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Daily practices and special events: exploring grinding technologies at the two neighbouring settlements of Kleitos in Late/Final Neolithic northern Greece

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ABSTRACT – *The article offers a detailed analysis of the grinding tool assemblage from the two neighbouring, partially contemporary and almost entirely excavated Late/Final Neolithic settlements of Kleitos, northwestern Greece. The data shed light on various choices regarding the organisation of the production and management of these implements. According to the evidence, grinding tools were not only used as part of the daily routine, but were also often used in special events. The limited rates of exhausted implements, the extreme fragmentation, and special patterns of deposition indicate the complex manipulation of grinding implements beyond their primary functions.*

KEY WORDS – *grinding tools; ground stone technology; Neolithic; macrolithic artefacts; Aegean pre-history*

Vsakodnevni običaji in posebni dogodki: raziskava žrmelj na dveh sosednjih naselbinah v Kleitosu v času poznega/končnega neolitika v severni Grčiji

IZVLEČEK – *V članku predstavljamo podrobno analizo zbira žrmelj iz dveh sosednjih, delno sočasnih in skoraj v celoti izkopanih naselbin v kraju Kleitos na severozahodu Grčije. Podatki osvetljujejo različne možnosti pri organizaciji produkcije in upravljanju teh orodij. Dokazujemo, da žrmlje niso bile le del vsakodnevnih običajev, ampak so bile pogosto uporabljene pri posebnih dogodkih. Omejene količine uporabljenih orodij, izredna fragmentiranost in posebni vzorci odlaganja predmetov kažejo na bolj kompleksno obdelavo žrmelj, ki presegajo njihovo osnovno namembnost.*

KLJUČNE BESEDE – *žrmlje; tehnologija glajenih orodij; neolitik; makrolitske najdbe; egejska prazgodovina*

Introduction

Grinding tools constitute an important part of prehistoric technology. Diverse in function, as ethnographic and archaeological research has shown, these implements have been employed in a wide range of production activities in relation to both organic and inorganic substances (see Horsfall 1987; Schroth 1996 for a summary of available ethnographic data from North America; Wright 1994:241 for several references to ethnographic and historical evidence). Regardless of their being informative on so many aspects of past societies – subsistence strategies,

dietary habits, processing and craft activities, to mention but a few – a relevant contextualized analysis has long been missing from the prehistoric research in Greece and the Balkans in general, with few notable exceptions (e.g., Moundrea-Agrafioti 2007; Hersh 1981; Procopiou 1998; 2013; Procopiou et al. 1998; Poursat et al. 2000; Runnels 1981; Stroulia 2010; 2017; Tsoraki 2008).

The goal of this article is thus to present an in-depth examination of one of the largest recovered grind-

ing tool assemblages from prehistoric Greece to date, originating from two neighbouring Late/Final Neolithic settlements, Kleitos I and Kleitos II, and to highlight aspects of the communities that produced and used them. The detailed examination of the assemblage combines a techno-morphological analysis and a biographical approach that focuses on the separate stages of a tool's life-cycle. Moreover, the contextualization of the available data provides a detailed framework for the evaluation of the spatial aspects of the production, use and disposal of grinding implements. The analysis reveals a series of patterned choices regarding the manufacture and manipulation of these tools, with various possible economic, social and cultural connotations.

The site

The Kleitos site is located close to the modern city of Kozani, northwestern Greece (Fig. 1), and within the limits of the alluvial Kitrini Limni Basin, an area densely populated during prehistoric times (*Andreou et al. 1996.568–569, 575; Fotiadis 1988; Fotiadis, Hondroyianni-Metoki 1997.21; Karamitrou-Mentesidi 1987*). Two Late and Final Neolithic settlements, partially overlapping in terms of chronology and in striking proximity, were discovered and excavated in almost their entirety, a rare case in Greece. The Kleitos excavations were part of a large-scale rescue programme conducted by the former 30th Ephorate of Prehistoric and Classical Antiquities in response to the imminent expansion of the nearby lignite mine of the Public Electricity Company.

The earliest of the two installations, Kleitos I, is a flat, 'extended' settlement covering an area of c. 2ha and bounded by a system of ditches and fences (Fig. 2). According to conventional chronological data, the site belongs to the early phase of the Late Neolithic, i.e. late 6th – early 5th millennium BC (*Ziota 2011.215, 227; Ziota et al. 2013a.59*). Ten ground floor, detached buildings have been preserved. They were quadrilateral in plan and rather spacious, judging by the best preserved examples, with an estimated size of up to 100–120m², some

also bearing signs of a possible upper storey (*Ziota et al. 2013a.59, 64*). Each of them had one to three separate building phases, almost all destroyed by fire. Various thermal and storage clay structures were found in building interiors, as well as outdoor areas (*Ziota 2014a.323–326*).

Less than 100m northeast of Kleitos I lies the second settlement. According to ceramic finds, the earliest phase of Kleitos II is partially contemporary with the first settlement, with the habitation extending to the late phase of the 4th millennium BC (*Ziota et al. 2013a.71–73*). Overall, Kleitos II is smaller (0.25ha) and more densely structured (Fig. 2), with five preserved dwellings, two of which are significantly smaller in dimensions, with limited open spaces in-between (*Hondroyianni-Metoki 2011; Ziota 2011; 2014a; 2014b*). Although the relation of the two neighbouring sites with the differentiated size and spatial organisation is still vague, the idea of them being two distinct habitation phases of the same community has to be rejected (*Ziota 2014a.332*).

Finally, numerous Bronze Age pits and parts of a ditch, Roman and Byzantine burials and stray finds, along with the stone foundations of an elongated building of unclear dating, all attest to the long-lasting post-Neolithic use of the space (*Hondroyianni-*



Fig. 1. Map of Greece and prehistoric sites mentioned in the text.

Metoki 2011.231, 243; Ziota 2014b.53, 60–62; Ziota et al. 2013b.50–51).

The sample

The Kleitos ground stone tool assemblage was the subject of a PhD dissertation (*Chondrou 2018*) in the context of which around 4000 finds were analytically examined. The current paper focuses exclusively on the grinding tool category, which comprises 614 items; 554 originating from Kleitos I, 38 from

Kleitos II and 10 from the area between the two settlements (Tab. 1). From this assemblage, a set of 12 finds derive from a different chronological horizon. They were found inside a series of Middle Bronze Age pits dug in the Neolithic strata in the area of Kleitos II and its margins, and will be examined elsewhere.

Regarding the aforementioned numbers, a substantial divergence between the assemblages of the two nearby settlements is attested in all tool categories,

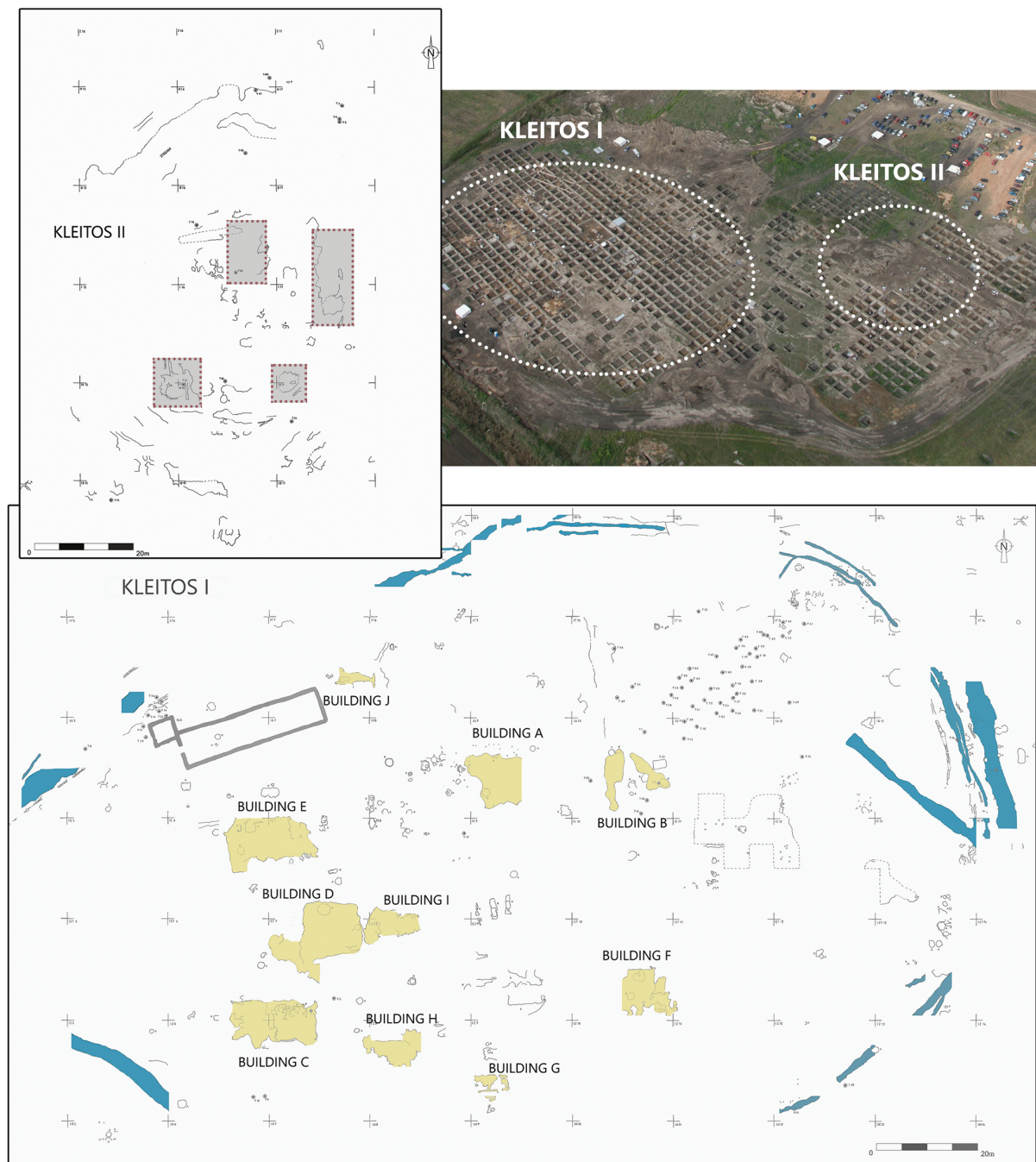


Fig. 2. Aerial photograph of the excavation and plan of the two sites with the areas of building remains and peripheral ditches highlighted.

with the Kleitos I finds always more abundant (see *Chondrou 2018*). However, the high variance in the frequency of grinding tools between the two settlements must be – at least partially – attributed to the high degree of fragmentation. As an example, the proportion of fragments that represent a portion smaller or equal to 1/8 of the original grinding implement in Kleitos I is double that of its neighbouring settlement.

Typology

The activity of grinding requires the pairing of a lower, stationary implement (*passive tool i.e. quern*) and an upper mobile one (*active tool i.e. handstone*). The latter moves on top of the use-surface of the static implement in order to grind matter between their surfaces. The use-surfaces of the two paired implements should fit together perfectly to ensure their optimal operation, *i.e.* the highest degree of efficiency (*Delgado-Raack, Risch 2009.6; Menasanch et al. 2002.83*). The complementarity of the grinding tool surfaces is achieved through the manufacturing process, but also evolves through use, since the surfaces of the implements that form a functional pair are worn gradually in a corresponding manner. Therefore, the configuration of the use-surface of a milling tool is not solely the result of manufacture. Rather it is a morphological element with a functional dimension, interrelated with the morphology and dimensions of the tool's paired implement, and the kinetics involved in its use (see *Adams 1999; de Beaune 1989; 2004; Delgado-Raack 2008; Menasanch et al. 2002; Nierlé 1983; 2008; Procopiou 1998; Stroulia et al. 2017; Zimmermann 1988*). Based on the above, we can distinguish three main grinding tool types (Fig. 3):

- A more or less elongated quern that functions in conjunction with a handstone whose length exceeds the width of the quern (Fig. 3A). This is the 'overhanging type', a term referring to the fact that the ends of the handstone protrude beyond the limits of the quern. The handstone is used in a linear back-and-forth reciprocal motion, being held with both hands, placed either on the tool's ends – used in this way as handles – or on the back of the tool (*i.e.* dorsal surface), but again close to the two ends. As a result, the force is exerted laterally (*Hamon, Le Gall 2013.113*). Through the gradual wear of the

	Querns	Handstones	Indeterminate
KLEITOS I	121	207	226
Area between the settlements	1	9	0
KLEITOS II	18	10	10
MBA pits	6	5	1
Total	146	231	237

Tab. 1. Distribution and frequency of grinding tools per main spatial unit and tool type.

tools, the handstone and quern develop a characteristic, complementary configuration of the profiles of their use-surfaces. Often the quern acquires a convexity along the width axis of its surface and a concavity along the long axis, while the handstone develops a concavity along its long axis and a convexity along the width axis (Fig. 4). However, interesting divergences have been noted, suggesting that use-surface morphology is the complex result of various parameters such as its initial manufacture and subsequent maintenance, and the gestures applied during use (see *Delgado-Raack, Risch 2009.7–8*).

- A quern combined with a shorter handstone, used in a linear back-and-forth reciprocal motion (Fig. 3B). In this case the length of the handstone is smaller than the width of the quern. Therefore, the lateral zones of the use-surface of the quern develop less wear than its central part, due to limited contact with the handstone (or none at all). Thus the use-surface of the quern gradually becomes concave longitudinally and concave in width.

