Herausgeber*innenkollektiv, eds. 2021. *Pearls, Politics and Pistachios. Essays in Anthropology and Memories on the Occasion of Susan Pollock's 65th Birthday*: 167–84. DOI: 10.11588/propylaeum.837.c10742.

A Perfect Circle. Production of Soft-Stone Vessels: Objects from the Late Umm an-Nar Site al-Maysar, Oman

Aydin Abar*

This work is dedicated to Susan, who I consider a paragon in many ways: she is a bright scholar, an empathetic supervisor, and a wonderful person. She has never lost track of the blind spots in our field, and she stirred my interest in micro-topographies, which eventually led me on the path to techniques, gestures, and their traces on object surfaces.

Introduction

The term soft-stone comprises steatites and other phyllitic rocks, including chlorites. While differing in terms of their chemical compounds, all are very similar in material qualities: they tend to be easy to work, as long as they are freshly mined (*bergfrisch*) or stored in humid conditions. Soft-stone was used as a raw material in different regions of Western Asia at least as early as the Pre-Pottery Neolithic period (Oudorová 2019, 22).

In Southeast Arabia, soft-stone as a raw material came in to use in the 4th millennium (Biagi et al. 1984, 55). It was used to produce small beads and earrings (Coppa et al. 1985, 99; Usai 2018, 57). The production of soft-stone vessels seems to have emerged in the last third of the 3rd millennium (David 1996, 35). In the Southern Iranian Highlands the development of the tradition to produce decorated soft-stone bowls appears to be much older and can be traced back to the Neolithic phases of Tepe Yahya.[1] Here the production of decorated vessels played a role through most of the 3rd millennium and further intensified in periods IVC and IVB, recently dated to the late third quarter of the 3rd millennium BCE (Potts 2001, 201). It is assumed that imports from the Southern Iranian Highlands to Southeast Arabia, dating to the mid-3rd millennium, initiated local production at the latter (David and Phillips 2008, 122), but substantiation of this claim requires further investigation.

Intercultural Style soft-stone vessels from the Iranian Highlands were an important good in the course of the 3rd millennium BCE and they have been found throughout Western Asia. In contrast, the vessels of the so-called Umm an-Nar style are mostly found in the lower regions along the Persian Gulf and Southeast Arabia. Even though some samples have been excavated at Susa and in some major Mesopotamian cities, their numbers are considerably lower compared to Southeast Arabia. Hélène David's evaluation (1996, 38) that they were neither meant nor produced for export is therefore highly convincing. Most samples were found at burial grounds, though finds from settlements are not unknown. Objects of all styles have been the topic of both monographs and articles and caused a vibrant debate about their role in the interregional exchange (Possehl 2007).

Early Bronze Age soft-stone vessels

Throughout my doctoral dissertation "Beyond the Ecstasy of Copper", I dealt with a number

* Institute for Archaeological Studies, Pre- and Protohistory, Ruhr-Universität Bochum, Bochum (Germany)

1 In fact, Tepe Yahya shows an extensive tradition of soft-stone use (see Kohl 1974, 37).

of different finds, including copper tools and copper fragments, smelting residues, technical ceramics, pottery, soft stone vessels, as well as marine mollusc shells, from sites along a wadi close to the village of al-Moyassar (ash-Sharqiyah North Governorate of Oman). They were collected between 1978 and 1988, during surveys and excavations of the Deutsches Bergbau-Museum Bochum under the direction of Gerd Weisgerber. Most finds come from the settlement area of al-Maysar 1 (**Fig. 1**) and from the graves of al-Maysar 18 situated further to the south. The majority of soft-stone objects depict simple geometric motifs including horizontal grooves and bands of dot-in-double-circle ornaments. The material dates between the Late and Final Umm an-Nar/Early Wadi Suq period (ca. 2300–1900 BCE), which makes it contemporary with Hili Phase IIf–IIg (Cleuziou 1989) and Period IV of Ra's al Jinz 2 (Azzarà and De Rorre 2018).[2]

I macroscopically and microscopically examined a number of different semi-finished and finished soft-stone vessels to better understand the history of the production traces visible on the inner and outer surfaces. These traces serve as the basis for hypotheses regarding the paths of production of such vessels chosen by the producers, from the blank to the ready-made object.

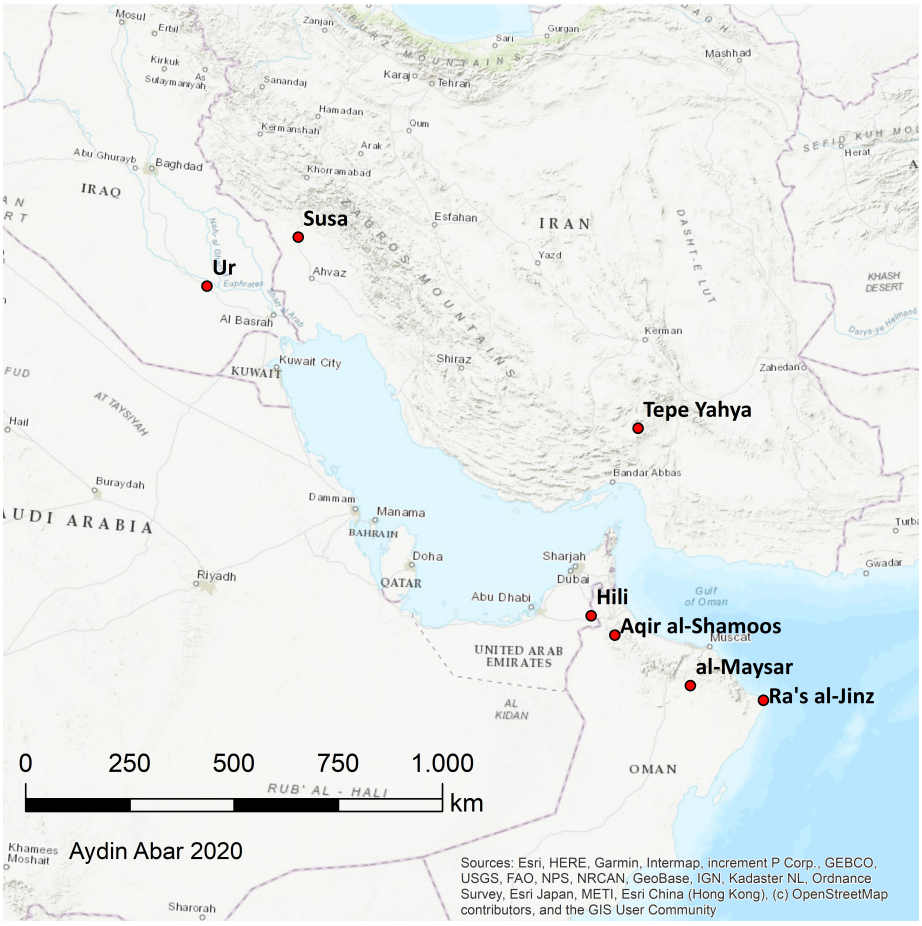

Fig. 1. Map of sites mentioned throughout the article. Digitising: Aydin Abar; CC BY-NC-SA 4.0.

2 Detailed information on the location will be presented in a forthcoming publication (Abar in prep.).

3 A small bowl appears on Plate 176 between U.12696 and U.12492, but was most probably forgotten prior to the cataloguing process (see Woolley 1934).

In the following, I provide a short summary on the work conducted in the field of soft-stone vessels before describing several pieces and the traces visible on them, to then conclude with my hypotheses about the possible tools and techniques responsible for the traces.

Research history

Bronze Age soft-stone vessels have been the subject of scholarly debates for decades. Most work conducted so far has focused on macroscopic concerns, mostly dealing with the general shape of vessels, their dating, and their distribution.

