Occupation Duration and Identification of Technological Traditions: Insights from the Late Middle Paleolithic Site of Nahal Dimona 24 in the Negev Desert, Israel

MAYA ORON*
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem; and, Israeli Antiquities Authority, Nahman Avigad 1, 9370726 Jerusalem, ISRAEL; ORCID 0000-0003-0213-2325; mayaoron@gmail.com

NAOMI PORAT
Geological Survey of Israel, 32 Yesha'ayahu LeibowitzSt., 9692100 Jerusalem, ISRAEL; ORCID 0000-0002-5900-2460; naomi.porat@gsi.gov.il

ERELLA HOVERS
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem, ISRAEL; and, Institute of Human Origins, Arizona State University, Tempe, AZ, USA; ORCID 0000-0002-7855-6573; hovers@mail.huji.ac.il

*corresponding author: Maya Oron; *mayaoron@gmail.com*

submitted: 16 Niovember 2023; revised: 16 January 2024; accepted: 17 January 2024

Handling Editor in Chief: Karen Ruebens

ABSTRACT

Nahal Dimona 24 is a Middle Paleolithic rock shelter, the first Middle Paleolithic sheltered site identified and excavated in the arid Negev region, southern Israel. The site exhibits at least one well preserved *in situ* archaeological horizon that was dated by optically stimulated luminescence (OSL) to MIS 3–4 (Late Middle Paleolithic). The lithic assemblage from Nahal Dimona 24 is dominated by the centripetal Levallois knapping mode, sharing technological characteristics with earlier Middle Paleolithic sites from the southern Levant such as Qafzeh Cave and Nesher Ramla Quarry. At the same time, Nahal Dimona 24 differs from other late Middle Paleolithic sites mainly in the paucity of unidirectional convergent Levallois strategy and triangular end-products. Within the southern Levant Middle Paleolithic, dominance of centripetal Levallois knapping mode has frequently been associated with MIS 5 chronology and is seen by some as a cultural marker of human demic diffusion into the Levant during this time span. Based on the lithic assemblage and OSL ages from Nahal Dimona 24, we suggest that within the technological variability of the Middle Paleolithic in the Levant, the dominance of a specific lithic production mode is not a sufficient cultural or chronological marker. We further propose that since long stratified sequences may be a result of many visits by different human groups, short-term occupations like Nahal Dimona 24 might shed new light on the use of the different modes of Levallois preparation in the late Middle Paleolithic since they may better reflect the use of specific technological traditions related to Levallois preparation.

INTRODUCTION

Numerous well-documented excavations and detailed publications of Middle Paleolithic (MP) sites from the southern Levant yielded a rich and diverse record for this cultural period that lasted from ~250 ka to ~50 ka, at which point the first Upper Paleolithic lithic industries appear in the region (Hovers 2009: appendix 6; Hovers and Belfer-Cohen 2013). These MP industries include lithic techno-typological characteristics broadly shared with European and African lithic traditions of comparable ages (e.g., Levallois, Laminar and Discoidal *débitage* systems; Bar-Yosef and Meignen 1992; Bar-Yosef et al. 1992; Boëda 1995; Bordes 1973, 1988; Delagnes and Meignen 2006; Goren-Inbar 1990; Hovers 1998, 2009; Jelinek 1981; Picin et al. 2013; Shea 2008; de la Torre et al. 2013). MP lithic assemblages from the southern Levant conform to a general classification of the 'Levantine Mousterian,' characterized by Levallois technology and moderate frequencies of lightly retouched side-scrapers (akin to the European 'typical Mousterian;' Bar-Yosef 2006). MP assemblages in the southern Levant are dominated by Levallois as the distinctive (but never exclusive) formal flaking system, and most of the intra-site and inter-site variability is manifested in the variable ways and frequencies of combining methods (i.e., unidirectional, bidirectional, or centripetal flaking) and modes (recurrent and preferential) of production. The assemblages are distinguished based on quantitative technological differences, for example, scar patterns on Levallois cores and products (Goren-Inbar and Belfer-Cohen 1998; Hovers and Belfer-Cohen 2013). This technological variability has long been explained along a linear chronological sequence, modelled from the long sequence in Tabun Cave. The chrono- typological model is rooted in Garrod's (1934) initial typology-based chronological division (the ratio of points to scrapers), which she ultimately dismissed. Later, Copeland (1975) proposed a model of linear chronological changes in MP lithic variability. Her 'Tabun-type' assemblages were named after the layers of Tabun cave (B, C, and D types), each defined by the dominant morphology of Levallois blanks (i.e., triangular, oval/rectangular, or elongated) and core preparation methods (unidirectional-convergent, centripetal, and bidirectional or unidirectional and laminar). Because technological changes were identified along the stratigraphic sequence, the implication (made explicit by Bar-Yosef 1998 [and references therein]) was that each assemblage type corresponded to a temporal phase of the Levantine MP and could be used to determine the chronological placement of unstratified or undated assemblages.

The model has been challenged based on data from various sites and absolute chronological determinations that have been accumulating over the last three decades (see discussion in Hovers and Belfer-Cohen 2013). For example, Levallois centripetal flaking methods, both recurrent and preferential, assigned by the model to sites dating to 130–90 ka (MIS 5) are present in significant frequencies in younger sites such as Amud (sub-unit B4; 68.5±3.2 ka (Hovers 2004; Valladas et al. 1999) and Quneitra 53.9±1.7 ka (Goren-Inbar 1990; Ziaei et al. 1990). Still, the dominance of centripetal Levallois knapping is sometimes categorically linked with MIS 5 chronology. It is regarded by some researchers as a cultural marker of modern humans and is associated with both their dispersal out of Africa (Blinkhorn et al. 2021; Groucutt et al. 2019; although see, e.g., Ekshtain and Tryon 2019), as well as with a newly defined human population in the Levant (Zaidner et al. 2021).

The well-preserved assemblage of Nahal Dimona 24 (ND24), originating from a dated context, allows a detailed comparison to other MP assemblages, aiming to reconstruct the technological behavior of the hominins who inhabited ND24 and to conduct an inter-site comparison with other assemblages from the region and neighboring regions for a better understanding of role of the centripetal Levallois phenomenon. This analysis allows us to address two main questions in Middle Paleolithic research:

1. Is the dominance of a specific production mode a sufficient cultural or chronological marker for assigning an assemblage to a specific chronological time span within the MP?
2. How may short-term occupations, such as ND24, inform our understanding of the cultural and adaptive context in which different modes of Levallois production were used?

THE SITE OF ND24

ND24 is a rock shelter in the Northeastern arid Negev, southern Israel (Figure 1a). The rock shelter is situated on the western bank of a tributary of Nahal Dimona, cutting into the limestone, dolomite, and chalk strata of the Turonian Shivta and Nezer formations (Figure 1b, c). The terrain around the site consists of exposed rock surfaces and steep wadi walls with waterholes along the stream. Small patches of alluvial terrace sediments are preserved along the wadi banks. The rock shelter itself is ~30m long and 3–5m deep, with a sediment profile that is preserved mostly in its southern and central parts, while rock surfaces are exposed in its northernmost area (see Figure 1b).

MATERIALS AND METHODS

FIELD WORK

Two excavation seasons were conducted in the rock shelter during 2018–2019. Excavation was carried out in a 0.25 sq m grid, in artificial vertical cuts (spits) of 5cm. All sediments were dry-screened using a 5mm mesh. The location of finds exceeding 2cm in size was recorded using a total station. A raw material survey was conducted by foot in the immediate surroundings (a radius of 1.5–2km) of the site.

OSL DATING

Sediment samples for optically stimulated luminescence (OSL) dating were collected from within and below the archaeological horizon of unit 3 (MSD-3, 4 and MSD-1, respectively). As the bedrock is entirely carbonaceous, the source of the quartz is aeolian, blown in during dust storms and accumulated at the same time as the archaeological materials. Given that ND24 is close to the site of Nahal Yitnan 7, situated in a similar landscape and within a similar geological environment with similar quartz particle sources, OSL field sampling, sample preparation, dose rate evaluation, and luminescence measurements closely followed the protocols used for Nahal Yitnan 7 (details in Oron et al. [2023]). Briefly, equivalent dose (De) values were measured on the purified quartz using the OSL signal and the single aliquot regenerative (SAR) dose protocol (Murray and Wintle 2000). Twenty to twenty-five aliquots (2mm) were measured for each sample, and the average De and errors were calculated using the central age model (CAM, Galbraith and Roberts 2012). Dose rates were calculated from the concentrations of the radioactive elements U, Th, and K, measured on the additional sample by ICP-MS (U and Th) or ICP-OES (K). Moisture contents were estimated at 5±3%, as appropriate for this arid region, and the cosmic dose was evaluated from current burial depths.

FLINT ANALYSIS

The study of the lithic assemblages is established as a tool for understanding human behavior and social processes in prehistory, since lithic technology is perceived as a material

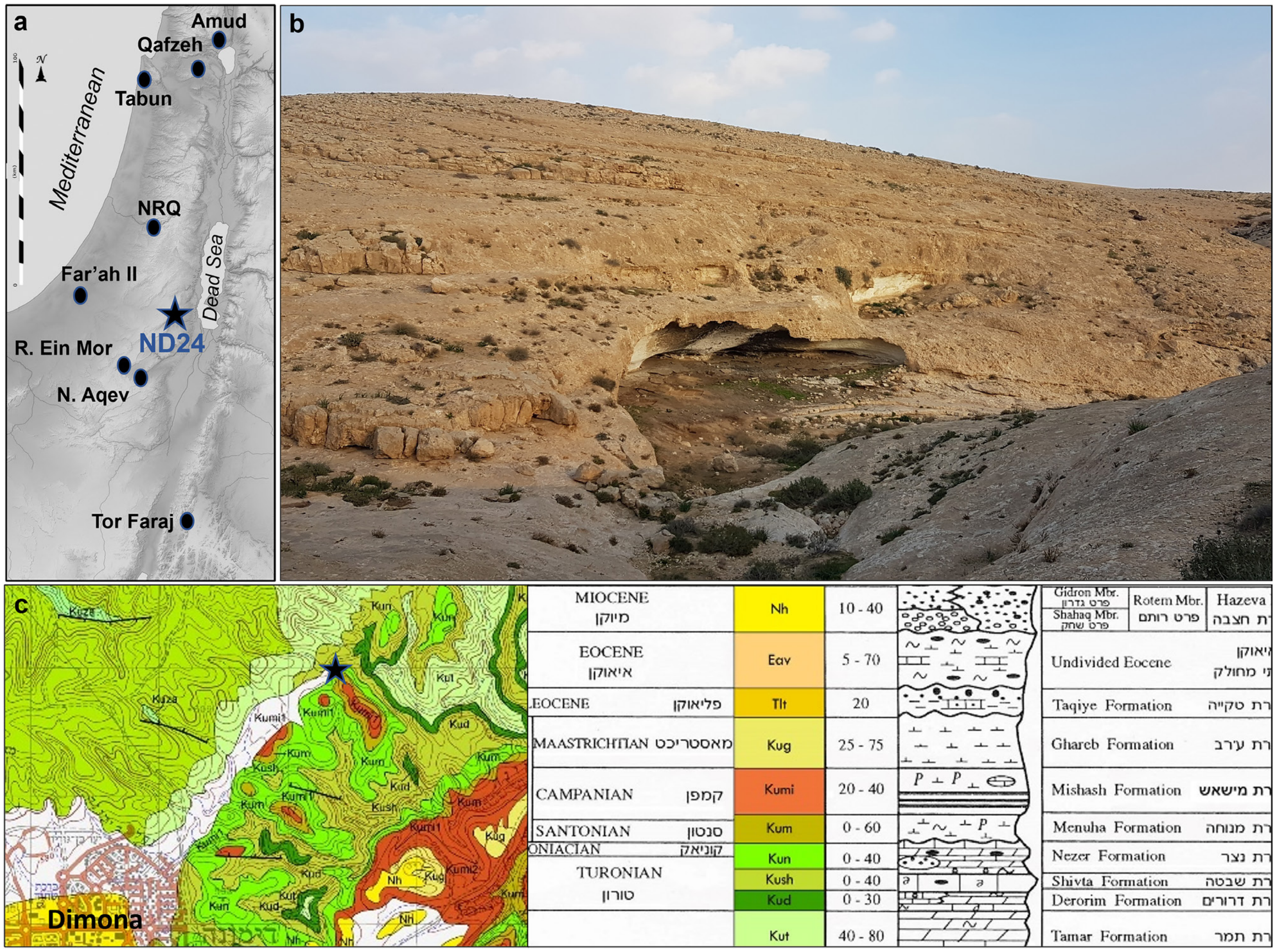

Figure 1. a) Regional map showing the location of ND24 and other MP sites; b) the ND24 rock shelter, view from the South; c) geological map of the site area (Roded 1996) showing the limestone and dolomite rock exposures (in various shades of green) and the main flint bearing formations (Mishash in red and Hazeva in yellow).

expression of cultural and social norms (Lemonnier 1992; Tostevin 2012). While it is assumed that lithic manufacture, as part of human behavior, can reflect functional responses to the environment (Binford 1973; Binford and Binford 1966; Perlès 1992), the techno-typological characteristics of artifacts are also interpreted as part of a complex human behavior including both functional and cultural components (Binford 1973; Bordes 1973; Kuhn 1995; Rolland and Dibble 1990).

