



HAL
open science

**An integrated approach based on archaeometry,
use-wear analysis and experimental archaeology to
investigate the function of a specific type of basin
diffused in the Predynastic sites of lower Egypt (4th
mill. BC)**

Jade Bajeot, Isabella Caricola, Laura Medeghini, Vittorio Vinciguerra,
Vanessa Forte

► **To cite this version:**

Jade Bajeot, Isabella Caricola, Laura Medeghini, Vittorio Vinciguerra, Vanessa Forte. An integrated approach based on archaeometry, use-wear analysis and experimental archaeology to investigate the function of a specific type of basin diffused in the Predynastic sites of lower Egypt (4th mill. BC). *Quaternary International*, 2020, pp.135-149. 10.1016/j.quaint.2020.03.023 . hal-03129316

HAL Id: hal-03129316

<https://hal.science/hal-03129316>

Submitted on 26 Sep 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

An integrated approach based on archaeometry, use-wear analysis and experimental archaeology to investigate the function of a specific type of basin diffused in the Predynastic sites of Lower Egypt (4th mill. BC)

Jade Bajeot¹, Isabella Caricola², Laura Medeghini³, Vittorio Vinciguerra⁴, Vanessa Forte⁵

¹ University of Toulouse 2 Jean Jaurès, UMR 5608 TRACES, Toulouse, France.
jadebajeot@gmail.com

² Newcastle University, School of History, Classics and Archaeology, Newcastle Upon Tyne, United Kingdom.

isabella.caricola@newcastle.ac.uk

³ Department of Earth Sciences, Sapienza University of Rome, Rome, Italy.
laura.medeghini@uniroma1.it

⁴ DIBAF, University of Tuscia, Viterbo, Italy.
vincigue@unitus.it

⁵ Laboratory of Technological and Functional Analyses of Prehistoric Artefacts (LTFAPA), Sapienza University of Rome, Rome, Italy.
vanessa.forte@uniroma1.it

Abstract

This paper focuses on the functional analysis of a specific oval shaped basin diffused in Lower Egyptian Predynastic sites during the first half of the 4th millennium BC. These oval shallow ceramic basins are characterised by a flat and wide inner surface that is covered by a layer of small rock fragments pressed into the clay matrix. Several archeologists have interpreted them as grinding tools, but the limited number of samples unearthed thus far and their poor state of preservation made this interpretation uncertain. Here we present the results of a preliminary integrated study based on the combination of experimental archaeology and petrographic, use-wear and residue analyses carried out on two samples from the Predynastic site of Maadi. The use-wear analysis of the archaeological fragments highlighted traces of an intentional grinding and light pounding of oily substances, which is also partially supported by the organic residue investigation. These results were tested through experimental tests that confirmed these basins are most likely mortars.

Establishing the actual functional activities performed in such a unique type of vessel is important not only for understanding the social behaviors of the Lower Egyptian Predynastic communities and the dynamics related to the diffusion of such basins, but it also provides a new methodological framework for Egyptian Predynastic studies.

Keywords: *Predynastic Egypt; Lower Egyptian Culture; pottery; use-wear analysis; residue analysis; experimental archaeology*

1. Introduction

Over the last thirty years, the efforts of archaeologists specialised in Predynastic Egypt have been focused on the Nile Delta with the aim of characterizing Lower Egyptian Culture (from this point forward LEC) and to evaluate its role in the process of homogenization of the

material culture and social structure that interested the whole Egyptian territory immediately preceding the birth of the Egyptian State at the end of the 4th mill. B.C. Several excavations and surveys have been carried out at various sites, such as Maadi (Rizkana and Seeher, 1987, 1988, 1989, 1990; Hartung et al., 2003; Bajeot, 2017), Kom el-Khilgan (Midant-Reynes and Buchez, forthcoming), Minshat Abu Omar (Kroeper and Wildung, 1994), Tell Ibrahim Awad (Brink van den, 1992) and Tell el-Kanater (Levy and Brink van den, 2002), and many others are still underway (Tell el-Fara'in/Buto - Von der Way, 1997, Faltings, 2002, Faltings and Köhler, 1996; Tell el-Iswid - Midant-Reynes and Buchez, 2014; Tell el-Samara – Guyot, 2016; Tell el-Farkha - Chłodnicki and Geming, 2012, Ciałowicz et al., 2018; Sais/Sa el-Hagar - Wilson et al., 2014).

The picture that has emerged from the analysis of the ceramic material retrieved in the oldest layers (Buto Ib-IIb) of the LEC sites is that of a domestic production related to daily tasks (processing and use of edible and non-edible substances, storage and transport) (Köhler, 1997; Guyot, 2015: 9; Bajeot, 2017: 93; Bajeot and Roux, 2019; Hartmann, in press). According to Bajeot and Roux 2019, local pottery was manufactured with only one type of fabric, made with Nile silt tempered with plant remains and insufficiently kneaded, as evidenced by the large voids that characterise the matrix. The recorded finishes are two: a burnishing treatment or a thin clay slip applied with the hands. Each of these surface treatments is limited to a specific range of forms. The typology is represented by a large variety of shapes that could satisfy all the needs of the community, highlighting a certain degree of specialisation of forms (in conjunction with a finish) on the basis of their function; however the variability of shapes within the same type points to a non-standardised production attributable to a household environment.

On the occasion of a recent resuming of the unpublished records of the Italian excavations carried out in the Lower Egyptian site of Maadi (Cairo), a particular type of basin has attracted attention within these ceramic assemblages (Bajeot, 2017). These are large open vessels characterised by an oval and shallow shape with a large diameter (normally about 70 cm), straight short walls and a simple rim (Fig.1). The internal and external surfaces are covered by a slip of fine clay and the inner surface is burnished (Bajeot and Roux, 2019: 169-170; Fig.6.f). Their peculiarity derives from the presence of a dense layer of small rock fragments located on the internal clay surface; they are absent in the matrix and seem to have had a functional purpose. The chronological distribution of these vessels is very limited as they seem to appear during the phase Buto Ib and disappear during Buto IIa (Buto Ib-IIa correspond to Naqada IIA/B). Up to now they have only been found in the settlements where these phases have been documented: in Maadi, located in Cairo (Rizkana and Seeher, 1987: 42; Hartung et al., 2003: 183; Bajeot, 2017: 86, 196), Tell el-Fara'in/Buto in the western Delta (Faltings, 2002: 107; Hartmann, in press), as well as in Tell el-Iswid (Bajeot and Roux, 2019: 169-170) and Tell el-Samara (F. Guyot, personal communication), which are both situated in the eastern Delta (Fig.2).

FIG.1

These oval-shaped basins are very typical of the LEC and, with the exception of the four abovementioned sites, nothing similar exists in Egypt, neither during the Predynastic nor the pharaonic times. The closest comparisons found thus far are the so-called Mesopotamian

“husking trays”; Greek, Etruscan and Roman pottery mortars; a particular pot still in use in rural Southern India; and a type of mortar still used in Ghana.

The “husking trays” are large, shallow and oval open vessels whose internal surface is covered with different patterns of impression and/or incisions. A rare variant with tiny rock fragments pressed into the internal surface, very similar to our basins, has been found in the Neolithic site of Tell Sabi Abyad in Siria (Nieuwenhuyse et al., 2010: Fig.2). The old interpretation of these vessels as trays for husking cereals has been recently abandoned in favour of the theory that sees them as pans for baking bread. The incisions and rock fragments are considered an expedient to keep the bread from sticking to the surface (Voigt, 1983: 59; Nieuwenhuyse 2008: 117; Taranto, *in press a-b*).

In Greek, Etruscan and Roman cultures, pottery bowls and basins characterised by an internal surface strewn with small rock fragments are well known. These pots were mortars used for pounding soft food for the preparation of dips, pastes and doughs (for Greek and Etruscan mortars see: Matteucci, 1987 and Villing and Spataro, 2009; for the Roman mortars see: Cramp et al. 2011).

The Indian exemplary is diffused in rural contexts of Southern India and consists of a cooking pot called *ralla catti* that has stone fragments fixed on the inner surface. These pots are still part of the household kit today and are used to cook and then mash lentils or spinach (Roux, 2003: 769-770).

The Ghanaian grinding bowls, called *apotoyewaa* or *asanka*, are large rounded bowls with a pattern of grooves on the internal surface. These vessels still constitute a basic tool for the Ghanaian kitchen and are employed to crush vegetables and liquids with a pestle to obtain pastes and sauces (<http://ceramicsinghana.blogspot.it/2012/09/mpraeso.html>).

With regards to the LEC basins, even though their function is currently unclear some hypotheses have been proposed: Menghin and Amer (1932: 26) and, later, Rizkana and Seeher (1987:42; Pl.53), the first archaeologists to find and study these specimens at Maadi, assumed that they could be “grinding bowls” for processing soft material, probably of organic origin. Conversely, on the basis of comparisons with the Mesopotamian “husking trays”, the shallow shape and the flat and large bottom covered with stone fragments could also be connected to bread baking. The lack of a shared and verified hypothesis regarding the function of these vessels led the authors to analyse two fragments of these basins that came from the site of Maadi in order to test the main functional hypotheses and provide a final interpretation based on a scientific investigation.

