The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern Levant): A multi-scale use-wear approach for assessing the assemblage functional variability

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Abstract

In the archaeological record, Ground Stone Tools (hereafter GST) represent an important tool group that provides invaluable data for exploring technological development and changes in resource exploitation over time. Despite its importance, Lower and Middle Paleolithic (MP) GST technology remains poorly known and understudied. The MP record of the Levant constitutes a compelling case study for exploring the nature and character of GST technology. Especially the site of Nesher Ramla (Israel, end of Marine Isotope Stage 6/beginning of 5) has provided one of the world's largest GST assemblages from MP contexts.

Aiming at evaluating the variability of tool types at the site from a technological and functional perspective, this study follows an analytical approach which integrates different scales of analysis. Our workflow seeks to generate and combine qualitative and quantitative data allowing: 1) the identification of damage areas, and 2) functional analysis, based on the location, distribution, and characterization of use-wear traces.

This study shows a substantial level of diversification in resource exploitation (e.g., mineral, hard animal material and likely perishable components). Results show the presence of several tool types on which diagnostic use-wear can be associated with different activities. Importantly, our analysis indicates the presence of various hammerstone types showing distinct wear characteristics. The variability observed within the hammerstones likely reflects different functions, including in some

cases the processing of distinct worked materials. Ultimately, this study contributes to our understanding of the significance of GST technology for the ecological dynamics of MP populations.

Keywords: Ground Stone Tools; Middle Paleolithic; Levant; Use wear; Experiments; Quantification

1. Introduction

The study of ground stone tools (GST) is essential to understanding the evolution of human behavior through time and space. Their appearance in the archaeological record stretches from the earliest evidence of human activity to the present day and crosses a wide geographic distribution. In fact, these artifacts represent one of the most persistent and durable technological adaptations in the evolution of human behavior. Their use has been documented from early prehistory to the present day among several primate groups (Carvalho et al., 2008; Dubreuil et al., 2015; Falótico et al., 2019; Goren-Inbar et al., 2002; Hayes, 2015; Luncz et al., 2019; Pop et al., 2018). By definition, this group of tools includes any stone that is manufactured or used through abrasion, polish, or impact (Adams, 2002, 2014). Although “Ground Stone Tools” is one of the most widespread terms used for these implements, other terms – such as macro-lithic tools (Adams et al., 2009; Caricola et al., 2018) or non-flaked tools (de la Torre & Mora, 2010) – have also been employed in the literature. In this study, we use the terms GST since it is the most inclusive terminology (Adams, 2014).

As shown by the different terminologies used in the literature, researchers have been suggesting a wide range of use for the various morpho-types included in the GST group, encompassing – among others – activities related to the processing of organic materials (e.g., plants, animal matters), and to the exploitation of mineral products (e.g. ochre processing and lithic knapping). Due to their wide range of possible uses, these artifacts are likely to preserve direct evidence of a large number of past activities, including the processing of perishable elements (e.g., organic materials). Hence, this makes the study of GST a very important topic when addressing past human behavioral traits, since these tools could show major changes in resource exploitation strategies (Assaf et al., 2020; Beaune, 2004; Dubreuil & Savage, 2014; Revedin et al., 2010).

In the Levant, GST have been documented in the Lower Paleolithic period (Goren-Inbar et al., 2002, 2015; Rabinovich et al., 2008; Shimmelmütz et al. 2021). During the Levantine MP (ca. 250-

47 Ka BP) (Mercier, 2003; Mercier et al., 2007; Rebollo et al., 2011; Valladas et al., 1999, 2013), GST have been reported from several sites, namely at Nesher Ramla ~170-80ka BP (Prévost & Zaidner, 2020; Zaidner et al., 2014, 2018), Far'ah II, ~49-47ka BP (Gilead & Grigson, 1984; Goder-Goldberger et al., 2020), Ein Qashish ~70-55 ka BP (Been et al., 2017; Ekshtain et al., 2019; Hovers et al., 2008; Malinsky-Buller et al., 2014), Quneitra ca. 55 ka BP (Zineni ESR in Goren-Inbar, 1990; Oron & Goren-Inbar 2014 for the TL), and Umm El Tlel ca. 70 BP (Boëda et al., 2008; Griggo et al., 2011). In the open-air sites of Hummal and Quneitra, GST have been associated with knapping (Hauck, 2010) and animal bone processing (Hovers et al., 2008; Oron & Goren-Inbar, 2014). From these sites, the assemblage of GST includes artefacts such as hammerstones, anvils and other processing tools (Ekshtain et al., 2019; Goren-Inbar et al., 2002, 2014, 2015). In most of these sites, GST are made of limestone or basalt and occur in many of the MP sites in low numbers. Their frequencies, diversity and level of standardization dramatically increase in later periods, especially during the Natufian (Wright, 1992; Belfer-Cohen & Hovers, 2005). Several hypotheses have been suggested to explain the development of GST technology through the Paleolithic. These include diversification in the exploitation of resources, likely reflecting the processing of mineral, animal (e.g., bone processing) as well as vegetal products, such as plants, wild cereals, and oily fruits (e.g., pistachio, acorn). Exploitation of the latter is attested in the Levant by the identification of paleobotanical remains in MP archaeological layers of Kebara and Doura Cave (Aharonovich et al., 2014; Lev et al., 2005; Matsutani, 1984).

Although some preliminary and general interpretations have been suggested, our current knowledge regarding the significance of GST variability and function in the MP of the Levant remains very limited. GST have been mainly recognized in open-air sites, while their presence seems to be very rare in caves and rock-shelters. The reasons for this distribution pattern are still unknown. It can either be: 1) due to a research bias related to the difficulty in the identification of these artifacts, which are mainly represented in coarse-grained rocks and in many cases without knapping preparation; 2) related to the specific function of these items and their presence in association with different site-types, which is likely to reflect different human behavioral strategies; 3) the caves in the MP were usually used as base camp sites and hominins could purposefully remove the GST from the sites for cleaning of the living areas or other non-functional purposes.

Understanding this differential distribution of MP GST relies partly on our ability to improve our current analytical methods for identifying and characterizing GST implements, and the

understanding of the specific function(s) of the different types of tools, as well as their representation within and between archaeological sites.

