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Ochre *Chaînes Opératoires* in Neolithic Greece: The Case of Kremasti-Kilada

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In memory of Kaddee Vitelli;
she played with clay as well as ochre

Abstract

While red ochre had been exploited in the Aegean since the Upper Paleolithic, its use became more substantial and diverse during the Neolithic. The evidence comes in the form of: decoration of artifacts such as pottery; red-stained tools and containers; painted plaster; ochre pigment contained in vessels; an ochre mine; deliberately shaped ochre artifacts; worked and unworked pieces of ochre. It is the last category that we discuss in this paper by focusing on the assemblage from the Late Neolithic site of Kremasti-Kilada. With roughly 80 specimens, this is the largest assemblage known from Neolithic Greece. Our paper explores the Kremasti ochre chaînes opératoires through macroscopic, geochemical, and use-wear analysis, experimental work, ethnographic observations, and contextual data. We also discuss possible implements used to treat ochre, as well as potential surfaces or objects on which the processed material was applied. Finally, we draw comparisons with other assemblages in the same region and beyond, placing the Kremasti collection in its wider Aegean Neolithic context.

Keywords: Greece, Neolithic, ochre, chaînes opératoires, portable X-ray fluorescence, use-wear analysis

Résumé

Bien que l'exploitation de matières colorantes soit attestée en Grèce dès le Paléolithique supérieur, son utilisation s'intensifie et se diversifie considérablement au cours du Néolithique. Les témoins de cette évolution comprennent: décorations ocrées retrouvées sur divers types d'artefacts tels que la poterie; outils et contenants présentant des résidus ocrés; enduits muraux de couleur rouge; récipients contenant des pigments; un site d'extraction; artefacts en ocre intentionnellement façonnés; blocs bruts et utilisés. Cet article s'attache à l'analyse de cette dernière catégorie, à travers l'étude de l'assemblage du site Néolithique récent de Kremasti-Kilada. Comprenant environ 80 blocs, cet ensemble est le plus important connu à ce jour pour la Grèce néolithique. Notre étude explore les chaînes opératoires de traitement et d'utilisation des matières colorantes minérales indurées à ce site. Elle se fonde sur l'intégration de différentes approches comprenant examens macroscopiques et géochimiques, étude des traces d'usure, recherches expérimentales et ethnographiques et enfin analyses des données contextuelles. Par ailleurs, notre analyse considère également les outils potentiellement utilisés pour transformer les matières colorantes ainsi que les surfaces et objets sur lesquels ces matières ont été appliquées. En outre, des comparaisons avec d'autres assemblages de la même région et d'ailleurs permettent de placer le matériel de Kremasti dans un contexte néolithique égéen plus large.

Mots-clés : *Grèce, Néolithique, matières colorantes, chaînes opératoires, spectroscopie de fluorescence X portable, analyse des traces d'usure*

1. Introduction

First, a definition: ochre is a generic term used by archaeologists for a range of earths, minerals, and rocks that comprise iron oxides and iron hydroxides – most commonly hematite and goethite (Dapschauskas *et al.*, 2022; Hodgskiss 2023; Wadley, 2005a). Ochres are variably colored. It is the red ones that we explore in this paper.

Ochre has been used since the Lower Paleolithic (Dapschauskas *et al.*, 2022; Watts *et al.*, 2016). Most commonly, it has served as pigment in decorative, cosmetic, and ritual contexts – for painting, marking, smearing, or covering living and dead bodies, artifacts, architectural elements, or natural surfaces. However, the ethnographic, historical, and archaeological records include additional functions – as abrasive for fine polishing, hide tanning agent, additive in adhesives, medicinal substance, sunscreen, etc. Pieces of ochre have also been deliberately shaped into specific objects, such as ornaments (e.g. Asher *et al.*, 2020; Billard *et al.*, 2016; Bueno Ramírez *et al.*, 2023; Dapschauskas *et al.*, 2022; Domingo *et al.*, 2012; Dubreuil & Grosman, 2009; Helwig *et al.*, 2014; Hodgskiss, 2013a: 22-23, 2020, 2023; Hodgskiss & Wadley, 2017; Hovers *et al.*, 2003; Huntley, 2021; Peile, 1979; Photos-Jones *et al.*, 2018; Rifkin, 2015a, 2015b; Robitaille, 2021: 151-155; Sagona, 1994; Schotsmans *et al.*, 2020, 2022; Watts, 2015; Wolf *et al.*, 2018).

Ochre exploitation in the Aegean has its origins in the Upper Palaeolithic. The most impressive evidence from this period consists of an underground mine located at Tzines, on the Macedonian island of Thasos. Extraction of the mineral began c. 20,000 years ago making this the oldest known underground mine in Europe (Koukouli-Chryssanthaki & Papadopoulos, 2009; Koukouli-Chryssanthaki & Weissgerber, 1993, 1999; Levato 2016; Weissgerber *et al.*, 2008). How the mined material was circulated and where it ended up are not known, but the use of ochre (or substances that look like ochre) has been reported from Upper Paleolithic sites elsewhere in Greece. Such a substance, for example, was detected on grooved bones, deer canines, or perforated shells from the rockshelters of Klidi and Kastritsa in Epirus and Klissoura Cave 1 in the Peloponnese, while pieces of 'hematite' were uncovered at Melitzia Cave, also in the Peloponnese (Adam, 2009; Adam & Kotjabopoulou, 1997; Darlas, 2018; Darlas & Psathi, 2016; Kotjabopoulou & Adam, 2004; Stiner, 2010).

The Mesolithic evidence includes shell and stone ornaments with an ochre-like coating, as well as red-stained macrolithic (i.e., ground stone) tools from Franchthi Cave in the Peloponnese (Perlès, 2018: 167-175; Stroulia, 2010a: 17-26). Ochre was also identified in burials at the open-air site of Maroulas, on the Cycladic island of Kythnos (Sampson *et al.*, 2010: 41).

Ochre usage became both more substantial and more variable during the Neolithic. The evidence comes in several forms: decoration of artifacts (e.g. pottery), painted plaster, red-stained containers and tools, ochre powder found in containers, an ochre mine, objects crafted from ochre, as well as modified and unmodified ochre nodules (e.g. Chondroyianni-Metoki, 2009: 402; Coleman, 1977: 28; Koukouli-Chryssanthaki & Papadopoulos, 2009; Levato, 2016; Maniatis & Tsirtsoni, 2002; Theodoraki, 2018: 76, 107-116). It is the last category that we investigate here by using the assemblage of Kremasti-Kilada (henceforth Kremasti) as a case study.

Our paper explores the ochre *chaînes opératoires* at Kremasti by 1) integrating macroscopic, geochemical, and use-wear analysis of the ochre lumps with experiments, ethnographic observations, and excavation data; 2) discussing potential ochre processing implements; 3) examining potential surfaces on which ochre was applied. Moreover, we make comparisons with other assemblages in the same region and elsewhere, placing the Kremasti material in its broader Greek Neolithic context.

A few notes on terminology. Three terms pertain to artifact anatomy. 'Faces' is used here for a specimen's broad surfaces, 'sides' for the long, narrow surfaces flanking the faces, and 'ends' for the short, narrow extremities.

One term refers to preservation. 'Complete' is used not only for unbroken specimens but also those missing a part small enough or from such a location as to leave the basic dimensions essentially unaffected.

Two other terms concern function. In the literature, 'grinding' and 'abrasion' are often used as synonyms (e.g. Dayet *et al*. 2014; Hodgskiss, 2010, 2013a, b; 2020; Hodgskiss & Wadley, 2017; Logan & Fratt, 1993; Peterson, 1984: 133; Velliky *et al.*, 2018; Wadley, 2005a; Wolf *et al.* 2018). In this paper, these terms are differentiated. 'Grinding' refers to pulverization of foodstuffs and minerals with a pair of implements – one stationary, the other mobile. Pulverization occurs when the active component is moved over the passive one and against the processed material. 'Abrasion', on the other hand, involves a single passive tool, against which, a rock, mineral, bone, or shell is moved for the purpose of shaping or extracting fine-grained material (see also below).

Finally, the chronological framework for the Aegean Neolithic adopted in this paper is as follows: Early Neolithic: 6700/6500–5800/5600BC; Middle Neolithic: 5800/5600-5400/5300BC; Late Neolithic: 5400/5300-4700/4500BC; Final Neolithic: 4700/4500-3300/3100BC (Andreou *et al.*, 2001).

2. THE SITE

Kremasti is located in the prefecture of Kozani, in west Macedonia, northern Greece (Fig. 1). It is one of 30 Neolithic (mostly tell) sites identified in a 35 km² basin called Kitrini Limni (Chondroyianni-Metoki, 2009: 60-61, 2017, 2020, 2022, in press a, b; Fotiadis, 1988; Karamitrou-Mentesidi, 1986). Discovered during construction work for a major highway, Kremasti became the target of salvage excavations in 1998-1999 under the direction of Chondroyianni-Metoki. The excavations covered roughly two acres and uncovered numerous features consisting of pits, ditches, and cremation burials (Fig. 2). The features are dated to the Late Neolithic period (c. 5340-4930BC) and distributed among four different phases: A (latest) through D. All features are adjacent to a low tell. Though not systematically excavated, diagnostic finds from surface survey and test digging indicate that the tell is contemporaneous with these features. Hence, it is presumed to represent the associated

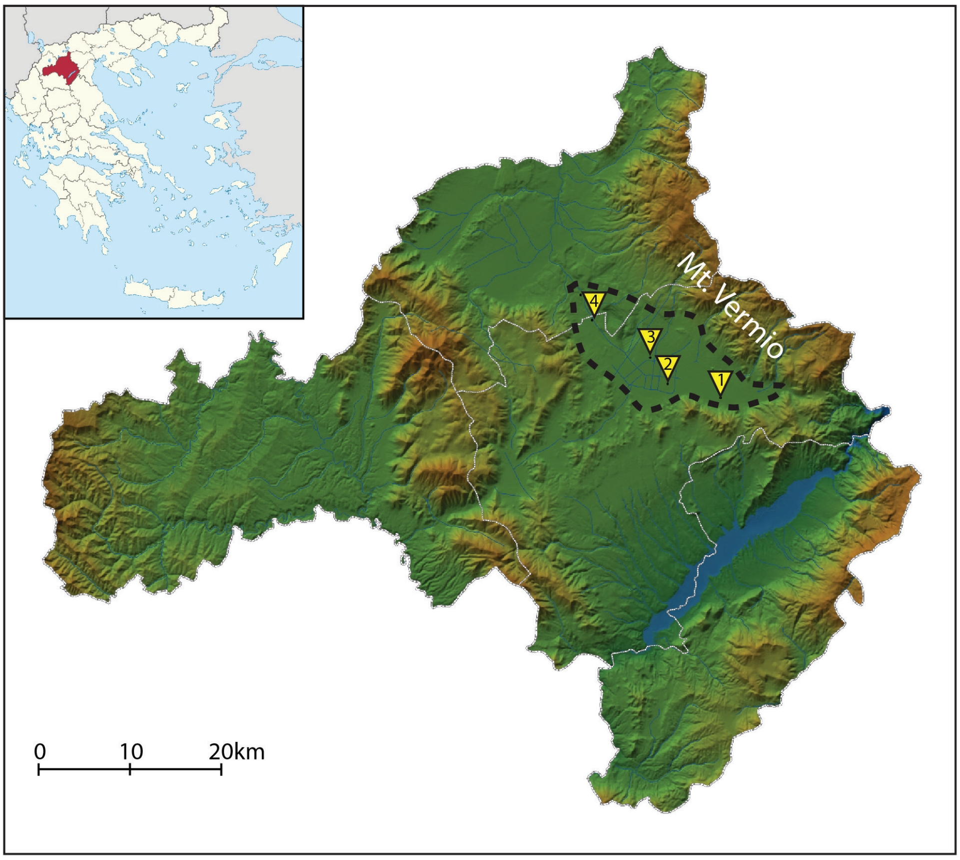


Fig. 1 – Map of prefecture of Kozani with locations of Kremasti (1) and three other sites in the Kitrini Limni Basin mentioned in the text: Megalo Nisi Galanis (2), Kleitos (3), and Pontokomi-Souloukia (4). Kitrini Limni is indicated by dashed line. Graphics: Sofia Vlahopoulou.

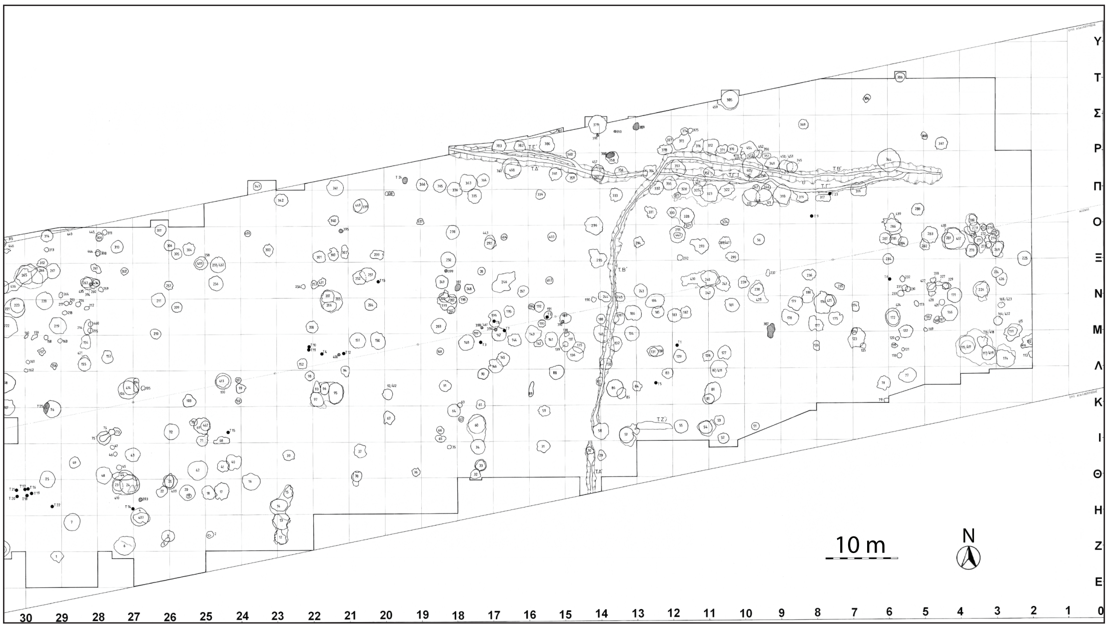


Fig. 2 – Plan of the excavated area at Kremasti. Round features represent pits or cremation burials, linear features represent ditches. Drawing: Thomai Vakouftsi.

settlement (Chondroyianni-Metoki, 2009: 1-5, 63-155, 2010, 2020, 2022).

A total of 462 pits were identified (Fig. 2). As large as this number may be, limited testing has confirmed the presence of additional such features in the vicinity. Occasionally overlapping, the pits are variously sized and shaped. Most (n=216) belong to phase C, roughly 100 are dated to each of the phases B and D, with approximately 40 assigned to phase A. These features yielded the vast majority of finds, comprising remnants of burnt structures, pottery, stone tools, animal and human remains, figurines, as well as ornaments. Sixty-five percent of the pits show evidence of a single episode of use, in which they were filled with this or that kind of material. The rest were used more than once, as reflected by the presence of multiple strata. A pottery refitting project produced no inter-layer joins, an indication that the contents of different strata originate from different contexts (Chondroyianni-Metoki, 2009: 156-276, 330-334, 2020, 2022; Silva, 2023: 142).

Fifteen pits showed clear evidence of structured deposition as they contained carefully arranged regular- and miniature-sized pots. Another two contained inhumations. The contents of most pits, on the other hand, appear to have been haphazardly thrown in. However, for reasons explained elsewhere, the excavator does not view the pits as mundane features into which everyday waste was dumped. She argues instead that these were dug in specific shapes in order to dispose of, deposit, or bury material that for one reason or another was deemed unsuitable for use or inappropriate for remaining amongst the living. For her, pit digging and infilling at Kremasti was a widespread social practice with symbolic connotations (Chondroyianni-Metoki, 2009: 156-276, 631-646, 2020, 2022).

The excavations identified a total of six ditches (Fig. 2). They are V- or U-shaped in cross-section, with a maximum width of 2.5 m. Although different ditches and ditch segments were dug at different times, together they form a T-shaped complex. The arms of the T run East-West and North-South, with lengths of 74.0 m and 27.0 m, respectively. These dimensions, however, represent only the excavated part of the complex. Some of the ditches extend beyond the investigated area leaving the original size of the complex undetermined. The ditches disturbed earlier pits but cutting of ditches by later pits also occurred. In general, ditches yielded relatively small amounts of finds. The function of the ditch complex is for the moment unclear. Given its open plan, a defensive role should be ruled out. Ditch digging for clay mining is more plausible but still uncertain. Whatever practical purposes, if any, the Kremasti ditch complex may have served, its geometric shape and alignment with the cardinal directions leave little doubt of its symbolic dimensions (Chondroyianni-Metoki, 2009: 277-305, 624-627, 2020, 2022).

Twenty-three cremation burials were excavated (Fig. 2). All are secondary: the dead body was burnt elsewhere, with a portion of the cremated remains interred in a shallow pit. With one exception, these burials belong to the site's final phase (A) and post-date most pits and ditches. Given their location outside the settlement's residential sector, they are assumed to belong to a cemetery. If so, this is the earliest known cemetery in west Macedonia (Chondroyianni-Metoki, 2009: 306-316, 627-630, 2010, 2020, 2022).

3. NUMBERS, PRESERVATION, MORPHOMETRY

Among the huge quantities of Kremasti finds are over 2500 macrolithics. The overall project of their publication has been undertaken by Stroulia in collaboration with Dubreuil and Robitaille (use wear analysis and associated experiments), as well as Melfos and Kantiranis (identifications of raw materials and associated geological surveys) (Dubreuil *et al.*, 2023; Stroulia, 2010b; Stroulia & Dubreuil, 2011; Stroulia & Chondrou, 2013; Stroulia *et al.*, 2017). Roughly 300 specimens (from ten pits) were studied by Danai Chondrou in the context of a MA thesis (Chondrou, 2011).

The Kremasti macrolithics include a total of 77 pieces of ochre—of which seven were first presented in the above thesis (Chondrou 2011: 136-138). This is the largest ochre corpus reported from Neolithic Greece. Notably, the second largest derives from Kleitos, another site in Kitrini Limni (Chondrou, 2018: 294-301). Both Kremasti and Kleitos have seen massive excavations, and it is tempting to consider this as the reason for their relatively large ochre assemblages. However, the complete absence of such items from the equally extensively excavated site of Makriyalos, farther east in the region of Macedonia (Tsoraki, 2008), or the discovery of only three specimens among the huge number of stone finds at Avgi, farther west (Bekiaris, 2018: 156-157), argue against a hypothesis of excavation biases.

Traces of use were identified on 50 of the Kremasti ochre pieces (65%). The remaining 27 carry no use-wear. As indicated by the unmodified specimens and the unaltered parts of the utilized ones, the raw material consists of amorphous and (more rarely) tabular pieces detached naturally from the parent bedrock. With a couple of exceptions, their natural surfaces are irregular. Ranging from light to dark red, the colors are assigned to the Munsell 5R Hue, with roughly ten falling in the 7.5R Hue. To avoid scratching the specimens, we chose not to use the Mohs scale. However, they seem to be relatively hard.

Close to 30% of the nodules are cracked. The presence of cracks on not only unutilized surfaces but also utilized ones (Fig. 3b, 4) raises the possibility of exposure to intense heat that, indeed, followed use. This hypothesis needs further investigation, but heat exposure could have taken place during the (house?) fires that generated the burnt architectural remains and other items found in the pits (Chondrou, 2011: 94-95, 113; Chondroyianni-Metoki, 2009: 220-227; Stroulia *et al.*, 2017). Archaeological and ethnographic studies have documented the use of heating to turn yellow, gray, or tan ochre varieties to red (Pradeau, 2015: 49; Robitaille, 2021: 276; Rosso, 2017; Salomon *et al.*, 2012; Wadley, 2005a). As sexy as it may sound, deliberate thermal treatment is implausible for Kremasti: the ochre lumps that served as raw materials were red to begin with. The presence of cracks on utilized areas also argues against this hypothesis.

Only eighteen of the utilized specimens are complete. Their metric ranges and averages are as follows: length: 1.7-11.7 cm ($\bar{x}$=4.6 cm), width: 1.6-9.1 cm ($\bar{x}$=3.4 cm), thickness: 0.6-3.9 cm ($\bar{x}$=1.8 cm), and weight: 2-316 g ($\bar{x}$=59 g) (Fig. 3-4, 7). Of the non-utilized specimens thirteen are complete. They are comparable in size to their utilized counterparts as indicated by their mean dimensions: length: 5.1 cm, width: 3.7 cm, thickness: 1.7 cm, and weight: 49 g. Overall, it appears that usage did not substantially alter the original lump dimensions.

With a couple of exceptions, none of the fragmentary specimens seems to derive from nodules larger than the complete ones. Coupled with the above data, this suggests that the harvested materials were small, rarely surpassing 10 cm.