This research, based on petrographic, use-wear and residue analyses integrated with experimental archaeology, has provided the opportunity to build, define and test the multidisciplinary approach adopted here, and to possibly develop and apply it in future projects. This represents a novelty in the study of Predynastic Egypt; in this field, use-wear analysis and experimental archaeology are still in their beginning stages and have mostly been limited to lithic materials (Mazzucco, 2016; Nagaya, 2015).

FIG.2

2. Materials and Methods

2.1 Archaeological materials

The analysed samples are two fragments coming from the site of Maadi and stored in the Museo delle Origini of the Sapienza University of Rome. They were collected for analytical

purposes during the archaeological excavations carried out in Maadi by an Italian expedition led by S. M. Puglisi from the Sapienza University of Rome at the end of the 1970s (Caneva, et al. 1989; Bajicot, 2017). Both ceramic samples are peripheral fragments of bases with part of the wall (Fig.3). The external surfaces are corroded, but the inner ones still preserve traces of the slip and of the burnishing; the burnishing is limited to the internal walls, where the stone fragments characterising the internal base of the basin are absent.

FIG.3

2.2 Methods

Fragments of these basins have recently been found in other sites of the Nile Delta but unfortunately, apart from typological and technological studies, it was not possible to carry out archaeometric and use-wear analyses on them; furthermore, the small number of fragments retrieved thus far have completely eroded surfaces making use-wear analysis impossible. The limited number of archaeological fragments available for the investigation led the authors to build a dedicated methodological framework in order to collect as much data as possible regarding the activities that were possibly performed with these vessels. For this reason, the ceramic fragments have been subjected to archaeometric and use-wear analyses with the aim of defining their technological features and of tracking the traces left behind by functional activities such as use-wear and residues. The multiple analyses were integrated with a dedicated experimental framework due to the necessity of identifying not only which elements have come into contact with the basins, but also the type of processing to which they have been subjected.

2.2.1 Petrographic analysis in thin section

A thin section was obtained from Sample 2 and analysed by optical microscopy in thin section. Petrographic analysis was performed using a ZEISS D-7082 Oberkochen polarizing microscope (Department of Earth Science, Sapienza University of Rome) following the Whitbread (1986, 1995) criteria. Inclusions, matrix and pores, the three main components of ceramics, are considered and described. In particular, the study of inclusions is based on the description of their frequency (predominant, dominant, frequent, common, few, very few, rare, very rare), grain size (maximum dimension in mm), distribution, shape (elongated, rounded), roundness (very angular, angular, sub-angular, sub-rounded, rounded, well-rounded), mean distance among inclusions (close, single and open-spaced) and alignments. The pores are classified based on their shape (planar, channels, *vughs* and vesicles), frequency, size (mega, macro, meso and micro) and alignment. Finally, the matrix is described in colour and the optical activity is also discussed. The petrographic results have been useful for choosing proper raw materials for the experimental replica and for collecting general information regarding the range of temperatures.

2.2.2 Use-wear analysis on ceramic and rock fragments

An integration of use-wear analysis on ceramic and lithic surfaces – a non-destructive analysis – was necessary due to the variety of materials that comprise the vessels studied. The archaeological and experimental surfaces (ceramic and rock fragments) were analysed through optical microscopy (OM), optical light microscopy (OLM) and scanning electrical

microscopy (SEM) in order to define, compare and interpret the alterations caused by use activities.

The ceramic surfaces of the archaeological and experimental vessels (1 and 2) were observed using a Nikon SMZ-U stereo microscope, with 1x objective, 10x eyepiece and magnifications from 0.75x to 7.5x. Use-wear analysis was applied following Skibo (1992) and Forte et al. (2018) criteria in order to localise surface alterations associated with function and identify the patterns of use-wear that could suggest which activities were likely carried out using this specific kind of vessel.

The archaeological and experimental rock fragments were observed using a Zeiss Axio Zoom V16 binocular stereo microscope, oculars PI 10x/23, objective 1x/0.25 FWD 56 mm, with progressive magnifications ranging between 10x and 80x. Micro-wear investigation has been performed at a higher magnification (10-500x) through a Zeiss Scope A.1 metallographic microscope equipped with 10x oculars and with objectives ranging from 10x to 50x. The use-wear has been described following the parameters known in literature (Adams et al., 2009; Caricola et al., 2018; Hamon, 2006; Rots, 2005; Tringham et al., 1974; Van Gijn, 2010). Finally, the Scanning Electronic Microscope (SEM) was used to observe the modifications of the lithic surfaces at high resolution (Hitachi TM 3000, magnification range 15x-30.000x) for obtaining a three-dimensional image of the rock fragments and of the polishes.

The analysis of the experimental sample was carried out after it was washed with demineralised water and neutral soap (Derquim®).

We described the functional traces following the tribology based variables proposed by Adams and al. 2009. These variables are organized in four categories: adhesives (residues), fatigue (fracture, crack, pits and frosted appearance), abrasive (striation, levelling, grain edge rounding) and tribo-chemical wear (polish or sheen).

2.2.3 Organic Residue Analysis

Chemical analysis was utilised in order to identify lipid biomarkers of organic residues present in the ceramic samples from Maadi. Lipids were analysed using gas chromatography-mass spectrometry (GC-MS), which is a very useful technique for establishing the presence of specific foods stored or otherwise contained in ceramic and lithic vessels (Kumar Das et al., 2018, Eerkens, 2005, Evershed, 1993).

This analysis was only performed on Sample 2 due to its favourable state of preservation; in contrast to Sample 1, which was damaged by prolonged contact with hands, Sample 2 had been manipulated to a much smaller extent.

GC-MS analysis was carried out on a Hewlett-Packard 5890 series II plus gas chromatograph (Agilent Technologies) equipped with a RTx5 fused silica column (5% diphenyl/95% dimethyl arylenepoly-siloxane 25 m × 0.25 mm, film thickness 0.1 mm, Restek), interfaced with a Hewlett-Packard mass selective detector 5971a (Agilent Technologies) operated by HP Enhanced ChemStation software, version A.03.00. Interface temperature: 280°C; MS source temperature: 180°C; ionization energy: -70 eV; scan range: 35–500 atomic mass units; scans per second: 1.65. GC conditions: splitless injection (splitless time 0.5 min) at 280°C, oven temperature was kept at 100°C for 8 min, then programmed to 300°C at a rate of 12°C/min. The carrier gas was helium at a flow rate of 1.33 mL/min.

Prior to the GC-MS analysis, powder samples (about 200 mg) obtained from Sample 2 were transferred to a 2 mL vial and 100 mL of a 2:1 mixture of chloroform to methanol was added. The mixture was manually agitated for 5 min and sonicated for 15–20 min (Eerkens, 2005). The solvent mixture was separated by centrifugation, transferred to a clean 2 mL vial, and gently evaporated under a vacuum. Then 200 mL of n-hexane and 100 mL of 0.5 M NaOH methanol solution were added and the solution was sonicated for 6 min (Li et al, 2009).

The vials sat for 5 min before the supernatant n-hexane parts was transferred to new glass vials. The n-hexane layers were washed with pure water 3 times in order to remove any trace of methanol alkaline. Anhydrous Na₂SO₄ was used to absorb the trace water remaining in the n-hexane solution. 0.5 mL of n-hexane layer was injected into the GC-MS for analysis.

The identification of the compounds was carried out by computer matching the resulting mass spectra with the NIST mass spectral library, and/or by comparison with mass spectra of known standards. The quantification of each compound was obtained by calculating the area of each of the corresponding peaks in the total ion current (TIC) acquisition.

3. Experimental framework

In order to test the possible purposes of the LEC ceramic basins, an experimental replica inspired by the archaeological remains and based on the technological data resulting from the compositional analyses (see above) was made and used for performing several activities. The activities—bread baking and the processing of flax seeds and palm fruits—were established on the basis of the results of use-wear analysis and chemical analysis.

The aims of this experimental program were the following: 1) to determine if the rock fragments were applied before or after the coating step, as the extended use alteration of the artefacts' surface makes it difficult to comprehend. This step plays a key role in better understanding the alteration processes that interested the archaeological remains; 2) to gather a comparative collection of damages and wear caused by specific activities to verify the interpretation of the traces observed on the archaeological samples; 3) to test the resistance and durability of the vessel during each period of use; 4) to build an experimental reference collection.

3.1. Experimental replica of the ceramic vessel

The multi-analytical approach to the archaeological material allowed for the identification of the raw materials used to produce the basins, the nature of the stone fragments along the internal surface of the vessel base (identified as calcareous rock fragments), and highlighted the presence of plant remains (straw) that were intentionally added as temper. These elements permitted us to collect the suitable materials to manufacture a scaled replica of the vessel. After modelling the oval shallow basin (Fig.4 c-e), a calcareous rock was crushed on a ground stone in order to obtain small fragments (Fig.4 a-b). The fragments ranging from 0.3 to 0.7 mm were selected to cover the internal surface of the basin. Due to the wide abrasive wear along the archaeological vessels, it was not possible to establish if the application of the calcareous fragments was done after coating as the last step of manufacture, or if the coating was applied as a final treatment. For this reason, both technological sequences were applied on the replica dividing the vessel into two main areas: on one half the calcareous fragments were applied and then coated with the slip; on the other half, the rock fragments were applied after the coating step (Fig.4 e-f). This allowed us to

observe how these surfaces deteriorated during use activities, thus revealing the actual sequence of production. Based on observations of the ceramic surfaces preserved in certain areas (Fig.3), the experimental vessel was burnished with a pebble; lastly, according to the results of petrographic analysis, the replica was fired at a temperature of 650°C.