Focusing on understanding the variability and function of GST, this study centers on the analyses of the GST artifacts from Nesher Ramla, specifically on the Unit V, which represents the largest GST assemblage so far known in the Levantine MP. This analysis offers a unique opportunity to investigate the functional variability of GST during the MP in an open-air context. Our study relies on a multi-scale approach, combining qualitative and quantitative data acquisition, and is supported by the development of an experimental reference collection. The reference collection is briefly presented in the Materials and Methods section but more fully discussed in a dedicated paper (Paixao et al. 2021). The goal of this article is to explore the variability in tool morpho-types and use-wear patterns found in Unit V GST assemblage. While functional interpretations are suggested here as hypotheses, some of these require testing in future experiments, our goal is to assess whether this uniquely large assemblage is dominated by tools related to flint knapping or if other activities are also represented.

2. The site of Nesher Ramla (Israel)

Nesher Ramla is an open-air site located on the western slopes of the Judean hills bordering the Mediterranean coastal plain of Israel (Fig. 1). It was excavated as a rescue project during 2010-2011 (Zaidner et al., 2014, 2018).

Geologically, Nesher Ramla can be defined as a sinkhole, formed by sagging and deformation of the surface due to collapse of an underground karstic void (Frumkin et al., 2015; Zaidner et al., 2014). The 8 meters of archaeological sediments were discovered below 12 meters of sterile infill, in the middle of the funnel-shaped depression. The archaeological sequence is divided into six main archaeological units (I-VI; Fig. 1 B) dated to the end of Marine Isotopic Stage (MIS) 6 and MIS 5 (160-80 ka BP) (Guérin et al., 2017; Zaidner et al., 2014). All the units are rich in lithic and faunal remains as well as GSTs and manuports. Their frequencies vary along the sequence, however, with units III and V showing the highest density of archaeological materials compared to the upper units I and II (Centi & Zaidner, 2020; Prévost & Zaidner, 2020; Zaidner et al., 2018) (Fig. 1).

The overall technology of the knapped lithic assemblages is characterized by the use of the Levallois reduction system for flake production. Although a specific reduction sequence for the production of naturally backed knives has been identified, the assemblage lacks elongated blanks,

and point production is underrepresented (Prévost & Zaidner, 2020; Zaidner et al., 2014, 2018). The retouched tool assemblages are mostly composed of intensively retouched side-scrapers and tools with lateral tranchet blow (Prévost et al. this issue; Zaidner & Grosman, 2015). Nesher Ramla also presents the largest assemblage of bulb retouchers known in the Middle East for MP contexts (Centi and Zaidner, 2020). In terms of raw material exploitation, the knapped lithic assemblage is dominated by a local Mishash flint followed by the exploitation of flint from indeterminate sources and Eocene flint which are considered to be non-local or semi-local (Ekshtain and Zaidner, this issue).

In terms of faunal remains, all units are marked by large faunal assemblages, dominated by aurochs, equid, and tortoise remains (Zaidner et al., 2014., Crater Gershtein et al., 2020). The site is also rich in well-preserved combustion features composed of ash and charcoal (Friesem et al., 2014; Pietraszek et al., in press).

2.1. The archaeological horizon of Unit V

Unit V of Nesher Ramla dated to the beginning of MIS 5 is a 20-30 cm thick layer of brown-gravelly clay that extends over an area of ca. 50-60 m². The entire layer was excavated. The layer is characterized by the presence of large anthropogenic accumulations of animal bones, limestone pebbles, cobbles and boulders and knapped lithic artifacts. Also, features associated with combustion and characterized by the accumulation of a considerable amount of burned bones and wood ash have been identified (Friesem et al., 2014). The lithic assemblage of Unit V is still under analysis; however, preliminary observations show technological patterns similar to the ones observed for the upper units (Zaidner, pers. comm).

Unit V contains 471 non-knapped stone items categorized as pebbles, cobbles, and boulders, mainly of limestone and rarely of flint. This number does not include fragments of ‘*nari*’, a calcite crust that developed on the surface of Senonian chalk that constitutes the local eroded calcrete bedrock. The limestone pebbles, cobbles, and boulders do not occur naturally at the site (Friesem et al., 2014; Zaidner et al., 2018) and, therefore, it is likely that they had been brought there deliberately. The artifacts appear distributed through the entire unit, but it was possible to identify some concentrations (Fig. 1 A). Among these 471 non-knapped stones, 185 are categorized as GST due to the presence of use-wear. This study is focused on the characterization of this artefactual group, exploring technological variability and function.

3. Materials and methods

3.1. Methodological workflow

In this study, 471 items were analyzed, including pieces categorized as pebbles, blocks, cobbles, and boulders (Tab. 1 and 2). These artifacts consist mostly of limestone (97.5%) plus a small amount of flint (2.5%). It should be noted here that we are using the term ‘artifact’ in a broad sense, to designate implements showing evidence of having been used with or without minimal prior manufacture.

The variability and exceptional preservation of this large assemblage provide a unique opportunity to explore and apply a multi-scale approach to this type of tools, combining qualitative and quantitative data (Dubreuil & Savage, 2014; Marreiros et al., 2020). Our analytical workflow includes four main steps:

- a) *Sorting and sampling*: all stone artifacts (excluding debitage by-products such as flakes) collected from Unit V during the excavations were sorted and subjected to a preliminary examination, combining naked eye and stereo-microscope observations in order to assess surface preservation and identify possible anthropic alterations. The following technological and functional analyses included all the materials with clear and visible evidence of use-wear or implements that show surfaces suitable for preservation of micro use-wear. All the materials that do not occur naturally in the site (e.g., river pebbles) – excluding the *nari* rock fragments that are a natural by-product of the local eroded bedrock (Frumkin et al., 2015; Zaidner et al., 2014) – were selected for detailed analyses.
- b) *Residue sampling and cleaning*: before cleaning (with running tap water), items presenting a high potential for use-wear traces and residues preservation were selected for further analysis. The sampling for further residue analyses followed standard protocols such as the micro-pipette extraction method (Hayes, 2015). Analysis of the residue samples is still in progress and will in future be combined with the use-wear analysis presented here.
- c) *Technological and typological characterization*: All artifacts were measured (length, width, thickness) and weighed. Typologically, they were classified as anvils (wear concentrated in the central area, interpreted as passive tools), hammerstones (impact marks on their extremities or edges), abraders (tools with striations or levelling indicative of abrasion motion), pestles (tools with mixture of characteristics interpreted as impacts and crushing

189 motions) and choppers (with an irregular cutting edge). This follows the categorization
190 commonly used and established by J. Adams (2014).