Early examples of soft-stone vessels with incised dot-in-double-circle ornaments displayed in Western literature derive from Woolley's excavations at Ur; he described them as vessels made from basic diorite "with incised concentric circles" (Woolley 1934, 380).[3] In 1973 Pierre de Miroschedji published the first detailed study on objects from the French excavations at Susa. Interpreting the stylistic differences chronologically, he sorted the material into three categories: the oldest were the so-called *série ancienne*, followed by an intermediary style labelled *série récente*, and ending with the *série tardive* (de Miroschedji 1973). A completely different approach was chosen by Phil L. Kohl in his doctoral dissertation. Dealing with rough-outs, semi-finished objects, and finished objects as well as refuse, his aim was the reconstruction of the modes of production and distribution of soft-stone vessels produced at the site of Tepe Yahya, Iran (Kohl 1974). In the following decades Jutta Häser (1990; 1991) and Hélène David (1991; 1996; 2002; David et al. 1990) focussed on soft-stone vessels from Southeast Arabia, paying greater attention to the chronology and materiality of the vessels, as well as the possible origin of raw materials used in their production. David, with her profound knowledge on vessels and objects from Hili, Al Ain, UAE, modified de Miroschedji's categorization, demonstrating that the main difference was not chronological, but regional, and that Umm an-Nar Style vessels (de Miroschedji's *série récente*) are generally restricted to the Gulf area and Southeast Arabia (David 1996, 31).

In a recently published article, Harrower and colleagues (2016) describe the production of Iron Age soft-stone vessels at Aqir al-Shamoos in Oman, showing that during this time period the rough-out of half-products was carried out close to the quarry itself, a method outlined previously by Harrell and Brown (2008, 49) for medieval Egyptian quarries.

According to Harrower et al. the work can be broken down into five major steps: the producer made a first rough-out, using a chisel with a width of ca. 5mm (Harrower et al. 2016, 201); the shape was then further elaborated using the same tool. Subsequently, the surfaces were smoothed roughly, which still left the deeper chisel marks visible. These were then smoothed out again. In the final stage the surface was polished thoroughly. One feature of all objects from Aqir al-Shamoos is that no decoration was recorded, leading the authors to posit that the vessels were taken to another site and decorated there (Harrower et al. 2016, 205). Traces visible in the published photos suggest that work was conducted helicoidally and concentrically around the vessels, indicating the use of further tools, as in the case of the rough-out of a lid (Harrower et al. 2016, 203, Fig. 7). The same holds true for traces visible on the internal surface: variations are visible, and in general traces have a parabolic shape and are relatively long (Harrower et al. 2016, 205, Fig. 10).

Research direction

Aside from the few aforementioned publications, we know very little about the macroscopically and microscopically visible traces related to the production of vessels and decorative ornaments. Such work is complicated because of the state of publication of such objects. A plethora of vessels have been published as drawings, but little or

no attention was ever paid to document irregularities and characteristic differences between ornaments, which could help discern the proper techniques and their variations. However, exactly these differences may indeed help us to understand crafting traditions and the paths along which producers aligned tools, skills, and gestures, that were passed from master to apprentice. To understand the traces might also help us to discern regionally distinct production traditions in Southeast Arabia, and shed light on the provenance of objects found in Mesopotamia, Iran, and the Indus.

Methodological approach

Admittedly the outcome presented here is based on a rather intuitive traceological approach. As one example, I conducted most of this work in 2014 without following any already established protocol.

First, I examined the samples macroscopically and determined which parts and areas might be worth looking at with stronger/higher magnification. As a second step I used a Zeiss Stemi 2000-C binocular with x10 eyepieces and a lens magnification of 0.65 to 5, resulting in a total magnification range of x6.5 to x50, and a Zeiss KL 1500 LCD double gooseneck lamp for lighting. I used the same lamp to produce glancing light conditions, which allowed a better visualisation of surface traces. Following these steps, I used a Keyence VHX 2000 digital microscope in combination with two lenses, the VH-Z00R RZ ∞-x50 and the VH-Z20R RZ x20-x200, again in combination with the aforementioned Zeiss double gooseneck light source. Samples were set on a foil-covered bedding of adhesive paste, allowing small-scale adjustments regarding the angulation to further improve lighting conditions. Unfortunately, my documentation of my working steps was not perfect, sometimes missing the exact magnification used in the single case on the single object, but the general range of magnification at which I took photos ranges from x10 to x200, with most ranging between x20 and x50.

Objects under consideration

In the following I sketch the context of the objects, offer a rough description and a list of what the microscopic work conducted allowed me to observe. More information, including detailed photos and drawings and colour specifications will be found in my upcoming publication (Abar in prep.).

Find number: DA 2131[4]

Context: al-Maysar 1, North, stratification unknown.

Description: larger roughed-out vessel (**Fig. 2**), no ornamentation on the surface, roughly smoothed outer surface.

Analyses: The inner surface shows several cut traces with a minimum width of 10 mm, several traces close to each other show variations between 2.5 mm and 5.3 mm. It seems feasible to assume the use of a chisel which was held in different angles leading to the large range variation regarding the width of the marks. In general, the patterns are much less systematic than in the case of the vessels from Aqir al-Shamoos (Harrower et al. 2016, 205, Fig. 10).

Find number: DA 4185

Context: al-Maysar 1, Structure 3, well, -10.65 m below the surface.

Description: fragmented soft-stone vessel, base sherd.

4 The find numbers are the digits under which the archaeological remains are registered by the Ministry of Heritage and Tourism of the Sultanate of Oman.

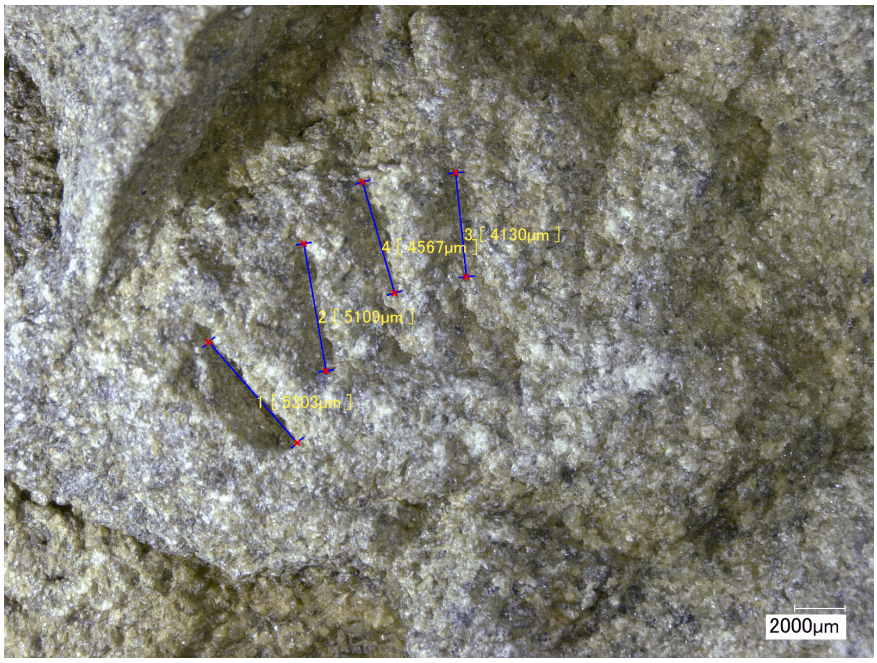

Fig. 2. Several tool marks on the internal base surface. Photo: Aydin Abar; CC BY-NC-SA 4.0.

Analyses: Both surfaces show similar sized ridges: the visible striations on the outer surface (n=6) have a width of 62 µm to 197 µm, a median of 83 µm, and a mean of 114 µm, with a standard deviation of ±59 µm. The striations on the inner surface (n=5) have a width of 46 µm to 185 µm. The median is 131 µm and the mean is 120 µm with a standard deviation of ±52,4 µm. Both surfaces are glossy and seem to have been polished, but the striations do not show a particular alignment.

