Grinding and abrading activities in the earlier Neolithic of northern Greece: a multi-proxy and comparative approach for the site of Pontokomi-Souloukia

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ABSTRACT – *Despite their widespread presence and potential to shed light on various aspects of prehistoric life, for a long time Neolithic macrolithics attracted little scholarly attention. The situation, however, is rapidly changing as more and more assemblages are being studied and published systematically. The study of the grinding and abrading tools from the earlier Neolithic site of Pontokomi-Souloukia in northern Greece is part of this recent trend, as it integrates macroscopic examination, use wear, microbotanical and macrobotanical analysis, an experimental program, ethnographic data, as well as contextual analysis. In this article, we present the results of our study and make comparisons with other assemblages, placing the Pontokomi-Souloukia material in its wider Aegean Neolithic context.*

KEY WORDS – *Neolithic; Greece; grinding and abrading tools; use wear analysis; residue analysis*

Mletje in brušenje v zgodnjem neolitiku v severni Grčiji: multi-proksi in komparativni pristop k najdišču Pontokomi-Souloukia

IZVLEČEK – *Kljub razširjenosti in sposobnosti osvetliti različne vidike življenja v prazgodovini, so neolitski makroliti pritegnili le malo raziskovalne pozornosti. Ocena se hitro spreminja, saj je sistematično analiziranih in objavljenih vse več zbirov. Mednje sodi tudi študija orodij za mletje in brušenje iz zgodnje neolitskega naselja Pontokomi-Souloukia v severni Grčiji, saj vključuje makroskopsko analizo, analizo sledov uporabe, mikro in makro botanične analize, eksperimentalni program, etnografske podatke in kontekstualno analizo. V članku predstavljamo rezultate naše študije in zbir primerjamo z drugimi. Gradivo z najdišča Pontokomi-Souloukia tako umeščamo v širši egejski neolitski kontekst.*

KLJUČNE BESEDE – *neolitik; Grčija; orodja za mletje in brušenje; sledi uporabe; analize rezidijev*

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Introduction

Despite their ubiquitous presence at Aegean Neolithic sites, involvement in most (if not all) *chaînes opératoires*, and potential to illuminate various aspects of prehistoric life, for a long time macrolithics[1] attracted little scholarly attention. It is not an exaggeration to state that traditionally they represented one of the most neglected materials from Neolithic Greece. When relevant information was reported, it often consisted of a few cursory paragraphs in the 'small finds' section of a site publication (*e.g., Evans 1964.229–231*). Some tools, abandoned at the site after the completion of the excavation, were not considered worthy of even such a superficial treatment. This is the bad news.

The good news is that the situation is rapidly changing. In the last fifteen years or so, the field of Aegean Neolithic macrolithics has witnessed dramatic growth as more and more assemblages are being studied and published systematically. As a result, significant progress has been made in exploring raw materials, manufacturing processes, aspects of use, practices of discard, as well as social and symbolic dimensions (*e.g., Almasidou 2019; Bekiaris 2007; 2018; 2020; Bekiaris* et al. *2017; 2020; in press; Chadou 2011; Chondrou 2018; 2020; Chondrou* et al. *2018; 2021; Chondrou, Valamoti 2021; Lewis* et al. *2009; 2011; Ninou 2006; Stergiou* et al. *2022; Stroulia 2002; 2010a; 2010b; 2018a; 2018b; 2020; Stroulia, Chondrou 2013; Stroulia* et al. *2017; 2022; Tsoraki 2008; 2011a; 2011b; 2011c*).

Despite these developments, the field suffers from two serious imbalances. The first is geographic. Much more is known about the macrolithic industries of northern Greece than those from sites farther south; reports (of varying length and quality) are available for almost 30 assemblages from Macedonia, Thrace, and Thessaly compared to roughly 10 from the southern part of the country. The second imbalance is chronological. The available information for industries dated to the later part of the Neolithic by far exceeds that for earlier materials; there are roughly twice as many reported Late or Final Neolithic assemblages as those belonging to earlier phases (*see Bekiaris* et al. *2020.146–147; Stroulia in press*).[2]

By focusing on the earlier Neolithic material from the site of Pontokomi Souloukia in the Kitrini Limni Basin, in the prefecture of Kozani, west Macedonia, this article tackles none of the geographic bias but does address the chronological one. As such, (1) it sheds light on the macrolithic implements of the first agropastoral communities that occupied the Aegean; (2) it contributes to an understanding of the diachronic evolution of the macrolithic industries and related practices in this part of the world.

The Site

Kitrini Limni was a busy place in the Neolithic. As revealed by surface surveys or accidental discoveries related to various development projects, from the 7^{th} to the 4^{th} millennium BCE, this $35km^2$ basin

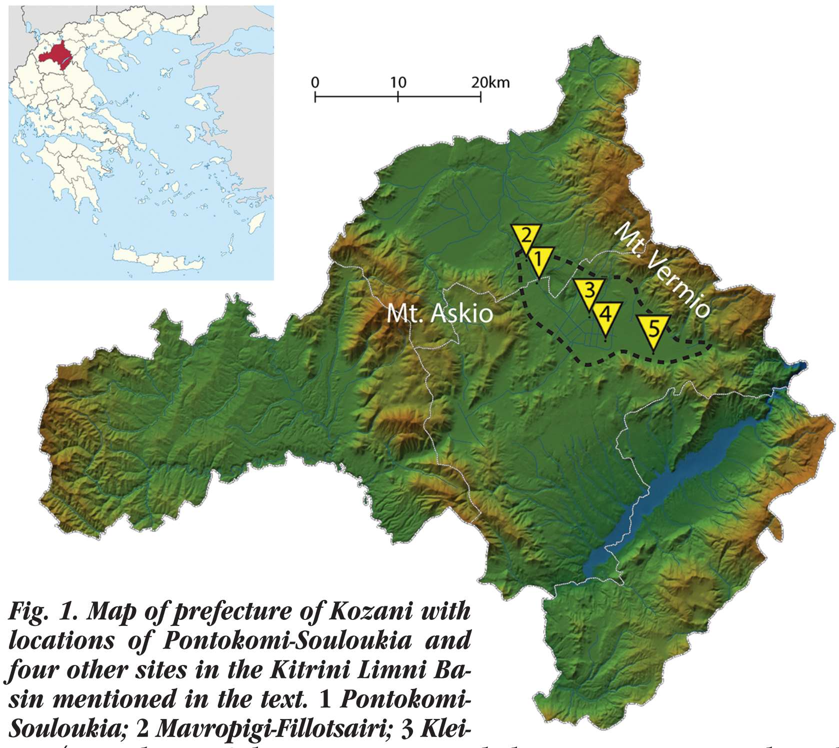

Fig. 1. Map of prefecture of Kozani with locations of Pontokomi-Souloukia and four other sites in the Kitrini Limni Basin mentioned in the text. **1** ***Pontokomi-Souloukia;*** **2** ***Mavropigi-Fillotsairi;*** **3** ***Kleitos;*** **4** ***Megalo Nisi Galanis;*** **5** ***Kremasti-Kilada. Kitrini Limni is indicated by dashed line. Graphics by Sofia Vlahopoulou.***

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1 For a discussion of the term 'macrolithics' and its advantages over the traditional term 'ground stone', see Adams *et al.* (*2009. 43–44*) and Stroulia (*2018a.202*).

2 The few assemblages that span the Neolithic period were not taken into account in these calculations.

served as the homeland for 30 settlements (*Chondroyianni-Metoki 2020; in press a; b; c*). One of the earliest among them is Pontokomi Souloukia (henceforth Souloukia) (Fig. 1).

Located on the western edge of the basin, Souloukia covers *c.* 1.0–1.2ha and dates to the second half of the 7th millennium and the beginning of the 6th. Roughly half of the site was severely damaged in the past few decades by the construction of a highway, a railroad, and other infrastructure-related projects. The other half (*c.* 0.4ha) was targeted by salvage excavations in the context of large-scale coal mining operations (*Chondroyianni-Metoki in press b; Karamitrou-Mentessidi* et al. *2010.39–46; Ziota* et al. *2014.77–79*).

Carried out by the Ephorate of Antiquities of Kozani between 2010 and 2017, the excavations revealed two contiguous but distinct areas. The centre of the site has the form of a low tell with anthropogenic deposits reaching a maximum thickness of 2m. This represents the residential sector as indicated by the remains of successive post-framed buildings. Five (mostly infant) human burials and one animal burial were found inside the buildings, while a concentration of 15 or so pits was excavated immediately to the south. A preliminary study of the stratigraphy and pottery of a single trench revealed three Early Neolithic building horizons and one dating to the early Middle Neolithic. Only *c.* 0.1ha was dug, but the residential area is estimated to have covered between 0.25 and 0.5ha (*Chondroyianni-Metoki in press b*) (Fig. 2a–d).

The surrounding flat area comprises the non-residential sector and includes three types of features: ditches, pits, and clay structures. Two ditches were uncovered. The first – on the western edge of the site – was linear, measuring *c.* 55m in length, 2m in maximum width, and 2.1m in maximum depth (*Chondroyianni-Metoki in press b*). The second – on the site's eastern part – was roughly curvilinear, measuring *c.* 14.5m in length, 2.4m in maximum width, and 1.4m in maximum depth (*Karamitrou-Mentessidi* et al. *2010.41–43, 45*). The functions of the ditches remain enigmatic, as there is no evidence that they connected with each other or surrounded the site (Fig. 2e).

Dispersed around the non-residential area are more than 40 pits of various sizes.[3] Their contents consist of pottery, lithics, faunal material, and figurines, but generally speaking, they yielded a small number of finds (*Chondroyianni-Metoki in press b; Karamitrou-Mentessidi* et al. *2010.43–44; Ziota* et al. *2014.78*). It is tempting to interpret these features as containers for ordinary waste disposal, but their dispersal over a large area is certainly intriguing.

East of the residential area (not far from the eastern ditch), the excavations uncovered a partially preserved clay structure with ashes – probably the remains of a hearth. North of the residential area, a second clay structure was excavated. It was elliptical in plan, with whitish clay coating the interior walls. Another structure may have existed west of the residential sector where masses of clay were uncovered along with, among others, a large number of grinding tools (Fig. 2f). Additional clay structures are vaguely mentioned in the preliminary reports (*Chondroyianni-Metoki in press b; Karamitrou-Mentessidi* et al. *2010.43; Ziota* et al. *2014.78–79*).

Significantly, the bipartite settlement structure, with a tell-like residential centre and a surrounding flat, extra-residential periphery, recognized at Souloukia, does not characterize Mavropigi-Fillotsairi, the other extensively excavated Early Neolithic site of Kitrini Limni (*Karamitrou-Mentessidi* et al. *2013; 2015*). It has, however, been identified at Kremasti-Kilada, which dates to the Late Neolithic (*Chondroyianni-Metoki 2009; 2020*). To the best of our knowledge, this settlement layout is not known from other parts of Greece and thus may represent a regional variation. Whether regional or not, this bipartite configuration argues against the long-held, simplistic dichotomy between tell sites and flat/extended sites and underlines the diversity of the ways in which Aegean people organized their settlements in space during the Neolithic (see also *Kotsakis 1999.69–70; Krahtopoulou 2019.77–82; Sarris* et al. *2017; Toufexis 2017.23–30, 333–362*).

Materials and methods

The Souloukia excavations uncovered large amounts of pottery, various quantities of stone and bone tools, an unusually high number of figurines, as well as a few rather uncommon artefacts (*i.e.* two clay house models, a marble vessel, and a bone flute) (*Chondroyianni-Metoki in press a; b; Karamitrou-Mentessidi* et al. *2010.44–45; Ziota* et al. *2014.79*).

The stone tool inventory includes nearly 400 macrolithics. Among them are the roughly 170 grinding

3 Intriguingly, a single pit dates to the Final Neolithic (*Chondroyianni-Metoki in press b*).

Fig. 2. Excavation views. Residential sector:* a *remains of burnt building;* b *postholes;* c *pits;* d *pot burial. Extra-residential sector:* e *ditch;* f *area with grinding tools, pieces of raw material, as well as masses of clay possibly from a clay structure. Photos by A. Chondroyianni-Metoki.

tools, abrading implements, and related pieces of raw material that make up the focus of this paper.