- 191 d) *Use-wear imaging*: This step of the analysis combines low and high-power microscopy
192 (Adams et al., 2009; Dubreuil et al., 2015; Dubreuil & Savage, 2014; Fullagar, 2014;
193 Hayden, 1979; Keeley, 1974, 1980; Rots, 2013; Bofil et al., 2013; Hayes et al., 2018;
194 Caricola et al., 2020). The first phase is based on macro-observation with a stereo
195 microscope (ZEISS Stemi 305) and microscopic observation using a portable microscope
196 (Dino-Lite Edge AM7915MZT) (see acquisition settings in SOM 1). This phase of the
197 workflow focuses on the preliminary analysis and documentation of the surfaces
198 (natural/anthropic alterations), and on a general characterization of raw materials
199 properties.

200 We created a virtual grid divided into 9 squares for each surface (called A and B) to register
201 the location of the macro wear traces. The tool was orientated according to its longitudinal
202 axis.

203 For a more detailed characterization and imaging of the use-wear at macro scale, we used
204 a digital camera (Nikon DSLR camera, model D610 with a Nikon AF-S VR Micro-Nikkor
205 105 mm f/2.8G IF-ED lens) and a 3D digital automated microscope ZEISS Smartzoom 5
206 (equipped with a PlanApo 1.6×/0.1 objective and an integrated segmented LED ring light)
207 in order to capture larger areas with low magnification. All the artifacts included in this
208 study were also scanned with a portable scanner (HP 3D Structured Light Scanner Pro S3
209 [DAVID SLS-3] (see acquisition settings in SOM1). The 3D models were used for
210 documentation and morphometric analyses.

211 For the microscopic approach, a reflected light microscope (ZEISS Axio Scope.A1 MAT,
212 objective EC Epiplan 10x/0.25 M27 FWD=11.0 mm and Objective EC Epiplan 20x/0.4
213 M27 FWD=3.2mm) was used to analyze the areas with polish formation. During the
214 analysis, all pictures were acquired with the dedicated software ZEISS Zen Core, using the
215 image Extended Depth of Focus (EDF) stacking module to generate in-focus images. In
216 order to combine our qualitative approach with micro quantitative data we used confocal
217 microscopy. This technology has already been demonstrated to be an accurate and valuable
218 tool for micro-polish characterization (Calandra et al., 2019; Evans et al., 2014; Evans &

Donahue, 2008). A sample of 12 polished areas from 4 tools was selected for scanning with a confocal microscope, in order to quantitatively characterize the topography of the different polish identified in the assemblage. The samples for confocal microscopy were selected to represent the variability observed in the assemblage using reflected light microscopy. All micropolish surface texture acquisitions were done using a 3D Laser Confocal microscope (LSM 800 MAT mounted onto an Axio Imager.Z2 Vario light microscope, Carl Zeiss Microscopy GmbH). The C Epiplan-Apochromat 50×/0.75 objective was used for all data acquisitions. The field of view (FOV) was 255.6x255.6 µm and the pixel size (spacing) was 0.0852 µm (see additional acquisition settings in SOM 1).

The resulting 3D surface data were processed in batch in ConfoMap v8.1.9286 (a derivative of MountainsMap Imaging Topography developed by Digital Surf, Besançon, France).

All surface processing and analysis was done using templates adapted from Calandra et al. (2019), Schunk et al. (in preparation) and Paixão et al. (2021) for the surface roughness standard following ISO 25178 (ISO 25178-2) (analysis workflow detailed in SOM 2). When possible, three areas within the micropolish were measured. For some of the artifacts this was not possible, due to the low degree of polish formation or unclear and non-diagnostic classification of the polished area (SOM 3).

All data analysis and plotting were performed in the open-source software R (see SOM 3). In this study, surface texture quantification was first explored on a small sample of tools showing different wear patterns. This initial test mainly aimed at evaluating our qualitative classification of the microwear traces identified. All surface processing and analysis was done using templates adapted from Calandra et al. (2020) for the surface texture areal analysis, following ISO 25178-2 parameters (International Organization for Standardization, 2012), furrow parameters, texture direction parameters, and texture isotropy parameters.

After acquisition, digital images (including overviews, areas of interest and particular macro features) were edited using GIMP (free open-source image editor, available at <https://www.gimp.org/>, v.2.10.18). All edited images were later combined and processed using Inkscape (free and open-source vector graphics editor, available at <https://inkscape.org/>, v.0.92.4).

3.2. *Experimental reference proxy and use-wear analysis*

Bone processing and flint knapping activities are the two most straightforward explanations accounting for the large accumulation of GST at Nesher Ramla. The significance of these activities is indicated by both the macroscopic identification of impact marks and the characteristics of the archaeological unit composition, which is rich in knapped materials and fragmented bones (Crater Gershtein et al., 2020). However, criteria for the identification of bone processing use-wear on GST and for differentiating bone processing from flint knapping has yet to be clearly established. Consequently, we prioritized experimental replication of both activities in order to build a comparative ‘library’ documenting diagnostic use-wear on limestone cobbles. Thus, a first set of controlled experiments was designed to compare percussion (or thrusting percussion) activities on bone (*bone breaking*) and flint (*knapping*). For that purpose, we used a mechanical apparatus (Inotec, SMARTTESTER) that enabled us to control and record a large number of parameters (e.g., force, position, number of impacts) (see more details in Calandra et al., 2020; Paixão et al. 2021).

In our experiment, a total of 23 tools were used: 12 for bone breaking and 11 for flint knapping. All the tools are limestone river cobbles collected in Nahal Ayalon riverbed, located a few hundred meters away from the Nesher Ramla site. They were selected because of their similarities (shape, raw material and aspect of the surface) with the archaeological artifacts. Using a specifically designed mechanical setup, the hammerstones were assembled in the device according to a standard position (60 cm from the contact material in a vertical axis). The impact force for all the experimental tools was standardized by using the same drop distance and the same added weights (2.5 Kg). Fifteen items were used for 50 impacts, and the others were used more extensively (up to 500 impacts). One anvil was used for each contact material used (one for flint and one for bone). This set of experiments also allowed a clear characterization of macro and micro wear traces generated during the contact with bone and flint. This data was used as a comparative collection for the analyses of the archaeological tools. As previously mentioned, the complete details of the set up and the results from this experimental program are presented in a separate paper (Paixão et al., 2021).

Wear traces were identified and documented following the common terminology of GST studies (Adams 2002, 2014; Adams et al., 2009; Dubreuil et al., 2015; Dubreuil and Savage 2014). Use-wear traces were systematized into three main categories: abrasive (e.g. striations, surface

leveling), impact (surface macro fractures) and micropolish (i.e. sheen). For the micropolish analysis, we defined different types in order to group the use-wear according to the polish characteristics, taking into consideration the distribution of the mesh, the level of penetrations in the micro-topography, the morphology of the cross section, the texture, contours of the polish, and the presence of other features such as striations and abrasive tracks.