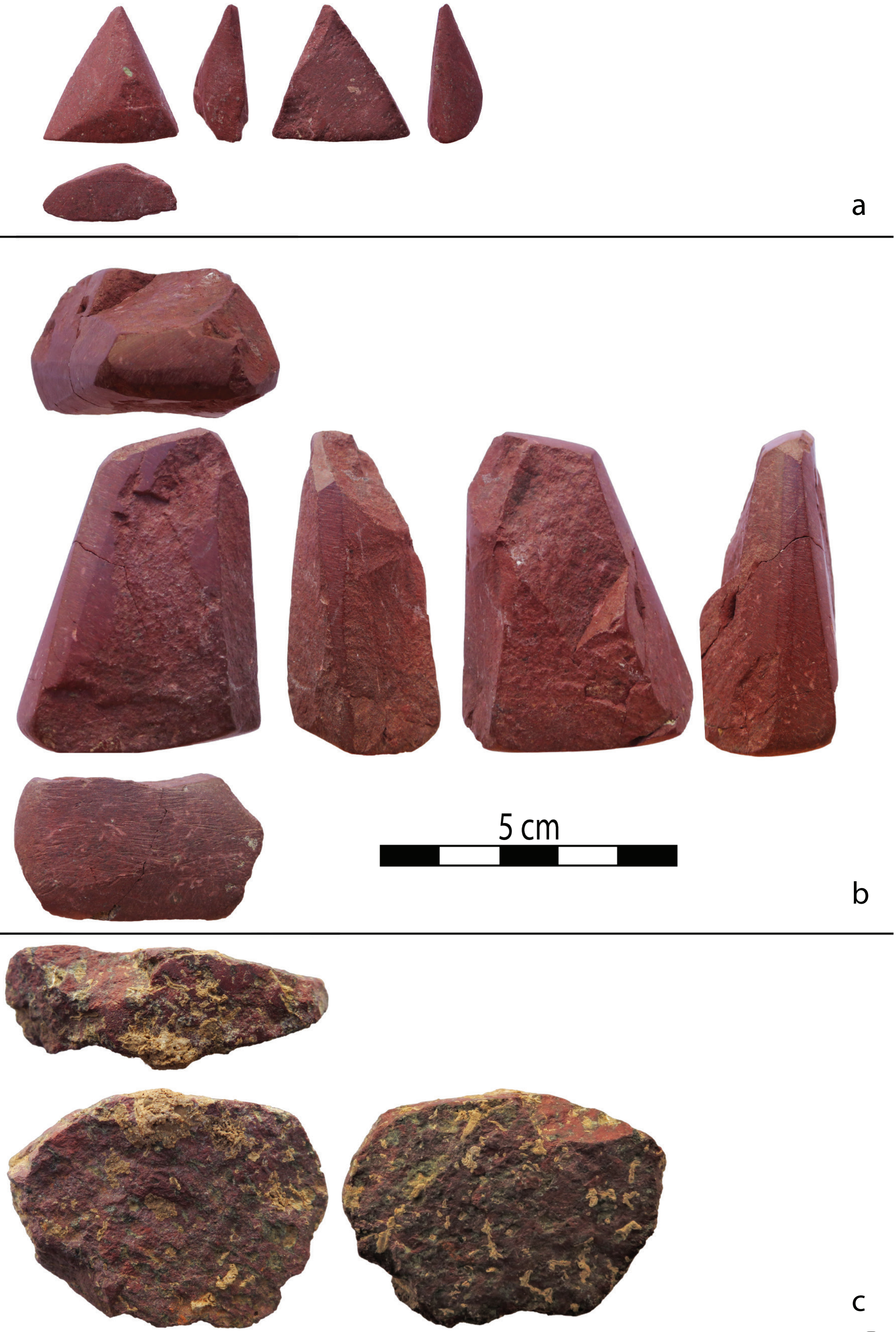


Fig. 3 – Three small specimens. a. #615 (Group 5): Faces, sides, and one end (all abraded). b. #618 (Group 4): Faces, sides, and ends (all with abrading wear, see also cracking). c. #3255 (Group 2): Faces and abraded periphery. Scale 1:1. Photos: A. Stroulia.

Fig. 4 – Specimen #3282 (Group 3): Faces (one abraded) and one side (abraded and cracked). Scale 1:2. Photos: A. Stroulia.

4. RAW MATERIAL IDENTIFICATION

Portable X-ray fluorescence is a convenient, inexpensive, and non-destructive technique for *in situ* analysis of materials or examination of large numbers of specimens. Despite its limitations (Ditchfield *et al.*, 2023), it was considered the most suitable for examining the rock/ore types of the Kremasti ochre specimens. The concentrations of nine major-element oxides (SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, K_2O, Ti_2O, and P_2O_5) and several trace elements (e.g., Ba, Cu, Cr, Ni, Rb, Sr, Y, Zr, and Zn) were determined via a Bruker S1 Titan 600 pXRF apparatus that included a 4 W Rh X-ray tube and a silicon drift detector (resolution <145 eV), with 5 mm spot size. The device was calibrated using the GeoExploration package. The analysis was conducted in three energy ranges (15, 30 and 50 kV) for 30 s each (a total of 90 s). The major elemental concentrations calculated with the Geoexploration mode were calibrated using certified reference materials (CRMs). Calibration curves with R2 values greater than 0.9 were obtained for major elements. The international standards NIST-278, JMS-1 Marine sediment, JMS-2 Marine sediment, SDO-1 Shale, SGR-1 Shale, JP-1 Peridotite, JB-1b Basalt, JB-2a Basalt, JGb-1 Gabbro, Jsy-1 Syenite, JG-1a Granodiorite, NCS DC 71302 Andesite, JA-2 Andesite, JA-3 Andesite, NCS DC 71305 Rhyolite, JSl-1 Slate, JSO-1 Soil, and JF-1 Feldspar were analyzed in order to ensure the proper quantification of the trace elements. For all trace elements, calibration curves with R2 values higher than >0.97 were obtained.

Following macroscopic examination to determine their physical properties, all but one of the seventy-seven ochre nodules were analyzed.[1] They were accordingly classified into six groups: Fe-Ni laterites (n=59, 77%), brecciated laterites (n=5, 7%), bauxitic laterites (n=5, 7%), Ca-rich laterites (n=3, 4%), cherts (n=3, 4%), and limestone (n=1, 1%) (Annexe 1).

Autochthonous lateritic nickel ores form through intense weathering of ultramafic rocks (peridotite, dunite, and serpentinite) in humid and tropical-subtropical conditions, and are always enriched in chromium, nickel, iron, and magnesium (Eliopoulos & Economou-Eliopoulos, 2000; MELFOS & VOUDOURIS, 2022). Iron, attributed to the presence of hematite and goethite, is the main reddish colorant agent of laterites. Due to erosion, autochthonous Fe-Ni laterites are commonly degraded, transported, and deposited in shallow sea environments, at karst formations within sedimentary carbonate rocks, such as limestones. These laterites are classified as allochthonous, and form either pisolitic textures or compact breccias with silcretes. Sometimes they contain a considerable amount of CaO, forming Ca-rich laterites. Bauxitic laterites are occasionally generated in karsts by the sedimentary mixing of weathering products of various origins, and are high in Al_2O_3.

1 One specimen was not available for analysis.

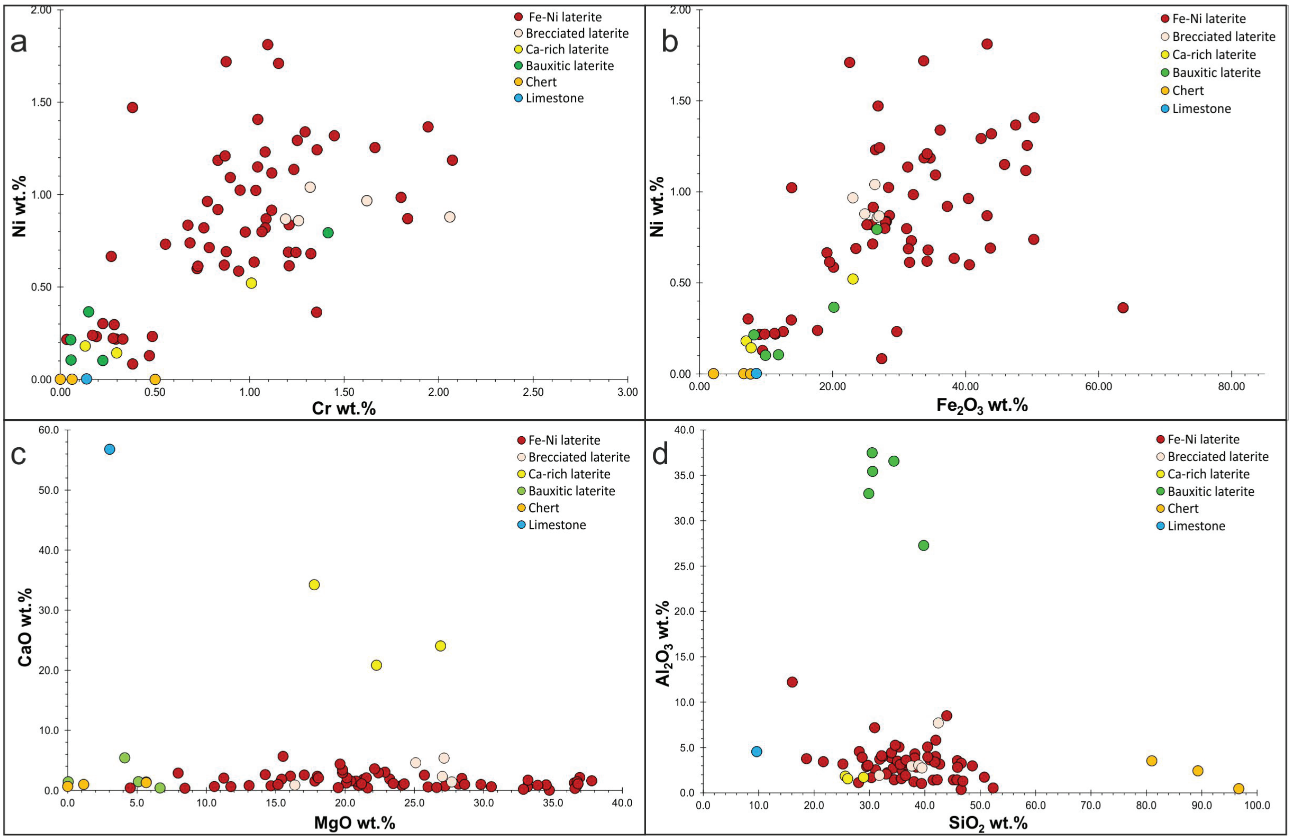


Fig. 5 – Biplot diagrams of the Kremasti ochre nodules. a. Cr vs. Ni; b. Fe2O3 vs. Ni; c. MgO vs. CaO; d. SiO2 vs. Al2O3. Graphics: V. Melfos.

The majority of the lateritic nodules (67 specimens) from Kremasti contain small or large hematitic pisolites, and are characterized by the presence of Cr (0.03-2.07 wt.%), Ni (0.08-1.81 wt.%), and Fe_2O_3 (7.0-63.67 wt.%), which are distinctive features of the lateritic ores. There is a slight positive correlation between Cr and Ni, and between Ni and Fe_2O_3 in the various laterite types (Fig. 5a-b). The discrimination between Fe-Ni laterites, bauxitic laterites, and Ca-rich laterites was based on the elevated concentrations of CaO for the Ca-rich laterites (20.83-34.23 wt.%) and of Al_2O_3 (17.28-33.99 wt.%) for the bauxitic laterites (Fig. 5c-d). The ochre nodules classified as brecciated laterites were discriminated based on angular fragments cemented by a finer reddish material, and on elevated Cr (1.19-2.06 wt.%) and Ni (0.86-1.04 wt.%) concentrations.

In the context of her thesis, Chondrou (2011: 136, Table B4) conducted SEM-EDS analysis of one of the Kremasti specimens. Her results are compatible with our pXRF analyses of the same specimen, taking into consideration that the spot size in SEM-EDS is 2 µm, while in pXRF is 5 mm. Note, however, that we classified this item as a Fe-Ni laterite, while she characterized it as a sedimentary rock rich in magnesium, silicon, and iron.

In contrast with the laterites, the three archaeological chert specimens (80.99 to 96.68 wt.% SiO_2, 2.10 to 7.68 wt.% Fe_2O_3) and the single limestone one (56.78 wt.% CaO, 8.55 wt.% Fe_2O_3) are free of Ni since they are not associated with the nickel laterites. Their red color is attributed to an elevated concentration of hematite.

The pXRF analysis of the prehistoric specimens revealed that the residents of Kremasti targeted laterites and for the most part a Fe-Ni variety. None of them could have been procured from the basin of Kitrini Limni itself, the bottom of which consists of clay marl (Fotiadis, 1988; Fotiadis *et al.*, 2019). However, according to the literature (Alevisos & Repouskou, 2011; Economou-Eliopoulos, 2003; Eliopoulos & Economou-Eliopoulos, 2000) and our own geological survey, lateritic ores are common in the vicinity. We have identified nine laterite outcrops and one concentration of laterite pieces in a seasonal stream at distances 9 to 25 km from the site. They are located on the western part of Mt. Vermion and around the city of Kozani, north and south of Kitrini Limni, respectively. The lateritic ores are closely associated with the ultramafic rocks of the area (autochthonous). Some of the laterites are allochthonous, are incorporated within limestones, and are characterized as Ca-rich laterites or bauxitic laterites.

Comparisons between the prehistoric specimens and geological samples collected at the above locations will be discussed in the context of a forthcoming publication that explores which ochre sources were exploited by the Kremastiotes and why.

5. OCHRE LUMP PROCESSING IN THE LITERATURE

The literature includes a variety of ochre lump processing methods. They are listed below:

1. Abrasion of an ochre piece on a passive stone surface with or without the help of water. Dry abrasion yields fine powder that can be sprinkled directly onto another surface such as a hide, dead body, or floor. Alternatively, powder is mixed with water or another binder to form a more or less thick liquid that can be applied, for example, on a person's skin, a pot, or a wall. Wet abrasion, on the other hand, generates a paste that can be similarly applied.[2] Abrasion results in one or more smooth, flattened, striated surfaces on the ochre piece and multiple, stained, abraded surfaces on the passive implement (see Hamon *et al.*, 2016; Hodgskiss, 2010, 2013b, 2020, 2023; Hodgskiss & Wadley, 2017; Langley & O'Connor 2019; LOGAN & Fratt, 1993; Pradeau, 2015: 76; Pradeau *et al.*, 2016; Rifkin, 2012; Robitaille, 2021: 154; Rosso, 2017; Schotsmans *et al.*, 2020, 2021; Velliky *et al.*, 2018; Wadley 2005a, b). Besides the production of pigment, abrasion has been employed to convert ochre nodules into objects, such as ornaments (e.g., Asher *et al.*, 2020). It should be emphasized that in some of the above publications the process of abrasion is often referred to as 'grinding' or, more rarely, 'rubbing.'

2. Percussion, consisting of breaking ochre nodules into small pieces that are subsequently pulverized on a passive surface with a hammerstone. It leaves behind loose powder (not as fine as that obtained through dry abrasion), stained passive and active tools, and ochre crumbs (e.g., Bosquet *et al.*, 2016; Dayet *et al.*, 2014; Hamon *et al.*, 2016; Hodgskiss, 2020; Hodgskiss & Wadley, 2017; Mauran, 2023; Pradeau, 2015: 180; Robitaille, 2021: 277; Rosso, 2017; Velliky *et al.*, 2018).

3. Grinding of ochre lumps between a lower passive and an upper active stone tool (Fig. 6a). It is sometimes preceded by breaking the material into smaller chunks. It leaves behind powder (somewhat coarser than that produced through dry abrasion), stained passive and active implements, and ochre crumbs (Domingo *et al.*, 2012; Hamon *et al.*, 2016; Hodgskiss, 2020; Pradeau, 2015: 269; Rifkin, 2012, 2015a, b; Robitaille, 2021: 155; Rosso, 2017).

4. Scoring (including scratching, incising, and engraving) the ochre piece with a sharp tool to extract powder or create designs in a decorative/symbolic context. If the former is the goal, multiple deep incisions are necessary (Hodgskiss, 2010, 2020, 2023; Hovers *et al.*, 2003; Rifkin, 2012; Velliky *et al.*, 2018).

5. Scraping the surface of an ochre nodule with a sharp edge. It produces powder and forms wide, concave, scraped areas on the nodule itself (Hodgskiss, 2020; Langley & O'Connor 2019; Pradeau, 2015: 76; Rifkin, 2012; Watts, 2015).

6. The aforementioned techniques concern almost exclusively the production of pigment. The last one pertains instead to the direct transfer of color as it consists of the application of the ochre piece itself on a specific surface. The application can be dry or wet. The targeted surface can be hard (like stone), medium hard (like wood), or soft and supple (like human or animal skin). Direct application of ochre nodules on hard surfaces produces facets on the former and colored areas on the latter. When elongated nodules are used with the ends, they are converted into so-called crayons—characterized by three or more facets converging to a point.

2 Kaddee Vitelli (personal comm.) used a variation on this theme in her experimental work: abrading the ochre, in a small puddle of water on the inside of a small clay bowl, which served as both abrading tool and container for the resulting paint.

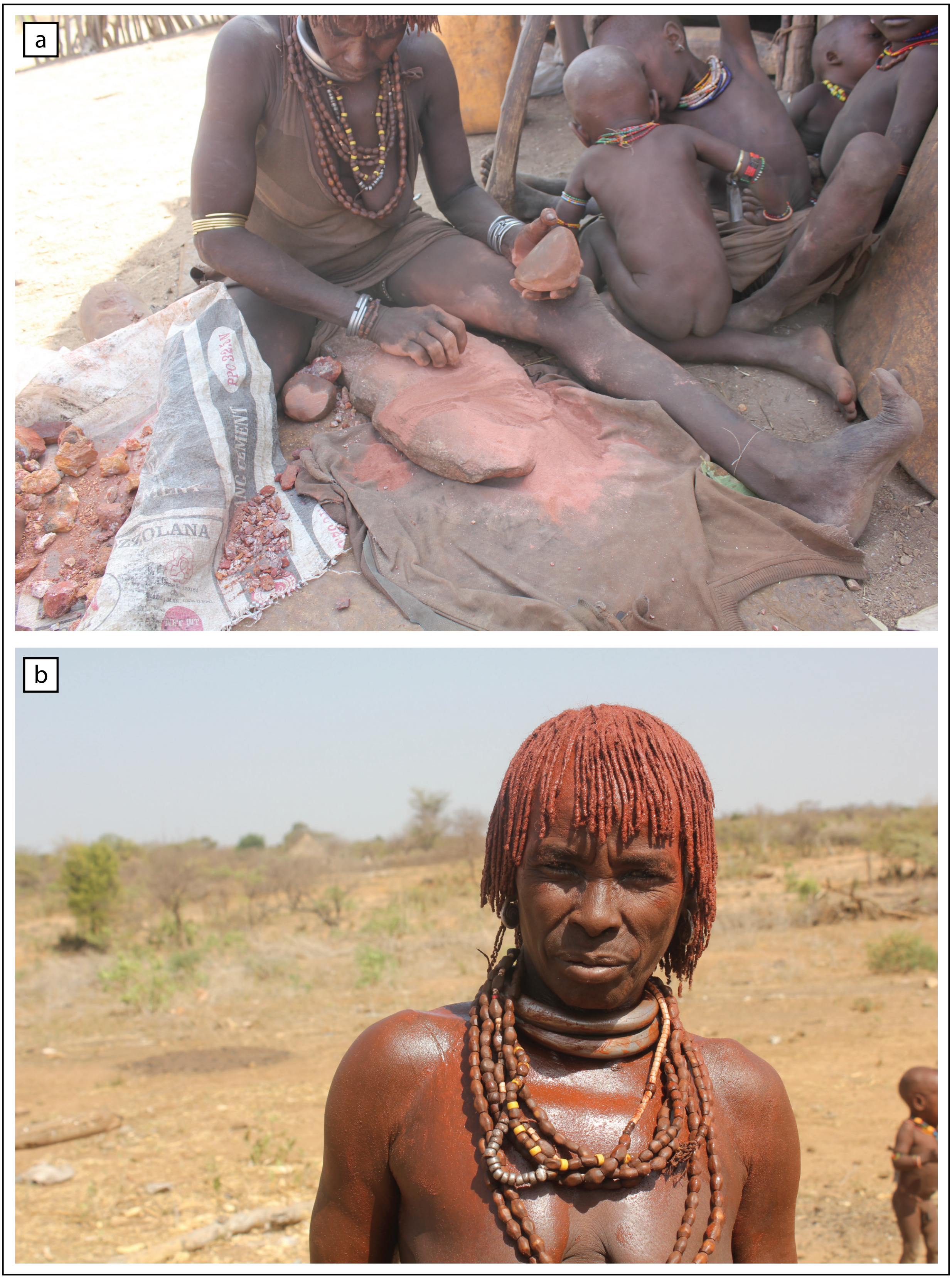


Fig. 6. – a. Ochre grinding by Hamar women in Ethiopia. b. Hamar woman's hair coated with ochre pigment. Photos: J. Robitaille.