Find number: DA 4258

Context: al-Maysar 1, Structure 31, Trench 13, 20 cm below the surface.

Description: wall and rim sherd fragment of soft-stone bowl, decorated with two bands of dot-in-double-circle incisions positioned between horizontal ridges; the central ridge most likely shows the beginning and the end of the cutting movement, the ends do not merge, but run parallel to each other for ca. 1.5 cm.

Analyses: The striations on the outer surface (n=16) have a width of 48 µm to 197 µm. The median is 64 µm and the mean 82 µm with a standard deviation of ±41.8 µm. The inner surface shows striations (n=5) with a width of 46 µm to 185 µm. The median is 131 µm and the mean 120 µm with a standard deviation of ±52.4 µm. Most striations seem to run concentrically. Two dot-in-double-circle motifs were more closely examined (**Fig. 3**). The central hole of the first has a diameter of 2.4 mm (**Fig. 3, top**), the second circle has an inner diameter of 4.9 mm and a width of 2.4 mm (**Fig. 3, bottom**). The second circle has an inner diameter of 1.1 cm and a width of 2.6 mm. The central hole of the second ornament has a diameter of 2.5 mm, the first circle has an inner diameter of 2.5 mm and a width of 2.4 mm, and the outer circle has a diameter of 1.1 cm and a width of 2.4 mm. Both ornaments are fairly similar in dimension as well as their particular micro-topographies. They depict a series of very small grooves and ridges, and the walls situated towards the centre have a comparably low angle.

Find number: DA 4284

Context: al-Maysar 1, Structure 3, in the upper layers of stone debris.

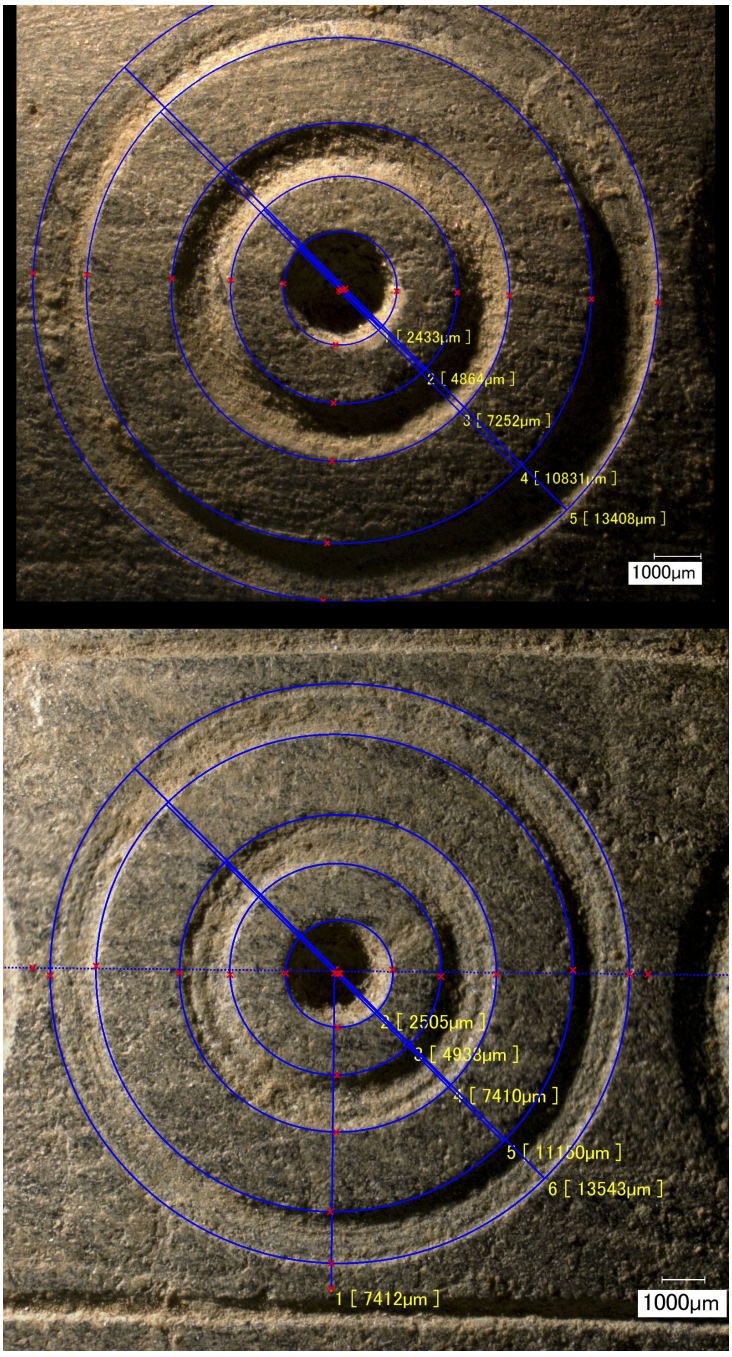

Fig. 3. Two ornaments showing the tool marks inside the grooves. Photo: Aydin Abar; CC BY-NC-SA 4.0.

Description: fragment of soft-stone vessel, mostly base sherd, coarser concentric striations visible on the inner surface, same surface highly polished to glossy.

Analyses: A number of striations (n=7), most likely on the outer surface, were detected. Their width varies between 47 µm and 70 µm, the median is 47 µm, and the mean is 57 µm with a standard deviation of ±8.6 µm. They seem comparably parallel to each other and aligned concentrically.

Find number: DA 4346

Context: al-Maysar 18, detailed context unknown.

Description: broken cylindrical soft-stone vessel with three preserved rows of dot-in-double-circle ornaments.

Analyses: Most striations on the cylindrical vessel seem to be running helicoidally along the surface. Similar traces on the flat base run parallel to each other. The striations seem to have been cut by the incisions of the dot-in-circle motifs. Measured striations on the outer surface (n=23) have a width of 46 µm to 255 µm, with a median of 96 µm, a mean of 119.4 µm, and a standard deviation of ±59.8 µm. Internal striations (n=40) have a width of 22 µm to 266 µm, with a median of 125.50 µm, a mean of 135.5 µm, and a standard deviation of ±77.8 µm. The measured dot-in-double-circle ornament has a central hole with a diameter of 2.2 mm, the small circle has an inner diameter of 4.3 mm and a width of 2.7 mm, and the outer circle has an inner diameter of 1.1 cm and a width ranging from 1 mm to roughly 2.4 mm. The ornament is fairly irregular. This may be owed to the convex surface and the resulting difficulties maintaining the tool alignment. The walls of the incision illustrate a relatively flat angle.

Find number: DA 4347

Area: unclear, probably al-Maysar 18.

Description: rim sherd of soft-stone bowl, dot-in-double-circle decoration between two horizontal grooves, macroscopically visible striations running diagonally on the outer surface, striations visible on the inner surface are far more concentric.

Analyses: The measured striations on the outer surface (n=18) (**Fig. 4, top**) have a width ranging from 113 µm to 347 µm, with a median of 192 µm, a mean of 205.8 µm, and a standard deviation of ±71.6 µm. The striations on the internal surface (n=20) (**Fig. 4, bottom**) have a width of 60 µm to 183 µm, with a median of 103.5 µm, a mean of 109.1 µm, and a standard deviation of ±37.7 µm. Marks on both surfaces differ greatly: the outer surface shows rather short but coarse ridges (median ca. 200 µm), which are either vertical or crosshatched, while the internal surface shows well-aligned traces running along the concentric axis of the bowl.

Find number: DA 4348

Context: al-Maysar 18.

Description: fragment of soft-stone bowl, rim sherd with concentric groove below the rim and a row of dot-in-double-circle motifs directly below.