Analysis of the flint assemblage from ND24 was conducted under the reduction sequence concept (Boëda 1995; Soressi and Geneste 2011), aiming to reconstruct the different technological steps within the reduction sequences, from the phase of raw material selection and acquisition to end-products, when possible. Within this framework, it is assumed that the technological steps reflect choices made by individuals, based on behaviors familiar to them from the existing pool of knowledge within a group (namely, different technological, economic, social, and symbolic options; Perlès 1992).

All artifacts larger than 2cm were described for their techno-typological aspects according to a list of qualitative and quantitative attributes, under the commonly used methodology in research of the Levantine MP (Bar-Yosef et al. 1992; Boëda et al. 1990; Bordes 1980; Goren-Inbar 1990; Hovers 1997, 2009).

Length and width of blanks were measured according to their technological axis, while thickness was measured in maximum point. For cores, the maximum length, width, thickness, and circumference were recorded. The identification of Levallois cores was in accordance with the definition provided by Boëda (1995; Boëda et al. 1990). Surficial cores that show two hierarchical surfaces but do not fall into Boëda's definition were categorized separately as hierarchical surface cores (Prévost and Zaidner 2020; White and Ashton 2003). The characteristics of Levallois products were derived from Boëda's definition as suggested by Hovers (2009). Retouched artifacts were classified according to Bordes' (1961) typological list. Because of the small number of artifacts that are clearly produced by preferential methods (see below), we did not separate them from the items made by recurrent methods.

Artifacts smaller than 2cm were counted and divided into three groups—flakes (presenting a clear bulb of percussion), fragment, or burnt (including both micro-flakes and fragments).

All the assemblages from ND24 were studied using the same methodology, however the focus of this paper is on the assemblage from the main archaeological horizon excavated at the site within sedimentological Unit 3 (see below). The results of the lithic analysis were used to reconstruct the technological behavior and place it in its regional context. Some specific properties of the assemblage were used in combination with field observations on the density and distribution of artifacts to address the question of occupation duration. We consider the quantitative distribution of raw materials, the dispersion measures of metric properties, and the proportional representation of specific technological categories, artifact densities, and spatial appearance as potential proxies of occupation length (see Mitki et al. 2021 for a critical review and references).

RESULTS

EXCAVATION AND STRATIGRAPHY

An excavated area of 13m² in the middle of the rock shelter revealed several stratified *in situ* sedimentological units partly exposed by slope processes (Figure 2). The uppermost unit 1 formed as a result of the modern use of the shelter by local herders and consists of an accumulation of up to 0.5m of goat and sheep dung and some stone arrangements. This unit mostly covers the inner part of the shelter (see Figure 2a-c, f). Unit 2 is a hard, cemented carbonate horizon found only in the inner part of the shelter, from the modern drip line towards the back wall. It contains very few small flint artifacts. This unit seems to be mainly a post-occupation accumulation of dust and chalk that eroded from the shelter walls.

Unit 3 is partly cemented with carbonates in the inner part of the shelter, where the chalk walls are weathering and contributing carbonates to the sediments. The unit slopes gently to the east, where it is exposed by the present-day slope erosion approximately 4m from the back wall of the shelter. Unit 3 contains the main archaeological horizon exposed over an area of 13m². The horizon is approximately 20cm thick and was exposed in all the excavated squares. Lithic artifacts in this horizon (n=4325) were embedded mostly horizontally, with an average artifact frequency of 323 items per m²; standardized to volume of excavated sediment, artifact density averages 425 items (>2cm) per m³ (ranging between 37 and 712, SD=237.3). The analysis of this assemblage is the main focus of the current paper (see below).

Units 4 and 5 are loess accumulation units that were only exposed in two test pits of 0.25m² in the area excavated near the back wall of the shelter and on the eastern edge of the excavation areas (see Figure 2d). Unit 4 contains very few archaeological artifacts and separates the rich archaeological horizon of unit 3 from the lower horizon found in Unit 5, which is buried at a depth of 0.5–6m beneath the surface. This lower archaeological horizon seems to be rich with lithic artifacts, many of which show signs of burning. However, given the small exposure areas of units 4 and 5, additional fieldwork is needed to understand their nature.

The archaeological horizons in ND24 include some faunal remains, in addition to lithics. The recovery of faunal remains, albeit fragmented, is a rare find in MP sites in the arid Negev where preservation is typically poor. Most of these faunal remains are ostrich eggshell fragments (n=344), but the assemblage includes also some highly fragmented mammalian bones (n=92, only four of which are larger than 2cm). Additionally, one fragment of *Glycymeris* sp. (Supplementary Material 1: Figure S1a) was recovered. The distribution of faunal remains within and between the archaeological horizons in ND24 is uneven (Figure 3), possibly indicating post-depositional processes or/and differential use of space (for more information on the faunal remains see Supplementary Material 1).

The spatial distribution of lithic artifacts in Unit 3 is mostly homogenous, with artifacts exposed in all excavated squares (see Figure 3). Kernel density models of flint artifacts show two main concentrations in the northern and southern part of the excavated area. When examining the spatial distribution of specific lithic categories (e.g., cores, flakes, Levallois blanks, core trimming elements (CTE's), retouched items, etc.), none show a unique pattern that significantly differs from the general distribution of flint artifacts. It is possible that these concentrations represent distinct episodes of human activity. On the other hand, they are possibly two 'windows' into a single occupation surface, an interpretation that might be in line with the small size of the rock shelter. Since the excavation area is discontinuous, the behavioral significance of this distribution remains equivocal.

OSL AGES

The OSL ages fall within MIS 4–3, ranging from 55±3 ka to 72±4 ka, (Table 1; Supplementary Material 2). The age of MSD-4 is not stratigraphically coherent with the two other ages (see Figure 2); it should be similar to or younger than MSD-3, however, it is significantly older (see Table 1). This sample is from the inner part of the shelter (behind the present-day drip line), where the unit is partly cemented due to the significant contribution of carbonates dissolved from the shelter walls. In contrast, samples MSD-3 and MSD-1 originate from the uncemented sediments further to the east. Possibly, carbonate cementation could have lowered the dose rate of sample MSD-4 over time, rendering the currently measured dose rates incompatible. It should be noted, however, that dose rates for all samples are very similar, in the range of 0.93–0.95 Gy/ka, whereas the De value of the older sample is higher (see Table 1). Due to the limited number of samples, we cannot determine at present whether the younger or older ages are more reliable, therefore the full range, all within the Late MP, is considered.

THE LITHIC ASSEMBLAGE

The lithic assemblage from ND24 (n=4566, Table 2) originates mainly from the archaeological horizon of Unit 3. Some artifacts were collected from the surface around the

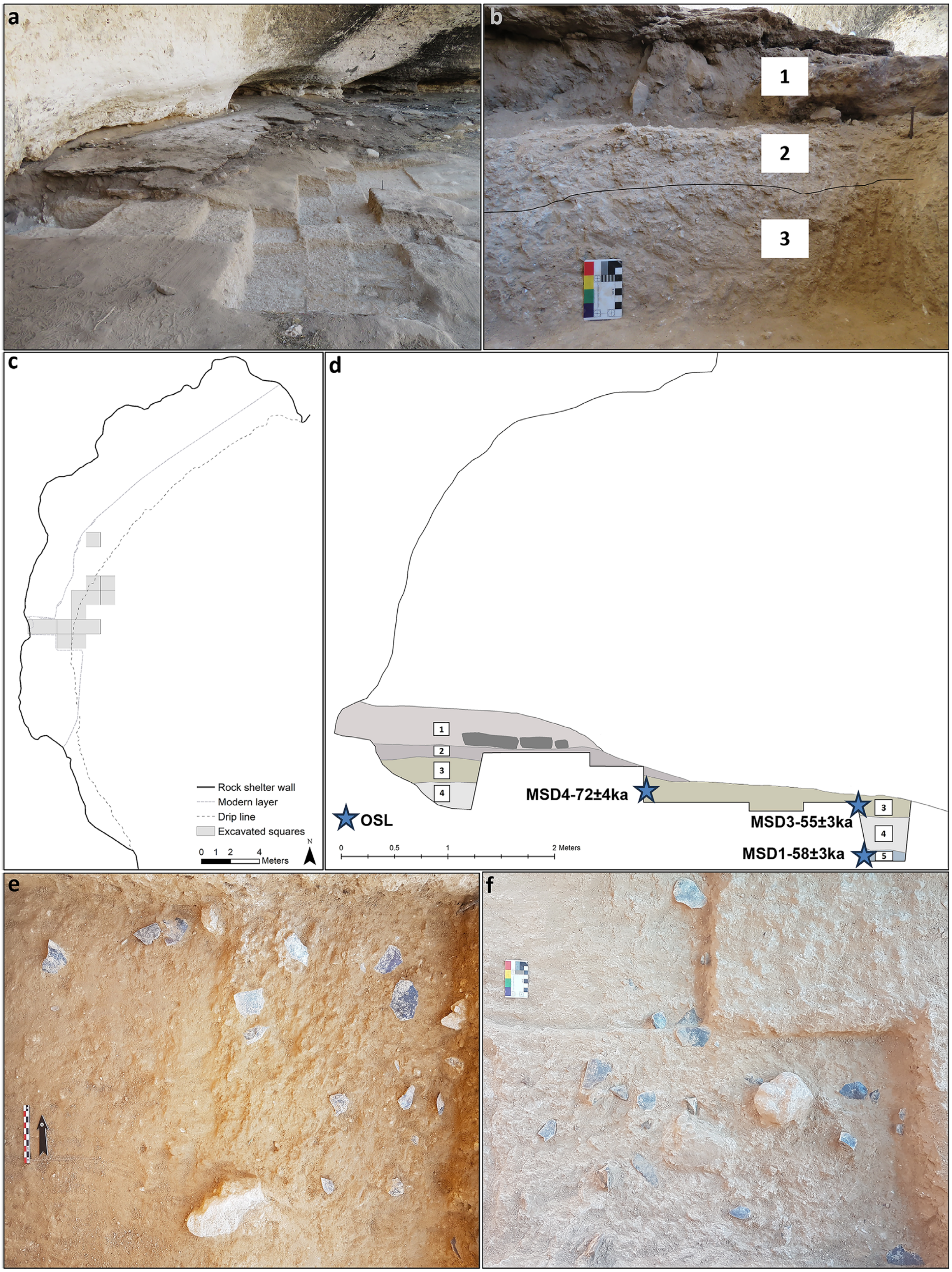

Figure 2. a) The excavation area, view from the south; b) section showing units 1–3; c) the rock shelter plan; d) profile of the rock shelter, showing the distribution of sedimentological units across the site and in the excavation area; e, f) artifacts in situ *during the exposure of the archaeological horizon in unit 3.*

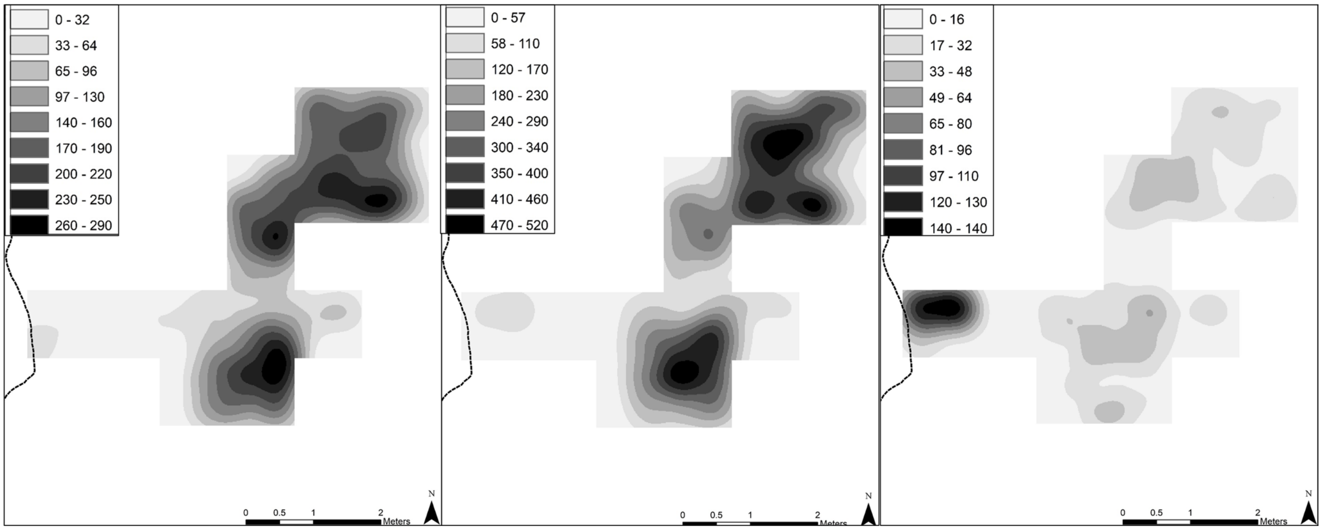

Figure 3. Kernel maps of artifacts in Unit 3: a) lithics >2cm; b) lithics <2cm; c) ostrich eggshell fragments.

rock shelter as well as from the archaeological horizon within Unit 5, reached in the lower part of the eastern test pit (see Table 2). These assemblages are small and will not be discussed in detail beyond presenting their inventories (see Table 2).