- A quern used in conjunction with a small handstone, in a 'free', curvilinear motion (Fig. 3C). The small dimensions of the handstone allow its handling with one hand. The use-surface of the quern is concave in both axes (*i.e.* a 'basin-like' morphology), possibly – but not necessarily – as a result of both manufacture and use, while the use-surface of

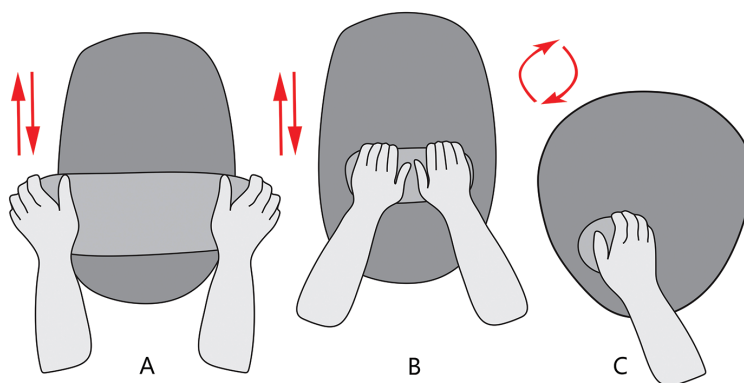


Fig. 3. Three main grinding tool types. Note the way in which the active tool – handstone – is held in each case (drawing by the author).

the handstone is convex (or flat-convex) in both axes.

The presented typology was applied to the Kleitos grinding tool assemblage. It is worth noting though that due to the extreme degree of fragmentation there were cases where it was not possible to determine the passive or active function of an implement, nor its typological classification. Even in the cases where linear traces were detected on the use-surface of a fragment, it was not possible to correlate the direction of motion with the overall morphology of the initial tool, and thus to fully decode the kinematics involved in its use.

Preservation

A basic feature of the grinding tool assemblage from Kleitos is the high rate of fragmentation, which reaches 97%: out of a total of 602 milling tools from Neolithic strata, only 18 are preserved intact or almost intact. The pattern applies to both handstones and querns, worn-out tools with very low thickness and thus highly sensitive to accidental breakages, as well as bulky tools with long remaining use-lives. The magnitude of the phenomenon cannot be attributed to post-depositional processes: (a) the percentage does not include modern breakages that occurred during the excavation process or post-excavation manipulation of the material; (b) the vast majority of the material originates from layers unaffected by modern ploughing. Therefore, a linkage between this attribute and the way the implements were used and manipulated should be sought.

Another characteristic is the very strong presence of fire in at least 1/3 of the assemblage. Fire exposure is more frequently encountered in fragmented specimens, suggesting a relation between high fragmentation and burning. The impact of fire varies. Some of the tools have sustained significant damage, while others do not exhibit macroscopically visible alterations, although their recovery contexts suggest their

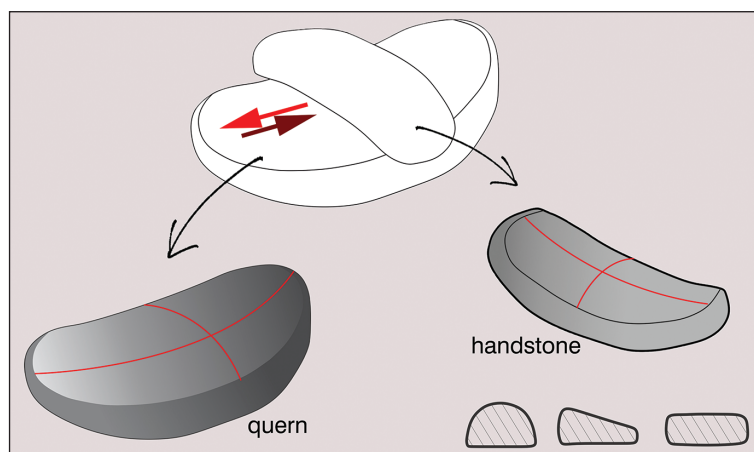


Fig. 4. Main type of grinding tool pair in Kleitos (type 1). The active surfaces of the quern and handstone are complementary, concave along the one axis, convex along the other. The most commonly occurring transverse sections of handstones are plano-convex, wedge-shaped, rectangular (drawing by the author).

exposure to fire (e.g., within a building destruction layer). This may be related to the different conditions of exposure to fire, but also to the different reactions of lithic materials to high temperatures (e.g., Deal 2012; Ryan 2010). Therefore, it should be considered almost certain that the percentage of tools exposed to fire was actually much higher than the figure given.

Manufacture: raw materials

In the alluvial plain of Kitrini Limni, where Kleitos is situated, appropriate lithic sources are absent (Fotiadis 1988:45, 49). None of the selected rock types were readily accessible or within a short distance – of less than 10km – from the settlement. As such, the procurement of various materials from areas beyond the borders of the plain was required. Overall, a quite limited range of raw materials selected for the manufacture of grinding tools has been identified in both Kleitos settlements, suggesting their systematic, non-random exploitation. However, the representation rates differ significantly between the two sites. Two sedimentary rocks, sandstone and microconglomerate¹, are the most common rock types in Kleitos I, while pyroxenite, gneiss, and schist have a more limited presence. In Kleitos II, sandstone remains the most commonly found raw material, although there is a sharp increase in the tools

¹ Conglomerate is a sedimentary rock of highly varied mineralogical composition, comprised of coarse grains with a diameter larger than 2mm in a finer clay or calcitic matrix. Strictly based on geological vocabulary, the term 'microconglomerate' is invalid. It is adopted here, nevertheless, since the author considers it important to be able to differentiate raw materials of significantly different granulometry, all labelled under the term 'conglomerate'. There are conglomerates composed of pebbles and cobbles, and others of granules. In the case of Kleitos the coarse grains are larger than 2mm but smaller than 1cm. Whenever bigger particles are present, they represent no more than 5–10% of the complete rock mass of each artefact.

made from gneiss, while significant declines in those made from microconglomerate and pyroxenite (Fig. 5). It is also worth noting that there is some variation within distinct lithological groups (e.g., different types of sandstone and microconglomerate). This diversity, more pronounced in Kleitos I, is associated with various properties that would affect the grinding process and the characteristics of the resulting product (see Chondrou et al. 2018.30; Delgado-Raack et al. 2009).

Extensive inspection of the areas surrounding Kleitos led to the conclusion that the inhabitants acquired raw materials from multiple sources, including one almost 25km to the south. The basic procurement strategy was the exploitation of secondary sources, such as stream and river beds or surface concentrations of rolled material. Kleitos grinding implements quite often retain parts of the naturally smoothened surfaces of the original boulders used for their production, due to the limited extent of manufacture traces along their body. No signs of quarrying have been identified, an observation that is in accordance with the data obtained from other Aegean grinding tool assemblages (e.g., Middle/Late Neolithic Stavroupoli, Alisøy 2002a.565–566; Late Neolithic Makri, Bekiaris 2007.43; Late Neolithic Toumba Kremasti, Chondrou 2011.80; various prehistoric sites in the Argolid, Runnels 1981.75–76; Neolithic Alepotrypa Cave, Stroulia 2018.234; Late Neolithic Makriyalos, Tsoraki 2008.69).

Manufacture: techniques

As far as the production sequence is concerned, the general tendency in the Kleitos assemblage was the low work investment in the manufacture of grinding implements. Consequently, the size and shape of the pieces of raw material would have been an important selection criterion in order to keep the production sequence short. In other words, there must have been a hunt for boulders that would already – in their natural form – approach the desired morphometrical traits of the final artefacts.

The almost complete absence of rough-outs, manufacture debris, as well as suitable unmodified raw material pieces does not support in situ manufacture. One must assume that the production of these implements – or at least the execution of the initial production stages – was carried out outside the settlement grounds and that the tools arrived at the site either fully formed or as semi-finished artefacts. This practice has some advantages, as highlighted by

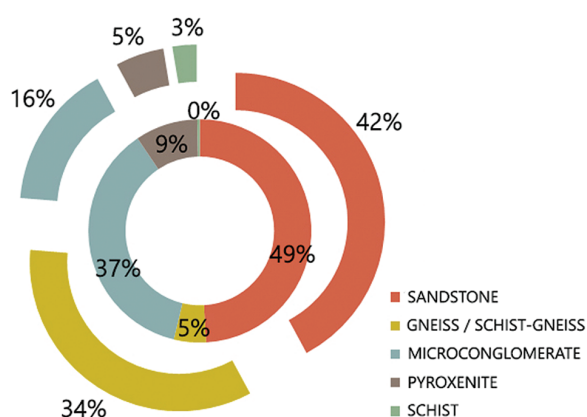


Fig. 5. Relative percentages of different raw materials used for the manufacture of grinding tools in Kleitos I (inner circle) and Kleitos II settlement (outer circle).

other researchers (e.g., Hayden 1987.26; Runnels 1981.105), since it limits the volume of objects to be transported and helps avoid significant losses in time and energy in the case of manufacturing accidents. However, the few unmodified boulders (Fig. 6) and rough-outs at a very early stage of manufacture found on-site indicate that there were some possible deviations from this norm.

Kleitos grinding implements usually retain the general shape of the initial piece of raw material used, since manufacturing was mostly limited to the formation of the tool's use-surface and its periphery, only rarely extending throughout the body of the tool. The techniques applied were flaking, pecking and, in very few cases, abrasion.

Flaking was in many cases the initial technique applied. A wide, flattish surface, an element of the natural configuration of the initial piece of raw material, served as a striking platform for the application of peripheral blows. In the absence of such a surface, it is likely that one would have been formed through flaking or pecking. Traces of this technique are preserved in the periphery of a number of finds, confirming that it was a common stage of the manufacture sequence for both querns and handstones. The peripheral flaking had a continuous or discontinuous application, most commonly with a top-to-bottom orientation of impact (i.e. from the ventral surface towards the dorsal). In several cases, however, a combination of opposite-oriented strokes is encountered (Fig. 7). Bidirectional flaking on the peripheral zone of the tool was applied only when the natural shape of the boulder was appropriate (i.e. it had sides with abrupt convexity); this would allow blows from both the top and lower part of the sides.

A certain degree of technical knowledge would have been necessary to achieve this. As a rule, the application of peripheral flaking was limited in extent, aiming at a slight adjustment of the natural configuration of the initial piece of raw material. In contrast, the removal of large flakes for a radical morphological change was rare. In a few cases, a combination of coarser and finer flaking is evident. The latter was secondarily applied, even more selectively and locally, in order to correct specific points of the design.

Flaking was usually applied to the immediate periphery of the use-surface and rarely to a larger part of the sides; in these instances, it was only applied sporadically. There are also limited cases where the dorsal side (*i.e.* base) of the querns was formed by flaking, in part or in whole or its periphery exclusively. In the case of handstones, the application of flaking to the dorsal side is rare and never on the whole. In total, 31% of Kleitos I querns and 26% of the handstones have traces of flaking, compared to 56% and 30% respectively in Kleitos II. Despite a stronger presence of this technique in Kleitos II material, its application was generally similar: targeted application focusing on the shaping of the periphery of the tool's use-surface and, in some cases, its dorsal side. It is indicative that flaking is wholly applied in just one tool in the full assemblage studied.

Pecking, as opposed to flaking, was a technique of limited mass removal. It was applied either as a 'sequential' step to flaking, to smoothen out anomalies, or – more often – independently. Especially in the case of handstones, pecking had a highly autonomous role in the manufacturing sequence, since only 3% of the tools with flaking also had pecking applied to the same parts of their bodies. Generally speaking, the percentage of handstones with pecking on their non-active surfaces (32% in Kleitos I and 50% in Kleitos II) indicates that this technique was clearly applied more extensively than flaking.

In the case of querns, pecking on their non-active surfaces (36% of Kleitos I querns and 44% in Kleitos II) presents a different distribution pattern when comparing the two sites. In Kleitos I pecking often extends to the sides of the quern,

while in Kleitos II it mainly covers the tool's base (87% of the cases), partially or wholly, or is limited to its periphery. This divergence in manufacturing design may represent a different intended purpose. In Kleitos I the technique seems to have been aimed at the attribution of the final contour and normalization of natural anomalies on the non-active surfaces of the artefacts. On the other hand, in Kleitos II it was probably aimed at creating a mildly rough surface that would enhance the adhesion between the tool and bearing surface.

Beyond the shaping of the non-active surfaces of a grinding implement, pecking was also necessary for the formation of its use-surface, which was probably the final stage of the manufacturing sequence. The systematic, dense pecking was a highly time-consuming process (*Schneider 1996.306*). It may also have been combined with (limited) abrasion, since it is necessary for an active surface to have a rough texture but also a uniform development. The abrasion could be performed either with an abrasive tool or with the tool that it was intended to be paired with, *i.e.* the corresponding handstone (for two ethnographic examples, see *Gast 1968.350; Teklu 2012.65*). A combined examination of the two implements of a functional pair was also important in order to ensure their optimal complementarity (*Bofill 2014.443*). The necessary 'matching' of the use-surfaces of the two implements may have had a decisive influence on the organisation of the manufacturing process by imposing their contemporary manufacture. This is, for example, supported by the ethnographic example from Mali, where each quern was manufactured together with its coupled handstone and usually an extra as a spare (*Hamon, Le Gall 2013.112*).



Fig. 6. A sandstone boulder most probably collected to be formed into a handstone, with its natural configuration very close to the morphometrical traits of the intended artefact.

