Between object and subject: multiple approaches to a prehistoric human-shaped pot from Romania

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ABSTRACT – *The current paper aims to reveal the potential of combining multiple approaches (techno-functional analysis, experimental archaeology, and X-ray Computed Tomography) when it comes to studying unique earthenware artefacts, such as the prehistoric human-shaped pot discovered within the tell settlement from Sultana-Malu Roşu (Romania), that belongs to the Kodjadermen-Gumelniţa-Karanovo VI civilization (KGK VI) which thrived during the 5th millennium BC. This human-shaped pot, also known as 'The Goddess of Sultana', is an emblematic artefact that fascinates with its shape, gestures, and decoration. It was apparently made from a standard clay paste recipe and using basic forming techniques, with little care for the internal surface. This vessel also has several hidden cracks and some manipulation traces on its backside. In order to explore its relevance, our approach to this particular human-shaped pot included the use of archaeological data in correlation with other techniques in order to decipher the manufacturing process for such vessels, the possible way of using them, but also the meanings that they might have had for past human communities.*

KEY WORDS – *Balkans; Eneolithic; anthropomorphic pot; CT scans; technological analysis; experimental archaeology*

Med objektom in subjektom: različni pristopi k preučevanju prazgodovinske antropomorfne posode iz Romunije

IZVLEČEK – *V članku predstavljamo potencial združevanja različnih pristopov (tehnično-funkcionalna analiza, eksperimentalna arheologija in računalniška tomografija) pri študijah unikatnih glinenih predmetov, kot so prazgodovinske antropomorfne posode, kakršne so bile odkrite na tell-naselbini Sultana-Malu Roşu (Romunija) iz stopnje Kodjadermen-Gumelnita-Karanovo VI v 5. tisočletju pr. n. št. Antropomorfna posoda, znana tudi kot boginja Sultane, je značilna najdba, ki izstopa po obliki, potezah in okrasu. Oblikovana je bila iz običajne lončarske mase z uporabo osnovnih tehnik oblikovanja in dodelavo zunanje površine. Na notranji strani so vidne številne razpoke in sledovi izdelave. V raziskavo smo vključili arheološke podatke in jih povezali s tehnično-funkcionalnimi analizami, eksperimentalno arheologijo in računalniško tomografijo z namenom prikaza procesa izdelave tovrstnih posod, možnega načina uporabe ter njihovega pomena za pretekle skupnosti.*

KLJUČNE BESEDE – *Balkan; eneolitik; antropomorfna posoda; rentgenska računalniška tomografija; tehnološka analiza; eksperimentalna arheologija*

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Introduction

The emergence of fired clay human-shaped pots is undoubtedly a technological breakthrough and a clear evolution of the artistic conception of human communities and that of the social development of humankind. This type of object is generally considered part of the spectrum of figural art in prehistoric communities (*Schwarzberg, Becker 2017*). It represents a particular category of vessels, undoubtedly different from 'everyday pottery' (*Opriş* et al. *2017*).

Currently, it is evident that the meaning of these anthropomorphic vessels, alongside all human figurines documented in the Neolithic and Eneolithic (Chalcolithic or Copper Age) in different parts of the world is related to corporeal identities, and the way that people from the past understood existence and perceived the human body (*Bailey 2013; 2015*). The old assumptions regarding their religious or mythological meanings (*e.g.*, cult items, representations of divinities, Mother-Goddesses, *etc.*) are no longer in use, as proved by critical approaches postulated over time (*e.g., Meskell 1995; Biehl 2006; Bailey 2013; 2015; 2017*).

The current paper will explore the technological background of an emblematic human-shaped pot for the prehistory of the Balkans, known as 'The Goddess of Sultana', in order to trace its meanings and how it actually was used by people in the past.

Our approach on this particular human-shaped pot from Sultana-Malu Roşu will include using archaeological data in correlation with techno-functional analysis and use-wear analysis, along with experimental archaeology and X-ray Computed Tomography (XCT). The main goal is to decipher the manufacturing process of such vessels, the possible way of using them, and their implied meanings. The use of multiple approaches is very effective, as demonstrated by our previously published studies (*Ignat* et al. *2017; 2018; 2019; Manea* et al. *2019*).

Archaeological background

The tell settlement from Sultana-Malu Roşu is located in southeastern Romania (N 44°15'41.5853", E 26°52'15.3378"), near the Danube River and the border with Bulgaria (Fig. 1.a). Archaeologists have known the site since 1923, when the first excavations began. The tell settlement is located on the high terrace of the Mostistea River, and it was used

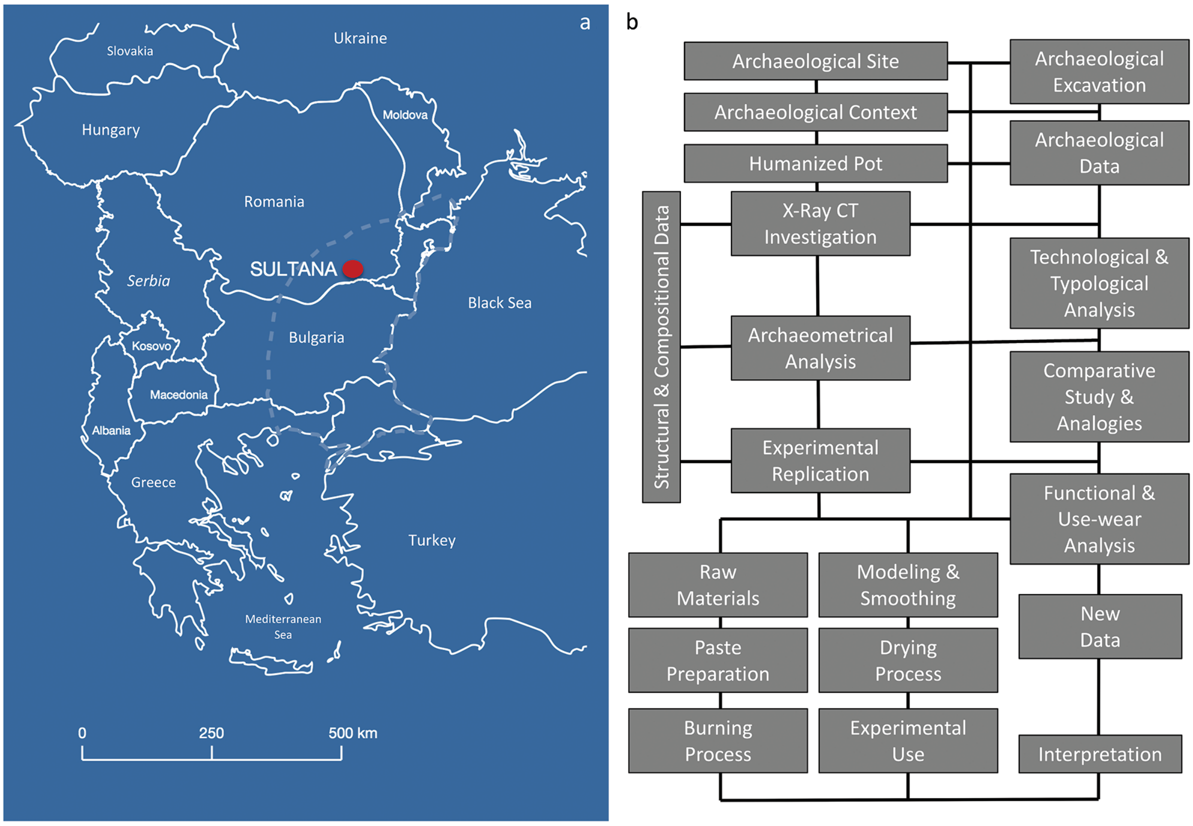

Fig. 1.* a *location of the tell settlement from Sultana-Malu Roşu in the area of the Kodjadermen-Gumelniţa-Karanovo VI civilization;* b *the research algorithm used in our paper.

for more than 500 years by the Kodjadermen-Gumelniţa-Karanovo VI (KGK VI) communities in the second half of the 5th millennium BC (*Lazar* et al. *2016*).