Raw Material Exploitation

Local Campanian flint of the Mishash Formation is the most common raw material at ND24 (63.5%), characterized as generally homogeneous, fine-grained, and semi-translucent brown to gray in color. The Mishash flint was most likely extracted from an outcrop on the hill above the rock shelter (~250m from the site, see Figure 1c), where similar raw material is abundant and flaked Levallois items are present on the surface. Striped flint typical of the Miocene conglomerates from the Hazeva group is also available in the site's proximity, within the local wadies (see Figure 1c), yet it is very rare in the assemblage (1.9%). Other types of raw material knapped at ND24 were not identified in the immediate surroundings (i.e., in the surveyed area within a radius of 1.5–2km from the site), and their sources are currently unknown. Of these unknown raw materials, the most common is a brown homogenous flint (16% of the assemblage). This raw material is represented in all the technological categories. Importantly, it is the only raw material other than the local Mishash flint that was observed among the cores (Figure 4).

Raw materials among the retouched items show more variability than in the rest of the assemblage. The local Mishash flint constitutes only 40% of the retouched pieces, while brown flint appears in higher frequencies among retouched items (35%) compared to the debitage categories. Other types of flint from unknown sources that compose altogether 7% of the whole assemblage are 20% of the retouched items. Cortical items (with more than 50% cortex on the dorsal face) and core trimming elements (CTE) show similar compositions to all other debitage items, (with 65%–75% of Mishash flint, 15%–20% of brown flint, and ~10% of other raw materials). Mishash flint is the most common among the Levallois cores (71%), while most of the cores-on-flake (COFs) are made of brown flint.

Unit 3 Assemblage

The assemblage from unit 3 (see Table 2) is characterized by high frequencies of debris (62%), mainly chips (<2cm). Many of the items (51%) show clear flake attributes (bulb of percussion) and are likely the result of knapping or retouch activities on-site.

The debitage is dominated by flakes (60.4%), while blades and bladelets are few (4% and 1.8%, respectively). Cortical elements and CTEs appear in significant frequencies (7.8% and 9.3% of the debitage respectively). Levallois

TABLE 1. FIELD AND LABORATORY DATA FOR OSL SAMPLES.

Lab code	Depth (m)	K (%)	U (ppm)	Th (ppm)	Alpha (Gy/ka)	Beta (Gy/ka)	Gamma (Gy/ka)	Cosmic (Gy/ka)	Dose rate (Gy/ka)	N	OD (%)	De (Gy)(1)	Age (ka)
MSD-1	0.6	0.50	0.82	1.6	0.003	0.471	0.275	0.203	0.95±0.03	25/25	10	55.6±1.2	58±3
MSD-3	0.25	0.47	0.74	2.0	0.003	0.450	0.276	0.236	0.97±0.03	25/25	22	53.4±2.4	55±3
MSD-4	0.35	0.48	0.83	1.9	0.004	0.466	0.284	0.224	0.98±0.03	20/20	18	69.8±3.0	72±4

Grain size for all samples: 90–125 µm. N: number of aliquots used for De calculations. OD overdispersion, a measure of the scatter in the sample beyond that expected from instrumental noise. Water contents estimated at 5±3%, cosmic dose calculated from current burial depth, not taking into account possible changes in position of overhang. De and errors were calculated using central age model.

TABLE 2. COMPOSITION OF THE LITHIC ASSEMBLAGES OF ND24.

	Unit 3			Unit 5			Surface		
	n	% in category	% in total	n	% in category	% in total	n	% in category	% in total
Cortical (>50%)	120	7.8	2.8	0	0.0	0.0	10	11.1	8.3
Flakes	927	60.4	21.4	19	70.4	15.8	40	44.4	33.1
Blades	61	4.0	1.4	2	7.4	1.7	3	3.3	2.5
Bladelets	28	1.8	0.6	1	3.7	0.8	0	0.0	0.0
Levallois flakes	141	9.2	3.3	1	3.7	0.8	11	12.2	9.1
Levallois points	11	0.7	0.3	1	3.7	0.8	0	0.0	0.0
Levallois blades	29	1.9	0.7	1	3.7	0.8	1	1.1	0.8
Pseudo Levallois point	5	0.3	0.1	0	0.0	0.0	0	0.0	0.0
Kombewa flake	10	0.7	0.2	0	0.0	0.0	0	0.0	0.0
Resharpen spall	1	0.1	0.0	0	0.0	0.0	0	0.0	0.0
Burin spall	1	0.1	0.0	0	0.0	0.0	0	0.0	0.0
NBK*	62	4.0	1.4	2	7.4	1.7	3	3.3	2.5
CTE*	138	9.0	3.2	0	0.0	0.0	22	24.4	18.2
Total Debitage	**1534**	**100.0**	**35.5**	**27**	**100.0**	**22.5**	**90**	**100.0**	**74.4**
Tools	**92**	**100.0**	**2.1**	**0**	**0.0**	**0.0**	**5**	**100.0**	**4.1**
Cores	**17**	**100.0**	**0.4**	**0**	**0.0**	**0.0**	**5**	**100.0**	**4.1**
Chucks	10	0.4	0.2	0	0.0	0.0	0	0.0	0.0
Chips	2672	99.6	61.8	93	100.0	77.5	21	100.0	17.4
Total Debris	**2682**	**100.0**	**62.0**	**93**	**100.0**	**77.5**	**21**	**100.0**	**17.4**
Total	**4325**	**100.0**	**100.0**	**120**	**100.0**	**100.0**	**121**	**100.0**	**100.0**

*NBK: Naturally Backed Knife; CTE: Core Trimming Element.

items, most of which are flakes, are 11.8% of the debitage and 4.3% of the entire assemblage (see Table 2 for the full inventory). Cores and retouched items appear in very low frequencies (0.4% and 2.1% respectively).

Lithic Technology

The most dominant identifiable reduction sequence represented in the core and debitage categories of the unit 3 assemblage is Levallois flake production, reflected in Levallois index (IL) of 34.9.

Most cores in the assemblage are small (Figure 5), and their maximum length does not exceed 100mm, with an average of 62mm. The Levallois cores (n=8, including one Levallois COF) are split evenly between the recurrent and preferential flaking concepts and most of them are less than 80mm long and 60mm wide when discarded (see Figure 5). On seven out of the eight cores, centripetal Levallois flaking was used at the observable last stage of removals. The remaining core shows a bi-directional scar pattern (Figure 6a). Four non-Levallois COFs were found in unit 3 (Table 3), two of which are Nahr Ibrahim (Goren-Inbar 1988; Solecki and Solecki 1970). The COF exhibit 3 to 7 scars removed from a single striking platform, exploiting mainly one face of the flake (dorsal in two cases and ventral for the other two). Two of the blanks for the COF were Levallois flakes.

The short, expedient COF reduction sequences (Figure 6b) also may have produced Kombewa flakes (n=10). One non-Levallois hierarchical surface core and a multiple surface core were also identified. These are highly reduced and it is difficult to determine if they represent intentional and separate reduction sequences or had been used initially as Levallois cores and exploited more expediently when their geometry did not allow further production of Levallois items (see Table 3).

All the cores from unit 3, apart from the COFs, bear cortex on the preparation surface. Most of the decortication stage seems to have taken place out of the site for both local and non-local raw materials. This inference is supported by the small size of most of the cortical items, 72% of which have a maximal length of less than 5cm. However, decortication was non-exhaustive, which resulted in relatively high numbers of naturally backed knives (NBK) and some cortical flakes. Five out of the seven Levallois cores were discarded with more than 50% cortex cover of the preparation surface. On three of them there are scars indicating removal of flakes with a cortical back.

Dorsal face scar patterns on both debitage and cores suggest that the main reduction strategy for the Levallois sequences was associated with centripetal knapping (e.g., centripetal and orthogonal scar patterns), followed by bi-

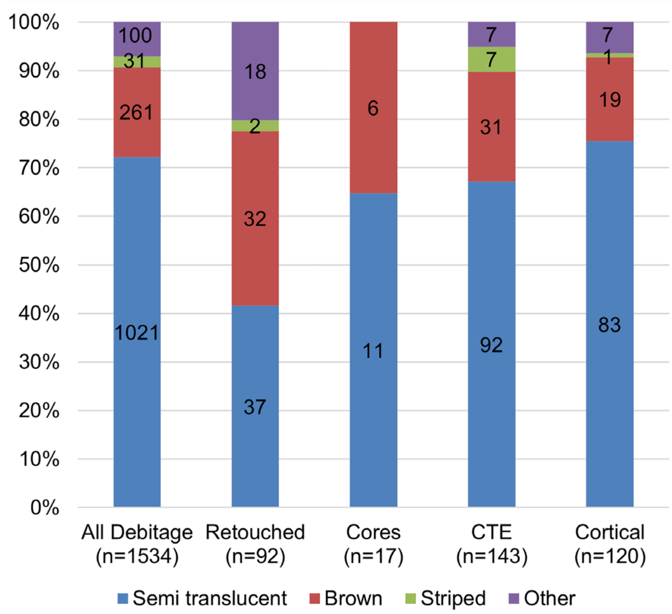

Figure 4. Raw material frequencies in different lithic categories.

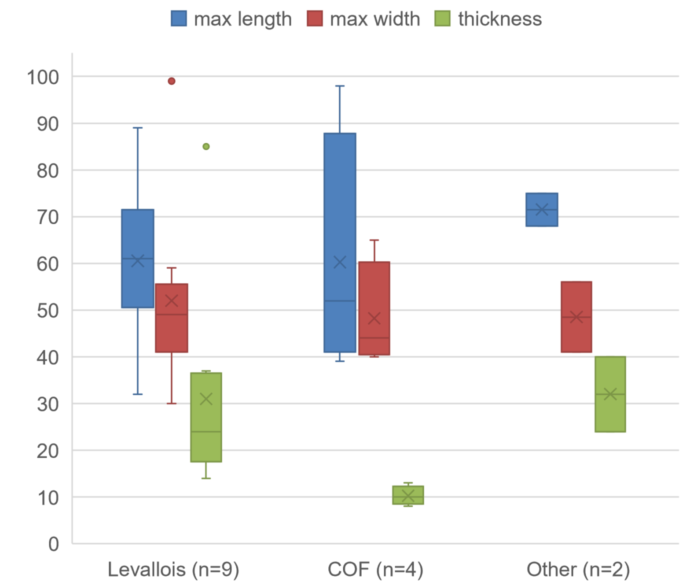

Figure 5. Metric attributes of cores.

directional production. Centripetal dorsal face scar pattern is the most frequent on Levallois cores and blanks as well as on non-Levallois blanks (Figure 7). Bidirectional dorsal scar patterns are evident in all groups but most frequent within the Levallois blanks and the NBKs. The unidirectional-convergent scar pattern is very rare in the ND24 assemblage and appears mostly on Levallois blanks, among which its frequency is 8%. Very few items indicate the use of preferential reduction methods (a single flake bearing the 'horse shoe' scar patterns and three points with classical Y-pattern).

When separating the orthogonal from the centripetal scar patterns, Levallois blanks (both retouched and unretouched) show nearly the same proportions of bidirectional and centripetal scar patterns (26% and 21% respectively, Figures 8a, 9). The various orthogonal scar patterns were recorded on 17% of the Levallois products. For the non-Levallois blanks (both retouched and unretouched) the orthogonal dorsal scar patterns are the most common ones (51%) followed by cortical (12%), centripetal (10%), and bidirectional (8%).

Levallois blanks in the ND24 assemblage are characterized by prepared striking platforms, mostly facetted (73%). *Chapeau de gendarme* striking platforms are rare (4%, Figure 8b, see Figure 9). The non-Levallois items show less preparation of the striking platforms with plain platforms being most common (41%), followed by dihedral (21%) and facetted (18%). Other striking platform types represented in small quantities are punctiform, crushed, and cortical.