The term 'grinding tools' refers to implements used to pulverize or crush foodstuffs and minerals. These artefacts operate in pairs comprising a lower stationary component and an upper mobile one. In the literature, the first is often referred to as a millstone, quern, metate, grinding slab, *etc*., the second as a handstone, mano, grinder, rider, roller stone, rubber, *etc*. (*e.g., Adams 2014.142–145; Cappers* et al. *2016. 391–392; Elster 2003.186; Evans, Renfrew 1968.71; Hamon, Le Gall 2013.113; Hayden 1987.187; Tsoraki 2008.91, 97; Wright 1992.61; Wright, Baysal 2012.3*). Here we use the more neutral terms 'passive tool' and 'active tool', respectively. The term 'abrading tools' refers to implements used without a complementary component for shaping/maintaining other artefacts (*e.g.*, celts, bone tools, and ornaments) through abrasion. We should emphasize that the differentiation between grinding and abrading tools as well as that between passive and active grinding implements serve analytical purposes. As seen below, the Souloukia residents did not always conform to these distinctions.

Since the systematic study of both the stratigraphy and pottery is pending, a distinction between Early Neolithic and early Middle Neolithic specimens has not been possible. However, given that three of the four building horizons in the residential area are Early Neolithic, we assume this to be the date of the majority of specimens. Be that as it may, in this article all specimens are referred to collectively as earlier Neolithic.

All but six of the roughly 130 abrading and grinding tools were subjected to use wear analysis with a stereoscope (10–80x magnification) and a metallographic microscope (100x and 200x magnification) (Robitaille). Preservation of microwear was moderate to low. Acetate and polyvinyl siloxane casts were made of used surfaces that were preserved reasonably well. Use wear analysis was conducted in conjunction with an extensive experimental program that involved a variety of materials: cereals, pulses, nuts, bone, shell, stone, and wood (Robitaille, Stroulia). Microwear was identified on a total of 63 specimens.

Residue analysis following a protocol and nomenclature defined by Rosa M. Albert *et al.* (*1999*) and Marco Madella *et al.* (*2005*) was carried out on 14 unwashed specimens: 13 grinding tools (both work and dorsal faces were sampled) and one abrading implement (both used surfaces were sampled). Six control samples were analysed as well. The detected phytoliths were examined with a Leica DM 750 microscope at 400x magnification. For each sample, calculations were made for the number of phytoliths per 1g of sediment, the percentages of grass and dicotyledonous phytoliths, as well as those of weathered and multicellular morphotypes. Phytoliths that can be associated to use with a reasonable degree of confidence were identified on only five of the sampled artefacts (*Ögüt 2018*).

The Souloukia grinding and abrading tools are among the first from Neolithic Greece to have been subjected to use wear and residue analyses.[4] In this paper, we present the general results of these analyses, but more detailed data on both, as well as the experimental program, will be published elsewhere.

While the analysis of microbotanical remains has been completed, the examination of the macrobotanical material has not. No more than a small sample has so far been analysed (Kotsachristou). Only preliminary observations have therefore been possible regarding the plants processed and consumed at the site.

The study of the Souloukia grinding and abrading tools is particularly important. The severe underrepresentation of earlier Neolithic assemblages in the literature (noted above) is one reason. There are another two: these assemblages have been treated superficially or happen to be very small. For example, over 100 grinding and abrading tools from Achilleion were presented in fewer than two pages (*Winn, Shimabuku 1989.268–272*), while the roughly 70 specimens from Nea Nikomedeia were discussed in only seven paragraphs (*Pyke 1993.103, 108–109, 111*). The macrolithic material from Prodromos, on the other hand, was studied systematically, but includes fewer than 15 grinding and abrading tools (*Moundrea 1975.92–99*).

By integrating macroscopic examination with use wear and residue analysis, experimental, macrobotanical, and ethnographic data, as well as contextual analysis, our study of the substantial Souloukia assemblage helps fill this gap and thereby clarify the role these implements played in the lives of the communities that made Greece their home in the earlier part of the Neolithic.

This paper operates at three levels: (1) It presents the results of our multi-proxy study of the Souloukia tools by discussing the raw materials and their acquisition; the choices made in the context of manufacture and the priorities that these reflect; the specimens' morphometric and technofunctional characteristics; the processed food and non-food substances; as well as the tools' spatial distribution and processes of discard. (2) It makes references to assemblages from four sites in Kitrini Limni (Kremasti-Kilada, Kleitos, Megalo Nisi Galanis, and Mavropigi-Fillotsairi) as well as others elsewhere, placing the Souloukia material in both its regional and wider Aegean Neolithic context. (3) It utilizes the limited available information on contemporary industries and makes comparisons to later ones in an attempt to place the Souloukia material in its synchronic and diachronic framework.

Abrading tools

Only six specimens were securely identified as abrading tools. All derive from the residential sector. An additional specimen – found outside the residential area – carries no use wear but may represent raw material intended for an abrading tool.

The Souloukia abrading tools share two basic commonalities: (1) all are *a posteriori* – the raw material was put directly to use without modification; (2) all were used passively. These tools, on the other hand, exhibit significant morphological and lithological differences that allow a distinction between two groups.

Group 1 comprises four specimens of tabular fine-grained sandstone. This type of raw material is not

4 For other studies, see Danai Chondrou *et al.* (*2021*) and Anna Stroulia *et al.* (*2017.3–7*).

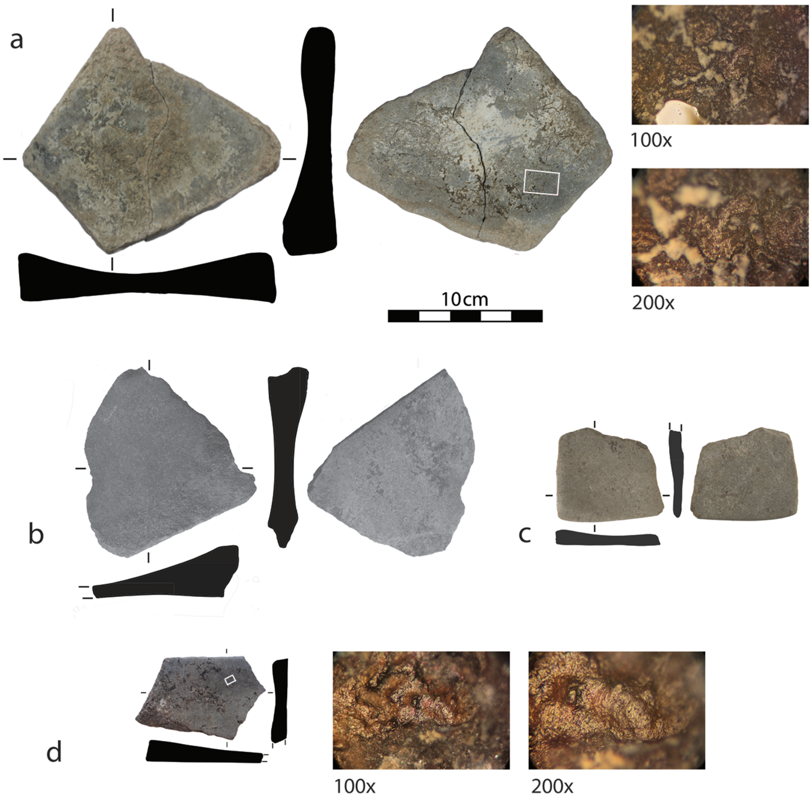

Fig 3. Abrading tools (Group 1): **a** ***faces A (left) and B (right), sections, and use wear views of complete specimen GS325 (metallographic microscope);*** **b** ***faces and sections of fragmentary specimen GS95;*** **c** ***faces and sections of fragmentary specimen GS190;*** **d** ***used face, sections, and use wear views of fragmentary specimen GS56 (metallographic microscope). Drawings by T. Gouliafas, photos by A. Stroulia and J. Robitaille.***

found in the Kitrini Limni Basin, the bottom of which consists of clay marl and lacks stones larger than 5cm (*Fotiadis 1988.45; Fotiadis* et al. *2019.5–6*). It is not found anywhere else in the local landscape either. The closest source is located on the slopes of Mt. Vourinos, close to the village of Agia Paraskevi, about 25km south of the site.[5] The sandstone crops out naturally in the form of plaques of varying thickness (*Stroulia, Dubreuil 2011.3*).

Only one tool in this group is complete. It is not however intact, as it was found in two pieces (the breakage probably being post-depositional). This specimen is polygonal and measures 14.3x13.8x3.4cm. The other three are fragmentary. None appears to derive from a tool larger than the complete one. On this basis, it is fair to say that all specimens in Group 1 are small and thin.

The extent and intensity of use, as well as the ensuing morphological changes, vary from tool to tool. The two thickest specimens – one complete, the other fragmentary – were used on both faces. The use was intensive enough to create concave configurations. The faces of the complete specimen are parallel, but one (A) is deeper than the other (B) (Fig. 3.a). Face A features a central ovate, concave *c.* 9x6cm area. Due to the presence of concretion, no microwear was identified on this face, but that detected on face B appears compatible with the abrasion of bone. This is the only abrading tool subjected to residue analysis. A relatively high proportion of wood phytoliths were detected on face A. However, since many of them consist of skeletons rather than weathered morphotypes, they may not be use-related (*Ögüt 2018*). The faces of the fragmentary specimen are diagonal (Fig. 3.b). Again, one face is deeper than the other, but both show an increasing depth towards the thinnest edge. We were not able to specify the material that was processed on these faces, but according to the use wear analysis, it was neither bone nor wood.

One of the thinnest specimens was also used on both faces. Judging by the fact that one face is more or less flat, while the other is lightly concave with an increasing depth from one side to the other, the two faces were not used with equal intensity. Use wear analysis points to wood processing, at least for one of the faces (Fig. 3.c). Finally, the fourth and equally thin specimen was used on only one face, resulting in the formation of a slightly concave area. The processed material was most likely bone. This is the least utilized of the Souloukia abrading tools (Fig. 3.d).

Group 2 includes two tools. Both are much more massive than those making up Group 1. This is well illustrated by the complete specimen, which measures *c.* 31x19x11cm (Fig. 4). The raw material consists of waterworn boulders, gneiss in one case and sandstone of a coarser variety than that used for

5 This is probably the only primary source of fine-grained sandstone in the prefecture of Kozani.

Group 1 in the other. In both tools, one of the faces is lightly convex but has a lightly concave used area measuring *c.* 15x8cm. In neither case has the processed material been determined.

Our general conclusion is that the Souloukia abrading tools were involved in the production (and/or maintenance) of bone objects such as those that were excavated (see *Karamitrou-Mentessidi* et al. *2010.45*) as well as wooden artefacts that were not preserved. It is important to note that bone or wood abrasion has been hypothesized for certain Greek Neolithic macrolithic tools on a macroscopic basis (*e.g., Bekiaris 2018.276–277; Chondrou 2018.227–228; Fotiadis* et al. *2019.31; Stroulia 2010a.40–54, 2018a.211–212; Tsoraki 2008.102–10*), but this is the first time that such functions are documented for the Neolithic Aegean.

Significantly, no wear related to stone abrasion was detected. This is unexpected in light of the over 100 excavated celts. We find it plausible that celt shaping and resharpening took place outside the settlement. Such a hypothesis is compatible with the almost complete absence of unfinished specimens. On the basis of ethnographic evidence, both practical and non-practical considerations may have been behind the off-site production and maintenance of celts at Souloukia. Among several Irian Jaya groups, celt grinding is carried out away from the compounds, usually by a river or stream. This activity is invested with a strict prohibition along gender lines as it must take place out of view of women (*Pétrequin, Pétrequin 1993.373*).

Abrading tools of tabular fine-grained sandstone have been uncovered at three other Kitrini Limni sites: Kremasti-Kilada (*Chondrou 2011.101–102; Stroulia, Dubreuil 2011.1*), Megalo Nisi Galanis (*Fotiadis* et al. *2019.31*), and Kleitos (*Chondrou 2018.200–230*). Similar artefacts have also been reported from Servia,[6] a site in the prefecture of Kozani but not in Kitrini Limni (*Mould* et al. *2000.155–157*). Microscopic analysis of a sample from Kremasti-Kilada by Laure Dubreuil revealed use wear somewhat compatible to that produced experimentally through stone abrasion and scraping unfired bone-dry clay vessels (*Stroulia, Dubreuil 2011.2*). Kremasti-Kilada, Megalo Nisi Galanis, Kleitos, and Servia date to the Middle, Late, or Final Neolithic and are thus later than Souloukia, but the presence of such tools on all five sites points to a certain regional tradition of exploiting fine sandstone tabular pieces from the same source for a variety of abrading purposes. Finally, we should note that farther north and west, but also in Macedonia, the Late Neolithic site of Avgi yielded over 60 tabular pieces of fine-grained sandstone. They are of generally larger dimensions than those found at the above sites and were employed in a cooking rather than an abrading context (*Bekiaris* et al. *in press*).

