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RE-EXAMINATION OF PREDYNASTIC POTTERY FROM MINSHAT ABU OMAR (NILE DELTA, EGYPT)
X-RAY STUDIES ON FORMING TECHNIQUES: PRELIMINARY REMARKS

Abstract: A type of electromagnetic radiation known as X-rays has been known in ceramic research since the 1930s. X-radiography is applied mainly to investigate clay fabric and to identify manufacturing details. In clay fabric identification, the method could be used to determine size, proportions, type and even general mineralogy of inclusions or tempers. Moreover, it can be successfully applied to identify, verify or better understand primary forming techniques as well. The purpose of this paper is to investigate Egyptian Predynastic pottery production by means of X-radiography in order to determine the primary forming techniques used for making four small ceramic vessels: bag-shaped jars and lemon-shaped jar from the cemetery at Minshat Abu Omar in the Eastern Nile Delta. The vessels are now in the collection of the Poznań Archaeological Museum and X-radiography was chosen as the study method because of its non-destructive nature allowing to penetrate the walls of vessels from the museum collection. Two primary forming techniques (pinching and coil-building) were identified during the analysis. The studied vessels were made of two segments by hand. Pinching was used to build the belly, while the shoulder, neck and rim were made by coiling. The application of two different forming techniques as well as the effort invested in joining coils and vessel segments imply that their makers were fairly skilled in their craft. The vessels reveal these 'secrets of the trade' only when exposed to X-rays.

Keywords: Minshat Abu Omar; pottery; Predynastic Period; X-radiography

Introduction

It is generally accepted that the oldest Egyptian Predynastic pottery was handmade although only a few details are known about the forming techniques. Pinching and hollowing are mentioned among the earliest methods of forming ceramic vessels from a lump of clay (Arnold 1993, 15-18; Wodzińska 2009, 1, 147). Simple, handmade manufacturing is typical for the Neolithic and Chalcolithic[1] periods, when a vast majority of vessels were made in the domestic context for the household's own needs (Köhler 1997). The first indisputable evidence of specialization in pottery production appears as early as at the end of the Naqada I period in Upper Egypt and in the Naqada II period in southern and northern Egypt (Friedman 1994, 911-915; Takamiya 2004; Hendrickx 2011, 93; Mączyńska 2015, 72, Fig. 2). The second part of the Naqada II period saw also the emergence of part-time specialists working in the household industry[2] mode of production (Köhler 1997; Mączyńska 2021). However, simple, handmade manufacturing and firing methods continued to prevail across the Egyptian Nile Valley in the Naqada I and II periods. A gradual and linear progress in pottery production has been suggested for the later Naqada II period and no major breaks in technology or typology have been identified (Hendrickx *et al.* 2002, 279). Innovation and improvements are mostly confined to the emergence of new vessel shapes as well as more elaborated surface treatment techniques and decoration patterns. Recent research on the ceramic technology concerning the pottery from two sites (Tell el-Samara and Tell el-Iswid) allows one to determine the *chaîne opératoire* for the Naqada II period (Buto Ib/IIa – Buto IIb). According to J. Bajeot and V. Roux (2019, 163-164, Fig. 5), vessels of the local Lower Egyptian tradition were handmade without rotative kinetic energy (RKE). The forming techniques included coil-building and pinching.

The purpose of this paper is to investigate Predynastic pottery production by means of X-radiography in order to determine the primary forming techniques used for making four small ceramic jars. The vessels were collected from the cemetery at Minshat Abu Omar in the Nile Delta in graves dated to the second part of the Naqada II period (Pl. 1: 1). They are now

[1] The chronology after Köhler 2010, tab. 3.1. See also Stevenson 2016, Table 1.