Direct application on softer surfaces—most appropriately termed "rubbing'—is feasible only with ochres of high coloring power (Domingo *et al.,* 2012; Hamon *et al.,* 2016; Hodgskiss, 2013b, 2020; Hodgskiss & Wadley, 2017; Jodry *et al.,* 2016; Langley & O'Connor 2019; Rifkin, 2012; Velliky *et al.,* 2018; Wadley, 2005a; Watts, 2015).

The ochre processing methods described above are known from various chronocultural contexts such as Middle Stone Age Africa and the Levant, Upper Paleolithic Europe, Neolithic Anatolia, as well as historical or contemporary Australian Aboriginal, Native American, and African groups (Dayet *et al.,* 2014; Domingo *et al.,* 2012; Hamon *et al.,* 2016; Hodgskiss, 2013b; Hovers *et al.,* 2003; PEILE, 1979; Peterson, 1984: 133; Pradeau, 2015; Rifkin 2015a, b; Robitaille, 2021: 276; Schotsmans *et al.,* 2020, 2022). Combinations are also known. The scoring of previously abraded ochre pieces or their rubbing on soft surfaces has been reported, for example, from Palaeolithic sites in South Africa and Indonesia (Hodgskiss, 2013a: 16, 2013b; Langley & O'Connor 2019).

6. OCHRE LUMP PROCESSING AT KREMASTI

All Kremasti ochre nodules were examined macroscopically. Additionally, each specimen was subjected to use-wear analysis by Robitaille with an Olympus SZ40 stereomicroscope (5-30x magnification) and an Olympus Metallurgical microscope MF (100x and 200x magnification). For use-wear analyses of ochre lumps from other parts of the world, see, for example, Dayet *et al.,* 2014; Hamon *et al.,* 2016; Hodgskiss, 2010; Langley & O'Connor, 2019; Mauran, 2023; Rifkin, 2012. All but those of Mauran were carried out under lower magnifications.

With five exceptions, all 50 utilized Kremasti specimens bear traces of only one of the aforementioned techniques: abrasion. Since this is the main ochre processing method documented at the site, it is treated in detail in separate sections.

One of the exceptions bears exclusive evidence of scoring in the form of several random scratches on an uneven surface. Their purpose is unclear, but they are certainly too short and subtle to have aimed at the production of powder.

The remaining four exceptions are both scored and abraded. More specifically, the piece illustrated in Fig. 7a is thin and flattish, with slight abrasion on both faces. One face (A) is crossed by three long, straight incisions. Two are parallel and are crossed diagonally by the third one.

In the specimen shown in Fig. 7b, one surface (A) bears eight longer or shorter, mostly straight incisions. Five follow the nodule's longitudinal axis but for the most part are not parallel. The other three follow different directions, crossing some of the previous lines. An adjacent, narrower surface (B) features four long incisions arranged in two contiguous pairs. The first pair consists of straight lines meeting at a sharp angle, while the second comprises one straight and one curvilinear line converging in a similar manner. Due to breakage, almost none of the incisions are complete. A third surface (C) bears two short parallel lines. In neither of the above two specimens (Fig. 7a-b) is scoring deep enough to have produced nothing but a minimal amount of powder, yet it does form distinct linear patterns that may have had a decorative or symbolic dimension. These patterns appear on an irregular background, however, and the less exciting possibility that one or another Kremastiote etched them out of sheer boredom should not be ruled out...

The specimen of Fig. 7c bears multiple, roughly unidirectional scores on one of its faces (A). This face is flattish to slightly convex and well smoothed from intense abrasion that preceded scoring. A final specimen, on the other hand, shows random longer and shorter incisions on two slightly abraded faces.

In all cases, scoring probably involved a sharp stone tool.

7. ZOOM ON ABRASION

Forty-nine of the fifty utilized ochre nodules at Kremasti bear abrading wear exclusively or (in four cases) along with scoring. According to visual examination, for the most part the abrading wear consists of facets. More rarely, abrasion flattened the highest spots of otherwise irregular surfaces (see also Hodgskiss, 2010) or altered the texture but not the shape of convex surfaces.

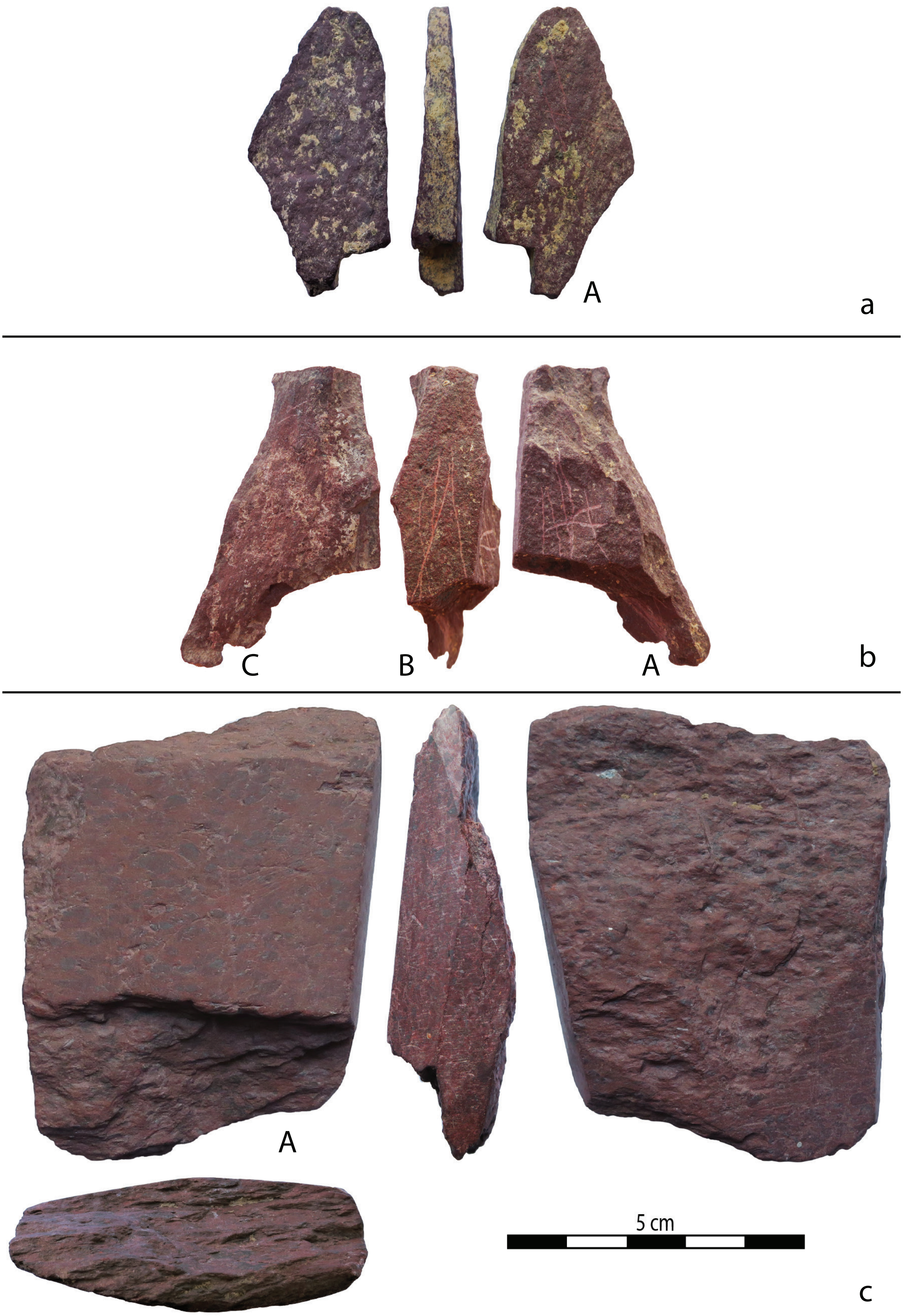


Fig. 7 – Three specimens with scoring. a. #621 (Group 2): Faces and one side. Scoring on face A. Slight abrading wear not visible in the photos. b. #633 (Group 2): Three adjacent surfaces, all with scoring. Slight abrading wear not visible in the photos. c. #3763 (Group 3): Faces, one side, and one end. Scoring on face A. Clear evidence of abrasion as well. Cracking on the side. Scale 1:1. Photos: A. Stroulia.

Criteria	Variability		
Numbers associated with radar map	1	2	3
1. Distribution (on the surface)	sparse	covering	concentrated
2. Density (within the polish)	separated	adjacent	connected
3. Microtopographic context	only on high topography	penetrating on low topography	observed on high and low topography
4. Morphology in cross section	domed	sinuous	flat
5. Texture	rough	fluid	smooth
6. Contours (or limits)	sharp	diffuse	
7. Thickness	thick appearance	thin appearance	
8. Opacity	translucent	opaque	translucent/opaque
9. Brightness	high	medium	low

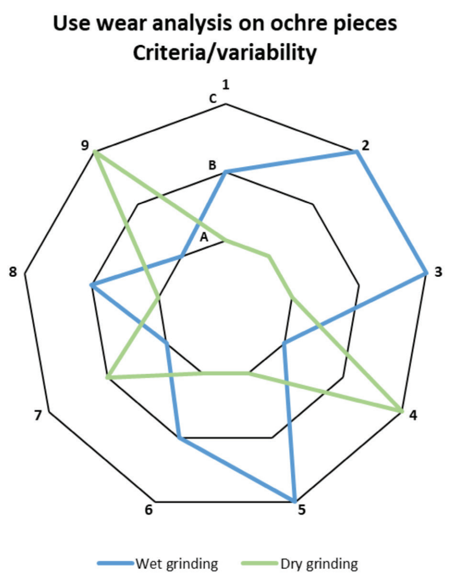


Fig. 8 – Table and radar map with criteria and variability used for use-wear analysis of Kremasti ochre nodules. Graphics: J. Robitaille.

Typically, facets have soft boundaries and cover an entire face, side, end, a ridge between two surfaces, or portions thereof. Combinations of facets of the above types may be present on the same piece, sometimes along with flattened high spots and/or abraded convex surfaces. Because of the specimens' generally small size (especially low thickness), sides, ends, and ridges tend to be the most convenient for use. However, while, in some instances, these bear the most extensive or all abrading wear, in others, faces are also abraded.

The number of facets per specimen varies from one to eleven. Usually but not necessarily, adjacent facets indicate rotation of the ochre piece during the same abrasion episode, meant to alleviate discomfort (especially pronounced with small nodules), target fresh coarser areas, and/or avoid parts with hard inclusions (see also Rifkin, 2012; Wadley, 2005a). Multiple, non-adjacent facets may or may not reflect a series of temporally separated episodes.

Seldom are facets entirely flat. Slight transverse convexity is the norm. While generally smooth, facets lack sheen. Inspected with the naked eye, they often (albeit not always) display fine striations. With rare exceptions, the striations are roughly unidirectional and most often diagonal or transverse to the facet's long axis.

Metallographic microscopy (100x and 200x) revealed two distinct traceological patterns: A and B. Pattern A is characterized by micropolish in the form of fine reflective striations on the surface of the grains or on the high microtopography. The distribution of the micropolish is sparse, and its density is separated. The contours of the areas with micropolish are sharp. Moreover, the micropolish is thin, translucent, and of low brightness. Its morphology in section is flat, with a rough texture (Fig. 8-9a).

Pattern B, on the other hand, is characterized by the formation of micropolish on the high but also low microtopographical contexts. Its distribution is covering, and its density is connected. The contours of the areas with micropolish can be described as diffuse. In addition, the micropolish appears thick, opaque, and highly bright. Its morphology in section is domed with a smooth texture (Fig. 8-9).

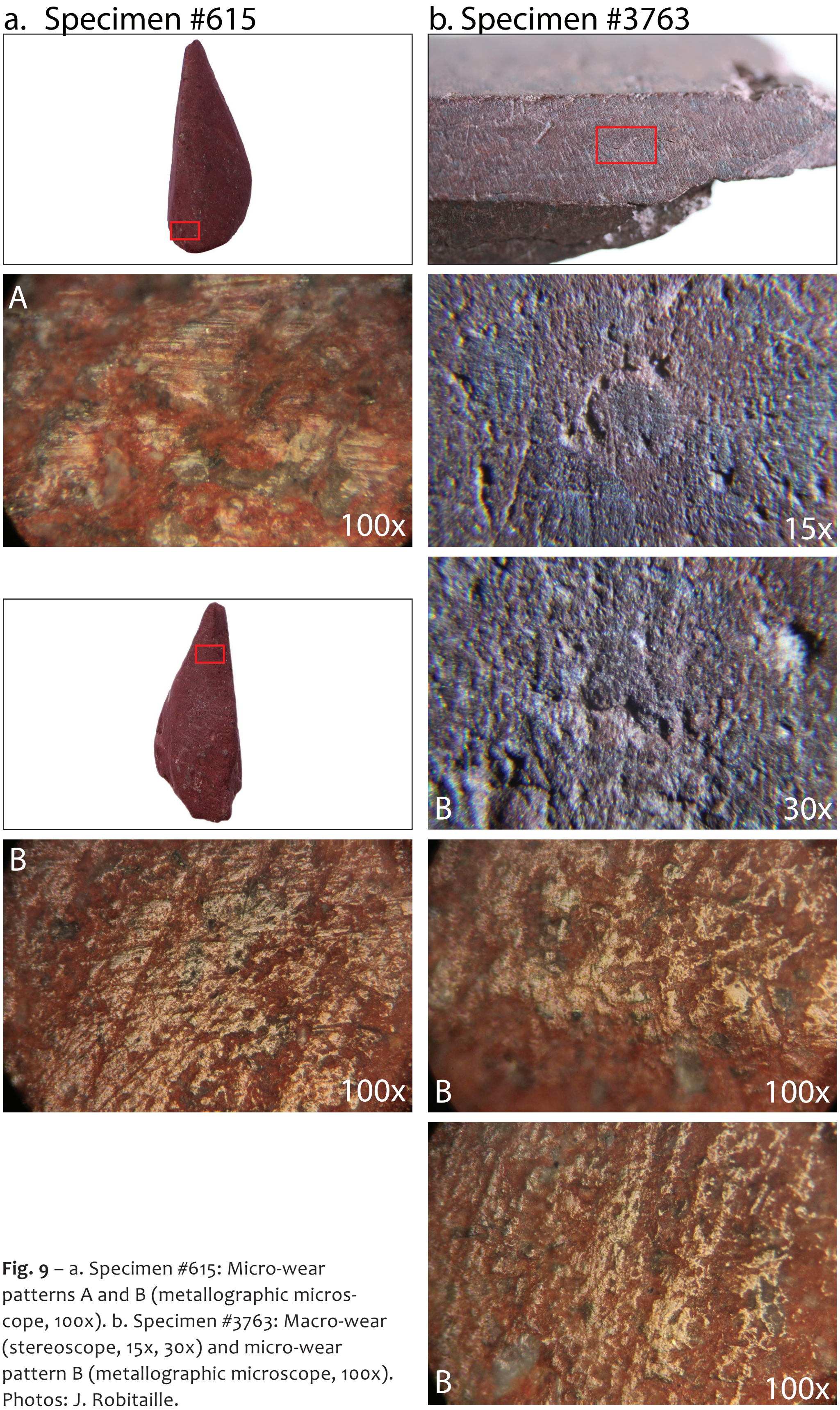


Fig. 9 – a. Specimen #615: Micro-wear patterns A and B (metallographic microscope, 100x). b. Specimen #3763: Macro-wear (stereoscope, 15x, 30x) and micro-wear pattern B (metallographic microscope, 100x). Photos: J. Robitaille.

Fig. 10 – Experimental dry ochre abrasion; experimental ochre paint applied on wooden stick, fired clay pot, and human skin. Photos: Andrew Strezewski and A. Stroulia.

Pattern A was detected on only two of the abraded specimens. Pattern B was identified on all 49 abraded pieces, including those with pattern A (Fig. 9a). In the latter, the two patterns may or may not overlap, but either way B is by far more extensive than A. Four of the items with pattern B are also scored (see above).

According to experiments by Stroulia and Robitaille, patterns A and B appear to represent two variations of abrasion. More specifically, pattern A matches the use-wear produced experimentally through dry abrasion. The experiment involved one of the ochre nodules collected in our geological survey. Measuring 4.7 x 3.0 x 1.7 cm, the nodule was of trapezoidal plan and had an irregular surface. Abrasion targeted a 3 cm-long edge and took place on the flat face of a tabular piece of fine-grained sandstone. Due to its small size, the nodule was held between the thumb and index finger. The motion was reciprocal and roughly longitudinal. The experiment lasted five minutes, after which a smooth, slightly convex facet 0.9 cm in maximum width was formed. Abrasion yielded fine reddish powder subsequently mixed with a small amount of water. The resulting paste was applied on a fired clay pot, a wooden stick, as well as the experimenter's skin (Fig. 10, 12).

Fig. 11 – Experimental ochre abrasion with the help of water; experimental ochre paste applied on unfired clay pot and human skin. Photos: A. Stroulia.

Pattern B appears compatible with use-wear produced experimentally through wet abrasion. This experiment involved another of the edges of the trapezoidal nodule employed in the previous one. This edge was c. 4 cm long. Abrasion took place on the flat face of a tabular piece of fine-grained sandstone with the help of water. We held the nodule with the thumb and index finger, dipped it in water, and moved it in a reciprocal, roughly longitudinal manner over the passive surface. During the experiment, the piece was moistened again and again. After five minutes, a smooth, slightly convex facet developed varying between 0.5 and 0.7 cm in width. Abrasion generated a red paste that was applied on a dry, unfired clay pot, as well as the experimenter's skin (Fig. 11-12).

Three notes regarding the experiments and the two types of abrasion in general:

1. The slight convexity of the experimentally produced facets matches that noted on the Kremasti specimens. A similar convexity has been reported by other scholars of archaeological ochres (Chondrou, 2018: 295; Hodgskiss, 2013b; Dayet *et al.*, 2014; Rifkin, 2012). It has been argued that this feature reflects the concave shape of the passive tools on which abrasion was carried out (e.g., Chondrou, 2018: 295). However, the fact that we produced

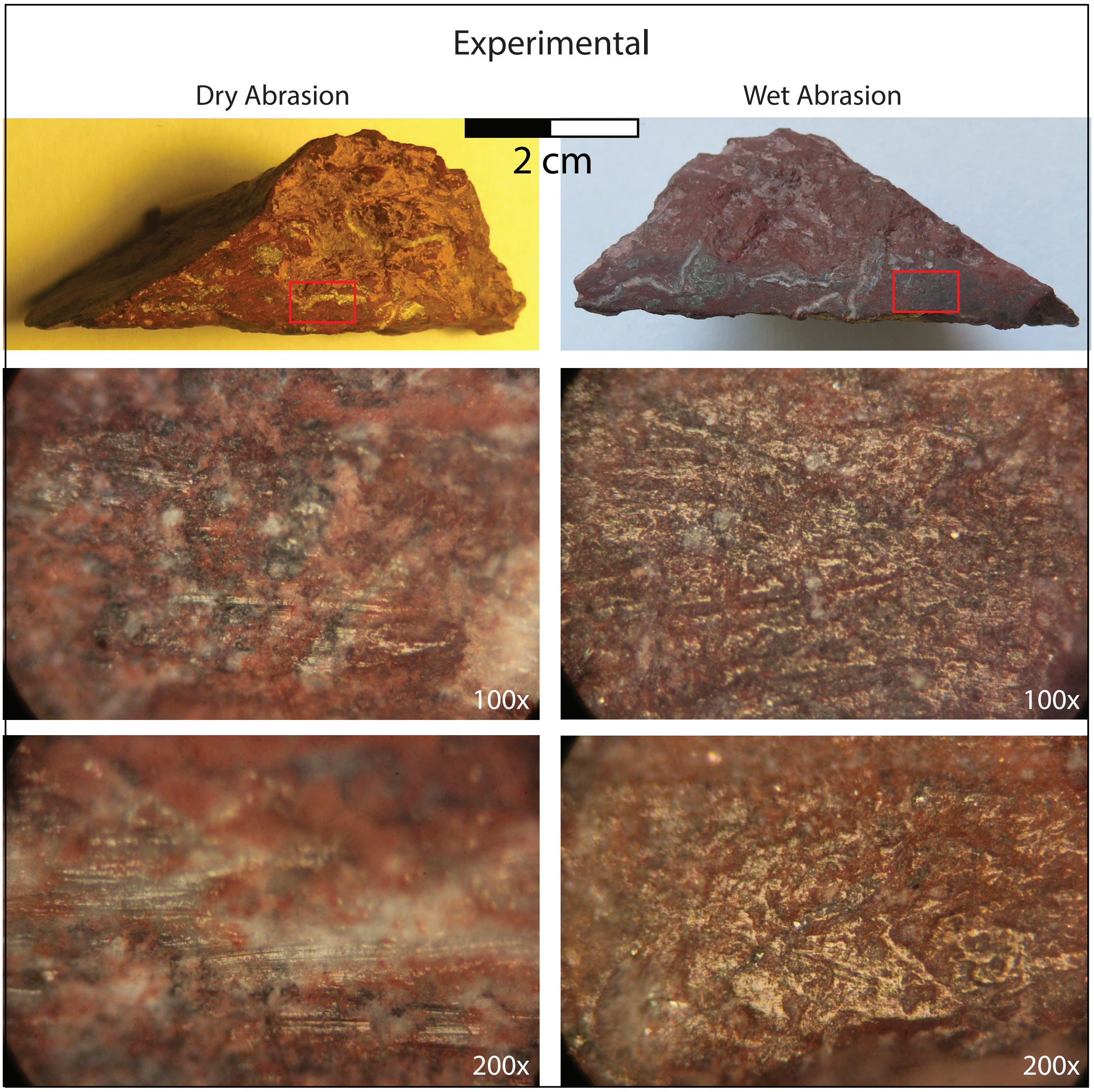


Fig. 12 – Geological ochre sample used experimentally for dry and wet abrasion with resulting micro-wear (metallographic microscope, 100x and 200x). Photos: J. Robitaille and A. Stroulia.

slightly convex facets through abrasion on flat, not concave, passive surfaces, shows this explanation to be inadequate, at least in some cases. We are more inclined to attribute the convexity of the experimental facets (and thus at least some prehistoric facets) to minor shifting of the abrading angle during use – a mini rotation of sorts. The shifting was so subtle that we did not realize it during the experiments. In retrospect, we believe that it was caused by a constant (if unconscious) need to abrade a coarser portion of the ochre piece. More experimentation is needed to test this hypothesis, however.