In 1965 a human-shaped vessel known as 'The Goddess of Sultana' (Fig. 2.a) was discovered by chance in the area of the tell settlement (*Marinescu-Bîlcu, Ionescu 1967*). The name given to this artefact reflects the Gimbutasian interpretation of the archaeologist who discovered this vessel and attributed a meaning that is currently considered out of date, as suggested by various criticisms formulated by different scholars (*Bailey 2013; 2015; 2017*).

Unfortunately, there are not many details about the archaeological context of this discovery. Most probably, as we previously noted (*Opriş* et al. *2017*), the secondary burning traces observed on the exterior of this vessel represent strong indicators that it was found in a burned house. Unfortunately, any other data regarding the association of this human-shaped vessel with other features or artefacts are missing. However, from a typological point of view, it fits well in the humanized pottery series characteristic of KGK VI communities (*Voinea 2005*). The absence of any data regarding the stratigraphic context made impossible its assignment to a specific phase (*e.g.*, A1, A2, or B1) of that civilization, but based on available radiocarbon data, we could set the possible timeframe between 4546–3973 cal BC (2σ calibrated) (*Lazar* et al. *2016; 2018*).

This particular human-shaped vessel is internationally renowned and has been included in numerous catalogues of collections and exhibitions (*Marinescu-Bîlcu, Ionescu 1967; Wielen-van Ommeren* et al. *2008; Anthony, Chi 2010; Lazar 2015*) but also in synthetic works dedicated to Neolithic and Chalcolithic anthropomorphic representations (*Andreescu 2002; Ignat, Opriş 2015; Opriş* et al. *2017*).

Currently, the pot is part of the National History Museum of Romania collection in Bucharest, Romania (inv. nr. 102236).

Materials and methods

The multiple approaches used on the human-shaped pot from Sultana-Malu Roşu were based on the research algorithm illustrated in Figure 1.b.

Generally, this kind of interdisciplinary investigation has the potential to reveal different relevant information regarding the technological background of the artefacts that, in correlation with other data types (*e.g.*, archaeological context, functional and use-wear traces, *etc.*), could offer an integrative interpretation about past human's material culture and its multiple meanings.

The archaeological investigation of the anthropomorphic pot was made by following the recommendations regarding ceramic analysis available in various studies published over time (*Rye 1981; Rice 1987; Skibo* et al. *1989; Skibo 2013; Orton, Hughes 2013; Hunt 2016*), and considered a technological-typological study, but also the examination of use-wear traces (*Skibo 2013*). This approach involved measuring the vessel's dimensions (length, height, diameter, *etc.*), weight, and volume (Tab. 1). A binocular magnifier was used for use-wear investigation, along with photos taken with a camera and a macro lens.

Prehistoric archaeological discoveries represent a significant challenge compared to other chronological periods (*e.g.*, antiquity, medieval age, *etc.*) due to the lack of complementary sources of information (*e.g.*, written sources, oral information, inscriptions,

Fig 2. The human-shaped vessel known as 'The Goddess of Sultana':* a *the original (left – frontal view; right – lateral view);* b *the experimental replica (left – frontal view; right – lateral view).

etc.). Under these circumstances, the data provided by archaeological investigations remain the only ones that can help us understand these prehistoric communities and their material creations. Unfortunately, these are also limited, far from encompassing all the information needed to fully understand the behaviour of past individuals and their decision-making regarding different aspects of daily life (*e.g.*, food procurement, production of material goods, raw material exploitation, basic choices, *etc.*). Experimental archaeology aims to verify the techniques, procedures, and processes involved in obtaining certain objects or structures and then assess the theories and hypotheses based on archaeological data, thus facilitating the possibility of providing new contributions to knowledge and understanding of the past (*Lazar 2015*).

For the experimental replication of the anthropomorphic pot from Sultana-Malu Roşu, we applied the methods and protocols developed by our team and previously published (*Ignat* et al. *2017; 2018; 2019*). Generally, this kind of approach could offer us essential data about the invisible elements of the past, regarding the technological process (*e.g.*, *chaîne opératoire* employed in making these prehistoric clay items), which are not identified in the archaeological excavation (*Lazar 2015*). Therefore, the primary aim was to verify the manufacturing process, with all technological segments (*e.g.*, gathering raw materials, paste preparation, the drying and firing methods) involved.

When it comes to XCT investigations, during the last few decades this kind of imaging method has been increasingly applied in archaeological research (*Kahl, Ramminger 2012; Thér 2016; Kozatsas* et al. *2018; Ross* et al. *2018; Park* et al. *2019*). This type of analysis can provide details about the internal structure of the artefacts that cannot be otherwise disclosed but through destructive investigations. Naturally, the more that is known about the inner structure of an object then the more speculations about the way it was manufactured or about the roles it might have played can be made. In particular, the application of XCT for the study of prehistoric clay artefacts proved to be an excellent non-invasive approach, being especially relevant to investigate the internal structure and/or hidden details of unbroken/intact archaeological objects.

The XCT scans reported in this paper were performed with a Nikon XT H 225 device that contains a micro-focus X-ray source (225kV maximum voltage, 1mA maximum current, focal spot size: 3µm below 7W and up to 225µm at 225W) that provides a conical X-ray beam, a Varian 2520 flat panel detector (127µm pixel size; 1900x1516 active pixels), and an accurate 5 axes positioning system, that allows the movements of the sample in the X, Y, and Z direction, as well as its rotation with 360° and tilting by ±30°. The average voxel size is roughly 1.5x 10^5µm^3. This equipment allows the inspection of relatively large volume objects with high image resolution and an ultrafast CT reconstruction. The X-ray tube working parameters were optimized for the tomography of clay artefacts, namely a tube voltage of 100kV and a current intensity of 45µA. The entire volume of the objects was scanned in 360 steps, representing the full rotation of the object around its central axis. The acquisition time for the full tomographic scan was roughly 6 minutes, while the image reconstruction performed with VG Studio Max 3.0 software took several hours. The XCT image analysis was carried out to inspect the reconstructed images visually. This approach was followed because VGStudio Max 3.0 software is a general-purpose tool for 3D reconstruction. The analysed voids result from a visual inspection of the slices, and therefore not all the identified voids are perpendicularly oriented concerning the orthoview planes.