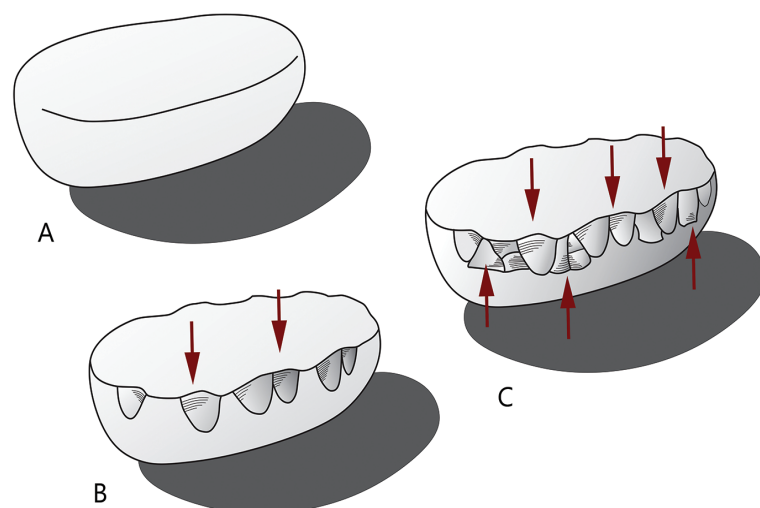


Fig. 7. Different stages and versions of flaking: A unmodified curvilinear boulder with a flattish surface that will serve as an impact platform; B unidirectional and discontinuous peripheral flaking; C bidirectional and continuously-applied peripheral flaking (drawing by the author).

A comparison, where possible, between different parts of the same artefact revealed a clear differentiation between pecking marks on non-active and active surfaces. Pecking marks on the non-active surfaces of the querns are typically medium- to large-sized ($\geq 5\text{mm}$ diameter), quite shallow and sparse in distribution, as opposed to traces on the use-surfaces which are generally smaller and denser. This probably reflects a difference in the mode of percussion, but also the use of hammers of different morphologies for the shaping of the two types of surfaces. In a single case, differentiated pecking traces were identified in the non-active surfaces of the same tool: on the lateral sides, the 'typical' medium-sized, circular pits with a U-shaped section, and on the dorsal side more elongated and semi-circular traces suggesting strokes given at an acute angle.

Finally, the application of abrasion, in order to smoothen the surfaces of a tool at the end of the manufacturing process, is extremely rare. Only seven querns and 10 handstones show traces of smoothing on their non-active surfaces, after receiving partial pecking of their bodies.

No expedient grinding tools were found in Kleitos, in contrast to many other Greek Neolithic assemblages (e.g., Middle/Late Neolithic Stavroupoli, *Alisøy 2002a.567*; Late Neolithic Makri, *Bekiaris 2007.43*; Middle/Late Neolithic Avgi, *Bekiaris 2020*; Late Neolithic Megalo Nisi Galanis, *Stroulia 2005.576*; Neolithic Franchthi, *Stroulia 2010.35*; Neolithic Alepotrypa, *Stroulia 2018.209*; Late Neolithic Makriyalos,

Tsoraki 2008.69). Instead, all Kleitos specimens present some degree of work investment, even though usually low. Their manufacture reveals the existence of a strategic design behind their sequence of production, regarding both the shaping techniques applied and their execution that took into account the optimal utilization of the original piece of raw material.

Overall, despite the generally low degree of investment in Kleitos grinding tool manufacture, various modes of application of individual techniques have been detected in terms of execution (e.g., uni-/bidirectional flaking) and extent of tool coverage. This variation does not seem related to the raw materials used (for a sim-

ilar observation on the assemblage from Neolithic Stavroupoli see *Alisøy 2002a.567*), but rather to personal choices and the morphology of the boulders used (see further below). Undoubtedly, there are norms regarding the manufacturing process, but their inhomogeneous application seems to indicate the existence of many manufacturers who shaped their equipment as they pleased. The criteria appear to be more practical than aesthetic, but they may also reflect varied degrees of technical skill. For example, flaking of raw materials with a highly inhomogeneous structure, such as microconglomerates, or with intense schistosity, such as schist-gneiss, involves high technical risk and requires experience (see *Procopiou 2013.47*). Regarding the divergences in production detected between Kleitos I and Kleitos II, these also appear unrelated to the raw materials, as the rock types and natural boulders used are the same.

Morphometrical traits

In the assemblage of both Kleitos I and Kleitos II, querns paired with 'overhanging' handstones operated in a back and forth reciprocal motion (*i.e.* type 1 grinding tools) are predominant. The handstones have use-surfaces concave along the length axis and slightly convex along the width axis (Fig. 8.A-C). The latter coincides with the direction of the tool's motion, as testified also by the linear traces visible at low magnification, more rarely also macroscopically. The querns have use-surfaces concave along the length axis, slightly convex along the width axis

(Fig. 8.D-F). Clusters of linear traces have a common orientation, parallel to the length axis of the tool. In contrast, the other two tool types (type 2 and type 3) have a much more limited representation. Only 26 out of 140 querns in the entire assemblage have a use-surface concave in both axes, indicating pairing with a smaller handstone used in a rectilinear or 'free' curvilinear motion, a type identified in 48 out of 226 handstones (Fig. 9). Overall, type 2 and 3 tools represent 21% of Kleitos I grinding implements and almost 11% of Kleitos II – with indeterminate pieces being excluded from this count. The precise determination of the ratio of these two types is hindered by the very high degree of fragmentation and poor preservation due to fire exposure, erosion or the extensive presence of sediment. Notwithstanding the above limitations, it can be safely said that type 3 tools constitute the least represented group of grinding equipment in Kleitos.

Tool type 1 morphology has been recently deemed “*unexpected and counter-intuitive*” (Stroulia et al. 2017.4). In reality, nevertheless, what is truly impressive about it is its late identification in the archaeological research. Although the idea of tools resembling small querns but functioning as handstones has been suggested by researchers for decades, and the existence of different morphological types of grinding tools has been noted (e.g., Hersh 1981; Nierlé 1983; Plassart 1928.25–26; Zimmermann 1988), these typological clarifications have rarely or partially been taken into account in the succeeding work, at least in southeastern Europe. This is exactly the main obstacle to the analytical examination of the spatial and chronological distribution of type 1 and type 2 implements and their interrelation. However, it is certain that, contrary to earlier estimations according to which the Neolithic handstones were shorter than the Bronze Age ones (Runnels 1981.147), tool type 1 had a strong and steady presence throughout the Greek Neolithic, ever since its early phases (e.g., Early Neolithic site of Ayios

Vlasis, Chondrou pers. obs.), and continuing throughout the Bronze Age era (e.g., Early Bronze Age Ayios Athanasios, Chondrou et al. 2019; Late Bronze Age West House in Akrotiti, Moundrea-Agrafioti 2007.103). Instead, type 3 tools generally seem to represent a rarity (see Stroulia 2010.56; Valamoti et al. 2013.182). Whenever present in Greek assemblages, either Neolithic or Bronze Age, they are always limited in numbers (e.g., Middle/Late Neolithic Stavroupoli, Alisøy 2002a; Late Neolithic Toumba Kremasti, Chondrou 2011.95–96; Neolithic Franchthi, Stroulia 2010.54–56; Bronze Age Mesimeriani Toumba, Alisøy 2002b; Late Bronze Age West House in Akrotiti, Moundrea-Agrafioti 2007.78).

In both Kleitos settlements grinding implements have a predominantly curvilinear outline. This morphological trait appears to be mostly associated with the initial form of the exploited raw materials (*i.e.* cobbles and boulders), and to a lesser extent with deliberate manufacture. The overwhelming majority of both querns and handstones have a single use-

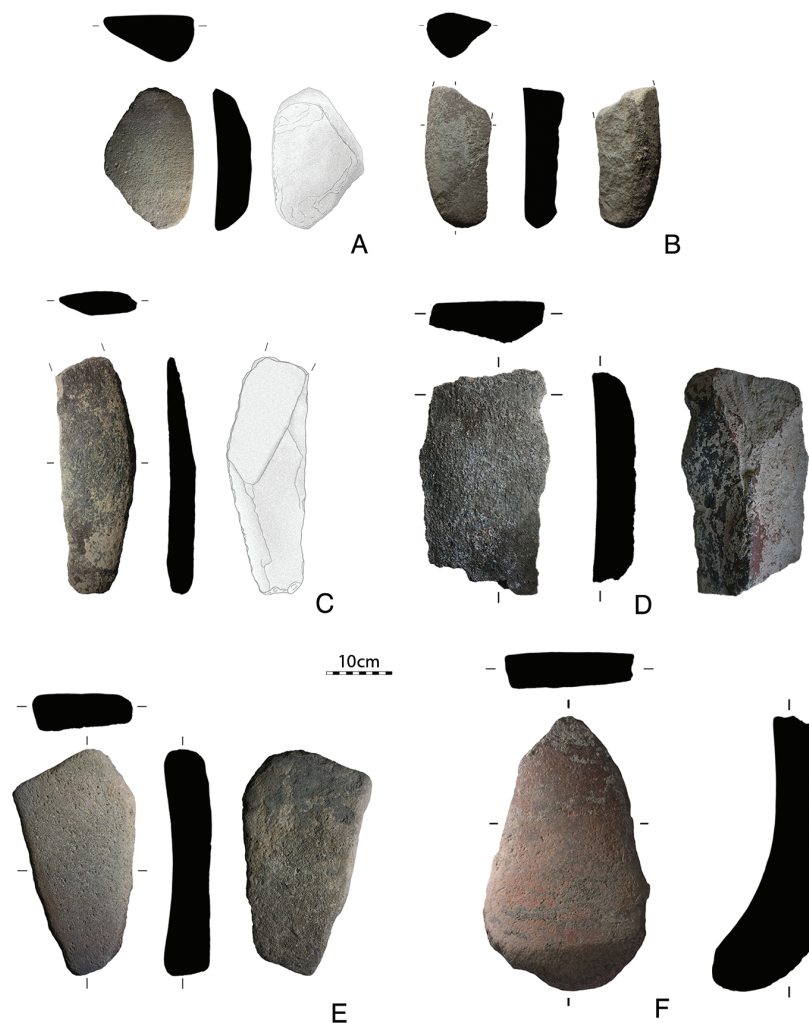


Fig. 8. Type 1 handstones (A–C) and querns (D–F).

surface. Interestingly enough, at least four out of the six exceptions of querns with two use-surfaces in Kleitos I share as a common feature the concave in both axes profile of their active surfaces, suggesting pairing with small-sized handstones in a linear or curvilinear motion (*i.e.* tool types 2 and 3). In Kleitos II, the percentage of querns with two use-surfaces is higher (22% compared to nearly 5% in Kleitos I), but with no association to specific tool types. Handstones with two use-surfaces are also exceptions to the rule, reaching nearly 13% in Kleitos I and 10% in Kleitos II.

A key element of the morphology of the querns, irrespective of their contour, is that their shape is optimized for the maximum possible use-surface. On the other hand, the bottom surface that rarely receives extensive shaping maintains the usually convex or flattish natural morphology of the original boulder. This is important, since the stability of a quern is necessary during the grinding activity. In the case of many Kleitos implements this would be ensured thanks to the morphology of their bases. There are, however, also cases with a highly irregular, convex or angular bottom surface, for which one should assume the use of additional supports (*e.g.*, rocks, pieces of wood) or their partial immersion in the soil, with or without some inclination.

Handstones exhibit a variety of transverse sections: wedge-shaped/lopsided sections (47%) and flat-convex ones (31%) dominate, while the elongated quadrilaterals, curvilinear (elliptical and oval) and trian-

gular sections present much smaller percentages (Fig. 4). In an overall examination, this variety appears to be largely the result of both the morphology of the original pieces of raw material, as well as the manufacturing choices. Surfaces with an angular morphology, often asymmetrical, were systematically selected to form the dorsal side of the handstone. This practice, mostly associated with type 1 handstones, resulted in a wedged transversal configuration of the tool, where the maximum thickness was not in the middle but closer to one side. There are also cases where the desirable morphology was secured through the application of manufacturing techniques, possibly because of the inconvenient shape of the initial piece of raw material. This observation is of particular interest, since the wedge-shaped transverse cross-section of the handstones has been previously considered a feature resulting solely from the tool's use, *i.e.* kinematics, pattern and degree of resulting wear (Adams 2002a.112–113 and Fig. 5.12). In the case of Kleitos, the most commonly encountered wedge-shaped cross-section of the handstones has been shown to be a desirable characteristic associated with the tools' manufacture – although it would certainly have been enhanced later on through use and subsequent wear – and most probably aiming at facilitating the handling of the tool (see *Moundrea-Agrafioti 2007.80* for a similar observation on another archaeological assemblage).

The fragmentary state of Kleitos grinding implements does not allow a full assessment of their metrical traits. In Kleitos I all the intact querns exceed 30cm in length, with average dimensions of 34.4cm x 20.92cm x 7.28cm. On the other hand, fragmented tools that represent a sufficient part of the initial (*i.e.* intact) implement testify to the existence of a metrical range, in fact giving the impression of the prevalence of small-sized tools with a length of ≤ 30 cm. Thus the length of querns ranged significantly up to a maximum of 35.7cm. In Kleitos II, the sole almost intact quern, with a total length of more than 47cm, is exceptionally large, while a fragmented one that retains 3/4 of its total volume would not exceed 35cm in its intact form.



Fig. 9. Type 2 and 3 fragmented handstones (A, B) and querns (C–E).

Together the two clearly depict the coexistence of grinding tools of different dimensions. Regarding metrical attributes in relation to different tool types, both type 1 and type 2 tools present size variation. Type 3 implements, on the other hand, are too fragmented for safe assessments of their metrical range. What can be said with some certainty is that they all had rather small initial proportions.