The most frequent shape for Levallois products is subrectangular, and when adjoined with rectangular and oval items (typically resulting from centripetal flaking; Van Peer 1992; Bar-Yosef 1998) this group constitutes 57.4% of all Levallois products. Triangular and sub-triangular Levallois

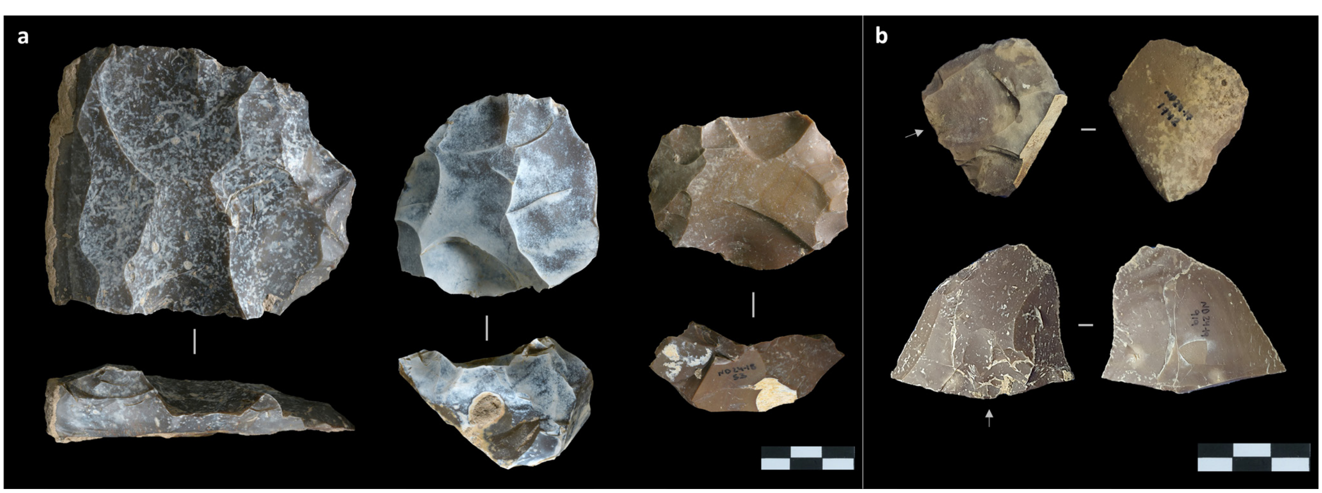

Figure 6. Cores from Unit 3: a) Levallois cores; b) COFs (photos by C. Amit [IAA]).

TABLE 3. CORE TYPOLOGY.

Core type	n	%
Levallois core	7	41.2
Levallois core on flake	1	5.9
Hierarchical surface core	1	5.9
Core on flake	4	23.5
Multiple surface core	1	5.9
Core fragment	3	17.6
Total	**17**	**100.0**

products constitute only 7% and 5%, respectively (Figure 8c). Sub-rectangular and rectangular shapes are also most frequent for non-Levallois items (43%), followed by irregular (25%) and oval (11%) items.

The average number of dorsal scars on Levallois blanks is 6.1 (s.d. 2.2), with more than half of the items showing four to six scars and few with less than three or more than

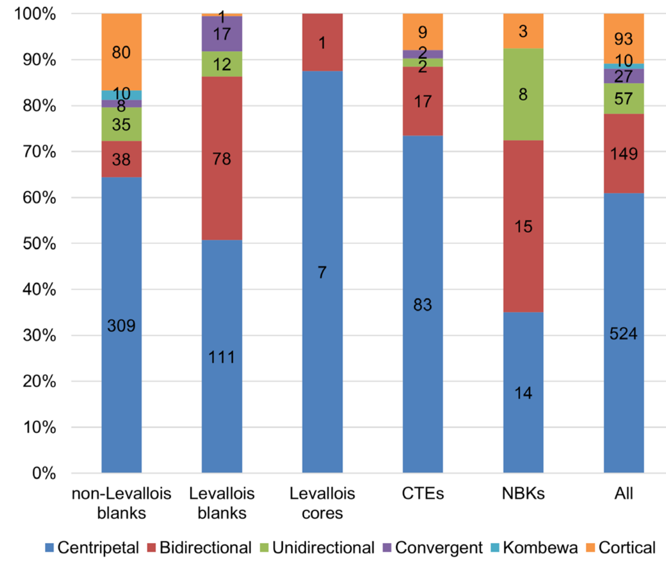

Figure 7. Dorsal face scar patterns on all items from ND24 (retouched items are included in each category according to blank; CTEs and NBKs include Levallois and non-Levallois; broken and unidentifiable items are excluded).

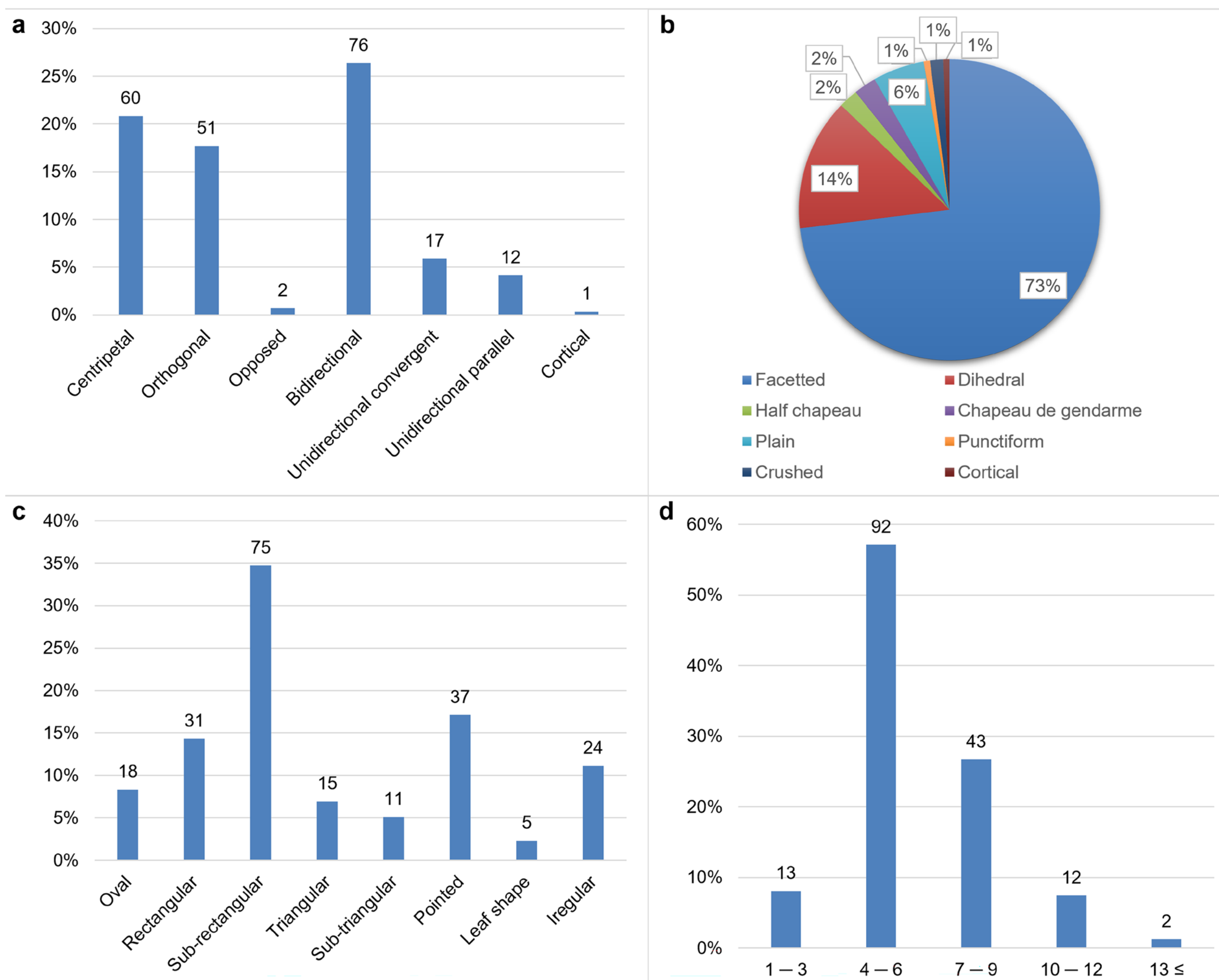

Figure 8. Technological attributes of Levallois blanks: a) dorsal face scar pattern; b) types of striking platforms; c) blank shape; d) number of dorsal scars. (Retouched items are included in each category acording to blank; broken and unidentifiable are excluded.)

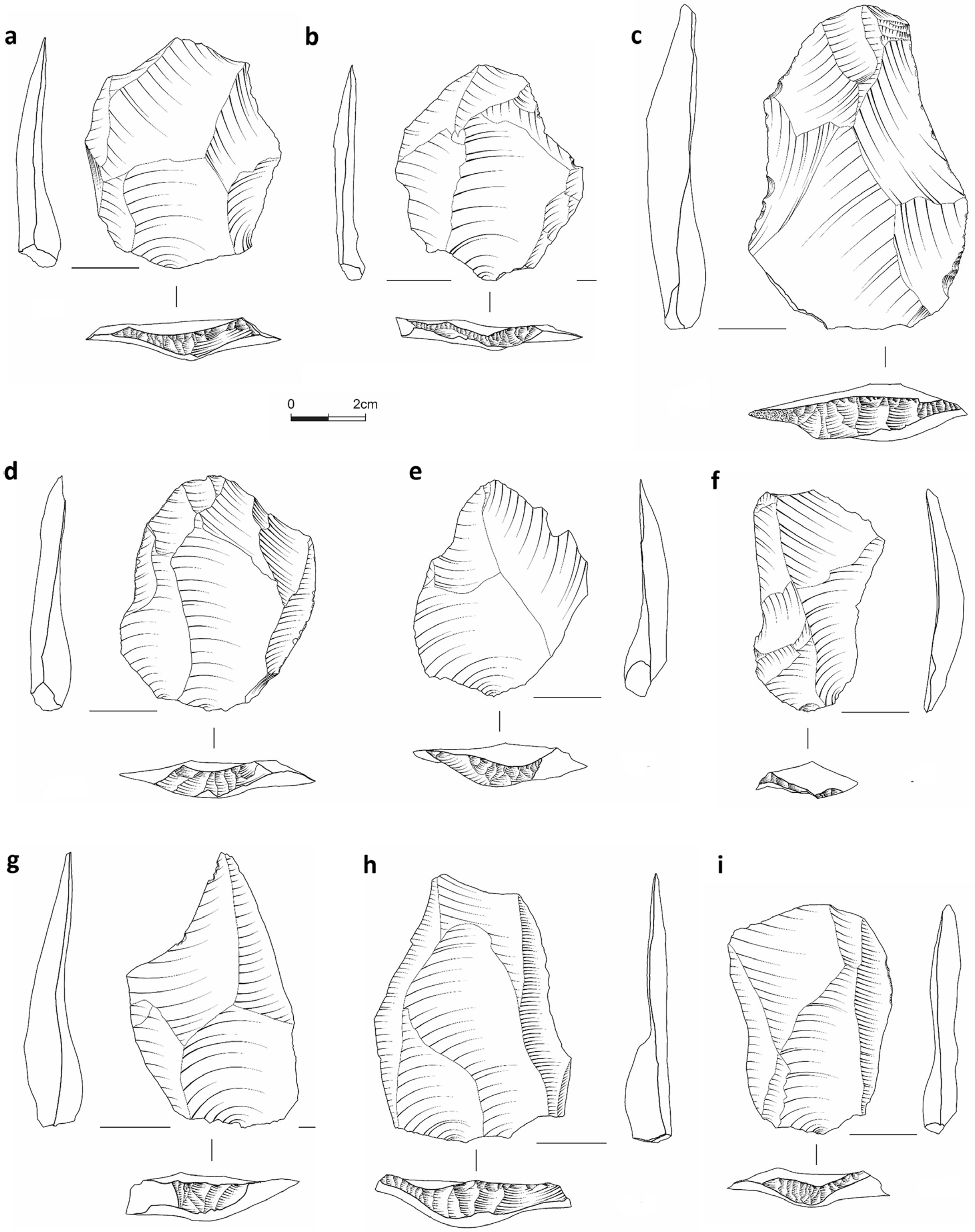

Figure 9. Levallois flakes from unit 3 showing centripetal (a-f) and bi-directional (g-i) dorsal scar patterns (drawings by S. Alon).

ten (Figure 8d). Non-Levallois blanks have less dorsal scars; in 51% of these items there are only up to three scars.

Both Levallois cores and Levallois flakes bearing bidirectional scar patterns are longer in average compared to all other items, with the exception of non-Levallois cortical items that are slightly longer in average (Figure 10). This size distribution may suggest that centripetal and bidirectional strategies were used in the same sequences, starting with bidirectional production and moving to centripetal exploitation. The single Levallois core bearing a bidirectional scar pattern is larger than all other Levallois cores, which bear centripetal patterns and are rather exhausted. Levallois points and blades are slightly longer on average than Levallois flakes and CTE's; however, the size differences among Levallois blanks are not statistically significant (Supplementary Material 3).