The interpretation of the XCT images was made according to the methodology developed in the latest studies that involved the analysis of archaeological clay artefacts by XCT-images (*Kahl, Ramminger 2012; Green* et al. *2017; Ignat* et al. *2017; 2018; Kozatsas* et al. *2018; Manea* et al. *2019; Park* et al. *2019*).

Results

Archaeological data

From the preservation point of view, the human-shaped vessel from Sultana was discovered in a complete state, without visible cracks, with only an ear missing (the right one, now restored with plaster) and some secondary burning traces on the exterior surface (*Opriş* et al. *2017*).

This particular human-shaped pot represents a person in a standing position. The bottom is disproportionate compared to the top. The thighs, buttocks, pelvis, and hips regions are highlighted, showing clear elements of steatopygia. The upper limbs are stylized, placed very high, and stuck to the body. The elbows are bent, the right arm resting on the left, which in turn has placed its fingers under the chin. The facial area is well represented. An arched projection renders the eyes. The nose is outlined, and the mouth is shown by a triangular notch, underlined with holes. Two large ears are added on the sides, pierced with four holes. On top of the figurine, the round neck of the vessel is attached, with a threshold for supporting a lid (missing). The vessel was fully painted with white decoration (*e.g.*, spirals, circles, stripes, palmettes, and a triangle for the genital area). The attitude of this character, represented as a standing human with one hand brought to the mouth, seems a meditative one, which reminds us of the 'Thinker of Cernavoda' (*Marinescu-Bîlcu, Ionescu 1967*). However, according to a new interpretation, it can represent a human in a 'dead position' based on gestures and wear-trace analysis (*Opriş* et al. *2017*).

If we consider the anatomical elements presented, the humanized pot can be considered realistic only to a small extent because it does not reflect a complete representation of the human body. Certainly, the general shape of the pot suggests a human in a standing position with most anatomical features presented (*e.g.*, head, body, hands, legs). Some of them are designed very schematically (*e.g.*, hands) to a scale that does not correspond to a natural body and is disproportionate to the other anatomical elements. The other ones (*e.g.*, head, legs) are represented on a proportional scale and are much more realistic. Regarding the facial attributes of the vessel from Sultana-Malu Roşu, it displays sufficient elements, highlighting the most relevant facial physiognomy (eyes, nose, mouth, eyebrows, ears), placed anatomically correctly. The eyes and mouth are depicted as incised lines, and the hands, nose and ears are embossed. There are four holes in the left ear and another ten under the mouth, possibly signs of some form of body piercing (*Opriş* et al. *2017*).

Although it was previously discussed that the represented person would be a woman (*Marinescu-Bîlcu, Ionescu 1967*), we have already shown that the piece does not present sufficient anatomical elements to assign it to this gender because some relevant body parts for this category (*e.g.*, breasts, vulva) are missing (*Opriş* et al. *2017*).

Nevertheless, the analysed vessel presents a series of features that make it a true masterpiece of prehistoric art.

Techno-typological analysis

Strong evidence about the technique used to make this vessel is missing since the inner surface was smoothed and the external surface was polished. The macroscopic analysis of the surfaces allowed us to observe that the paste was tempered with grog and contained natural non-plastics like rare, rounded and sub-rounded, calcareous inclusions (up to 5mm) and fine white mica (*Opriş* et al. *2017*). This paste recipe is widespread for the Eneolithic pottery discovered within the Sultana-Malu Roşu tell settlement (*Ignat* et al. *2013*). Moreover, since the vessel

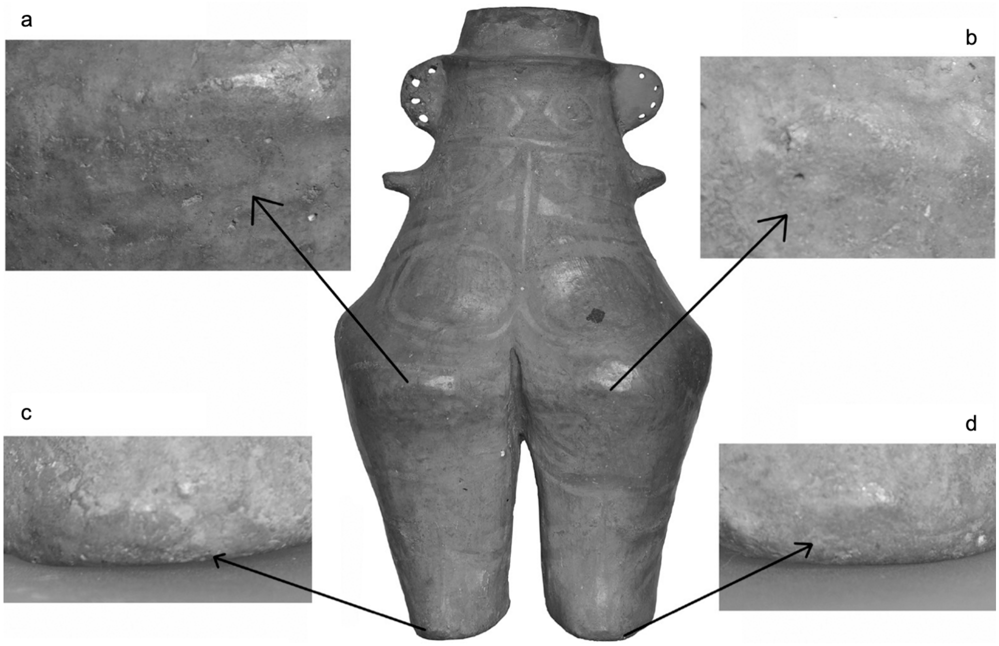

Fig. 3. The use-wear analysis: the abrasion traces on buttocks (**a-b*****) and heels (*****c-d*****) areas of the human-shaped pot. Without scale (after* **Opriş** *et al.* **2017*****).***

is intact, unbroken, and represents an artefact catalogued in the collection of national heritage, it is impossible to take samples for a different kind of archaeometrical analysis. The non-destructive XCT scans performed on this item thus offered supplementary data (see the dedicated section below).

All external surfaces were painted with specific motifs in white dye before the initial firing, but the secondary firing partially damaged it. There is a hypothesis that the painted motifs represent some form of tattoo art (*Marinescu-Bîlcu, Ionescu 1967*).

From a typological perspective, the investigated pot falls into human-shaped vessels that represent a standing person. The item is similar to other humanized pots discovered within the tell settlement from Sultana-Malu Roşu (*Opriş* et al. *2017*) or other contemporary sites belonging to KGK VI communities (*Andreescu 2002; Voinea 2005*).

Functional and use-wear analysis

One of the main functional features is represented by the storage capacity of the recipient, in our case 2 litres, an element that places it in the type of medium storage vessel. According to the morphometric analysis and experimental replication, it can be used very well as a container, especially for liquids or 'flowing solids' (like cereal grains) (*Opriş* et al. *2017*).