Analyses: Striations on the outer surface (n=7) have a width of 62 µm to 214 µm, with a median of 98 µm, a mean of 125 µm, and a standard deviation of ±63.6 µm. Traces on the internal surface (n=11) have a width of 69 µm to 118 µm, with a median of 88 µm, a mean of 89 µm, and a standard deviation of ±13.4 µm. The inner surface shows relatively well-aligned striations in areas close to the rim: they are aligned along a concentric axis, while traces closer to the base are more chaotic. A measured dot-in-double-circle ornament has a diameter of 1.8 mm, the inner circle has an inner diameter of 3.8 mm and a width of 1.5 mm, and the second circle has an inner diameter of 8.3 mm and a width of 1.2 mm. Several dot-in-double-circle ornaments were cut by the horizontal groove running slightly below the rim.

Find number: DA 4350

Context: al-Maysar 18, a few cm below the surface.

Description: fragment of a soft-stone bowl, base, and part of the wall.

Analyses: The striations on the outer surface (n=73) have a width of 85 µm to 218 µm, a median of 130 µm, a mean of 129.6 µm, and a standard deviation of ±27.5 µm. The inner

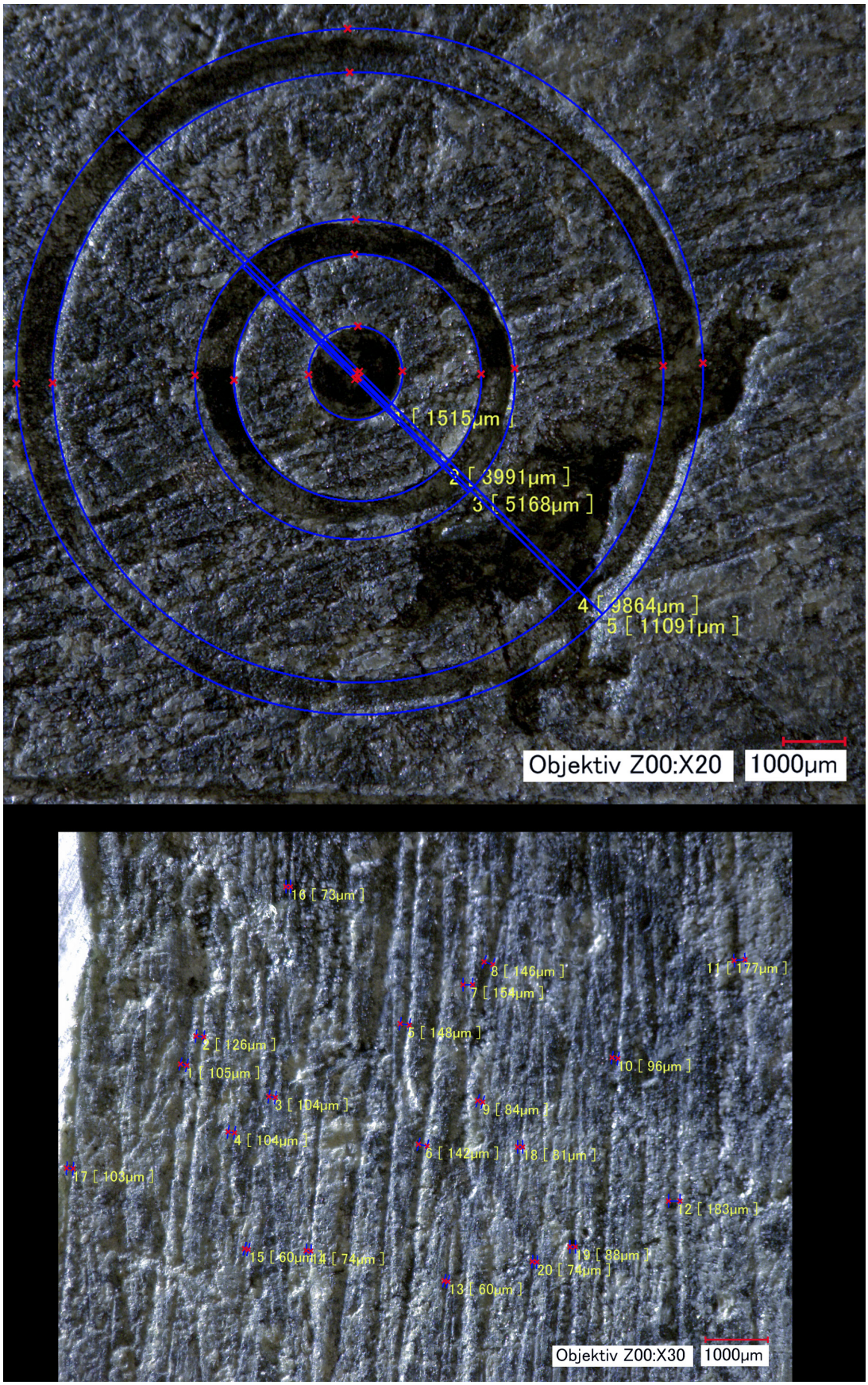

Fig. 4. Outer surfaces of the same vessel; grooves of the ornaments are cut with different angle compared to ***Fig. 3****. Photo: Aydin Abar; CC BY-NC-SA 4.0.*

surface shows striations (n=23) with a width of 138 µm to 427 µm, with a median of 213 µm, a mean of 213 µm, and a standard deviation of ±77.35 µm. The traces on the outer surface are thinner and run along the base, then curve up into the area of the wall. The internal surface shows very broad striations, which seem to run vertically down along the wall. Slightly thinner ridges run perpendicularly, but unfortunately it remains unclear whether the thin grooves are cutting the thicker ones.

Find number: DA 4472

Context: al-Maysar 18, few centimetres below the surface.

Description: fragment of box-shaped vessel with lines and double-dot-in-circle ornaments.

Analyses: The outer surface looks well-polished (**Fig. 5, top**), while the internal surface was worked to a lesser extent, still showing a number of different, partially repetitive traces (**Fig. 6**). At least four almost vertical grooves with a width of ca. 4 mm are visible, superimposed by fine striations, many of them with a width ranging between 250 µm and 400 µm. The external surface shows two perpendicular lines on two of the edges of the vessel. It very much looks as if the groove below the rim was incised first and then cut by the second, vertical groove. Although partly broken away, measuring the dot-in-double-circle ornament was possible (**Fig. 5, bottom**). The central hole has a diameter of 1.4 mm, the inner diameter of the first circle is 4.5 mm with a width of 1.6 mm, the second circle has an inner diameter of 9.3 mm and measures 1.3 mm in width. The walls of the incised ornament are angled steeply, unlike e.g. DA 4346.

Find number: DA 4724

Context: al-Maysar 1, Structure 4, Trench 20, Phase 2.

Description: fragment of decorated soft-stone bowl.

Analyses: Striations on the outer surface (n=14) have a width of 20 µm to 44 µm, with a median of 31 µm, a mean of 31.4 µm, and a standard deviation of ±6.7 µm. The inner surface shows striations (n=11) with a width of 10 µm to 174 µm, a median of 15 µm, a mean of 57 µm, and a standard deviation of ±60.5 µm. The external surface is fairly smooth, running diagonally across the surface close to the rim, while striations on the inside are rather concentrically aligned. The measured dot-in-double-circle ornament has a central drill hole with a diameter of 1.6 mm, and the first circle has an inner diameter of 3.6 mm and a width of 1.3 mm. The second circle has an inner diameter of 8 mm and a width of 1.5 mm. The angle of the incision seems steeper than in the case of DA 4346, and the central hole and the inner circle seem more deeply incised than the large circle.

Find number: DA 4737

Context: al-Maysar 1, Structure 6, Trench 29, probably in the area close to the entrance to Room 4, Phase 2.

Description: base fragment of a round soft-stone box, decorated with incised horizontal lines.

