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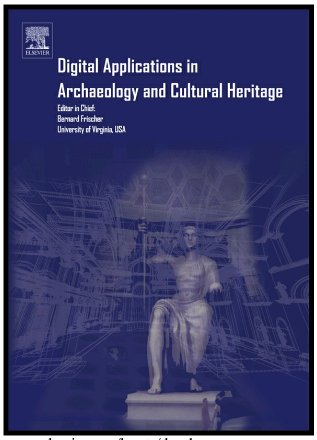

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An integrated 3D shape analysis and scientific visualization approach to the study of a Late Bronze Age unique stone object from Pyla-Kokkinokremos, Cyprus

Sorin Hermon[1], Martina Polig[1], Jan Driessen[2], Greta Jans[2], Joachim Bretschneider[3]
[1]The Cyprus Institute;
[2]Université catholique de Louvain;
[3]Universiteit Gent

Abstract

Scientific visualization is a well-recognized method of inquiry into data across a wide range of disciplines. 2D still images have a long history of use in archaeology, mainly depicting artifacts, structures or plans of archaeological sites. 3D models have a relative long history in modern archaeology, mostly for presentations to the public, musealisation services or engagement in education programs. The article below aims at filling the gap, by presenting a chaine opératoire archaeological investigation of an artifact, by implementing methods of scientific visualization and shape analysis on the 3D digital and physical replicas of the object. The item is a unique stone object found at the Late Bronze Age site of Pyla-Kokkinokremos; the article details the methodological approach, implemented analysis pipeline and critical discussion of adopted methodology and the resulting archaeological interpretation.

Keywords: 3D shape analysis, scientific visualization, Late Bronze Age Archaeology

1. Introduction

Despite the widespread use of 3D documentation in archaeology (Brutto and Meli 2012, Remondino and Campana 2014, Hermon and Niccolucci 2015, Galeazzi 2016) and scientific visualization in various disciplines (Johnson 2004, Chen and Floridi 2013), their use in archaeological research (Llobera 2011, Grosman 2016) and particularly on artifacts analysis is still limited and sporadic. A few examples where scientific visualization on 3D models of archaeological objects has been systematically applied for research purposes are studies focusing on improving the reading of cuneiform tablets (e.g. Mara *et al*. 2011, Fisseler *et al.* 2017), elucidating typo-technological questions on Lower Palaeolithic handaxes (Grosman *et al*. 2008) or their post-depositional damages (Grosman *et al.* 2011), classifying pottery fragments (Karasik and Smilansky 2011), characterizing tooth marks morphologies on animal bones (Arriazza *et al*. 2017, Yravedra *et al.* 2017) or more generally quantitative analysis methods deriving from 3D models of artifacts (Hermon *et al.* 2001, Saragusti *et al.* 2005, Shott and Trail 2010). Recent examples of 3D geometry analysis applied on archaeological material are their contribution for physical and virtual restoration of fragmented artifacts (Arbace *et* al. 2013, Palmas *et al.* 2013, Phillips *et al*. 2016) or the characterization of the smoothness of surfaces for rugosity analysis on Upper Palaeolithic grinding stones (Longo *et al.* in press).

The current study presents a "chaine opératoire" (Geneste 1985) approach to the study of a unique decorated stone object uncovered in Cyprus at the Late Bronze Age (ca. 1200 BC) archaeological site of Pyla – Kokkinokremos (Bretschneider *et al*. 2015), based on the integration of 3D shape analysis and scientific visualization principles (Hermon 2008, 2012). Aspects such as object's history and techniques of manufacture, handling and possible use are discussed. The systematic steps taken for its 3D documentation and subsequent scientific visualization and shape analysis are critically presented, in order to define a future framework and protocol to follow for such investigation of archaeological artifacts. As such, the results of the work presented below may serve as a methodological basis for future interrogations of archaeological artifacts based on 3D scientific visualization.