The convexity of the flaking surface of Levallois cores was maintained by the removal of NBKs and *debordant* flakes, including partial *debordants* and pseudo-Levallois points (Figures 11, 12). Other ways for core maintenance

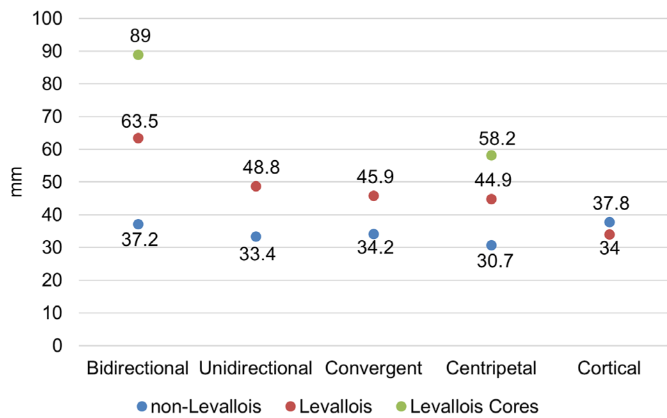

Figure 10 Average maximal length of Levallois cores and blanks and non-Levallois blanks with different dorsal scar patterns.

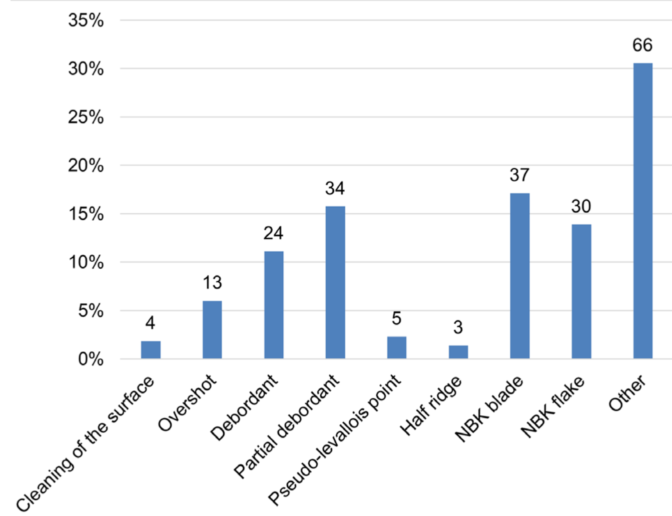

Figure 11. Types of CTEs (retouched and unretouched).

were surface cleaning after knapping mistakes such as hinges, by renewing the surface with a removal of large, in some cases overshot, flakes (see Figures 11, 12).

Retouched Items

The lithic assemblage of unit 3 includes 92 retouched items (Table 4, Figure 13) that are 2.1% of the assemblage and 5.6% of the items larger than 2cm. The most common type is retouched flakes (37%), followed by the side-scraper group (25%), and notched and denticulated items (16.3%). End-scrapers, burins, and truncated items are rare in the unit 3 assemblage; together they constitute 5.4% of all retouched items. The most common blanks among the retouched items are Levallois and non-Levallois flakes (Figure 14), 41.3% and 26.1%, respectively. Other types of blanks are significantly less frequent, including Levallois points and blades (7.6% and 6.5%, respectively).

Limestone Objects

Several limestone objects were also found in unit 3, only two of which show clear modifications and traces of use and may have been used as hammerstones (Figure 15).

Figure 12. a) CTEs from unit 3: 1) overshot; 2–3) debordant; *4–5) partial* debordant; *b) refitted NBK used for convexity maintenance after the removal of a Levallois flake (photos by C. Amit [IAA] and M. Oron).*

TABLE 4. RETOUCHED ITEM TYPES IN UNIT 3.

Typology	n	%
Retouched Levallois point	2	2.2
Single straight scraper	5	5.4
Single convex side scraper	15	16.3
Single concave side scraper	1	1.1
Double side scraper	2	2.2
End scraper	1	1.1
Burin	2	2.2
Truncation	2	2.2
Notch	10	10.9
Denticulate	5	5.4
Retouched flake	34	37.0
Retouched blade	7	7.6
Massive tool	1	1.1
Tool fragment	5	5.4
Total	**92**	**100.0**

Others may be manuports or a result of natural weathering of the local limestone in the shelter.

DISCUSSION

Short-term occupations are often interpreted as task specific localities within a logistic satellite site system. Some of these are associated with a curated tool-kit used by highly mobile groups (Binford 1979; Kuhn 1992, 1995). Within this context, Kuhn (1994) proposed that the geometry and dimensions of Levallois cores and blanks provide high potential utility relative to their mass, making them cost-effective in contexts of transport. Following this logic, Centi and Zaidner (2020) suggested that large and flat Levallois flakes and highly productive Levallois cores were components of the hunter-gatherers' mobile toolkit in low density occupations along the sequence of Nesher Ramla Quarry (NRQ). Further, low densities of lithic artifacts have also been linked to a relative abundance of retouched items and more intensively retouched tools (Centi and Zaidner 2020; Clark and Barton 2017; Kuhn and Clark 2015; Riel-Salvatore and Barton 2004). The well-preserved archaeological horizon excavated in unit 3 is relatively shallow, without visible spatial features and shows relatively low artifact densities, all suggesting that it represents a short-term occupation, or a few repeated short visits to the site (Barton and Riel-Salvatore 2014; Binford 1980; Clark and Barton 2017; Mitki et al. 2021).

The technological organization of the ND24 assemblage shows a mixture of attributes that does not support one simple interpretation of site function. The low number of retouched items and the lightly retouched tools do not fit the expected relationship between low densities of artifacts and high frequencies of retouched items. A main reason for that is most likely that knapping, being a significant activity contributing to the accumulation of unit 3 lithic assemblage, produced high frequencies of debitage and CTEs. The technological characteristics and the differences in dimensions of the various artifact classes observed in the assemblage suggest that the initial stages of reduction took place off-site (e.g., the small size of cortical items and non-Levallois debitage). Still, flint knapping appears to have been one of the activities conducted on-site, as cores were most likely brought to the site at least partly decorticated. This seems to be the case for both the local semi-translucent raw material of the Mishash formation outcrop as well as for the allochthonous brown flint used for both Levallois and COFs reduction. The composition of raw materials of the small collection of retouched items is variable compared to the rest of the assemblage, which suggests that many of them were introduced into the site as blanks or as already modified tools, some from more distant areas. Given the low frequencies of retouched items, retouch may not have been an important part of the reduction sequence carried out. Alternatively, retouched items may have been produced and removed from the site after their production and/or use. The latter scenario is indeed suggested by the large number of micro-flakes that could derive from platform faceting or from retouching the artifacts.

On the other hand, prepared Levallois cores and large flakes were brought from distant location(s) and used in the site, although raw material availability was not a constraint in ND24. The dominance of Levallois production and use of large Levallois flakes (as tools and COFs) in the assemblage of unit 3 are consistent with the use of these items as part of a mobile toolkit. The scarcity of cores compared to debitage suggests similar behavior, either in the form of off-site core transportation or a high frequency of imported flakes.

Currently, it is hard to understand the role of the short-term occupation in ND24 within its local strategic mobility system, due in part to the poor preservation of the faunal remains and to the lack of other sites dated to the late MP in the Dimona area. Nonetheless, the composition of the assemblage and the significant levels of transport of both raw materials and of lithic products in different stages of reduction into the locality (and possibly out of it) points towards a dynamic system of high mobility, typically indicating short-term occupation(s) (e.g., Mitki et al. 2021). Combined with the depositional history reconstructed from our field observations, the data suggest that the lithic assemblage of ND24 is a result of a short-term campsite where probably a mixture of activities took place.

ND24 AND LITHIC VARIABILITY IN THE MP

All of the Levallois reduction methods are present in all MP assemblages in the southern Levant. MP lithic variability, in general, and during the late MP in particular, is manifested in nuanced differences in the frequencies of combinations of modes and methods of Levallois production (e.g., the Levallois preferential or recurrent modes and unidirectional, bidirectional, or centripetal methods for shaping the

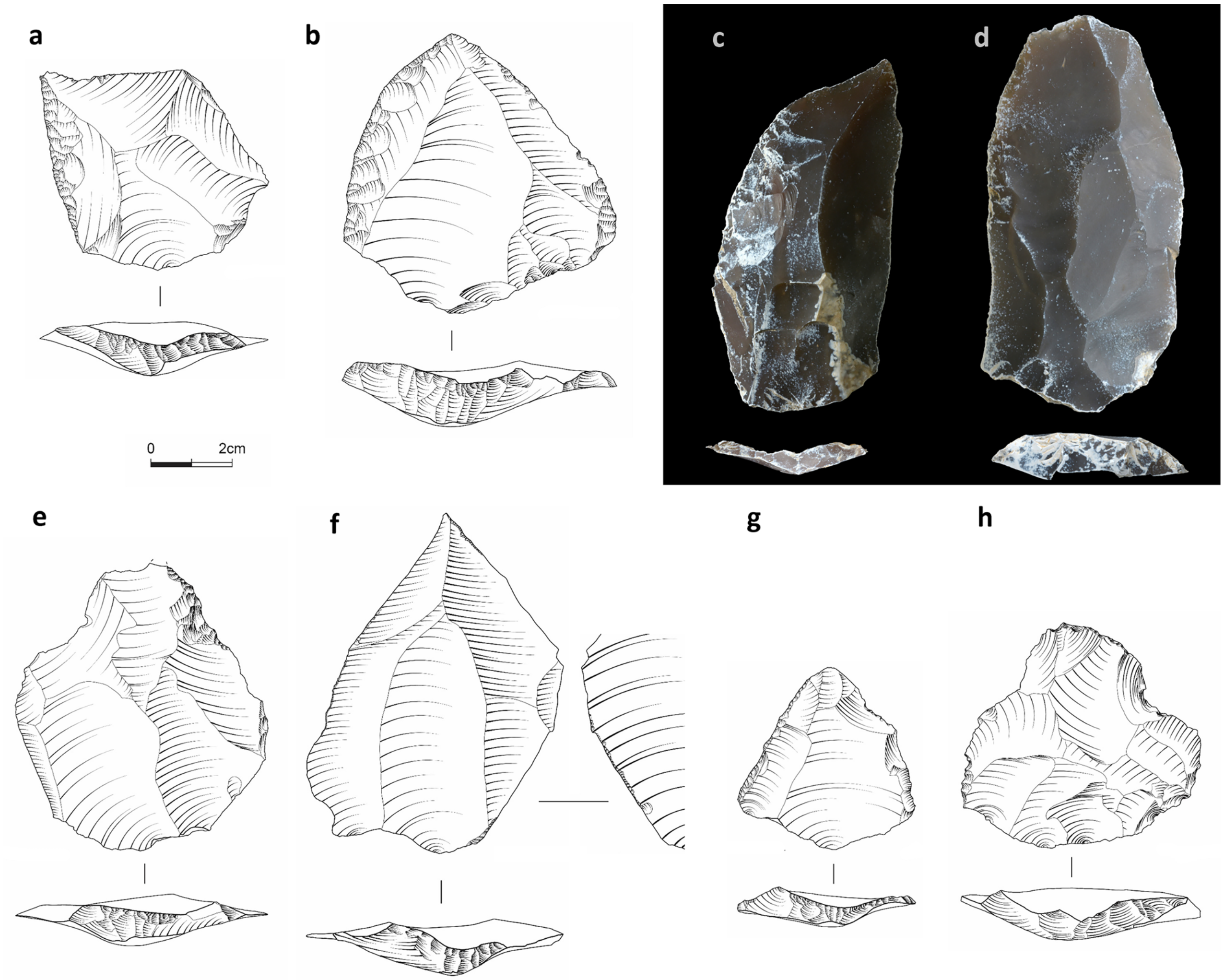

Figure 13. Retouched items: a-d) side scrapers; e-g) retouched Levallois blanks; h) notched flake (drawings by S. Alon; photos by C. Amit [IAA]).

core flaking surface; Hovers and Belfer-Cohen 2013), often appearing with other formal flaking systems (e.g., semi-rotated cores; Malinsky-Buller et al. 2014; Meignen 1998; Mitki et al. 2021). This is most prominent in the late MP, but evident also in MIS 5 sites, and to a lesser degree also in the Early MP sites (Figure 16; Supplementary Material 4). This technological variability has long been explained by a linear chronological model based on the long sequence in Tabun Cave (Bar-Yosef 1998; Copeland 1975; Jelinek 1975, 1982). More recently, this model has been challenged by ac-

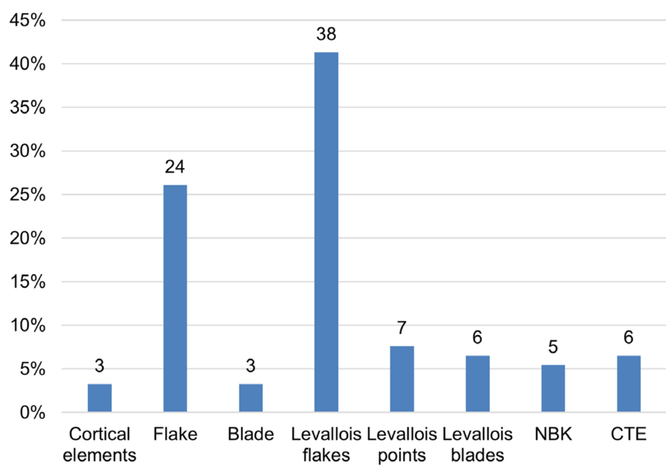

Figure 14. Frequencies of blanks of the retouched items.