Analyses: Of particular interest are the internal traces of the base. The most prominent trace is a hole in the base with a diameter of approximately 2.7 mm (**Fig. 7**), which has an almost circular flaking on the outer surface. It seems viable to interpret these traces as an accidental punch-through from the inside during production, resulting in the conical flaking on the outer surface as a result of the kinetic energy and the typical spread of shock waves. Further, deeper grooves with widths between 0.9 mm and 1.4 mm are visible, two of them leading roughly into the direction of

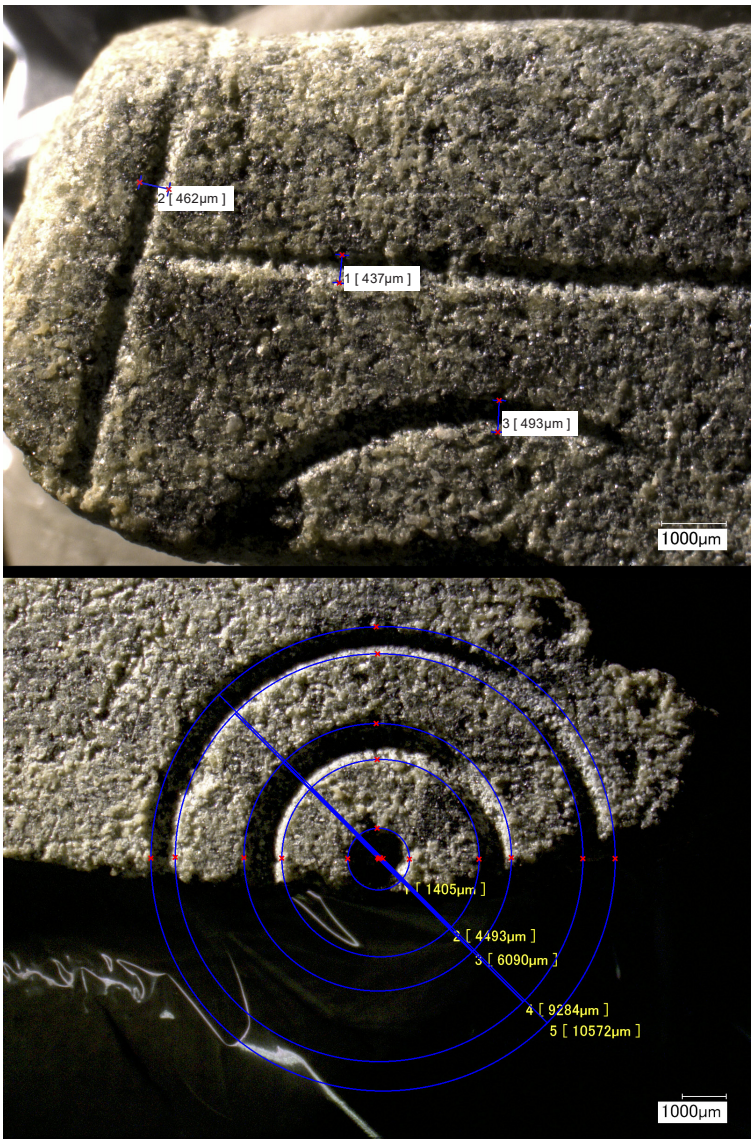

Fig. 5. Outer surfaces of box. Photo: Aydin Abar; CC BY-NC-SA 4.0.

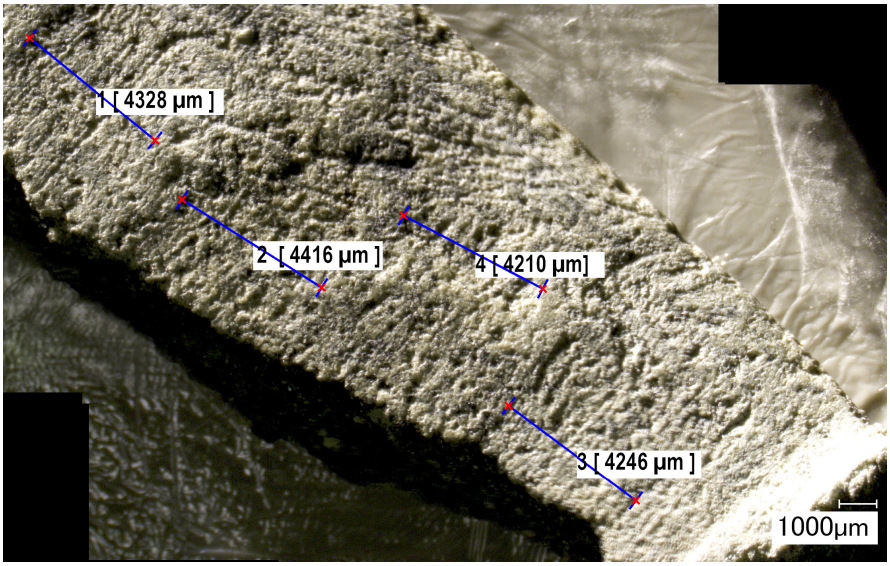

Fig. 6. Internal surface of box showing different tool marks and striations. Photo: Aydin Abar; CC BY-NC-SA 4.0.

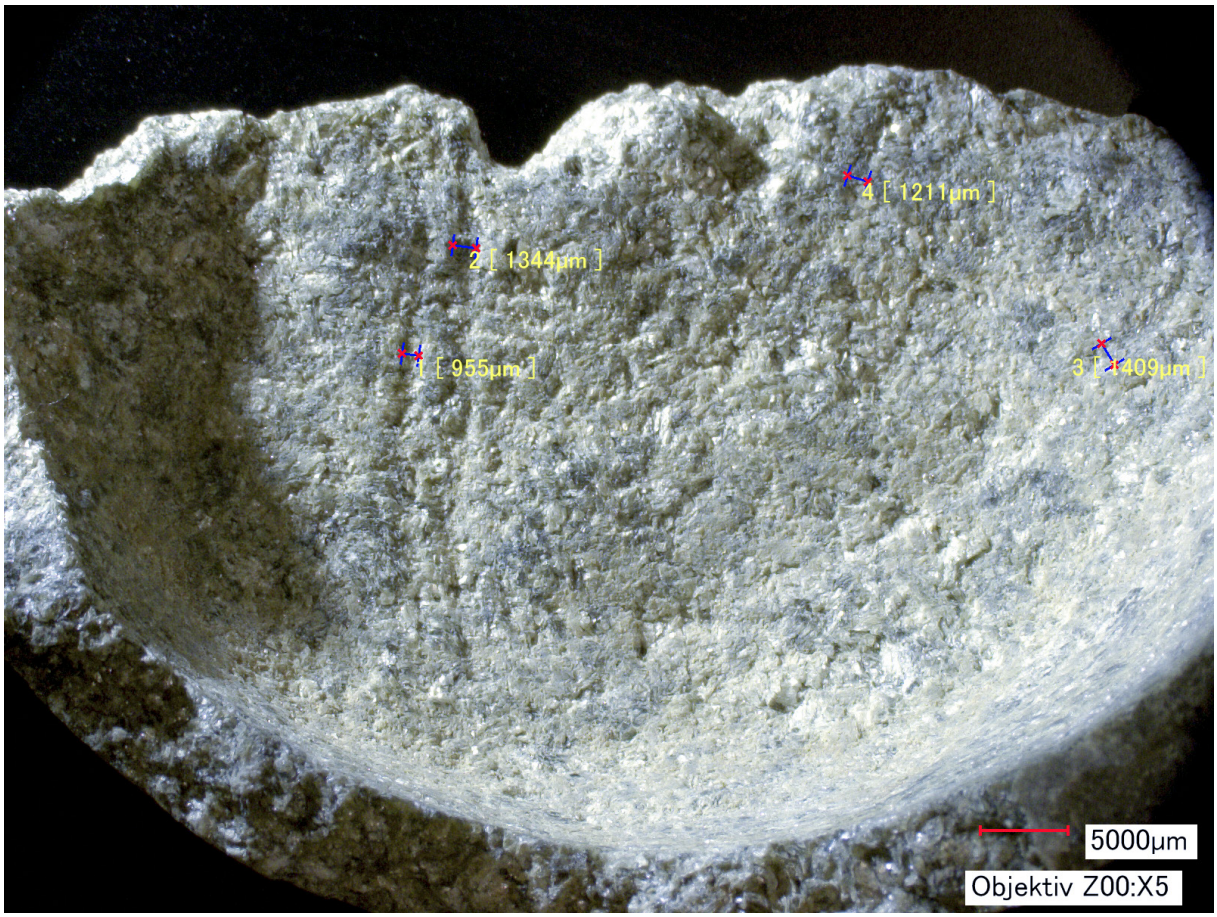

Fig. 7. View on the inner part of the base with different tool marks. Photo: Aydin Abar; CC BY-NC-SA 4.0.

the hole. This might be indicative of one of the tools in use, which most likely has been some sort of an awl used with an indirect percussive technique.