The use-wear analysis (*Schiffer, Skibo 1989; Skibo 2013*) made on this humanised pot indicates that it was used repeatedly, this being proved by the presence of some abrasion traces on different sides of the pot. Interestingly, even though we are dealing with a vessel that, according to its shape, should be used in a vertical position, most abrasion traces are not on the base (soles) but mainly on the back of the heels and buttocks (Fig. 3). This fact demonstrates that this vessel was used most of the time on its back position. Moreover, the lack of some specific marks on the soles could be evidence that while complete, the vessel was not moved (*Opriş* et al. *2017*).

The experimental replication

In order to identify the invisible elements of the past technological process and follow the features of the humanized vessel from Sultana-Malu Roşu, we tried to make an experimental replica (Fig. 2.b) using a local source of clay and prehistoric technologies. The experimental replica was made prior to the XCT analysis of the original pot, using only available macroscopic data and the potter's experience and intuition.

The previous archaeometrical analyses performed on both Eneolithic pottery from the tell settlement and local clay sources around the site (*Ignat* et al. *2019*) indicated a local source for the clay used for making pottery. The source that had the most common features with the pottery from the site is located on the shore of the Mostiştea Lake, about 300 meters north-west of the tell settlement. This source was denoted as Source nr. 8. From there, we collected two types of clay: one brown with sparse (<5%) carbonate concretions and one greyish-white in colour also with sparse (<5%) carbonate concretions in composition (*Ignat* et al. *2019*).

The paste recipe used for modelling the experimental human-shaped pot was a mix made out of greyish-white clay (75%) and grog (25%, with granules <5mm).

The vessel's shape was modelled by hand by an archaeologist with limited experience in pottery making. The forming sequence was performed outdoors, in a shaded place during a day with moderate wind. According to the primary forming typology developed by Owen Rye (*1981*), coiling combined with pinching were the methods used. Thus, the bases of the feet were the first to be modelled, the process performed by hand and with the help of a bone spatula used for scraping. Afterwards, the whole body was built by using small coils of clay. After every two or three coils were added, the outer part of the vessel in that area was scraped with a bone spatula and then smoothed with a dried reed stem and water. The thickness of the walls was maintained at about 0.5cm. The anthropomorphic features such as arms, mouth, nose, eyes, eyebrows and ears were added and modelled right after the vessel was shaped. The whole vessel was built in a single sequence giving that the lower constructed parts had been gradually drying during the forming process that took six hours. The final height of the vessel was 37cm. After one day of drying, a crack appeared in the area where the legs join, visible from both the outside and inside of the pot.

The finishing method used was polishing the external surface with a fine river pebble after the vessel was dried indoors for two days. This process lasted one hour and a half (90min).

A wood stick with human hair bound at an end was used as a brush to decorate the vessel. The paint was made of crushed carbonate concretions (*c.* 75%), collected from the shore of Mostiştea Lake, mixed

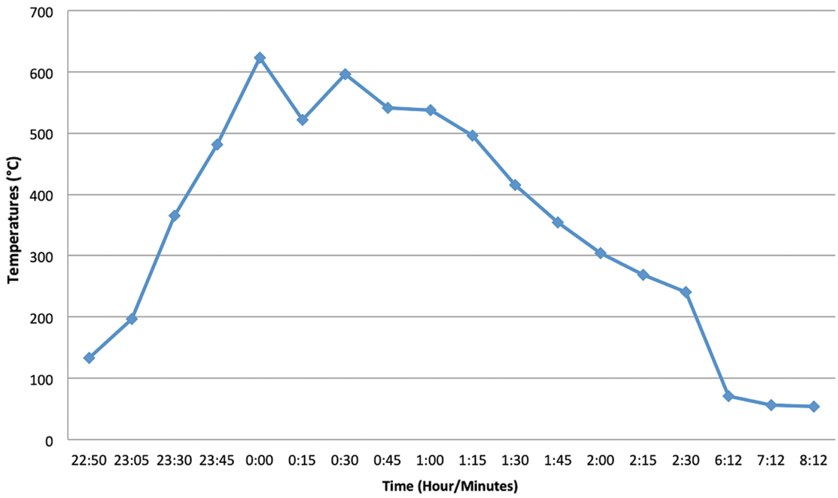

Fig. 4. The firing temperatures recorded on the experimental human-shaped vessel during the combustion process.

with egg white (*c.* 25%). Painting the decoration took almost three hours (170 minutes). However, the process was not very complicated, involving only some basic artistic skills and an experimental brush to replicate the painted motifs documented on the original item.

After one year, the vessel was fired in a big kiln with two chambers that replicated an Eneolithic pottery kiln discovered in Ukraine (*Tencariu 2015*). The fire was powered with 85kg of dry wood, and the maximum temperature obtained was 786°C in the centre of the kiln after three hours of the firing. The maximum temperature measured on the Goddess replica was 623°C. The firing temperatures recorded on the experimental human-shaped vessel during the combustion process are shown in Figure 4. After three hours of firing, the access door in the back of the kiln was opened, and no more wood was added. The grill under the vessel was crushed by the end of the firing, but the replica of 'The Goddess of Sultana' remained unbroken.

Imaging investigations

The XCT approach involved scanning the original archaeological object, as well as the experimental replica. In the latter case, for correct and complete control of the recorded data, following the objective to trace the technological elements related to the production of the humanized vessels, we made several XCT-scans both on the object after drying and also after its firing. In this way, we tried to record how the object transformed during the two major processes involved in making prehistoric ceramic vessels. Moreover, the imaging investigations performed on the experimental replica offer the great advantage of analysing an object made under controlled conditions, for which all the production sequences and quantities of raw materials used have been recorded, thus allowing a reasonable interpretation of the resulting imaging data and their correlation with the structural and composite data of the analysed item. Moreover, this type of information becomes an accurate reference index that can be used in the case of archaeological artefacts for which this kind of data is missing.

Due to the large dimensions of both the original pot and experimental replica compared to the measurement capacity of the X-ray detector, the imaging investigations were made in three stages for every pot (lower, middle and upper parts, applied on original pot, dried replica and fired replica, respectively).

Generally, considering the potential of the imaging investigations to answer different questions regarding pottery technology (*Berg 2008; Kahl, Ramminger 2012; Ignat* et al. *2017; 2018; Kozatsas* et al. *2018; Manea* et al. *2019*), our approaches aimed to identify the following aspects: (i) characteristics of ceramic paste; (ii) primary forming techniques; (iii) joins of the anatomical elements on the pot; (iv) surface finishing; (v) cracks or repairs.

Goddess of Sultana pot	Weight (g)	Capacity (l)	Max. pot diameter (cm)	Height (cm)
Original	1873	2.0	19.8	32.3
Replica (after modelling)	3335	n/a	23.6	37.0
Replica (after drying)	2790	n/a	22.5	35.2
Replica (after firing)	2540	3.3	22.0	34.5

Tab. 1. The size and weight of the experimental human-shaped vessel at different stages of production compared to the original pot.