[2] The 'household industry' mode is borrowed from the pottery production model proposed by E.C. Köhler (1997, Fig. 2) for the Nile Delta. The mode is characterized by seasonal production, low technical level, and small-scale distribution. Moreover, potters subsistence was not dependent on their craft. In this mode, pottery production heavily depends on climate conditions.

in the collection of the Poznań Archaeological Museum. X-radiography was chosen as the study method because of its non-destructive character allowing to penetrate the vessels walls. The choice of the vessel forms was determined by their high relative frequency in the assemblages of the Naqada II period in the Egyptian Nile Valley and the Delta (Köhler 2014). In the opinion of the author, the study allows to identify the primary forming technique used not only for the Minshat Abu Omar site, but probably also for other locations in Upper and Lower Egypt, where such vessels were commonly produced and used over the 4th millennium BC.

Ceramic Radiography

A type of electromagnetic radiation known as X-rays has been used in ceramic research since the 1930s (Carr 1990; Berg 2008, 1177; Berg and Ambers 2017, 543). However, it was O. Rye in 1977 (see also 1981) who presented the fundamental rules and advantages of radiography for ceramic studies. In the 1990s, the technique and its application were described in detail and summarized by C. Carr and E.B. Riddick (1990; Carr 1990, 1993).

X-rays penetrate an object in proportion to its thickness and the atomic density of the material. Radiography creates a greyscale image of features or parts that differ in composition, thickness, density or even capability of transmitting X-rays (Carr 1990, 14; Berg and Ambers 2011, 367-368; 2017, 550-555).

In pottery research, X-radiography is used mainly to investigate clay fabric and to identify manufacturing details (Middleton 2005, 78-88; Berg 2008, 1177; Berg and Ambers 2017, 543-545). Additionally, the technique is useful in determining the current condition of the analyzed items and in identifying joints, faults, breaks, and repairs. Furthermore, it can be helpful in investigating authenticity as a tool for identification of forgeries. In clay fabric identification, X-radiography has been used to determine size, proportions, type, and even general mineralogy of inclusions or tempers, based on different radiodensities of clay and other paste ingredients (Berg and Ambers 2017, 545-546). The method can be successfully used to identify, verify or better understand primary forming techniques, as it allows one to analyze the shape and orientation of mineral particles, voids, and organic fragments in the paste (Rye 1977, 206-207; see also Rye 1981; Carr 1990, Fig. 1; Berg 2008, Fig. 1). Although pinching, drawing, coil-building, slab-building, moulding, and wheel throwing could be recognized successfully in a X-radiograph, secondary forming methods such as scraping, trimming, smoothing are more difficult to pinpoint because of their limited interference in clay structure. The only exception is the paddle and anvil technique, in which considerable pressure is applied to vessel walls (Rye 1981, 207, Pl. 3b; Middleton 2005, 88).

Characteristic X-ray Features of Forming Techniques

Taking into account the state of research on the pottery technology in the Predynastic period, the author explores features typical for pinching, drawing and coil-building, which are easily recognizable in an X-radiograph. Each of these forming techniques could be used during the formation of the four vessels selected for the analysis. All of them are pressure techniques performed without RKE (Roux 2019, 54, 60-61). It was O. Rye (1977, 206) who recognized that 'the application of pressure to plastic clay causes mineral particles, voids and organic fragments to take up a preferred orientation.' Moreover, in his opinion, the orientation depends on temper shape and size, clay plasticity, and the force and direction of the applied pressure. Rye (1977) noticed that prismatic, needle-like and plate-like particles larger than 1mm can be successfully recognized in X-radiographs.

Due to the large quantity of a fine to medium organic temper, the X-radiography seems to be a suitable method to investigate the primary forming technique of the selected vessels. However, the presence of a large quantity of an organic temper could make the study difficult since too many inclusions could obscure important features (Berg and Ambers 2011, 374).

Pinching is a common forming technique of making small vessels by 'transforming a clay mass into a hollow volume with discontinuous point interdigital pressures' (Roux 2019, 60). Drawing is another technique typical for small pots: 'the walls of a vessel are formed by thinning a lump of clay by discontinuous interdigital or inter-palm pressure, vertically from the bottom to the top' (Roux 2019, 60-61). The pressure leaves diagnostic features in the fabric, which can be detected by X-rays (Rye 1977; Berg and Ambers 2017, 547). In a pinched vessel orientation of particles is parallel to the wall in the cross-section, and random on the walls and base. Similar orientation has been observed in the case of drawn vessels, where the particles tend to be parallel in the cross-section, random or weakly vertical on the wall, and random to weakly radiating on the base (Carr 1999, Fig.1; Berg and Ambers 2017, 547, Fig. 30.1).