The average dimensions of the handstones in Kleitos I are 24.61cm x 12.05cm x 6.02cm, based exclusively on the intact samples. If we take into account both the intact specimens and the fragmented ones that retain intact the respective axis of measurement, the resulting metrical range is significantly wide: 9.2 to 37.2cm length, 8.4 to 16.8cm width and 3.4 to 8.6cm thickness. From the intact and almost intact samples (n=11), two present marginal dimensions: a small handstone with a length of less than 10cm and an asymmetrical oval outline, and a strongly elongated (3.1:1 length/width ratio), elliptical one that is almost 40cm long (Fig. 8.C). Between the two marginal cases there are tools 20 to 33cm long, which are difficult to group because of their varying proportions and limited number. Their weight also presents a strong variation: 546 to 5500g. What is clear, nevertheless, is a trend for elongated shapes: most of the handstones are very narrow, as evidenced by the high values of the length/width ratio (all but one ≥ 1.5 , and more than half ≥ 2). With regard to Kleitos II, the length range cannot be ascertained due to fragmentation, yet there are samples that clearly suggest metric variation.

The aforementioned variations, largely due to the characteristics of the exploited boulders, may also indicate the more opportunistic exploitation of the available raw materials, where the pursuit of uniformity in the collected rocks is not a (primary) concern.

Aspects of use

Regarding the materials processed, grinding tools have been traditionally associated with the processing of cereals and other edible plant species. Recent functional studies, including use-wear and residue analyses (e.g., Adams 1988; 2002b; Albert, Portillo 2005; Bofill et al. 2014; Delgado-Raack 2008; Del Pilar Babot, Apella 2003; Dubreuil 2002; 2004; 2009; Hamon 2008a; Hamon et al. 2011; Liu et al. 2010; Procopiou et al. 1998; 2002; Veth et al. 1997), combined with a variety of ethnographic data (e.g., Arthur 2014; Gould 1968; Horsfall 1987:336; Roux 1985), shed new light into the functional dynamics

of these tools. Grinding implements could in fact be actively involved in a wide range of activities, besides cereal grinding, such as the processing of legumes, tubers, roots and bulbs, nuts, fresh and dried fruits, herbs and spices, acorns, meat, bones, wood, tobacco, minerals, clay, pigments, salt, etc.

The forthcoming use-wear analysis of Kleitos material is expected to shed light onto various aspects of function. What can be said at the moment is that the morphometrical and typological variety identified in the Kleitos assemblage could be a possible indicator for the existence of a range of diversified milling activities. For example, and as noted above, type 1 grinding tools dominate the Kleitos assemblage, in sharp contrast to type 3 implements. Out of the four highly fragmented querns that can be safely attributed to the latter type, two do not bear any indication of pecking on their use-surfaces. This differentiation could be related to the uses of the tools. For example, Laurie Nixon-Darcus and Catherine D'Andrea (2017) identified the preference for grinding surfaces of different textures for the treatment of different products, with rough surfaces being exclusively reserved for grinding large seeds (e.g., sorghum, wheat, barley), while those with finer textures were utilized for the processing of small-sized plant species (e.g., millet). Similarly, in Nepal the querns used for spice processing were of fine materials and without pecking (Baudais, Lundström-Baudais 2002:170). Moreover, the identification of one of the few type 3 querns in a house interior along with other type 1 grinding tools offers evidence of technological diversification at the household level. The co-existence of different tool types in the same functional context is attested elsewhere, for example in the unique Late Bronze Age milling workshop in Room 3a of West House in Akrotiri, equipped with permanently installed grinding tools able to support the systematic, massive production of flour (Moundrea-Agrafioti 2007:82, 102–103). These cases reinforce the idea that typological diversity may be a feature of functional significance.

Several experiments highlight differences in the functionality of the various tool types depending on the material to be ground. Montserrat Menasanch et al. (2002:95) have shown an advantage of type 1 tools for the processing of hulled grains, since the morphology facilitates the separation, during milling, of the ground product and the hard but also lighter grain husks. The same tool type in other experiments has proven to be particularly effective for grinding dry or slightly roasted cereal grains (Lidström-Holm-

berg 2004.205–206). Furthermore, Caroline Hamon (2008b.202, 206–207) detected a change in the grinding technology of northwestern Europe at the end of the Neolithic period, with type 1 tools being abandoned in favour of type 2 implements. She emphasizes the possible association of this change with the replacement of hulled barley by the naked variety, and thus the interrelation of dietary, cultural and economic choices. The latter case supports the idea of a functional specialization of specific tool types, with tool type 1 better suited for dehulling and then grinding of cereals. On the other hand, in different regions of Mali (Dogon and Minyanka country), where the use of type 1 and 2 grinding tools continues until today, the choice between the two is purely dependent upon cultural choices, irrespective of the edible materials to be processed (Hamon, *Le Gall* 2013).

Function-related aspects might also be involved in the metrical variation of the technical equipment attested in the Kleitos assemblage, among others at the household level. The relation between the metrics and function of grinding tools is an issue that has received a lot of discussion. Small-sized querns with a length of ≤ 30 cm are quite often encountered in Greek Neolithic assemblages, and some researchers have shown support for their inefficiency, at least for the systematic production of flour (Runnels 1981.250–251; Stroulia 2010.37, 39, 48). Instead they proposed a multifunctional role for these implements for the treatment of various organic and inorganic substances (Runnels 1981.153; Stroulia 2010.50–51; Tsoraki 2008.100). Experimentally, however, it has been possible to demonstrate that small grinding tools can be used for the production of flour along with coarser derivatives (e.g., ‘bulgur’, groats) and that various pre-treatments of the grain may significantly enhance the efficiency of the process (e.g., Bofill et al. 2020; Chondrou et al. 2018; Hersh 1981.434–462; Valamoti et al. 2013). Thus, the limited size of grinding tools does not necessarily preclude certain functions. This is also supported by the ethnographic record that attests to the existence of a variety of technological choices. There are cases of a strong correlation between tool size and use, and others with no such distinctions. In Tichitt, Mauritania, there are four types of grinding tools according to metrical and functional criteria (Roux 1985.41), while in north Cameroon, tool pairs reserved for spices differ in size from those employed in cereal processing (Gelbert 2005.324). On the other hand, in some nomadic groups of northern Sahara the difference between coarse and fine flour

production is the number of strokes of the handstone over the generally limited working length of the quern used indistinctively for grinding activities (Gast 1968.348–349). Furthermore, no one can exclude the possibility that the predominance of small-sized tools in Kleitos and elsewhere was related to the production scales rather than specific uses, reflecting small production and consumption units, as suggested, for example, for the Late Neolithic Makriyalos assemblage (Tsoraki 2007.293). Finally, tools of limited size could even be associated with mobility and site-occupation patterns (e.g., Nelson, Lippmeier 1993; Schlanger 1991).

Therefore, the meaning of typological and metrical variation detected within assemblages is not straightforward, and definitely calls for further investigation through context-specific studies combined with functional analyses. It is important to bear in mind that the range of functions of these tools, as clearly documented ethnographically, can be determined by a variety of parameters, some of which, such as cultural and socio-economic factors, are very difficult or even impossible to detect archaeologically. For example, in the village of Sibou, northwest Kenya, specific taboos are in play concerning the highly specialized use of certain grinding tools for the production of castor oil exclusively by elderly women (e.g., Shoemaker et al. 2017.424–425). On the other hand, in Ethiopia grinding tools proved to be an ideal indicator of social differences and nutritional fluctuations within the strictly stratified society of the Gabo tribe (e.g., Arthur 2014). Even the personal preferences of the users can determine the way these implements are employed (e.g., Horsfall 1987.358).

The raw material of the implements that together make up a grinding pair is certainly of some interest. In the ethnographic record there are cases where the paired implements are made of the same raw material (e.g., the Mursi people in Maki, Ethiopia, Robitaille 2016.432, or the craftsmen of traditional stone grinding tools in North America that formed the coupled implements out of the same piece of rock, Aschmann 1949.685), but also cases of paired tools made of different raw materials and with different granulometry. The aim was to ensure the desired quality of the obtained product. For example, the nomads of Sahel, north Sudan, have for each grinding slab two matching handstones made from different raw materials for the two stages of grinding, a coarser one and a finer one that transforms the meal into flour (Schön, Holter 1988.159). In Sukur, Africa, successive grinding with a transition from

a coarse to a finer handstone was the way to obtain fine flour for women who had only one quern (David 1998:23). Finally, in Marakwet, Kenya, the process of producing sorghum and corn flour is conducted in two distinct stages, with the employment of handstones of different textures and weights, all part of the same toolkit (Shoemaker et al. 2017: 423–424). In the case of Kleitos a major limitation is the inability to restore the grinding tool pairs, *i.e.* to identify the coupled implements, due to the high degree of fragmentation and the scattered distribution of the finds. Only in three isolated cases, found within buildings of Kleitos II, is it highly probable that the tools found belong to the same pair. In all of these cases, the associated quern and handstone are made of the same raw material (gneiss in two cases, sandstone in the third). However, it is possible that grinding pairs of different raw materials and textures were employed either at separate stages of the same grinding process or independently for a different quality of product. For example, milling experiments with tools made of microconglomerate – a popular choice, especially in Kleitos I – have shown that the particular type of material does not allow control over the quality of the product obtained (Chondrou et al. 2018). In contrast, sandstone tools permit regulation of the granulometry of the material produced (Procopiou 2013: 46–47 and Tab. 2.1). It is therefore a possibility that the raw material variability detected in Kleitos can be associated with different intended production yields. Tools made of highly heterogeneous, coarse-grained microconglomerate could have been utilized mainly for the production of coarse products, whereas tools with a more homogeneous structure and a finer texture could have aimed at more refined derivatives (see below).

Moreover, there are certain use-related morphological traits worth mentioning. A few handstones in our sample exhibit a thin, elongated facet along one side of the use-surface of the tool, perpendicular to its movement axis. This characteristic feature is espe-

cially interesting, since it points to a particular gesture during the grinding process: in the rectilinear reciprocal movement on the surface of the quern, a light tilting of the handstone (*i.e.* the raising of the bottom part of the tool at an angle) during its upward stroke that brings the tool back to its original position, close to the operator (Fig. 10). This would serve to ‘re-capture’ the grain dispersed over the surface of the quern, in order to grind it again with another stroke of the handstone. Simultaneously it would lead to the wearing down of the farthest from the operator elongated edge of the use-surface of the handstone and the formation of a thin facet, with its long axis perpendicular to the direction of motion of the handstone. An ethnographic reference to this distinct kinematic during the grinding process originates from Maki, Ethiopia (Robitaille 2016: 433). This move differs from holding the handstone completely parallel to the surface of the quern or from striking it back-and-forth during the reciprocal motion, which would result in different configurations of the use-surfaces of the tools, the first in a fairly flat surface, the second in the formation of two facets parallel to each other (Adams 2002a: 103–106; and for ethnographic observations, David 1998: 35; Bartlett 1933: 15–19). The detection of this feature in some specimens of our sample, along with its absence in many other cases, indicates variability in the kinetics applicable within the same technical process (*i.e.* grinding). We should nevertheless also bear in mind that the visibility of such facets depends not only on the kinetics applied, but also on the treatment that these tools receive during their life-cycle. Thus, for example, dense re-pecking of the use-surface for the maintenance of its roughness or peripheral flaking for the reshaping of its contour might completely remove the related traces.

A group of querns whose use-surface is tilted on one side, resulting in the wedge-shaped configuration of their transversal section, deserves special mention. In contrast to the wedge-shaped cross-section of the handstones (see above), this lop-sidedness of

	KLEITOS I														KLEITOS II												
Building	A			B		C		D		E		F	G	H	I		J	1		2			3			4	
Building phase	A	B	C	A	B	A	B	A	B	A	B				A	B		A	B	A	B	C	A	B	C		
Quern		2				2	1	3		1		3			1	1	2		1							1	
Handstone		2		2		1		4	2	3	1	1	1			1		1							2	2	
Indeterminate	1				1	1	1	3	1	2	1	1					1								1		
Total number of grinding tools	1	4		2	1	4	2	10	3	6	2	5	1		1	2	3		2							3	3

Tab. 2. Distribution of grinding tools originating from building interiors in Kleitos I and Kleitos II settlements presented per generic type and building phase.

querns seems less likely related to manufacture and more linked to the way the tools were used. Perhaps it is the result of the tools' tilted mounting during use. Nicholas David (1998:38) likewise interpreted the asymmetric growth of the milling cavities formed on bedrocks as a result of the natural tilting of their support. It could also be associated with the operator applying uneven pressure on the two sides of the handstone during grinding (David 1998:38 rejects this version, but its plausibility is certified experimentally, see Stroulia et al. 2017:17–18).