4. Results

Observation by the naked eye and at low and high magnifications allowed us to identify a large number of items with possible evidence of anthropic alterations (Tab. 3.; n=185, c.39% of the entire assemblage). This group consists of pebbles, cobbles, and blocks with a considerable metric and weight variation.

4.1. Technological and typological characterization

From the typological perspective, the artifacts with use-wear traces were categorized as anvils, hammerstones, abraders, pestles, and choppers. All GST are made of limestone, except for a few hammerstones made of flint (i.e., flint pebbles). The maximum length of most artifacts ranges from 42 to 176 mm (Fig. 2), with a mean weight of approx. 450g (Fig. 3).

These ranges of measurements are found in all tool categories, yet several anvils and one chopper are larger. A considerable number of tools show a level of fragmentation, and in some cases small fragmented areas are associated with the impact areas (SOM 3).

4.2. Use-wear analysis

Based on macro-observations, our sample can be divided between tools with impact marks (n=140), with polished areas (n=24), striations (n=6), and items that show a combination of different types of wear (n=15). The impact marks are present in most of the tool types. However, they are much more common on hammerstones (n=104), and anvils (n=19). Some cases exhibit combinations of the three types of use-wear i.e., impact marks, striation, and polish formation (categorized as Mixed). The abraders are characterized by the exclusive presence of polish (n=8) and sometimes associated with striations (n=2). The group of tools categorized as 'other', include

tools with all types of wear, but the presence of polish is the most common one (n=16) (Tab. 3, and see SOM 3).

On most of the tools, the use-wear is located near the extremities, corresponding to A1, A2 and A3 positions according to our grid. Some tools also show use-wear concentration in their central areas (position A5); these were mainly interpreted as anvils. Generally, the marks are concentrated in a single location; however, some hammerstones do have marks on both extremities. When a tool exhibits more than one active area, the use-wear usually displays only impact marks. (see SOM 6).

4.2.1. Low magnification analysis

Following inspection by the naked eye, the results of low magnification observation also show that it is generally possible to distinguish between two main groups of anthropogenic impact marks. Type 1 (identified on 27 tools), although showing low level of alteration of the tool surface, is mainly characterized by clear concentrations of impacts. Type 2 (identified on 82 tools) is characterized by impacts with a considerably higher level of surface penetration in contrast to type 1. Type 2 is often associated with flake removals (Fig. 4).

Concerning macro wear traces, Type 2 (82 cases against 27 from Type 1) is the most represented category within the different types of tools in the assemblage. From the category Type 1, these impacts were identified in much lower frequencies on all tool types, with the exception of pestles (which may not be significant, due to the small number of specimens identified in this assemblage, 2 to 1). Within the hammerstones group, on which most of the macro wear traces were identified, this dichotomy between Type 1 (21) and Type 2 (65) is again substantial, making this distinction clear (Tab. 4 and 5).

Impact wear can relate to percussive motion and contact with hard matter. It is typically associated with flint knapping and stone working (Paixão et al., 2021). Most of the hammerstones in our sample may fit into this functional category. However, a low development of impact marks was also observed in our bone breakage experiments, which was also associated with the development of a specific form of micro-polish (Paixão et al., 2021 and see below). At this stage of the research, it seems improper to associate type 1 impacts with bone breakage, as similar low development of impact marks could eventually be associated with other use contexts. However, incorporating high

magnification analysis appeared important here for identifying bone breakage activity. High magnifications were also used in this study to further investigate the polished areas observed on 24 GST in our sample.

4.2.2. High magnification analysis

Microscopic analyses at high magnification allowed the identification and description of a total of 29 tools with clear evidence of micro polished areas (i.e., sheen). The polish development on these tools was generally identified within a single active area and in a few examples on two active areas. Polish formation was observed on various tool types, including hammerstones, abraders and choppers. Four main categories of polish (A, B, C and D) were defined based on their characteristics, each related to specific formation contexts based on our experimental database and on the literature (Tabs. 6 and 7).

The types A (27.59%), B (34.48%) and D (31.03%) are represented in similar proportions, while type C (6.90%) appears much less frequently. It is important to underline that – in general – the frequency of micro-polish is low compared with the occurrence of macro traces. Type A was identified on abraders (n=4) and on one hammerstone. On the other hand, Type B was found in all types except for the pestle category. Type C occurs primarily on tools categorized as abraders and hammerstones. Type D was identified in most cases on tools categorized as undefined (Fig. 5 and 6).

In sum, many tools present impact marks that can clearly be associated with percussion activities. Some hammerstones, anvils and choppers show a combination of impact marks, polish, and striations (SOM3). An overlap (same area on the tool) between impact marks and polish is observed on just a few implements. That is the case, for instance, of several choppers showing Type 1 impact marks (low development) associated with Type B polish. Another example is found on a few hammerstones with Type 2 impacts associated with Type A polish (see SOM 3). While part of the variation in impact type, association and location of wear on the tool surface may be related to similar functional contexts of formation, it is suggested here that some of the differences in use-wear patterns can be associated to the use of the tools for different functions. Before discussing these hypotheses, use-wear pattern variability is first further explored through 3D and surface texture analysis.

4.2.3. 3D micro Surface texture analysis

One of our main goals here is to assess the various types of polish distinguished in this study, as well as the similarities between archaeological and experimental polish, using a quantitative approach. In this perspective, the following aspects were considered: the surface texture areal parameters ISO 25178-2 (International Organization for Standardization, 2012), furrow parameters, texture direction parameters, and texture isotropy parameters. (see SOM 2 for the analysis workflow and SOM 7 for the final reports and data of the Confocal surface texture analysis, <https://zenodo.org/deposit/4611581>). Figure 7 plots the combination of all parameters for the different polish types described (colors), in the archaeological (represented by circles in the graph) and experimental (triangle) samples (Fig.7). Although based on a small sample, the plot of all measured parameters shows similar values between experimental and archaeological polish for each type distinguished here. In what concerns the differentiation of polish, the most significant distinction is observed between Type A and B, as values diverge from each other and from the other two types of polish in all seven parameters. This trend is clearly shown as well by the boxplot of all parameters mean values (SOM 4). Nevertheless, this trend is not observed between polish Type B and C. In fact, from our qualitative assessment it was also clear that the two types of polish share some similar features. Hence, this comparison would benefit from additional experiments, which were beyond the scope of this paper. This question, as for the other polish types, needs to be further explored via experimental replication.