2. Methodological approach: scientific visualization and 3D shape analysis

The potential of manipulating 2D/3D digital objects in virtual environments for increased learning experiences has been critically discussed widely since a few decades (e.g. Goin 2001, Rountree *et al.* 2002, Morgan Spalter and van Dam 2008), with examples from archaeological applications as well (Hermon and Kalisperis 2011), in particular focusing on the virtual reconstruction of monuments and simulation of their possible function and social role (Frischer and Fillwalk 2012, Johnson and Solis 2016, Faka *et al* 2017, Hermon *et al*. 2017). When analyzing small objects, with features exhibiting small and irregular shapes, like the object under investigation, a particular attention is devoted to shading and lightning conditions of the virtual working space. Screen space ambient occlusion (SSAO) is a method introduced a decade ago to increase the performance of game engines (Shanmugam and Arikan 2007, Kajalin 2009), but since then applied in scientific visualization environments as well (Sabbadin *et al*. 2016). Briefly, ambient occlusion relates to the obstruction of light by the surrounding geometry on each point of a given surface, meaning that more occlusion results in less light and vice versa, and resulting for example in corners or narrow spaces being shaded. SSAO is now embedded in the rendering menu of Meshlab and therefore easily applicable, the result being a global illumination look on the 3D model, with realistic shading, based on the geometry of the object and its skin topology. Together with the shadow mapping rendering option (Callieri *et al.* 2011), the result is a 3D model rendered with realistic lighting and shadowing and suitable for further visual investigation, by changing light directions, the positioning of the object in the 3D space or applying various shaders options (see below).

Shaders are another technique of representing an object's shape considering its geometry to increase the approximation of light distribution, based on the topology of the object's external skin (shape through shading). It has been discussed since more than twenty years (e.g. Saito and Takahashi 1990, Oren and Nayar 1995, Pharr and Green 2004). Radiance scaling (Vergne *et* al. 2010) is a technique to represent the shape of a surface through shading, by adjusting the reflected intensity of light, which is dependent on curvatures on its surface and thus enhancing convexities and concavities. Shading is applied on the 3D model's vertices; the user may gradually change the enhancement level from none to full using a slider button, the result being rendered in real-time. Various options of radiance scaling (such as Lambertian or color descriptors) enable different visualization methods that enhance or reduce geometric features. It was particularly useful describing the carving method and overall manufacture of the investigated object (see below). Xray shader enables the visualization of the point cloud in a "transparent" mode, thus enhancing the capability of comparing opposite surfaces (Athanasiou *et al*. 2013, Decker *et al.* 2017). In this case, xray shader was instrumental in visualizing the "negative" of concavities and thus assess their shapes and characteristics (see below). Meshlab offers a wide range of shaders options, which allows users to interact with the 3D object through light using various mathematical transformations, all being dependent on the surface geometry of the investigated object and offering results that vary accordingly.

Another method for exploring the geometric properties of the investigated object is through colorizing curvatures based on two principles; the first one is based on the robust implicit abstract moving least squares (RIMLS) approach (Öztireli *et al*. 2009) and implemented in Meshlab by colorizing vertices of a mesh using the curvature of the underlying surface, while the second is based on the algebraic point set surfaces (APSS) for the local fitting of algebraic spheres (Guennebaud and Gross 2007), which requires points of the 3D model to be set with oriented normals. Such colorizations enable the visualization of irregularities along a surface, useful for example for the characterizing of the rugosity of a surface (Longo *et al.* in press), or, (see below), the identification of types of marks, such as manufacture, use or hafting.

3. Description of the 3D documentation process

A mobile laboratory unit, consisting of a 4x4 wheel truck with a custom-made cabin on its chassis and equipped with foldable tables, light and electricity, suitable for a wide range of scientific measurements, was deployed to the archaeological museum in Larnaca, Cyprus, in order to optimize the documentation process and analysis of selected finds. The overall shape of the object was 3D documented with a structured white light scanner (Aicon Smart SCAN) with a capture density of 40μ. In order to optimize the 3D acquisition process the internal space of the cabin was darkened and the scanner's field of view was set as to cover the entire object in a single scan episode (49 x 40 mm FOV). The color texture of the object was captured with a Canon EOS 600D camera and an EF20mm f/2.8 USM lens in a light tend. The resulting photographs were color calibrated in the Adobe Lightroom software and used to create a texture map in Agisoft Photoscan, which was applied to the 3D scanned model.