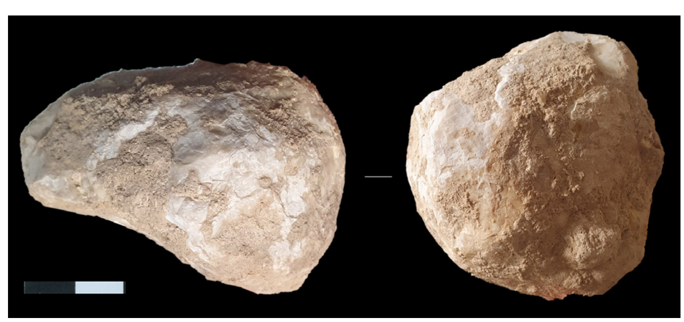

Figure 15. Limestone artifact used as a hammerstone (photos by M. Oron).

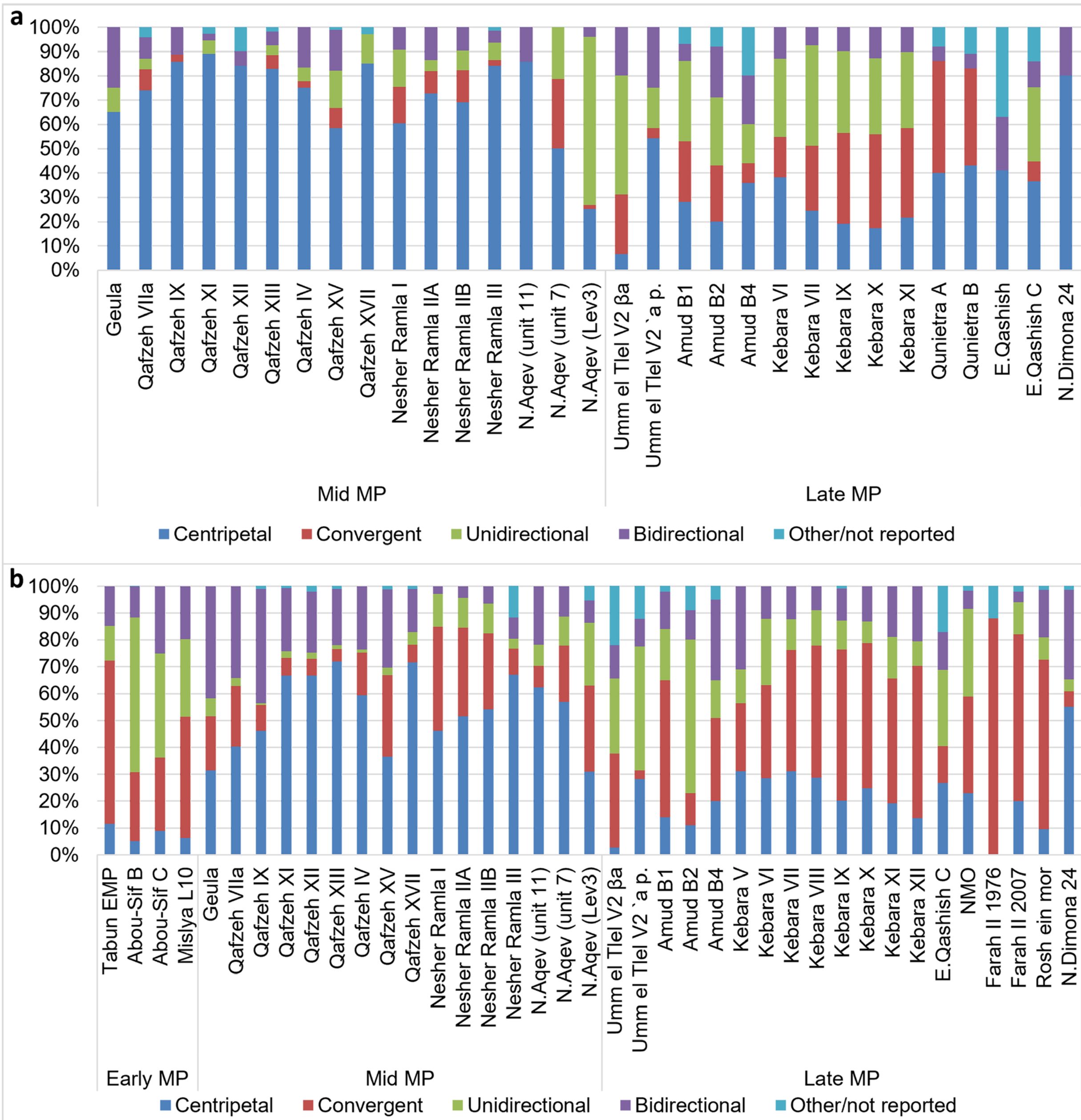

*Figure 16. Scar patterns on Levallois cores (a) and blanks (b) for dated assemblages from the Levant, compared with ND24 on the right (data from: Abadi et al. 2020; Barzilai et al. 2021, 2022; Centi and Zaidner 2021; Goder-Goldberger and Bar-Matthews 2019; Goder-Goldberger et al. 2020; Hovers 2004, 2009; Hovers et al. 2008; Meignen 2019; Mitki et al. 2021; Munday 1976; Pagli 2013; Prévost and Zaidner 2020; Shimelmitz and Kuhn 2013; Wojtczak and Malinsky-Buller 2022; Zaidner and Weinstein-Evron 2012, 2020). *NMO data is unpublished.*

cumulating data, additional research, and changes in theoretical approaches (Goren-Inbar and Belfer-Cohen 1998; Hovers 1997, 1998; Hovers and Belfer-Cohen 2013).

Still, this linear chronological model remains influential in Levantine MP studies, due to several characteristics of MP lithic assemblages in the region:

- The relative technological homogeneity of the Early MP assemblages (dated to between 250 ka and 160 ka), characterized by laminar and unidirectional Levallois reduction modes (Shimelmitz and Kuhn 2013; Wojtczak and Malinsky-Buller 2022; Zaidner and Weinstein-Evron 2020).
- The prevalence of centripetal Levallois reduction, purportedly in sites dating to MIS 5 (120–90 ka), such as Qafzeh (layers XXIV–XV) (Hovers 2009: 267–273; Valladas et al. 1988) and NRQ (Prévost and Zaidner 2020; Zaidner et al. 2021).
- The prevalence of the unidirectional convergent flaking methods in many late MP sites (dating to between 70 ka and 50 ka) such as Amud (sub-units B2 and B1) and Kebara (especially units X–IX) in the Mediterranean zone (Hovers 1998, 2004, 2009; Meignen and Bar-Yosef 1992;

Valladas et al. 1999), Lower Besor sites in the northern Negev (Goder-Goldberger et al. 2020, 2023), Tor Sabiha and Tor Faraj in southern Jordan (Groucutt 2014; Henry and Miller 1992; Henry 1995), and Hummal A1 in Syria (Hauck 2011).

When the full spectrum of the Levantine MP record is considered, a more complex picture emerges. In Tabun Cave, layer C that is dominated by centripetal Levallois mode yielded somewhat older dates than Qafzeh cave or NRQ (134±8 to 178±10 ka, Mercier and Valladas 2003), and the relevant assemblage from Layer B is currently poorly dated (Hovers 2009: Appendix 6). Long sequences in multilayer sites, mainly when post-dating the early MP, show some technological variability between assemblages (Centi and Zaidner 2020; Ekshtain and Tryon 2019; Hovers 1998, 2009). Centripetal Levallois flaking is present in significant frequencies also in MP assemblages such as Amud (subunit B4, Hovers 2004), Kebara (Abadi et al. 2020), and Quneitra (Goren-Inbar 1990), dated to MIS 4–3. In fact, high technological variability, both within the Levallois production system and in the use of other modes of production, is perceived as a central characteristic of the Late MP in the Levant (Abadi et al. 2020; Goder-Goldberger 2020; Hovers 1998).

Different explanations, rooted in different theoretical frameworks and sometimes based on different data sets, were proposed for the technological variability between and within assemblages in the southern Levant. Meignen and Bar-Yosef (1992) suggested that the linear chronological trend (e.g., the Tabun Model) could be explained by changes of technological *traditions* that were adopted sequentially by human groups in the southern Levant, resulting in a linear trend of technological change. Based on the assumption that ameliorated climate conditions (i.e., higher water availability) would lead to more 'downtime,' hence promoting higher investment in core preparation, Munday (1979) linked the abundance of broad and short Levallois debitage with dry climatic conditions. Conversely, convergent Levallois flaking and the production of elongated debitage, arguably requiring more intensive core preparation, were produced more abundantly during periods of higher participation, which in the arid Negev would be more beneficial.

Lithic variability in the Levantine MP has also been attributed to the presence of two hominin species in the region during this time span. Jelinek (1977, 1982) noted a decrease in the variance of width/thickness ratio of flakes along the Tabun sequence. Premising that modern humans were responsible for the later assemblages at this site, and that they had superior manual skills that allowed them better control over flake shapes and dimensions, he attributed the decreased variance to the replacement of Levantine Neanderthals by modern humans. Lieberman and Shea (1994; Shea 1998) suggested that MP modern humans and Neanderthal relied on different ways of mobility (but see Lieberman 1998) and distinct strategies of hunting, a behavioral difference that they linked directly to the lithic assemblages. In this scenario, pointed Levallois items were hunting tools used by Neanderthal populations in a more technology-dependent hunting strategy compared to modern humans.

More recently, Shea (2006) emphasized the similarities between assemblages in the southern Levant MP, arguing that a process of convergence (rather than cultural transmission between populations) was the main 'homogenizing' factor. He argued that whatever variability existed in key lithic technological elements was recursive and related to the discontinuous occupation in the Levant by either Neanderthals or modern humans. To him, the recognizable differences in the nature of reduction sequences between the lithic industries of MIS 5 (Qafzeh and Skhul) and later MP assemblages (Kebara, Amud) reflect the movements of the two human populations into the region, followed by their local extinctions and replacement by their competitors (see also Rak 1993). This scenario again aligns with the Tabun sequence as a model and yardstick for the main trajectories of change in the Levantine MP. Importantly, the argument hangs on the perception of biological separation of Neanderthals and moderns into distinct species (Shea 2006: 202), which is not supported by current paleogenetic evidence. Indeed, paleogenetic data led to an inference that hybridization between African and Neanderthal populations took place in western Asia prior to MIS 5 (Posth et al. 2017).

Another factor to be considered in this context is cultural norms and traditions. The foundation for this approach lies in the view of a lithic assemblage as an outcome of the set of decisions planned and implemented by knappers following learned knowledge (Lemonnier 1992; Schiffer and Skibo 1987; Tostevin 2000). The 'know-how' is passed on from one generation to another, and if maintained through time, it is manifested in regional cultural traditions that can be identified by technological traits (Boyd et al. 2013; Foley and Lahr 2003). Similarities in lithic assemblages across continuous space and time are considered a reflection of contact and social interaction, assuming that the degree and depth of cultural transmission is related to the degree of social intimacy. Higher similarities among assemblages in distinct stages of the whole reduction sequence (from the preparation of the core, through blank morphology to the final knapping product and the social context it was used in) indicate higher rates of contact and transmission (Tostevin 2012, 2019).

Overall, the regional database does not support simple single-cause explanations (e.g., climatic change, raw material availability, or a rigid dichotomy between hominin species) as the main drivers of technological variability within and between MP assemblages in the Levant in the Mediterranean zone (Hovers 2006, 2009).

For the arid zone, some researchers focused on mobility patterns as determined by environmental factors, specifically the differences between the Mediterranean zone and the arid environment. For example, Crew (1975) suggested that the arid conditions resulted in short duration of occupations in the desert sites; combined with availability of raw material, this led to less core preparation and as a result shorter and thicker Levallois products and lower percentages of side-scrapers. Shea (1998) interpreted the higher percentage of points in the Negev sites (compared to the Mediterranean zone sites) as a reflection of distinct hunting strategies in response to differences in resource structure due to environmental conditions. Following the intensive fieldwork carried by the Central Negev Project in the Zin area, Munday (1976) as well as Marks and Freidel (1977) attempted to reconstruct settlement patterns and inter-site lithic technological variability, mainly related to local raw material and water sources. More recently Pagli (2013) showed that differences in the lithic variability of the arid El Kowm in Syria, in the inland regions of the Levant, compared with the Mediterranean environment, can be explained by different mobility patterns of human groups. In her view, the nature of changes within each sequence included in her study is best explained by distinct separate occupation periods, reflecting long-distance mobility of different human groups in the desert sites in contrast to continuous occupation in the Mediterranean zone sites. Bonilauri et al. (2023) suggested that some aspects of the technological variability within the El Kowm basin may have resulted from increased mobility and cultural interaction between the MP populations of the Syrian Plateau and those in the Southern Levant or even central Saudi Arabia during MIS 5a and early MIS 4.