FIG.4

3.2. Experimental tests

The experimental vessel was used for baking bread and processing several vegetal materials. The former—baking bread—allowed us to test the functionality and the formation of use-wear associated with such an activity, which could be indicated in the localised fire traces observed on the archaeological sample and in the recent interpretation of the Near Eastern “husking trays” as pans for baking bread (Balossi Restelli and Mori, 2014; Taranto, in press a-b).

Regarding the processing of vegetal material, a preliminary microscopic observation of the archaeological samples highlighted the presence of traces of mechanical levelling associated with a rounding of the surfaces, as well as organic film and polishes on the surface of the calcareous fragments located on the internal base of the vessel. According to the use-wear analysis, these traces are compatible with the treatment of oily vegetal substances, which are unfortunately only partially confirmed by the chemical analyses applied to Sample 2 (see paragraphs 3.2 and 3.3). The particular morphology of the rock fragments led us to test grinding and light pounding activities on vegetal materials rich in oil.

In order to understand the motion of the vessels—that is, the progressive transformation of a worked surface as a result of the contact between it and another surface (Adams et al., 2009)—we have chosen to conduct specific experiments with single substances. The experimental framework included the treatment of oily substances such as flax seeds and palm fruits to obtain oils and a bread baking test (Tab.1). Flax has been recorded by the paleobotanical investigations made on the Predynastic sites of the Delta (Cappers, 2017; Emery-Barbier, 2014), whereas palm fruits do not appear to be local but were tested because of their fibrous and oil-rich components. The experimental framework of food processing was carried out in one basin replica in order to observe functional modifications along distinct surface areas of the same item. Nevertheless, to avoid the risk of overlapping activities and use traces, the internal base of the experimental basin was intentionally divided into four quadrants—named A, B, C and D—in order to favour the analysis of the diverse use traces caused by each material processed separately (Fig.5). Bread baking was chosen as the first use activity and involved exclusively the surface of Quadrant C; as confirmed by use-wear analysis, the rock fragments in contact with the bread did not show any wear, which allowed for the use of the same quadrant during the subsequent experimental trial: flax seed processing. Flax seed processing was carried out along Quadrants C and D. Although the liquid part of the seed processing spread across the whole bottom of the basin, the mechanical action of seed grinding/pounding was contained in the quadrants cited above. Finally, the basin area corresponding to Quadrants A and B were dedicated exclusively to palm fruit processing (Fig.5).

FIG.5

TAB.1

3.2.1. Bread baking

Two flat breads prepared with emmer flour and water were baked in Quadrant C. The first test was conducted without the addition of oil, whereas in the second vegetable oil was added in the vessel. The vessel was heated on embers for a few minutes (15 minutes for each baking) before the placement of the dough. The baking was successful; the bread did not stick to the bottom even in the absence of vegetable oil, the vessel remained intact, and the slip was not removed. The rock fragments did not present any modifications (Fig.6, Tab.1).

FIG.6

3.2.2. Flax seed processing

Flax seeds (1kg) were ground inside the ceramic vessel (Quadrants C and D) to facilitate the release of oily substances. The seeds were processed through 2 tests: 1) using an active wood grinder/pestle; 2) using an active stone grinder/pestle, in both cases utilising a light amount of pressure associated with a back and forth movement (resting percussion). In the second step of the experiments, water was added to stimulate the release of the oil and brought to boiling temperature (Fig.7; Tab.1). Two tests were conducted with different percentages of water. It has been observed that with a low quantity of water in the mixture, it is possible to obtain a dense and gelatinous oil. The ceramic vessel was not damaged after these two experiments.

FIG.7

3.2.3. Palm fruit processing

Palm fruits (1.5kg) were opened with a light amount of pressure, associated with a back and forth movement (resting percussion), using an active lithic tool (Quadrants A-B). This gesture allowed for the separation of the fibrous part of the fruit from the pit. The result was a puree of fibrous material rich in oil. This puree was heated with water and boiled for a few minutes. The result consisted of a rich yellow oil that was filtered (Fig.8; Tab.1).

After the experiment, the base of the ceramic vessel remained efficient, without any abrasions or extractions. At the end of this experiment a mistake (a very strong blow with the pestle) produced a fracture in the experimental vessel.

FIG.8

4. Results

4.1 Petrographic analysis of the archaeological sample

The sample is characterised by 10% of inclusions that are equant and elongated, from angular to sub-rounded, with a variable distribution from single to open-spaced. Dominant are quartz and feldspars (equant and elongated, from angular to sub-angular and ranging from 0.3 to 0.6 mm in size) (Fig.9). Fragments of calcareous sedimentary rock are frequent, equant and elongated, from angular to sub-angular and ranging from 0.3-1.25 mm in size. Common clay pellets and nodules of iron oxides have also been identified. The inclusions on the surface of the analysed samples are fragments of calcareous sedimentary rock with coarse grain size (1.25-4.0 mm).

The porosity is estimated as 20% with respect to the total surface of the thin section. It is mainly represented by irregular *vughs* (meso and micro) and micro-vesicles. Part of the identified pores are due to the decomposition of plant remains, added to the paste with maximum dimensions of 8.0 mm. The matrix is variable in colour, ranging from red to black, and optically active.

Optical analysis gave a preliminary indication of the technological and material knowledge useful for choosing proper raw materials for the experimental replica and for collecting general information regarding the range of firing temperatures. In particular, the clay used was calcareous, characterised by the presence of quartz and feldspars with the addition of plant remains, which were added to the paste to make it more durable, porous and strong (Phonphuak and Thiansem, 2012). The paste was inadequately mixed, as testified by the presence of clay pallets, and was then probably shaped by coiling as testified by the lack of alignment in both the inclusions and the pores (Reedy, 2008). Fragments of ground calcareous sedimentary rock were added on the surface for a specific functional reason.

FIG.9

Finally, it was fired at a low temperature and the firing process was not completely controlled. Indeed, the colour of the matrix is heterogeneous, ranging from red (usually associated with oxidising atmosphere conditions) to black, connected to reducing atmosphere. The occurrence of both atmospheres, as well as the heterogeneous distribution of matrix colours, suggests uncontrolled firing conditions.

Considering the optical activity of the matrix, the firing temperatures are estimated to have been lower than 850°C. Furthermore, the absence of alteration traces on the calcareous inclusions supports the hypothesis of a temperature lower than 750°C before the start of the decarbonation process.

4.2 Use-wear analysis of the experimental sample

4.2.1 Ceramic

The ceramic replica shows localised use-wear along the internal and the external surfaces.

Use alterations on the ceramic surface were caused by mechanical, thermal and chemical wear, and in some cases by a combination of all three.

No invasive traces developed after the first experimental protocol (baking bread). Only labile soot traces, caused by contact with the embers during the baking process, featured on the external base (Fig.10 a), and a localised labile carbon deposit appeared along the articulation bottom/wall in half of the vessel. These traces are due to an incipient carbonisation process of the content interesting the area that reached a temperature higher than 100°C (Fig.10 b).

During the following experiments more invasive mechanical wear developed along the internal and external surfaces. Indeed, the area used to process palm fruits shows a levelling of localised and limited spots along the external base, caused by the continuous displacement of the vessel during its use (Fig.10 c). The ceramic surface was affected by extended levelling processes (Fig.10 d) caused by the pounding and grinding of the palm fruits using an active stone tool (i.e. handstone/pestle).

FIG.10

Regardless of the diverse working areas, the external surface shows superficial depressions due to the damage and separation of the coating, likely affected by corrosive wear (Fig.10 e-f). This kind of alteration developed mainly during and after the last experimental sessions coinciding with a period of non-use. These use traces interest areas along the rim and the external walls that are usually not involved in prolonged mechanical stress. The damage is evolving and is likely caused by the absorption of the acidic components of the oil processed in the vessel, which is likely favoured by the adoption of low-firing technology. Unfortunately, the ceramic replica was accidentally broken during the last experimental session; this is not connected in any way to the functionality and efficacy of the vessel for the grinding of soft materials.

4.2.2 Rock fragments

The rock fragments and the surface of the experimental ceramic vessel were documented before its use. The rock fragments were angular with random distribution, and their surfaces showed a regular micro-topography (Fig.11 a-c).

Bread baking (Quadrant C) did not change in any way the morphology and structure of the rock fragments on the bottom of the vessel (Fig.11 l-m).

In Quadrants C and D, the calcareous fragments did not change their morphology as a result of the processing of flax seeds using a wood grinder/pestle. Edge rounding in their highest parts has been observed. Conversely, using a stone grinder/pestle, the rock fragments presented a mechanical levelling, with a regular distribution on the internal base of the vessel (Fig.11 d-f). The observed micro-polishes were distributed on top of the rock fragments and demonstrated a smooth texture and domed topography that is associated with micro-striations and sheen (Fig.12 a-c).