2. We found wet abrasion to be easier than its dry counterpart. However, the resulting paste dries up quickly and must be applied immediately or otherwise rehydrated. For this reason, it may be perceived as an inferior, less efficient product than the powder extracted through dry abrasion. Yet to the degree that, to be used as pigment, ochre powder is most often converted into a semi-liquid form, we consider this to be an erroneous impression. In terms of storability and transportability, ochre paste may also appear as a less advantageous material than powder. This is not

necessarily true either. The paste dries up on the surface where it is produced and can be 'stored' there for later rehydration and use. If the abrading tool is small, it can be easily transported along with the dried paste. If a substantial amount of paste is generated, it dries up into a cake, pieces of which can be easily transferred elsewhere (personal comm. with Kaddee Vitelli). Regardless, the fact that wet abrasion represents more or less the exclusive ochre lump treatment at Kremasti suggests that the inhabitants found paste not only suitable for their purposes but also preferable to powder.

3. While we are aware of ochre abrasion experiments carried out by other scholars (e.g., Hodgskiss, 2010, 2013b, 2020; Rifkin, 2012; Wadley, 2005b), we know of only two certain (if not necessarily explicit) ethnographic cases of such abrasion. Both involve water.

The first pertains to the Acoma potter Lucy Lewis and her daughters Emma and Dolores. The process has been described thusly: 'The pigment rock is moistened with a little water each time the potter grinds [abrades] it against the stone to make paint. Emma's grinding [abrading] technique… is to hold the pigment rock so just one point of it touches the grinding [abrading] stone. With a swirling motion she moved it in circles, beginning at the top right-hand corner of the stone and moving diagonally across to the lower left' (Peterson, 1984: 133) [bracketed clarifications added].

The second case refers to Hamar men in Ethiopia who abrade goethite nodules on a stone slab with the help of water (Fig. 13). They then use these nodules to apply the produced paste on their clay-coated hair. The paste is sometimes employed in a similar manner for body decoration. Note that Hamar women process a different type of ochre (hematite) differently (by heating and grinding), but for the same purpose of personal adornment (Robitaille, 2021: 154; forthcoming) (Fig. 6b).

Judging by the substantial archaeological evidence of ochre abrasion, we believe that this practice has been much more common ethnographically than is indicated by these two accounts. It likely remains hidden behind the lack of systematic reports on recent ochre lump processing or vague and misleading references to ochre 'grinding.'

We close this section by going back to Kremasti. Apparently, pulverized material was not the only product of ochre abrasion. On

Fig. 13 – Wet ochre abrasion by Hamar men. Photo: J. Robitaille.

rare occasions, this technique was employed to shape lumps into beads. Four such ornaments were uncovered by the excavations (Chondroyianni-Metoki, 2009: 408-414, 2022).

8. THE ABRASION CONTINUUM

Earlier, we divided the Kremasti ochre assemblage into utilized and unutilized specimens. Nevertheless, a more nuanced approach that takes into account the extent of abrading wear, reveals a continuum. By definition, a continuum cannot be divided, but for analytical purposes five broad groups were distinguished. Two notes before these are presented: 1) For obvious reasons, emphasis is given to complete specimens. 2) Unlike other scholars who calculate the degree of usage per specimen by the number of utilized areas (e.g., Hodgskiss, 2013b; Hodgskiss & Wadley, 2017), we chose instead to focus on the extent of use-wear on a specimen's entire surface. This approach was considered more meaningful for the Kremasti collection which includes pieces with several utilized areas but only a minimal overall surface bearing use-wear, and *vice versa*.

Group 1 is found on one end of the spectrum and comprises the 27 lumps that lack traces of use—they make up over one third of the assemblage. Thirteen are complete. The presence of non-utilized specimens indicates the procurement of nodules in anticipation of future needs rather than sporadic gathering for immediate use (see also Domingo *et al.,* 2012). Why all these items were never put to use we don't know. What is certain, at some point the choice was made to take these useful pieces of raw material out of the residential space and into negative features (pits and ditches). A hypothesis of provisional storage must be ruled out—there is no evidence for it. These specimens were 'buried' for good.

As unexpected as withdrawing non-readily available pieces of raw material from the active fabric of the culture may be, this is only one instance of a broader 'wasteful' behavior at Kremasti. The pits and ditches also received complete, non-exhausted, perfectly functional, or deliberately broken artifacts, as well as articulated (and thus unconsumed) sheep and cattle remains (Chondrou, 2011: 164-170; Chondroyianni-Metoki, 2009: 354, 360, 2022; Silva, 2023: 145, 155, 180, 183, 187, 189, 194, 215; Silva *et al.*, 2020; Stroulia, 2010b; Stroulia & Chondrou, 2013; Stroulia *et al.*, 2017; Tzevelekidi, 2012).

Group 2 comprises lightly abraded lumps—use-wear identified on less than 25% of the surface. Eleven are complete. Some were only minimally abraded. This is the case with the specimens of Fig. 7a-b. This is also the case with one of the largest specimens in the assemblage (10.0 x 7.0 x 2.3 cm), which bears only a couple of tiny, utilized areas on one face. More extensive but still limited use-wear was identified on the specimen of Fig. 3c, which measures 5.2 x 3.7 x 1.6 cm. Abrading wear is found on only one part of the periphery. The periphery is certainly more convenient for use than the faces. At least four fragmentary nodules appear to belong to *Group 2* as well.

The limited wear reflects very brief episodes of use, as well as the extraction of tiny amounts of colorant. Notably, more than half of the items in *Group 2* represent some of the largest nodules in the assemblage. The specimens of this group are as enigmatic as the non-utilized lumps of *Group 1* since they consist of raw materials brought to the site from elsewhere but only lightly exploited before being decommissioned within negative features in the non-residential area.

Group 3 comprises moderately abraded specimens—use-wear covers 25-50% of the surface. Four complete specimens and at least one fragment belong to this group. Measuring 11.7 x 9.1 x 2.7 cm, the specimen shown in Fig. 4 is the largest in the assemblage. Only one face and one side are utilized. For a second example from the same group, see Fig. 7c.

Group 4 comprises substantially abraded lumps—use-wear covers 50-75% of the surface. Only three specimens (all complete) were assigned to this group, one of which is shown in Fig. 3b. It measures 5.2 x 4.0 x 2.4 cm and has a roughly trapezoidal plan and transverse section. Abrasion targeted mostly its ends and sides, with one of the two faces partly abraded and the other left almost completely unabraded. Both ends and one side are multifacetted, making this specimen a typical example of the rotation to which a number of nodules were subjected (see above).

Group 5 comprises intensely/extensively abraded lumps—use-wear extends over 75% of the surface. Four complete specimens are assigned to this group. None is larger than 4.5 cm in maximum dimension. Eight fragments appear to belong to the same group and, with one exception, derive from small nodules as well. Some items are entirely abraded. For example, the one illustrated in Fig. 3a measures 2.2 x 2.2 x 1.0 cm and is one of the smallest complete specimens in the assemblage. It has a regular triangular shape, the result of abrasion of all its surfaces. Indeed, its perfectly symmetrical plan, along with another two, very small, intensely or completely abraded specimens (one also triangular), led to the suspicion that all three items may represent unfinished (unperforated) pieces of jewelry. While the excavation yielded a handful of ochre beads, the scarcity of stone pendants in general (n=7) (Chondroyianni-Metoki, 2009: 408-414, 2022) rather argues against this possibility. The hypothesis that these items served instead as (unperforated) amulets is equally appealing but also unlikely; no wear that could be attributed to handling or wrapping was detected.

Generally speaking, there appears to be an inverse relationship between the extent of usage and size, with larger nodules bearing less extensive use-wear than smaller ones. This would seem to suggest that small, extensively or entirely abraded specimens are but (semi-)exhausted versions of originally large nodules. Yet the absence of large, well-abraded lumps argues against a continuity between bigger and smaller specimens. On this basis, we consider it plausible that the heavily utilized nodules were small to begin with. This is even more intriguing since 1) small lumps would have been inconvenient to manipulate during use; 2) only small amounts of pigment would have been obtained.

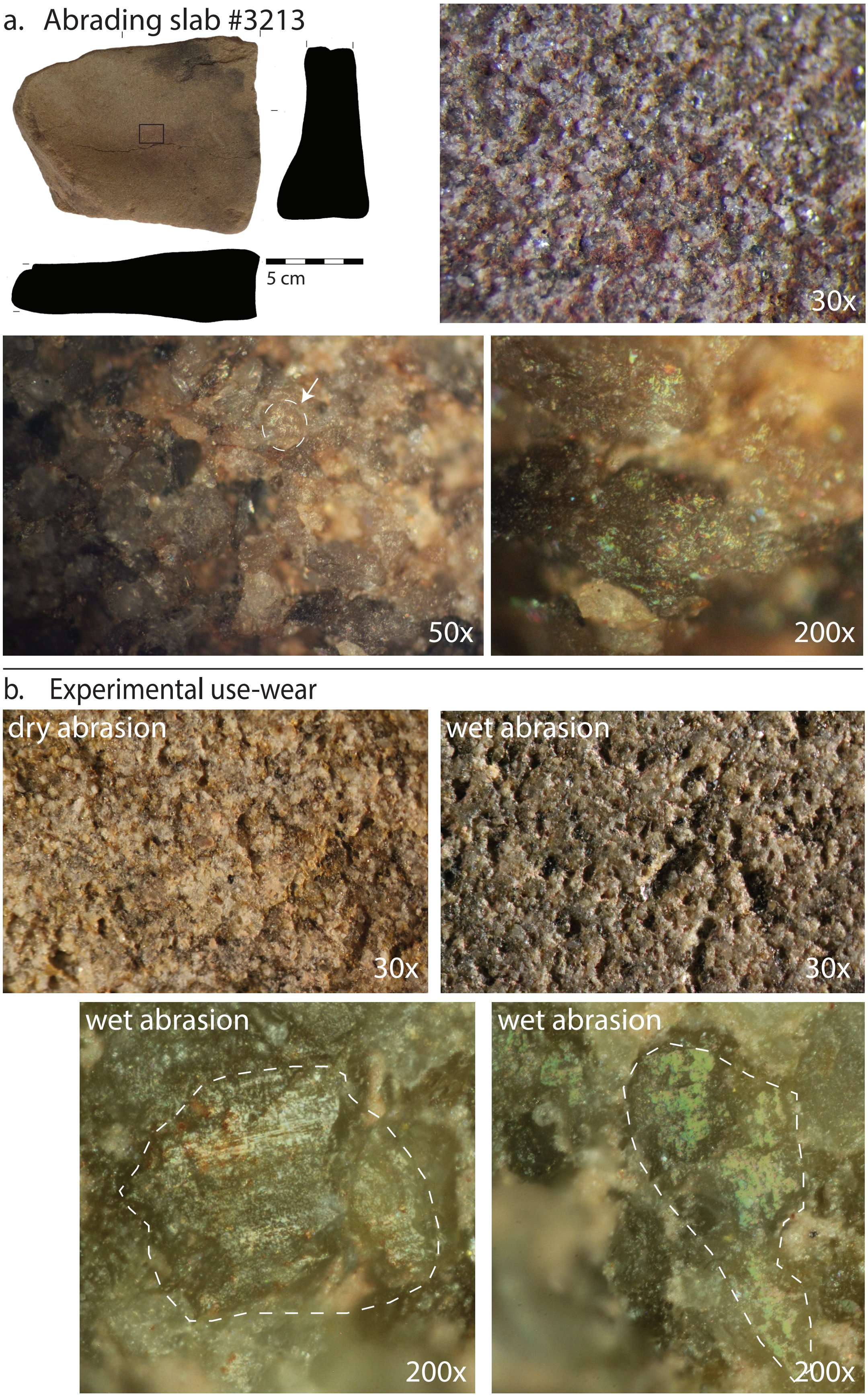
Equally significant, extensively/entirely abraded specimens are in the minority (c. 20%). Most lumps brought to the site (c. 55%) were discarded without being utilized or after only limited usage. Evidently, there was neither a practice nor an intention of substantial exploitation of these non-readily available resources. Not only did the Kremasti folks produce little ochre pigment overall but apparently were in no great need for additional amounts.

9. OCHRE PROCESSING TOOLS

The only candidates for the passive tools on which ochre abrasion took place at Kremasti consist of over 150 thin, tabular, fine-grained sandstone slabs. These did not belong to paired toolkits and were used *a posteriori* in a manner that created smoothed, lightly concave, and wavy work faces (Chondrou, 2011: 101-103; Stroulia & Dubreuil, 2011). Nearly all are broken and about one third appear to have been exposed to fire. All specimens were examined macroscopically, with a sample of 14 subjected to use-wear analysis by Dubreuil with a Zeiss stereomicroscope (5-30x magnification) and an Olympus BHMJ metallographic microscope (50-500x magnification) with differential interference contrast (DIC). Faint reddish stains that may or may not derive from ochre were detected on one of the faces of a single tool. Its use-wear was compared to those developed in the context of two additional experiments. These were carried out by Dubreuil and involved wet and dry ochre abrasion on two different sandstone surfaces for 60 and 20 minutes, respectively.[3] The micropolish development was found to be more extensive on the archaeological surface than either of the experimental ones. Besides, the micropolish of the prehistoric implement is associated with the smoothing of grain microfractures, something not observed in the experimental cases (Fig. 14). More experimentation is needed to clarify the nature of these differences.

Could red traces have existed on the Kremasti sandstone slabs but been eliminated by post-excavation washing? To test this hypothesis comparisons were carried out between the microwear of the 13 specimens without color stains in the analyzed prehistoric sample and that developed on the experimental sandstone surfaces through wet and dry ochre abrasion. While exhibiting substantial traceological variation, the archaeological sandstone slabs show intensive grain leveling, as well as a certain flat, thick, and highly reflective polish that point to the processing of a semi-flexible, abrasive matter with a lubricant. The traces generated experimentally through wet abrasion, on the other hand, consist of abundant grain microfractures, with a thin, flat, and smooth or flat

3 This set of ochre abrasion experiments and the one described earlier (as well as the associated use-wear analyses) were conducted at different times and locations to address different questions.


a. Abrading slab #3213
5 cm
30x
50x
200x
b. Experimental use-wear
dry abrasion
30x
wet abrasion
30x
wet abrasion
200x
wet abrasion
200x

and striated, mildly reflective micropolish. No micropolish development was observed with dry abrasion. The above comparisons suggest that the Kremasti sandstone slabs do not represent the passive tools on which ochre pieces were abraded. If so, it is fair to assume that such implements are not part of the excavated assemblage.

Wherever they may have ended their biographies, the missing ochre abrading tools must have served as palettes too, or so we believe given the nearly universal employment of wet abrasion at the site. As palettes, they would have provided the surfaces needed to contain and remoisten the paste, mix it with other binders than water, and transfer the pigment to the surfaces intended for coloring (see Schotsmans *et al.*, 2021). It is important to note that in both aforementioned ethnographic cases of ochre abrasion, the involved tool surfaces have no other functions than ochre processing (Peterson, 1984: 133; Robitaille, 2021:155). We consider such a specialization plausible for the missing Kremasti ochre abrading implements as well.

In this context, we should also mention a fragmentary tool, probably a recycled celt, studied in the context of Chondrou's thesis (2011: 119-120). It bears red residue of roughly 1 cm in diameter on its preserved end. SEM-EDS analysis of a sample revealed a high iron content, pointing to iron oxide or hydroxide. Chondrou hypothesized that this tool was used to mix ochre-based pigment with a binder.

Which tools were involved in ochre scoring at the site we do not know. Perhaps such tools will be identified when the systematic study of the lithic tool assemblage is undertaken.

Finally, the following data are relevant: No crumbs or small fragments that could have resulted from ochre percussion or crushing were located by the excavation (Chondroyianni-Metoki, 2009). Such material, nevertheless, may not be expected in the first place given that almost all Kremasti finds derive from secondary contexts. Only two macrolithic tools, on the other hand, combine (active) percussive wear with macroscopically visible reddish traces that may or may not represent ochre (observations by Stroulia; see also Chondrou, 2011: 122-132).

None of the over 300 Kremasti stone artifacts that have been classified as grinding tools carries macroscopic reddish stains (Chondrou, 2011: 74-113; Stroulia & Dubreuil, 2011; Stroulia *et al.*, 2017). Neither have such traces been identified on the 19 among them analyzed microscopically by Dubreuil (Stroulia & Dubreuil, 2011; Stroulia *et al.*, 2017). While not formal grinding tools, a handful of *a posteriori* river cobbles combining reddish traces with abrasive wear may have served as upper active tools for grinding a red material on a lower passive surface (observations by Stroulia). Whether that substance consisted of ochre has not been determined.

Be that as it may, it appears that percussion and grinding were rarely (if ever) used by the Kremastiotes to treat ochre.[4] Why this was so we are not sure, but there is no reason to believe that such a choice was dictated by the properties of the raw material. Yet, these properties may very well explain why direct application on other surfaces was not employed at the site. As we found out through unsuccessful attempts to directly mark a wooden object, an unfired pot, and a scrap of leather with the collected geological samples, the ochre types found at Kremasti do not have a high color transfer potential.

10. OCHRE APPLICATIONS

The previous sections established two key points: 1) the product of ochre abrasion at Kremasti was colorant almost exclusively in paste form; 2) small quantities of paste were obtained overall. What the applications of the produced paste may have been is the subject of this section.

Our search for excavated objects and surfaces onto which the abraded ochre would have been

Fig. 14 (facing page) – a. One face (with faint reddish traces) and sections of Kremasti abrading sandstone slab #3213; use-wear under stereoscope (30x) and metallographic microscope (50x and 200x). b. Use-wear developed experimentally on sandstone slab through dry and wet ochre abrasion under stereoscope (30x) and metallographic microscope (200x). Photos: L. Dubreuil and A. Stroulia. Drawing: Thomai Vakouftsi.

4 The possibility of such practices having taken place outside the excavated area or of most reddish stains on percussive and grinding tools been eliminated by post-excavation washing cannot be ruled out.

transferred yielded inconclusive or negative results. Inconclusive evidence derives from three types of artifacts: pottery, figurines, and house models. Most of the pottery (over 85,000 sherds) has been thoroughly examined by Silva (2023; see also Chondroyianni-Metoki, 2009: 330-360; Saridaki, 2019: 447-506; Silva *et al.*, 2020). Over 75% are largely undecorated. Only 33 sherds feature red patterns. They make up a tiny fraction of the 1386 sherds classified as tableware (Silva, 2023: 157-158). Red stains that could have resulted from containing or mixing ochre pigment were not identified in pots' interior walls. Red slip or paint is visible on twelve of the 78 (mostly clay) figurines and on both clay house models unearthed at the site (Chondroyianni-Metoki, 2009: 362-372). Whether the red decoration on the above three types of artifacts is ochre-based is impossible to tell without targeted analyses. Assuming that it is, however, these objects are too few to suggest that this was the primary ochre application at the site.

Negative evidence comes from a variety of remains and has been hypothesized for yet others that were not retrieved. More specifically, all eight recovered clay 'stamps" were utilized, but none bears macroscopically visible red stains. Nor was any red residue detected on the 425 (mostly shell) ornaments found at the site (Chondroyianni-Metoki, 2009: 362, 408-414, 2022).

No features (e.g., clay walls, hearths, and platforms) were excavated *in situ*. The fragments of walls found in pits were all burnt. Regardless, the hypothesis of ochre-based decoration of architectural elements does not appear congruent with the low amounts of pigment that would have been produced from the abrasion of the site's ochre specimens.

None of the lithic or bone tools have been checked for red residue that could imply the use of ochre as an ingredient in compound hafting adhesives (for relevant prehistoric and historical examples, see Wadley, 2005b, 2010). Regardless, the fact that this technology requires dry powder argues against such usage.