Fig. 4. Complete abrading tool GS243 (Group 2): work face and profile. Photos by A. Stroulia.

Grinding Tools

Raw material type, procurement

The Souloukia excavations yielded a much higher number of grinding than abrading tools. One hundred twenty-six specimens were securely identified as grinding tools, while one and possibly up to four specimens represent roughouts (Figs. 5–9). In addition, 31 pieces of gravel were recovered of material similar to that employed for grinding tools but without traces of manufacture or use. At least 20 of these are complete or substantially preserved and thus likely represent unworked nodules intended for grinding tools. Of the remaining specimens, some are very fragmentary, while others have surfaces covered by concretion or altered by fire. Whether these belong to tools or raw nodules is impossible to tell.

If tabular sandstone was the preferred material for abrading implements, it was used rarely for grinding

6 They are referred to as 'palettes' by the excavators.

tools. For the latter, Souloukiotes almost always chose gneiss in the form of cobbles and boulders. In this sense, the grinding tool assemblage is remarkably homogeneous, a reflection of a deeply embedded tradition that spanned several generations. The gneiss used comes in various degrees of coarseness, is often oxidized with a characteristic red/brown colour, has a high quartz content and is thus quite hard, typically includes no mica, and its surface is usually anomalous and/or has vesicular areas (Figs. 5–9). As we found out by experimentally producing a work face through pecking, this type of gneiss is characterized by high workability. Moreover, because of its hardness it does not require frequent resharpening, nor does it produce much grit during use. Or so we discovered through our grinding and cooking experiments. This was a good choice.

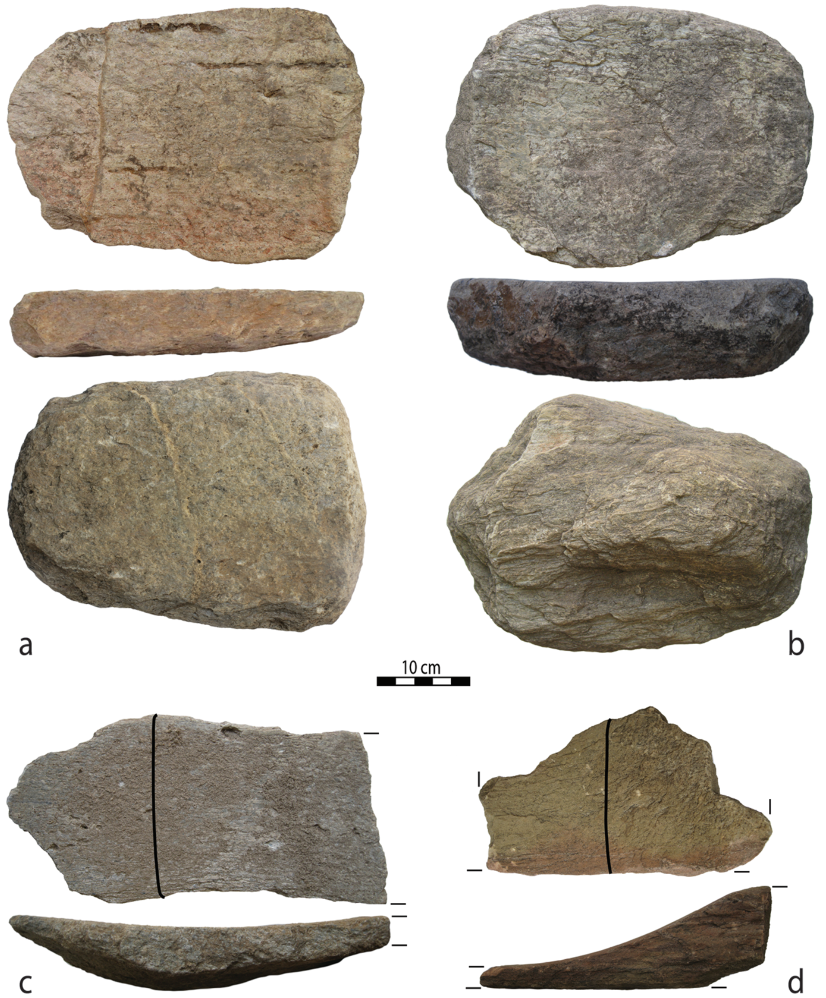

Fig. 5. Passive tools: **a** ***intended work face, dorsal face, and longitudinal profile of complete roughout specimen GS307;*** **b** ***concave/concave work face, dorsal face, and longitudinal profile of complete specimen GS71;*** **c** ***concave/convex work face and longitudinal profile of fragmentary specimen GS244;*** **d** ***concave/convex work face and longitudinal profile of fragmentary specimen GS250. Photos by A. Stroulia.***

Primary gneiss sources are found on two of the mountains surrounding Kitrini Limni: Mt. Askio to the west and Mt. Vermio to the east (Fig. 1). Both sources are extensive, but Mt. Askio is the closest to Souloukia. Although no petrographic analyses have been conducted, macroscopic similarities indicate that as a rule Mt. Askio gneiss was utilized by the Souloukiotes. Nevertheless, with a handful of possible exceptions procurement did not take place at primary sources. The material is waterworn and thus must have been collected at more proximate secondary locations.

A comparison between Souloukia and other Kitrini Limni sites regarding the raw materials of grinding tools revealed one fundamental similarity. In all cases, secondary sources were exploited (Kremasti-Kilada: *Chondrou 2011.81, 106; Stroulia, Dubreuil 2011.1;* Kleitos: *Chondrou 2020.291;* Megalo Nisi Galanis: *Stroulia 2002.576*).

This comparison also revealed two patterned variations:

❶ The almost exclusive focus on a singular material noted at Souloukia is not paralleled in the later Neolithic assemblages of Kremasti-Kilada (*Chondrou 2011.80–81; Stroulia* et al. *2017.3*), Kleitos (*Chondrou 2020.290–291*), and Megalo Nisi Galanis (*Fotiadis* et al. *2019.30–31*), which are characterized by a variety of materials. Gneiss is part of this variety but never the dominant lithology. On this basis and in a preliminary fashion, we would like to hypothesize that in Kitrini Limni an earlier Neolithic focus on a single material was followed by the exploitation of diverse lithologies. What needs and/or opportunities could have led to such a diversification cannot be systematically discussed with the available data. However, a simplistic and straightforward equation between the number of raw material types and processed substances does not appear to be the answer. As seen below, the use wear of the Souloukia specimens points to processing a variety of substances. Be that as it may, the nearly exclusive use of a single material for grinding tools appears to have been rare in Neolithic Greece. To the best of our knowledge, the only other sites in which this practice has been documented are Dikili Tash (*Bekiaris* et al. *2020.147*) and Alepotrypa Cave (*Stroulia 2018a.205*), in the northern and southern parts of the country, respectively. Both date to the later part of the Neolithic.

❷ The Mt. Askio gneiss used at Souloukia is macroscopically different from the varieties employed at Kremasti Kilada and Megalo Nisi Galanis (observations by Stroulia) that appear to originate in Mt. Vermio. Notably, these two sites are located in the eastern part of the basin and thus closer to Mt. Vermio than Mt. Askio. On this basis, we would argue that western and eastern Kitrini Limni communities exploited different regional sources of gneiss. Since all these varieties are of good quality, the distance from the sources may very well have been the determining factor behind these choices. Hopefully, these hypotheses will be tested in the future through comparative petrographic analyses.

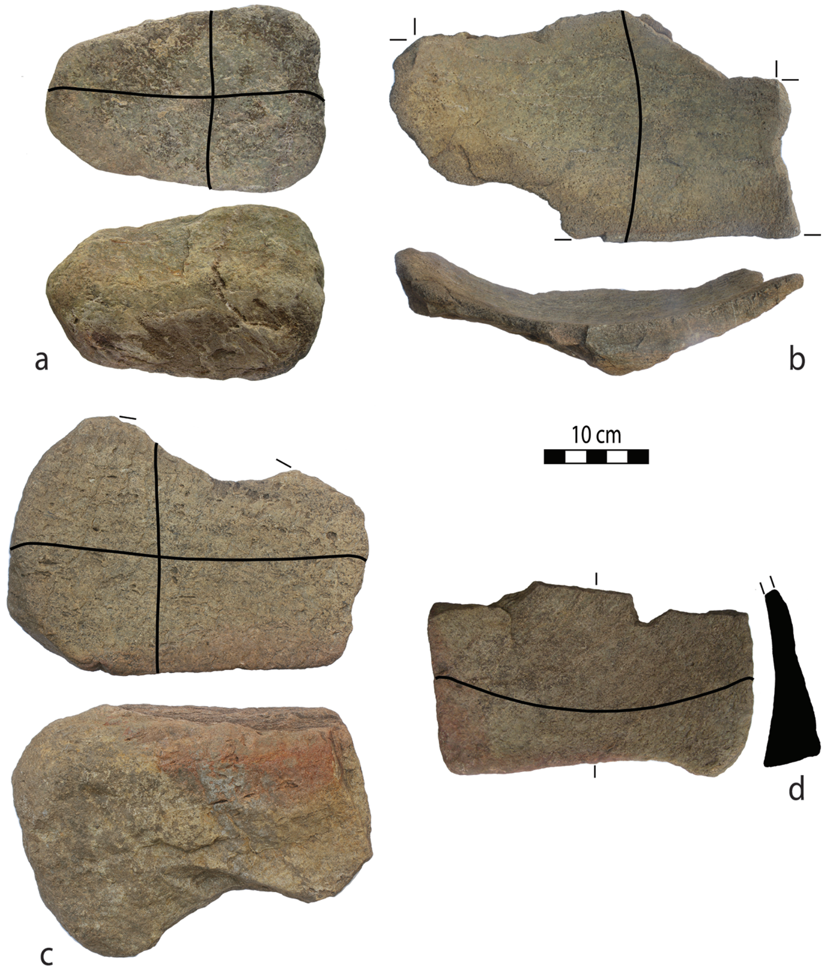

Fig 6. Passive tools:* a *complete specimen GS277 with concave/concave work face and dorsal face used in the context of recycling;* b *concave/concave work face and longitudinal profile of fragmentary specimen GS255;* c *concave/concave work face and dorsal face of nearly complete specimen GS324;* d *concave/concave work face and transverse section of fragmentary specimen GS388. Drawing by T. Gouliafas; photos by A. Stroulia.

Manufacture

As mentioned above, the Souloukia excavations uncovered at least 20 unmodified gneiss cobbles and boulders that were probably intended for grinding tools. Their presence is indicative of two practices: (1) raw material was brought to the site without prior processing at the sources; (2) larger quantities of raw materials than those immediately needed were periodically collected in anticipation of future needs – the hallmark of curation practices. With the available evidence, it is impossible to tell how the collected raw material was distributed, but the recovery of raw nodules from both the residential and non-residential areas at the very least points to the lack of a single communal spot where raw material was kept awaiting future use. The fact, moreover, that only one roughout was positively identified (Fig. 5.a) indicates that no designated manufacturing locus existed either (at least in the excavated area).

The scarcity of unfinished specimens noted at Souloukia matches that known from other Kitrini Limni sites; see Kremasti Kilada (*Chondrou 2011.81–82, 134; Stroulia* et al. *2017.4*), Kleitos (*Chondrou 2020. 291*), and Megalo Nisi Galanis (observation by Stroulia). No such match applies to unworked specimens. While by no means high, the number of such specimens at Souloukia is rather substantial when compared to Kleitos (*Chondrou 2020.291*) and Megalo Nisi Galanis (*Stroulia 2002.576*),[7] which are characterized by an almost complete absence of unmodified cobbles and boulders. Indeed, the combined paucity of raw nodules and roughouts in the huge assemblage of the almost fully excavated site of Kleitos led to the hypothesis that tools arrived in a more or less finished state (*Chondrou* et al. *2018.31; Chondrou 2020.291*). A similar scarcity characterizes assemblages from sites beyond Kitrini Limni such as Makriyalos (*Tsoraki 2008.81*), Alepotrypa Cave (*Stroulia 2018a.234*), Avgi (*Bekiaris 2018. 221*), and Platia Magoula Zarkou (*Stroulia in press*). This pattern deserves systematic investigation, but it appears to suggest a widespread practice of off-site grinding tool production in Neolithic Greece.