Two versions of the 3D digital models were saved. The first version, used in all the analyses described below, is the result obtained from the alignment and the merging of the scan data within Optocat 2015R, the scanner's proprietary software. A second version (used to 3D print a replica of the object) was created by applying a Poisson screened surface reconstruction (Kazhdan and Hoppe 2013) to the first, by using Meshlab (Cignoni *et al.* 2008), in order to close minor surface gaps that appeared within some incisions. When comparing the number of faces and respective vertices between the two models, we noted that the Poisson reconstruction reduced the number of faces and vertices by ca. 10% from the scanner generated 3D model (which has 3,807,556 faces and 1,905,863 vertices). The point density is uniform throughout the object's surface (ca. few μ). This means that only minimal occlusions occurred and basically all the object's geometric characteristics were accurately 3D recorded. Metrology tests performed on the used scanner (Bathow *et al.* 2010) testify for its accuracy to reproduce with high fidelity the geometry of an object, particularly when scanning Lambertian surface objects (Schaepman-Strub *et al.* 2006), such as of the discussed artifact, with a low reflectance ratio and thus most suitable for 3D optical scanners. The 3D models were positioned in the virtual space properly aligned along a xyz axis, within a bounding box and displaying a background grid with the object's silhouette as reflected on each plane. The visualization of such details facilitates consequent quantitative investigation of the object and correct assessment of its orientation in the 3D space. Finally, the Poisson 3D model was used for 3D printing a physical replica of the object in white polyactic acid (PLA), with a CubePro 3D printer. Even though the weight of the replica differs from the original object, being much lighter, the capability to simulate its manipulation, assess its manufacture process and investigate possible uses greatly enhanced the interpretation process.

4. Description of the archaeological site and the investigated object

The archaeological site of Pyla-Kokkinokremos is subject to an on-going archaeological investigation that started in the early 50's of the last century and continues today, with shifts in research teams and intensities of investigation (Bretschneider *et al*. 2015, Brown 2017). Its exceptional nature, being short-term lived while at the same time extremely rich in terms of diversity of material culture and industrial activities is exemplified by the variety of objects best described as belonging to the wider Eastern Mediterranean cultural sphere of influence. The site is located ca. 10 km. east of the modern town of Larnaca (Figure 1a), on a small natural plateau rising at 83 m.a.s.l. (Figure 1c), at ca. 800 m. from today's coastline. While describing in details the archaeological nature of the site and its past people is beyond the scope of this article, suffice is to say that the various excavations missions, and in particular the most recent one (Bretschneider *et al*. 2015) yielded a large corpus of objects attracting the interest of researchers due to their uniqueness and potential contribution to the understanding of cultural processes that occurred at the end of the Bronze Age in the region.

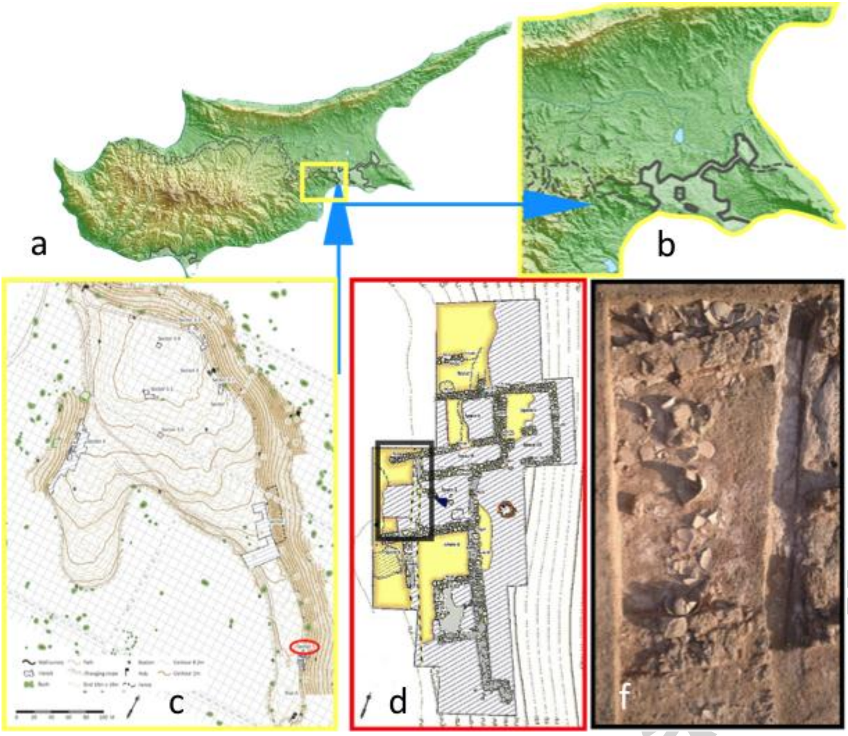

Figure 1. (a) – location of the site on the Cyprus relief map; (b) – the site location; (c) the plateau on which the site is located; (d) –Sector 5 of the excavation; (f) – aerial image of the trench where the object was found.