Characteristics of the ceramic paste

The most visible non-plastics in the clay recipe of the original pot and experimental replica were the *carbonate concretions* inclusions (Fig. 5). Their density, shape, size and distribution (Tab. 2) indicate their presence in the clay matrix as natural in-

Characteristics of ceramic paste	Original human-shaped vessel	Experimental replica (after drying process)	Experimental replica (after firing process)
Natural inclusions	*Carbonate concretions:* • whitish or light grey in colour • rare density (1–2%) • size 1–5mm • high sphericity • well-rounded, rounded or sub-rounded *Organic matter:* • black in colour (voids) • rare density (<1%) • elongated, ovoid or spherical	*Carbonate concretions:* • whitish or light grey in colour • sparse density (2–5%) • size 1–10mm • high and low sphericity • sub-rounded, sub-angular or angular	*Carbonate concretions:* • whitish or light grey in colour • sparse density (2–5%) • size 1–10mm • high and low sphericity • sub-rounded, sub-angular or angular
Tempers	*Grog:* • hardly noticeable • light grey or ash grey in colour • undeterminable density • dimensions 1–2mm • low sphericity • angular	*Grog:* • hardly noticeable • light grey or ash grey in colour • undeterminable density • dimensions 1–2mm • low sphericity • angular	*Grog:* • hardly noticeable • light grey or ash grey in colour • undeterminable density • dimensions 1–2mm • low sphericity • angular
Clay matrix	• no particularities could be distinguished	• no particularities could be distinguished	• no particularities could be distinguished
Voids	• black in colour • sparse density (3–5%) • size 1–15mm • irregular, elongated, ovoid or spherical shapes • vertical, diagonal or horizontal orientation	• black in colour • rare density (1–2%) • size 1–15mm • irregular, elongated or ovoid shapes • vertical or mostly random orientation	• black in colour • rare density (1–2%) • size 1–15mm • irregular, elongated or ovoid shapes • vertical or mostly random orientation

Tab. 2. Characteristics of ceramic paste resulted from the X-ray CT performed both on the original human-shaped vessel and experimental replica (dry and fired).

clusions specific for the clay sources. There are slight differences in density, roundness, and shape between the original pot and the experimental replica. The high sphericity and the rounded shapes of the carbonate concretions show that the clay source used for the original pot was a redeposited sediment gradually washed and eroded by the alluvial waters. The clay used for the experimental replica was collected from the base of the loess deposit near the site (from a depth of about 4m). The movement of the carbonate concretions from this layer was slower over time, and thus their roundness and shape are of both high and low sphericity, and many of them have sub-angular and angular shapes. Nevertheless, the presence and characteristics of the carbonate concretions in the original pot point out to a local clay source exploited in the vicinity of the Sultana-Malu Roşu tell settlement.

The presence of grog in the original pot was observed when both surfaces were analysed in detail with the naked eye and the digital reconstruction of the scraped interior areas (Fig. 7.A1). As was already stated, the clay recipe used for the experimental replica contained 25% grog. Knowing this information, it was interesting that grog was hardly noticeable as non-plastic inclusions in all the tangential sections of the analysed pots (Fig. 5), even though the digital images were processed in various light intensities in order to highlight the non-plastics from the clay matrix. The difficulty of identifying grog inclusions in pottery through XCT analysis has also been reported by Wolf-Achim Kahl and Britta Ramminger (*2012*). According to them, this is a consequence of the similarity between the attenuation coefficients of the grog and fired clay matrix. In the case of the tangential sections of the unfired replica, the observations were identical (Fig. 5.B1-3) and showed no noticeable differences when unfired and fired clay was analysed using XCT images.

The fine clay matrix had no different particularities in the radiographic images of the analysed vessels.

The voids were observed in radial sections (Fig. 6) and are marked by black patches inside the vessel's walls. Their sources can differ depending on the technological variation in the production chain (*Kahl, Ramminger 2012*). The ones in the original pot have a sparse density and various sizes and shapes (Tab.

2). The ovoid and spherical ones (Fig. 6.A1-2) could have been organic grains (possible seeds) that vanished during the firing process. Some of the elongated voids from the feet walls seem to be formed due to the disappearance of organic matter during combustion (Fig. 6.A3). The sparse frequency shows that the organic inclusions were natural or accidental in the clay and not intentionally added as temper. Other elongated and irregular voids were formed during the modelling of the pot and will be discussed in the section assigned to primary forming techniques. The void network in the experimental replica remained virtually the same after the firing process (Tab. 2; Fig. 6.B1-3,C1-3).

Firstly, this situation is due to the absence of organic inclusions in the clay used for the experimental replica. Secondly, this is a solid clue that no significant changes in the clay fabrics occurred during the firing. Consequently, the primary void network in the experimental replica was formed during the modelling and drying process.

Primary forming techniques (Tab.3)

The identification of primary forming techniques (*Rye 1981; Rice 1987; Thér 2016*) has been mainly based on a visual analysis of the inclusions and void orientations observed in the radial sections (*Kozatsas* et al. *2018*). The tangential and horizontal sections were also analysed, but their examination brought a minor contribution to the final interpretation of the forming techniques. The observations were made on three different parts of the vessels (lower, middle and upper) according to the XCT-images obtained for each part (Fig. 6).

The elongated and irregular voids in the core walls of the lower part of the original pot (the feet) predominantly have a vertical orientation or more rarely a diagonal one (Fig. 6.A3). Their morphology and orientation can be recognized as traces left by coiling combined with sequential pinching, a technique that uses coils to build the walls followed by pinching for modelling the shape and to control the thickness of the walls (*Thér 2016*).

Both horizontal and vertical voids are detectable in the middle part of the original pot (Fig. 6.A2). The horizontal ones attest to the coiling technique, while the vertical ones indicate pinching after adding the coils. A flattened patch was used to reinforce the back of the vessel (Fig. 6.A2, down left). In the case of the experimental replica, the coiling technique is more noticeable in the XCT-images of the middle part, considering the presence of horizontal cracks and voids.

The upper part of the original pot has voids that are relatively vertically oriented (Fig. 6.A3), similar to those identified in the lower part of the vessel. The most probable technique used for the primary forming of this part of the vessel was coiling and pinch-