Four other hypotheses—all related to perishable materials—were also considered. The first refers to the employment of ochre in the context of hide tanning and/or dyeing—a practice known ethnographically, for example, from Africa and South America (Rifkin, 2011; Wadley, 2005b; for relevant experiments, see Papakosta, 2006: 230-247; Vavelidis *et al.*, 2014). It is not considered likely for Kremasti since it requires dry powder, and indeed in substantial quantities. Red-stained stone tools that would have been involved in the process are, moreover, lacking.

The second hypothesis pertains to the use of ochre pigment in dyeing fibers and textiles, something known, for example, from prehistoric Andean populations (see Barnard *et al.*, 2016; for relevant experiments, see Papakosta, 2006: 256-261; Vavelidis *et al.*, 2014). Although such a context accommodates a liquid ochre format, it requires much more substantial quantities of colorant than those seemingly produced at Kremasti.

According to the third hypothesis, ochre pigment was used to decorate wooden objects—something we tried experimentally as mentioned above (Fig. 10). An ethnographic example pertains to Australian Aboriginal shields, boomerangs, and clubs painted or coated with red ochre (Paterson & Lampert, 1985). To the degree that it does not contradict the extraction of small amounts of pigment in paste form, we consider this hypothesis more promising for Kremasti than the previous two. We should note here that very few wooden artifacts have been uncovered from Greek Neolithic sites. They derive from lakeside settlements in the area of Florina, west Macedonia, and include digging tools, hafts, and ornaments (CHRYSOSTOMOU *et al.*, 2015). To the best of our knowledge, none has been studied systematically and no painted or other decoration has been reported.

The fourth and last possibility refers to ochre application on the human body itself. By accommodating the production and use of small quantities of paste, this is also more promising than the hide- and textile-related hypotheses. This application comes in two versions. In the first, paste is used to paint, mark, or tattoo the body on purely cosmetic grounds or in a symbolic/ritual context. Skin decoration was one of the ways in which we used the pigment obtained experimentally (Figs. 10-11), while the use of hematite paint for facial patterns has, for example, been reported for indigenous groups in southern

Africa (Rudner, 1983).[5] As for ochre pigment usage in tattooing, it is, for example, known archaeologically, historically, and ethnographically from Native American and Pacific island groups (Deter-Wolf *et al.,* 2021; Kononenko *et al.*, 2016).

The second version of ochre application on the human body is medicinal. It exploits this mineral's styptic and antiseptic properties for the treatment of wounds, bruises, burns, bleedings, and swellings (Audouin & Plisson, 1982; Huntley, 2021; Photo-Jones *et al.*, 2018; Velo, 1984). This is precisely the way ochre has been used by the Gudadja of northwestern Australia, as the following instructions reported by Peile (1979: 11) vividly illustrate: 'Cover the spear wound with warm leaves. Chew ochre and spit it out all over the wound, wet it (in the mouth) and spit it out all around. The wound will soon dry up. Sing and it will become well. The wound will form a cicatrice and become dry, it will become small, form a scab and the skin on the wound will soon fall off.'

No preserved bodies have been retrieved from the Aegean Neolithic, but body paint or tattoos make up one of the interpretations for certain figurines' painted or incised lines and patterns that presumably do not represent anatomical details (Mina, 2005: 157-169; Talalay, 1993: 70-72). As for the medical treatment of the body in this chronocultural context, it is *terra incognita*.

Be that as it may, whether the target was pots, figurines, wooden masks, or bodies, ochre application would not have been a regular activity at the site, or so we assume not only for reasons mentioned above but also because the few dozens of excavated ochre nodules span a period of roughly 400 years. This implies only occasional and casual ochre-related activities. Alternatively, and tantalizingly, ochre (and the red color it yields) may have been associated with and reserved for special or extraordinary bodies, objects, and occasions.

5 More common in the ethnographic record is coating or smearing the body and/or hair with ochre in the context of initiation and other ceremonies or as part of a beautification habitus (e.g., Rifkin, 2015b; Robitaille, 2021: 151; Sagona, 1994). Such massive applications, however, would require much larger amounts of paste than those produced at Kremasti.

11. DEPOSITION AND SPATIAL DISTRIBUTION

Like the majority of the Kremasti finds, most ochre pieces—n=58 or 75%—derive securely from pits. At least 28 are assigned to phase C, with at least twelve, three, and one attributed to phases B, D, and A, respectively. More than anything else, the above distribution probably reflects the relative frequency of pits of different phases in general (Chondroyianni-Metoki, 2009: 165).

Generally speaking, each of the represented pits yielded a single piece of ochre. Two pits—with multiple strata—deviate from the rule as they contained two or three specimens each. In the first case, three broken utilized pieces were found in the same stratum. In the second, two utilized specimens (one complete, one fragmentary) were excavated in two non-consecutive strata. Multiple specimens may or may not come from a few other pits that overlap one another or with the ditches (Chondroyianni-Metoki, 2009).

All ochre lump-bearing pits yielded other finds as well, such as pottery, grinding tools, lithics, animal bones, and remnants of burnt structures. Six also contained disarticulated human bones and, in one case, burials as well. Of these, two had a single stratum. The other four had multiple strata. Ochre pieces and human remains were part of the same stratum in three of these pits. The fourth one, with seven strata, presents a more complex picture. Disarticulated human bones were found in strata 2-7, with strata 1 and 3 containing an animal and a human burial, respectively. One ochre piece was uncovered in stratum 5 (Chondroyianni-Metoki, 2009: 111-112, 124-125, 130-134, 2010, 2020; Triantaphyllou, 2008; Tzevelekidi, 2012). All ochre specimens found in the vicinity of skeletal remains are utilized.

Only five of the ochre nodules (6%) are securely associated with a ditch. They are almost equally distributed between two of the six ditches. Two are utilized, the rest are not. The paucity of ochre specimens in ditches appears consistent with the small number of finds in this feature type in general (Chondroyianni-Metoki, 2009: 277-305).

No ochre piece was included in a cremation burial. This is to be expected too given the general absence of finds, other than pottery and beads, from this feature type (Chondroyianni-Metoki, 2009: 310-316, 2010, 2020, 2022). Finally, seven specimens (9%) originate from areas that are not associated with the above feature types (Chondroyianni-Metoki, 2009). All but two are utilized.

While ochre pieces were found in various parts of the excavated area, the majority (over 75%) originated from the eastern sector. There is nothing surprising about this broad concentration since this sector features the highest density of features in general (Chondroyianni-Metoki, 2009, 2020, 2022) (Fig. 2). Notably, no significant discrepancies were detected in the spatial distribution of utilized and non-utilized lumps or the type of features in which they ended their biographies. Nor are there major differences in the types and richness of materials that accompanied them at their final destinations. Both used and unused specimens were found mostly, but not always, in pits with many other remains. Apparently, ochre pieces were treated similarly in the context of discard and deposition whether they had seen prior use or not. This is part of a more general pattern for the Kremasti negative features which received a mix of utilized and unutilized, intact and broken, functional and non-functional materials (Chondrou, 2011: 164-170; Chondroyianni-Metoki, 2009; Stroulia, 2010b; Stroulia & Chondrou, 2013; Stroulia *et al.*, 2017).

Finally, it is tempting to assume that ochre pieces and other remains found in the same pit (or pit stratum) derive from the same original residential context. The coexistence in some cases of burnt and unburnt materials argues against such an assumption, however. An example comes from pit #148. Its single stratum contained, among others, ash remains, pieces of vitrified clay, one broken burnt grinding tool, and one cracked utilized ochre specimen, but also artifacts that apparently were not exposed to fire such as a partial house model, broken celts, and both complete and fragmentary chert blades. It appears that the items that ended up in the same pit (or pit stratum) were often compiled from various contexts. The opposite is also true, as suggested, for example, by the presence of joining pieces of the same macrolithic tool in different pits. As defining as the practice of 'burying' large quantities of materials within negative extra-residential features was for the Kremasti community, both its logic and logistics remain elusive. For sure, however, it was complex (Chondrou, 2011:164-170; Chondroyianni-Metoki, 2009; Stroulia, 2010b; Stroulia & Chondrou, 2013).

12. FROM KREMASTI TO THE REST OF KITRINI LIMNI AND BEYOND

Besides Kremasti, ochre pieces are known from a small number of Aegean Neolithic sites. Three of them—Kleitos, Pontokomi Souloukia, and Megalo Nisi Galanis—are located in Kitrini Limni and thus in the Kremasti neighborhood (Fig. 1). The most meaningful comparisons can be drawn with Kleitos which, as mentioned earlier, yielded the second largest corpus. Its 55 specimens date to the Late and Final Neolithic (Chondrou, 2018: 294-301) and are thus partly contemporaneous with those of Kremasti.

The Kremasti and Kleitos assemblages share three main commonalities: 1) The ochre nodules are small in both cases as illustrated by a simple comparison of their average length, width, and thickness: Kremasti: 4.8 x 3.4 x 1.7 cm vs. Kleitos: 4.1 x 2.1 x 1.6 cm (personal comm. with Danai Chondrou); 2) Abrasion is more or less the exclusive ochre lump treatment;[6] 3) Tools involved in ochre processing are rare.

There is, on the other hand, a number of differences:
1) While almost all ochre pieces from Kremasti were identified as laterites, the majority of the Kleitos ochre lumps were characterized as very fine-grained sandstones with a high iron content on the basis of a single thin section (Chondrou, 2018: 297, Tables B.1.1, B.2.4, personal comm. with Danai Chondrou); 2) While the Kremasti specimens are rather hard, most of those from Kleitos have been characterized as 'extremely soft' (Chondrou, 2018: 300, original in Greek[7]); 3) While the Kremasti collection includes unmodified nodules, that from Kleitos comprises solely utilized specimens; 4) While unused or lightly used lumps represent the majority at Kremasti, the specimens from Kleitos are 'to a

6 Dry abrasion was hypothesized for most of the Kleitos specimens on the basis of similarities with use-wear produced experimentally through such treatment of an ochre nodule on a piece of coarse sandstone (Chondrou, 2018: 296-297). Comparisons with use-wear produced by experimental wet abrasion are being currently carried out (personal comm. with Danai Chondrou).

7 All translations into English are by Stroulia.

large degree exhausted or almost exhausted' (Chondrou, 2018: 297, original in Greek); 5) Finally, while the Kremasti specimens were actively 'buried' within negative features often with little or no usage, the Kleitos specimens display a more conventional biographic trajectory, having been discarded after intense use. The assemblages must be compared systematically, but this simple juxtaposition seems to suggest that the two neighboring communities procured nodules with different properties and utilized them with different degrees of intensity.

Pontokomi-Souloukia dates to the Early Neolithic and the beginning of the Middle Neolithic (Chondroyianni-Metoki, 2017, in press a, b; Karamitrou-Mentessidi *et al.,* 2010; Stroulia *et al.,* 2022; Ziota *et al.,* 2014). Its six excavated ochre nodules are less than 10 cm in maximum dimension and bear use-wear consistent with wet abrasion. pXRF analysis conducted for the purposes of this paper showed that they comprise four Fe-Ni laterites, one bauxitic laterite, and one hematite.

Excavations at Megalo Nisi Galanis (Fotiadis *et al.,* 2019) uncovered four small ochre pieces assigned to the Late and Final Neolithic. With one exception, they are all utilized, wet abrasion being the sole treatment. According to pXRF analysis, they consist of Fe-Ni laterite (n=3) and Ca-rich laterite (n=1).

The (almost complete) absence of abrading tools or other stone tools with red stains at both Kremasti and Kleitos parallels that noted at Pontokomi Souloukia and Megalo Nisi Galanis (Fotiadis *et al*., 2019; Stroulia *et al.,* 2022). Be that as it may, the (almost complete) lack of evidence of ochre processing by percussion, grinding, scraping, scoring, or rubbing at these four Kitrini Limni sites points to a regional and diachronic tradition of extracting red colorant by abrasion.

Beyond Kitrini Limni, we know of another ten assemblages. Alepotrypa Cave in the Peloponnese yielded 14 (mostly) Final Neolithic 'hematite lumps' (Stroulia 2018). All specimens are complete and no larger than 8 cm. All but one are utilized, as indicated by one or more smooth flattened areas on their surface. None has been subjected to use-wear analysis, but the lack of macroscopically visible striations was tentatively attributed by Stroulia to rubbing a not very hard surface such as wood or hide. However, in retrospect, this hypothesis appears improbable given the low color transfer power of the raw material.

At least ten 'lumps of red and yellow ochre' have been reported from various Early through Late Neolithic strata at Knossos, on the island of Crete (Evans, 1964: 238), 'numerous' fragments of unutilized 'hematite/limonite lumps' dated to the Final Neolithic and the Early Bronze Age were excavated at Limenaria, on the island of Thasos (Bassiakos *et al.,* 2018; see also Nerantzis & Papadopoulos, 2013), while 'several fragments of yellow and red coloring matter' were uncovered at the central Greek site of Elateia inside a Late Neolithic pit characterized as a ritual deposit (Weinberg, 1965). No further information on these specimens has been provided.

Finally, the following sites yielded between one and three specimens:

Avgi (Macedonia): 3. Identified as 'bauxites,' two derive from Late Neolithic strata, the third is of undetermined date. All bear intense traces of abrasion. The complete among them is 4.5 in maximum dimension (Bekiaris, 2018: 156-157; Stergiou *et al.,* 2022; Stratouli *et al.,* 2020).

Drakaina Cave (island of Kephalonia): 3. Two brown goethite pebbles and one red hematite nodule ranging between 2 and 3 cm in maximum dimension. They are abraded and date to the Late Neolithic (Bekiaris, forthcoming; Melfos & Stratouli, 2008).

Lerna (Peloponnese): 1. Measuring c. 3 cm in maximum dimension, it is referred to as 'hematite,' is abraded on all its surfaces, and dates to the Middle Neolithic (Banks, 2015: 206).

Dikili Tash (Macedonia): 1. It is described as a soft ferruginous lump that imparts red color when touched (Darcque *et al.,* 2020: 258-263; personal comm. with Zoï Tsirtsoni).

Rachmani (Thessaly): 1. It is referred to as 'Paint, a lump of red ochre' and was excavated inside a Final Neolithic house (Wace & Thompson, 1912: 53, 259).

Franchthi Cave (Peloponnese): 1. Referred to as 'red stone—probably ocher,' this specimen is 5 cm in maximum dimension, is of roughly pyramidal shape, and has one abraded surface. It derives from mixed Neolithic deposits (Stroulia, 2010a: 116-117).

Like those of Kremasti, the ochre lumps found at the above sites were likely obtained on the surface. Yet, surface collection may not have been the only ochre procurement method in Neolithic Greece. Tzines, the ochre mine on Thasos mentioned earlier, was probably exploited during the Neolithic as well (Koukouli-Chryssanthaki & Weissgerber, 1993, 1999; Levato, 2016; Weissgerber *et al.,* 2008). Unfortunately, a project aiming to identify sites which the mine would have supplied has yet to be undertaken. However, Limenaria, located on the same island, is an obvious candidate. Referring to the use of ochre in Late Neolithic ceramic decoration at the site of Ftelia, Aloupi (2002) mentions the abundance of this material 'in the neighbouring iron mines,' raising the possibility of Neolithic ochre mining on the island of Mykonos as well. We know of no reports of ochre nodules from this site, however.

The above data seem to suggest that: 1) only a few Greek Neolithic communities utilized ochre; 2) in most, ochre usage was extremely limited; 3) abrasion was the primary ochre processing technique. Nevertheless, a more holistic perspective reveals a much more complex prehistoric reality.

Take, for example, Drakaina Cave. The site yielded only three abraded ochre pebbles but over 50 grinding tools with yellow, brown, and red ochre stains on their active parts, as well as others coated with ochre pigment (Bekiaris, forthcoming; Melfos & Stratouli, 2008). Equally significant, XRD analysis of pigment samples taken from the above tools, as well as pot sherds, showed that brown goethite—abundant in the surroundings—was possibly converted to red hematite through heating at temperatures above 250–300°C (Melfos & Stratouli, 2008). Not only does this evidence indicate that grinding (perhaps combined with heating) was the primary ochre processing technique at Drakaina, but also suggests that large amounts of pigment were produced.

Equally telling are data from sites with no ochre lumps. One of them, Theopetra Cave (Thessaly), yielded a passive grinding tool with a medial, red-stained zone, as well as a small, red-stained globular tool that appears to have been used for crushing. Analyses of samples from the stained surfaces identified the red residue as iron oxide with small quantities of iron hydroxy-oxide (i.e., goethite). They also raised the possibility of deliberate firing of the mineral (Facorellis & Boyatzis, in press). Though no other such tools have been identified (personal comm. with Nina Kyparissi), the evidence is sufficient to suggest that ochre grinding, percussion, and, likely, heating were parts of the ochre *chaîne opératoire* at the site.[8]

Grinding or percussive tools with red stains that have not been analyzed but possibly derive from ochre, are known from sites such as Makri in Thrace, Dikili Tash, Sitagroi, Kryoneri, Stavroupoli, Makriyialos, and Avgi in Macedonia, Prodromos and Platia Magoula Zarkou in Thessaly, as well as Franchthi Cave (Alisøy, 2002; Bekiaris, 2007: 45, 52, 82, 2018: 231-232, 244; Elster, 2003; Malamidou, 1997; Moundrea, 1975: 105; Sériadès, 1992; Stroulia, 2010a: 44-45, 55, 85, 92, 99-101, 110, 113, 2022; Tsoraki, 2008: 95-98). Clearly, abrasion was not always the primary method for extracting colorant from ochres in Neolithic Greece. Other methods, such as grinding and percussion, were also employed, indeed, efficiently enough to leave behind no ochre fragments retrievable with standard excavation techniques. The choice between one or the other technique may have had to do with the hardness of the available raw material, its color transfer potential, the amount of needed pigment, or other non-technical considerations.

Only one of the sites with ochre nodules yielded actual remnants of processed ochre. A pot dug among the debris of a burnt Late Neolithic house at Dikili Tash contained a black crust which, through FTIR spectroscopy and other analyses, was shown to consist of pure iron oxide pigment in powder form (Maniatis & Tsirtsoni, 2002).

Although not chemically or mineralogically analyzed, the following finds (all Late Neolithic) are relevant since they potentially represent

8 Another site with no ochre lumps, Koroneia (Macedonia), yielded a percussive tool with traces of what SEM analysis showed to consist of 'iron oxide, probably goethite.' Since these traces are found on both intact and broken surfaces, however, they may be due to accidental contact with the mineral rather than a mineral-related use (Almasidou, 2019: 84-85).

masses of processed ochre or objects involved in containing/storing/mixing/applying ochre. At Sitagroi, remains of 'red ochre' were uncovered inside a broken worked *Unio* valve and two clay ladles (Elster & Nikolaidou, 2003; Nikolaidou, 2003; Shakleton, 2003). At Dimini (Thessaly), globular clumps of a red coloring substance were found inside a marine shell (Tsountas, 1908: 342-343). At least two miniature marble vases with red staining in their interiors were reported from Promachon-Topolnica (Macedonia) (Koukouli-Chryssanthaki *et al.*, 2003; Koukouli-Chryssanthaki *et al.*, 2007; Paleologou, 2007).[9] At Makriyalos, a small marble artifact was uncovered with two shallow red-stained cavities. It was referred to as a 'pebble mortar,' but the lack of percussive wear (Tsoraki, 2008: 101, Pl. 4.25) makes a characterization as a container more plausible. Finally, Avgi yielded a sandstone slab whose concave face bears a thick, deep red crust. Short curvilinear striations on the crust were interpreted as brush stroke traces, leading to the hypothesis that this object functioned as a palette (possibly in the context of recycling) (Bekiaris, 2018: 303, pl. 227). The general paucity of artifacts that contained (or may have contained) ochre pigment raises the suspicion that they were fashioned mostly of perishable materials (e.g., wood). The possibility that red stains in the interior of clay and stone vessels were eliminated post-depositionally or post-excavation cannot be ruled out, however.

Turning to applications, the use of ochre in pottery decoration has been confirmed at the Macedonian sites of Megalo Nisi Galanis, Polyplatanos, Dikili Tash, and Sitagroi, Thessalian sites such as Otzaki, Zerelia, Rodia, and Tsangli, Kitsos Cave in Sterea Ellada, as well as the island sites of Drakaina Cave, Ftelia, and Kephala (Aloupi, 2002; Aloupi-Siotis & Kalogirou, forthcoming; Coleman, 1977: 10-11, 28; Courtois, 1981, 2004; Fotiadis *et al.*, 2019; Gardner, 2003; Letsch & Noll, 1983; MELFOS & Stratouli, 2008; Rondiri & Asderaki-Tzoumerkioti, 2016; Sakalis *et al.*, 2013; Wace & Thompson, 1912: 259). The only documented case of ochre use on figurines derives from Dimini (Topa & Skafida, 2008). Finally, ochre was identified on unperforated but possibly ornamental shells from Paliambela Kolindros (Theodoraki, 2018: 76, 107-115).