One of the unique finds at the site is a small object of ca. 5 cm height, shaped as a reversed L from a greenish stone (steatite, picrolite?), carved on its outside skin (Figure 2ca,b). It was found on the eastern slope of the plateau, within Sector 5 of the excavation, which is a wide trench of 14x10 m. where well-delineated architectural spaces and a variety of material culture remains were unearthed (Bretschneider *et al*. 2015). The object was collected from the filling of a modern cable trench (Figure 1d), which most probably consists of the soil removed when the trench was dug. Therefore, the original archaeological context of the object can be associated with the surrounding archaeological deposit, which is the inside space of a large structure (Figure 1c). Since no intrusive material has been collected from the area and in general the material culture of the site is particularly restricted in terms of cultural chronology and homogeneity (Bretschneider *et al*. 2015), we may assume that the analyzed object belongs to the same material culture and is not intrusive. A possible connection with metal items (chisels?) found in the adjacent room is addressed below. Once uncovered, the object was professionally cleaned from soil impurities, sent for storage at the deposits of the Larnaca regional archaeological museum of the Cyprus Department of Antiquities and given the registration number 00095-M-001.

The investigated object is small; according to measurements of the bounding box of its 3D model (Figure 2c), its maximum sizes are 56x26x39 mm. Once the 3D model of the object was obtained, black-and-white ortho projections of each side of the object were prepared, in order to easily assess its size and particularities (Figure 3). Its raw material is a homogeneous greenish stone without impurities (Figure 2 a, b).

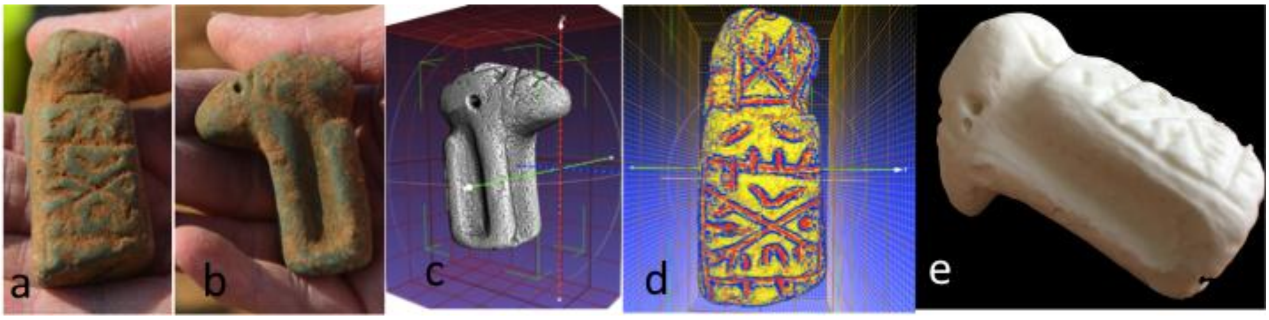

Figure 2. The object at its discovery (a,b), its 3D model (c), rugosity analysis (d) 3D printed replica.

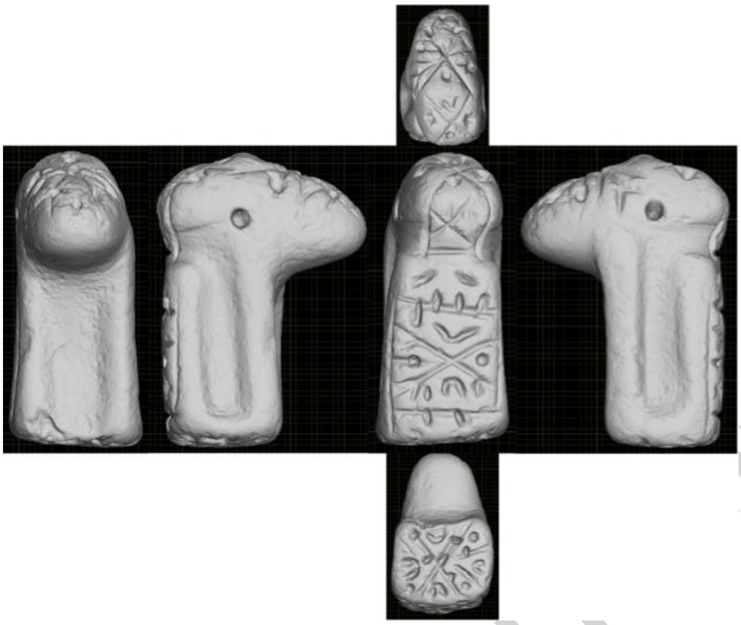

Figure 3. Ortho-2D projections of each of the object's faces.