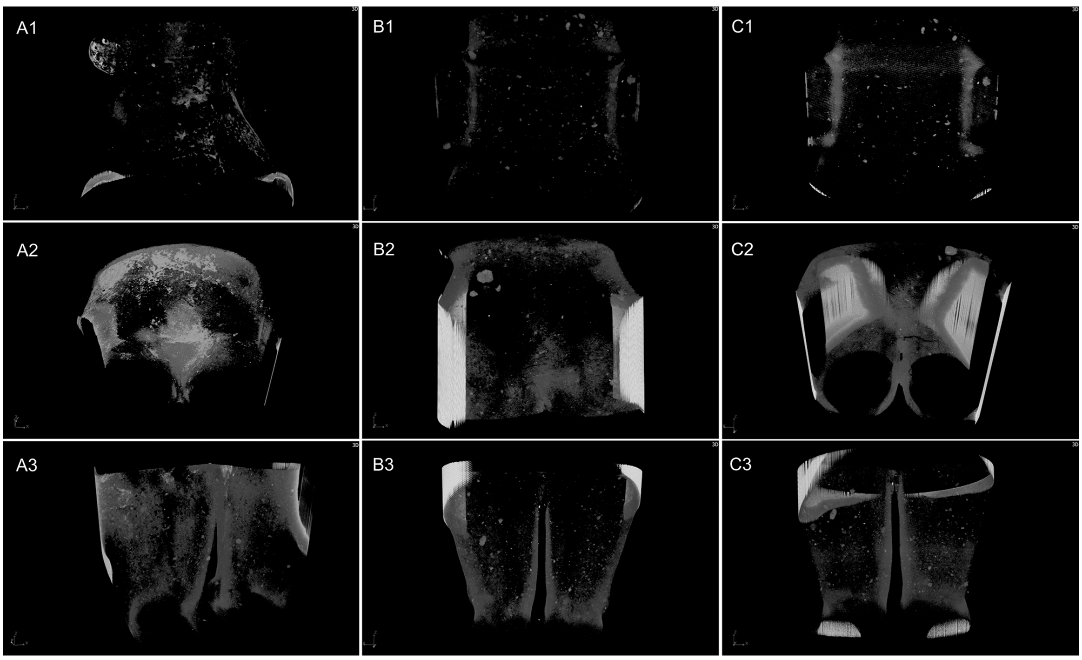

Fig. 5. CT-images of tangential sections of the original pot (*A1-3*), dried experimental replica (*B1-3*) and fired experimental replica (*C1-3*).

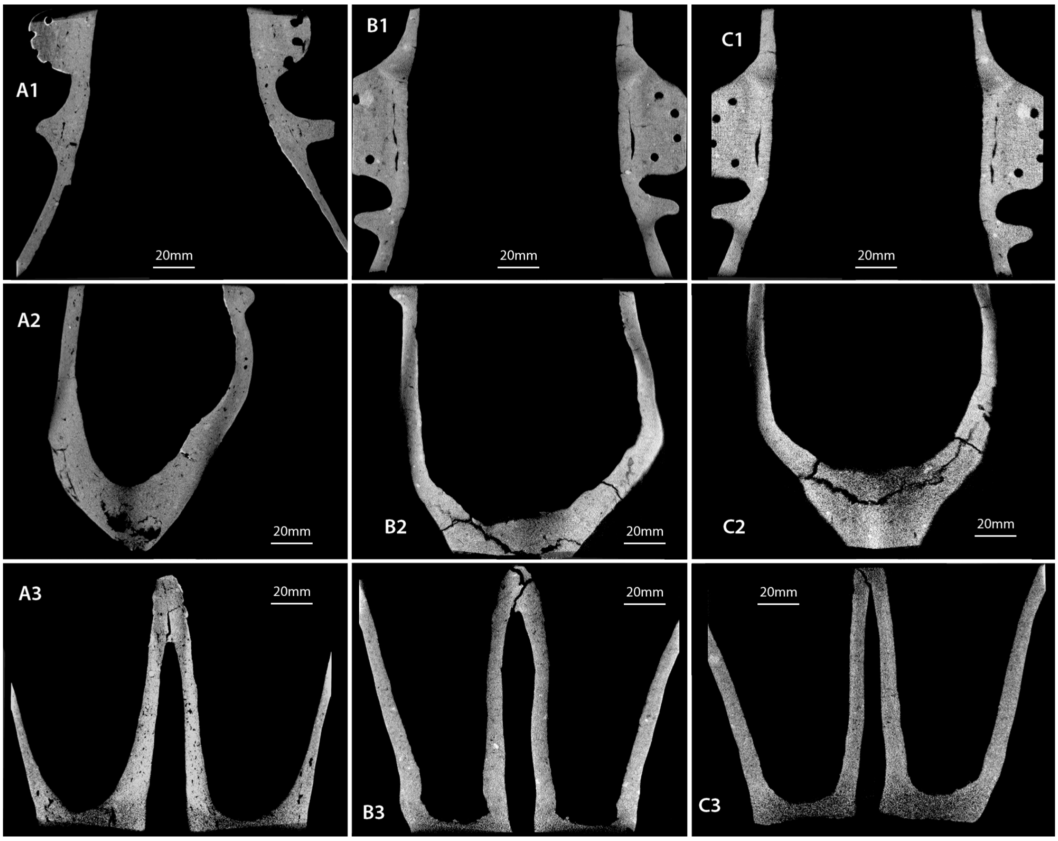

Fig. 6. CT-images of radial sections of the original pot (*A1-3*), dried experimental replica (*B1-3*) and fired experimental replica (*C1-3*).

ing. The coiling used to build the upper part of the experimental replica was detectable only in specific areas of the XCT-images. The application of the rim as a separate coil is the most visible, while the rarely encountered horizontal voids can be interpreted as traces left by the use of the coiling technique.

Joins of the anatomical elements on the pot (Tab. 3)

The embossed anatomical elements on the original pot (hands, nose, ears) could have been made in three ways: (a) by dragging clay from the vessel's walls, (b) separately modelled and then attached to the vessel or (c) gradually formed by attaching small pieces of clay modelled in place. Right after the vessel was built, the anatomical elements of the experimental replica were attached as pieces of clay that were subsequently modelled into the desired shape. Prior to joining the anatomical elements, the vessel's surface was prepared by scraping and moistening with water. The radial section of the upper part of the original pot (Fig. 6.A3) shows elongated voids in the joining areas of the hands and ears, indicative of a wet join performed while both the vessel's walls and anatomical elements were wet and moist (*Kozatsas* et al. *2018*). In the radial section of the experimental replica (Fig. 6.B3,C3), the same pattern is visible for the joining of the ears, but there are no noticeable traces to indicate the joining of the hands. The joining of the nose was not visible in the XCT-images, neither for the original pot nor the experimental replica.

Surface finishing (Tab. 3)

The XCT-images for the internal surface of the original pot (Fig. 7.A1-3) showed multiple traces of scraping and smoothing in vertical and diagonal paralleled stripes that can be interpreted as traces left by the potter's hand. In contrast, the external surface was well polished (no tool traces left) and then decorated by painting (Fig. 8.A1-3). The interior of the experimental replica was constantly scraped with a bone spatula and then smoothed with a reed stem during the vessel's building process. Consequently, the traces left and identified on the XCT-images consist of small lines of horizontal or diagonal orientation (Fig. 7.B1-3,C1-3). Inside the pot, traces of fingers can only be spotted in the middle area (Fig. 7.B2,C2). The external surface of the replica vessel was well polished using a river pebble, and the traces left are not detectable in the XCT-images (Fig. 8.B1-3).