Finally, as noted above, specimens (handstones and querns) with two opposite use-surfaces are rare in Kleitos. It has been argued that the formation of multiple use-surfaces on a tool is a practice aimed at extending its use-life, since it increases the number of usable surfaces on the same object (Adams 1993:336). Different possible accounts exist for the shaping of these tools: they were either manufactured from the beginning with two different active surfaces, or the second surface was the result of later shaping. In the case of handstones with two use-surfaces, if this configuration was part of the initial design aimed at parallel use in combination with the same passive tool, frequent switching between the two surfaces would be necessary, so that both remain compatible with the quern, following the changes of its profile morphology caused by the progressive use-wear (Adams 2002a:114). In Kleitos, however, many of the handstones with two use-surfaces are not consistent with this practice, since their use-surfaces do not coincide morphologically, meaning that their profile differs: one surface is concave on the longitudinal axis and the other convex (for simi-

lar observations regarding other assemblages see Tsoraki 2008:91 for Makriyalos, and Stroulia 2018:209 for Alepotrypa). This could indicate pairing of the tool with different passive implements from each side, or even an active function of the tool with the one use-surface and a passive function with the other. Unfortunately, the latter cannot be clarified due to the fragmented state of the available samples. The temporal dimension of the function of the two use-surfaces of a single tool is also open to question: they could represent parallel uses of the tool or successive stages of the artefact's life-cycle. Another observation is that in some cases different use-surfaces of the same tool present different use-wear: one surface is smooth and polished, while the other one is lacking polish and has a rougher texture (see Tsoraki 2008:91 and Stroulia 2010:41 for similar notes on the Makriyalos and Franchthi assemblages, respectively). This could suggest their use in relation to different materials or even the same one, but at different stages of its processing (see Stewart 1942, as referenced in Schroth 1996:58, and for a similar proposition for the material from Sitagroi, Biskowski as cited in Elster 2003:186).

Management practices

Like many other types of implements, grinding tools may undergo a series of maintenance activities to enhance their functionality, such as re-pecking of their use-surface. Despite a reduction in the tool's life-duration through this process, the tool gains a renewed abrasive texture, increasing its efficiency (Bartlett 1933:4; Hersh 1981:470; Wright 1993:352). This was definitely a process that was per-

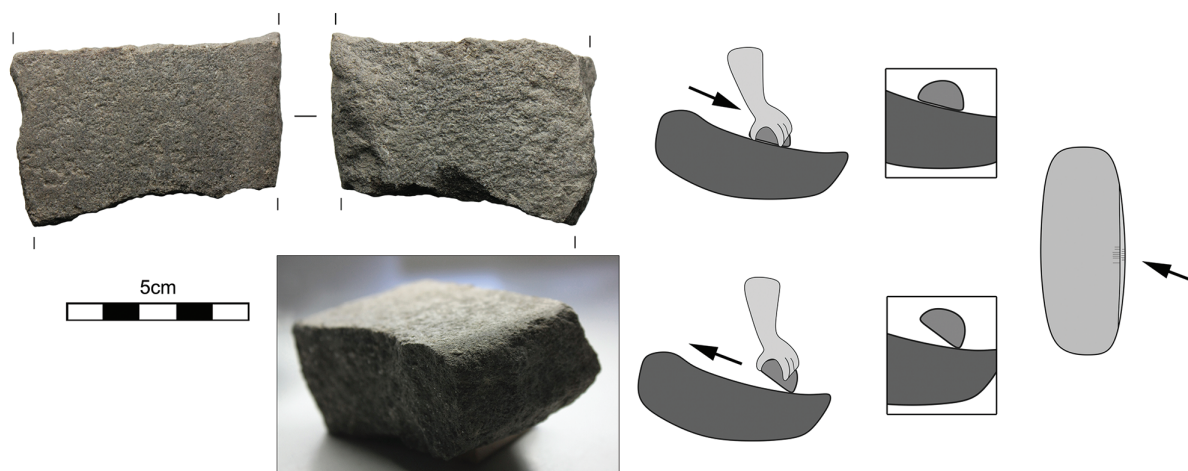


Fig. 10. Handstone used in a rectilinear, reciprocal motion (drawing on the right). In the upward movement, due to a mild tilting of the tool, only the lateral distal part of its use-surface is in contact with the surface of the quern, resulting in the formation of an elongated facet along its one long side, visible in plan view (right). On the left, fragment of a handstone from Kleitos I with this distinct characteristic (drawing and photographs by the author).

formed periodically in Kleitos, as evidenced by the numerous grinding implements with traces of pecking on their use-surfaces, more or less obliterated by subsequent use-wear. In the Iron Age site Almisarique, in the Iberian Peninsula (Risch 2008.14–15), it has been observed that the renewal of the roughness of the use-surface through percussion would only be performed on querns, while the handstones would still be used even after the elimination of their irregularities through the gradual smoothing and levelling caused by the cumulative use-wear. However, this is definitely not the case in Kleitos. Not only do all handstones have signs of pecking, but there is also a unique example of a handstone with an incomplete rejuvenation of its use-surface (Fig. 11) offering a clear indication of the *in situ* performance of such activities. Ethnographic examples show that surface rejuvenation can be a time-consuming process (see Hamon, *Le Gall* 2013.112–113). The frequency of application could vary from a few days to several weeks (e.g., Robitaille 2016.443, seven to ten days; Shoemaker et al. 2017.426, one to three weeks), depending on a number of factors, such as the hardness and durability of the raw material of grinding tools, frequency and mode of use (Shoemaker et al. 2017.426).

As noted above, due to the location of the Kleitos settlements inside the alluvial basin of Kitrini Limni, all the necessary pieces of raw material would have to be sought and transferred (as complete or incomplete artefacts) from areas outside its boundaries, at a distance greater (possibly by far) than 10km. One would expect that the lack of directly accessible sources of material would lead to: (a) the application of wear-management strategies; (b) systematic practices for prolonging the tools' functionality; (c) high rates of worn-out tools due to their extensive use. However, the overall picture does not meet expectations. With the exception of rejuvenation, there are very low rates of post-manufacture technical treatment of grinding equipment, either in relation to their initial function or beyond that. There are, for example, cases of fragmented querns that have been reshaped into handstones or of broken

handstones subjected to limited reshaping (usually at the edges of the fractured surfaces) in order to continue to be functional. However, such cases of re-designing grinding tools with the aim of reusing them in the same or different context are extremely limited (less than 2% in Kleitos I and completely absent from Kleitos II), and certainly do not represent the norm in the management practices of grinding equipment in the Neolithic Kleitos.

Moreover, there is an impressively limited presence of exhausted tools: only 5% of the milling tools per site can be described as (nearly) exhausted (handstones and querns almost equally represented), while no such find was detected in the area between the two settlements. Judging from our data, there is no visible correlation between the degree of use of the tools and the degree of work invested in their manufacture. However, there seems to be a link with the raw material of the tools, since those made of micro-conglomerate and gneiss have an average thickness smaller than the tools made of other raw materials, which could support their more extensive or intensive use, if not related to the dimensions of the original raw material pieces used. Could the relative absence of worn-out grinding tools be attributed to different treatments, such as different discard patterns? The available evidence does not support such a hypothesis. First of all, the full-scale archaeological research in Kleitos allows clear visibility throughout the extent of the residential area. Secondly, the same absence is noted in both settlements, a fact that reinforces the validity of the observation. After all,

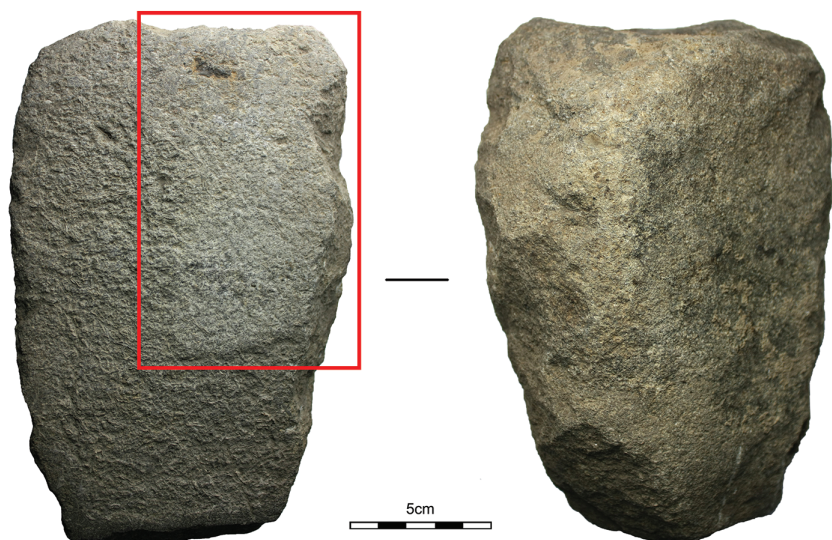


Fig. 11. A type 2 handstone from Kleitos I with unfinished rejuvenation. More than a quarter of its use-surface (area marked in red frame) remains slightly elevated without having received dense re-pecking like the rest.

there is no evidence for the massive extraction of anthropogenic material beyond the limits of the two sites, and the archaeological material in the exposed area between them is particularly limited.

It should be stressed that grinding tools, and in particular querns, have potentially long life spans that can reach up to several decades, as evidenced by the ethnographic record (see *Horsfall 1987.342–343; David 1998.55; Nixon-Darcus 2014.97, 105*). In the case of Kleitos, it seems that the maximization of the exploitation of grinding tools was *not* a primary consideration of the inhabitants who had the tendency *not* to use their grinding tools until the point of exhaustion.

Spatial analysis

As previously mentioned, Kleitos I yielded the largest amount of grinding implements among the three spatial units, *i.e.* the two settlements and the area between them (Tab. 1), an observation consistent with the general distribution of the whole ground stone tool assemblage (*Chondrou 2018*). The overall distribution of the findings covers the entire residential area of the two settlements, with the overwhelming majority (84%) linked to external areas. This wide dispersal is the result of a palimpsest of successive and superimposed production and discard activities, and factors resulting in a random material displacement. No differentiation is detected according to the degree of work invested in the tool manufacture or according to different tool-types. The small group of type 2 and 3 tools follows the distribution of the type 1 majority. On the other hand, the material from the area between the two settlements is minimal, and based on its state of preservation resembles mostly refuse deposits.

Only 55 grinding tools (47 in Kleitos I and eight in Kleitos II) are associated with the interior of built domestic space (Tab. 2). Their distribution in Kleitos I is highly inhomogeneous, ranging from zero to ten specimens per dwelling. In Kleitos II it appears more uniform, although grinding tools are present in only 1/3 of the building phases (*i.e.* three out of nine). All grinding tools originating from building interiors are in a fragmented state of preservation, a fact that significantly hinders the complete assessment of domestic grinding equipment and the investigation of possible patterns in morphometric differentiation. However, it can be easily observed that almost all of the querns are quite thick (7.25cm average thickness), and thus have long remaining use-

lives. Comparing the grinding implements from Kleitos I and Kleitos II buildings (taking into account passive, active and indeterminate ones), a divergence is detected. As a general pattern, Kleitos I dwellings tend to have at least two grinding pairs in their interiors (the inventories from five building phases meet this condition), while Kleitos II dwellings one quern and one or two handstones. Based on ethnographic examples that demonstrate the relationship between the number of querns and number of household members preparing the meals (*e.g., David 1998.23*), it would be tempting to see these quantitative variations in household equipment as a reflection of differences in the size of household groups of Kleitos I and Kleitos II. This assumption may be supported by the fact that the majority of Kleitos II dwellings are significantly smaller in size compared to their counterparts in Kleitos I. There are nevertheless several other ethnographic studies that illustrate differences in household grinding tools for other reasons, such as economic, social, personal, *etc.* (*e.g., Arthur 2014; Robitaille 2016*). Interestingly, the grinding pairs found in Kleitos II houses consist of tools made of the same rock type, while the third implement – when present – is of different material. Similarly, in all but one Kleitos I dwellings with more than two grinding tools, two or even three different rock types are represented. In a few cases different tool types or tools of different metrical groups are present. This diversity suggests a possible complementary role for at least some of these tools, being reserved for different stages of the same grinding process (*e.g., coarse/fine grinding*) or for the processing of different products.

So far no stable features associated with grinding activities have been identified: no fixed equipment, no clay ‘bins’ that could function as specialized places for grinding. Although rectangular clay constructions have been found in the interior of some dwellings, resembling clay features with rims delimiting milling areas found elsewhere in Eastern Europe (*e.g., Burdo et al. 2013.101, 103; Kalchev 2013*), there were no associations with grinding implements and the analysed archaeobotanical data do not support a relevant use (Stylianakou, pers. com.). However, in two cases, one in an open area in Kleitos I and the other inside or directly outside a dwelling in Kleitos II, grinding tools were found associated with clay structures in such a way that they might initially have been located inside or on top of them.

In the absence of significant indications of the existence of stable grinding tools, one can imagine the

grinding implements of Kleitos, generally limited in size and weight, to have been carried easily from one place to another, or even from interior to exterior areas, domestic or communal. Seasonal or other types of changes in workspaces would therefore be possible by moving the necessary equipment and changing its context of function, when required, from private to more open (for ethnographic examples, see Roux 1985; Cutting 2006; Hamon, *Le Gall* 2013). Nevertheless, there are clear indications that grinding activities were closely connected to the domestic space. Nowhere in Kleitos do we come across concentrations of grinding tools in external areas lacking an association with specific buildings. Instead, the findspots of grinding implements that seem to reflect contexts of use rather than contexts of disposal activities are located inside dwellings or outside, but in their immediate periphery. The latter, according to the spatial analysis of all ground stone categories, represents an extension of the built space of the household, able to accommodate a variety of activities. Grinding was certainly one of these, as illustrated by the frequent finding of milling tools outside but near the built boundaries of the dwellings, in a few cases in places with additional formations, such as fence-partitions and plastered floors.