Two manufacturing techniques were employed for grinding tools at Souloukia: pecking and flaking (Figs. 5.a, 9.a). Both are known from other sites in Kitrini Limni and elsewhere; see Kremasti-Kilada (*Chondrou 2011.82–83, 106–107; Stroulia, Dubreuil 2011*), Megalo Nisi Galanis (*Stroulia 2002.576*), Kleitos (*Chondrou 2020.291–293*), Avgi (*Bekiaris 2020.4*), Makriyalos (*Tsoraki 2008.114*), Koroneia (*Almasidou 2019.90, 99–100*), Franchthi Cave (*Stroulia 2010a.35*), Alepotrypa Cave (*Stroulia 2018a. 206*), and Platia Magoula Zarkou (*Stroulia in press*).

The process of manufacture at Souloukia was neither comprehensive nor systematic: work faces were most often created through pecking. Portions not intended for use, on the other hand, were as a rule left in their raw state or received localized treatment in order to facilitate the tool's gripping/resting or ensure a specific plan (Figs. 5.b, 6.a and c, 9.a–c).

This manufacturing approach was aided by a raw material acquisition strategy that favoured cobbles/boulders with sizes and shapes similar to those of the intended tools or with portions that could be strategically incorporated into the final tool shape. Two examples: the first is a roughout of a passive tool measuring *c.* 33x23x5.5cm., with one naturally flattish surface that could be converted into a work face with minimal pecking (Fig. 5.a); the second example – an active tool – measures *c.* 20x19x 17.5cm, pointing to use with two hands. Its dorsal face has a naturally ridged shape that must have facilitated gripping during grinding (Fig. 8.c).

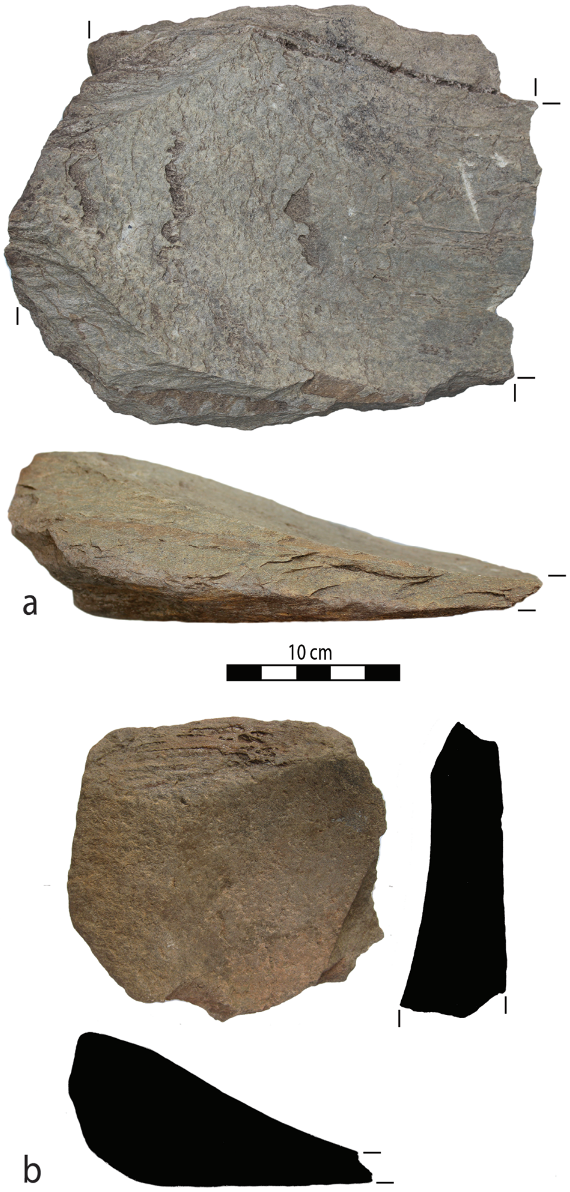

Fig. 7. Passive tools:* a *concave/concave work face and longitudinal profile of fragmentary specimen GS389;* b *concave/concave work face and sections of fragmentary specimen GS385. Drawings by T. Gouliafas, photos by A. Stroulia.

The above strategy expedited manufacture, it did result, however, in tools with uneven/anomalous dorsal and peripheral surfaces or asymmetrical plans (Figs. 5.b, 6.a and c, 8.c, 9.c). Clearly, this was not considered a sufficiently serious problem to make the people of Souloukia invest more effort in tool making. Clearly, saving time and energy took priority over appearance. A similar attitude is reflected in the assemblages of other Kitrini Limni sites and

7 The case of Kremasti-Kilada is ambiguous. More than 300 fragmentary specimens without traces of manufacture or use were excavated, but how many represent unworked raw materials and how many consist of unmodified tool portions we cannot tell (*Stroulia* et al. *2017.23*).

beyond, which are also characterized by a low manufacturing investment and/or non-comprehensive treatment of the raw materials – see Megalo Nisi Galanis (*Stroulia 2002.576*), Kleitos (*Chondrou 2020. 291*), Kremasti-Kilada (*Chondrou 2011.82–83, 106–107; Stroulia* et al. *2017.4*), and Makriyalos (*Tsoraki 2008.114*).

Morphometric characteristics

Only 30 (24%) of the Souloukia grinding tools are complete or nearly so. The vast majority (n=96) are fragmentary. This imbalance is far from remarkable, since Aegean Neolithic grinding tool assemblages (at least those with available preservation information) are dominated by fragments (see *Bekiaris* et al. *2020.157–158; Stroulia in press*). What is noteworthy is the stark contrast between the frequencies of complete specimens at Souloukia and other Kitrini Limni sites. As it turns out, at Kremasti-Kilada, Kleitos, and Megalo Nisi Galanis, such specimens are extremely rare, accounting for <4%, 3%, and <1% of the total, respectively (*Chondrou 2011.91–95, 111–113, 164–165; 2020.290; Fotiadis* et al. *2019.31; Stroulia 2002.576; Stroulia, Chondrou 2013.125–126; Stroulia* et al. *2017.3*). The hypothesis of deliberate breakage has been put forward for all three assemblages. The fact that the Souloukia material is earlier than the other three raises the possibility that grinding tools were subjected to different treatments and assigned different dimensions by earlier and later Neolithic communities in Kitrini Limni.

On the basis of microwear analysis, morphometric characteristics and/or work face configuration, 63 tools (50%) were identified as passive, 47 (37%) as active. All identifications refer to primary uses. Due to fragmentation or surface alteration, it has been impossible to determine whether the remaining 16 specimens were used passively or actively.

The numerical prevalence of passive tools is intriguing. As known from ethnographic sources, active tools wear out faster and thus have shorter life spans than passive ones (see *Delgado Raack, Risch 2016. 129; Hayden 1987.193; Nixon-Darcus, D'Andrea 2017.206; Risch 2008.22; Robitaille 2016. 438*). That is why, for example, among the Minyanka of Mali two active tools are produced for each passive one (*Hamon, Le Gall 2013.112*), while among the Konso, Hamar, Mursi, and Dorze of Ethiopia each passive tool is used with two active ones over its lifespan (*Robitaille 2016.445; 2021. 240, 546*). On this basis, one would expect the Souloukia assemblage to feature precisely the reverse imbalance, *i.e.*, a higher proportion of active than passive tools.

What is even more unexpected, similar discrepancies between passive and active tools have been noted at other Greek sites such as Alepotrypa Cave (*Stroulia 2018a.208*), Franchthi Cave (*Stroulia 2010a.79–94*), Iliotopos (*Chadou 2011.134*), and Makriyalos (*Tsoraki 2008.Tab. 5.28*). They are also known from other periods or countries; see, for example, several Neolithic sites in Serbia (*Galdikas 1988.*

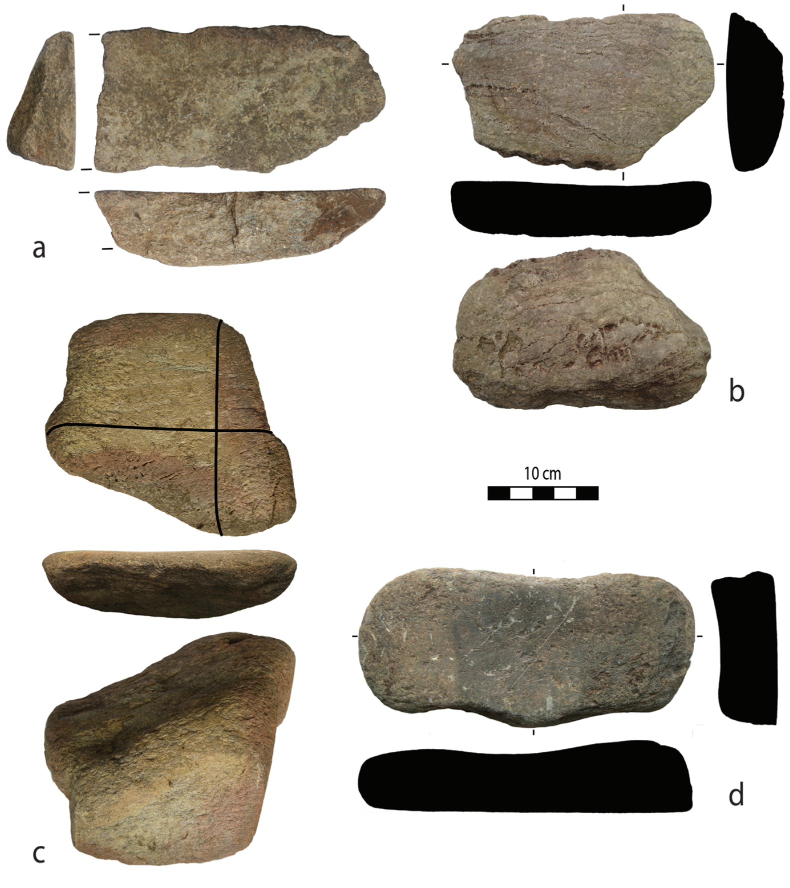

Fig. 8. Active tools:* a *concave/convex work face and profiles of fragmentary specimen GS97;* b *concave/convex work face, dorsal face, and sections of complete specimen GS292;* c *slightly concave/convex work face, dorsal face, and profile of complete specimen GS247;* d *recycled dorsal face and sections of complete specimen GS238. Drawings by T. Gouliafas, photos by A. Stroulia.

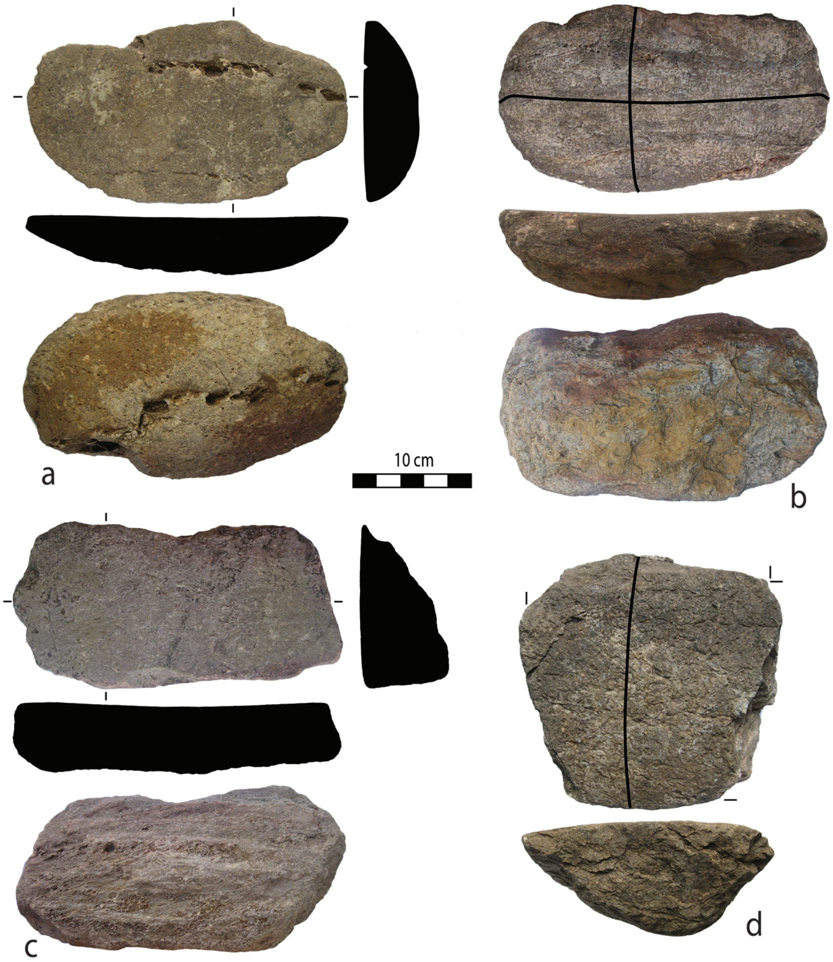

Fig. 9. Active tools: **a** ***concave/convex work face, dorsal face, and sections of complete specimen GS257;*** **b** ***concave/convex work face, dorsal face, and longitudinal profile of complete specimen GS254;*** **c** ***concave/convex work face, dorsal face, and sections of complete specimen GS289;*** **d** ***convex/convex work face and transverse profile of fragmentary specimen GS316. Drawings by T. Gouliafas, photos by A. Stroulia.***

341; Vučković 2019. 228), the Greek Bronze Age site of Toumba Thessalonikis (*Tsiolaki 2009.61–62*), certain Pre-Dynastic and Bronze Age Egyptian sites (*Robitaille 2015; Samuel 2010.466*), as well as Bronze Age sites in southern Iberia (*Delgado Raack, Risch 2009.10; 2016.129; Risch 2002.111–127*). We suspect that this is a widespread phenomenon, one that has been severely underappreciated in the literature.