The processing of palm fruits (Quadrants A and B) produced a mechanical levelling with the presence of a high sheen and the grain surface appeared sinuous and rounded (Fig.11 g-i). Micro-levelling oriented on the grain surface and micro-striations were observed. The micro-polishes are characterised by a smooth texture and domed topography; micro-pits are also present (Fig.12 d-f).

The rock fragments analysed through the Scanning Electronic Microscope show the presence of areas of mechanical levelling associated with long and deep striations. These types of traces are the result of the contact between the ceramic vessels, the processed fat material (i.e. palm fruits and flax seeds) and the active stone tool. The latter was used following a forward and backward movement, associated with a light/gentle pounding. This type of use-wear – i.e. oriented mechanical levelling associated with long striations – finds a complement in those found on the archaeological calcareous fragments (Fig.13).

FIG.11

FIG.12

FIG.13

4.3 Use-wear analysis of the archaeological samples

4.3.1 Ceramic

The analysed archaeological ceramic samples (Samples 1 and 2) are characterised by an extended corrosive wear process involving both the internal and external surfaces (with the exception of limited areas that retain traces of a burnishing process), small localised internal carbon deposits and external soot, and levelled areas (Fig.3 and 14). Unfortunately, the limited size of the fragments makes it difficult to understand the presence of a patterning in the internal and external distribution of fire traces.

The alteration involving both samples is an invasive deterioration of the vessels, probably increased by post-depositional alteration processes that affected the weakened surface of a low-fired ceramic vessel (Fig.3).

FIG.14

4.3.2 Rock fragments

Concerning the rock fragments present on the internal surface of the archaeological samples (Samples 1 and 2), macro- and micro-traces have only been observed on the best-preserved samples. The fragments analysed through the Scanning Electronic Microscope show the presence of areas of mechanical levelling associated with long and deep striations (Fig.13 a-b).

Under the stereo microscope, the rock fragments appeared levelled. At higher magnifications (60-80x), it was possible to observe that the apical part of the grain appeared sinuous and rounded with the presence of a sheen. The polishes are distributed on the top of the rock fragments, with a smooth texture and domed topography; micro-pits and striations are also present (Fig.15).

These preliminary observations of the archaeological finds permitted us to hypothesise a surface alteration associated with use activities. More specifically, the use-wear on the calcareous rock fragments may correspond to grinding (back and forth movements) and a light/gentle pounding, which could have caused a macro-levelling and macro-striations visible on the top of the rock fragments (Fig.15 a-f).

FIG. 15

4.4. Organic residue analysis

GC-MS analysis of the lipid extract from Sample 2 produced a relatively simple chromatogram showing the composition of free fatty acids (Fig.16). These are saturated C16:0 and C18:0 and monounsaturated C18:1. Comparing the relative peak area of the three fatty acids we can observe the presence of a relatively high quantity of unsaturated oleic acid (C18:1, RT 12.29, 37%) that degrades more easily than saturated acids (Eerkens, 2005), probably depending on the favourable post-depositional conditions of the region of Maadi, from where the sample comes from (Copley et al., 2001). Indeed the arid and dry environment of that region also allowed the preservation of organic materials such as wood, seeds and fabric (Bajeot, 2017). Saturated palmitic (C16:0, RT 10.79, 53%) and stearic (C18:0, RT 12.49, 10%) are respectively the most and the least abundant of all the fatty acids. Generally their detection indicates the presence of animal fat (ruminants) in the extract (Kimpe et al., 2004); however, the smaller amount of stearic (C18:0) than palmitic (C16:0) acid, in conjunction with the high amount of oleic (C18:1) acid, is coherent with the presumed processing of vegetable products (seeds, oil) in the vessels (Mayyas, 2018).

The peaks at RT 15.57 and 17.39 were assigned at di (2-ethylhexyl) phtalate (DEHP) and squalene, respectively. The first is a plasticizer, a contaminant introduced in the sample probably by contact with plastic packing material used to store the vessel fragment; the second indicates a small amount of contamination from human fingerprints. Its low concentration suggests that the fatty acid profile has not been altered by the presence of lipids present in human skin.

Although the chromatographic analysis does not reveal the presence of additional markers of plant lipids, such as sterols, alkanes and waxes, and cannot therefore be considered conclusive, the results do not conflict with those obtained using other methods of investigation and provide useful general guidance.

FIG.16

5. Discussion and conclusions

The multidisciplinary approach adopted for this research has allowed us to analyse the technological and functional aspects of a specific type of shallow oval basin that appears to be characteristic of the LEC ceramic assemblage. Currently these vessels have been found in all the Lower Egyptian sites featuring layers dating to Buto Ib-IIa (Naqada IIA/B), including Maadi, Tell el-Iswid, Tell el-Fara'in/Buto and Tell el-Samara.

These vessels were modelled by hand with the pinched coil technique (Bajeot and Roux, 2019) using a clay with quartz, feldspars and frequent carbonatic sedimentary rock fragments, intentionally tempered with straw. As demonstrated by the petrographic analysis, the clay was probably not levigated before adding the temper and the dough was not well kneaded. The combination of the petrographic analysis and the controlled production of the experimental basin provided reliable evidence for the correct shaping sequence.

Based on the production of the experimental replica and on the use-wear analysis of the ceramic surface surrounding the rock fragments, it was possible to ascertain that once the basin was shaped it was coated with liquid fine clay; the internal base was then strewn with fragments of calcareous rock pressed into the clay matrix. Finally, once leather hard, the internal walls of the basin were burnished and the pot was fired at a low temperature (around 700° C), probably in an open fire. The presence of the rock fragments was probably intended to form a rough functional surface suitable for specific processes identifiable through the analysis of surface modifications and related wear processes. The morphology of the calcareous fragments and the use-wear observed at low and high magnification on our archaeological samples (e.g. mechanical levelling, rounding, sheen and polishes) allowed us to hypothesise that the archaeological basins were used for processing oily materials through specific gestures of grinding (back and forth movements) associated with a gentle pounding. This hypothesis was confirmed directly by the results of the dedicated experimental protocols. Based on the comparative material, on the chemical analysis and on the use-wear analysis, the replica of the basin was tested for processing more than one soft and oily matter such as flax seeds and palm fruits. Moreover, an additional bread baking test was carried out to evaluate the use of these basins according to the interpretation of the Near-Eastern "husking trays" as pans.

As demonstrated by the experiments, bread baking and mixing liquids (the oil obtained from the processing of flax seeds and palm fruits) did not change the structure of the rock fragments, and the possible modifications that these activities could cause over time

probably would not coincide with the traces left by the more invasive mechanical activities tested in the replica. A real change in the appearance of the rock fragments was indeed observed only in conjunction with an active stone tool (e.g. grinder/pestle) for grinding and pounding activities. Moreover, the traces identified on the archaeological samples clearly corresponded to those left on the replica by the processing of palm fruits. This indicates that the basins may have been used to grind and pound products (edible or not), or any combination of products, with texture and properties similar to those of palm fruits (soft, fat and fibrous), but whose nature is still unknown. In fact, while the residue analysis has provided a general indication of the possible treatments of fatty vegetal substances, it has not allowed for the identification of the specific product, as the necessary additional markers of plant lipids have not been found.

Another aspect that could be considered an indicator of the processing of oily materials is the alteration affecting both the ceramic surfaces of the archaeological samples and of the experimental replica. Although the superficial detachment of the ceramic surface observed on the archaeological samples may have been caused by post-depositional alterations, we cannot exclude a connection between this damage and the absorption of corrosive substances as observed during the experiments. The acids contained in the oily materials have corrosive properties that, in the case of the experimental basin, accelerated the deterioration of the ceramic surfaces, a result that was probably also favoured by the low firing temperature of the vessels themselves. With regards to the archaeological samples we may be dealing with a combination of two phenomena: damage caused by the acids of oily substances and by post-depositional alterations.

Based on the comparative material, such as the Indian *ralla catti* that are used to cook and pound lentils or spinach, the experimental vessel was tested for crushing and pounding soft substances and then heated. It proved to be effective; the experimental replica did not present fractures due to fire contact and responded positively to the different experimental tests. Black residues of burnt oil caused by the oil heating phase were observed on the experimental sample and might correspond to the translucent organic black spots observed on the archaeological samples. This multifunctional character—allowing for both cooking and grinding—could explain the predilection for these pottery basins over stone mortars to perform grinding and pounding activities, and could be evidence of a specific processing (for culinary or non-culinary purposes) practiced by the Predynastic communities of Lower Egypt during a determined period. The chronological and geographical distribution of these basins is in fact very limited: they only characterise the Lower Egyptian sites during a specific period (Buto Ib-IIa), then production stopped and they were not substituted by vessels that seem to have had a similar function. At Tell el-Iswid the disappearance of this production, accompanied by other changes in pottery typology (Bajeot and Roux, 2019), is part of a larger phenomenon that sees transformations also affecting the organisation of the settlement and of its spaces. There is in fact a shift in the orientation of the structures and the appearance of numerous large storage facilities and, later, the construction of the first mud-brick buildings (Buechez, forthcoming). The outcomes of this evolution have also been observed at Tell el-Fara'in/Buto (Hartmann, in press) and at Tell el-Farkha (Cichowski, 2008: 33-40; Ciałowicz, 2012: 149-162; Adamski and Rosińska-Balik, 2014: 23-36). This tendency has been interpreted as an evolutionary dynamic related to a shift in food production and consumption (Bajeot and Roux, 2019) that, in its later stage, is probably related to an increase in the processing of agricultural products for the making of beer

(Hartmann, in press). In this way our study constitutes a first step in analysing these aspects through a different approach.