Interestingly there is a general lack of proximity between grinding stones and thermal/cooking structures, both in exterior and interior areas. In fact, building interior zones associated with clay structures – systematically located in Kleitos I dwellings along the northern wall, rarely along part of the western one as well – are often (almost) empty of grinding implements and other types of ground stone tools. Instead, in a few secure cases, the grinding implements were found in very close association with vessels. If not a reflection of equipment in storage, this could suggest grinding in direct association with the storage locus of the material to be ground or of the resulting product of the grinding activity. The evidence from Kleitos is in high contrast to the general pattern of domestic activities clustered around the hearth or oven observed in numerous Neolithic sites in the Balkan area (Hodder 1990.59; Souvatzi 2013.55, and for various examples see also Bailey 2000; Todorova 1978.52; Tringham 1971.112–113; Tringham et al. 1985.431). Therefore, it is quite likely that, in

the case of Kleitos, grinding activity involving food-stuff was, as a rule, spatially – perhaps also temporally – separated from cooking.

Deposition practices

Grinding tools, among other artefacts, that resemble refuse can be detected all over the settlement grounds, with higher frequencies mostly, but not exclusively, in areas in the peripheral unstructured zone of the settlement, around the built nucleus (especially in Kleitos I). These artefacts, secondarily disposed of in these marginal areas, bear signs of different pre-depositional processes, such as burning or multi-fracturing, that suggest varied origins. They could be the remains of maintenance activities executed in the domestic areas of the settlement, but possibly of other kinds of activities as well.

In Kleitos I, where the tool assemblage is more abundant and allows for a better analysis, neither the ditches surrounding the settlement, nor the pits on settlement grounds appear to be primarily contexts of refuse disposal. In fact, variations in their contents and patterns in their filling have been identified that point to deliberate and selective actions of deposition. Grinding tools constitute the predominant ground stone tool component of Kleitos I pits, and the second most common – after edge tools (*i.e.* axes, adzes, chisels) – in ditches. A closer look suggests a strong association of querns with pit infills. With one exception all grinding tools inside pits in Kleitos I are querns (Fig. 12). The same does not apply in the case of ditches, where querns and handstones appear in equal numbers. Moreover, grinding tools are further associated with specific types of pits: in Kleitos I, where the practice of opening pits within area of the destroyed debris of buildings is recurrent, whenever these pits contain ground stone tools, grinding tools are a constant find. Finally, looking



Fig. 12. Two examples of querns intentionally deposited in pits (both cases from Kleitos I).

exclusively at the finds disposed of intact in such contexts (pits and ditches), although only four in number, they are all querns. Owing to their volume these artefacts would have long remaining use-lives and would probably be considered valuable. Besides, given the fact that large pieces of raw material were not readily available, but brought into the settlement from further away, the manufactured items incorporated, by definition, a remarkable amount of labour for their production.

Aside from the few intact specimens, the rule seems to be that grinding implements are deposited fragmented, in both pits and ditches. Some examples raise suspicions of deliberate destruction, either due to irregular breakage patterns or due to visible percussion marks that are not related to any kind of maintenance episode, *i.e.* reshaping or repair of the implement (Chondrou 2018).

The above observations suggest a patterned behaviour regarding the ways ditches and pits were filled. There seems to be not only a separation of the two complementary members of the grinding pair at the time of deposition (passive/quern and active/handstone), but also a selective disposal of a specific tool type in a particular context. Thus, the presence of only one of the two members of the grinding pair in the context of deliberate disposal/deposition does not appear in the case of Kleitos to reflect a *pars pro toto* signification mechanism, as it has been argued for other European Neolithic assemblages (see Graefe 2009.75), where cases of intentional deposition of grinding tools, often as hoards, are well documented (see Hamon 2008b; 2008c; Beneš et al. 2015). The choice to include only one of the two coupled implements in specific deposits reveals their differentiated significance rather than a 'connotative' use of either one. Ethnographic data support such a symbolic 'autonomy' of the members of the grinding pair and the active relationship between them (*e.g.*, Corbeil 1985 and Parsons 1970, as cited in Lidström Holmberg 1998.125; moreover, in several Minyanka villages in Mali the handstone symbolizes the child and the quern the woman, Hamon, Le Gall 2011.27).

Examining the state of preservation in relation to the context indicates another pattern: grinding tools originating from domestic areas in both settlements are completely fragmented, often showing signs of multiple breakages, which cannot be attributed to damage from the destruction of the building or to intense burning and erosion. And while in a few cases conjoining fragments are found, no grinding

implement could be fully restored (Chondrou 2018.395–397). In contrast, the edge-tools from domestic contexts are systematically found intact. This observation should be put in the general context of burned houses. All but one separate building phase in Kleitos I and several in Kleitos II were destroyed by fire. The houses were not all contemporaneous and there are no indications of a generalized fire that destroyed all or part of the settlement at once (Ziota 2014a.326). Instead, the dwellings seem to have been destroyed by fire in separate events. Regarding the house inventories, although all separate categories of finds have not yet been studied, there is the general impression of a low frequency of small finds that contrasts with the significant size of the houses themselves. This could be an indication of a systematic, at least partial, evacuation and abandonment of houses prior to their destruction by fire. Few exceptions are detected. One of them, the earliest of the three phases of Building 3 in Kleitos II, stands out from the rest for its state of preservation, its rich inventory and the presence of a significant amount of stored products, evidence that suggest it was destroyed by fire in the context of an accident, without the inhabitants having the opportunity to remove the building's contents (Ziota 2014b.59–60).

Two cases of grinding implements buried under thermal structures may constitute a special type of deposition. Examples of tools incorporated in built features in such a way that they form part of the structure's floor or its substructure are known from other Greek Neolithic sites (*e.g.*, Middle Neolithic hearth in Servia site, Mould et al. 2000.146). In Kleitos, however, the tools are buried underneath the clay features, with no visible structural correlation. In one of the cases a handstone was broken (intentionally?) into at least five pieces, three of which were buried close to each other and underneath a clay structure. A similar find is reported from the Neolithic stratum in Franchthi cave: the pieces of an intentionally broken quern were buried underneath a 'built fireplace' (Stroulia 2010.51–52).

To sum up, intact and broken grinding tools are systematically detected in contexts unrelated to their original function (*e.g.*, pits and ditches). Even those found in domestic contexts exhibit a state of preservation that cannot be explained in functional terms. The detection of recurrent patterns points to the existence of complex processes and actions that have influenced the formation of the archaeological archive. Breakage and fire seem to play an active role in these practices, in the context of which every-

day objects such as millstones are used, among other things, in ways that convey meaning. The intentional breakage of tools is certainly not a new concept. The deliberate destruction of stone tools has been supported in other cases as well: in Late Neolithic Toumba Kremasti, a site in close proximity to Kleitos (Chondrou 2011; Stroulia, Chondrou 2013; Stroulia 2014) where huge quantities of anthropogenic material were found discarded in pits around the settlement, in the also neighbouring Late Neolithic site of Megalo Nisi Galanis (Stroulia 2005:576), in Late Neolithic Makriyalos (Tsoraki 2008:106–108, 122–125), in Middle/Late Neolithic Avgi (Bekiaris 2020) and in Late Neolithic Dispilio (Ninou 2006:106), to name but a few examples regarding sites located in northern Greece. In the Balkans, John Chapman (2000a; 2000b) reports numerous cases where archaeological data seem to imply the practice of deliberate destruction. Interestingly enough he, too, observes a differentiated treatment of grinding tools and edge tools (Chapman 2000c:93–94).

Discussion

The analysis of the grinding tool assemblages from Kleitos I and Kleitos II allowed a detailed examination of these artefacts' life-cycles and a glimpse into various social, economic, cultural as well as symbolic aspects of technology in the two nearby Neolithic settlements.

Kleitos grinding tools were the outcome of a non-standardized production based on the exploitation of selected not readily accessible raw material sources, and on generally low rates of work investment. In both settlements the overall morphometrical variability and diverse manufacturing sequences observed seem to be the combined result of the varied morphology of the original boulders and of personal choices. The evidence suggests the off-site production of tools, but on-site maintenance and use.

As far as the marked discrepancy in the exploitation of specific raw materials for the manufacture of grinding implements between the two sites, there are various possible interpretations. One is that the two settlements applied a differentiated model of exploitation of the surrounding sources. An overview of the raw material acquisition for all Kleitos ground stone tool categories reveals a general pattern of divergence: some raw materials frequently found in one settlement are limited or completely absent in the other. The overall picture shows that the two settlements were to some extent exploiting

different areas of their landscape (Chondrou 2018). This change in the selected raw materials may, in fact, attest to a diversified socio-economic mechanism employed in the utilization of the natural sphere and the production of the material culture.

On the other hand, the change in the lithic material could reflect function-related parameters (see Procopiou 2014:239 for a similar proposition for the change in the raw material used for grinding tools in Neopalatial Crete). It has been shown experimentally that microconglomerate material is an unsuitable choice for a 'fine-flour oriented' production (Chondrou et al. 2018), thus a change to gneiss might relate to the different desired characteristics of the ground product.

In Kleitos, grinding was one of the activities organized at the household level rather than a communal one. Even though the portable nature of the grinding equipment would permit a shift in their context of action, the analysis showed a close connection with the domestic space. Yet, there seems to be a clear spatial separation of grinding and cooking activities: grinding tools are mostly located in zones of the built and non-built domestic space lacking thermal structures.

As an integral and valuable part of the means of production of Kleitos society, the grinding implements do not seem to receive the expected manipulation. Being artefacts with potentially long use-lives, made of raw materials with an off-site provenance, one would anticipate extensive curation. Yet the rates of redesigned, reused and recycled tools are low, the same as the rates of exhausted implements. Instead, there are high fragmentation rates of bulky artefacts with breakage patterns that do not relate to extensive use or accidental wear. In the intra-household inventories, broken grinding implements repeatedly missing their conjoining parts contrast to the presence of complete edge-tools, adding to the idea of deliberate destruction of the dwellings and a process of selective and intentional decommissioning of their means of production. Perhaps it is the close association of grinding tools to the entity of the 'house' and their importance to the survival and reproduction of the 'household' and, by extension, of the whole community, that strengthens their symbolic value and dictates their special treatment in the context of out of the ordinary events. As Katherine I. Wright (2014) notes, such acts of deliberate destruction of valuable household property might well attest to the existence of cultural norms

prohibiting the transmission of wealth from one generation to the next, thus contributing to the reinforcement of collective/communal identities.

Thus, the Kleitos grinding tool assemblage constitutes an example of how intrinsic and extrinsic values may be manifested in the material culture. The grinding tools made from raw materials that are a product of systematic collection and transport, empowered through their integral role in time-consum-

ing daily practices at the heart of the domestic life (see Brück 2001; 2006a; 2006b), are variously manipulated. They rarely reach the end of their use-lives through long-term usage, and instead they are often employed in coded actions with multiple possible symbolic connotations. Although the borderline between secular and ritual contexts is not always clear, grinding implements certainly seem to be functioning in both.

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References

- Adams J. L. 1988. Use-wear analyses on manos and hide-processing stones. *Journal of Field Archaeology* 15(3): 307–315. <https://doi.org/10.1179/009346988791974394>
1993. Toward understanding the technological development of manos and metates. *KIVA* 58(3): 331–344. <https://doi.org/10.1080/00231940.1993.11758213>
1999. Refocusing the role of food-grinding tools as correlates for subsistence strategies in the U.S. Southwest. *American Antiquity* 64: 475–498. <https://doi.org/10.2307/2694147>
- 2002a. *Ground stone analysis: A technological approach*. The University of Utah Press. Salt Lake City.
- 2002b. Mechanisms of wear on ground stone surfaces. In H. Procopiou, R. Treuil (eds.), *Moudre et broyer: L'interprétation fonctionnelle de l'outillage de mouture et de broyage dans la Préhistoire et l'Antiquité. I. Méthodes. Actes de la table ronde internationale, Clermont-Ferrand, 30 nov. – 2 déc. 1995*. Editions du CTHS. Paris: 57–68.
- Albert R. M., Portillo M. 2005. Plant uses in different Bronze and Iron Age settlements from the Nuoro province (Sardinia). The results of phytolith analyses from several ceramic fragments and grinding stones. *Anejos de Complutum* 10: 109–119. <https://revistas.ucm.es/index.php/CMPL/article/view/CMPL0505220109A>
- Alisøy H. A. 2002a. Consumption of ground stone tools at Stavroupoli. In D. Grammenos, S. Kotsos (eds.), *Sostikes anaskafes sto Neolithiko oikismo Stavroupolis Thessalonikis*. Publications of the Archaeological Institute of northern Greece. Thessaloniki: 561–608.
- 2002b. Ground stone tools from Mesimeriani Toumba. In D. Grammenos, S. Kotsos (eds.), *Anaskafi ston Proistoriko oikismo »Mesimeriani Toumba« Trilofou N. Thessalonikis. Anaskafikes periodoi 1992, 1994–1996, 2000, 2001*. Publications of the Archaeological Institute of northern Greece. Thessaloniki: 277–314.
- Andreou S., Fotiadis M., and Kotsakis K. 1996. Review of Aegean Prehistory V: The Neolithic and Bronze Age of northern Greece. *American Journal of Archaeology* 100 (3): 537–597. <https://www.jstor.org/stable/507028>
- Arthur J. W. 2014. Culinary crafts and foods in southwestern Ethiopia: An ethnoarchaeological study of Gamo groundstones and pottery. *African Archaeological Review* 31(2): 131–168. <https://www.jstor.org/stable/43916695>