Risch and his colleagues attributed the predominance of passive implements in southern Iberian assemblages to the use of unpreserved wooden active specimens (*Delgado Raack, Risch 2009.17; 2016. 139; Menasanch* et al. *2002.108; Risch 2002.111–127*). Such a hypothesis does not appear valid for Souloukia. The microtopography of the work faces of passive tools points to active counterparts made of stone. There must be another explanation, and this will be discussed later in this work.

The Souloukia passive tools are typically elongated. Their plans are subrectangular, subtrapeze, or ovate, with occasional subsquare or elliptical cases (Figs. 5–7). Active tools are also elongated, with subrectangular, ovate, and, more rarely, subtrapeze, subsquare, or subtriangular plans (Figs. 8–9).

The eleven complete (or nearly so) passive specimens range from *c.* 23 to 45.5cm in length, from *c.* 15.5 to 28.5cm in width, and from *c.* 4.5 to 17.5cm in thickness, averaging *c.* 31cm, 19cm, and 7.7cm, respectively. The 52 fragments average *c.* 23.5cm in length, 17cm in width, and 7.5cm in thickness. The average length of the complete specimens is slightly over the standard limit of 30cm between small and large specimens. This may lead to the general conclusion that the Souloukia passive tools were of moderate size. However, the average length of the many more incomplete specimens is relatively high – an indication that most tools were originally large. This hypothesis is reinforced by the fact that quite a few of the fragments represent half or less of the complete tool, as well as by the high mean width and thickness of the fragmentary specimens in general. On this basis, we would argue that the Souloukia assemblage includes several small (mostly complete) passive specimens, but large ones make up the majority (Figs. 5–7).

The picture conveyed by the active tools is more straightforward. The 17 complete specimens are clearly large. They range from *c.* 16 to 30cm in length, from *c.* 10.5 to 19cm in width, and from *c.* 4.5 to 9cm in thickness, averaging *c.* 23cm, 15cm, and 6cm, respectively. With respective averages of *c.* 15cm, 12cm, and 6cm, the 30 fragments appear to derive from equally big tools. With one possible exception, we consider all active specimens to have been two-handed (Figs. 8–9). The combined metric data of all specimens (passive and active, complete and incomplete) suggest that the grinding toolkits employed by the residents of Souloukia were for the most part large.

The active tools could have been used in conjunction with large passive implements such as those found. Active specimens that would have been compatible with the identified small passive ones, on the other hand, appear to be missing. This is a second discrepancy between passive and active tools.

Given their large sizes, it is tempting to assume that the active implements operated in an overhanging manner. However, both macroscopic and microscopic examination suggest that, as a rule, their length was roughly similar to or slightly higher than the width of the associated passive tools. Specimens whose length substantially exceeded the width of their passive counterparts are not common in this assemblage. Overhanging specimens have been reported from Kleitos (in Kitrini Limni), Ayios Vlasis, Stavroupoli, and Dikili Tash (*Chondrou 2020.293–294; Chondrou* et al. *2021.6–9*). It is, however, unclear whether these tools were slightly or substantially longer than the width of the associated passive tools.

Given that a number of passive and active specimens weigh over 7kg and 4kg, respectively, it is also tempting to assume that at least some of the Souloukia grinding toolkits were fixed in place. However, no grinding installations were uncovered by the excavators. In fact, such an assumption projects to the past our Western modern relationship with heavy objects. The relationship of prehistoric people with such objects may have been different, as illustrated by ethnographic examples from Ethiopia. Among the Dorze, passive tools weighing 11–25kg are regularly moved from their storage location inside the house to the yard of the compound where they are used. The Hamar passive tools range in weight from 8 to 60kg. The heaviest among them remain inside the house, but the lighter ones are often moved between indoor and outdoor areas. In most cases, tools are transferred on a daily basis. Other movements are periodical, depending on the season, the substances to be processed, or the context of use of the ground product. With certain exceptions, the tools do not leave the boundaries of the compound. The exceptions refer to special occasions. Among the Mursi and the Hamar, tools are taken to farther locations for processing large quantities of grain in a group context. The processed grain is then used to make beer for weddings or other festive events (*Robitaille 2021.181;* see also *Hamon, Le Gall 2013.117*).

We close this section with the overall sizes of Neolithic Aegean grinding tools. General claims have been made about "*the predominance of milling tools of relatively limited dimensions in many...sites*" (*Chondrou* et al. *2018.37*; see also *Valamoti* et al. *2013.171, 184*). We disagree with this characterization and consider it to be a misconception shaped by high rates of fragmentation. Our examination of the sizes of both complete and fragmentary specimens has revealed a more nuanced picture. Some Neolithic assemblages include both small and large specimens; see Servia (*Mould* et al. *2000.146–155*), Stavroupoli (*Alisøy 2002*), and Platia Magoula Zarkou (*Stroulia in press*). Others comprise primarily small tools; see Franchthi Cave (*Runnels 1981.101; Stroulia 2010a.37–38*) and Lerna (*Banks 2015.184; Runnels 1981.101*). Yet others, like Souloukia, appear to include primarily large specimens; see Kremasti-Kilada (*Stroulia* et al. *2017.4*; observation by Stroulia) and Alepotrypa Cave (*Stroulia 2018a.204, 208–209*).[8]

With its earlier Neolithic date, the Souloukia assemblage demonstrates that the use of large-sized grinding tools was not a later development. Rather, such implements were a part of the material culture of the first sedentary communities established in the Aegean. What is more, the four largest specimens from Souloukia (Fig. 5.b–c)[9] are among the most massive known from Neolithic Greece (for examples from Kitrini Limni and elsewhere, see *Chondrou 2011.83–84; Mould* et al. *2000.150; Stroulia* et al. *2017.4; Touloumis 2002.108–109*). Not only did early Aegean farmers have grinding tools of large dimensions, they had some of the largest ones yet found.

Morphofunctional characteristics

The Souloukia tools typically have only one work face. There are nine exceptions to this rule. Two passive (3%), five active (11%), and two indeterminate specimens have two parallel or diagonal work faces

8 See also *Bekiaris* et al. *2020.154*.

9 They measure 45.5x21x17.5cm, 42x28.5x20cm, 41x28.5x9cm, and 40x19.5x7cm.

with similar or different configurations. These numbers do not include tools with localized use wear on the dorsal face (see below). The scarcity of double work-face specimens indicates that creating two work faces was not a common means for prolonging a tool's use life at Souloukia. The higher percentage of active tools with two work faces, on the other hand, suggests that these were considered more appropriate for use with both faces than passive ones.

Regarding other Kitrini Limni assemblages, the situation varies. Double work-face tools are rare at Kleitos (*Chondrou 2020.299*), but more common at both Kremasti-Kilada (*Chondrou 2011.74–113; Stroulia* et al. *2017.4*) and Megalo Nisi Galanis (*Stroulia 2002.576*). Since all sites are found in the same region, the variation cannot be attributed to differences in raw material availability and accessibility, and instead possibly reflects individual or cultural preferences (see also *Robitaille 2021.815*). Whatever the case, a similar variation characterizes the Aegean as a whole. For example, specimens with two work faces account for roughly a quarter of the assemblage at Makriyalos (*Tsoraki 2008.91, Tabs. 5.14 and 5.24*), but close to 60% at Alepotrypa Cave (*Stroulia 2018a.207, 209*). There is a constant in the midst of this variation, however. Among tools with two work faces, active ones always represent the majority.

As documented by use wear analysis, the Souloukia grinding tools functioned in a reciprocal fashion. None was used in a circular/elliptical manner, even though such a suspicion was initially raised for a couple of roughly square or elliptical passive tools whose work face is concave along both axes. Use wear analysis, macroscopic examination, and/or morphometric characteristics of specimens from sites, such as Kremasti-Kilada (*Chondrou 2011.95–96; Stroulia* et al. *2017.4*), Kleitos (*Chondrou* et al. *2018.31; Chondrou 2020.293*), Avgi (*Bekiaris 2018. 230, 243*), Makri (*Bekiaris 2007.45*), Makriyalos (*Tsoraki 2008.98–100*), Koroneia (*Almasidou 2010. 100*), and Franchthi Cave (*Stroulia 2010a.40–46*), indicate that use in a back and forth manner was typical not only in Kitrini Limni but Greece in general (see also *Bekiaris* et al. *2020.143–144*).

Due to fragmentation, it has not been possible to securely identify the configuration of the work faces of all the Souloukia specimens. That said, a variety of configurations have been identified. Opposed work faces may or may not have the same shape.

Most commonly, the work faces of passive tools are concave both longitudinally and transversally (or concave/concave). At least 30 such specimens (48%) were identified (Figs. 5.b, 6–7). In this respect, the Souloukia assemblage appears to be atypical. No other assemblage from Kitrini Limni exhibits a preponderance of concave/concave passive tools; see Kleitos (*Chondrou 2020.293–294*), Kremasti-Kilada (*Chondrou 2011.85–88*; observation by Stroulia), and Megalo Nisi Galanis (observation by Stroulia). With a couple of exceptions, the same is true for assemblages from other sites, such as Franchthi Cave (*Stroulia 2010a*), Makriyalos (*Tsoraki 2008.99*), Iliotopos (*Chadou 2011.73*), Platia Magoula Zarkou (*Stroulia in press*), Dispilio (*Ninou 2006.28–56*), and Apsalos (*Ninou 2006.72–90*). The exceptions refer to the assemblages of Avgi (*Bekiaris 2018.228*) and Alepotrypa Cave (*Stroulia 2018a.207*).

Nineteen of the Souloukia passive tools (30%) have a work face that is concave longitudinally but convex transversally (or concave/convex) (Fig. 5.c–d). This is the second most frequent configuration among passive specimens. Both concave and convex curvatures can be only slight. Concave/convex specimens tend to be larger than concave/concave ones. Regarding other Kitrini Limni sites, concave/convex passive tools represent the majority at Kleitos (*Chondrou 2020.293–294*) but are rare at Megalo Nisi Galanis (observation by Stroulia). Likewise, in the Aegean in general such tools are common at some sites (see Platia Magoula Zarkou: *Stroulia in press*), less common at others (see Avgi: *Bekiaris 2018.228*), and nearly absent at others still (see Makriyalos: *Tsoraki 2008.Tab. 4.39*).

Lastly, four of the Souloukia passive tools have work faces that are convex along both axes (or convex/convex). This is an odd configuration and we can only hypothesize that these specimens were used *a posteriori*, the convexity representing the natural shape of the raw material.[10]

According to established typologies as well as ethnographic and experimental data, passive tools with concave/concave work faces are compatible with active tools whose work faces are convex/convex. Passive tools with concave/convex faces, on the other hand, are compatible with active tools that are also concave/convex (*e.g., Delgado Raack, Risch 2009.7; 2016; Lidström Holmberg 2004.213; Risch 2008.20; Robitaille 2016.443; Stroulia* et al. *2017. 19*).