The effects of cultural processes on the arid Negev area have received far less attention in the literature, partly due to the rarity of assemblages from well-preserved, dated contexts. This situation, however, has changed recently. Some workers focused on techno-typological similarities between assemblages from the arid regions of the southern Levant and the Mediterranean zone, interpreting them as an indication of cultural similarities. In such scenarios, the similarity in lithic technology is deemed to reflect movements of people and ideas into the arid region, facilitated during periods of ameliorated climatic conditions (i.e., higher water availability) (Barzilai et al. 2022; Goder-Goldberger et al. 2016; Henry 2003). Hovers (2001, 2009; Hovers and Belfer-Cohen 2013) suggested that during the late MP, groups moving within the Mediterranean zone of the southern Levant occupied smaller and more densely packed territories, such that adherence to a group's cultural norms created site-specific/regional technological traditions (and see Krakovsky 2017; Krakovsky et al. in prep.), regardless of any putative biological assignation. Studies of the lithic material from NRQ, pointing to site-specific technological idiosyncrasies (Centi et al. 2019; Prevost et al. 2020; Zaidner et al. 2021) are consistent with this conclusion.

The lithic assemblage from unit 3 in ND24 is dominated by the centripetal Levallois flaking method, with centripetal scar patters on 80% of the Levallois cores and 55% of the Levallois products, followed by significant use (20% and 33% respectively) of bidirectional Levallois flaking. These technological choices closely resemble those seen in MIS 5 assemblages in the southern Levant, e.g., Qafzeh Cave in northern Israel and Nahal Aqev in the Central Negev (see Figure 16; Supplementary Material 4, Tables S1, S2). In Qafzeh, centripetal Levallois flaking is dominant in all layers (apart from XV), with a heavier tendency toward the preferential mode in the older assemblages; bidirectional flaking also appears in significant frequencies (Hovers 2009). In Nahal Aqev, the lithic assemblages dated to MIS 5 show a preference for centripetal Levallois flaking, observed on 50%–86% of the Levallois cores and 57%–62% of the Levallois products (Barzilai et al. 2022). Despite its late MP date, the ND24 assemblage is more closely aligned with those two assemblages and is clearly different technologically from contemporaneous assemblages such as those of Kebara and Amud in the Mediterranean zone. In both sites, centripetal scar patterns are present in lower frequencies (17%–38% of the Levallois cores and 14%–31% of the products) and unidirectional and convergent scar patterns appear in high frequencies (Hovers 1998, 2004, 2009; Meignen and Bar-Yosef 1992; Valladas et al. 1999).

The lower Besor sites of Farah II, B27, and B37 (Goder-Goldberger et al. 2020, 2023) are of special interest here. These sites, located in the northern Negev ~55km northwest of ND24, are broadly contemporaneous with it. Like the assemblage of unit 3 in ND24, the Besor sites are interpreted as short-term occupations and also show very homogenous technological composition as reflected in the Levallois reduction (although it is not the only reduction sequence). In contrast to ND24, the dominant Levallois flaking mode in these sites is unidirectional convergent. This underlines the lack of inherent dependence between the prevalence of a specific Levallois flaking method and a chronological or even geographical context within the Levantine Late MP. The differences in the technological choices between the assemblages of ND24 and the lower Besor sites may be most feasibly explained by the existence of different technological traditions.

Further, it may be suggested that the relative technological homogeneity of the Negev assemblages stems from high mobility strategies that result in shorter and more sporadic visits compared to the extensive occupation of some sites in the Mediterranean environment. Indeed, Hovers (2001, 2009) suggested that in the arid and semi-arid zones MP groups may have exploited larger territories due to the clumped distribution of subsistence resources, which would lead to an expectation of more diffused technological traditions (see above). Although we cannot reconstruct a site system for ND24, we can carefully suggest that long-distance mobility within larger territories, following the availability of resources, resulted in short, and maybe more sporadic, visits to any given locality. Similar suggestions were voiced, generally for arid regions in the Levant (Hovers 2001, 2009) and specifically for the arid Syrian desert (Pagli 2013). This in turn explains intra-assemblage homogeneity. Under this scenario each assemblage may be a result of the specific adaptive and cultural choices made by a human group over a short time span, as opposed to more intensive occupation sites that may represent many returns and the use of different Levallois reduction systems at the same site.

It is tempting to relate these differences to logistical mobility with base camps and "satellite" task-specific localities in the Mediterranean zone as opposed to residential systems of high mobility in the desert. However, we cannot exclude the use of different combinations of high mobility residential systems and logistic systems in the whole region, conditioned by the seasonal availability of resources (Hovers and Belfer-Cohen 2013; Malinsky-Buller et al. 2021). Further, it was suggested that hunter-gatherer societies in lower latitudes, such as the southern Levant Mediterranean zone, adopted settlement strategies that were more oriented toward residential mobility (Binford 1980, 1990; Hovers 2009; Kelly 1983). The desert environments certainly presented more acute seasonal conditions and more patchy resource distributions, leading to higher mobility than in the Mediterranean environments. Under such conditions each site was more sporadically used and was occupied for shorter periods. Well-preserved sites in the Negev, such as ND24 or the lower Besor sites, present a view into the adaptations to immediate environments of people conforming to relatively homogeneous technological traditions.

SUMMARY AND CONCLUSIONS

We propose that since long, stratified MP sequences time-average the material residues of many visits by different groups, their lithic technologies tend to be highly variable. In contrast, short-term occupations such as ND24 likely better reflect the use of specific technological traditions related to Levallois preparation in the context of adaptive behaviors in the arid zone and provide a more 'distilled' view of cultural norms expressed through the technological practices of these mobile groups.

The technological traits of the late MP ND24 assemblage suggest high technological resemblance with earlier MP sites from the southern Levant such as Qafzeh Cave, NRQ, and Nahal Aqev, all spanning the time between the end of MIS 6 to MIS 5. At the same time, ND24 differs from other late MP sites mainly in the paucity of unidirectional convergent Levallois strategy and triangular end-products as well as in the general high technological homogeneity, e.g., the dominance of one reduction sequence. This assemblage provides further support to the notion that within the technological variability of the MP in the Levant, the dominance of a specific production mode is not a sufficient marker for assigning an assemblage to a specific time span. The differences between the technological composition of ND24 and the broadly contemporaneous lower Besor sites, both identified as short-term occupations, may therefore point to the existence of different late MP lithic traditions in the arid Negev. This, in turn, raises new and interesting questions about population dynamics in an area that has been described both as an out of Africa corridor as well as an attractor of populations from the Mediterranean zone of the Levant, Africa, and Arabia.

ACKNOWLEDGMENTS

The excavation project was supported by the Irene Levi-Sala CARE Archaeological Foundation and by the Institute of Archaeology of the Hebrew University of Jerusalem through the Ruth Amiran Fund for Archaeological Research in Israel. Artifacts were photographed by C. Amit (IAA) and drawn by S. Alon. We thank G. Sharon for allowing us to use unpublished Levallois counts data from NMO. Maya Oron has been supported by the Israel Antiquities Authority scholarship program.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author (MO).

REFERENCES

Abadi, I., Bar-Yosef, O., Belfer-Cohen, A., 2020. Kebara V-A contribution for the study of the Middle-Upper Paleolithic transition in the Levant. PaleoAnthropology 2020, 1–28. https://paleoanthropology.org/ojs/index.php/paleo/article/view/794

Barton, C.M., Riel-Salvatore, J., 2014. The formation of lithic assemblages. J. Archaeol. Sci. 46, 334–352. https://www.doi.org/10.1016/j.jas.2014.03.031

Bar-Yosef, O., 1998. The chronology of the Middle Paleolithic of the Levant. In: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia. Plenum Press, New York, pp. 39–56.

Bar-Yosef, O., 2006. Between observations and models. In: Hovers, E., Kuhn, S.L. (Eds.), Transitions before The Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age. Springer, New York, pp. 305–325.

Bar-Yosef, O., Meignen, L., 1992. Insights into Levantine Middle Paleolithic cultural variability. In: Dibble, H.L., Mellars, P. (Eds.), The Middle Paleolithic: Adaptation, Behavior, and Variability. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, PA, pp. 163–182.

Bar-Yosef, O., Vandermeersch, B., Arensburg, B., Belfer-Cohen, A., Goldberg, P., Laville, H., Meignen, L., Rak, Y., Speth, J.D., Tchernov, E., 1992. The excavations in Kebara Cave, Mt. Carmel. Curr. Anthropol. 33, 497–550.

Barzilai, O., Abulafia, T., Shemer, M., May, H., Orbach, M., Frumkin, A., Yeshurun, R., Sarig, R., Porat, N., Hershkovitz, I., 2021. Rediscovering Geula cave: a Middle Paleolithic cave site in northern Mt. Carmel, Israel. Quatern. Int. 624, 181–197. https://www.doi.org/10.1016/j.quaint.2021.03.007

Barzilai, O., Oron, M., Porat, N., White, D., Timms, R., Blockley, S., Zular, A., Avni, Y., Faershtein, G., Weiner, S., Boaretto, E., 2022. Expansion of eastern Mediterranean Middle Paleolithic into the desert region in early marine isotopic stage 5. Sci. Rep. 12, 1–13. https://www.doi.org/10.1038/s41598-022-08296-9

Binford, L.R., 1973. Interassemblage variability: The Mousterian and the functional argument. In: Renfrew C.

