity. The necessary lighting levels vary from individual to individual, based on several factors such as the contrast between the task and background, the age and health of the individuals, as well as the speed and accuracy when performing the task (DAWSON *et al.*, 2007). The other alternatives, namely the windows at the east, north and west sides, produced luminance and illuminance values at much lower levels than the ones suggested for working environments. For example, a window at the west side produced values reaching 100 lux with an average of 70, although a view-independent analysis gave much lower values. Also, luminance values proved that the interior would have appeared even darker to its users. Thus, it seems that these three openings do no facilitate the diffusion of light to such an extent so as to consider these alternatives a solution to the problematic aspects of the dataset. The construction of windows at the east and west sides is also constrained by the fact that the geomagnetic prospection indicated the existence of two more unexcavated rooms at the east and west sides of this annex, which may be contemporary to Room 13.

The low lighting values obtained for the light coming through the windows can be partially explained by the walls' thickness, which sometimes exceeds 1 metre, thus preventing any significant impact of daylight to the interior. The luminance and illuminance values increase when the structural models with two northern windows, or a window at each side of the building, are rendered. Although these two may have provided a more suitable working space (however, not ideal for such a work in terms of illumination), we cannot give a definitive answer about their existence. In addition, the construction of a window at the partition wall, or the existence of a lower partition, may not have been structurally possible, since the heavy superstructure of the building required a stable ground floor. Lastly, an opening at the roof does not seem possible, according to the archaeological evidence.

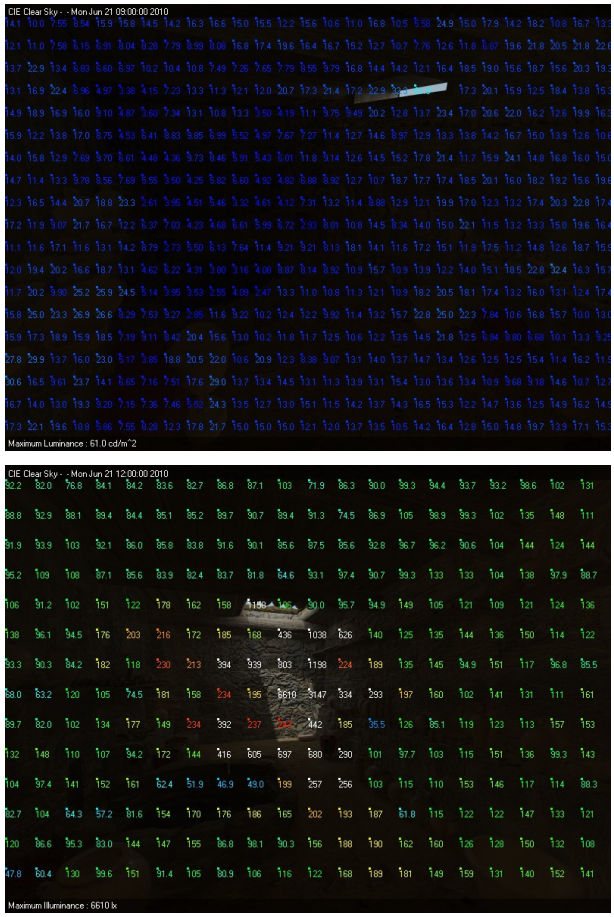

Figure 11: *Rendered Image Overlay of the 'Ceramics Workshop'. Top: Window in the north wall. Luminance does not exceed 61 cd/m2. Bottom: Although an opening at the roof provides sufficient light, it is not structurally possible (© Papadopoulos, C.).*