10 For some Copper Age Iberial parallels, see Risch 2008.20.

Given the higher ratio of concave/concave *vs.* concave/convex passive tools at Souloukia, one would expect a concomitant higher ratio of convex/convex *vs.* concave/convex active specimens. Yet this is not the case: concave/convex active specimens surpass convex/convex ones by a ratio of 2.5 to 1. There are, moreover, three active tools with flat/flat work faces. These would have been compatible with passive flat/flat tools. No such specimens have been identified, however. The discrepancy between passive and active tools regarding work face configurations is as intriguing as those mentioned above with respect to numbers and sizes. More about this later, but it is worth noting that a discrepancy regarding work face shapes has also been noted in the assemblage of Alepotrypa Cave (*Stroulia 2018a.209*).

We close this section with two more morphofunctional features referring to active and passive tools, respectively.

❶ A small number of active tools are characterized by a wedge-like transverse section – the result of differential wear between the proximal and distal sides (Fig. 9.c). A similar configuration has been noted at Kremasti-Kilada (*Chondrou 2011.108; Stroulia* et al. *2017.4*) and Kleitos (*Chondrou 2020.295*). In the literature, this uneven wear has been mainly interpreted as the result of application of extra pressure on the proximal side of the tool during grinding (*Adams 2014.114; Bartlett 1933.11–16; Stroulia* et al. *2017.17–18*).[11] To avoid the negative effect of this unevenness on the tools' use lives, Hopi grinders traditionally employed a specific wear management strategy as they periodically rotated their 'manos' so that the proximal side became the distal one, and vice versa (*Bartlett 1933.15–16*). Clearly, such a strategy was not used for the wedge-like Souloukia active tools. Yet it may have been popular among the Souloukia grinders, or so is suggested by the lack of a wedge-like configuration among the majority of active tools.

❷ The work face of a handful of passive tools exhibits a very strong longitudinal angle (Figs. 5.d, 7). We assume that highly inclined gravels were deliberately selected. The rationale behind this choice remains elusive, however. We are not aware of such passive specimens from other Greek Neolithic sites, and if they exist, they are rare.

Processed materials

Before discussing the substances processed with grinding tools at Souloukia, we should note the following:

❶ Although almost all specimens were subjected to traceological analysis, microwear was identified on roughly half (n=59 or 47%). The microwear discussed in this section resulted from primary uses (for that pertaining to secondary functions, see next section).

❷ The series of experiments conducted in conjunction with use wear analysis involved: grinding free threshing wheat (both dry and parched); dehusking emmer wheat and subsequently grinding the clean grain; dehusking hulled barley and subsequently grinding the clean grain; grinding lentils (both dry and soaked); grinding dry and parched chickpeas; grinding acorns. All these experiments were carried out with the same gneiss grinding toolkit. The last two experiments – abrading a piece of stone and a bovine femur – involved the passive component of the toolkit only.

❸ Thirteen grinding tools (six passive, six active, and one indeterminate) were subjected to residue analysis. In eight cases, very few or no phytoliths were detected (*Ögüt 2018*). A low amount of phytoliths may be the result of prehistoric cleaning or a non-plant related use. The first hypothesis is likely for five of these specimens, which according to use wear analysis were used for plant processing. The second hypothesis is plausible for two specimens with use wear associated with an unspecified abrasive but flexible material. None of these hypotheses could be evaluated for the eighth specimen, whose use wear remains undetermined.

❹ The excavations yielded a large quantity of charred macrobotanical remains, only a small sample of which has so far been analysed. The sample is dominated by cereal remains – a reflection of the importance of cereal cultivation, processing, and consumption at the site. Four cereal varieties have been identified: einkorn wheat (*Triticum monococcum*), emmer wheat (*Triticum dicoccum*), 'new' glume wheat type, and hulled barley (*Hordeum vulgare*). A very high proportion of the assemblage consists of glume wheat chaff, presumably the by-product of dehusking. Whether the chaff was burnt in the context

11 But see Chondrou (*2020.295*), who considers the wedge-like transverse sections of active tools at Kleitos as the result of specific raw material choices and/or design.

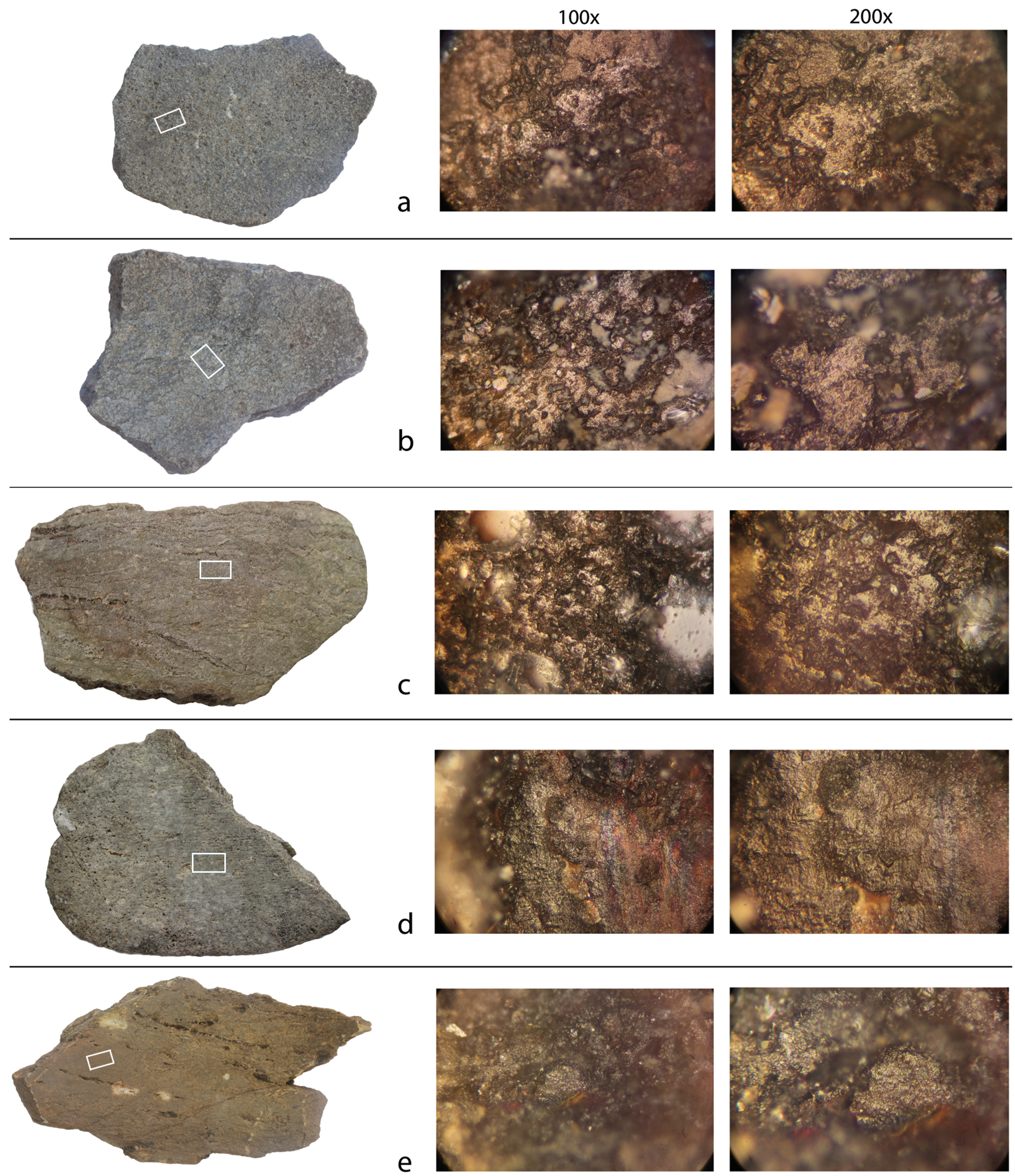

Fig. 10. Use wear views of work faces of specific tools at 100x and 200x magnifications (metallographic microscope):* a *GS252, use wear that appears consistent with cereal grinding;* b *GS268, use wear that appears consistent with cereal grinding;* c *GS292, use wear that appears consistent with grinding of wet (possibly soaked) lentils;* d *GS288, use wear resulting from processing an undetermined flexible but abrasive material;* e *GS285, use wear that appears consistent with grinding dry dirt or clay. Photos by J. Robitaille and A. Stroulia.

of accidents or utilized as fuel is impossible to tell. Pulses are present in low proportions, with lentils (*Lens culinaris*) being the most common. Fruits, such as cornelian cherry (*Cornus mas*), are also represented in very small amounts, while wild/weed species (*Chenopodium* sp. and *Polygonum aviculare*) occur very sporadically.

The cereal dominance noted among macrobotanical remains is mirrored in the results of use wear analysis. Over 75% of tools with identifiable microwear show traces compatible with processing cereals – dry emmer and barley, to be more specific (Fig. 10.a and b). Five of these specimens were subjected to residue analysis. Of these, the phytoliths found on the work faces of four also suggest a cereal-related function (Fig. 11). However, differences in the proportions of weathered and multicellular morphotypes lead us to suggest that two were used for grinding, while the other two may have been used for dehusking.[12] The morphotypes found on the work face of the fifth specimen were too weathered to allow a determination of the processed plants (*Ögüt 2018*). At any rate, it appears that cereals were processed on passive tools with work faces of all configurations (concave/concave, concave/convex, and convex/convex). The active tools used for these tasks are both concave/convex and convex/convex. Clearly, there is no association between cereal grinding and a specific toolkit type.

Judging from the results of traceological analysis of specimens from other sites – *e.g.*, Kremasti-Kilada, Kleitos, Ayios Vlasis, Stavroupoli, and Dikili Tash (*Chondrou* et al. *2021; Stroulia, Dubreuil 2011.3*) – cereal processing may have been the dominant function of grinding tools in both Kitrini Limni and the Aegean as a whole. As a rule, clean grain was ground. Only a few specimens from Ayios Vlasis, Stavroupoli, and Dikili Tash carry evidence of hulled grain grinding. However, an association with dehusking was proposed with a reasonable degree of confidence for only a couple of specimens from Ayios Vlasis. In all other cases it was not possible to assess whether the end goal of grinding was dehusking or the production of a fibrous meal that may or may not have been later subjected to some kind of cleaning (*Chondrou* et al. *2021.7–9*; see also *Procopiou 2003.23–33*). Either way, the available data suggest that in Neolithic Greece grinding tools were not typically used for dehusking. Given the pervasiveness of chaff (*Valamoti 2010*) and the paucity of (suitable) stone mortars (*Bekiaris* et al. *2020.144; Stroulia 2020.5*), it can be assumed that this task was carried out by pounding grains on wooden mortars or with other ethnographically known methods that would leave no archaeological signature under ordinary taphonomic conditions (see *David 1998.25–28; D'Andrea, Mitiku 2002.204; Hillman 1984.129–131; Peña-Chocarro, Zapata 2003.107–110; 2014.230–231; Robitaille 2021.241–242*).

The use wear of a handful of Souloukia specimens appears compatible with that produced by the experimental grinding of wet (probably soaked) lentils (Fig. 10.c). Four are active with concave/convex or convex/convex work faces, and one is passive with a concave/concave work face, suggesting a lack of differentiation between the toolkits employed for cereal and pulse processing.

While known for some time for Bronze Age Cyclades (*Sarpaki 2001.32*), legume grinding was documented only recently for prior time frameworks through use wear analysis of later Neolithic tools (*Chondrou* et al. *2021.2*). The Souloukia findings now extend Aegean pulse flour production farther back, to the earlier part of the Neolithic, as do the new findings from the neighbouring site of Mavropigi-Fillotsairi (*Ninou forthcoming*).