Find number: DA 4762

Context: al-Maysar 1, Structure 6, Trench 28, Room 3, Phase 1, the object was found below the actual structure, belonging to a phase with many fire settings.

Description: rough-out of a small soft-stone vessel with multiple traces on both surfaces.

Analyses: Both surfaces show clear signs of systematic shaping. The traces on the outer surface (n=6) have a width between 1.9 mm and 3.86 mm, the median is 3.23 mm, and the mean 3.0 mm with a standard deviation of ±0.7 mm. The grooves on the inner surface (n=8) range between 1.95 mm and 3.79 mm, the median is 3.03 mm, and the mean 2.94 mm with a standard deviation of 0.58 mm. Grooves on the outer surface run concentrically around the vessel (**Fig. 8, top**) and the appearance of tool marks suggest that the flaking was conducted horizontally and not from the rim towards the bottom. The same holds true for most marks on the internal surface (**Fig. 8, bottom**); only in the central area do marks run in the direction of the vessel centre and not concentrically.

Find number: DA 5280

Context: al-Maysar 1, Structure 20, Trench TT3, surface.

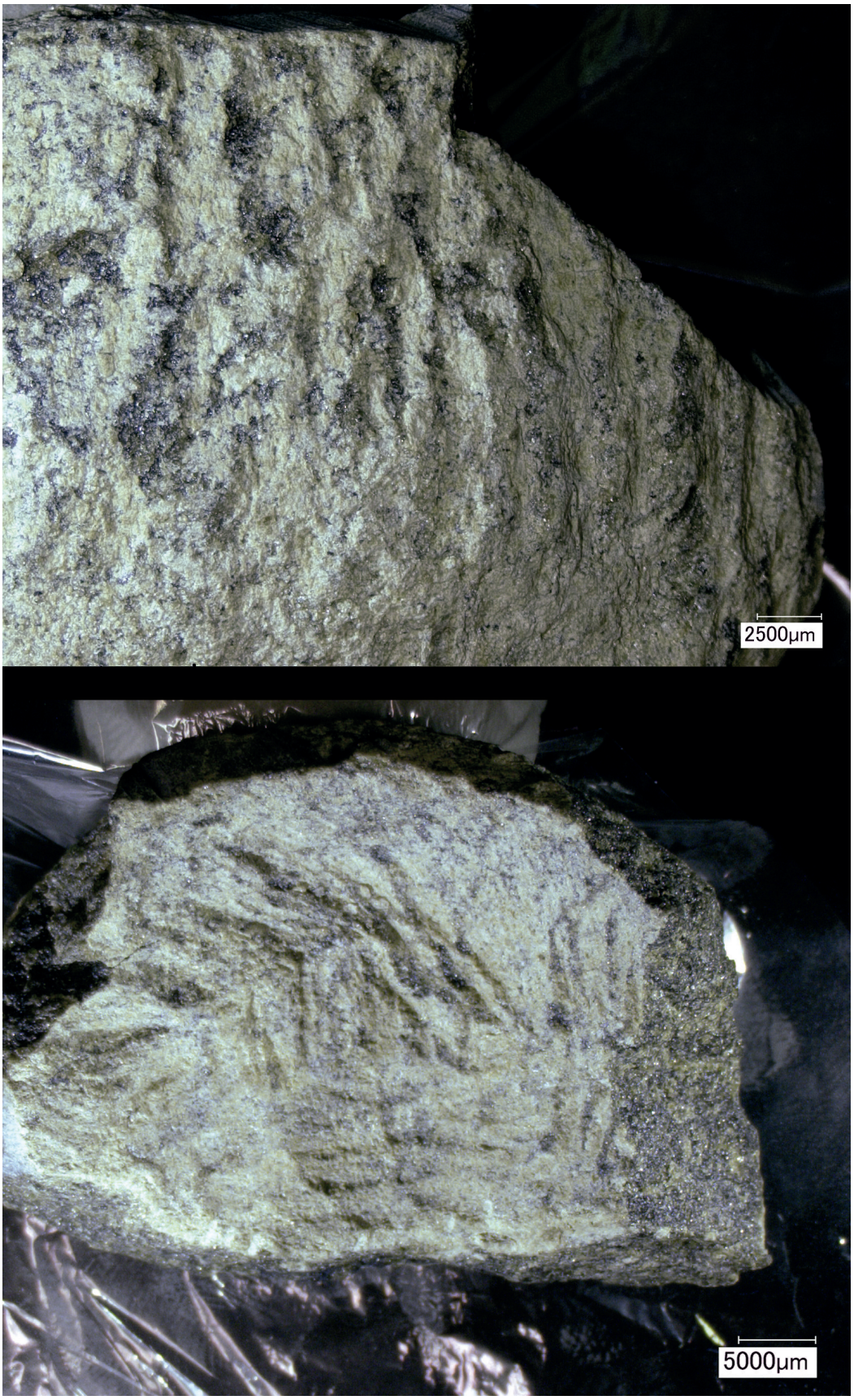

Fig. 8. Top: outer surface with tool marks; bottom: internal surface with tool marks. Photo: Aydin Abar; CC BY-NC-SA 4.0.

Description: truncated soft-stone cone with different work traces (**Fig. 9**).

Analyses: The lateral surface of the cone shows several tool marks ranging from 10 mm to 30 mm that reach from the tip down to the base. The slightly concave surface of the base shows a large number of pick marks covering the whole surface.

Find number: no find number, object from Hili, UAE

Context: Hili, Al Ain, no further information.

Description: the sample from the archives of the DBM must have come from Hili. Unfortunately, the background remains unclear, but one assumption is that Serge Cleuziou might have given a sample to Gerd Weisgerber.

Analyses: Striations on the outside surface (n=56) have a width of 7 µm to 175 µm, with a median of 34.5 µm, a mean of 38.4 µm, and a standard deviation of ±28.9 µm. Internal striations (n=29) have a width of 10 µm to 459 µm, with a median of 44 µm, a mean of 86.4 µm, and a standard deviation of ±108.3 µm. Very particular is the observation that the horizontal ornamental groove above the dot-in-double-circle ornaments seems to consist of short segments strung together with intersection points in the final section of the lines (**Fig. 10**).

Discussion

Dot in double circle

Reviewing the 20 measured double-dot-in-circle ornaments, the central drillings have a range between 1.41 mm and 2.53 mm, with a median and mean around 2.04 mm, and a standard deviation of ±0.31 mm. The inner diameters of the inner circles range from 3.61 mm to 5.52 mm, the median is 4.64 mm, and the mean is 4.56 with a standard deviation of ±0.60 mm. The width of the inner circles ranges from 0.91 mm to 3.08 mm, the median is 1.53 mm, and the mean is 1.7 mm with a standard deviation of ±0.63 mm. The second circles range from 7.64 mm to 11.15 mm, with a median of 10.31 mm, a mean of 9.86 mm, and a standard deviation of ±1.14. The width of the outer circle ranges from 0.82 mm to 2.64 mm, the median is 1.5 mm, and the mean is 1.58 with a standard deviation of ±0.49mm.