Repairs or cracks (Tab.3)

The original pot has no visible cracks when examined by the naked eye. However, the investigation of the images obtained by XCT revealed several cracks that appear mainly in the joining area of the feet but also on the middle part of the pot (Figs. 6. A2-3; 7.A2). The first ones are related to the pressure exerted on the joining area of the feet while the upper part was built, and the standing pot was slightly moved during the work. The same cracks appeared on the experimental replica during the building process (Figs. 6.B2,C2; 7.B2,C2). The horizontal crack from the middle part (Fig. 7.A2) of the original pot was most probably formed due to a deficiency in joining the coils used for the primary forming. Other diagonal cracks in the same area could result from the secondary firing of the pot. The horizontal cracks in the experimental replica also appear in the middle part (joining of the coils) and at the joining of the rim with the vessel's body (Fig. 6.B1,C1).

Discussions

The multiple approaches used to examine the inside and the outside of a human-shaped pot from Sultana-Malu Roşu allowed us to obtain a specific data set regarding the characteristics of the humanized pottery produced by these prehistoric communities. Our goal was to focus on the manufacturing process that past potters followed to make such humanized vessels. This approach allows us to record some exciting data and identify the invisible elements about the *chaîne opératoire* undocumented in the archaeological record. Firstly, it should be noted that despite the complex appearance of the vessels with human morphological attributes, the manufacturing process would not be a great challenge for a potter with regular experience in the field. As we previously showed, various stages of collection and preparation of raw materials alongside the modelling process fit well in the pottery production standards manufactured by hand. Moreover, the anatomical components are easy to achieve and do not require special skills. The painting decoration process is also included in the production standards previously observed (*Ignat* et al. *2012; 2013; 2017; 2018; Ignat, Opriş 2015; Opriş* et al. *2017*). The time required is imposed not by the shape of the ceramic vessel but by the complexity of the painted motifs, for which some artistic skills are needed.

However, beyond these general observations there was a series of changes in how the experimental container behaved in different stages of production. Thus, according to the data presented in Table 1, we observe that the object's size and weight changed in

Forming features	Original human-shaped vessel	Experimental replica (after drying process)	Experimental replica (after firing process)
Primary forming techniques	• coiling + pinching (?), flattened patches in the lower part of the feet • horizontal coiling and flattened patches for the middle part of the pot • coiling + pinching (?) for the upper part	• no particularities could be distinguished for the lower part (feet) • hardly noticeable horizontal coiling for the middle part • horizontal coiling for the rim	• no particularities could be distinguished for the lower part (feet) • hardly noticeable horizontal coiling for the middle part • horizontal coiling for the rim
Joins of the anatomical elements on the pot	• ears and hands added after the primary forming of the pot	• ears clearly added after the primary forming of the pot	• ears clearly added after the primary forming of the pot
Surface finishing	*Internal:* • vertical scraping with the fingers on the feet • diagonal and vertical scraping and smoothing with the fingers in the middle and upper part *External:* • polished with a hard tool	*Internal:* • horizontal and diagonal scraping and smoothing with a hard tool • fingers prints in the middle part *External:* • polished with a hard tool	*Internal:* • horizontal and diagonal scraping and smoothing with a hard tool • fingers prints in the middle part *External:* • polished with a hard tool
Cracks or repairs	• crack in the feet joining area • horizontal crack in the back of the middle part • no traces of repairs	• multiple cracks in the feet joining area • no traces of repairs	• multiple cracks in the feet joining area • no traces of repairs

Tab. 3. Forming features resulted from the X-ray CT performed both on the original human-shaped vessel and experimental replica (dry and fired).

the different stages of the manufacturing process. All the recorded changes are related to the chemical-physical characteristics of the paste used for the pot making process, and its evolution during the drying and firing stages.

More valuable data regarding the compositional and structural aspects of the original pot were provided by the XCT investigation and comparison with the experimental replica. The XCT-images have allowed for the first time to view inside the walls of the original pot and consequently helped us characterize its ceramic paste. The presence of natural non-plastic inclusions such as rare spherical carbonate concretions and sparse organic matter, followed by the comparison with the inclusions from the experimental replica that was made with clay collected near the site, are indicative of a raw clay collected from a local deposit of alluvial nature. The hypothesis that the original pot was manufactured locally is strengthened by the presence of grog used as temper, a long-term tradition in making ceramic paste recipes observed for most of the Eneolithic pottery found within the tell settlement from Sultana-Malu Roşu. The shape, size and orientation of the voids indicate that the original pot was primarily formed by coiling followed by pinching, and in some cases, the flattened patches were used to reinforce the walls. However, some questions on this topic still remain, mainly because when these primary forming techniques (*e.g.*, coiling and pinching) were applied on the experimental replica, their specific traces were only partially revealed by the XCT analysis. More clearly, results were obtained regarding the joining of the anatomical elements. The arms and ears of the original pot were attached after the building of the vessel's walls, while the nose, mouth and eyebrows did not bear any traces indicative of joining to the pot. The internal surface of the original pot was only scraped and smoothed by fingers. This little care for the internal surface made it unusable for liquid contents, even if its shape recommends it for this kind of use (*Skibo 2013*). In contrast, the external surface was well polished and decorated by painting. The XCT-images also revealed hidden cracks in the joining area of the feet and the middle part of the original pot. The high similarity with the cracks observed in the experimental replica can be a solid argument that both vessels were built using comparable steps and construction techniques.

When it comes to the possible functional attributions that the analysed human-shaped pot could have fulfilled, we were able to identify some features that might suggest certain functions. However, a clear interpretation is difficult to achieve based only on the structural and typological particularities of the archaeological artefact and the experimental replica. As mentioned earlier, certain elements (such as the volume or the shape) may suggest a distinct function for this particular vessel, for example, its use as a recipient for short-term storage of liquids or for

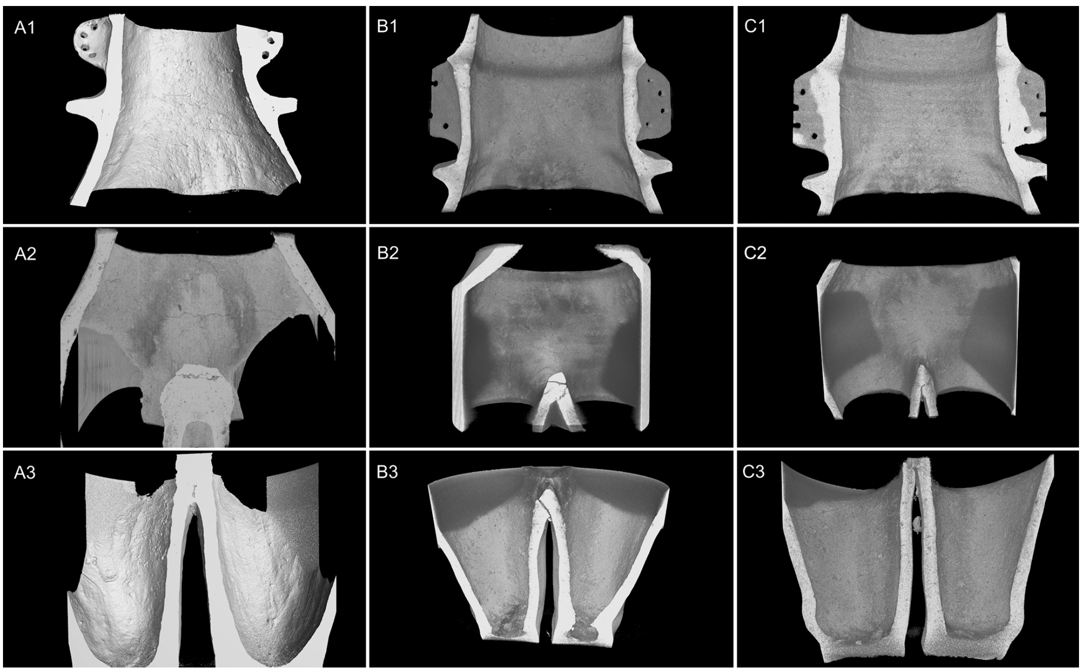

Fig. 7. 3D CT-images of the internal surfaces of the original pot (*A1-3*), dried experimental replica (*B1-3*) and fired experimental replica (*C1-3*).