A visual examination, corroborated with a 3D curvature analysis (Figure 1d and below) confirms that the object is in a relatively mint condition, with no marks of chipping, erosion, breakage, or any other sign of natural or anthropogenic inflicted damage, except a small chipping with eroded edges visible on its front side (Figure 3). The only possible signs of harm (?) are a series of non-parallel short "cuts" (ca. 5 mm long and ca. 1 mm deep) appearing on the L's short segment top, along its both edges, from the corresponding sides. Their purpose is unknown; they are not aligned with or integrated within the incisions pattern, therefore a different purpose should be proposed.

The object has a generically inverse L shape, with a slightly oblique base (Figure 3) and thus cannot support itself vertically. Since the object does not have a flat and horizontal base and its right corner is slightly rounded and offset (Figure 3) we may assume that the object was not meant to stand vertically unsupported. Due to its irregular shape and numerous details, it is difficult to provide a textual description of the object. It displays an intrinsic incisions pattern along its exterior skin on top, bottom and back, consisting of lines, rounded concavities and crescent marks (Figure 3). The sides and the front part of the object were "sculpted" into a kind of canals, for a still unclear purpose (Figure 2c). The possibility that these served for an unknown type of hafting cannot be excluded. A transversal hole, 4 mm. in diameter, was drilled from both sides of the short segment of the L-shape.

5. Description of the object's chaine opératoire

Initiation

There are no signs of stone cutting or chipping along the skin of the object. Therefore, the possibility that the artisan who made it chose a stone that was close to the final desired size of the object cannot be rejected. Apparently the object was carefully smoothed after carving the stone into its required shape and prior to be incised. An overall roughness analysis on the surface of its 3D model (Figure 2d) revealed no differences along its neighboring areas, confirming this action. Moreover, in some parts it is still possible to discern longitudinal lines testifying for smoothing its surface, particularly along the side canals.

Manufacture - Transversal hole

A transversal hole, 4mm. in diameter, was drilled at the proximal edge of the first third section of the short L segment of the object. Apparently it was pierced from both sides, due to the short length of the drill (Figure 4). The drilling technique consisted probably on chipping a small depression first, in order to position and stabilize the drill on the desired location on the object's surface and then a rotational drilling occurred using vertical movements of a bow, with a drill fixed at its tip (see also Gwinnett and Gorelick 1993, Vargiolu *et al*. 2007). Microscopic images along the borders of the holes did not reveal any signs or residues of the drill used. Figure 4b shows the almost parallel longitudinal relative position of each hole, when aligned to the horizontal axis of the object. The central axis running through the center of the holes has a slight offset of ca. 2° magnitude from the horizontal normal of the figurine. Moreover, the diameter of each entrance hole is almost identical; most probably the holes were drilled with drills of a same diameter while the object was fixed on a vise bench.

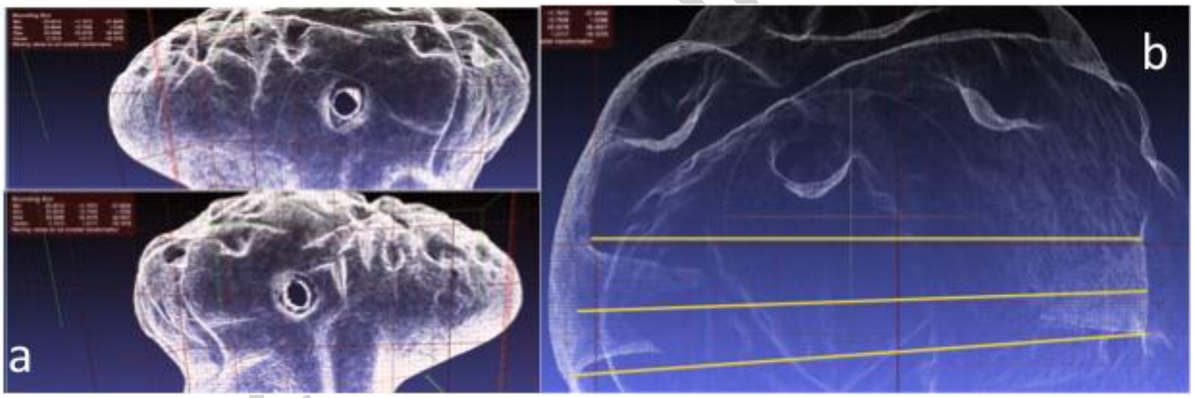

Figure 4. xray rendering of the 3D model: (a) contours of the hole and (b) alignment along its horizontal axis.