Notwithstanding the retrieval in the aforementioned sites of basins with a similar shape but without rock fragments on the internal base that could have been used for more general activities such as baking bread or cooking other foods (Rizkana and Seeher, 1987: Pl.53; Guyot, 2015: Fig.9), we cannot exclude the idea that the basins with rock fragments were also used to process products of animal origin or to perform other types of activities. For this reason, new and more detailed experiments will hopefully be conducted in the future to clarify further aspects of the function of these vessels.

This preliminary study has left several questions open but has allowed us to establish and test the framework of a methodology, still needing to be perfected and expanded, that has proven to be effective and original in the field of Predynastic Egypt, where this type of approaches are still at their beginning stages. The multidisciplinary approach has brought together several tests whose results, taken alone, would have been considered weak, but if considered together, can sustain the final functional reconstruction. If on the one hand the typological analysis, based on comparisons, has not allowed for a final functional interpretation but only unverified hypotheses, on the other hand a multidisciplinary approach has proven that it is possible to track the evidence of actual mechanical gestures performed within these vessels. This pilot study shows in fact the potential of this multidisciplinary method to provide new insights on the function of ancient pottery, thus contributing to the reconstruction of the social behaviours of the Egyptian Predynastic groups and their dynamics.

Authors' contribution

Organisation and coordination of the research: Jade Bajeot and Vanessa Forte

Typological analysis and archaeological context: Jade Bajeot

Use-wear analysis: Vanessa Forte (Ceramic) and Isabella Caricola (rock fragments)

Petrographic analysis: Laura Medeghini

Residues analysis: Vittorio Vinciguerra

Experimental Archaeology: Vanessa Forte (basin reproduction and bread baking test) and Isabella Caricola (flax seed and palm fruit tests)

The authors contributed equally to the discussion of the results and to the writing of this article.

Acknowledgments

The authors would like to thank Marcella Frangipane and Cecilia Conati Barbaro for according them the permission to analyse the samples from Maadi stored in the collection of the Museo delle Origini (Sapienza University of Rome, Rome, Italy).

The authors would also like to thank the anonymous reviewers who provided useful comments and suggestions to improve and strengthen the article and to the guest editors of the special issue *Africa under the microscope*, Giulio Lucarini and Sonja Tomasso.

Bibliography

Adamski, B., and Rosinska-Balik, K., 2014. Brewing technology in Early Egypt. Invention of Upper or Lower Egyptians?, in: Makzysnka, A., (ed.), *The Nile Delta as a centre of cultural interactions between Upper Egypt and the Southern Levant in the 4th millennium BC*. Poznan, 299-318.

Adams, J., Delgado, S., Dubreuil, L., Hamon, C., Plisson, H., Risch, R., 2009. Functional Analysis of Macro-Lithic Artefacts: A Focus On Working Surfaces in: Stenke, F., Eigeland, L., Costa, L.J., (eds) *Non-flint raw material use in prehistory: Old prejudices and new directions*, Oxford: BAR International Series 1939, 43-63.

Balossi-Restelli, F., and Mori, L., 2014. Bread, baking moulds and related cooking techniques in the Ancient Near East, *Food and History, Revue de l'Institut Européen d'Histoire de l'Alimentation*, 39-55.

Bajeot, J., 2017. *Predynastic Maadi in context. The research of the Italian Expedition Revisited (1977-1986)*, Studi di Preistoria Orientale 4, Rome.

Bajeot, J., and Roux, V., 2019. The Lower Egyptian Culture: new perspectives through the lens of ceramic technology, *Archéo-Nil* 29, 157-178.

Buchez, N., 2019. Tell el-Iswid, Rapport d'Activité 2018, *Supplement au Bulletin de l'Institut Français d'Archéologie Orientale* 118, 127-136.

Brink van den, E.C.M., 1992. *The Nile Delta in transition: 4th. - 3rd. Millennium B.C.*, Tel Aviv.

Caneva, I., Frangipane, M., Palmieri, A., 1989. Recent Excavations at Maadi (Egypt), in: Krzyżaniak, L. and Kobusiewicz, M. (eds.), *Late Prehistory of the Nile Basin and the Sahara*, Poznan: Archaeological Museum, Studies in African Archaeology 2, 287-293.

Cappers, R. T. J., 2017. Botanical remains, in: Bajeot J., *Predynastic Maadi in context. The research of the Italian Expedition Revisited (1977-1986)*, Studi di Preistoria Orientale 4, Rome, 165-171.

Caricola, I., Zupancich, A., Moscone, D., Mutri, G., Falcucci, A., Duches, R., Peresani, M., Cristiani, E., 2018. An integrated method for understanding the function of macro-lithic tools. Use wear, 3D and spatial analyses of an Early Upper Palaeolithic assemblage from North Eastern Italy, *PloS one* 13(12), e0207773.

Chłodnicki, M., and Geming, M. M. 2012. Lower Egyptian Settlement on the Central Kom, in: Chłodnicki, M., Ciałowicz, K. M., Mączyńska, A., (eds.), *Tell el-Farkha I - Excavations 1998-2011*, Poznan, Krakow, 89-104.

Ciałowicz, K.M., 2012. Lower Egyptian settlement on the Western Kom, in: Chłodnicki, M., Ciałowicz, K.M., and Mączyńska, A., (eds.), *Tell el Farkha I. Excavations 1998-2011*. Poznan-Krakow, 149-162.

Ciałowicz, K.M., Czarnowicz, M., Chłodnicki, M., 2018. *Eastern Nile Delta at the turn of the 4th Millennium BC*, Kraków-Poznań.

Cichowski, K., 2008. The brewery complex from Tell el-Farkha. Archaeological aspects of the discovery, in: Midant-Reynes, B., Tristant, Y., Hendrickx, S., (eds.), *Egypt at its Origins 2, Proceedings of the Second International Conference "Origins of State", Predynastic and Early Dynastic Egypt, Toulouse (France), 5th-8th September 2005, Orientalia Lovaniensia Analecta 172*. Leuven, 33-40.

Copley, M.S., Rose, P.J., Clapham, A., Edwards, D. N., Horton, M.C., Evershed R. P., 2001. Detection of palm fruit lipids in archaeological pottery from Qasr Ibrim, Egyptian Nubia, *The Royal Society* 268, 593-597.

Cramp, L.J.E., Evershed, R.P., Eckardt, H., 2011. What was a mortarium used for? Organic residues and cultural change in Iron Age and Roman Britain, *Antiquity* 85, 1339-1352.

Eerkens, J.W., 2005. GC-MS analysis and fatty acid ratios of archaeological potsherds from the western great basin of North America, *Archaeometry* 47, 83-102.

Emery-Barbier, A., 2014. Tell el-Iswid: l'économie de subsistance au IV^e millénaire d'après les résultats des analyses des micro-restes végétaux, in : Midant-Reynes B., Buchez N. (eds.) *Tell el-Iswid 2006-2009*, Institut Français d'Archéologie Orientale, Fouilles de l'IFAO 73, Le Caire, 281-289.

Evershed, R.P., 1993. Biomolecular Archaeology and Lipids, *World Archaeology* 25, 74-93.

Faltings, D., 2002. The chronological Frame and Social Structure of Buto in the Fourth Millennium BCE, in: Brink van den, E. C. M., and Levy, T. E., (eds.) *Egypt and the Levant. Interrelations from the 4th through the Early 3rd Millennium B.C.E.*, London/New York, 165-170.

Faltings, D., and Köhler, E. C., 1996. Vorbericht über die Ausgrabungen des DAI in Tell el-Fara'in/Buto 1993 bis 1995, *Mitteilungen des Deutschen Archäologischen Instituts* 52, 87-114.

Forte, V., Cesaro, S. N., Medeghini, L. 2018. Cooking traces on Copper Age pottery from central Italy: An integrated approach comprising use wear analysis, spectroscopic analysis and experimental archaeology, *Journal of Archaeological Science: Reports* 18, 121-138.

Guyot, F., 2015. The Predynastic Pottery from Tell el-Iswid (Nile Delta), Preliminary Report on the Lower Egyptian Culture Assemblage, *Bulletin de la liaison de la Céramique Égyptienne* 25, 5-35.

Guyot, F., 2016. Les transitions culturelles du VI au IV millénaire, rapport d'activité, *supplément au Bulletin de l'Institut Français d'Archéologie Orientale* 116, 181-187.

Hamon, C., 2006. *Broyage et abrasion au Néolithique ancien. Caractérisation technique et fonctionnelle des outillages en grès du Bassin parisien*, BAR International Reports S1551, Oxford.