Coil building is the third forming technique used in the Predynastic period. In this case, a vessel is built up of coils – a roll of paste which spirals around the vessel wall (Middleton 2005, 84-85). The vessel is created with horizontally placed coils, which could be thicker than the eventual thickness of the vessel wall. During vessel formation, the coils are compressed. They may be joined by pinching, drawing, and spreading (Roux 2019, 55; Thér 2020, 172, Fig. 4). Clay transformation typical of coil-building is also recognizable in X-radiography. Voids between adjacent coils are often visible. Moreover, particles are distributed in a concentric way on the base and are horizontally parallel on the walls (Middleton 2005, 84-86; Berg and Ambers 2017, 547, Fig. 30.1). In the cross-section, particles are random, but as a result of the coil formation, they can exhibit horizontal parallel orientation as well (Carr 1990, Fig.1; Berg and Ambers 2017, Fig. 30.2; Thér 2020, Fig. 9). The coil joints could also be illustrated by breaks in the vessel walls caused by the structural weakness of the connections (Thér 2020, 172). Importantly however, a high degree of compressive transformation may affect particle orientation in coils, which makes it difficult to spot the traces of forming (Thér 2020, 172).

Minshat Abu Omar

Minshat Abu Omar is a site located in the Eastern Nile Delta, 150km NE of Cairo (Pl. 1: 1). First registered in 1966 during an archaeological survey by H. W. Müller, the site was explored between 1978 and 1991 by the Munich East-Delta expedition under the direction of Dietrich Wildung. Located on a *gezira*, it consists of a settlement and a cemetery. The ten seasons of explorations focused mostly on the necropolis, where the archaeologists excavated graves dated to the Pre/Early Dynastic and the Greco-Roman periods (Kroeper and Wildung 1994, 2000). The settlement has never been investigated, although its location was identified by means of an auger program on a sandy hill slope some 500-700 meters away from the cemetery (Krzyżaniak 1989, 1992, 1993). Pre/Early Dynastic graves from the Minshat Abu Omar cemetery have been divided into four main chronological groups according to ceramics and burial types. The oldest graves (group I) have long been treated as burials of a Naqadian community and consequently regarded as evidence for the Naqadian expansion to the north (i.e. Kaiser 1985, 1987). However, more detailed recent analyses of offerings and burial customs of the oldest graves indicate that they were of local origin. Group I graves are entirely Lower Egyptian in character and are linked to the Lower Egyptian Cultural Complex (Köhler 2008, 528; Dębowska-Ludwin 2014; Mączyńska 2014, 2015).

Ceramic Collection from Minshat Abu Omar at the Poznań Archaeological Museum

Some of the grave goods found at Minshat Abu Omar are now stored in the Poznań Archaeological Museum in Poland. The collection consists mostly of pottery, although individual stone objects are present as well. It is a long-term loan offered by Munich's Staatliches Museum Ägyptischer Kunst to the Poznań Archaeological Museum in recognition of its participation in the expedition and the contributions of its researchers. The excavation project at Minshat Abu Omar from 1979 to 1990 was headed by Professor Lech Krzyżaniak, former director of the Poznań Archaeological Museum (Chłodnicki 2019, 9-10). The ceramic collection consists of 25 vessels dated to the Predynastic and Early Dynastic periods. They represent forms characteristic for the period between the second part of Naqada II until the 1st Dynasty.