Otherwise, ochre/iron oxide has been hypothesized as the main ingredient of red paint applied on pots, ornaments, figurines, and models at sites such as Franchthi Cave, Sitagroi, Knossos, Mandalo, Ai Yiannis, and Dispilio (Elster & Nikolaidou 2003; Gimbutas 1986; Jones, 1986: 770, 778; Ifantidis, 2019: 155; Nikolaidou 2003; Perlès, 2023: 245, 314, 341; Ramirez Valiente, 2023; Vitelli, 1999: 69). While this is the most likely hypothesis, lack of testing or inconclusive test results leave open the possibility of the red paint deriving from iron-rich clay, cinnabar, or even realgar,[10] not ochre.[11]

To the best of our knowledge, the only secure instance of ochre-based decoration or marking of architectural elements consists of three red-colored plaster fragments from Dikili Tash. IR spectroscopy and other analyses confirmed that the red color is due to hematite (Dandrau 1997, cited in Maniatis & Tsirtsoni, 2002). Pieces of plaster with red decoration were also excavated at Kleitos (Ziota *et al.*, 2013; personal comm. with Hristina Ziota) and Dispilio (Almatzi *et al.*, 1998; personal comm. with Dimitri Kloukina). No samples have been tested for the presence of ochre, however.

Finally, we know of only one site with a mortuary ochre association. At Alepotrypa Cave four hematite lumps (including one non-utilized) were recovered from a burial and two so-called ossuaries (Katsarou, 2018; Stroulia, 2018). This stands in contrast with the more pronounced ochre presence in the Neolithic funerary domain of other parts of Neolithic Europe and Anatolia (e.g. Billard *et al.*, 2016; Boz & Hager, 2013; Hamon *et al.*, 2016; Kitzig & Ramminger, 2016; Marinova, 2023; Pradeau, 2015: 67-69; Schotsmans *et al.*, 2020, 2022; Stavreva, 2018; Thevenet, 2016).

9 Devetzi (1996: 135) also makes a vague reference to red-stained stone vessels. Information regarding their provenience is not provided, however.

10 The use of cinnabar has been documented for Late Neolithic figurines from Dimini (Topa & Skafida, 2008). See also Carter (2008) and Fostiridou (2012) for similar evidence from Early Cycladic as well as Macedonian Hellenistic and Roman figurines. The use of realgar is mentioned by ancient Greek authors and has been documented for the decoration of a throne found inside a classical tomb in Macedonia (Kakamanoudis, 2012: 15).

11 Another portable material on which ochre may have been applied is animal skin. We are referring here to a grinding tool from Kleitos with red stains on one of its faces believed to be from ochre. Traceological analysis pointed to a hide-related use probably in a recycling context. The functional association between the stains and hide-processing is, however, uncertain (Chondrou *et al.*, 2022).

Our survey aimed to compile secure and potential ochre-related data from the Neolithic Aegean. While not exhaustive, it made clear that: 1) ochre usage was not confined to the sites that yielded ochre nodules; 2) the frequency of ochre lumps does not necessarily reflect the extent or intensity of a community's involvement in ochre exploitation; 3) various techniques and tools were employed in ochre processing; 4) the resulting pigment was applied to a variety of artifacts and surfaces. How extensive or intensive ochre exploitation may have been, however, what the logistics of raw material procurement were, and to which degree our perspective has been distorted by the paucity of thorough macrolithic studies, the decay of perishable materials, or the effects of post-depositional processes and post-excavation practices, cannot be assessed without systematic exploration of ochre sources, use-wear analysis, geochemical characterization of raw materials and pigments, as well as contextual investigation.

13. EPILOGUE

In this paper, we approached the 80 or so ochre lumps excavated at Kremasti from multiple angles. Systematic macroscopic examination was combined with pXRF analysis, traceological analysis, experimental use-wear replication, contextual analysis, and ethnographic observations. Tools possibly employed to process ochre at the site were discussed as were potential applications of the processed mineral. In addition, relevant material from neighboring and other Greek Neolithic sites was presented, placing the Kremasti assemblage in its regional and wider context.

With a handful of exceptions, the Kremasti ochres consist of laterites. Of these, a Fe-Ni variety represents the majority. Nodules were acquired in anticipation of future needs as indicated by the substantial percentage of specimens that bear no use-wear. Why these pieces were never put to use we cannot tell, but their interment in pits and ditches underlines the importance of digging and filling negative features for the Kremasti community.

The collected lumps were small and were treated nearly exclusively by abrasion. Almost always abrasion took place with the help of water, the objective being the production of pigment in paste form. The fact that wet abrasion represents more or less the sole ochre processing method at the site suggests 1) very strict ideas regarding both the 'right' way to treat the lumps and the 'right' product of this treatment; 2) an enduring ochre technology tradition that was passed from generation to generation.

While abrading implements were excavated at the site, none appears to have been involved in ochre processing. Such tools may have remained in the domestic arena. Alternatively, they were disposed of in unexcavated negative features in the non-residential sector of the site. Whatever the case, the fact remains that ochre nodules and abrading tools were intertwined at the use stage but ended their biographies in separate contexts.

Given the scarcity of artifacts with paint that could have been ochre-based, we assume that the paste generated at Kremasti was for the most part applied on perishable surfaces. Of the various possibilities we considered, wooden artifacts and the human body itself emerged as the most promising candidates. Whatever these applications may have been, nevertheless, they were probably infrequent, or so is suggested by the relatively small number of utilized ochre lumps, their generally limited use-wear, and, by extension, the small amounts of paste that would have been produced during the long life of the community. On this basis, we would not rule out the possibility that ochre paste was involved in special occasions

If ochre usage was not common at the site, the same apparently applies to other coloring minerals. The only evidence derives from sherds. Nine show black decoration that may be manganese-based, with a single specimen bearing white post-firing paint that possibly represents kaolin (Silva 2023: 156-157, 168). With mineral pigments being so rare in the excavated assemblage, should we assume that the Kremasti material culture was more or less devoid of painted objects and surfaces? Not at all. It is most likely that plant- or animal-based pigments/dyes were extensively employed for textiles, wooden artifacts, etc. Possible candidates are the red colorants extracted from the root of *Rubia Tinctorum*, known as rose madder, common madder, or dyer's madder; and the insect *Porphyrophora hameli* Brandt, known as Ararat or Armenian cochineal. Both are known in Greece not only from recent times but antiquity as well. They were identified, for example, on clay figurines and paintings from Macedonian funerary contexts dating between the 4th century BC and 1st century AD (Fostiridou, 2012: 31-33, 99-101; Kakamanoudis, 2012: 55-153). Also, we cannot rule out the use of saffron, a plant that is not only indigenous to Greece but was also domesticated there during the Bronze Age (Kazemi-Shahandashti *et al.,* 2022). Today, large quantities of saffron are produced in the very region where Kremasti is located. The beginnings of cultivation in the area go back at least to the 17th century AD, with imports of bulbs of the domesticated type *Crocus Sativus L.* from Europe (Nikitidis, 2019: 46-48; Voutsina, 1999). However, wild saffron varieties are known from northern Greece (Nikitidis, 2019: 99-175) and may have been exploited in the Neolithic. Reasonable as these hypotheses may sound, how colorful the Kremastiote artificial world was and in which ways, perhaps we will never know.

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Bibliography

Adam E., 2009. Searching for Territoriality over a Limited Territory: The Case of Greece. *In:* F. Djindjian, J. Kozłowski & N. Bicho (eds), *Le concept de territoires dans le Paléolithique supérieur européen*. Oxford, Archaeopress: 85-92.

Adam E. & Kotjabopoulou E., 1997. The Organic Artefacts from Klithi. *In*: G. Bailey (ed), *Klithi: Palaeolithic Settlement and Quaternary Landscapes in Northwest Greece. Vol.1: Excavation and Intra-Site Analysis at Klithi.* Cambridge, McDonald Institute Monographs: 245-259.

Alevizos G. & Repouskou E., 2011. Ore Microscopy and Microanalysis of the Nickeliferous Iron Ores from Komnina Vermion Area (NW Greece). *Geomaterials*, **1**: 46.

Alisøy H. A., 2002. Consumption of Ground Stone Tools at Stavroupoli. *In:* D. Grammenos & S. Kotsos (eds), *Σωστικές Ανασκαφές στο νεολιθικό οικισμό Σταυρούπολης Θεσσαλονίκης.* Thessaloniki, Publications of the Archaeological Institute of Northern Greece: 561-608.

Almasidou E., 2019. *Τα τριπτά εργαλεία από το νεολιθικό οικισμό στη λίμνη Κορώνεια.* MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Almatzi A., Anagnostou I., Giagkoulis T. & Chourmouziadi A., 1998. Πρώτες πληροφορίες για την τεχνολογία των λιμναίων οικισμών της προϊστορίας. *In: Ancient Greek Technology, Proceedings of the 1st International Conference, Thessaloniki 1997.* Thessaloniki, Association for the Study of Ancient Greek Technology/ Thessaloniki Technical Museum: 425–429.

Aloupi E., 2002. Pottery Analysis from the Late Neolithic Settlement in Ftelia, Myconos (Cyclades): Provenance, Technological and Functional Considerations. *In:* A. SAMPSON (ed.) *Neolithic Settlement at Ftelia, Mykonos*. Rhodes, University of the Aegean: 279-297.

Aloupi-Siotis E. & Kalogirou A., forthcoming. Non-Destructive Analysis and Experimental Replication of 5th Millennium BC 'Crusted' and Pattern Painted Pottery from West Macedonia, Greece. *In:* Filippaki, E. et al. (eds), *Proceedings of the 7th Symposium of the Hellenic Society of Archaeometry "Archaeology-Archaeometry: 30 Years Later."* Oxford, Archaeopress.

Andreou S., Fotiadis M. & KOTSAKIS K., 1996. Review of Aegean Prehistory V: The Neolithic and Bronze Age of Northern Greece. *American Journal of Archaeology*, **100**: 537-597.

Asher B. P., Hofman J. L. & Holen S. R., 2020. Hematite Beads from the Frost Clovis Site, Logan County, Colorado. *Plains Anthropologist*, **65**: 281-297.

Audouin F. & Plisson H., 1982. Les ocres et leurs témoins au Paléolithique en France: enquête et expériences sur leur validité archéologique. *Cahiers du Centre de Recherches Préhistoriques,* **8**: 33-80.

Banks E. C., 2015. *Lerna VII. The Neolithic Settlement*. Princeton, American School of Classical Studies at Athens.

Barnard H., Boytner R., Khandekar N. & Schleicher M., 2016. Painted Textiles: Knowledge and Technology in the Andes. *Ñawpa Pacha, Journal of Andean Archaeology*, **36** (2): 209-228.

Bassiakos Y., Nerantzis N. & Papadopoulos S., 2018. Late Neolithic/Early Bronze Age Metallurgical Practices at Limenaria, Thasos: Evidence for Silver and Copper Production. *Archaeological and Anthropological Sciences*, **11**: 2743-2757.

Bekiaris T., 2007. *Τριπτά εργαλεία από το Νεολιθικό οικισμό της Μάκρης Εβρου*. MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Bekiaris T., 2018. *Τεχνολογίες τριπτών στη Νεολιθική της Βόρειας Ελλάδας: Ο νεολιθικός οικισμός της Αυγής Καστοριάς*. PhD Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Bekiaris T., forthcoming, Ground Stone Tools from Drakaina Cave: Grounds for Thought. *In*: G. Stratouli (ed), *Drakaina Cave on Kephalonia Island. A Place of Social Activity during the Neolithic*.

Billard C., Savary X., Dupret L. & Hamon C., 2016. Premières données sur l'exploitation de l'hématite en Basse-Normandie durant la Préhistoire récente: ses contextes archéologiques et géologiques, son insertion dans le cadre de la néolithisation de l'ouest du Bassin parisien. *Anthropologica et Præhistorica*, **125/2014**: 63-87.

Bosquet D., Constantin C., Goemaere E., Hamon C., Jadin I. & Salomon H., 2016. Provenance, exploitation et utilisation de l'hématite oolithique au Néolithique ancien en Belgique: contextes et problématiques. *Anthropologica et Præhistorica*, **125/2014**: 121-151.

Boz B. & Hager L., 2013. Living above the Dead: Intramural Burial Practices at Çatalhöyük. *In:* I. Hodder (ed), *Humans and Landscapes of Çatalhöyük: Reports from the 2000–2008 Seasons*. London, British Institute at Ankara; Los Angeles, Cotsen Institute of Archaeology Press: 413-440.

Bueno Ramírez P., Barroso Bermejo R. & De Balbín Behrmann R., 2023. Pigments for the Dead: Megalithic Scenarios in Southern Europe. *Archaeological and Anthropological Sciences*, **15**: 148.

CARTER T., 2008. Cinnabar and the Cyclades: Body Modification and Political Structure in the Late EB I Southern Aegean. *In:* H. Erkanal, H. Hauptmann, V. Şahoğlu & R. Tuncel (eds), *Proceedings of the International Symposium The Aegean in the Neolithic, Chalcolithic and the Early Bronze Age, October 13th - 19th 1997, Urla - İzmir (Turkey)*. Ankara, Ankara University: 119-129.

Chondrou D., 2011. *Τριπτά εργαλεία από τη νεολιθική θέση της Τούμπας Κρεμαστής Κοιλάδας*. MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Chondrou D., 2018. *Η τριπτή λιθοτεχνία από τους προϊστορικούς οικισμούς Κλείτος Ι και Κλείτος ΙΙ της λεκάνης της Κίτρινης Λίμνης Κοζάνης*. PhD Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Chondrou D., Bofill M., Procopiou H., Vargiolu R., Zahouani H., Almasidou E., Bekiaris T., Ninou I. & Valamoti S. M., 2022. Grinding Practices in Prehistoric North and Central Greece: Evidence from the Use-Wear Analysis. *In:* S. M. Valamoti, A. Dimoula & M. Ntinou (eds), *Cooking with Plants in Ancient Europe and Beyond: Interdisciplinary Approaches to the Archaeology of Plant Foods*. Leiden, Sidestone Press: 269-296.

Chondroyianni-Metoki A., 2009. *Μη οικιστικές χρήσεις χώρου στους νεολιθικούς οικισμούς. Το παράδειγμα της Τούμπας Κρεμαστής Κοιλάδας*. PhD Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Chondroyianni-Metoki A., 2010. Η καύση των νεκρών στο νεολιθικό οικισμό της Τούμπας

Κρεμαστής Κοιλάδας στην Κίτρινη Λίμνη Ν. Κοζάνης. *In:* N. Merousis, E. Stefani & M. Nikolaidou (eds), *Ιρις. Μελέτες στη μνήμη της καθηγήτριας Α. Πιλάλη-Παπαστερίου*. Thessaloniki, Editions Kornilia-Sfakianaki: 213-234.

Chondroyianni-Metoki A., 2017. Ποντοκώμη, θέση Σουλουκιά. *Αρχαιολογικόν Δελτίον (Χρονικά)*, **72**: 671-684.

Chondroyianni-Metoki A., 2020. Outside the Residential Place at the Neolithic Settlement of Toumba Kremastis Koiladas, Northern Greece. *In:* N. N. Tasić, D. Urem-Kotsou & M. Burić (eds), *Making Spaces into Places: The North Aegean, the Balkans and Western Anatolia in the Neolithic.* Oxford, BAR Publishing: 53-71.

Chondroyianni-Metoki A., 2022. Κοσμήματα της νεότερης νεολιθικής περιόδου από την Τούμπα Κρεμαστής Κοιλάδας. *In:* N. Merousis, M. Nikolaidou & E. Stefani (eds), *Μυρρίνη: Μελέτες Αιγαιακής Προϊστορίας, Τιμητικός Τόμος για την Αικατερίνη Παπαευθυμίου-Παπανθίμου.* Thessaloniki, Archaeological Museum of Thessaloniki: 329-349.

Chondroyianni-Metoki A., in press a. Κίτρινη Λίμνη Κοζάνης: Τα χαρακτηριστικά της κατοίκησης της περιοχής, υπό το φως των νέων ανασκαφικών δεδομένων από την περιοχή των λιγνιτωρυχείων της ΔΕΗ. *Πρακτικά Συνεδρίου Αρχαιολογικές έρευνες και μεγάλα Δημόσια Εργα,* ***8-9****. Δεκεμβρίου 2017.*

Chondroyianni-Metoki A., in press b. Κίτρινη Λίμνη 2016-2017: Τα ανασκαφικά δεδομένα από την περιοχή των λιγνιτωρυχείων της ΔΕΗ. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη,* **31**, 2017.

Chrysostomou P., Jagoulis T. & Maeder A., 2015. The 'Culture of Four Lakes': Prehistoric Lakeside Settlements (6th-2nd mill. BC) in the Amindeon Basin, Western Macedonia, Greece. *Archäologie Schweiz*, **38**: 24-32.

Coleman J. E., 1977. *Keos I. Kephala: A Late Neolithic Settlement and Cemetery.* Princeton, American School of Classical Studies.

Courtois L., 1981. Étude physico-chimique de la céramique. *In:* N. Lambert (ed), *La grotte préhistorique de Kitsos (Attique). Missions 1968-1978*. Athens, École française d'Athènes: 373-389.

Courtois L., 2004. Les techniques de la céramique. *In:* R. Treuil (ed), *Dikili Tash I: Village Préhistorique de Macédoine orientale, Fouilles de Jean Deshayes (1961-1975), volume 2*. Bulletin de Correspondance Hellénique, Supplement 37. Athens, École française d'Athènes: 1-25.

Dapschauskas R., Göden M. B., Sommer C. & Kandel A. W., 2022. The Emergence of Habitual Ochre Use in Africa and its Significance for the Development of Ritual Behavior during the Middle Stone Age. *Journal of World Prehistory*, **35**: 233-319.

Darcque P., Koukouli-Chryssanthaki H., Malamidou D., Treuil R. & Tsirtsoni Z., 2020. *Dikili Tash, village préhistorique de Macédoine orientale II, volume 2: Histoire d'un tell: les recherches 1986-2016*. Athens, École française d'Athènes.

Darlas A., 2018. Η παλαιολιθική εποχή στη νότια Πελοπόννησο: είκοσι χρόνια έρευνας στη χερσόνησο της Μάνης. *In:* E. Zimi, A.-V. Karapanagiotou & M. Xanthopoulou (eds), *Το Αρχαιολογικό Εργο στην Πελοπόννησο (ΑΕΠΕΛΙ), Πρακτικά του Διεθνούς Συνεδρίου Τρίπολη, 7-11 Νοεμβρίου 2012.* Kalamata, Greece, University of the Peloponnese: 9-19.

Darlas A. & Psathi E., 2016. The Middle and Upper Paleolithic on the Western Coast of the Mani Peninsula (Southern Greece). *In:* K. HARVATI & M. ROKSANDIC (eds), *Paleoanthropology of the Balkans and Anatolia: Human Evolution and its Context*. Dordrecht, Springer: 95-117.

Dayet L., D'errico F. & Garcia-Moreno R., 2014. Searching for Consistencies in Châtelperronian Pigment Use. *Journal of Archaeological Science*, **44**: 180-193.

Deter-Wolf A., Peres T. M. & Karacic S., 2021. Ancient Native American Bone Tattooing Tools and Pigments: Evidence from Central Tennessee. *Journal of Archaeological Science: Reports*, **37**: 103002.

Devetzi T., 1996. Λίθινα σκεύη. *In:* G. Papathanassopoulos (ed.), *Ο Νεολιθικός Πολιτισμός στην Ελλάδα.* Athens, N. P. Goulandri Foundation, **135**: 286-288.

Ditchfield K., Huntley J., Ward I., Webb J., Doelman T. & Kurpiel R., 2023. Sourcing Stone and Ochre Artifacts: A Review of Why it Matters in Australia (and Beyond). *In*: C. Speer, R. M Parish & G.

Barrientos (eds), *Sourcing Archeological Lithic Assemblages: New Perspectives and Integrated Approaches.* Utah, The University of Utah Press: 52-67

Domingo I., García-Borja P. & Roldán C., 2012. Identification, Processing and Use of Red Pigments (Hematite and Cinnabar) in the Valencian Early Neolithic (Spain). *Archaeometry*, **54** (5): 868-892.

Dubreuil L. & Grosman L., 2009. Ochre and Hide-Working at a Natufian Burial Place. *Antiquity*, **83**: 935-954.

Dubreuil L., Robitaille J., Gonzalez-Urquijo J., Joao Marreiros J. & Stroulia A., 2023. A 'family of wear': Traceological Patterns on Pebbles Used for Burnishing Pots and Processing Other Plastic Mineral Matters. *Journal of Archaeological Method and Theory*, **2023**. https://doi.org/10.1007/s10816-022-09597-z

Economou-Eliopoulos M., 2003. Apatite and Mn, Zn, Co-Enriched Chromite in Ni-Laterites of Northern Greece and their Genetic Significance. *Journal of Geochemical Exploration*, **80**: 41-54.

Eliopoulos D. G. & Economou-Eliopoulos M., 2000. Geochemical and Mineralogical Characteristics of Fe-Ni and Bauxitic-Laterite Deposits of Greece. *Ore Geology Reviews*, **16** (1-2): 41-58.

Evans J. D., 1964. Excavations in the Neolithic Settlement of Knossos, 1957-60. Part I. *The Annual of the British School at Athens*, **59**: 141-240.