4.3. Functional interpretation

Based on the combination of various analytical scales, it was possible to suggest a functional-typological characterization for the GST that includes: hammerstones (n= 108), anvils (n= 22), pestles (n=1), abraders (n=11) and chopper tools (n= 10). Some artifacts identified here as tools do not show diagnostic traces sufficient to enable an attribution to a specific tool-type and were recorded as undefined (n = 33). Further experimentation and analyses are needed to understand these implements (Fig.8).

We identified different use-wear traces that can result from contact with different types of materials, namely mineral, hard animal tissue (e.g., bone) and likely other, softer, vegetal resources (e.g. acorns, pistachios).

From the four types of micro wear polish identified in the archaeological materials, two (A and B) present characteristics that match the reference collection generated by our experimental program and allow us to argue for distinctive evidence of bone and mineral contact. Type C was interpreted on the basis of the physical properties of micro-wear and still needs to be explored further.

- Mineral

In the present assemblage the wear associated with hard materials and minerals has been identified on hammerstones and abraders. Use-wear traces that are associated with activities resulting from the processing of hard materials, like minerals, are very frequent. In most cases these consist of impact marks (n=82), and sometimes polish (n=8) (Tab. 8). The characteristics observed on the archaeological materials together with the experiments indicate that a large number of tools can be associated with flint knapping for extracting flakes or for striking platform preparation; some may also have been used for retouching (when polish and striations are found in a small, delimited area). The possibility of ochre processing as documented for other MP contexts (Hodgskiss, 2020) should not be excluded for some of the abraders identified in this site, but this needs to be further explored by combining more experiments with residue analysis.

- Hard animal material (bone and antler)

A total of 32 tools present use-wear characteristics potentially associated with bone processing activities, including macro wear and polish formation (Tab. 8). In our study, we observed that some tools (choppers) were primarily prepared by the creation of an irregular edge which was possibly used to break the bones (n=2). These tools show polish areas on the edges that are associated with bone working. Some other tools, without preparation of an edge (e.g., hammerstones), also present use-wear generally associated with bone contact (n=30); other scholars specifically associated this type of tool with bone breaking (de la Torre et al., 2013; Goren-Inbar et al., 2015; Venditti et al., 2021).

The polish characteristics (Type B) associated with bone contact (n=10) match the data from the experimental program. Evidence for bone contact in this assemblage is present on anvils, hammerstones and choppers.

- Other materials

Under high magnification, some tools classified as hammerstones and abraders show use-wear traces that are significantly different from the use-wear formed by mineral or bone contact (n=2) (Tab. 8). In those cases, the polish presents micro characteristics that may be associated with the processing of oily materials (e.g., acorns, pistachios) or hide (see Dubreuil & Grosman, 2009).

However, those hypotheses are mainly based on the micro topographic location (i.e. penetration depth) and distribution (i.e. spatial) of the polish. For the moment, our interpretations are based on the existing reference collections for this type of worked materials and similar raw materials. Further work is needed, including experiments with limestone to test these hypotheses. We suggest however that the specific characteristics of the type of polish discussed here (Type C) indicate evidence of contact with other types of products different from mineral and bone.

- Post-depositional processes

Some pebbles exhibit polish randomly distributed over the surface and characterized by non diagnostic features (n=9). We suggest that these polishes are not related to an intentional use, but may derive from post-depositional processes.

5. Discussion

Understanding GST function is important for making inferences regarding daily activities performed by past humans. The GST analysis can help unravel a wide range of activities, including those related to the processing of perishable materials.

In the MP of the Levant and beyond, GST normally appears in low frequencies and almost exclusively in open-air sites. Nesher Ramla is the only site that presents a high number of GST. This raises questions of relations between GST technology, site function and settlement pattern. Answering such questions requires understanding the activities in which the GST were involved.

The approach applied here has allowed us to characterize surface alterations at different scales; it is based upon the principle that, for a detailed understanding of the tools, different levels of magnification must be included in a complementary workflow (Dubreuil et al., 2015; Marreiros et al., 2020). The analysis of the tool's entire surface was crucial in identifying the artifacts presenting a high potential for micro use-wear preservation. Nevertheless, it should be underlined that some

activities leave traces that are only detectable at certain scales of observation. For instance, some activities lead to the formation of polished areas only observable at a microscopic scale (the so-called high-power approach).

Our study indicates that pebbles and cobbles of different sizes were used as tools without any preparation, the active area(s) corresponding to a cortical surface. The preparation of an irregular, asymmetrical active “edge” was also observed in some cases (i.e., for chopper-like tools)

The identification of macro and micro traces has allowed us to provide a detailed characterization of the use-wear patterns present in the assemblage. It is important to emphasize that macro traces were identified significantly more often than micro traces. An overlap between macro traces (e.g., impacts) and micro traces (e.g., polish) was rarely observed in this assemblage. Most of the tools where micro-polish was identified do not show conspicuous macro alteration. This characteristic is especially interesting as it can be indicative of individual tool use variability, not only in terms of materials processed but also in terms of types of actions/motions.

Based on previous use-wear studies, macro and micro wear traces are known to vary according to both kinematics and worked material (Adams, 2014; Dubreuil, 2004; Hamon, 2007). Hence, macro traces are influenced not only by the matter processed (e.g., flint vs. bone), but also by the way the tool is used (e.g., percussion vs grinding or cutting vs scrapping). Our analysis of Nesher Ramla GST shows that a limited number of tools present micro traces associated with macro traces. We suggest here that for some types of use-wear, this variability (i.e, the presence or absence of micro traces) is related to different activities/motion while working on the same type of matter (e.g., retouching flint vs extraction flakes).

Thus, the analyses at low and high magnification show that at Nesher Ramla GST were used for different types of actions, mainly for activities involving impact and abrasive motions. The range of traces identified are associated with two major domains:

- *Technology*: Some of the hammerstones identified are associated with knapping activities, and probably some tools were used for retouching. Other mineral contact activities such as ochre processing are not excluded. Despite the fact that ochre processing can be related to non-functional and symbolic behavior, this can also be related to technological aspects such as hide treatment (Dubreuil & Grosman, 2009). The importance of ochre processing among

current hunter-gatherer groups has been demonstrated by ethnographic research (Hayes, 2015). The possibility of ochre processing should be further explored.