Manufacture - Line incisions

After the object was shaped into its desired form, several lines were carved into it, which can be roughly divided into: (a) pattern lines, i.e. those carved on the base, the back and the top of the object (Figure 3), (b) long lines that form a kind of frame for these patterns, appearing along the edges of the back and continue to the top of the object and (c) short lines that appear only on the top of the object and cannot be associated with any design pattern (Figure 3). Type (a) and (b) lines, ca. 2 mm wide and ca. 2 mm. deep were apparently carved by hammering a (point?) chisel and smoothing the obtained depression with an additional tool (a tooth chisel?), while type (c) lines, which appear solely on the top of the object, may be the results of sharpening the edge of another tool. Investigating the 3D model itself and changing light directions it was possible to identify the entry point of the chisel and thus determine the hit direction and thus reconstruct the artisan's mode of operation. Relatively to the longitudinal axis of the object, it is apparent (Figure 5a) that lines were carved from mainly two directions (bottom of the object, with slight variations left and right) and another one from its left side. The possibility that the object was fixed on a particular device (a sort of vise bench) in order to obtain a higher stability during carving cannot be excluded. Figure 4c shows an xray shader rendering of the 3D model, looking from the top towards the bottom, presenting the concavities of the incision marks on the back of the object, "from its inside". One may note the regularity and shape continuity of the incision lines, indicating a clear investment to produce well-defined and well-shaped lines.

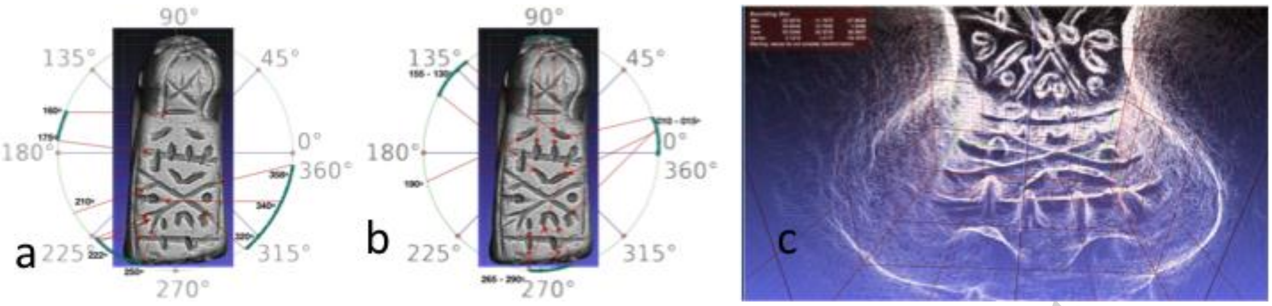

Figure 5. Blow directions for carving (a) the lines and (b) the incisions; xray shader rendering of carvings.

Manufacture - Crescent marks

Crescent marks appear on all the decorated faces of the object (bottom, top and back, cf. Figure 3). Their clear overlap over incised lines, as noted on the bottom at on the back of the object, indicates these were done at a later stage than lines. A close look at their carving method reveals they were carved using a different method than lines, being probably carved with a round or tooth chisel while hand holding the object in the hand and turning it around for each set of marks (Figure 5b). When observing the xray shader render of the 3D model (Figure 5c), one can clearly note that crescent shapes, in contrast to the incised lines, have irregular shapes, their internal depth and form varying from case to case. They also penetrate deeper into the stone, at ca. 4mm and thus exceeding the lines.

Manufacture - Rounded concavities

Ten concavities were noted on the bottom of the object (N=4), on the back (N=2) and on its top (N=4). All were apparently shaped using a same drill, to a similar depth of ca. 3 to 4 mm, and with diameters ranging between 2 – 2.8mm, averaging at 2.6mm (Table 1). At least in two cases concavities cut the incised lines, suggesting a later stage for their carving, possibly together with the crescent shaped marks. A geometrical observation of concavities shows that they have an irregular shape, only a few being almost perfectly rounded. This is notable also when looking at their profiles, using the xray shader rendering on the 3D model of the object (Figure 6).

Table 1. Diameters of concavities.