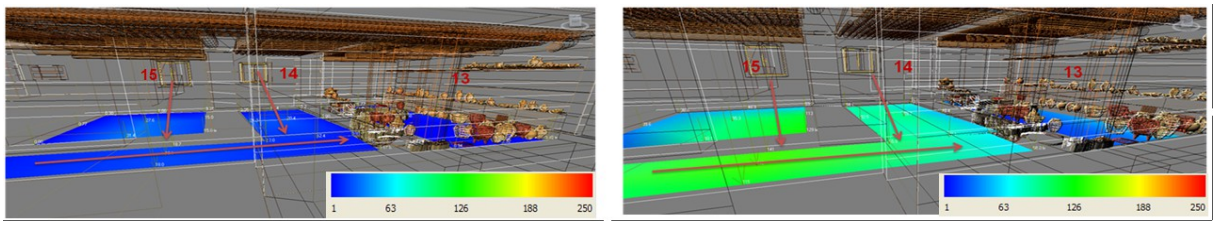

Figure 12: *Light meters indicating the amount of incident light (illuminance) entered in Room 13 from the openings of the adjacent rooms. Left: 21st December 2010 9am, Right: 21st March 2010 12pm (© Papadopoulos, C.).*

This extraordinary absence of windows may have meant the use of flame illumination. The data for this study has been derived from the author's master thesis, which adapted the work of Ioannis ROUSSOS (2003a, 2003b) from the University of Bristol, who worked on flame illumination. Traditional potters discouraged the suggestion of flame illumination, because although flame light may illuminate a potter's working bench, it also produces irregular shadows, which confuse the potter about the actual shape of the objects they are working on. Thus, several renderings were produced, under different kinds and numbers of artificial light sources, which to a certain extent confirm potters' statements and invalidate our assumption (fig. 13).

6. Secondary Archaeological Evidence

There is also secondary evidence that supplements our work by amplifying our argument for the actual use of room 13. Most of the times, either archaeology or computer methodologies are not sufficient on their own to provide answers to complicated research questions.

Figure 13: *The 'Ceramics Workshop' under flame light. Top: lamp burning wax. Bottom left: Three lamps burning wax and olive oil. Bottom right: lamp burning olive oil (© Papadopoulos, C.).*

The existence of a structure resembling a kiln outside Room 13, as well as the discovery of about 100 pots in this area, may be an indication that the production of pottery was undertaken at the exterior of room 13, as was the case with traditional potters in Crete.

One of the potters that collaborated in this project described his experience at a summer festival near Zominthos a few years ago, where he was asked to produce vessels on site. The products were left to dry during the night, however, the next day all of them had broken in pieces due to the great temperature disparity between day and night. Thus, it may indicate that an interior space was required for the vessels to safely dry in. This is also amplified by the fact that neither half-finished products non wasters were found in the interior.

As mentioned at the beginning, in the interior of the room some metal tools were unearthed. These have been interpreted as potter's tools. However, all the potters mentioned that they never use metal tools for their work, this being practice that goes back to their parents and grandparents. Also, the great quantity of animal bones may indicate that they were the remains of meals or storage, and some of the metal objects may have been associated to this idea.

The fine-grained soil found at the bottom of the basin is not necessarily purified clay. The common technique of sheathing containers with clay for waterproofing may indicate that the soil at the bottom are the remains of this practice. However, there is one more characteristic; there is a tiny opening, a channel at the partition wall, above the basin which, if not a post-excavation and conservation alteration, probably indicates running water. However, there is no evidence regarding the source (where the water was gathered and how it reached the basin) or where the water went after pouring it down the basin. As a conclusion, this paved basin may have been used as well for the storage of the purified clay or as a water tank (fig. 14). However, it is not easy to understand why anyone would have constructed such a labour-intensive pit for these purposes.

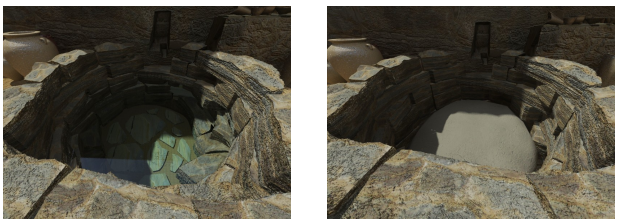

Figure 14: *The paved basin of the 'Ceramics Workshop'. Left: Basin used as water tank. Right: Basin used for storaging plastic clay (© Papadopoulos, C.).*

Lastly, among the various finds, no stone wheel bases, which are usually indicative of a potter's working bench, and are commonly used for positioning the wheel's shaft in a stable position, were found. The existence of a stand-alone wheel does not prove the existence of a workshop, since even in modern day Crete, potters have several spare wheels left in storage rooms.