Hartmann, R., in press. Local Aspects of the Pottery during the Later Lower Egyptian Culture at Tell el-Fara'in/Buto, in: Köhler, E.C., Junge, F., Kuch, N., Jeske, A.K., (eds.), *Egypt at its Origins 6. Proceedings of the Sixth International Conference "Origin of the State. Predynastic and Early Dynastic Egypt"*, Vienna, 10th – 15th September 2017. *Orientalia Lovaniensia Analecta*. Leuven, Paris, Bristol, CT.

Hartung, U., Abd el-Gelil, M., von den Driesch, A., Fares, G., Hartmann, R., Hikade, T., Ihdez, C. 2003. Vorbericht über neue Untersuchungen in der prädynastischen Siedlung von Maadi, *Mitteilungen des Deutschen Archäologischen Instituts* 59, 149-198.

Kimpe, K., Drybooms, C., Schrevels, E., Jacobs, P.A., Degeest, R., Waelkens, M. 2004. Assessing the relationship between form and use of different kinds of pottery from the archaeological site Sagalassos (southwest Turkey) with lipid analysis, *Journal of Archaeological Science* 31, 1503-1510.

Kroeper, K., and Wildung, D., 1994. *Minshat Abu Omar: ein vor-und frühgeschichtliche Friedhof im Niledelta*, Mainz am Rhein.

Kumar Das, S., Gosh, S., Isaksson, S., Lidén, K., Dey, A. 2018. Organic residue analysis in archaeological ceramics from Lahuradewa, India: role of contaminants, *Current Science* 115, 1456-1458.

Levy, T. E., and Brink van den, E. C. M., 2002. Interaction Models, Egypt and the Levantine Periphery, in: Brink van den E. C. M. and Levy T. E. (eds.), *Egypt and the Levant. Interrelations from the 4th through the Early 3rd Millennium B.C.E.*, London/New York: 3-38.

Li, J., Yue ,Y., Li, T., Hu, X., Zhong, H. 2009. Gas chromatography–mass spectrometric analysis of bonded long chain fatty acids in a single zebrafish egg by ultrasound-assisted one-step transmethylation and extraction, *Analytica Chimica Acta* 650, 221-226.

Matteucci, P., 1987. L'uso dei mortai di terracotta nell'alimentazione antica, *Studi Classici e Orientali* 36, 239-277.

Mayyas, A.S., 2018. Organic residues in ancient pottery sherds from sites in Jordan, *Mediterranean Archaeology and Archaeometry* 18, 61-75.

Mazucco, N., 2016. A Traceological Analysis of Tell el-Iswid Flaked Stone Assemblage from the Lower Egyptian Culture Layers: Technological and Economic Issues, in: Buchez, N., and Midant-Reynes, B., (eds.) *Tell el-Iswid, Rapport D'Activité 2015-2016, Supplément au Bulletin de l'Institut Français d'Archéologie Orientale* 2016, 59-62.

Menghin, O., and Amer, M., 1932. *The excavations of the Neolithic site of Maadi. First Preliminary Report (Season 1930-1931)*, Egyptian University Faculty of Arts Publication 19, Cairo.

- Midant-Reynes, B., and Buchez, N., 2014. *Tell el-Iswid 2006-2009*, Institut Français d'Archéologie Orientale, Fouilles de l'IFAO 73, Le Caire.
- Midant-Reynes, B., and Buchez, N., forthcoming. La nécropole prédynastique de Kom El-Khilgan, FIFAO.
- Nagaya, K., 2015. Drilling Stone Vessels at Nekhen, *Nekhen News* 27, 14-15.
- Nieuwenhuys, O.P., 2008. *Plain and Painted Pottery: The Rise of Late Neolithic Ceramic Styles on the Syrian and Northern Mesopotamian Plains*, Papers on Archaeology of the Leiden Museum of Antiquities 3. Turnhout: Brepols Publishers.
- Nieuwenhuys, O.P., Akkermans, P.M.M.G., van der Plicht J., 2010. Not so coarse, nor always plain – the earliest pottery of Syria, *Antiquity* 84, 71-85.
- Phonphuak, N., and Thiansem, S., 2012. Using charcoal to increase properties and durability of fired test briquettes, *Construction and Building Materials* 29, 612-618.
- Reedy, C., 2008. *Thin-Section Petrography of Stone and Ceramic Cultural Materials*, Archetype Publications, London.
- Rizkana, I., and Seeher, J., 1987. *Maadi I, The Pottery of the Predynastic Settlement*, Mainz am Rhein.
- Rizkana I., and Seeher J. 1988. *Maadi II, The Lithic Industries of the Predynastic Settlement*, Mainz am Rhein.
- Rizkana I., and Seeher J. 1989. *Maadi III, The Non-lithic Small Finds and the Structural Remains of the Predynastic Settlement*, Mainz am Rhein.
- Rizkana I., and Seeher J. 1990. *Maadi IV, The Predynastic Cemeteries of Maadi and Wadi Digla*, Mainz am Rhein.
- Rots, V., 2005. Wear traces and the interpretation of stone tools, *Journal of Field Archaeology* 30(1), 61-73.
- Roux, V., 2003. Ceramic Standardization and Intensity of Production: Quantifying Degrees of Specialization, *American Antiquity* 68.4, 768-782.
- Skibo, J. M., 1992. *Pottery function: a use-alteration perspective*. Springer

Stanley, J. D., 2002. Configuration of the Egypt-to-Canaan Coastal Margin and North Sinai Byway in the Bronze Age, in: Brink van den, E.C.M., and Levy, T. E., (eds), *Egypt and the Levant. Interrelations from the 4th through the early 3rd millennium BCE*. Leicester University Press, 98-117.

Taranto, S., in press a. The role of the Husking Trays in the Late Neolithic communities of the Northern Mesopotamia, *Acts of the conference "Broadening Horizons 5*, Udine, June 5th-8th, 2017.

Taranto, S., in press b. Husking tray: a shared technology between the Late Neolithic communities of the Near East?, *Proceedings of the XI International Congress on the Archaeology of the Ancient Near East (ICAANE)*, Munich, April 3rd-7th 2018.

Tringham, R., Cooper, G., Odell, G., Voytek, B., Whitman, A., 1974. Experimentation in the formation of edge damage: a new approach to lithic analysis, *Journal of Field Archaeology* 1 (1-2), 171-195.

Van Gijn A., 2010. *Flint in focus: lithic biographies in the Neolithic and Bronze Age*, Leiden, Sidestone Press.

Villing, A., and Spataro M., 2009. Scientific investigation of pottery grinding bowls from the Archaic and Classical Eastern Mediterranean, *British Museum Technical Bulletin* 3, 89-100.

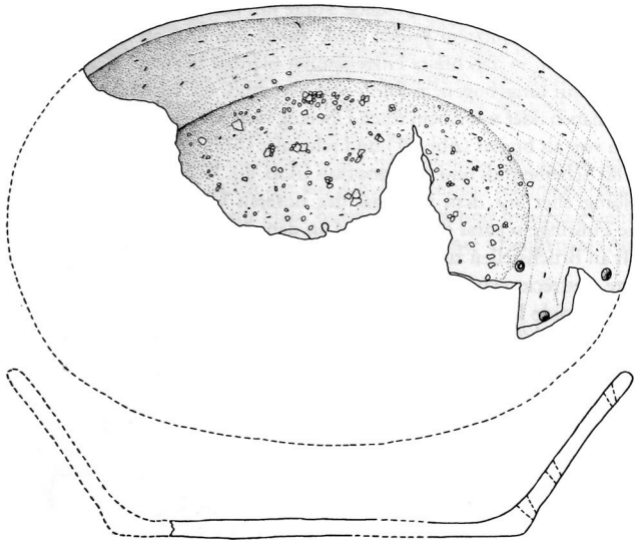
Voigt, M., 1983. *Hajji Firuz Tepe, Iran: the Neolithic settlement*, University Museum Monograph 50, Philadelphia.

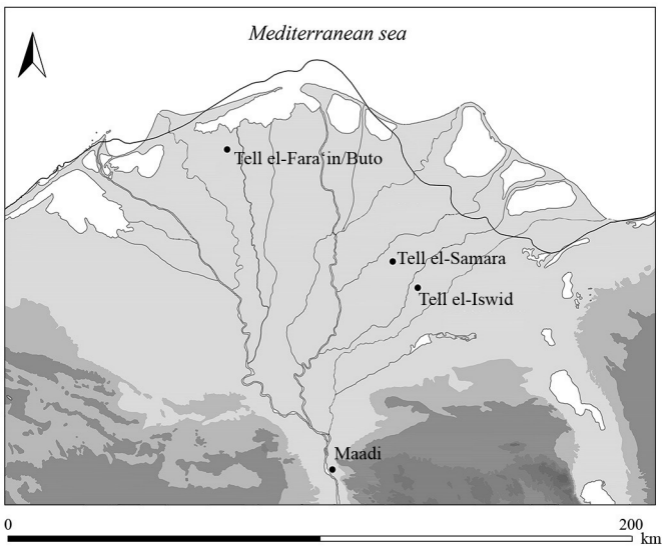
Von der Way, T., 1997. *Tell el-Fara'in - Buto I. Ergebnisse zum frühern Kontext. Kampagnen der Jahre 1983-1983*, Ägyptologische Abhandlungen 83, Mainz am Rhein: Harrassowitz Verlag.