The general regularity of the ornaments indicates that they were cut into the surfaces by the use of a tube drill, or centre drill, as already proposed by David-Cuny and Azpeitia (2012). The overall variability indicates that the exact shape of the tool might have varied. Traces on the specimen from Hili might rather suggest an adjustable tool in the shape of a compass. Variation is definitely less extensive if we look at ornaments on the same vessel, but even there we have some degree of variability. The variations described regarding the steepness or flatness of the sides point in the same direction. Together, these details make it probable that the incising elements of the tool were not too rigidly fixed inside a supposed handle; it is in any case unlikely that we are searching for a fixed system. The centre drill had to be moved several times, in many instances leaving a relatively rough topography inside the incision. The construction of the tool might be similar to what David-Cuny and Azpeitia (2012, 25) have proposed, but one could also think of small flint flakes having been hafted, both at the same time or as part of different workshop traditions.

Coarse surface traces

In a few cases coarse traces are visible on the surface. Four vessels offer the opportunity to analyse them: the cone DA 5280, the large rough-out DA 2131, the small semi-finished vessel DA 4762, and the box-fragment DA 4737. The coarsest marks are visible on DA 5280, with marks ranging from 10 mm to

Fig. 9. Rough-out with several tool marks, particularly on the upper left surface. Photo: Aydin Abar; CC BY-NC-SA 4.0.

Fig. 10. Overlapping cut-marks of horizontal groove. Photo: Aydin Abar; CC BY-NC-SA 4.0.

40 mm along the cone surface. The marks are clean as if made by a very flat and sharp-edged tool. The reverse side shows a large number of pick marks. The other three objects show marks ranging from 1.95 to 5.3 mm. In the case of DA 4762, the traces cover the outer surface concentrically, while on the inside the traces are slightly diagonal along the wall. A sharp change of direction is visible at the base, where the traces cover the surface parallel to each other.

Striations on the surfaces

Striations found on the surfaces of the vessels are the outcome of thorough contact between the surface and abrasive materials. While striations can potentially emerge at every stage from production to use and discard – even post-deposition – it seems that the most frequent striations range between 50 µm and 150 µm, which according to ISO 14688-1:2017 (International Organization for Standardization [ISO] 2017) falls into the range of coarse silt to fine sand. Considering this trend, it is a feasible hypothesis to assume that most striations are actually traces of an intentional smoothing process. This is further substantiated by the observation that most striations are aligned in patterns: rougher traces tendentially can be found aligned diagonally from the rim towards the base, while fine grained striations are more frequently horizontal and concentric. If we accept that the alignment of striations is related to the direction of movements of an abrasive surface against the surface to be smoothed, it seems further feasible to assume that long diagonal striations are related to abrasion from a solid surface (e.g. the movement of a ground stone over the surface, or the movement of the vessel surface over a ground stone). On the other hand, fine striations, particularly those inside the vessel, need another explanation. It is possible that sand and silt of a certain grain size was distributed on a piece of fur or leather, which then was used to smooth the surface.

Paths of production

Based on the evidence of the marks and the work conducted by Harrower et al. (2016), I propose the following paths of production, and will also hypothesise about the tools used:

The first important step was the production of a rough-out of the object desired. Based on the traces visible on DA 5280, I assume that possibly a copper adze with a cold hammered and hardened edge was used, similar to the object first published by Weisgerber (1980, 107, Fig. 78: 5 and 11). Stone tools were used to flatten other areas simultaneously, as the pick marks on DA 5280 indicate. Finer work both on the outer and inner surface was then conducted by the use of a chisel, which could have been made from copper (Weisgerber 1980, 107, Fig. 78: 6), but we should not prematurely rule out the use of flint tools. The traces differ from what Kohl has described based upon the objects at Tepe Yahya: in their case the shaping was conducted vertically from the rim towards the base, while in the case of the samples from al-Maysar, objects were shaped concentrically. At a certain point the producers changed to smoothing the surface. There are indications of both rough and fine smoothing, and a feasible assumption is that rough smoothing was conducted with a ground stone tool, producing short diagonal, sometimes crosshatched striations. Fine smoothing, in contrast, was conducted with sand of different grain sizes, leading to which might have implied the use of a piece of leather, onto which the sandy material was placed. The very last step was then the application of surface decoration in the shape of incised bands of dot-in-double-circle ornaments. David-Cuny and Azpeitia's (2012, 25) argument that a centre drill was used is very convincing and supported by all the samples I have reviewed to date. It remains an open question whether the motifs were encrusted or coloured with pigments. Several dot-in-double-circle ornaments were cut by concentric grooves below the rim, as well as between and

below them, indicating that these were the last to be applied. Some traces support the idea that a lathe was used, as the concentric lines look relatively straight. In a number of cases the end and the beginning of the lines do not match, but run parallel to each other. On the other hand, traces similar to those inside a vessel found at the site of Khafajeh, indicating the use of a lathe (Kohl 2001, 215), are not exhibited on any piece.

Conclusion

The approaches chosen by those who lived at al-Maysar show that they knew how to handle soft-stone as a raw material, by mastering a broad range of techniques and selecting between various tools to shape all sorts of objects. They had the necessary skills to fraction fine sediments into different grain sizes, a technique which also plays a role in the preparation of clays, such as those used for example for the very fine pottery typical for the closing centuries of the 3rd millennium BCE. The outcome was not always flawless, exemplified by several dot-in-double-circle ornaments that were not perfectly cut, but neither was it of utmost importance to avoid cutting them when applying concentric grooves.

The example from Hili (UAE) should be taken as a starting point to question whether objects were made using other techniques and tools at other sites in Southeast Arabia. If so, it might be possible to discern different craft traditions, which were so far indistinguishable from the drawings and photos published of such vessels so far. From this perspective I assume there is a good chance that similar studies on objects found in Mesopotamia and elsewhere might allow us to understand their provenance on the basis of (still to be reconstructed) production regions. This hypothesis is substantiated by the differences noted above between the samples I have studied and the traces on the samples from Tepe Yahya presented by Kohl.

A problem that I would like to tackle in the future, which is closely related to what Calandra and colleagues previously described (2019, 3), is the question of the comparability of measurements made at different magnification scales, which could put into question the measurements taken with the Keyence and the work-flow described previously.

Following the work conducted so far, I recommend the above as a first hypothesis for more thorough work to follow, which should include experiments to understand the material characteristics. The next step would be to return to the archaeological samples to better discern between the plethora of surface traces visible at different magnifications, asking which traces the usage of copper chisels would leave on the surface in comparison to flint tools, which traces ground stone tools would leave on the surface, and to which extent the use of leather and sand would leave marks similar to the noted striations. Further analytical methods to be applied include fine grained laser scans and the use of confocal microscopy in the case of very fine striations. Eventually, the analysis of traces on a set of experimental replicas might also provide important insights.

Work based on experiments and traceology analyses should also be expanded to ground stone tools (Dubreuil et al. 2015), which so far have been heavily understudied and only marginally published, not only in the case of the Southeast Arabian Peninsula, though these have to be considered essential in the processing of very different raw materials, be it crops or minerals and pigments. Along these more obvious usages one might also ask whether ground stone tools were used in the context of the surface treatment of beads and soft-stone vessels, and the processing of hide, leather, or bone (Bofill and Taha 2013; Hamon 2008).

This work wants to be only a first step towards a different approach to soft-stone

objects, which I consider a worthwhile endeavour that will allow for reflection and shed new light on old questions ranging from issues regarding production techniques to questions of provenance and dispersion.

References

Abar, Aydin. In preparation. *Beyond the Extacy of Copper. The Bronze Age Dwellers of al-Maysar*. Bochum: Deutsches Bergbau Museum.

Azzarà, Valentina M., and Alexandre P. De Rorre. 2018. "Socio-Cultural Innovations of the Final Umm an-Nar Period (C.2100–2000 BCE) in the Oman Peninsula: New Insights from Ra's Al-Jinz RJ-2." *Arabian Archaeology and Epigraphy* 29: 10–26. DOI: 10.1111/aae.12095.