7. Senses Make Place

Archaeology has been long haunted by the recording and interpretation of sites and artefacts at a visual level. Sight is reasonably considered the sense of science (CLASSEN, 1993) and ocularcentrism is usually privileged above other approaches (JAY, 1996; MACGREGOR, 1999). Characteristic of this tendency is the research under examination, which is based on the assumption that sight would have been the critical sensory engagement of the Minoans. Rarely other senses such as smell, taste and touch have been considered in archaeological contexts, resulting in interpretations that provide a limited and senseless experience of the past. Only hearing has been shyly introduced in the realm of archaeological interpretation, although the outcomes are usually challenged.

Buildings and artefacts were constructed to be experienced with all the senses that are recognised in the Western world, while sensory scientists challenge the notion that the physical world can be experienced only with five senses. Ethnographic studies have also proved that there are various cultures which develop different sensoriums and rank the senses in ways incomprehensible in comparison to our standards (CLASSEN, 1993), a factor that should not be underestimated in our interpretation of the 'Ceramics Workshop'. Aristotle, who considered vision the most developed of the senses, described touch as the principal sense and the foundation of human intelligence.

Blind people from birth develop the so called sensory compensation effect, to understand the world by using a concomitance of other senses. Tactility and hearing should be considered the dominant senses that let a blind person experience material culture. By using this as an analogy to our subject matter, it can be argued that other senses, especially touch may had facilitated potter's work. The construction of ceramics should have been a routine, as indicated by the recurring shapes found, which may suggest that pottery making may have been possible under dim or even flame light. The gradual adaptation to the low lighting levels may have boosted other senses, to counterbalance the limited visibility when performing various tasks in the room. Although it sounds obvious that, as a process similar to natural selection, people may had developed a range of sensory abilities to overcome the constraints of everyday life, these arguments cannot be satisfactorily raised for our case study and further discussion is needed.

Conclusion

We tend to superficially perceive the excavated sites as self-explanatory remains of the past, without considering other factors that had influenced the ways that people were experiencing them. Light and darkness are crucial factors in understanding both the architecture of buildings and the activities that take place, while a discussion on sensory experience comes foremost in order to get an overall, yet abstract idea of the past.

Before this project, Room 13 was characterised without any question as a ceramics workshop. The various peculiar characteristics were faced as exceptions to what is known to date about pottery production. However, our virtual windows to the past, proved that the contribution of light to the interior, was not sufficient to consider this construction as a working space. Mainly the lighting analysis, as well as several reasons closely related to the archaeology of this building and the ethnographic comparisons used, make it probable that the ceramics workshop was used for multiple tasks, such as the storage and drying of vessels produced in another area of the Central Building. Food and clay storage, as well as food consumption, may have also taken place. This research lead to the conclusion that that the initial interpretation of this area as a workshop should be critically re-evaluated.

However, by considering embodied practices and sensory ontologies in this context, it becomes apparent that our interpretation can be enhanced. The poor visibility in the 'Ceramics Workshop' might have been compensated by synaesthesia, i.e. conflation of senses, developed to overcome the absence of sufficient lighting conditions. Such approaches cannot provide definitive answers and can be criticised for their tendency to pivot on philosophical rather than tangible arguments, although they encourage a further discussion and understanding of the interaction of people with the material world.

Even the most complete archaeological dataset, will never result in a sufficient reconstruction of past reality. Although, the current approach is only a hypothetical approximation of Minoan prehistory, computer applications should be considered one of the most promising ways to approach incomplete, abstract and ambiguous archaeological evidence. This project made use of extant software rather than developing new methodologies, but it is only such careful implementation by archaeologists that new data, arguments and interpretation can be added to the existing archaeological record. A new era has already opened in traditional archaeology and we should not by-pass the potential of computer applications to answer complicated research questions and help us understand the past as it was experienced and not through the projection of our own beliefs onto it.

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