Whitbread, I.K., 1986. The characterization of argillaceous inclusions in ceramic thin sections, *Archaeometry* 28, 79–88.

Whitbread, I.K., 1995. *Greek Transport Amphorae: a Petrological and Archaeological Study*, British School at Athens, Fitch Laboratory Occasional Papers 4, Athens.

Wilson, P., Gregory, G., Tassie, G., 2014. *Sais II: the Prehistoric Period at Sa el-Hagar*, Egypt Excavation Society.





Mediterranean sea

Tell el-Fara'in/Buto

Tell el-Samara

Tell el-Iswid

Maadi

0 200 km

— The shoreline during the IV mill. B.C. Elaborated from: Stanley 2002 fig.5.15



a



c



d

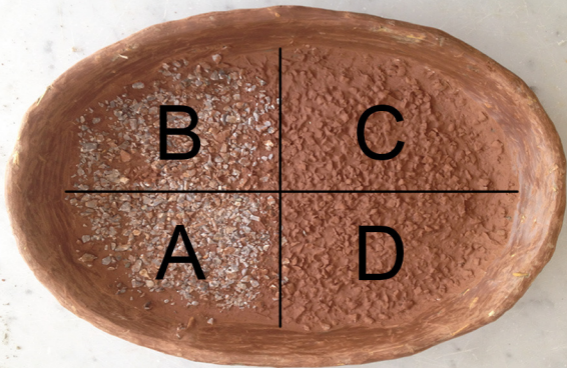


b



e





B

C

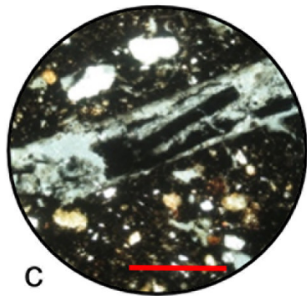
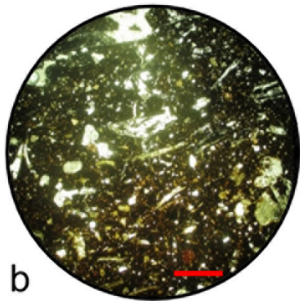
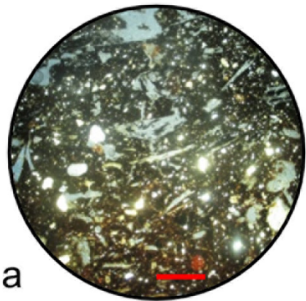
A

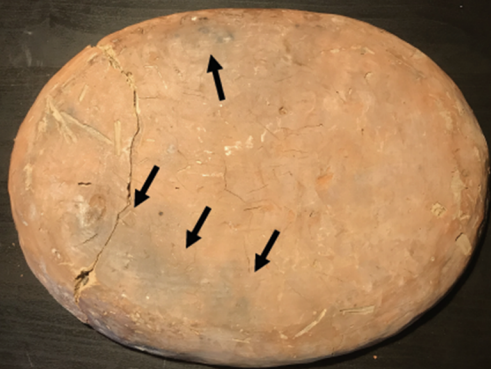
D







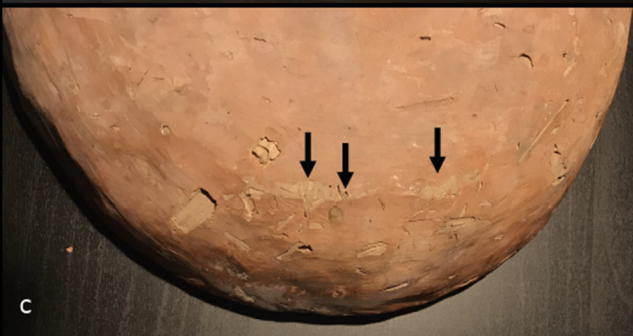




a



b



c



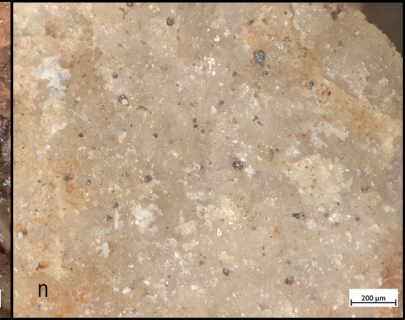
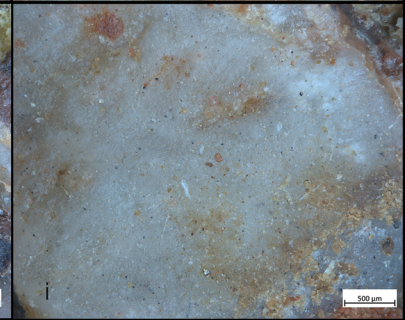
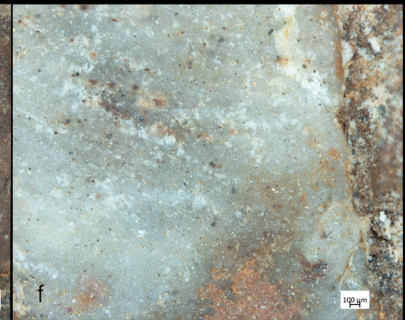
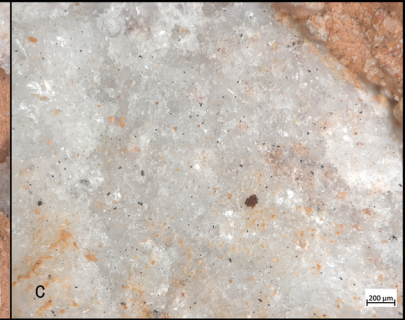
d

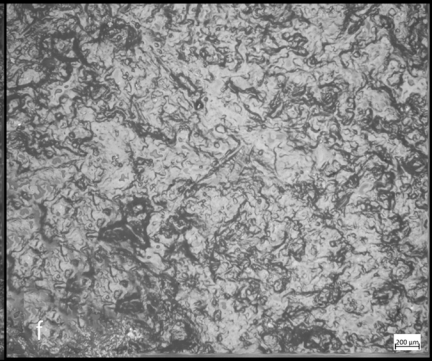
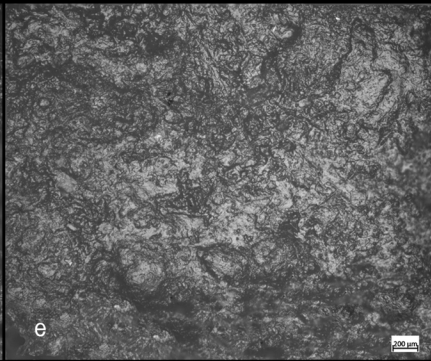
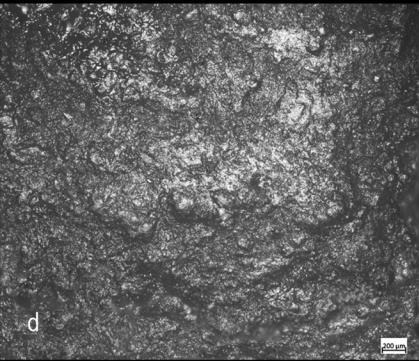
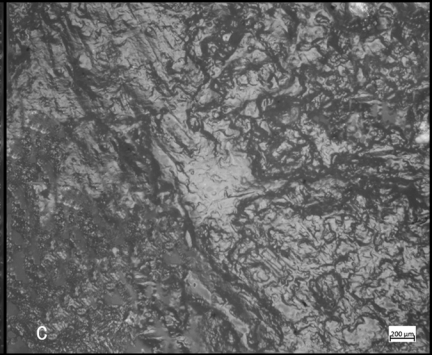
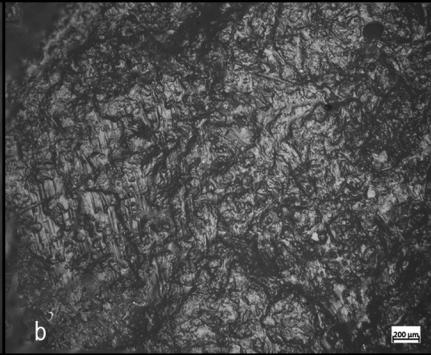
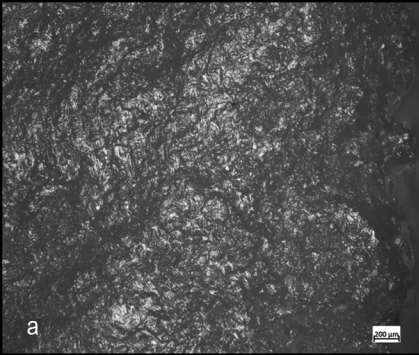