gathering and transferring them to another container. However, other characteristics (such as the little care for the internal surface or the multiple cracks inside the walls) make it impractical for liquid-related uses and indicate other functions. At the same time, its usage as a storage container for different types of 'flowing solids' (*Opriş* et al. *2017*), even if it is a more viable option, at some point may also become questionable due to the wear traces that suggest the use of this vessel for gathering rather than storage. Therefore, while several features may suggest one or more functions, the presence of other elements may dismantle the previous assumptions, thus creating a vicious circle in interpreting the function of such a pot. In this context, for an interpretation as accurate as possible regarding the function of this particular human-shaped vessel, further experiments must be conducted by using several replicas of it under different conditions (for example, using them for gathering different types of goods, transporting the vessels in different ways while empty or/and full, *etc.*). This approach, in correlation with the functional and use-wear information provided by the current study, may ultimately lead to a better understanding of how this vessel was used in the distant past.

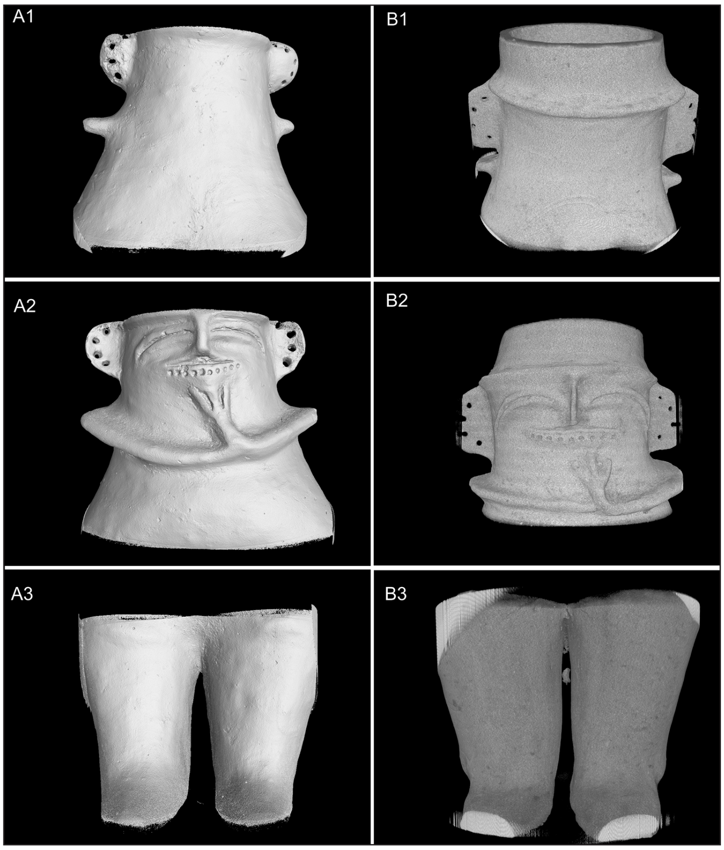

Fig. 8. 3D CT-images of the external surfaces of original pot (*A1-3*) and fired experimental replica (*B1-3*).

Conclusion

The present study revealed the potential of combining multiple approaches in investigating a unique Eneolithic pot discovered at Sultana-Malu Roşu. Thus, with the help of archaeological data and experimental archaeology, coupled with X-ray Computed Tomography, we have been able to identify multiple invisible aspects regarding the manufacturing process of the human-shaped pot known as 'The Goddess from Sultana'. By carefully following and analysing all the operational sequences (harvesting and preparation of raw materials, modelling and decoration of the pot, the drying and afterwards the firing process) in terms of the technology, time and skills required for the different stages of production, we managed to shed some light upon the methods used to obtain this final product and on what the entire process implied for the potter. Furthermore, the XCT investigation facilitated a detailed examination of the archaeological pot's internal structure, as well as that of the experimental replica, thus offering the possibility of identifying technological elements (characteristics of ceramic fabric, primary forming techniques, surface finishing, repairs or cracks) related to the chain of production. Moreover, the techno-functional analysis provided a small but interesting set of data, which allowed us to set up some new research goals for the near future to investigate how this human-shaped vessel – or similar ones – was used in the past.

Unfortunately, the correlation of all typological-stylistic, experimental, XCT-scan and techno-functional data about this unique humanized pot suggests a controversial function that at the moment can be framed neither as special nor as ordinary. However, this particular vessel, 'The Goddess from Sultana', indirectly reflects the ideology, beliefs, wishes, desires, visions about the world, humans, nature, daily life cycles and differing technological, organizational, and social approaches of past peoples. The tendency of human communities to represent the familiar silhouette of the human body or give objects a human (or quasi-human) form is a natural process of expressing the visual identity perceived by these people in the past. The act of adding typically human anatomical elements (*e.g.*, eyes, ears, hands, *etc.*) to inanimate objects is well documented in KGK VI communities. This seemingly technological act transforms inanimate objects into living objects, and thus active tools that are part of, live with and contribute to the daily setup of these people's lives. Some particular elements found in this study (*e.g.*, the use of the vessel in a horizontal position, not in a vertical one (which is the anatomical orientation of the figure), prove the complexity of the vision and imagination of prehistoric people, but also the high amplitude of the abstract dimension of the past minds that created and enlivened these artefacts. The way these abstract ideas are manifested through the material culture that these peoples created led (indirectly) to drawing inferences about the factors that governed the daily lives of those communities, and reflected their collective and individual identities. Moreover, humans do not behave under the influence of their senses alone but also through their individual and collective past experiences such as their upbringing correlated with the technological level of expression, beliefs, traditions, ideas, aims, fears, desires, symbols, and myths. These experiences contribute to each individual's unique view of the world, and in this way human groups that live together tend to develop a shared view of the world, which in turn influences their group material culture (*Henley* et al. *2020*).

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AUTHORS' CONTRIBUTIONS

CL supervised the study. VO, BM and TI performed the technological analysis of the human-shaped pot. ML, FC, and RB performed the X-ray Computed Tomography scans. BM, VO, and ML analysed and/or helped to interpret the XCT-scan data. VO made the experimental replicas, and quantification of the data. VO, BM, and CL wrote the manuscript with input from all co-authors. All authors read and approved the final manuscript.

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