Biagi, Paolo, Wolfgang Torke, Maurizio Tosi, and Hans-Peter Uerpmann. 1984. "Qurum: A Case Study of Coastal Archaeology in Northern Oman." *World Archaeology* 16 (1): 43–61.

Bofill, Maria, and Buchra Taha. 2013. "Experimental Approach to Hide-Processing: Tasks Combining the Use of Bone and Basalt Tools: The Neolithic Case of Tell Halula (Middle Euphrates Valley, Syria)." In *Experimentación en arqueología: Estudio y difusión del pasado*, edited by Antoni Palomo, Raquel Piqué y Huerta, and Xavier Terradas Batlle, 45–55. Girona: Museu d'Arqueologia de Catalunya.

Calandra, Ivan, Antonella Pedergnana, Walter Gneisinger, and João Manuel Marreiros. 2019. "Why Should Traceology Learn from Dental Microwear, and Vice-Versa?" *Journal of Archaeological Science* 110: 1–6. DOI: 10.1016/j.jas.2019.105012.

Cleuziou, Serge. 1989. "The Chronology of Protohistoric Oman as Seen from Hili." In *Oman Studies: Papers on the Archaeology and History of Oman*, edited by Paolo M. Costa and Maurizio Tosi, 47–78. Serie Orientale Roma 63. Rome: IsMEO.

Coppa, Alfredo, Roberto Macchiarelli, Sandro Salvatori, and Geraldina Santini. 1985. "The Prehistoric Graveyard of Ra's Al-Hamra (RH5): (A short preliminary report on the 1981-83 excavations)." *Journal of Oman Studies* 8 (1): 97–102.

David, Hélène. 1991. "A First Petrographic Description of the Soft Stone Vessels from Shimal." In *Golf-Archäologie: Mesopotamien, Iran, Kuwait, Bahrain, Vereinigte Arabische Emirate Und Oman*, edited by Klaus Schippmann, Anja Herling, and Jean-François Salles, 173–78. Buch am Erlbach: Leidorf.

David, Hélène. 1996. "Styles and Evolution: Soft Stone Vessels During the Bronze Age in the Oman Peninsula." *Proceedings of the Seminar for Arabian Studies* 26: 31–46.

David, Hélène. 2002. "Soft Stone Mining Evidence in the Oman Peninsula and Its Relations to Mesopotamia." In *Essays on the Late Prehistory of the Arabian Peninsula*, edited by Serge Cleuziou, Maurizio Tosi, and Juris Zarins, 317–35. Serie Orientale Roma 93. Rome: IsIAO.

David, Hélène, and Carl. S. Phillips. 2008. "A Unique Stone Vessel from a Third Millennium Tomb in Kalba." In *Intercultural Relations Between South and Southwest Asia: Studies in Commemoration of E. C. L. During Caspers (1934 - 1996)*, edited by Eric Olijdam and Richard H. Spoor, 118–23. Oxford: Archaeopress.

David, Hélène, Monique Tegyey, Joël Le Métour, and Robert Wyns. 1990. "Les vases en chloritite dans la péninsule d'Oman : une étude pétrographique appliquée à l'archéologie." *Comptes-Rendus de l'Académie des Sciences, Paris* 31 (1): 951–58.

David-Cuny, Hélène, and Johanne Azpeitia. 2012. *Failaka Seals Catalogue. Vol. 1, Al-Khidr*. Kuwait City: National Council for Culture, Arts and Letters.

Dubreuil, Laure, Daniel Savage, Selina Delgado-Raack, Hugues Plisson, Brigitta Stephenson, and Ignacio de la Torre. 2015. "Current Analytical Frameworks for Studies of Use-Wear on Ground Stone Tools." In *Use-Wear and Residue Analysis in Archaeology*, edited by João M. Marreiros, Juan F. Gibaja Bao, and Nuno Ferreira Bicho, 105–58. Cham: Springer.

Hamon, Caroline. 2008. "Functional Analysis of Stone Grinding and Polishing Tools from the Earliest Neolithic of North-Western Europe." *Journal of Archaeological Science* 35 (6): 1502–20. DOI: 10.1016/j.jas.2007.10.017.

Harrell, James A., and V. Max Brown. 2008. "Discovery of a Medieval Islamic Industry for Steatite Cooking Vessels in Egypt's Eastern Desert." In *New Approaches to Old Stones: Recent Studies of Ground Stone Artifacts*, edited by Yorke M. Rowan and Jennie R. Ebeling, 41–65. London: Equinox.

Harrower, Michael J., Hélène David-Cuny, Nathan Smiti, Ioana A. Dumitru, and Suleiman al-Jabri. 2016. "First Discovery of Ancient Soft-Stone (Chlorite) Vessel Production in Arabia: Aqir Al-Shamoos (Oman)." *Arabian Archaeology and Epigraphy* 27: 197–207.

Häser, Jutta. 1990. "Soft-Stone Vessels of the 2nd Millennium B.C. in the Gulf Region." *Proceedings of the Seminar for Arabian Studies* 20: 43–54.

Häser, Jutta. 1991. "Soft-Stone Vessels (1) from Shimal and Dhayah/Ras Al-Khaimah, U.A.E." In *Golf-Archäologie: Mesopotamien, Iran, Kuwait, Bahrain, Vereinigte Arabische Emirate und Oman*, edited by Klaus Schippmann, Anja Herling, and Jean-François Salles, 221–32. Buch am Erlbach: Leidorf.

International Organization for Standardization [ISO]. 2017. "Geotechnical Investigation and Testing – Identification and Classification of Soil." ISO 14688-1:2017. https://www.iso.org/standard/66345.html. Accessed 25.12.2019.

Kohl, Philip L. 1974. "Seeds of Upheaval: The Production of Chlorite at Tepe Yahya and an Analysis of Commodity Production and Trade in Southwest Asia in the Mid-Third Millennium." PhD diss., Harvard University.

Kohl, Philip L. 2001. "Reflections on the Production of Chlorite at Tepe Yaha: 25 Years Later." In *Excavations at Tepe Yahya, Iran, 1967-1975. Vol. 3, The Third Millennium*, edited by Carl C. Lamberg-Karlovsky and Daniel T. Potts, 209–30. Cambridge, MA: Harvard University Press.

de Miroschedji, Pierre. 1973. "Vases et objets en stéatite susiens du Musée du Louvre." *Cahiers de la DAFI* 3: 9–50.

Oudorová, Anna-Marie. 2019. "The Study of Two Grooved Stones from Late Pre-Pottery Neolithic Sites Ba'ja and Basta (Jordan): A Biographical Approach." BA thesis, Masaryk University.

Possehl, Gregory L. 2007. "The Middle Asian Interaction Sphere." *Expedition. The University Museum Magazine of Archaeology and Anthropology University of Pennsylvania* 49 (1): 40–42.

Potts, Daniel T. 2001. "Situating Tepe Yahya in Time and Space." In *Excavations at Tepe Yahya, Iran, 1967-1975. Vol. III: The Third Millennium*, edited by Carl C. Lamberg-Karlovsky and Daniel T. Potts, 195–207. Cambridge, MA: Harvard University Press.

Usai, Donatella. 2018. "Middle Holocene Omani Jewels: Thoughts on the Production of Softstone Earrings." In *Softstone: Approaches to the Study of Chlorite and Calcite Vessels in the Middle East and Central Asia from Prehistory to the Present*, edited by Carl. S. Phillips and St John Simpson, 55–61. Oxford: Archaeopress.

Weisgerber, Gerd. 1980. ""… Und Kupfer in Oman": Das Oman-Projekt des Deutschen Bergbau-Museums." *Der Anschnitt* 32 (2–3): 62–110.

Woolley, Charles Leonard. 1934. *The Royal Cemetery: A Report on the Predynastic and Sargonid Graves Excavated Between 1926 and 1931*. New York: Carnegie Corp.