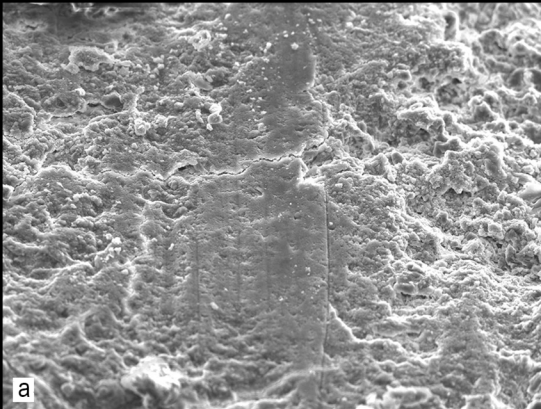
e



f



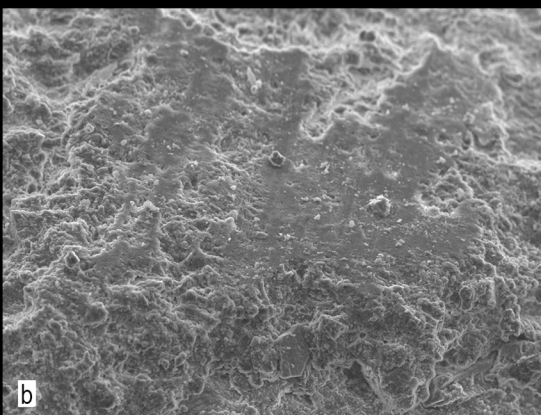




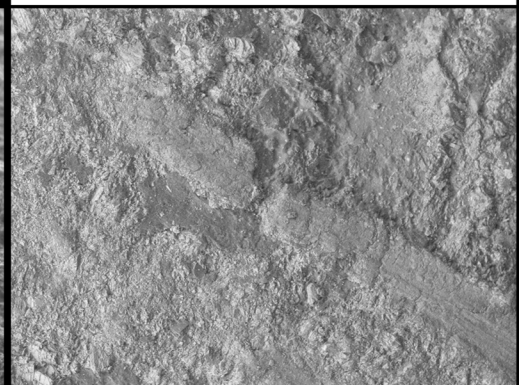
INGV SEI 10.0kV X1,200 10 μ m WD 8.3mm



c FLSD4.1 x400 200 μ m

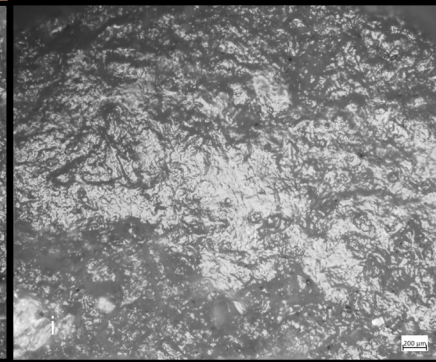
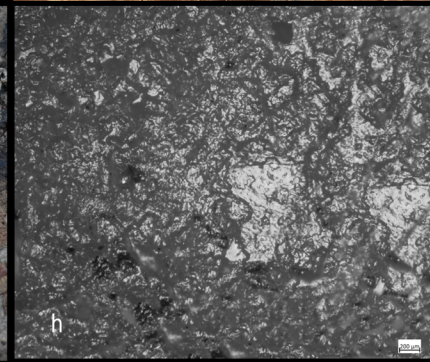
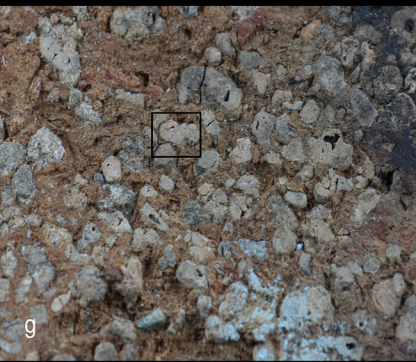
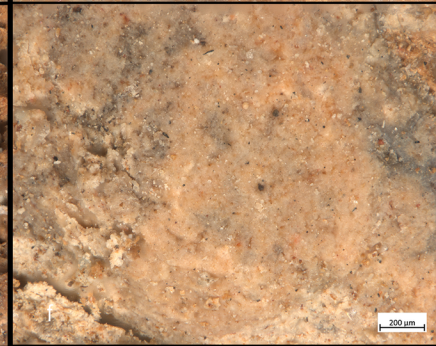
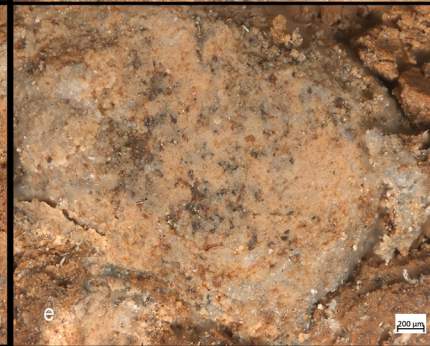
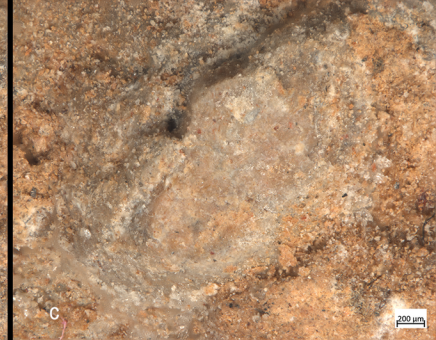
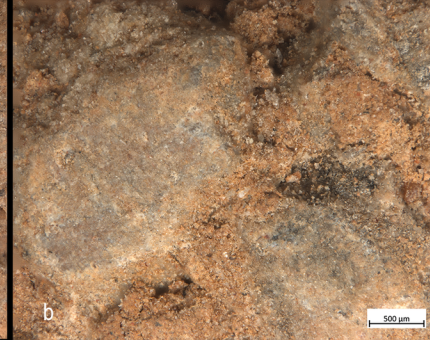
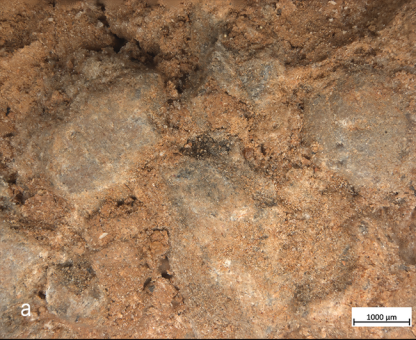


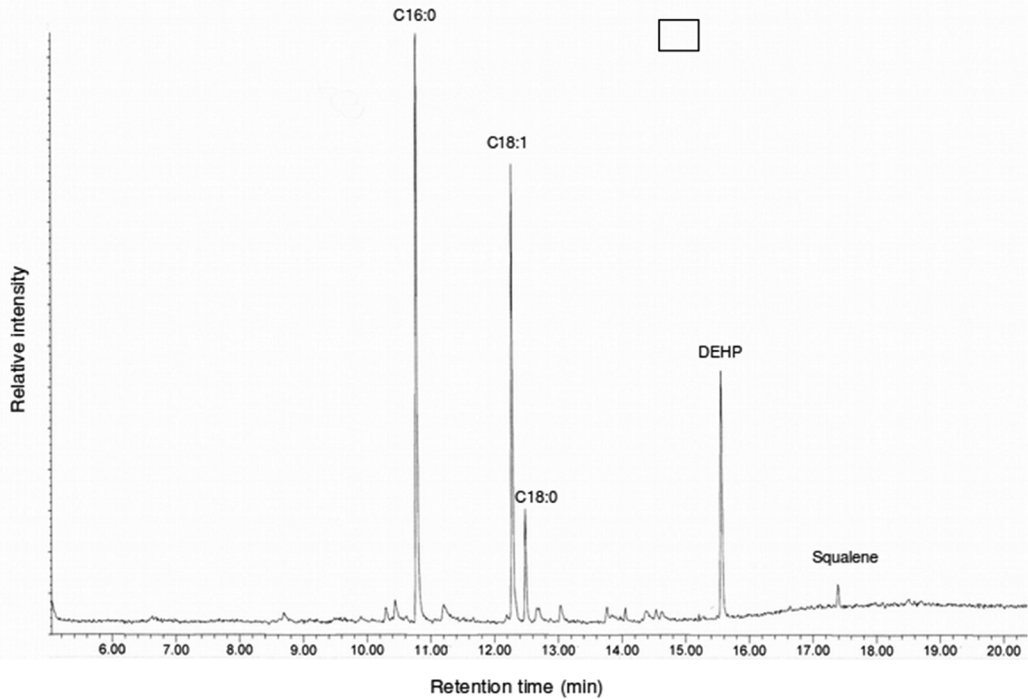
INGV SEI 10.0kV X850 10 μ m WD 7.9mm



d FLSD4.0 x600 100 μ m







Exp.	First Treatment	Second Treatment	Initial product	Oil Quantity	Time
Flax seeds oil	Gentle punding and grinding	Addition of water; heated on embers; filtered product.	1kg	800ml	2h 30m
Palm oil	Gentle pounding and grinding; separation of the pulp from the stone; pulp processing.	Pre-heating (boiling) of the fruits; addition of water; heated on embers; filtered product.	1.5kg	500ml	4h
Baking bread	//	Baked on embers	//	//	15m

Tab. 1: Experiments conducted with the replica. Type of treatment, quantity of oil obtained and time spent.