Elster E. S., 2003. Grindstones, Polished Edge-Tools, and Other Stone Artifacts. *In:* S. Elster & C. Renfrew (eds), *Prehistoric Sitagroi: Excavations in Northeast Greece, 1968-1970 Volume 2: The Final Report.* Los Angeles, the Cotsen Institute of Archaeology at UCLA: 175–195.

Elster E. S. & Nikolaidou M., 2003. *Paralipómena* and Other Plastic Forms. *In:* E. S. Elster & C. Renfrew (eds), *Prehistoric Sitagroi: Excavations in Northeast Greece, 1968-1970 Volume 2: The Final Report.* Los Angeles, the Cotsen Institute of Archaeology at UCLA: 421-452.

Facorellis Y. & Boyatzis S. C., in press. Physicochemical Pigments Analysis on Theopetra's Neolithic Grinding Stones. *In:* N. Kyparissi-Apostolika, G. Marshall & O. Apostolikas (eds), *Theopetra Cave in Thessaly, Greece, Volume I: The Neolithic Period.* HOCRED Publications, Greek Ministry of Culture and Sports.

Fostiridou A., 2012. *Ταυτοποίηση χρωστικών σε ειδώλια που βρέθηκαν κατά τις ανασκαφές του μετρό Θεσσαλονίκης.* MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Fotiadis M., 1988. Προϊστορική έρευνα στην Κίτρινη Λίμνη Ν. Κοζάνης. Μία σύντομη έκθεση. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **2**: 41-54.

Fotiadis M., HONDROYANNI-METOKI A., Kalogirou A., MANIATIS Y., Stroulia A. & Ziota C., 2019. Megalo Nisi Galanis (6300-1800bc): Constructing a Cultural Sequence for the Neolithic of West Macedonia, Greece. *The Annual of the British School at Athens*, **114**: 1-40.

Gardner E. J., 2003. Technical Analysis of the Ceramics. *In:* E. S. Elster & C. RENFREW (eds), *Prehistoric Sitagroi: Excavations in Northeast Greece, 1968-1970 Volume 2: The Final Report.* Los Angeles, the Cotsen Institute of Archaeology at UCLA: 283-295.

Gimbutas M., 1986. Mythical Imagery of the Sitagroi Society; and Figurine Catalog. *In:* C. RENFREW, M. Gimbutas & E. S. Elster (eds), *Excavations at Sitagroi: A Prehistoric Village, Volume 1.* Los Angeles, University of California: 225–301.

Hamon C., Billard C., Bosquet D., Constantin C. & Jadin I., 2016. Usages et transformation de l'hématite dans le Néolithique ancien d'Europe du Nord-Ouest. *Anthropologica et Præhistorica*, **125/2014**: 45-61.

Helwig K., Monahan V., Poulin J. & Andrews T. D., 2014. Ancient Projectile Weapons from Ice Patches in Northwestern Canada: Identification of Resin and Compound Resin-Ochre Hafting Adhesives. *Journal of Archaeological Science*, **41**: 655-665.

Hodgskiss T., 2010. Identifying Grinding, Scoring and Rubbing Use-Wear on Experimental Ochre Pieces. *Journal of Archaeological Science*, **37**: 3344-3358.

Hodgskiss T., 2013a. *Ochre Use at Sibudu Cave and its Link to Complex Cognition in the Middle Stone Age.* PhD Thesis, Johannesburg, University of the Witwatersrand.

Hodgskiss T., 2013b. Ochre Use in the Middle Stone Age at Sibudu: Grinding, Rubbing, Scoring and Engraving. *Journal of African Archaeology*, **11** (1): 75-95.

Hodgskiss T., 2020. Ochre Use in the Middle Stone Age. *Oxford Research Encyclopedia, Anthropology*. Oxford University Press USA. 10.1093/acrefore/9780190854584.013.51.

Hodgskiss T., 2023. Complex Colors: Pleistocene Ochre Use in Africa. *In:* A. Beyin, D. K. Wright, J. Wilkins & D. I. Olszewski (eds), *Handbook of Pleistocene Archaeology of Africa.* Springer Nature Switzerland: 1907-1916. https://doi.org/10.1007/978-3-031-20290-2

Hodgskiss T. & Wadley L., 2017. How People Used Ochre at Rose Cottage Cave, South Africa: Sixty Thousand Years of Evidence from the Middle Stone Age. *PLoS ONE*, **12** (4): e0176317.

Hovers E., Ilani S., Bar-Yosef O. & Vandermeersch B., 2003. An Early Case of Color Symbolism: Ochre Use by Modern Humans in Qafzeh Cave. *Current Anthropology*, **44** (4): 491-522.

Huntley J., 2021. Australian Indigenous Ochres: Use, Sourcing, and Exchange. *In:* I. J. Mcniven & B. David (eds), *The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea.* Online edition, Oxford University Press: https://doi.org/10.1093/oxfordhb/9780190095611.001.0001

Ifantidis F., 2019. *Practices of Personal Adornment in Neolithic Greece*. Oxford, Archaeopress.

Jodry F., Minni D. & Van Es M., 2016. L'acquisition et l'exploitation des roches riches en oxydes de fer en Alsace du Néolithique à La Tène. *Anthropologica et Præhistorica*, **126/2015**: 201-218.

Jones R. E., 1986. *Greek and Cypriot Pottery: A review of Scientific Studies*. Athens, British School at Athens.

Kakamanoudis A., 2012. *Τεχνικές ζωγραφικής στην Αρχαία Ελλάδα*. MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Karamitrou-Mentessidi G., 1986. Προϊστορικοί οικισμοί Κίτρινης Λίμνης (Σαριγκιόλ) Κοζάνης. *In: Αμητός: τιμητικός τόμος για τον καθηγητή Μανόλη Ανδρόνικο*. Thessaloniki, Aristotle University of Thessaloniki: 391-416.

Karamitrou-Mentessidi G., Lokana C. & Anagnostopoulou K., 2010. Δύο θέσεις της αρχαιότερης και μέσης νεολιθικής στην Ποντοκώμη και Μαυροπηγή Εορδαίας. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **24**: 39-51.

Katsarou S. 2018. When do the Dead Become Dead? Mortuary Projects from Ossuaries I and II, Cave Alepotrypa. *In:* A. Papathanasiou, W. A. Parkinson, D. J. Pullen, M. L. Galaty & P. Karkanas (eds), *Neolithic Alepotrypa Cave, in the Mani, Greece: in Honor of George Papathanassopoulos*. Philadelphia, Oxbow: 91-126.

Kazemi-Shahandashti S.-S., Mann L., El-Nagish A., Harpke D., Nemati Z., Usadel B. & Heitkam T., 2022. Ancient Artworks and Crocus Genetics Both Support Saffron's Origin in Early Greece. *Frontiers in Plant Science*, **13**: Article 834416.

Kitzig J. & Ramminger B., 2016. Use and Distribution of Colourants in Western LBK Sites. *Anthropologica et Præhistorica*, **126/2015**: 179-186.

Kononenko N., Torrence R. & Sheppard P., 2016. Detecting Early Tattooing in the Pacific Region through Experimental Usewear and Residue Analyses of Obsidian Tools. *Journal of Archaeological Science: Reports*, **8**: 147-163.

Kotjabopoulou E. & Adam E., 2004. People, Mobility and Ornaments in Upper Palaeolithic Epirus, NW Greece. *In*: M. Otte (ed), *La Spiritualité: Actes du Colloque de Liège (10-12 décembre 2003)*. Liége, Études et Recherches Archéologiques de l' Université de Liège, **106**: 37-53.

Koukouli-Chryssanthaki C. & Papadopoulos S., 2009. The Island of Thassos and the Aegean in the Prehistory. *In:* Y. Maniatis (ed), *ASMOSIA VII: Actes du VIIe colloque international de l'ASMOSIA Organisé par l'École française d'Athènes, le National Center for Scientific Research "DIMOKRITOS", la 18e éphorie des antiquités préhistoriques et classiques (Kavala) et l'Institut of Geology and Mineral Exploration Thasos, 15-20 septembre 2003*. Athens, École française d'Athènes: 1-18.

Koukouli-Chryssanthaki C. & Weissgerber G., 1993. Προϊστορικά ορυχεία ώχρας στη Θάσο. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **7**: 541-558.

Koukouli-Chryssanthaki C. & Weissgerber G., 1999. Prehistoric Ochre Mines on Thasos. *In:* C. Koukouli-Chryssanthaki, A. Müller & P. Papadopoulos (eds), *Thasos: Matières Premières et Technologie de la Préhistorie à nos jours.* Paris, De Boccard: 129-144.

Koukouli-Chryssanthaki C., ASLANIS I., VAISOV I. & VALLA M., 2003. Προμαχώνας-Topolniča 2002-2003. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **17**: 91-110.

Koukouli-Chryssanthaki C., Todorova H., Aslanis I., Vajsov I. & Valla M., 2007. Promachon-Topolnica: A Greek-Bulgarian Archaeological Project. *In:* H. Todorova, M. Stefanovic & G. Ivanov (eds), *The Struma/Strymon River Valley in Prehistory.* Sofia, Museum of History-Kyustendil: 43-78.

Langley M. C. & O'Connor S., 2019. 40,000 Years of Ochre Utilization in Timor-Leste: Powders, Prehensile Traces, and Body Painting. *PaleoAnthropology* 2019: 82-104.

Letsch J. & Noll W., 1983. Mineralogie und Technik der fruehen Keramiken Thessaliens. *Neues Jahrbuch für Mineralogie-Abhandlungen*, **147** (2): 109-146.

Levato C., 2016. Iron Oxides Prehistoric Mines: A European Overview. *Anthropologica et Præhistorica*, **126/2015**: 9-23.

Logan E. N. & Fratt L., 1993. Pigment Processing at Homol'ovi III: A Preliminary Study. *Kiva*, **58** (3): 415-428.

Malamidou D., 1997. Ανασκαφή στον προϊστορικό οικισμό 'Κρυονέρι' Ν. Κερδυλλίων. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **11**: 509-538.

Maniatis Y. & Tsirtsoni Z., 2002. Characterization of a Black Residue in a Decorated Neolithic Pot from Dikili Tash (Greece): An Unexpected Result. *Archaeometry*, **44(2)**, 229-239.

Marinova M., 2023. Relative Analogies in the Ritual Use of Red Mineral Pigments (Ochre, Hematite) in Neolithic and Eneolithic Burials from Xinjiang and Bulgaria. *In:* L. Xiao (ed), *Major Archaeological Discoveries along the Chinese Silk Road.* Singapore, Springer: 31-49.

Mauran, G. 2023. Red Balloon Rock Shelter Middle Stone Age Ochre Assemblage and Population's Adaption to Local Resources in the Waterberg (Limpopo, South Africa). *Archaeological and Anthropological Sciences*, **15**: 79. https://doi.org/10.1007/s12520-023-01778-5

Melfos V. & Stratouli G., 2008. Mineralogical Characterization of Pigments in Neolithic Paintings: The Case of Drakaina Cave, Kephalonia Island, Greece. *In: Volume of Abstracts of the 5th Symposium on Archaeometry, Hellenic Society of Archaeometry, Athens, 8 -10 October 2008*: O15 https://www.archaeometry.org.gr/attachments/el/symposia/5th_hsa_symposium_program.pdf

Melfos V. & Voudouris P., 2022. *Κοιτάσματα της Ελλάδας.* Undergraduate textbook. Athens, Kallipos, Open Academic Publications. http://dx.doi.org/10.57713/kallipos-32

Mina M., 2005. *Anthropomorphic Figurines from the Neolithic and Early Bronze Age Aegean: Gender Dynamics and Implications for the Understanding of Aegean Prehistory*. PhD Thesis, London, University College London.

Moundrea A., 1975. *Le site néolithique de Prodromos (Grèce). Outillage lithique et osseux. Position dans le contexte Thessalien.* MA Thesis, Nanterre, University of Paris X.

Nerantzis N. & Papadopoulos S., 2013. Reassessment and New Data on the Diachronic Relationship of Thassos Island with its Indigenous Metal Resources: A Review. *Archaeological and Anthropological Sciences*, **5**: 183-196.

Nikitidis N., 2019. *Οι κρόκοι της Ελλάδας*. Athens, self-published.

Nikolaidou M., 2003. Items of Adornment. *In:* E. S. Elster & C. Renfrew (eds), *Prehistoric Sitagroi: Excavations in Northeast Greece, 1968-1970 Volume 2: The Final Report.* Los Angeles, the Cotsen Institute of Archaeology at UCLA: 331-360.

Paleologou M., 2007. Προμαχώνας-Topolniča: Κοσμήματα και μαρμάρινα αγγεία: μία πρώτη προσέγγιση. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **21**: 347-354.

Papakosta H., 2006. *Προσδιορισμός ορυκτολογικής και χημικής σύστασης δειγμάτων ώχρας με φυσικοχημικές μεθόδους και δημιουργία προσομοιώσεων βαφών ώχρας σε δέρμα και σε ύφασμα* *με παραδοσιακές συνταγές βαφής*. MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Paterson, N. & Lampert R. J., 1985. A Central Australian Ochre Mine. *Records of the Australian Museum*, **37** (1): 1-9.

Peile A. R., 1979. Colors that Cure. *Hemisphere*, **23** (4): 214-217.

Perlès C., 2018. *Ornaments and Other Ambiguous Artifacts from Franchthi: Volume 1, The Palaeolithic and the Mesolithic*. Bloomington and Indianapolis, Indiana University Press.

Perlès C., 2023. *Ornaments and Other Ambiguous Artifacts from Franchthi: Volume 2, The Neolithic.* Bloomington and Indianapolis, Indiana University Press.

Peterson S. H., 1984. *Lucy M. Lewis: American Indian Potter*. New York, Kodansha International.

Photos-Jones E., Knapp C. W., Venieri D., Christidis G. E., Elgy C., Valsami-Jones E., Gounaki I. & Andriopoulou N. C., 2018. Greco-Roman Mineral (Litho)Therapeutics and their Relationship to their Microbiome: The Case of the Red Pigment Miltos. *Journal of Archaeological Science: Reports*, **22**: 179-192.

Pradeau J.-V., 2015. *Les matières colorantes au sein des systèmes techniques et symboliques au Néolithique (VI^e et V^e millénaires BCE) dans l'arc liguro-provençal*. PhD Thesis, Université Nice Sophia Antipolis.

Pradeau J.-V., Binder D., Verati C., Lardeaux J.-M., Dubernet S., Lefrais Y., Bell Ot-Gurlet L., Piccardo P. & Regert M., 2016. Stratégies d'acquisition des matières colorantes dans l'Arc liguro-provençal au cours des VIe et Ve millénaires cal. BCE. *Anthropologica et Præhistorica*, **126/2015**: 105-119.

Ramirez Valiente P., 2023. Red Ladies of Clay: Identifying Colour in Neolithic Figurines from Knossos Using Non-Invasive Methods. *Documenta Praehistorica*, **50:** 362-372.

Rifkin R. F., 2011. Assessing the Efficacy of Red Ochre as a Prehistoric Hide Tanning Ingredient. *Journal of African Archaeology*, **9** (2): 131-158.

Rifkin R. F., 2012. Processing Ochre in the Middle Stone Age: Testing the Inference of Prehistoric Behaviours from Actualistically Derived Experimental Data. *Journal of Anthropological Archaeology*, **31** (2): 174-195.

Rifkin R. F., 2015a. Ethnographic and Experimental Perspectives on the Efficacy of Ochre as a Mosquito Repellent. *The South African Archaeological Bulletin*, **70** (201): 64-75.

Rifkin R. F., 2015b. Ethnographic Insight into the Prehistoric Significance of Red Ochre. *The Digging Stick*, **32** (2): 7-10.

Robitaille J., 2021. *Approches ethno (archeo) graphiques et morphotechniques du Macro-outillage de quelques contextes ethiopiens*. PhD Thesis, Paris, École des Hautes Études en Sciences Sociales.

Robitaille J., forthcoming. Crushing Ochre in Ethiopia: Chaîne Opératoire, Macrolithic Tools Design, and Use-Wear. *Journal of Archaeological Science: Reports*.

Rondiri V. & Asderaki-Tzoumerkioti E., 2016. The 'Management' of Painted and Monochrome Pottery of Neolithic Thessaly, Central Greece: Technology and Provenance. *In:* E. PHOTOS-JONES (ed), *Proceedings of the 6th Symposium of the Hellenic Society for Archaeometry*. Oxford, British Archaeological Reports, S2780: 3-12.

Rosso D. E., 2017. Aproximación etnoarqueológica al uso de colorantes para el tratamiento del cabello: el caso de los Hamar (Etiopía). *Pyrenae*, **48** (2): 123-149.

Rudner I., 1983. Paints of the Khoisan Rock Artists. *Goodwin Series* **4**, 14-20.

Sagona A., 1994. The Quest for Red Gold. *In:* A. Sagona (ed), *Bruising the Red Earth: Ochre Mining and Ritual in Aboriginal Tasmania*. Carlton, Victoria, Melbourne University Press: 8-38.

Sakalis, A. J., KAZAKIS N. A., MEROUSIS N. & TSIRLIGANIS N. C., 2013. Study of Neolithic Pottery from Polyplatanos (Imathia) Using Micro X-Ray Fluorescence Spectroscopy, Stereoscopic Microscopy and Multivariate Statistical Analysis, *Journal of Cultural Heritage*, **14** (6): 485-498.

Salomon H., Vignaud C., Coquinot Y., Beck L., Stringer C. B., Strivay D. & D'errico F., 2012. Selection and Heating of Colouring Materials in the Mousterian Level of Es-Skhul (C. 100 000

Years Bp, Mount Carmel, Israel). *Archaeometry*, **54**: 698-722.

Sampson A., Kaczanowska M. & Kozłowski J. K., 2010. *The Prehistory of the Island of Kythnos (Cyclades, Greece) and the Mesolithic Settlement at Maroulas*. Krakow, The Polish Academy of Arts and Sciences and the University of the Aegean.

Saridaki N., 2019. *Τεχνολογία κεραμικής και κινητικότητα στην κεντρική και δυτική Μακεδονία στη Νεολιθική εποχή με βάση την πετρογραφική ανάλυση*. PhD Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Schotsmans E. M. J., Busacca G., Bennison-Chapman L. E., Lingle A. M., Milella M., Tibbetts B. W., Tsoraki C., Vasić M. & Veropoulidou R., 2020. Pigment Use at Neolithic Çatalhöyük. *Near Eastern Archaeology*, **83**: 156-167.

Schotsmans E. M. J., Busacca G., Bennison-Chapman L. E., Lingle A. M., Milella M., Tibbetts B. W., Tsoraki C., Vasić M. & Veropoulidou R., 2021. The Colour of Things: Pigments and Colours in Neolithic Çatalhöyük. *In:* I. Hodder & C. Tsoraki (eds), *Communities at Work: The Making of Çatalhöyük*. London, British Institute at Ankara: 263-327.

Schotsmans E. M. J., Busacca G., Lin S.c., Vasić M., Lingle A. M., Veropoulidou R., Mazzucato C., Tibbetts B., Haddow S. D., Somel M., Toksoy-Köksal F., Knüsel C. J. & Milella M., 2022. New Insights on Commemoration of the Dead through Mortuary and Architectural Use of Pigments at Neolithic Çatalhöyük, Turkey. *Scientific Reports*, **12**, 4055. https://doi.org/10.1038/s41598-022-07284-3

Sefériadès M., 1992. La pierre polie. *In:* R. Treuil (ed), *Dikili Tash: Village Préhistorique de Macédoine orientale, Fouilles de Jean Deshayes (1961-1975), volume I*. Bulletin de Correspondance Hellénique, Supplement 16. Athens, École française d'Athènes: 84-99.

Shakleton N. J., 2003. Appendix 9.2. Catalog of Worked Shell. *In:* E. S. Elster & C. Renfrew (eds), *Prehistoric Sitagroi: Excavations in Northeast Greece, 1968-1970 Volume 2: The Final Report.* Los Angeles, the Cotsen Institute of Archaeology at UCLA: 366-368.

Silva T., 2023., *Pottery and Social Interaction: Stylistic Variability of Early Late Neolithic Ceramic Vessels in Central and Western Macedonia*, Greece. PhD Thesis, Komotini, Democritus University of Thrace.

Silva T., Lymperaki M., Chondroyianni-Metoki A. & Urem-Kotsou D., 2020. Identifying Ritual at Late Neolithic Toumba Kremastis Koiladas: Ceramic Assemblages of Representative Contexts. *In:* N. N. Tasić, D. Urem-Kotsou & M. Burić (eds), *Making Spaces into Places*. Oxford, BAR Publishing: 73-86.

Stavreva V., 2018. Red Ochre - for Special Dead and Dangerous Dead (Use of Red Ochre in the Burial Practices during the Late Eneolithic by Data from the Territory of Bulgaria). *Pontica*, **51**: 115-133.

Stergiou C. L., Bekiaris T., Melfos V., Theodoridou S. & Stratouli G., 2022. Sourcing macrolithics: Mineralogical, Geochemical and Provenance Investigation of Stone Artefacts from Neolithic Avgi, North-West Greece. *Archaeometry*, **64** (2): 283-299.