- Aschmann H. 1949. A metate maker of Baja, California. *American Anthropologist, New Series* 51(4): 682–686. <https://doi.org/10.1525/aa.1949.51.4.02a00350>
- Bailey D. W. 2000. *Balkan Prehistory: Exclusion, incorporation and identity*. Routledge. London.
- Bartlett K. 1933. *Pueblo milling stones of the Flagstaff Region and their relation to others in the Southwest*. Museum of northern Arizona Bulletin No.3. Museum of northern Arizona. Flagstaff.
- Baudais D., Lundström-Baudais K. 2002. Enquête ethno-archéologique dans un village du nord-ouest du Népal: Les instruments de mouture et de broyage. In H. Procopiou, R. Treuil (eds.), *Moudre et broyer: L'interprétation fonctionnelle de l'outillage de mouture et de broyage dans la Préhistoire et l'Antiquité. I. Méthodes. Actes de la table ronde internationale, Clermont-Ferrand. 30 nov. – 2 déc. 1995*. Editions du CTHS. Paris: 155–180.
- de Beaune S. A. 1989. Essai d'une classification typologique des galets et plaquettes utilisés au Paléolithique. *Gallia Préhistoire* 31: 27–64. <https://doi.org/10.3406/galip.1989.2264>
2004. The invention of technology-prehistory and cognition. *Current Anthropology* 45(2): 139–162. <https://www.jstor.org/stable/10.1086/381045>
- Bekiaris T. 2007. *Triptá ergaleia apo to Neolithiko oikismo tis Makris Evrou*. MA thesis. Aristotle University of Thessaloniki. Thessaloniki. (in Greek)
2020. Ground stone technology in context: consumption of grinding tools and social practice at Neolithic Avgi, Northwestern Greece. *Journal of Lithic Studies* 7: 1–24. (On line edition) <https://doi.org/10.2218/jls.3078>
- Beneš J., Vondrovský V., Šída P., Divišová M., Kovačiková L., Kovárník J., and Vavrečka P. 2015. The rare deposition of Neolithic (SBK) grinding tools and Longhouse 8 from Hrdlovka (Czech Republic): Analysis and 3D virtual reconstruction. *Interdisciplinaria Archaeologica – Natural Sciences in Archaeology IANSA* 6(2): 161–179.
- Bofill M. 2014. *Inicio y consolidación de las prácticas agrícolas durante el neolítico en el levante mediterráneo (septentrional y central): el proceso de molienda y trituración a partir del análisis funcional del instrumental macrolítico*. PhD dissertation. Universitat Autònoma de Barcelona. Barcelona.
- Bofill M., Portillo M., Molist, M., and Albert R. M. 2014. Processing activities during the Levantine Neolithic and Early Bronze Ages using phytolith and use-wear analyses of grinding stone tools. In P. Bieliński, M. Gawlikowski, R. Koliński, D. Ławecka, A. Sołtysiak, and Z. Wygnańska (eds.), *Proceedings of the VIII International Conference on the Archaeology of the Ancient Near East, 30 April – 4 May 2012, University of Warsaw*. Vol. 2. Harrassowitz Verlag. Wiesbaden: 657–666.
- Bofill M., Chondrou D., Palomo A., Procopiou H., and Vamoti S. M. 2020. Processing plants for food: Experimental grinding within the ERC-project PLANTCULT. *Journal of Lithic Studies* 7: 1–26. (On line edition) <https://doi.org/10.2218/jls.3079>
- Brück J. 2001. Houses, bodies, pots, quern stones: meaning and metaphor in the English Later Bronze Age. In D. Gheorghiu (ed.), *Material, virtual and temporal compositions: on the relationship between objects*. British Archaeological Reports IS 953. Archaeopress. Oxford.
- 2006a. Fragmentation, personhood and the social construction of technology in Middle and Late Bronze Age Britain. *Cambridge Archaeological Journal* 16(2): 297–315. <https://doi.org/10.1017/S0959774306000187>
- 2006b. Death, exchange and reproduction in the British Bronze Age. *European Journal of Archaeology* 9(1): 73–101. <https://doi.org/10.1177/1461957107077707>
- Burdo N., Videiko M., Chapman J., and Gaydarska B. 2013. Houses in the Archaeology of the Tripillia-Cucuteni Groups. In D. Hofmann, J. Smyth (eds.), *Tracking the Neolithic House in Europe: Sedentism, Architecture and Practice*. Springer. New York: 95–115.
- Chapman J. C. 2000a. Pit-digging and structured deposition in the Neolithic and Copper Age. *Proceedings of the Prehistoric Society* 66: 61–87. <https://doi.org/10.1017/S0079497X00001778>
- 2000b. “Rubbish-dumps” or “places of deposition”? Neolithic and Copper Age settlements in Central and Eastern Europe. In A. Richie (ed.), *Neolithic Orkney in its European context*. McDonald Institute Monographs. Cambridge: 347–362.
- 2000c. *Fragmentation in archaeology: People, places, and broken objects in the prehistory of South-Eastern Europe*. Routledge. London and New York.
- Chondrou D. 2011. *Triptá ergaleia apo ti Neolithiki thesis tis Toumbas Kremastis Kiladas*. MA thesis. Aristotle University of Thessaloniki. Thessaloniki. (in Greek)
2018. *I tripti lithoteknia apo tous proistorikous oikismous Kleitos I kai Kleitos II tis lekanis tis Kitrinis Limnis Kozanis*. PhD dissertation, Aristotle University of Thessaloniki. Thessaloniki. (in Greek)

- Chondrou D., Valamoti S. M., Procopiou H., and Papadopoulou L. 2018. Grinding cereals and pulses in the Neolithic site of Kleitos: an experimental investigation of microconglomerate grinding equipment, final products and use wear. *Journal of Greek Archaeology* 3: 23–45.
- Chondrou D., Bofill M., Procopiou H., Vargiolu R., Zahouani H., Bekiaris T., Ninou I., Kasapidou G., McNamee C., Tsartsidou G., and Valamoti S. M. 2019. *Grinding practices in prehistoric Northern Greece: integrating archaeological and experimental data*. Paper presented at the 3rd AGSTR Conference. Copenhagen.
- Cutting M. 2006. More than one way to study a building: Approaches to prehistoric household and settlement space. *Oxford Journal of Archaeology* 25(3): 225–246. <https://doi.org/10.1111/j.1468-0092.2006.00259.x>
- David N. 1998. The ethnoarchaeology of grinding at Sukur, Adamawa state, Nigeria. *African review* 15(1): 13–63. <https://doi.org/10.1023/A:1022270208256>.
- Deal K. 2012. Fire effects on flaked stone, ground stone, and other stone artifacts. In K. C. Ryan, A. T. Jones, C. L. Koerner, and K. M. Lee (eds.), *Wildland fire in ecosystems: effects of fire on cultural resources and archaeology*. Rainbow Series, USDA Forest Service. Rocky Mountain Research Station. Fort Collins: 97–111.
- Delgado-Raack S. 2008. *Prácticas económicas y gestión social de recursos (macro)líticos en la Prehistoria reciente (III–I milenios AC) del Mediterráneo Occidental*. PhD dissertation. Universitat Autònoma de Barcelona. Barcelona.
- Delgado-Raack S., Risch R. 2009. Towards a systematic analysis of grain processing technologies. In M. de Araújo Igreja, I. Clemente Conte (eds.), *Recent functional studies on non-flint stone tools: Methodological improvements and archaeological inferences*. Proceedings of the Workshop. LAMPEA 23–25 May 2008, Laboratoire Méditerranéen de Préhistoire Europe-Afrique. Lisboa. <http://www.workshop-traceologia-lisboa2008.com>
- Delgado-Raack S., Gómez-Gras D., and Risch R. 2009. The mechanical properties of macrolithic artifacts: A methodological background for functional analysis. *Journal of Archaeological Science* 36(9): 1823–1831. <https://doi.org/10.1016/j.jas.2009.03.033>
- Del Pilar Babot M., Apella M. C. 2003. Maize and bone. Residues of grinding in northwestern Argentina. *Archaeometry* 45: 121–132. <https://doi.org/10.1111/1475-4754.00099>
- Dubreuil L. 2002. *Etude fonctionnelle des outils de broyage natoufiens: nouvelles perspectives sur l'émergence de l'agriculture au Proche-Orient*. PhD dissertation. Université de Bordeaux 1. Bordeaux.
2004. Long-term trends in natufian subsistence: A use-wear analysis of ground stone tools. *Journal of Archaeological Science* 31: 1613–1629. <https://doi.org/10.1016/j.jas.2004.04.003>
2009. Functional analysis of grinding tools from the natufian site of Mallaha: Toward an understanding of assemblage evolution in the Levant. *The Arkeotek Journal* 3(1). <http://www.thearkeotekjournal.org/tdm/Arkeotek/fr/archives/2009/1Dubreuil.xml>
- Elster E. S. 2003. Grindstones, polished edge-tools, and other stone artifacts. In E. S. Elster, C. Renfrew (eds.), *Prehistoric Sitagroi: Excavations in northeast Greece, 1968–1970, vol. 2: The Final Report* (Monumenta Archaeologica 20). Cotsen Institute of Archaeology at UCLA. Los Angeles: 175–195.
- Fotiadis M. 1988. Kitirini Limni, Nomou Kozanis, 1987. Προϊστορική Ερευνα. *To Archaeologiko Ergo sti Makedonia kai Thraki* 1: 51–61. (in Greek)
- Fotiadis M., Hondroyianni-Metoki A. 1997. Kitirini Limni: Diachroniki sinopsi, radiochronologiseis, kai i anaskafitou 1993. *To Archaeologiko Ergo sti Makedonia kai Thraki* 7: 19–31. (in Greek)
- Gast M. 1968. *Alimentation des populations de l'Ahaggar: étude ethnographique*. Arts et métiers graphiques. Paris.
- Gelbert A. 2005. Evolution du matériel de broyage des Dii de Djaba (Nord-Cameroun) durant les deux derniers siècles. Etudes ethno-archéologique et archéologique. In C. Raimond, E. Garine, and O. Langlois (eds.), *Ressources vivrières et choix alimentaires dans le bassin du lac Tchad*. IRD-Prodig, coll. Colloques et séminaires. Paris: 319–347.
- Gould R. 1968. Living Archaeology: the Ngaratjatjara of Western Australia. *Southwestern Journal of Anthropology* 24(2): 101–122. www.jstor.org/stable/3629417
- Graefe J. 2009. Mahlsteine: Funktion, Fertigung und Verbreitung. *Archäologische Informationen* 32(1–2): 75–81. <http://nbn-resolving.de/urn:nbn:de:bsz:16-ai-102573>
- Hamon C. 2008a. Functional analysis of stone grinding and polishing tools from the earliest Neolithic of northwestern Europe. *Journal of Archaeological Science* 35(6): 1502–1520. <https://doi.org/10.1016/j.jas.2007.10.017>
- 2008b. Meules rubanées, meules blicquiennes: nouvelles réflexions sur les dépôts du Hainaut (Belgique). In L. Burnez-Lanotte, M. Ilett, and P. Allard (eds.), *Fin des*