- *Subsistence*: The other major aspect reflected in this GST assemblage is *subsistence*. Some use-wear traces identified on hammerstones and choppers reveal contact with bone. These can be related to bone breakage for marrow extraction, a product of specific nutritional interest, since marrow possesses a high level of calories, fat, protein and vitamins, namely B12, E and A (Hassan et al., 2012). This hypothesis is corroborated by the archeozoological analysis of other units at the site (Crater Gershtein et al., 2020). Use-wear related to bone processing were identified on different types of GST. Tool morphological variability at Nesher Ramla may indicate two different types of activities involving bone processing, or alternatively the processing of different types of bone (e.g., anatomical parts or species). Some tasks required the preparation of an edge, (i.e., choppers) and others the use of unmodified cobbles.

Other activities such as plant, wild grain or fruit processing should not be totally excluded, as suggested in this study by the variability of use-wear traces, specifically suggested by Type C. This type of wear is observed on tools showing no or a limited number of impact marks. However, the characteristics of the micro-polish and striations indicate contact with a soft and flexible material, allowing the polish to develop in the lowest micro-topography. This significant development of the polish into the low microtopography led us to suggest a contact with oily products (e.g., pistachios, acorns, nuts). Although this requires further experimentation, it is worth mentioning that evidence for the exploitation of this kind of product has been recovered in sites dated to the Lower Paleolithic, such as Gesher Benot Ya'aqov (Goren-Inbar et al., 2015), as well as from MP contexts (Akazawa, 1974; Lev et al., 2005; Madella et al., 2002; Rosen, 2003). The preparation of those types of oily products for consumption using GST has been demonstrated by multiple ethnographic studies around the world (Driver, 1961; Hudson, 1976; Robitaille, 2016).

The hypothesis of plant, wild grain, nut, or fruit processing is based on preliminary interpretation of use-wear data and will need to be explored in the future. This includes expanding our experiments by using limestone pebbles for the processing of plant resources that may have been included in the MP population's diet.

6. Conclusions

Nesher Ramla is the largest MP GST assemblage retrieved in the Levant so far. This unique assemblage contains a large number of tools which, based on our analysis, reflect several activities related to the processing of different materials. In Unit V, many GST present areas with clear evidence of anthropic alterations, mainly in the form of impact marks, polish, and striations. The various scales of analyses used in this study have revealed clear differences between impact marks, both in terms of distribution and pit depth. Those variations can be related to different types of percussive/impact activities performed at the site, involving different contact materials such as flint knapping and bone breaking.

At the micro scale, it was possible to identify four types of micro polish, including traces associated with mineral and organic contact materials. Flint knapping and bone breaking dominate, and their identification is well supported by our experimental results. Other groups of use-wear present in the assemblage exhibit characteristics that could be associated with the processing of perishable organic materials such as acorns, pistachios, or other products with similar characteristics. However, more experiments using limestone items processing this type of product need to be performed in order to test this hypothesis.

In sum, the technological and functional variability observed among the GST at Nesher Ramla indicate that pebbles and cobbles used as tools were more important in the Levantine MP technological system than previously thought. What might explain the high frequencies of GST at Nesher Ramla when compared with other MP sites is still open to debate and suggests the need to explore further by investigating other assemblages from different types of sites. Nevertheless, the singularity of Nesher Ramla due to the characteristics of the site location and geomorphology has been suggested as a major factor for unique patterns of settlement and resources exploitation in the local landscape. In the case of the lithic assemblage, this is also reflected in the high frequency and variability of the GST technology at the site.

This paper also highlights the importance of conducting detailed analysis of GST in order to provide a solid foundation for inter-site comparisons, and to better understand the impact of this technology on MP populations in the Levant.

Data Availability

R scripts used for data analysis can be found at <https://github.com/Paixao-E/NRQgstusewear>. ConfoMap templates for each surface in MNT and PDF formats (including all original and processed surfaces, as well as all results) are freely available on Zenodo (<https://zenodo.org/record/4611581>).

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Figures:

Figure 1: Site location and stratigraphy: a) Unit V excavation b) stratigraphic profile with arrow pointing to the unit included in this study c) map with the location of the archaeological site of Nesher Ramla

Figure 2: Scatterplot showing artifact dimensions organized by typology and support type

Figure 3: Boxplot showing artifact weight organized by typology and support type

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806 *Figure 4: Examples of the different types of impact and polish wear traces: a) hammerstone with impact marks Type 2, b)*
807 *fractured area associated with impact Type 2, c) general photo of hammerstone with impact marks Type 1, d) fractured area*
808 *associated with impact Type 1, e) polish (red arrow) in association with impact marks (green arrow), f) general photo of chopper*
809 *tool, g) impact marks on chopper edge (all macroscopic images with 34x digital zoom, see acquisition details SOM1)*

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Figure 5: Examples of the different types of micro wear traces: a) polish Type A, b) polish Type B, c) polish Type C d) polish Type D, (all microscopic images with 10x and 20x objective, optical zoom)

Figure 6: General schematic representation of frequency and proportion of the use-wear location areas for the entire assemblage (see SOM4 for each tool type)

Figure 7: Laser scanner confocal surface texture analysis organized by the different types of polish

Figure 8: Examples of tools with impacts marks: a) Broken anvil with central impact marks, b) Hammerstones with concentrated impact marks

828 **TABLES:**829 *Table 1: General inventory of the GST assemblage from Unit V of Nesher Ramla, organized by raw-material and support*

Raw material	Block	Boulder	Pebble	Total
Flint	1	0	5	6
Limestone	68	7	390	465
Total	69	7	395	471

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832 *Table 2: Typological inventory of the GST at Unit V of Nesher Ramla*

Raw material	Abrader	Anvil	Chopper	Hammerstone	Manuport	Natural	Other	Pestle	Total
Flint	0	0	0	1	4	0	1	0	6
Limestone	11	23	13	108	220	43	46	1	465
Total	11	23	13	109	224	43	47	1	471

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835 *Table 3: Frequency of the different types of wear traces organized by tool type*

Typology	Mixed	Impact marks	Polish	Striations	Total
Abrader	0	1	8	2	11
Anvil	2	19	0	1	22
Chopper	1	10	0	0	11
Hammerstone	4	104	0	0	108
other	8	5	16	3	32
Pestle	0	1	0	0	1
Total	15	140	24	6	185

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838 *Table 4: Macro wear traces organized by tool typology*

Typology	Type 1	Type 2	Total
Anvil	1	10	11
Chopper	2	4	6
Hammerstone	21	65	86
Pestle	2	1	3
Undefined	1	2	3