Vessels Selected for Radiography

The four small vessels from the collection selected for X-ray studies were all registered in the oldest graves of the cemetery (group I). Three of them are the forms labelled as R65-65 by W.M.F. Petrie in *Corpus of Predynastic Pottery and Palettes*. They are often referred to as bag shaped jars. The fourth vessel is Petrie's R69, generally known as a lemon-shaped jar (Petrie 1921, Pl. XL). All the vessels are typical for the Naqada II period in the whole Egyptian Nile Valley including the Delta. Lemon-shaped jars and bag-shaped jars have been found in graves as offerings and in settlements of the Lower Egyptian Cultural Complex as well as the Naqada culture (e.g. Köhler 1992, 18-19; Friedmann 1994, 713, 908; Jucha 2005, 45; Jucha and Mączyńska 2011, tab. 2; Buchez and Midant-Reynes 2011; Guyot 2014; Mączyńska 2013; 2014, 121-138; Köhler 2014, 164-167; Wilson *et al.* 2014; Bajeot and Roux 2019, 162-166; Hartmann 2021).

Vessel 1 (Pl. 1: 2)
Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/14 Dep.[3]
Grave 166 (113), item no. 113/2 (Kroeper and Wildung 2000, 90)
Form: small jar with a round base, a spherical belly and a round rim[4]
Dimensions[5]: RD 5.6cm; MD 9.9cm; H 11.9cm
Fabric[6]: N IC
Colur: Munsell 2.5YR 5/4 reddish brown

Vessel 2 (Pl. 2: 1)
Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/20 Dep.
Grave 63 (179), item no. 179/1 (Kroeper and Wildung 1994, 81)
Form: small jar with a pointed base, a spherical belly and a round rim
Dimensions: RD 4.9cm; MD 9.6cm; H 11.9cm
Fabric: N IC
Color: Munsell 7.5YR 5/4 brown

Vessel no 3 (Pl. 3: 1)
Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/18 Dep.
Grave 57 (186), item no. 186/2 (Kroeper and Wildung 1994, 72)
Form: small jar with a round base, a spherical belly, a short neck and a round flaring rim
Dimensions: RD 3.2cm; MD 8cm; H 11cm.
Fabric: N IB1
Color: Munsell 5YR 5/3 reddish brown

Vessel no 4 (Pl. 4: 1)
Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/24 Dep.
Grave 105 (231), item no. 231/12 (Kroeper and Wildung 1994, 143)
Form: small jar with a pointed base, an ovoid belly, a short cylindrical neck and a pointed rim
Dimensions: RD 5.4cm; MD 10.2cm; H 15.5cm
Fabric: N IC
Colur: Munsell 2.5YR 4/8 red

[3] Registration numbers and catalogue numbers of the Poznań Archaeological Museum.

[4] According to Wodzińska 2009, 4-5.

[5] RD – rim diameter; MD – maximum diameter; H – height.

[6] According to the Vienna System (Nordström and Bourriau 1993, 168-182).

Identification of Forming Techniques of MAO Vessels at the Poznan Archaeological Museum

The forming technique identification was based on a combination of X-radiography and direct visual analyses of those features that were less clearly visible in X-ray images. Ecotron DR 1500L, Generator RTG Regen-2400 (50 KVp, 6.3mAs) was used to take X-rays. The images were enhanced with the ‘unsharp mask’ filter (PhotoScape software).

Vessel 1 (Pl. 1: 3-4)

Irregular and uneven walls, especially on the inside of the belly of the vessel, indicate hand-building. Moreover, the vertical orientation of organic fragments in the wall cross-section may indicate pinching. On the tangential section of the belly, the distribution of an organic temper is neither vertical nor horizontal, which could also be considered as a sign of pinching (Berg 2008, Fig. 1; Thér 2020, Fig. 9). The small size of the vessel makes this forming technique possible as well. The upper part of the vessel (the shoulders and the rim) shows a different orientation of inclusions, which may indicate that a different technique was used during primary forming. It seems that the upper part of the jar was probably formed by coil-building. The organic temper on the rim is arranged horizontally, which is often interpreted as a sign of coil building (Berg and Ambers 2017, Fig. 30.2). Directly below the shoulder, a seam between the upper coil-built part of the vessel and the belly is probably visible in the left cross-section (Pl. 1: 3).

Vessel 2 (Pl. 2: 2-3)

The vertical distribution of an organic temper in the wall cross-section suggests that pinching could have been used to form the vessel body (Berg 2008: Fig. 1.; Thér 2020: Fig. 9). Organic particles are oriented horizontally on and directly below the rim, thus indicating probable coil building for this part of the vessel. No coil joints are visible, although the seam of the upper and lower parts of vessels is visible probably where the wall is the thinnest in the left wall cross-section (Pl. 2: 2).