Use wear analysis of four tools points to grinding a flexible but abrasive material (Fig. 10.d). Residue analysis carried out on two of these specimens detected a minor amount of phytoliths, raising the possibility of a use unrelated to plants (*Ögüt 2018*). All tools are passive, with work faces that are concave/concave or concave/convex. What was processed on

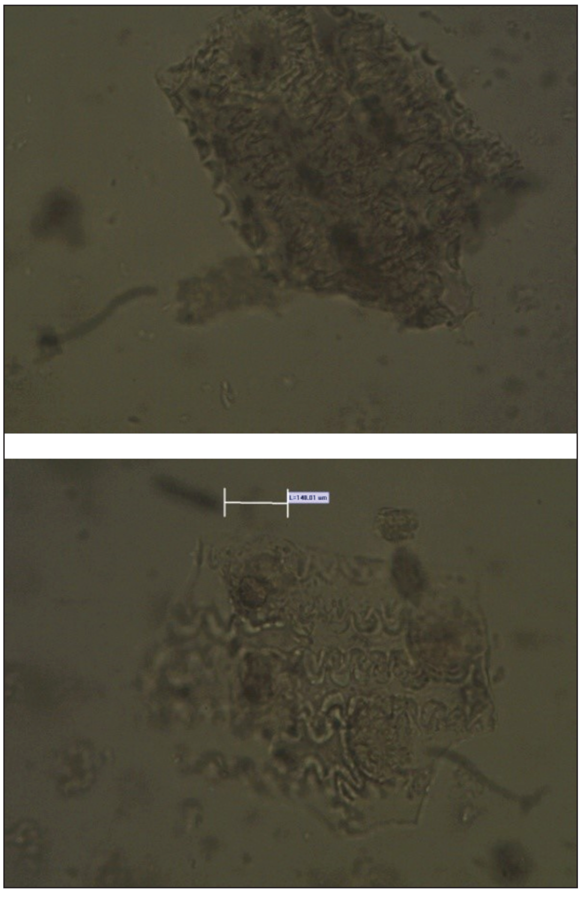

Fig. 11. Cereal phytolith silica skeletons from passive grinding tool GS309. Photos by B. Ögüt.

12 Regarding dehusking, the results of use wear analysis were inconclusive. The possibility that the same work faces were used for both grinding and dehusking cannot be ruled out.

these tools will hopefully be clarified through further experimentation.

No use wear compatible with acorn processing has been detected on the Souloukia tools. Danai Chondrou *et al.* (*2021.5*) reported Greek Neolithic specimens with microwear consistent with processing of 'greasy' substances, but whether the term refers to nuts, oily seeds, or both has not been clarified.

The Souloukia tools yielded no evidence of pigment processing either. In this sense they appear to follow a more general pattern. The association of grinding tools with pigment is relatively uncommon in the Neolithic Aegean. For some reported specimens, see Makri (*Bekiaris 2007.45*), Theopetra Cave (*Kyparissi-Apostolika 1996.68*), Stavroupoli (*Alisøy 2002. 573*), Dikili Tash (*Sériadès 1992.91*), Avgi (*Bekiaris 2018.229–232, 244*), Makriyalos (*Tsoraki 2008. 95, 98*), and Drakaina Cave (*Bekiaris in preparation*).

To conclude, the Souloukia grinding tools were primarily meant for processing foodstuffs. This is precisely what is expected on the basis of ethnographic data (*e.g., Bartlett 1933.3; Hamon, Le Gall 2013.109; Nixon-Darcus, D'Andrea 2017.193; Robitaille 2016. 433; 2021.773; Roux 1985.34–38; Searcy 2011.1*).

Reuse, recycling, use intensity

With one uncertain exception, there is no evidence of redesigning among the Souloukia grinding tools. The assemblage, nevertheless, includes 27 specimens (21%) with traces of reuse and recycling. The term 'reuse' refers here to similar uses of different parts of a tool, while 'recycling' refers to different uses of the same tool. Only one tool carries firm evidence of reuse. It is active with two work faces, both of which show wear consistent with cereal grinding. A large portion of the tool is missing, but the two faces appear to have different configurations – possibly a reflection of use with different passive work faces or kinematics.

Firm evidence of recycling has been identified on many more tools. Most (n=13) are passive. We have distinguished three varieties of recycling among passive tools. In none did recycling entail an active function. In the first and most common variety, the face which served the primary use was also involved in recycling. There are several combinations. In the most frequent among them, a work face was used first for grinding and later (only locally) for abrading (five instances). Other combinations are rarer, each typically represented by a single specimen: grinding an undetermined substance followed by (a) grinding a flexible but abrasive material; (b) grinding an unspecified soft material; (c) grinding dry dirt or clay (Fig. 10.e); (d) percussion. The last case involves the largest specimen in the assemblage (weighing over 25kg). Percussion took place in two stages, resulting in a larger, roughly ovate, concave area and an overlapping smaller, deeper, more circular area. Unfortunately, microwear was not preserved, leaving the precise use/s of these areas undetermined. Given their shallowness and the lack of clear borders, however, cereal dehusking is unlikely. In the second variety, the primary use involved one work face, recycling another. This variety is represented by two specimens: in the first, one of the work faces was used for cereal grinding, the other for processing a flexible but abrasive material; in the second, the work face was used for grinding an unspecified substance, the dorsal one for abrading. The third variety blends the previous two, with recycling involving both the work and dorsal faces. It is represented by a single specimen: its work face was used first for grinding and then (locally) for abrading, while the dorsal face was used for (localized) abrading as well (Fig. 6.a).

Seven active specimens were recycled. In all cases, recycling consisted of a double conversion of an active grinding tool to a passive abrading one. In all but one case, both primary and secondary uses involved a single face (Fig. 8.b). In the exception, primary and secondary uses were carried out by the work face and dorsal face, respectively (Fig. 8.d).

Finally, one of the indeterminate passive or active specimens was first used for cereal grinding and then for abrading with the same face.

Determining the abraded material was not possible in all cases. When it was, use wear was associated with bone or wood processing. No evidence of stone abrasion was identified.

Generally speaking, the recycling of several grinding tools at Souloukia into abrading implements suggests a certain flexibility on the part of the users regarding the two categories. That most cases of recycling involve such a conversion suggests that this was considered an appropriate use life trajectory for grinding tools. The fact, moreover, that most of the grinding tools used for abrading are complete and/or relatively thick indicates that recycling was not typically associated with breakage or exhaustion. Rather the choice was made to divert some perfectly good grinding tools to abrading usages. The infrequent secondary use of active specimens for passive grinding and the complete absence of the reverse type of recycling, on the other hand, indicate that passive and active grinding implements were largely conceived as different categories. Finally, that only one grinding tool was used in a percussive manner suggests that grinding and pounding functions were largely performed by different tools, and therefore grinding and pounding implements were conceived as distinct categories as well.

Not only do grinding tools exhibit a relatively low rate of reuse and recycling, but they were also used less than expected. This is well illustrated in both the thickness range (3.1–20cm) and average (6.9cm).[13] Schön and Holter (*1990.362–363*) reported that among the Mahria of Sudan, a passive tool is considered useless "*when it is thinner than 1cm,* i.e., *when a hole appears*". Active tools "*become useless when they ... get too thin,* i.e. *become barely 3cm or less in the middle and measure only a few millimetres at the edges*". Writing on Guatemalan tools, Michael T. Searcy (*2011.103*) noted that: "*It was not uncommon to see manos that were extremely thin (around 3cm), leaving the woman grinding only enough stone on the edges to hold with her fingertips*". If the Souloukia grinders had similar degrees of tolerance and similar ideas about the limits of their tools as their ethnographic counterparts, then none of the specimens can be considered exhausted. However, the situation is slightly more nuanced, as explained below.

Both the thickness range and average of the Souloukia specimens mentioned above refer to maximum measurements. However, minimum thickness is informative about use intensity and exhaustion, too. A handful of passive tools have a high maximum thickness but a very low minimum one. In fact, these specimens are broken in the area of minimum thickness. We consider these to be worn out (Fig. 5.d, 6.d).

If thickness offers a way to assess tool exhaustion, it is not the only one. The degree of concave curvature can also serve as an exhaustion indicator, at least in passive tools. According to Roux's ethnoarchaeological study in Mauritania, reciprocally operating passive tools with unrestricted work faces are discarded when reaching a depth of 4–5cm since they are not comfortable to use (*Roux 1985.57*). A comparable limit has been noticed by Jérôme Robitaille (*2021.398–399*) among the Hamar of Ethiopia who discard or recycle their passive tools when the work faces become 4–7cm deep. On this basis, two Souloukia tools with work faces deeper than 4cm can be considered as exhausted, too (Fig. 6.b). However, another Ethiopian group provides a note of caution: some of the passive implements used by the Konso are 25–30 cm deep. These tools are passed from generation to generation, their use lives reaching up to a hundred years (*Robitaille 2021.Appendix 138–142*) (Fig. 12).

Be that as it may, the vast majority of grinding tools at Souloukia were abandoned long before the end of their use lives. Why this is so is a question that will be addressed when the study of the stratigraphy, features, and other finds is completed, and the assemblage is viewed in the context of the site occupation as a whole. What we can say for the moment is that a similar conclusion was reached with respect to the assemblage from Kleitos (*Chondrou 2020.300–301*). Indeed, as a rule, Greek Neolithic assemblages are not dominated by exhausted tools. For a couple of exceptions, see Dikili Tash and Ayios Vlasis (*Chondrou, Valamoti 2021. 68*).

Spatial distribution, processes of discard

All six abrading tools, 45 grinding tools, three possible roughouts, and 15 unmodified pieces of raw material derive from the main residential area of the settlement.[14] Forty percent of the tools are complete or nearly so (15 grinding and three abrading tools). These were not found in association with the substances and objects they processed or (in the case of grinding implements) as parts of toolkits. The majority were likely not *in situ*. Both this and the absence of joining fragments suggest a certain post-use or post-breakage[15] movement of tools around space. This hypothesis is supported by the fact that a couple of fragments were converted into building materials, while another ended its biography in a pit.

However, the largest portion of the assemblage (almost 60%) was excavated outside the main residential area. This material comprises 81 of the grinding

13 These numbers refer to both complete and fragmentary specimens.

14 Whether they come from house interiors or open areas is unclear since the analysis of the excavated features and stratigraphy is pending.

15 As appealing as it may be, the hypothesis of storage of complete grinding tools in-between use episodes is not satisfactory, since it raises the question as to why only one component of the toolkit was stored away.

Fig. 12. Passive tools with very concave work faces used by Konso women in Ethiopia. Photo by J. Robitaille.

tools (64%), one roughout, as well as 17 gneiss gravels and one tabular sandstone piece without traces of manufacture or use – a total of 100 specimens. Notably, fifteen of the grinding tools are complete, representing half of all the complete specimens found at the site. Equally significant, grinding tools make up the only macrolithic type with a higher representation in the non-residential sector. Abrading tools, celts, hammerstones, and so on were exclusively or primarily found in domestic contexts.

Even more remarkably, most of the extra-residential grinding tools (n=63), along with several unworked gneiss cobbles and boulders, derive from an area measuring *c.* 300m^2 and located about 40m away from the house remains. These specimens were found in no particular arrangement, along with sherds, a substantial number of quartz pieces, a few figurine fragments, a concentration of rocks, as well as masses of clay probably from a small structure (Figs. 2.f, 13). Residue analysis of soil samples from this area detected a significantly lower density of phytoliths than those found on the tools (*Ögüt 2018*), arguing against the *in situ* use of these specimens. This hypothesis is reinforced by both the extremely high tool density in this area as well as the lack of a match between the work face configurations of passive and active specimens (most of the former are concave/concave, while most of the latter are concave/convex). More likely, these implements were transferred to this spot after utilization somewhere else. In fact, general differences in the characteristics of phytoliths identified on the tools and the control soil samples appear to indicate that these tools were amassed not at once, but gradually, over a period of time (*Ögüt 2018*). Where these specimens originated, we cannot tell for sure. Yet we consider the residential area as the most likely candidate, especially given the aforementioned indirect evidence of post-use and post-breakage movement of tools.

We do not know why this material would have been taken out of the residential space. However, the hypothesis that this area served as a locus of discard for broken or worn-out grinding implements should be ruled out, since this assemblage includes roughly ten complete specimens, none of which is exhausted. Nor is the provisional storage of tools with the intention of future reuse/recycling in the domestic arena (see *Tsoraki 2008.143*) a better explanation, since this assemblage includes several recycled specimens.