Total	27	82	109
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Table 5: Criteria of classification for macro traces type

Impact (macro) marks type	Description		Interpretation
	<i>Abrasive</i>	<i>Fatigue</i>	
Type 1	Low level of striations and scratching	Low level of surface crushing or fracturing	Bone breaking Semi-hard or soft materials
Type 2	Identification of macro striations Smoothed grain edges	High level of surface crushing or fracturing Areas with deep depressions High level of macro mineral crushing	Impact with hard mineral material knapping Abrasion and retouching

Table 6: Micro wear traces organized by tool typology

Typology	A	B	C	D	Total
Abrader	4	1	1	0	6
Anvil	0	1	0	0	1
Chopper	0	1	0	0	1
Hammerstone	1	2	1	0	4
Pestle	0	0	0	1	1
Undefined	3	5	0	8	16
Total	8	10	1	9	29

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855 *Table 7: Criteria of classification for micro traces type*

Polish types	Description	Interpretation
Type A	Micro polish (i.e. sheen) Generally, only on high microtopography Flat cross section Rough texture Sharp contours Frequent presence of abrasive tracks	Mineral contact material
Type B	Partially penetrating on low microtopography Domed cross section Fluid texture	Hard animal material (Bone and antler)
Type C	Deeply penetrating on low microtopography Domed cross section Smooth texture Diffuse contours	Oily contact material (e.g. acorn)
Type D	Random distribution on surface Polish spots with mix characteristics	Unclear Post-depositional processes

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858 *Table 8: Summary of functional interpretation*

Typology	Mineral	Organic hard materials	Interpretation	
			Other materials	No diagnostic traces
Anvil	10		1	11
Chopper	4		2	5
Hammerstone	65		21	1
Pestle	1		1	22
Abrader	4		1	1
Undefined	5		6	5
Total	89		32	2
				64

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861 **Supplementary Online Material (SOM)**

862 SOM1 – Equipment and imaging settings

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864 Paixão et al. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern

865 Levant): multi-scale use-wear approach for assessing the assemblage functional variability.

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Imaging technique	Equipment	Objective	
Photography	Nikon DSLR D160	Nikon AF-S VR Micro-Nikkor 105 mm f/2.8G IF-ED	
Imaging equipment	Equipment	Objective	
3D digital microscope	ZEISS Smartzoom 5	PlanApo 1.6×/0.1	
Imaging equipment	Equipment	Objective	
Stereomicroscope	ZEISS Stemi 305	0,75x FWD 128mm	
Imaging equipment	Equipment	Objective	
Upright microscope	ZEISS Axio Scope.A1 MAT	EC Epiplan 5x/0,13	
		EC Epiplan 10x/0,25	
		EC Epiplan 20x/0,4	
Imaging equipment	Equipment	Objective	
Transmitted light microscope	ZEISS Axio Lab.A1 Pol	N Achroplan Pol 50x/0,80/ WD=0,41 mm	
Imaging equipment	Equipment	Objective	Others
Laser Confocal microscope	LSM 800 MAT mounted onto an Axio Imager.Z2 Vario	50×/NA=0.75/WD=0.22mm	
		Illumination	Source: Laser
			Wavelength: 405 nm

			Intensity: 4%
		Settings	Scanning direction:
			Scanning speed: 8 (max)
			Bit depth: 16 bits
			Master Gain: 240-300 V
			Pinhole diameter: 54 μm (= 1 AU lateral optical resolution)
		Size and resolution	Zoom: 0.5x
			Field of View: 255.56 * 255.56 μm
			Frame size: 3000 * 3000 pixels
			X/Y pixel size: 0.0852 μm
			Step size: 0.25 μm
			Data quality: No noise cut
AU = Airy Unit, NA = numerical aperture, WD = working distance			

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SOM 2 - Confocal microscope analyses workflow and parameters

Paixão et al. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern Levant): multi-scale use-wear approach for assessing the assemblage functional variability.

The analysis workflow of the surface data acquired with the confocal microscope is adapted from the template defined by (Pedergana et al. 2020, Calandra et al. 2019a, Calandra et al. 2019b). This follows several steps which are included in a ConfoMap ST (v 8.1.9369) templates, a derivative of MountainsMap Imaging Topography (Digital Surf, Besançon, France). Two templates were used:

a) Template - Mirroring surfaces (impressions), this template was used to mirror the surfaces in x and z that have been acquired with the LSM 800 based on moulds instead of the original artefact surface.

b) Template - Processing analysis, this template to process all surfaces acquired with the LSM with the 50x/0.75 and 50x/0.95 objectives.

Workflows

Template - Mirroring surfaces (impressions)

1. Loading the original topography surface;
2. Mirrored surface (in X and Z);
3. Export mirrored surface

Template - Processing analysis

1. Loading the original topography surface;
2. Levelling (Least squares method by subtraction);
3. Form removal (polynomial of degree 3);
4. Thresholding the surface between 0.1 and 99.9% material ratio to remove the aberrant positive and negative spikes;
5. Outliers removal (maximum slope of 80°);
6. Applying Microroughness removed (S-filter, 2.5 μm);
7. Filling-in the non-measured points (NMP), necessary for the computation of some parameters;

8. Calculating ISO 25178-2 parameters (International Organisation for Standardisation, 2012), Furrow analysis, Texture direction, Texture isotropy, and SSFA. ConfoMap templates for each surface in MNT and PDF formats (including all original and processed surfaces, as well as all results) are freely available on Zenodo (<https://zenodo.org/record/4611581>).

Table 1: List of the ISO 25178 Surface texture areal parameters used in this study (Adapted from Calandra et al. 2009)