Vessel 3 (Pl. 3: 2-3)

The pinching technique is suggested by vertical voids visible in the wall cross-section (Berg 2008, Fig. 1.; Thér 2020, Fig. 9). The upper part of the vessel was also made of coils. The breaks visible in the right wall cross-sections probably correspond to the seam between a body and a neck (Pl. 3: 2).

Vessel 4 (Figs. Pl. 4: 2-3)

The belly of this vessel was formed probably by pinching, as indicated by the vertical orientation of the organic temper in the wall cross-section. The uneven internal surface of the walls is typical for hand-making. The upper part of the vessel was made of coils. In the left wall cross-section, two breaks are visible, probably corresponding to the seam between two vessel segments (Pl. 4: 2). Horizontal orientation of the temper in the neck and on the rim may indicate coil building as well (Berg 2008, 1; Thér 2020: Fig. 9).

Summary and Conclusions

X-radiography is a useful tool in studying pottery tradition. It allows to penetrate vessel walls in search of macro and micro traces not visible to the naked eye. Most vessels are ready-to-use products, devoid of any forming traces, which are intentionally removed in the course of the production process. X-radiography is capable of revealing these traces, thus enriching our knowledge of pottery production.

All the studied vessels were made of two segments formed by hand by two different techniques. The bigger part of the belly was probably formed by pinching, as indicated by the distribution and orientation of organic inclusions and voids.[7] In addition, the technique causes varying vessel wall thickness, visible in cross-sections (Roux 2019, 168). The upper parts of the bodies were made of coils, which is again suggested by the distribution and orientation of temper particles. The joints between coils are very difficult to observe in wall cross-sections. Only in two cases, seams between the upper and lower part of vessels were identified mostly on the basis of breaks visible in X-radiographs. It seems that potters carefully smoothed out and strengthened the joints during forming. The macroscopic verification of the inner surface revealed unusually thick walls in two cases (vessels 1 and 4) in the place of segment joints in the upper part of the vessel (Roux 2019, 146). Unfortunately, due to the secondary forming techniques such as smoothing, scratching or slipping, almost no traces of the primary forming techniques are visible on the external vessel surface.

[7] The forming techniques applied to both forms need further investigation on bigger samples from different locations in the Egyptian Nile Valley.

The high demand for lemon- and bag-shaped jars in the Predynastic Egypt was caused by their frequent use in everyday life and as grave offerings. These vessel forms are commonly found on settlement sites and cemeteries in the Delta and in the Egyptian Nile Valley. At Minshat Abu Omar, lemon-shaped jars and bag-shaped jars make up 53% of all ceramic vessels deposited in graves as offerings. On the settlement at Tell el-Farkha (Kom C), contemporary to the Minshat Abu Omar cemetery, lemon-shaped jars represent 45% of all closed forms in phases 1 and 2 (Mączyńska 2016, 90). The relative frequency of R65-R69 ranges from 75% to 20% in the area of the Naqada culture in the NII context[8] (Köhler 2014, 165-168, fig. 4). Both vessel forms were convenient to drink from and pour into, and easy to grasp and carry. The high content of an organic temper keeps liquids cool even in hot weather. They probably served as common liquid or snack containers, taken for short trips (Friedman 1994, 248, 261; Rice 2005, 231; Mączyńska 2021).

The technology, production techniques, and firing conditions of the Lower Egyptian Cultural Complex indicate that there was no specialization in pottery production. Lower Egyptian potters did not depend economically on their craft and produced vessels only for their own use (Köhler 1997). However, lemon-shaped jars and bag-shaped jars found at almost all Predynastic sites share the same shape, surface treatment and similar absolute dimensions within their type (height, rim diameter, maximum diameter and volumetric capacity – see Mączyńska 2021). It is plausible that they may have been produced in a very similar way in other locations in the Egyptian Nile Valley. Although the production process was not sophisticated and the small size of the vessels made their production easier, the application of two different forming techniques, including coil building, required a certain degree of skill. Considerable work and effort had to be invested in joining coils and vessel segments properly. The four studied jars from Minshat Abu Omar show that their makers were highly familiar with their craft and the vessels reveal 'secrets' of their production only when exposed to X-rays. The vessels could have been made by a part time specialist who operated in a domestic context, producing a limited number of vessel shapes in the household industry mode of production (Köhler 1997). The state of research on the organization of pottery production in Lower and Upper Egypt in the Naqada II period does not allow for a more detailed interpretation and the problem needs further investigation, especially with a full range of vessel shapes used in the periods and regions in question.