D1	D2	mean	groups
2.6	2.3	2.45	2.4 (5)
2.3	2.7	2.5	2.8 (5)
3.5	2.7	3.1	
2.8	2.6	2.7	
2.7	2.7	2.7	
2.4	2.4	2.4	
2.8	3.3	3	
2.7	2.8	2.7	
2	2.3	2.2	
2.5	2.4	2.45	

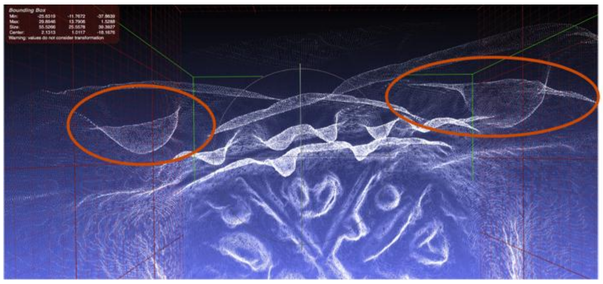

Figure 6. Profile of rounded concavities.

Possible use - Symmetry

The object is decorated with three types of carvings: lines, crescent shapes and rounded concavities. It is clear that crescent shapes and concavities overlap lines in some cases, but it is unclear if all are part of a single composition or multiple ones. When drawing an imaginary line along the vertical axis of the unfolded decorated parts of the object (Figure 3) it is clear that lines, in particular those diagonally crossing each other, are almost perfectly aligned along the central longitudinal axis of the object. The same is true regarding cavities, being symmetrically located along the same axis, but not for crescent shapes, which seem to be positioned according to other criteria. As shown above, crescent shapes were probably made with different tools and using other techniques than the lines. Moreover, they cut lines in several occasions. While lines are carefully carved and apparently smoothed, and rounded concavities maintain in most cases a symmetric and smoothed shape, crescent shapes vary in sizes, orientation and overall give the impression of a "sloppier" manufacture, i.e. less investment in their aesthetic appearance. It is therefore assumed that decorations were applied in at least two separated events, one yielding lines and rounded concavities and the other one the crescent shapes.

Possible use - the object as a seal

Intuitively, given the object's shape and its decorations along the bottom, back and top, one may assume it was used as a seal, by rotating it along its vertical axis (Figure 7a). The impression (stamp) of the object was extracted from its 3D model, by "peeling-off" its skin to the maximum depth of incisions and inverting their normals (Figure 7b). Since some of the lines carved on the back continue along the top of the object (from the long to the short segment of the inverse L), may indicate that the seal impression indeed was applied as shown in Figure 7 and not using separately segments of it. However, since no impressions on pottery objects resembling the discussed object were reported so far, either the object was applied on another type of material or it was not used at all as a seal. Microscopic images taken of its surface do not reveal any traces of intrusions or remains possibly hinting for its use as a seal. Other possible meanings of the carved signs can be hypothesized, such as the object being an amulet, and the carvings representing magical signs of a certain kind.

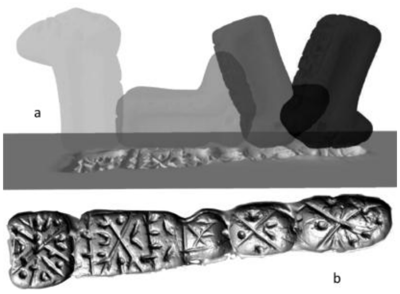

Figure 7. 3D impression of the skin's object.

Possible use – handling the object

Apparent marks left by hanging (hafting?) the object were identified extending out of the transversal holes (Figure 3). Intriguing is the fact that their orientation (measured from the center of the hole) is at ca. 190° from the center of one of the holes and at ca. 358° from the other, but joining its bottom and not the center (Figure 3), as in the case of the other. This contradicts the gravity center of the object, located along the long segment of the L shape. If the object would have hung loose (as a pendant), expected marks would have been seen around the 90° arc. Therefore, the possibility that the object was somehow tightly attached to a support of an unknown type is proposed. This supposition is further supported by the appearance of a smoothed area immediately below the transversal holes, forming a kind of a surrounding facie of ca. 6 mm in height, clearly visible when positioning the object at an inclination of 135° and illuminating it vertically from the bottom (Figure 8). Its smoothness becomes even more apparent when comparing it with other areas along the surface of the object, such as the internal channel-like shape along its side.

Figure 8. Possible hafting marks on the object.