Scale type	Standard	Category	Parameter	Description (condition)	Unit
Length-scale (profile)	ISO 4287 (1984-1996)	Amplitude	Rt	total height of the profile	
			Rp	Maximum profile height	
			Rv	Maximum profile valley depth (Rm 1984)	
			Rz	Maximum height of the profile (Ry 1984)	
			Ra	Arithmetical mean deviation of the assessed profile	
			Rq	Root mean square deviation of the assessed profile	
			Rsk	Skewness of the assessed profile (Sk 1984)	
			Rku	Kurtosis of the assessed profile (Amendment)	
			Rc	Mean height of the profile	
		Spatial	RS _m	Mean width of the profile elements (Sm 1984)	
		Hybrid	Rdq	Root mean square slope of the assessed profile	
			RPc	Peak count number (Amendment)	
		Functional	Rm _r	Material ratio of the profile	
			Rdc	Profile section height between two material ratios (Amendment)	
	ISO 12085	Motif	nmoti	number of motifs	no unit

			meh	mean Height	μm
			mea	mean Area	μm^2
			mev	mean Volume	μm^3
Area-scale	ISO 25178	Height	Sq	standard deviation of the height distribution, or RMS surface roughness	μm
			Ssk	skewness of the scale limited surface	no unit
			Sku	kurtosis of the scale limited surface	no unit
			Sp	maximum peak height	μm
			Sv	maximum pit height	μm
			Sz	maximum height of the scale limited surface	μm
			Sa	arithmetical mean height or mean surface roughness	μm
		Spatial	Sal	auto-correlation length ($s = 0.2$)	μm
			Str	aspect ratio ($s = 0.2$)	no unit
			Std	direction	°
		Hybrid	Sdq	root mean square gradient of the scale limited surface	no unit
			Sdr	developed interfacial area ratio of the scale limited surface	%
			Smr	areal material ratio function of the scale limited surface ($c = 1 \mu\text{m}$ under the highest peak)	μm
			Sm _c	areal material ratio function of the scale limited surface ($p = 10\%$)	
		Function and related parameters	Sdc	Surface Section Difference (extension of the Rdc)	
			Sxp	peak extreme height difference in height between p% and q% ($p = 50\%$, $q = 97.5\%$)	μm
			V _m	material volume at a given height ($p = 10\%$)	$\mu\text{m}^3/\mu\text{m}^2$
			V _v	void volume at a given height ($p = 10\%$)	$\mu\text{m}^3/\mu\text{m}^2$
			V _{m p}	material volume of peaks ($p = 10\%$)	$\mu\text{m}^3/\mu\text{m}^2$

			V _m _c	material volume of the core (p = 10%, q = 80%)	$\mu\text{m}^3/\mu\text{m}^2$
			V _{vc}	void volume of the core (p = 10%, q = 80%)	$\mu\text{m}^3/\mu\text{m}^2$
			V _{vv}	void volume of the valley (p = 80%)	$\mu\text{m}^3/\mu\text{m}^2$
		Related to segmentation	Spd	density of peaks	$1/\mu\text{m}^2$
			Spc	arithmetic mean peak curvature	$1/\mu\text{m}$
			S _{10z}	ten-point height of the surface	μm
			S _{5p}	five-point peak height	μm
			S _{5v}	five-point peak height	μm
			S _{da}	mean dale area	μm
			S _{ha}	mean dale area	μm
			S _{dv}	closed dales volume	μm^3
			S _{hv}	closed hills volume	μm^3
	ISO 12781	Flatness	FL T _t	peak to valley flatness deviation of the surface (Gaussian Filter, 0.025mm)	μm
			FL T _p	peak to reference flatness deviation (Gaussian Filter, 0.025mm)	μm
			FL T _v	reference to valley flatness deviation (Gaussian Filter, 0.025mm)	μm
			FL T _q	root mean square flatness deviation (Gaussian Filter, 0.025mm)	μm
	Other param.	Furrow analysis	mad _f	maximum depth of furrows according the = vectorisation of the micro-valley network	μm
			met _f	mean depth of furrows	μm
			med _f	mean density of furrows	cm/cm^2
		Direction	Tr	direction isotropy	%
			Tr _{1R}	first Direction	°
			Tr _{2R}	second Direction	°

			Tr3 R	third Direction	°
		Isotropy	IsT	isotropy	%
		Scale Sensitive Fractal Analysis		Smooth-rough crossover	
				Maximum relative length/area (Sdr on a surface)	
				Fractal dimension	
				Complexity (Similar to Sdq)	
				Scale of maximum complexity	
				Regression coefficient R ²	
				Heterogeneity of complexity	

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927 **SOM3. Extra information on the technological, morphological, and functional analysis data**
928 **from the GST of Unit V, Nesher Ramla (<https://github.com/Paixao-E/NRQgstusewear>)**

929 **SOM4. Reading and plotting Confocal data (<https://github.com/Paixao-E/NRQgstusewear>)**

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931 SOM 5 – Examples of Tools from Nesher Ramla (Unit V)
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933 Paixão et al. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V of Nesher Ramla
934 (Southern Levant): multi-scale use-wear approach for assessing the assemblage functional
935 variability.

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938 Figure 1: Anvil with flake removals, showing evidence of tool preparation

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Figure 2: Tools with flake removals forming a sharpened edge angle

Figure 3: Chopper tool from Nesher Ramla with polish formation(micro-type b)

Figure 4: Tool with impact marks and flake scars on the edge: Smart zoom microscope (34x) on the right and left images

Figure 5: Hammerstone from Nesher Ramla showing some intentional flake removals (macro-type 2): Smart zoom microscope (34x) on the right

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Figure 6: Hammerstones (macro-type 1)

Figure 7: Hammerstone from Nesher Ramla with polish formation associated with macro wear traces(macro-type 1 and micro type C): 10x on the bottom left and 20x on the bottom right (optical zoom)

Figure 8: Abrader tool from tool from Nesher Ramla (micro-type A): 1) 10x on the left 20x on the right (optical zoom) 2) 10x on the left 20x on the right (optical zoom) 3) 10x on the left 20x on the right (optical zoom) 4) 10x on the left 20x on the right (optical zoom)

Figure 9: Abrader from Nesher Ramla (micro-type A): 10x on the top 20x on the bottom(optical zoom)

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Figure 10: Undefined tool with polish formation (micro-type A) 10x on the left 20x on the right (optical zoom)

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 978 Figure 11: : Undefined tool from Nesher Ramla with polish formation (micro-type B): 10x on the
 979 top 20x on the bottom(optical zoom)
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983 Figure 12: Abrader tool from tool from Neshet Ramla (micro-type B): Smart zoom microscope
 984 (34x) on the top;)10x on the bottom left 20x on the bottom right (optical zoom)

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988 Figure 13: Undefined tool from Nesher Ramla (micro-type D): 10x on the top right 20x on the
989 bottom right (optical zoom)

SOM 6 - General schematic representation of the wear location areas by typology

Paixão et al. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern Levant): multi-scale use-wear approach for assessing the assemblage functional variability.

Figure 1 - All types

Figure 2- Hammerstones

Figure 3- Anvils

Figure 4- Pestles

Figure 5- Abraders

Figure 6- Choppers

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1015 Figure 7- Undefined types

1016 SOM 7. Final reports and data of the Confocal surface texture analysis done with ConfoMap
1017 (<https://zenodo.org/deposit/4611581>)