[8] Based on recorded cemetery assemblages.

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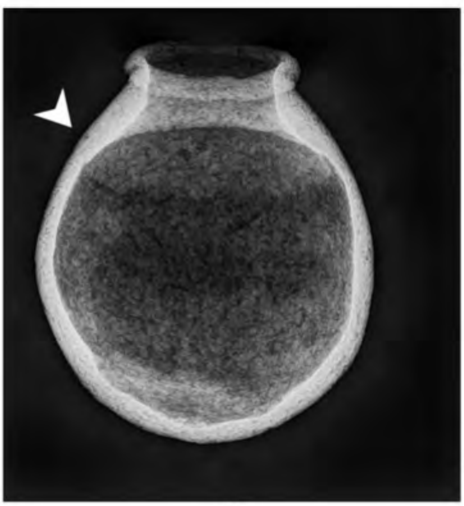

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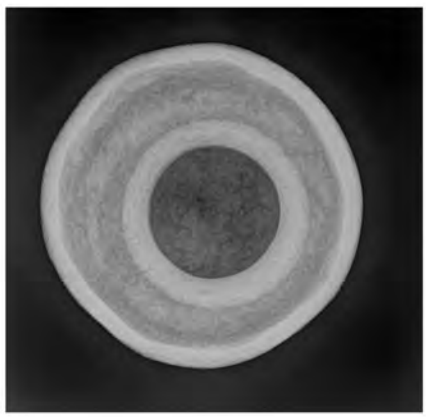

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Pl. 1: 1 – Map of Lower Egypt showing location of Minshat Abu Omar and the most important sites of the Lower Egyptian Cultural Complex

Pl. 1: 2 – Vessel 1 from Minshat Abu Omar (Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/14 Dep.) Photograph by P. Silska

Pl. 1: 3 – Enhanced radiograph of vessel 1 from Minshat Abu Omar

Pl. 1: 4 – Enhanced radiograph of vessel 1 from Minshat Abu Omar

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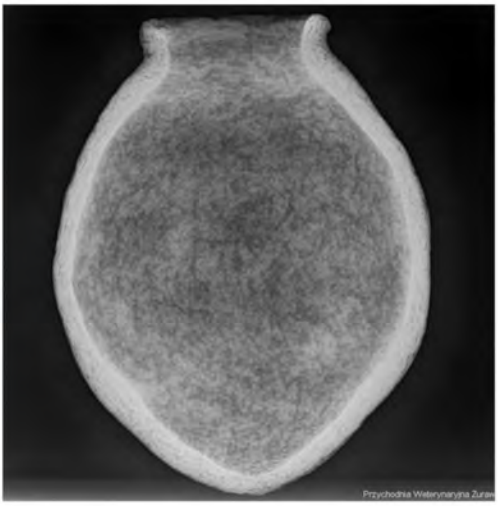

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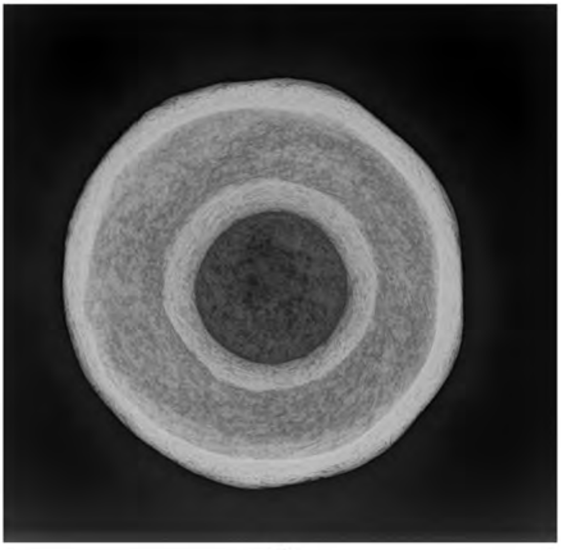