6. Summary and conclusions

A small stone object, carved along its exterior skin from bottom to top was found in a disturbed archaeological context at the Pyla-Kokkinokremos site, Cyprus. Given its early identification as a unique artifact, an effort was made to analyze it through scientific visualization and 3D shape analysis on its 3D digital and physical replicas for further experimentation. Following the successful implementation of the planned methodology, we propose a pipeline for future analyses of similar artifacts. It consists of:

1. 3D capture of the object's geometry at sub-millimeter resolution. The higher the level of detail obtained, the higher the amount of data available for analysis and interpretation. Avoid Poisson or similar mesh reconstructions as much as possible, in order to prevent surface simplification. Check quality of the 3D model for self-intersections, non-manifold edges, holes, shells or similar errors that might negatively affect the geometry analysis and scientific visualization interrogations.

2. Capture color information separately according to standards of professional photography (using a color chart for calibration, use of diffused light in order to avoid shadowing, etc.). Make sure that image resolution fits with the 3D model' s accuracy, in order to have a correct visualization of both color and geometric information at same level of detail.

3. Shadow mapping and screen space ambient occlusion can augment the visual analysis of an object, particularly if its skin exhibits intrinsic patterns and irregular geometries.

4. Apply shaders, such as radiance scaling, xray, etc. and change light directions in order to enhance the visual interpretation of the object.

5. Color curvature methods are instrumental in characterizing the skin of an object, particularly when looking to delineate smooth areas and isolate irregularities.
6. An accurate 3D representation of the impression of incisions may be obtained by digitally "peeling-off" its skin at maximum depth of these incisions and inverting their normals.
7. Additive manufacturing of the object and its impression contributes to the interpretation of the object, in terms of assertion of its manufacture, handling and possible use.

In terms of archaeological interpretation of the object, the following suggestions are made, based on the analysis of its 3D digital and physical replicas:

1. The object was first carved into the desired shape and then smoothed along its faces.
2. Incised lines were carved first, apparently using a round chisel and a hammer, while the object was fixed on a vise bench, with blows mainly from three adjacent directions. Once the lines were chiseled, they were smoothed and carefully shaped, to a depth of ca. 2 mm. they form a recurrent pattern on the bottom, the back and the top of the object.
3. Crescent shaped incisions were subsequently carved, using different tools and techniques. The object was probably held in the hand while incisions were made turning the object in a multitude of directions. The concavities are at a depth of ca. 4mm. and have an irregular internal shape, the artisan paying less attention to their internal smoothness. In a few occasions, these carvings overlap the incised lines, therefore it is suggested they had different purpose than lines. The fact that crescent concavities were carved deeper than lines may support the above supposition.
4. Rounded drilled concavities are a third type of incisions on the skin of the object. In at least two cases they overlap the incised lines, but not the crescent shape concavities; therefore they might belong to the same episode of carving as the later. Some have very regular shapes, with a careful investment in their shaping, others seem to be unfinished.
5. A transversal hole, 4mm. in diameter, was drilled from both sides of the object. Its axis crosses the object almost in parallel, indicating high skills of artisans, well planning the drilling from both sides of the object. A few line marks apparently exiting from the hole and surrounding the object suggest a kind of rope with which the object was attached to an unknown support. The area immediately below the hole displays similar marks, of a kind of circular facie apparently indicating a wrapping abrasion.
6. The skin bearing the incision marks was digitally peeled off at the deepest level of concavities, and their values inversed, in order to obtain an accurate 3D model of its incisions, assuming the object was used as a seal. The continuity of incisions from the back of the object to its top indicates that it might have been applied with a rotational movement, along its longitudinal axis. The difference in depths between lines and concavities may suggest different pressures to be applied when using the object as a seal.
7. The production location of the object is unknown; the presence of a group of metal chisels within the same archaeological context with the object may indicate that at least part of its carving was performed locally (the crescent shaped concavities?).
8. A microscopic survey within the incisions did not reveal color traces or material residues on which the seal might have been impressed. Since so far the object is unique in the archaeological geo-cultural and chronological repertoire of the region, corroborated with the lack of material with impressions that might resemble the incisions of the object, maintain the assertion that the object was a seal at a speculative level.

9. A detailed comparison of the object with possibly similar artifacts from the region is beyond the scope of this publication. The same regards the possible interpretation of the marks as possible writings, which will be addressed in a different publication. A survey of related literature (Keel 1994, Ben-Shlomo 2006, Oren 2000, Kopanias 2008, Ben-Shlomo 2010, Webb and Frankel 2012) did not reveal any similarities that might hint for analogies with a particular assemblage or object.

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