- traditions danubiennes dans le Néolithique du Bassin parisien et de la Belgique (5100–4700 av. J.C.). Autour des recherches de Claude Constantin.* Société Préhistorique française. Paris: 197–208.
- 2008c. The symbolic value of grindingstones hoards: Technical properties of Neolithic examples. In C. Hamon, B. Quilliec (eds.), *Hoards from the Neolithic to the Metal Ages. Technical and codified practices*. British Archaeological Reports IS 1758. Archaeopress. Oxford: 19–28.
- Hamon C., Le Gall V. 2011. Les meules en pays Minyanka (Mali): étude des carrières et techniques de production actuelles. In D. Williams, D. Peacock (eds.), *Bread for the people. The archaeology of mills and milling. Proceedings of a colloquium held in the British School at Rome 4th – 7th November 2009*. British Archaeological Reports IS 2274. Archaeopress. Oxford: 19–28.
2013. Millet and sauce: The uses and functions of querns among the Minyanka (Mali). *Journal of Anthropological Archaeology* 32(1): 109–121. <https://doi.org/10.1016/j.jaa.2012.12.002>
- Hamon C., Emery-Barbier A., and Messenger E. 2011. Quelle fonction pour les meules du Néolithique ancien de la moitié Nord de la France? Apports et limites de l'analyse phytolithique. *Revue archéologique de Picardie* 28: 515–521. <https://doi.org/10.3406/pica.2011.3355>
- Hayden B. 1987. Traditional metate manufacturing in Guatemala using chipped stone tools. In B. Hayden (ed.), *Lithic studies among the contemporary Highland Maya*. University of Arizona Press. Tucson: 9–119.
- Hersh T. 1981. *Grinding stones and food processing techniques of the Neolithic societies of Turkey and Greece*. PhD dissertation. Columbia University. New York.
- Hodder I. 1990. *The domestication of Europe: Structure and contingency in neolithic societies*. Blackwell. Oxford, UK.
- Hondroyianni-Metoki A. 2011. Kleitos 2009. I anaskafi sta anatolika oria tou Neolithikou oikismou »Kleitos 1« kai ston oikismo »Kleitos 2«. *To Archaeologiko Ergo stin Ano Makedonia* 1(2009): 231–244. (in Greek)
- Horsfall G. A. 1987. Design Theory and Grinding Stones. In B. Hayden (ed.), *Lithic Studies Among the Contemporary Highland Maya*. The University of Arizona Press. Tucson: 332–377.
- Kalchev P. 2013. *An early Neolithic two-level building at Tell Okrazhna bolnitsa in Stara Zagora*. Municipality of Stara Zagora. Stara Zagora.
- Karamitrou-Mentesidi G. 1987. Proistorikoi oikismoi Kitirnis Limnis (Saringiol) Kozanis. In S. Drougou, C. Saatoglou-Paliadeli, and M. Tiverios (eds.), *Amitos. Timitikos tomos yia ton kathiyiti Manoli Androniko, vol. 1*. Thessaloniki: 391–416. (in Greek)
- Lidström Holmberg C. 2004. Saddle querns and gendered dynamics of the Early Neolithic in Mid Central Sweden. In H. Knutsson (ed.), *Coast to Coast, arrival: Results and reflections. Proceedings of the final Coast to Coast Conference 1–5*. Uppsala Universitet. Uppsala: 199–231.
- Liu L., Field J., Fullagar R., Bestel S., Chen X., and Ma X. 2010. What did grinding stones grind? New light on early Neolithic subsistence economy in the Middle Yellow River Valley, China. *Antiquity* 84(325): 816–833. <https://doi.org/10.1017/S0003598X00100249>
- Menasanch M., Risch R., and Soldevilla J. A. 2002. Las tecnologías del procesamiento de cereal en el sudeste de la península ibérica durante el III y el II milenio A. N.E. In H. Procopiou, R. Treuil (eds.), *Moudre et broyer: L'interprétation fonctionnelle de l'outillage de mouture et de broyage dans la Préhistoire et l'Antiquité. I. Méthodes. Actes de la table ronde internationale, Clermont-Ferrand. 30 nov. – 2 déc. 1995*. Editions du CTHS. Paris: 81–110.
- Mould C. A., Ridley C., and Wardle K. A. 2000. The small finds: Stone. In C. Ridley, K. A. Wardle, and C. A. Mould (eds.), *Servia I: Anglo-Hellenic Rescue Excavations 1971–1973 (BSA Supplement 32)*. The British School at Athens. London: 112–190.
- Moundrea-Agrafioti A. 2007. Líthina ergalía. In C. Doumas (ed.), *Akrotiri Thiras Ditikí Ikía: trápezes, líthina, metállina, pikíla*. Athens Archaeological Society. Athens: 73–112.
- Nelson M. C., Lippmeier H. 1993. Grinding-tool design as conditioned by land-use pattern. *American Antiquity* 58(2): 286–305. <https://doi.org/10.2307/281971>
- Nierlé M. C. 1983. Mureybet et Cheik Hassan (Syrie): Outillage de mouture et de broyage (9e et 8e millénaires). *Cahiers de l'Euphrate* 3: 177–216.
2008. L'outillage de mouture et de broyage. In J. J. Ibáñez (ed.), *Le site néolithique de Tell Mureybet (Syrie du Nord) vol. II*. British Archaeological Reports IS 1843. Oxford: 539–568.
- Ninou I. 2006. *Analysis of grinding stones from Neolithic sites of northern Greece: Dispilio and Apsalos*. MA thesis, University of Southampton.
- Nixon-Darcus L. 2014. *The cultural context of food grinding equipment in northern Ethiopia: An ethnoarchaeo-*

- logical approach. MA thesis. Simon Fraser University. Vancouver.
- Nixon-Darcus L., D'Andrea A. C. 2017. Necessary for life: Studies of ancient and modern grinding stones in Highland Ethiopia. *African Archaeological Review* 34: 193–223. <https://doi.org/10.1007/s10437-017-9252-4>
- Plassart A. P. 1928. *Les Sanctuaires et les Cultes du Mont Cynthe*. Exploration Archéologique de Délos. Fascicule XI. E. de Boccard. Paris.
- Poursat J. C., Procopiou H., and R. Treuil. 2000. Oi oikia-kes drastiriotites sto Quartier Mu. I alesi kai i iphantiki. In *Pepragmena tou H' Diethnous Kritoloyikou Sinedriou, Heraklion 9-14 Septemvriou 1996, vol. A3: Proistoriki kai Archaia Elliniki Periodos*. Heraklion: 99–114. (in Greek)
- Procopiou H. 1998. *L'outillage de mouture et de broyage en Crete Minoenne*. PhD dissertation. Université de Paris 1 (Panthéon-Sorbonne). Paris.
2013. Les outils lithiques. In J. C. Poursat (ed.), *Vie quotidienne et techniques au Minoen Moyen II: fouilles exécutées à Malia: le quartier Mu*. Études Crétoises 34. École Française d'Athènes. Athens: 43–66.
2014. Barley meal processing in the Aegean world: A look at diversity. In P. C. Anderson, A. van Gijn, and J. Whittaker (eds.), *Early Agricultural Remnants and Technical Heritage (EARTH): 8,000 Years of Resilience and Innovation, vol. 2*. Oxbow Books. Oxford: 243–246.
- Procopiou H., Jautee E., Vargiolu R., and Zahouani H. 1998. Petrographic and use-wear analysis of a quern from Syvritos Kephala. In F. Facchini, A. Palma Di Cesnola, M. Piperno, and C. Peretto (eds.), *Actes du XIIème Congrès de l'UISPP, Forlì, 8–14 Septembre 1996. Workshop 17: Analyse fonctionnelle des Pièces Lithiques: Situation actuelle de la recherche, Tome II*. A.B.A.C.O Edizioni. Forlì: 1183–1192.
- Procopiou H., Anderson P., Formenti F., and Jordi J. T. 2002. Étude des matières transformées sur les outils de mouture: Identification des résidus et des traces d'usure par analyse chimique et par observation en microscopie optique et électronique. In H. Procopiou, R. Treuil (eds.), *Moudre et broyer: L'interprétation fonctionnelle de l'outillage de mouture et de broyage dans la Préhistoire et l'Antiquité. I. Méthodes. Actes de la table ronde internationale, Clermont-Ferrand. 30 nov. – 2 déc. 1995*. Editions du CTHS. Paris: 111–127.
- Risch R. 2008. Grain processing technologies and economic organisation: A case study from the South-East of the Iberian Peninsula during the Copper Age. *The Arkeotek Journal* 2(2): 1–3. <http://www.thearkeotekjournal.org/tadm/Arkeotek/fr/archives/2008/2Risch.xml>
- Robitaille J. 2016. The ground stone industry of the Mursi of Maki, Ethiopia: Ethnoarchaeological research on milling and crushing equipment techniques and functions. *Journal of Lithic Studies* 3(3): 429–456. <https://doi.org/10.2218/jls.v3i3.1680>
- Roux V. 1985. *Le matériel de broyage. Étude ethnoarchéologique à Tichitt (R.I) Mauritanie*. Mémoire no 58. Edition Recherches sur les civilisations. Paris.
- Runnels C. 1981. *A diachronic study and economic analysis of millstones from the Argolid*. PhD dissertation. Indiana University. Indianapolis.
- Ryan K. C. 2010. Effects of fire on cultural resources. In D. X. Viegas (ed.), *Proceedings of the VI International Conference on Forest Fire Research, 15–18 November 2010, Coimbra, Portugal*. University of Coimbra. Coimbra.
- Schlanger S. H. 1991. On manos, metates and the history of site occupations. *American Antiquity* 56(3): 460–474. <https://doi.org/10.2307/280895>
- Schneider J. S. 1996. Quarrying and production of milling implements at Antelope Hill, Arizona. *Journal of Field Archaeology* 23(3): 299–311. <https://www.jstor.org/stable/530484>
- Schön W., Holter U. 1988. Zum Gebrauch von Reib- und Mahlsteinen in der Ostsahara. *Archäologische Informationen* 11: 156–160.
- Schroth A. B. 1996. An Ethnographic Review of Grinding, Pounding, Pulverizing, and Smoothing with Stones. *Pacific Coast Archaeological Society Quarterly* 32(4): 55–75. https://www.researchgate.net/profile/Adella_Schroth2/publication/265480727
- Shoemaker A. C., Davies M. I. J., and Moore H. L. 2017. Back to the grindstone? The archaeological potential of grinding-stone studies in Africa with reference to contemporary grinding practices in Marakwet, northwest Kenya. *African Archaeological Review* 34: 415–435. <https://doi.org/10.1007/s10437-017-9264-0>
- Souvatzi S. 2013. Diversity, uniformity and the transformative properties of the house in Neolithic Greece. In D. Hofmann, J. Smyth (eds.), *Tracking the Neolithic house in Europe: Sedentism, Architecture and Practice*. Springer. New York: 45–64.
- Stroulia A. 2005. Lithina tripta apo tin Kitrini Limni Kozanis: proti prosengisi, prota erotimata. *To Archaeologi-*

ko Ergo sti Makedonia kai Thraki 17 (2003): 571–580. (in Greek)

2010. *Flexible stones: Ground stone tools from Franchthi Cave*. Fascicle 14, Excavations at Franchthi Cave, Greece. Indiana University Press. Bloomington, Indianapolis.

2014. Ergalia me kopsi apo tin Kremasti Kilada, nomou Kozanis: Viographikes paratiriseis. *To Archaeologiko Ergo sti Makedonia kai Thraki* 24 (2010): 63–71. (in Greek)

2018. Macrolithics: ordinary things in an extraordinary place. In A. Papathanasiou, W. A. Parkinson, D. J. Pullen, M. L. Galaty, and P. Karkanis (eds.), *Neolithic Alepotrypa Cave in the Mani, Greece. In honor of George Papathanassopoulos*. Oxbow Books. Oxford: 201–241.

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*. Presses universitaires de Louvain. Louvain: 109–131.

Stroulia A., Dubreuil, L., Robitaille, J., and Nelson K. 2017. Salt, sand, and saddles: Exploring an intriguing work face configuration among grinding tools. *Ethnoarchaeology* 9(2): 119–145. <https://doi.org/10.1080/19442890.2017.1364053>

Teklu G. 2012. *Ethnoarchaeological study of grind stones at Lakia'a in Adwa, Tigray Regional state, Ethiopia*. MA thesis. Addis Ababa University. Addis Ababa.

Todorova H. 1978. *The Eneolithic period in Bulgaria in the fifth millennium BC*. British Archaeological Reports IS 49. Archaeopress. Oxford.

Tringham R. 1971. *Hunters, fishers and farmers of eastern Europe, 6000–3000 BC*. Hutchinson. London.

Tringham R., Bruckner B., and Voytek B. 1985. The Opovo project: a study of socioeconomic change in the Balkan Neolithic. *Journal of Field Archaeology* 12: 425–444. <https://doi.org/10.1179/009346985791169832>

Tsoraki C. 2007. Unravelling ground stone life histories: the spatial organization of stone tools and human activities at LN Makriyalos, Greece. *Documenta Praehistorica* 34: 289–97. <https://doi.org/10.4312/dp.34.22>

2008. *Neolithic society in northern Greece: The evidence of ground stone artefacts*. PhD dissertation. University of Sheffield. Sheffield.

Valamoti S. M., Chondrou D., and Papadopoulou L. 2013. Plant food processing and ground stone equipment in

prehistoric Greece: An experimental investigation using seeds of einkorn and grass-pea. In P. C. Anderson, C. Cheval, and A. Durand (eds.), *Regards croisés sur les outils liés au travail des végétaux. XXXIIIe rencontres internationales d'archéologie et d'histoire d'Antibes*. APDCA. Antibes: 169–187.

Veth P., Fullagar R., and Gould R. 1997. Residue and use-wear analysis of grinding implements from Puntutjarpa Rockshelter in the Western Desert: Current and proposed research. *Australian Archaeology* 44: 23–25. <https://doi.org/10.1080/03122417.1997.11681590>

Wright M. K. 1993. Simulated use of experimental maize grinding tools from southwestern Colorado. *KIVA* 58(3): 345–355. <https://doi.org/10.1080/00231940.1993.11758214>

Wright K. I. 1994. Ground-stone tools and hunter-gatherer subsistence in southwest Asia: Implications for the transition to farming. *American Antiquity* 59(2): 238–263. <https://doi.org/10.2307/281929>

2014. Domestication and inequality? Households, corporate groups and food processing tools at Neolithic Çatalhöyük. *Journal of Anthropological Archaeology* 33: 1–33. <https://doi.org/10.1016/j.jaa.2013.09.007>

Zimmermann A. 1988. Steine. In U. Boelcke (ed.), *Der Bandkeramische Siedlungsplatz Langweiler 8, Rheinische Ausgrabungen* 28. Rheinland Verlag. Köln: 569–787.

Ziota C. 2011. O neolithikos oikismos »Kleitos 1« kai ta neotera dedomena yia tin proistoriki erevna. *To Archaeologiko Ergo stin Ano Makedonia* 1(2009): 211–230. (in Greek)

2014a. O oikismos tou Kleitou Kozanis sto evritero phisiko kai anthropoyenes perivallon tis Neoteris kai Telikis Neolithikis periodou. In E. Stefani, N. Merousis, and A. Dimoula (eds.), *Praktika Diethnous Sinedriou »1912– 2012: Ekato chronia erevnas stin proistoriki Makedonia«, Archaeologiko Mouseio Thessalonikis, 22–24 Noemvriou 2012*. Archaeological Museum of Thessaloniki. Thessaloniki: 323–336. (in Greek)

2014b. I anaskafi ston Kleito Kozanis to 2010. *To Archaeologiko Ergo sti Makedonia kai Thraki* 24(2010): 53–62. (in Greek)

Ziota C., Hondroyianni-Metoki A., and Maggouretsiou E. 2013a. Recent prehistoric research in the Kitrini Limni area of the Kozani prefecture. *To Archaeologiko Ergo stin Ano Makedonia* 2(2011): 57–82.

2013b. I archaeologiki erevna ston Kleito Kozanis to 2009. *To Archaeologiko Ergo sti Makedonia kai Thraki* 23(2009): 37–52. (in Greek)