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Pl. 2: 1 – Vessel 2 from Minshat Abu Omar (Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/20 Dep.) Photograph by P. Silska
Pl. 2: 2 – Enhanced radiograph of vessel 2 from Minshat Abu Omar
Pl. 2: 3 – Enhanced radiograph of vessel 2 from Minshat Abu Omar

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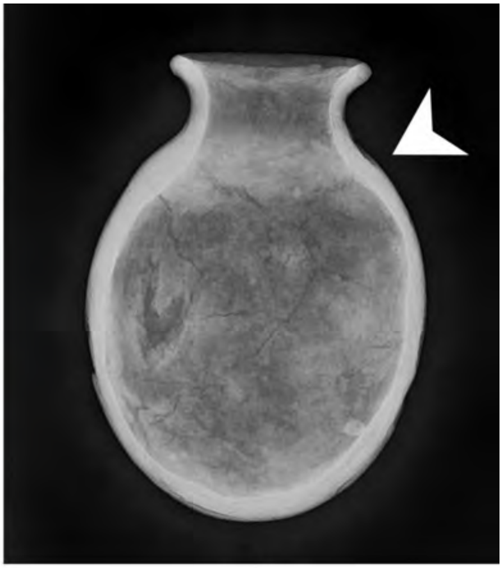

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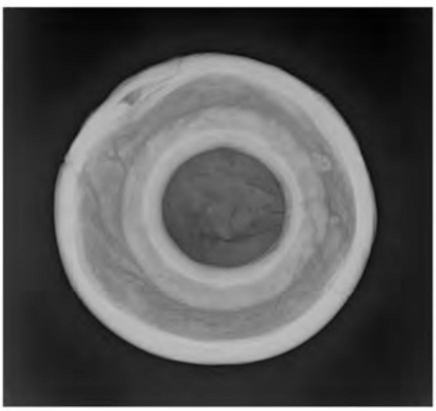

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Pl. 3: 1 – Vessel 3 from Minshat Abu Omar (Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/18 Dep.) Photograph by P. Silska
Pl. 3: 2 – Enhanced radiograph of vessel 3 from Minshat Abu Omar
Pl. 3: 3 – Enhanced radiograph of vessel 3 from Minshat Abu Omar

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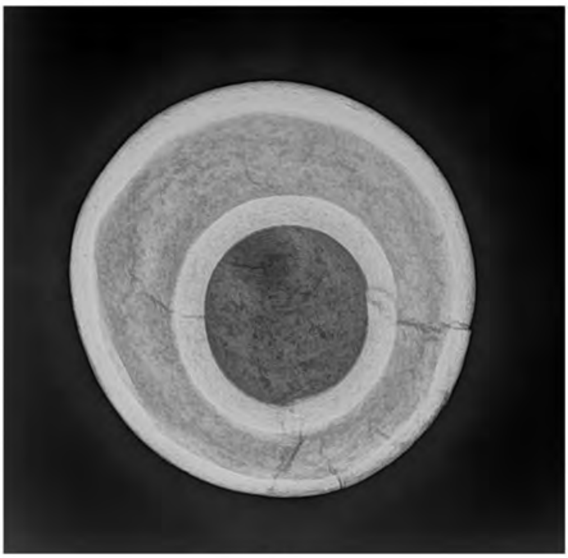

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Pl. 4: 1 – Vessel 4 from Minshat Abu Omar (Reg. No. MAP 1986:1 Dep.; Cat. No. MAP 1986:1/24 Dep.) Photograph by P. Silska
Pl. 4: 2 – Enhanced radiograph of vessel 4 from Minshat Abu Omar
Pl. 4: 3 – Enhanced radiograph of vessel 4 from Minshat Abu Omar