Be that as it may, the movement of material outside the residential area is not new in Aegean Neolithic archaeology. It is known, for example, from Kremasti-Kilada, a site in the Souloukia neighbourhood where massive quantities of artefacts, animal bones, building material, and so on were found within roughly 460 non-residential pits (*Chondrou 2011.52; Chondroyianni-Metoki 2009.387–389; 2020.54–56; Stroulia 2010b.63; Stroulia, Chondrou 2013.109; Stroulia* et al. *2017.2–3*). It is also known from Makriyalos, a site farther east in Macedonia, where enormous amounts of material were deposited into a huge negative feature known as Pit 212 (*Pappa* et al. *2004.84; Tsoraki 2008.126, 135*). Macrolithics, and grinding tools in particular, feature prominently in both deposited assemblages. Both Kremasti-Kilada and Makriyalos are later than Souloukia, but the combined evidence from all three sites possibly suggests that the transfer of material to areas outside the residential space took place at a small scale in the earlier phases of the Neolithic, but intensified in the later ones.

Moving perfectly usable tools out of domestic contexts may have not been enough for the people of Souloukia. The fact that the extra-residential concentration contains 66% of all active specimens but 51% of the passive ones raises the suspicion of an extra layer of manipulation. If our suspicion is correct, active and passive tools were treated differently, or to be more specific, the former were targeted for transfer more often than the latter. Why Souloukiotes would engage in such behaviour is anyone's guess, but if they did, they may have also moved active tools to other portions of the site that remain unexcavated. That would explain both the discrepancy between the numbers of passive and active specimens and the mismatch between their sizes and work face configurations mentioned above.

The differential treatment of passive and active tools is unexpected in light of the practical complementarity of the two implements. As stated by Cecilia Lidström Holmberg (*2004.226*), grinding toolkits represent "*dual objects with two parts that continuously construct each other*". It is also striking in light of ethnographic evidence that underscores the symbolic complementarity of the two grinding components. Among the Bemba of Zambia and the Hopi of the US Southwest, the relationship between a passive tool and an active one was used as a metaphor for the relationship between male and female identities and roles (*Lidström Holmberg 2004.227*), while among the Mursi of Ethiopia (*Robitaille 2016. 434*), the Minyanka of Mali (*Hamon, Le Gall 2011. 27*), and the Zapotec of Mexico (*Lidström Holmberg 1998.134; 2004.228*), it is/was used to convey the close link between a mother and a child. According to the Mursi in particular, "*the handstone must rest well on the grinding slab, just as a baby does on its mother's back*" (*Robitaille 2016.434, Fig. 3*) (Fig. 14).[16]

Unexpected as a differential treatment of passive and active tools may be, unequivocal evidence for such behaviour has been identified at another Kitrini Limni site. According to Chondrou (*2020.302–303*), all but one of the specimens found inside pits at Kleitos (I) are passive. Comparable patterns are known from two sites beyond Kitrini Limni. At Stavroupoli, one of the pits included mostly passive tools, while another featured primarily active ones, indicating a certain "*structuring of how and where material was deposited*" (*Alisøy 2002.581–582*). At Makriyalos, the passive specimens found within Pit 212 outnumber active ones by a ratio of *c.* 6:1 (*Tsoraki 2008.143, Tab. 6.28*).[17]

This phenomenon deserves systematic comparative study, but at this point we would like to point out three differences between Souloukia and these three sites. The first has to do with the state of preservation of the tools subjected to differential treatment. While at the other sites almost all specimens are broken, at Souloukia some are fragmentary, others are not. The second difference has to do with the features from which these tools were recovered. While at the other sites they were found in negative features, at Souloukia they were not. The third difference has to do with time. While the other sites date to the later Neolithic, Souloukia belongs to the earlier Neolithic. The significance of these differences remains to be investigated, but for the moment we would like to suggest that Kitrini Limni was the locus of selective grinding tool deposition in both the earlier and the later part of the Neolithic.

Epilogue

Despite the recent dramatic growth of Aegean macrolithic studies, very little is known about materials from the earlier part of the Neolithic. Our study of the grinding and abrading tools from the site of Pon-

Fig. 13. Partial view of concentration of grinding tools and unworked gravels in the non-residential sector of the site. Photo by A. Chondroyianni-Metoki.

16 For a different perspective, see Chondrou (*2020.303*).

17 For a few non-Greek examples of a differential treatment of passive and active tools, see Lidström Holmberg (*2004.222, 229–230*).

tokomi Souloukia, in the Kitrini Limni Basin, represents an attempt to address this gap.

By integrating systematic macroscopic examination, use wear and residue analysis, as well as macrobotanical, experimental, contextual, and ethnographic data, we explored these tools' raw materials, technomorphological characteristics, and functions, discussed their spatial distribution, and shed light on the ways they were conceived by their producers and users.

Fig. 14. Mursi lady grinding wheat outside the house with her baby on her back. Among the Mursi, 'golu oiné', the term used for the passive implement, means mother, while 'golu joiné', used for the active tool, refers to a baby. Photo by J. Robitaille.

The assemblage includes a small number of abrading tools. All are *a posteriori* and mostly of fine-grained sandstone obtained from a regional source. According to traceological analysis, wood and bone are the two materials processed with these tools. No evidence of stone processing was identified, but the several dozen celts excavated from the site hint at the presence of unrecovered abrading implements, perhaps close to sources of water.

The number of grinding tools is much higher, comprising over a hundred specimens. These were made of gneiss (another regional material) in a manner that was far from involved. Most were used in processing foodstuffs, cereals being the most common. A number were used for abrading purposes in the context of recycling. Generally speaking, grinding tools were not used as intensely as one would expect given the substantial masses of raw material they represent. Our study, moreover, pointed to discrepancies between the numbers and configurations of passive and active specimens that possibly resulted from differential discard processes.

Throughout this paper, comparisons were made with other sites in the area and elsewhere in an attempt to place the Souloukia assemblage in both a regional and a broader Aegean framework. These comparisons revealed, for example, that: similar abrading tools of similar material were employed at various sites of the Kitrini Limni basin; sites located at different parts of the basin used the type of gneiss that could be found in the nearest sources; the high proportion of concave/concave passive tools noted at Souloukia is not known from other Kitrini Limni assemblages and is extremely rare in Neolithic Greece as a whole; and the deposition of substantial amounts of material in non-residential areas at Souloukia parallels that known from a few later Neolithic sites in Kitrini Limni and elsewhere.

For the most part, these comparisons refer to later Neolithic assemblages. The one with which we close this paper references earlier assemblages, offering some insights into the roles of grinding tools in the context of the first Aegean agropastoral communities. While sufficient data for a meaningful and systematic assessment of the morphometric, technofunctional, and contextual characteristics of the few known earlier Neolithic assemblages is for the most part missing, basic information about the sizes of some of them is available. It thus appears that at certain sites – *e.g.*, Achilleion (*Winn, Shimabuku 1989. 268*), Sossandra (*Georgiadou 2015.42–43*), Revenia Korinos (*Besios, Adaktylou 2004.363*), and Ayios Vlasis (*Bekiaris* et al. *2020. 145*) – grinding tools were common as they were at Souloukia. At other sites – *e.g.*, Mavropigi-Fillotsairi (*Ninou* et al. *in press*), Paliambela Kolindros (*Tsartsidou, Kotsakis 2020.11*), and Prodromos (*Moundrea 1975.92–99*) – they were rare. The paucity of grinding implements cannot be considered an artefact of excavation biases since substantial areas were investigated at these sites or other macrolithic tools were found in considerable quantities. For example, the extensively excavated site of Mavropigi-Fillotsairi yielded only one specimen positively identified as a grinding tool (*Ninou* et al. *in press*). Prodromos yielded over 40 celts but only two passive grinding tools and (as far as we can tell) no active ones (*Moundrea 1975. 92–99*). The Early Neolithic strata of Paliambela Ko-

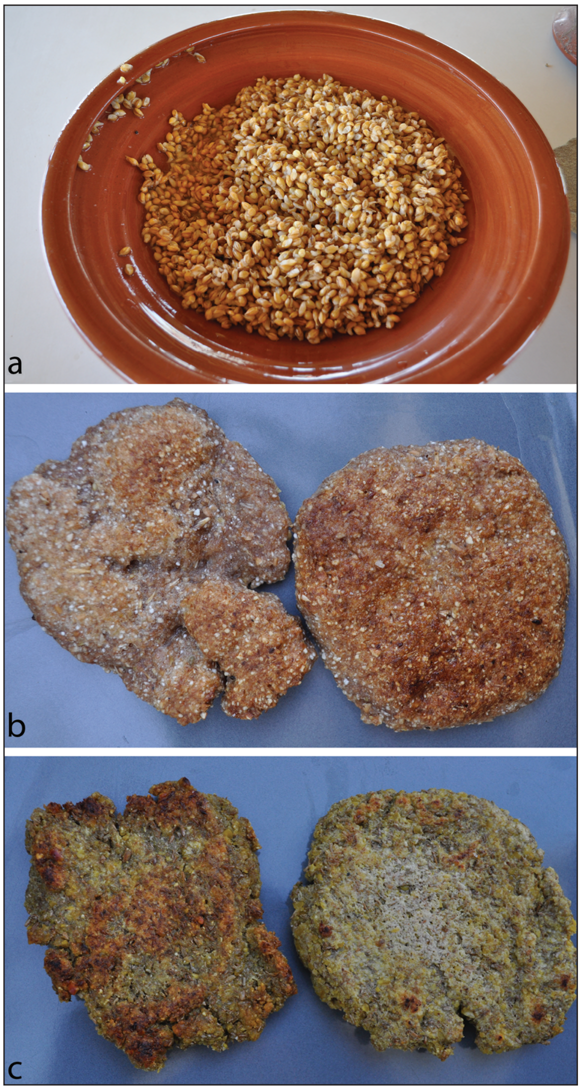

Fig. 15.* a *Boiled wheat grains such as those used for the traditional Greek dish koliva:* b *emmer wheat flat cakes;* c *lentil flat cakes. Photos by A. Stroulia.

lindros – one of the most systematically excavated sites in Greece – are characterized by an almost complete absence of grinding tools (*Tsartsidou, Kotsakis 2020.11*). This scarcity does not appear to reflect a different kind of occupation either. None of these sites represents a special use or seasonal settlement. Nor, lastly, does it appear to correlate with an absence of cereals and pulses, the types of substances typically processed with grinding tools. Such plant remains were found, for example, at both Mavropigi-Fillotsairi (*Karamitrou-Mentessidi* et al. *2013.2*) and Paliambela Kolindros (*Kotzamani, Livarda 2018.86–89; Tsartsidou, Kotsakis 2020.12*).

Without a thorough study and publication of earlier Neolithic assemblages, this discrepancy cannot be explained systematically. However, we would like in a preliminary fashion to offer two alternative hypotheses.

According to the first hypothesis, the discrepancy reflects two broad types of cereal and legume preparations. On the one hand, there were recipes that involved boiling, toasting, or parching of whole, split, or cracked seeds; *e.g.*, soups, stews, gruels, bulgur, koliva, *etc*. (for experimental versions of such preparations, see Fig. 15.a, *Dimoula* et al. *2020.Fig 5g*).[18] Grinding had no part in these preparations. On the other hand, there were recipes that involved flour/meal and thus required the use of grinding tools; *e.g.*, regular bread, flat bread (*e.g.*, pita or naan type), falafels, *etc*. (for experimental versions of two of these preparations, see Fig 15.b–c). In the context of this hypothesis, in some earlier Neolithic Aegean communities there was an emphasis on the first type of recipes. In others, the second type of recipes was used, either exclusively or alongside those of the first type.

If real, this distinction existed even within the same area: Mavropigi-Fillotsairi is less than 3km from Souloukia, while Paliambela Kolindros is not far from Revenia Korinos. Such culinary identities may have had a cultural/ethnic origin, reflecting the ancestral homelands of the different groups that occupied the Greek landscape at the beginning of the Neolithic (see also *Valamoti 2017.178–184*).

According to the second hypothesis, the scarcity of grinding tools at some sites is due to specific practices that involved the removal of tools from residential areas. Such practices would have amounted to more massive versions of the deliberate transfer of specimens identified at Souloukia.

We consider the former hypothesis as more likely than the latter, but both (and possibly others) should be tested when we acquire a better understanding of each individual assemblage. Be that as it may, such strong discrepancies in the sizes of grinding tool assemblages are not visible in the archaeological record of the later part of the Neolithic. During this period, more or less substantial numbers were the norm.

18 According to Sonya Atalay and Christine A. Hastorf (*2006.298–311*), these were common preparations for cereals and pulses in the Early Neolithic component of Çatalhöyük.

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