Stiner, M. C., 2010. Shell Ornaments from the Upper Paleolithic through Mesolithic Layers of Klissoura Cave 1 by Prosymna (Peloponese, Greece). *Eurasian Prehistory*, **7** (2): 287-308.

Stratouli G., Bekiaris T., Katsikaridis N., Kloukinas D., Koromila G., & Kyrillidou S. 2020. New excavations in Northwestern Greece: The Neolithic Settlement of Avgi, Kastoria. *Journal of Greek Archaeology*, **5**, 63-134.

Stroulia A., 2002. Λίθινα τριπτά από την Κίτρινη Λίμνη Κοζάνης. Πρώτη προσέγγιση, πρώτα ερωτήματα. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **17**: 571-580.

Stroulia A., 2010a. *Flexible Stones: Ground Stone Tools from Franchthi Cave*. Bloomington and Indianapolis, Indiana University Press.

Stroulia A., 2010b. Εργαλεία με κόψη από την Κρεμαστή Κοιλάδα, νομού Κοζάνης: βιογραφικές παρατηρήσεις. *Το Αρχαιολογικό Εργο στη Μακεδονία και στη Θράκη*, **24**: 63-71.

Stroulia A., 2018. Macrolithics: Ordinary Things in an Extraordinary Place. *In:* A. Papathanasiou, W. A. Parkinson, D. J. Pullen, M. L. Galaty & P. Karkanas (eds), *Neolithic Alepotrypa Cave, in the Mani, Greece: in Honor of George Papathanassopoulos*. Philadelphia, Oxbow: 200-241.

Stroulia A., 2022. The Platia Magoula Zarkou Macrolithics: A Thessalian Industry in its Aegean Neolithic Context. *In:* E. Alram-Stern, K. Gallis & G. Toufexis (eds), *Platia Magoula Zarkou. The Neolithic Period: Environment, Stratigraphy and Architecture, Chronology, Tools, Figurines and Ornaments*. Vienna, Institute for Oriental and European Archaeology: 310-344.

Stroulia A. & Chondrou D., 2013. Destroying the Means of Production: The Case of Ground Stone Tools from Kremasti-Kilada, Greece. *In:* J. Driessen (ed), *Destruction: Archaeological, Philological and Historical Perspectives*. Louvain, Presses universitaires de Louvain: 109-131.

Stroulia A. & Dubreuil L., 2011. *Ground Stone Tools from Kremasti-Kilada, Kitrini Limni, Northern Greece*. Unpublished grant report submitted to the Institute of Aegean Prehistory.

Stroulia A., Dubreuil L., Robitaille J. & NELSON K., 2017. Salt, Sand, and Saddles: Exploring an Intriguing Configuration among Grinding Tools. *Ethnoarchaeology*, **9** (2): 1-27.

Stroulia A., Robitaille J., Ögüt B., Chondrogianni-Metoki A. & Kotsachristou D., 2022. Grinding and Abrading Activities in the Earlier Neolithic of Northern Greece: A Multi-Proxy and Comparative Approach for the Site of Pontokomi-Souloukia. *Documenta Praehistorica*, **49**: 94-122.

Talalay L. E., 1993. *Deities, Dolls, and Devices: Neolithic Figurines from Franchthi Cave, Greece*. Bloomington and Indianapolis, Indiana University Press.

Theodoraki D., 2018. *Θαλάσσιοι πόροι στους Νεολιθικούς Οικισμούς της Βόρειας Ελλάδας: Εθνοαρχαιολογική έρευνα στην περιοχή του Θερμαϊκού Κόλπου και το οστρεοαρχαιολογικό σύνολο των Παλιαμπέλων*. MA Thesis, Thessaloniki, Aristotle University of Thessaloniki.

Thevenet C., 2016. Quelques hypothèses quant à l'usage des matières colorantes rouges dans les sépultures du Néolithique ancien du Bassin parisien. *Anthropologica et Præhistorica*, **126/2015**: 187-199.

Topa H. & Skafida E., 2008. Μελέτη ζωγραφικής επιφάνειας σε λίθινα και πήλινα αντικείμενα: Η περίπτωση των νεολιθικών ειδωλίων του Διμηνίου. Abstract of poster presented at the 2nd Symposium of prehistoric Archaeology, Volos, Greece, 4-7 December 2008. [2º Συνέδριο Προϊστορικής Αρχαιολογίας (uth.gr)]

Triantaphyllou S., 2008. Living with the Dead: A Re-Consideration of Mortuary Practices in the Greek Neolithic. *In:* V. ISAAKIDOU & P. TOMKINS (eds), *Escaping the Labyrinth: The Cretan Neolithic in Context*. Oxford, Oxbow Books: 139-157.

Tsoraki C., 2008. *Neolithic Society in Northern Greece: The Evidence of Ground Stone Artefacts*. PhD Thesis, Sheffield, University of Sheffield.

Tsountas C., 1908. *Αι προϊστορικαί ακροπόλεις Διμηνίου και Σέσκλου*. Athens, Athens Archaeological Society.

Tzevelekidi V., 2012. *Dressing for Dinner: Butchery and Bone Deposition at Late Neolithic Toumba Kremastis-Koiladas, Northern Greece*. Archaeopress, BAR Publishing, **S2451**, 157 p..

Vavelidis M., Varella E. & Papakosta H. G, 2014. Βαφή δέρματος, υφάσματος, ανθρώπινης επιδερμίδας και πετρωμάτων με ώχρα: Δημιουργία προσομοιώσεων βαφών με παραδοσιακές συνταγές και πειραματική απομίμηση. *Αρχαιολογία και Τέχνες* 118: [Βαφή δέρματος, υφάσματος, ανθρώπινης επιδερμίδας και πετρωμάτων με ώχρα – Αρχαιολογία Online (archaiologia.gr)]

Velliky E. C., Porr M. & Conard N. J., 2018. Ochre and Pigment Use at Hohle Fels Cave: Results of the First Systematic Review of Ochre and Ochre Related Artefacts from the Upper Palaeolithic in Germany. *PloS ONE*, **13** (12): e0209874.

Velo J., 1984. Ochre as Medicine: A Suggestion for the Interpretation of the Archaeological Record. *Current Anthropology*, **25**: 674.

Vitelli K. D., 1999. *Franchthi Neolithic Pottery 2: The Later Neolithic Phases 3-5*. Bloomington and Indianapolis, Indiana University Press.

Voutsina E., 1999. Στα ανθισμένα κροκοχώραφα: Μέσα στην ομορφιά, καλλιεργείται με μόχθο το πολυτελές άρτυμα. *Καθημερινή*, **April 18, 1999**.

WACE A. J. B. & THOMPSON M. S., 1912. *Prehistoric Thessaly*. Cambridge, Cambridge University Press.

Wadley L., 2005a. Ochre Crayons or Waste Products? Replications Compared with MSA 'Crayons' from

Sibudu Cave, South Africa. *Before Farming*, **2005** (3): 1-12.

WADLEY L., 2005b. Putting Ochre to the Test: Replication Studies of Adhesives that May Have Been Used for Hafting Tools in the Middle Stone Age. *Journal of Human Evolution*, **49**: 587-601.

WADLEY L., 2010. Compound-Adhesive Manufacture as a Behavioral Proxy for Complex Cognition in the Middle Stone Age. *Current Anthropology*, **51** (S1): S111-S119.

WATTS I., 2015. Pigments. *In:* A. S. GILBERT (ed.), *Encyclopedia of Geoarchaeology*. Dordrecht, Springer: 2-8.

WATTS I., CHAZAN M. & WILKINS J., 2016. Early Evidence for Brilliant Ritualized Display: Specularite Use in the Northern Cape (South Africa) between ~500 and ~300 ka. *Current Anthropology*, **57** (3): 287-310.

WEINBERG S. S., 1965. Ceramics and the Supernatural: Cult and Burial Evidence in the Aegean World. *In:* E R. MATSON (ed.), *Ceramics and Man*. Chicago, Aldine Publishing Company: 187-201.

WEISSGERBER G., ČIERNY J. & KOUKOULI-CHRYSSANTHAKI C. 2008. Zu paläolithischer Gewinnung roter Farbmineralien auf der Insel Thasos. *In:* Ü. YALÇIN (ed), *Anatolian Metal IV*. Bochum, Deutsches Bergbau-Museum: 179-190.

Annexe 1. pXRF geochemical analyses of the ochre nodules from Kremasti. bdl = below detection limit; min = minimum value; max = maximum value.

Kremasti	**wt.%**																							
Sample	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**MnO**	**MgO**	**CaO**	**K_2O**	**Ti_2O**	**P_2O_5**	**Tot**	**S**	**Cl**	**V**	**Cr**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**As**	**Se**	**Rb**	**Sr**	**Y**
612	21,68	3,43	47,54	0,49	14,66	0,75	0,04	0,04	bdl	**88,63**	bdl	0,04	0,03	1,94	0,02	1,37	bdl	0,02	bdl	bdl	bdl	bdl	bdl	bdl
613	28,16	4,56	43,22	0,10	20,97	0,80	0,11	0,02	0,07	**98,01**	bdl	bdl	0,02	1,09	0,09	0,87	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
614	45,82	1,44	11,26	0,14	34,74	0,02	0,04	0,02	0,10	**93,58**	0,03	bdl	bdl	0,28	bdl	0,22	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
615	45,17	1,44	11,39	0,14	36,54	1,23	0,02	0,03	0,06	**96,02**	0,03	bdl	0,01	0,29	bdl	0,22	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
616	41,93	4,00	13,80	0,11	33,19	1,69	0,18	0,04	0,90	**95,84**	bdl	bdl	0,01	0,28	0,01	0,30	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
618	45,86	3,55	12,58	0,08	36,71	0,76	0,08	0,02	0,17	**99,81**	0,09	bdl	bdl	0,49	bdl	0,23	bdl	0,02	bdl	bdl	bdl	bdl	bdl	bdl
621	41,51	1,41	26,45	0,33	27,21	0,72	0,09	bdl	0,08	**97,80**	bdl	0,04	0,02	1,08	0,05	1,23	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
624	29,51	2,91	42,33	0,38	17,82	1,54	0,01	bdl	bdl	**94,50**	bdl	0,09	0,02	1,25	0,05	1,29	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
625	35,93	2,45	33,70	0,36	23,22	1,89	0,06	0,02	0,07	**97,70**	bdl	bdl	0,01	0,88	0,09	1,72	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
627	25,21	3,18	40,43	0,22	15,53	5,67	0,06	bdl	0,14	**90,44**	bdl	0,04	0,02	0,78	bdl	0,96	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
628	33,22	2,21	25,86	0,34	21,31	1,82	0,04	bdl	0,08	**84,88**	bdl	bdl	0,01	0,76	bdl	0,82	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
631	43,96	8,50	34,20	0,16	8,45	0,35	0,13	0,15	0,73	**96,63**	0,03	bdl	0,03	0,87	0,09	0,62	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
632	46,88	1,30	9,79	0,24	36,74	1,44	0,24	0,07	0,25	**96,95**	bdl	bdl	bdl	0,33	bdl	0,22	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
634	39,41	1,02	23,50	0,18	32,86	0,18	0,13	0,02	0,13	**97,43**	bdl	bdl	0,01	1,21	0,02	0,69	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
635	42,69	3,16	20,15	0,22	28,62	0,99	0,07	0,02	0,12	**96,04**	bdl	bdl	0,01	0,94	0,01	0,59	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
2856	28,03	1,13	50,25	0,19	13,08	0,80	0,19	bdl	0,06	**93,73**	bdl	0,12	0,04	0,69	0,08	0,74	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
2880	32,20	4,10	37,25	0,16	19,82	3,42	0,08	0,03	0,89	**97,95**	bdl	0,05	0,02	0,83	0,04	0,92	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
2947	48,59	2,97	19,54	0,29	19,82	2,93	0,15	0,02	0,75	**95,06**	bdl	bdl	0,01	1,21	bdl	0,61	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
2996	33,98	4,42	27,92	0,18	22,88	3,03	0,16	0,02	0,24	**92,83**	bdl	bdl	0,01	0,67	0,03	0,83	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3006	34,47	1,44	19,15	0,09	36,93	2,15	0,03	0,01	0,06	**94,33**	bdl	bdl	0,01	0,27	bdl	0,67	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
3106	34,66	5,24	22,56	0,42	22,41	2,91	0,14	0,05	0,73	**89,12**	bdl	bdl	0,01	1,15	bdl	1,71	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3120	35,06	3,49	43,24	0,21	14,25	2,61	0,05	bdl	0,06	**98,97**	bdl	0,09	0,02	1,10	0,07	1,81	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3140	38,04	1,23	31,84	0,04	20,41	1,57	bdl	bdl	0,05	**93,18**	bdl	0,08	0,02	0,56	bdl	0,73	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3209	36,33	3,37	34,21	0,33	18,09	2,07	0,11	0,03	0,19	**94,73**	bdl	bdl	0,02	0,87	bdl	1,21	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3248	36,62	3,61	32,15	0,43	19,64	4,38	0,09	0,03	0,36	**97,31**	bdl	bdl	0,02	1,80	0,05	0,98	bdl	0,02	bdl	bdl	bdl	bdl	bdl	bdl
3250	30,37	1,68	45,85	0,29	17,06	2,55	0,08	bdl	0,12	**98,00**	bdl	0,11	0,02	1,04	0,10	1,15	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3282	38,14	3,27	31,13	0,13	24,27	1,08	0,04	bdl	bdl	**98,06**	bdl	0,05	0,02	0,98	0,04	0,80	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3286	33,88	3,88	28,54	0,24	28,19	1,03	0,04	0,02	0,12	**95,94**	bdl	bdl	0,02	1,84	0,02	0,87	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3364	38,22	4,30	33,76	0,55	18,00	2,35	0,05	bdl	0,10	**97,33**	bdl	0,02	0,02	2,07	0,07	1,19	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3386	35,58	3,13	27,85	0,18	25,72	2,53	0,04	bdl	0,07	**95,10**	bdl	bdl	0,02	1,07	0,02	0,80	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3387	35,79	1,57	29,65	0,04	30,55	0,61	0,06	0,02	0,04	**98,33**	bdl	bdl	bdl	0,19	bdl	0,23	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
3392	46,56	0,37	9,02	0,29	36,58	0,31	0,02	bdl	bdl	**93,15**	bdl	bdl	bdl	0,03	bdl	0,22	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
3469	38,03	3,72	28,41	0,40	25,98	0,57	0,03	bdl	0,05	**97,19**	bdl	0,06	0,02	0,95	0,03	1,02	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3512	28,68	3,90	38,27	0,39	21,54	2,10	0,10	bdl	0,17	**95,15**	bdl	bdl	0,02	1,02	0,08	0,63	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3535	41,79	3,39	26,10	0,49	23,47	1,13	0,05	bdl	0,12	**96,54**	bdl	bdl	0,01	1,12	0,04	0,92	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3580	36,52	1,90	40,57	0,12	15,42	1,85	0,03	0,02	0,05	**96,48**	bdl	0,05	0,01	0,72	bdl	0,60	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3617	33,03	2,07	43,72	0,09	15,17	0,97	0,01	bdl	0,03	**95,09**	bdl	0,15	0,03	0,88	bdl	0,69	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3706	18,64	3,77	49,26	0,45	16,06	2,36	0,18	0,05	1,70	**92,47**	bdl	bdl	0,02	1,66	0,03	1,25	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3738	38,16	3,84	31,40	0,11	20,13	2,07	0,06	bdl	0,05	**95,82**	bdl	bdl	0,02	1,25	bdl	0,69	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3763	46,59	3,27	13,85	0,36	33,15	0,59	0,02	bdl	0,05	**97,88**	bdl	bdl	0,01	1,03	bdl	1,02	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3807	32,37	3,97	25,18	0,15	34,51	0,91	0,08	bdl	0,18	**97,35**	bdl	bdl	0,01	1,08	0,03	0,82	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3820	31,87	3,71	34,36	0,13	26,61	0,48	0,06	bdl	bdl	**97,22**	bdl	0,02	0,03	1,32	0,08	0,68	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3825	31,13	2,54	34,67	0,23	24,10	0,83	0,05	bdl	0,14	**93,69**	bdl	bdl	0,01	0,83	bdl	1,19	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3880	40,54	3,96	26,85	0,36	22,13	3,59	0,19	0,02	0,44	**98,08**	bdl	bdl	0,01	0,38	0,05	1,47	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
3994	34,28	2,71	27,39	0,18	28,42	1,99	0,03	0,02	0,15	**95,17**	bdl	0,06	bdl	0,38	bdl	0,08	bdl	bdl	bdl	bdl	bdl	bdl	0,01	bdl
4018	52,34	0,54	7,30	0,08	36,81	1,09	0,02	bdl	0,06	**98,24**	bdl	bdl	bdl	0,22	bdl	0,30	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
4059	38,46	2,83	27,06	0,24	29,80	0,99	0,03	bdl	0,28	**99,69**	bdl	0,03	0,01	1,36	0,03	1,24	bdl	0,02	bdl	bdl	bdl	bdl	bdl	bdl
4220	35,33	5,04	43,89	0,35	11,26	2,03	0,18	0,05	0,41	**98,54**	bdl	bdl	0,01	1,45	bdl	1,32	bdl	0,02	bdl	bdl	bdl	bdl	bdl	bdl
4525	16,07	12,21	63,67	0,06	4,51	0,40	0,54	0,23	0,24	**97,93**	bdl	0,06	0,06	1,35	0,22	0,36	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4531	36,40	3,16	36,18	0,73	20,09	1,22	0,04	0,03	0,45	**98,30**	bdl	0,08	0,02	1,29	0,06	1,34	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4703	35,85	2,60	31,31	0,42	20,79	1,55	0,06	bdl	0,12	**92,70**	bdl	0,05	0,01	1,23	bdl	1,14	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4766	50,76	1,73	26,02	0,13	19,51	0,45	0,12	bdl	bdl	**98,72**	bdl	bdl	bdl	0,79	0,06	0,71	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4767	40,92	3,63	31,57	0,12	21,62	0,40	0,08	bdl	0,06	**98,40**	bdl	0,03	0,01	0,73	0,03	0,61	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4768	40,51	5,06	9,46	0,13	37,79	1,59	0,10	0,04	0,18	**94,86**	bdl	bdl	0,01	0,47	bdl	0,13	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4783	42,24	1,44	17,73	0,05	33,89	0,84	0,03	0,01	0,07	**96,30**	bdl	bdl	bdl	0,17	bdl	0,24	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4798	41,98	5,80	28,08	0,15	21,19	1,09	0,12	0,03	0,06	**98,50**	bdl	0,05	0,01	1,21	0,05	0,84	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4901	29,74	3,03	50,32	0,26	7,97	2,87	0,08	bdl	0,48	**94,75**	bdl	0,09	0,02	1,04	bdl	1,41	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4137a	45,91	2,81	35,47	0,17	11,76	0,62	0,09	0,03	0,09	**96,95**	bdl	0,05	0,01	0,90	bdl	1,09	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
4137b	30,94	7,18	49,06	0,22	10,58	0,65	0,16	0,05	0,11	**98,95**	bdl	0,10	0,02	1,12	0,15	1,12	bdl	0,01	bdl	bdl	bdl	bdl	bdl	bdl
min	16,07	0,37	7,30	0,04	4,51	0,02	0,01	0,01	0,03	**84,88**	0,03	0,02	0,01	0,03	0,01	0,08	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00
max	52,34	12,21	63,67	0,73	37,79	5,67	0,54	0,23	1,70	**99,81**	0,09	0,15	0,06	2,07	0,22	1,81	0,00	0,02	0,00	0,00	0,00	0,00	0,01	0,00

Wolf S., Dapschauskas R., Velliky E., Floss H., Kandel A. W. & Conard N. J., 2018. The Use of Ochre and Painting During the Upper Paleolithic of the Swabian Jura in the Context of the Development of Ochre Use in Africa and Europe. *Open Archaeology*, **4**: 185-205.

Ziota C., Hondroyianni-Metoki A. & Magouretsiou E. 2013. Recent Prehistoric Research in the Kitrini Limni area of the Kozani Prefecture. *In:* G. Karamitrou-Mentessidi (ed.), *The Archaeological Work in Upper Macedonia, Aiani – AEAM 2, 2011*. Aiani, Ministry of Culture and Athletics, 30th Ephorate of Prehistoric and Classical Antiquities, Archaeological Museum of Aiani: 57-83.

Ziota C., Anagnostopoulou K. & Lokana C., 2014. Το σωστικό έργο της Λ΄ Ε.Π.Κ.Α. στην Ποντοκώμη και στη Μαυροπηγή Κοζάνης το 2014. *Το Αρχαιολογικό Εργο στη Μακεδονία και Θράκη*, **28**: 77-88.

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																							Kremasti
Zr	**Nb**	**Mo**	**Rh**	**Ag**	**Cd**	**Sn**	**Sb**	**Te**	**Ba**	**La**	**Ce**	**Hf**	**Ta**	**W**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Th**	**U**	**Sample**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**612**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**613**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**614**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**615**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**616**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**618**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**621**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**624**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**625**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**627**
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bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**632**
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bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**2856**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**2880**
bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**2947**
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bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**3387**
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bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	**4137b**
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	**min**
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	**max**