(Ed.), The Explanation of Culture Change: Models in Prehistory. Duckworth Press, London, pp. 227–254.
Binford, L.R., 1979. Organization and formation processes: looking at curated technologies. J. Anthropol. Res. 35, 255–273. https://www.doi.org/10.1086/jar.35.3.3629902
Binford, L.R., 1980. Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. Am. Antiq. 45, 4–20. https://www.doi.org/10.2307/279653
Binford, L.R., 1990. Mobility, housing, and environment: a comparative study. J. Anthropol. Res. 46, 119–152. https://www.doi.org/10.1086/jar.46.2.3630069
Binford, L.R., Binford, S.R., 1966. A preliminary analysis of functional variability in the Mousterian of Levallois facies. Am. Anthropol. 68, 238–295.
Blinkhorn, J., Groucutt, H.S., Scerri, E.M., Petraglia, M.D., Blockley, S., 2021. Directional changes in Levallois core technologies between Eastern Africa, Arabia, and the Levant during MIS 5. Sci. Rep. 11, 1–11. https://www.doi.org/10.1038/s41598-021-90744-z
Boëda, E., 1995. Levallois: a volumetric construction, methods, a technique. In: Dibble H.L, Bar-Yosef O (Eds.), The Definition and Interpretation of Levallois Technology, Monographs in World Prehistory. Prehistory Press, Madison, pp. 41–65.
Boëda, E., Geneste, J.M., Meignen, L., 1990. Identification de chaine opératoires lithique du Paleolithic Ancient et Moyen. Paleo 2, 43–80.
Bordes, F., 1961. Typologie du Paléolithique Ancient et Moyen. CNRS, Paris.
Bordes, F., 1973. On the chronology and contemporaneity of different Paleolithic cultures in France. In: Renfrew C. (Ed.), The Explanation of Culture Change: Models in Prehistory. Duckworth Press, London, pp. 217–226.
Bordes, F., 1980. Le débitage Levallois et ses variants. Bull. Soc. Préhist. francaise 77, 45–49.
Bordes, F., 1988. Typologie du Paléolithique ancien et moyen. Presses du CNRS, Paris.
Boyd, R., Richerson, P.J., Henrich, J., 2013. The cultural evolution of technology: facts and theories. In: Richerson, P.J., Christiansen, M.H. (Eds.), Cultural Evolution: Society, Technology, Language, and Religion. MIT Press, Boston, MA, pp. 119–142.
Centi, L., Groman-Yaroslavski, I., Friedman, N., Oron, M., Prévost, M., Zaidner, Y., 2019. The bulb retouchers in the Levant: new insights into Middle Palaeolithic retouching techniques and mobile tool-kit composition. PloS One 14, e0218859. https://www.doi.org/10.1371/journal.pone.0218859
Centi, L., Zaidner, Y., 2020. Variations in lithic artefact density as a tool for better understanding Middle Palaeolithic human behaviour: the case of Nesher Ramla (Israel). Quatern. Int. 624, 4–18. https://www.doi.org/10.1016/j.quaint.2020.03.025
Centi, L., Zaidner, Y., 2021. The Levallois flaking system in Nesher Ramla upper sequence. J. Paleolit. Archaeol. 4, 9. https://www.doi.org/10.1007/s41982-021-00088-3
Clark, G.A., Barton, C.M., 2017. Lithics, landscapes & la longue-durée–curation & expediency as expressions of forager mobility. Quatern. Int. 450, 137–149. https://www.doi.org/10.1016/j.quaint.2016.08.002
Copeland, L., 1975. The Middle and Upper Palaeolithic in Lebanon and Syria in the light of recent research. In: Wendorf, F., Close, A. (Eds.), Problems in Prehistory: North Africa and the Levant. Southern Methodist University Press, Dallas, TX, pp. 317–350.
Crew, H.L., 1975. An examination of the variability of the Levallois method: its implications for the internal and external relationships of the Levantine Mousterian. Ph.D. Dissertation. University of California, Davis.
de la Torre, I., Martínez-Moreno, J., Mora, R., 2013. Change and stasis in the Iberian Middle Paleolithic: considerations on the significance of Mousterian technological variability. Curr. Anthropol. 54, S320–S336. https://www.doi.org/10.1086/673861
Delagnes, A., Meignen, L., 2006. Diversity of lithic production systems during the Middle Paleolithic in France. In: Hovers, E., Kuhn, S.L. (Eds.), Transitions Before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age., Interdisciplinary Contributions to Archaeology. Springer, New York, pp. 85–107.
Ekshtain, R., Tryon, C.A., 2019. Lithic raw material acquisition and use by early *Homo sapiens* at Skhul, Israel. J. Hum. Evol. 127, 149–170. https://www.doi.org/10.1016/j.jhevol.2018.10.005
Foley, R., Lahr, M.M., 2003. On stony ground: lithic technology, human evolution, and the emergence of culture. Evol. Anthropol. 12, 109–122. https://www.doi.org/10.1002/evan.10108
Galbraith, R.F., Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: an overview and some recommendations. Quatern. Geochronol. 11, 1–27. https://www.doi.org/10.1016/j.quageo.2012.04.020
Garrod, D.A.E., 1934. The Stone Age of Palestine. Antiquity 8, 133–150.
Goder-Goldberger, M., Bar-Matthews, M., 2019. Novel chrono-cultural constraints for the Middle Paleolithic site of Rosh Ein Mor (D15), Israel. J. Archaeol. Sci. Rep. 24, 102–114. https://www.doi.org/10.1016/j.jasrep.2018.12.021
Goder-Goldberger, M., Crouvi, O., Caracuta, V., Horwitz, L.K., Neumann, F.H., Porat, N., Scott, L., Shavit, R., Jacoby-Glass, Y., Zilberman, T., 2020. The Middle to Upper Paleolithic transition in the southern Levant: new insights from the late Middle Paleolithic site of Far'ah II, Israel. Quatern. Sci. Rev. 237, 106304. https://www.doi.org/10.1016/j.quascirev.2020.106304
Goder-Goldberger, M., Gilead, I., Boaretto, E., Edeltin, L., Horwitz, L.K., Jacoby-Glass, Y., Lavi, R., Neumann, F.H., Porat, N., Toffolo, M.B., 2023. Living in an ecotone: Late Middle Palaeolithic occupations in the lower Besor Basin, north-western Negev Desert, Israel. Antiquity 97(394), 1–8. https://www.doi.org/10.15184/aqy.2023.89

Goder-Goldberger, M., Gubenko, N., Hovers, E., 2016. "Diffusion with modifications": Nubian assemblages in the central Negev highlands of Israel and their implications for Middle Paleolithic inter-regional interactions. Quatern. Int. 408, 121–139. https://www.doi.org/10.1016/j.quaint.2016.02.008

Goren-Inbar, N., 1988. Too small to be true? Reevaluation of cores on flakes in Levantine Mousterian assemblages. Lithic Technol. 17, 37–44.

Goren-Inbar, N., 1990. The lithic assemblages. In: Goren-Inbar, N. (Ed.), Quneitra: A Mousterian Site on the Golan Heights, Qedem. Institute of Archaeology, The Hebrew University of Jerusalem, Jerusalem.

Goren-Inbar, N., Belfer-Cohen, A., 1998. The technological abilities of the Levantine Mousterians. In: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia. Plenum Press, New York, pp. 205–221.

Groucutt, H.S., 2014. Middle Palaeolithic point technology, with a focus on the site of Tor Faraj (Jordan, MIS 3). Quatern. Int. 350, 205–226. https://www.doi.org/10.1016/j.quaint.2014.06.025

Groucutt, H.S., Scerri, E.M., Stringer, C., Petraglia, M.D., 2019. Skhul lithic technology and the dispersal of *Homo sapiens* into Southwest Asia. Quatern. Int. 515, 30–52. https://www.doi.org/10.1016/j.quaint.2017.12.027

Hauck, T.C., 2011. Mousterian technology and settlement dynamics in the site of Hummal (Syria). J. Hum. Evol. 61, 519–537. https://www.doi.org/10.1016/j.jhevol.2011.01.014

Henry, D.O., 1995. The influence of mobility levels on Levallois point production, Late Levantine Mousterian, Southern Jordan. In: Dibble, H.L., Bar-Yosef, O. (Eds.), The Definition and Interpretation of Levallois Technology. Prehistory Press, Madison, pp. 185–200.

Henry, D.O., 2003. Human behavior and the stone tools from Tor Faraj. In: Henry, D.O. (Ed.), Neanderthals in the Levant: Behavioural Organization and the Beginnings of Human Modernity. Continuum, New York, pp. 60–85.

Henry, D.O., Miller, G.H., 1992. The implications of amino acid racemization dates of Levantine Mousterian deposits in Southern Jordan. Paléorient 18, 45–52.

Hovers, E., 1997. Variability of Lithic Assemblages and Settlement Patterns in the Levantine Middle Paleolithic: Implications for the Development of Human Behavior. Ph.D. Dissertation. The Hebrew University of Jerusalem.

Hovers, E., 1998. The lithic assemblage of Amud Cave, implications for understanding the end of the Mousterian in the Levant. In: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia. Plenum Press, New York, pp. 143–163.

Hovers, E., 2001. Territorial behavior in the Middle Paleolithic of the Southern Levant. In: Conard, N. (Ed.), Settlement Dynamics of the Middle Paleolithic and Middle Stone Age. Tübingen Publications in Prehistory, Tübingen, pp. 123–152.

Hovers, E., 2004. Cultural ecology at the Neandertal site of Amud Cave, Israel. In: Derevianko, A.P., Nokhrina, T.I. (Eds.), Arkheologiya i Paleoekologiya Evrasii [Archaeology and Paleoecology of Eurasia]. Institute of Archaeology and Ethnography SB RAS Press, Novosibirsk, pp. 218–231.

Hovers, E., 2006. Neandertals and modern humans in the Middle Paleolithic of the Levant: What kind of interaction? In: Conard, N. (Ed.), When Neandertals and Moderns Met. Kerns Verlag, Tübingen, pp. 65–86.

Hovers, E., 2009. The Lithic Assemblages of Qafzeh Cave. Oxford University Press, New York.

Hovers, E., Belfer-Cohen, A., 2013. On variability and complexity: lessons from the Levantine Middle Paleolithic record. Curr. Anthropol. 54, S337–S357. https://www.doi.org/10.1086/673880

Hovers, E., Buller, A., Ekshtain, R., Oron, M., Yeshurun, R., 2008. Ein Qashish—a new Middle Paleolithic open-air site in northern Israel. J. Israel Prehist. Soc. 38, 7–40.

Jelinek, A.J., 1975. A preliminary report on some Lower and Middle Paleolithic industries from the Tabun Cave, Mount Carmel (Israel). In: Wendorf, F., Marks, A.E. (Eds.), Problems in Prehistory: North Africa and the Levant. SMU Press, Dallas, TX, pp. 297–316.

Jelinek, A.J., 1982. The Middle Paleolithic in the southern Levant, with comments on the appearance of modern *Homo sapiens*. In: Ronen, A. (Ed.), The Transition from Lower to Middle Paleolithic and the Origin of Modern Man. British Archaeological Reports International Series 151, Oxford, pp. 57–104.

Kelly, R.L., 1983. Hunter-gatherer mobility strategies. J. Anthropol. Res. 39, 277–306. https://www.doi.org/10.1086/jar.39.3.3629672

Krakovsky, M., 2017. Decision Making Process and Technology: Is There a "Traditional" Operational Sequence? A Case Study of Levallois Points from Amud Cave. M.A. Thesis. The Hebrew University of Jerusalem.

Kuhn, S.L., 1992. On planning and curated technologies in the Middle Paleolithic. J. Anthropol. Res. 48, 185–214. https://www.doi.org/10.1086/jar.48.3.3630634

Kuhn, S.L., 1994. A formal approach to the design and assembly of mobile toolkits. Am. Antiq. 59, 426–442. https://www.doi.org/10.2307/282456

Kuhn, S.L., 1995. Mousterian Lithic Technology: An Ecological Perspective. Princeton University Press, Princeton, N.J.

Kuhn, S.L., Clark, A.E., 2015. Artifact densities and assemblage formation: evidence from Tabun Cave. J. Anthropol. Archaeol. 38, 8–16. https://www.doi.org/10.1016/j.jaa.2014.09.002

Lemonnier, P., 1992. Elements for an Anthropology of Technology. Anthropological Papers, Museum of Anthropology. University of Michigan Press, Ann Arbor.

Lieberman, D.E., 1998. Neandertal and early modern human mobility patterns: comparing archaeological and anatomical evidence. In: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia. Plenum Press, New York, pp. 263–275.

Lieberman, D.E., Shea, J.J., 1994. Behavioral differences between archaic and modern humans in the Levantine Mousterian. Am. Anthropol. 96, 300–332. https://www.doi.org/10.1525/aa.1994.96.2.02a00030

Malinsky-Buller, A., Ekshtain, R., Hovers, E., 2014. Organization of lithic technology at ʻEin Qashish, a late Middle Paleolithic open-air site in Israel. Quatern. Int. 331, 234–247. https://www.doi.org/10.1016/j.quaint.2013.05.004

Malinsky-Buller, A., Ekshtain, R., Munro, N., Hovers, E., 2021. Back to base: re-thinking variations in settlement and mobility behaviors in the Levantine Late Middle Paleolithic as seen from Shovakh Cave. Archaeol. Anthropol. Sci. 13, 112. https://www.doi.org/10.1007/s12520-021-01313-4

Marks, A.E., Friedel, D.A., 1977. Prehistoric settlement patterns in the Avdat/Aqev area. In: Marks, A.E. (Ed.), Prehistory and Paleoenvironments of the Central Negev, Israel, Vol. II, The Avdat/Aqev Area, Part 2 and the Har Harif. Southern Methodist University Press, Dallas, TX, pp. 131–158.

Meignen, L., 1998. Hayonim Cave lithic assemblages in the context of the Near Eastern Middle Paleolithic. In: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia. Plenum Press, New York, pp. 165–180.

Meignen, L., 2019. The Mousterian lithic assemblages from Kebara Cave. In: Meignen, L., Bar-Yosef, O. (Eds.), Kebara Cave, Mt. Carmel, Israel. The Middle and Upper Paleolithic Archaeology, Part II. American School of Prehistoric Research Bulletin. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA, pp. 1–147.

Meignen, L., Bar-Yosef, O., 1992. Middle Paleolithic variability in Kebara Cave, Israel. In: Akazawa, T., Aoki, K., Kimura, T. (Eds.), The Evolution and Dispersal of Modern Humans in Asia. Hakusen-Sha, Tokyo, pp. 129–148.

Mercier, N., Valladas, H., 2003. Reassessment of TL age estimates of burnt flints from the Paleolithic site of Tabun Cave, Israel. J. Hum. Evol. 45, 401–409. https://www.doi.org/10.1016/j.jhevol.2003.09.004

Mitki, N., Yeshurun, R., Ekshtain, R., Malinsky-Buller, A., Hovers, E., 2021. A multi-proxy approach to Middle Paleolithic mobility: a case study from the open-air site of ʻEin Qashish (Israel). J. Archaeol. Sci. Rep. 38, 103088. https://www.doi.org/10.1016/j.jasrep.2021.103088

Munday, F.C., 1976. Intersite variability in the Mousterian occupation of the Avdat/Aqev area. In: Marks, A.E. (Ed.), Prehistory and Paleoenvironments of the Central Negev, Israel, Vol. I, The Avdat/Aqev Area. Part 1. Southern Methodist University Press, Dallas, TX, pp. 57–68.

Munday, F.C., 1979. Levantine Mousterian technological variability: a perspective from the Negev. Paléorient 5, 87–104.

Murray, A.S., Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. Radiat. Meas. 32, 57–73. https://www.doi.org/10.1016/S1350-4487(99)00253-X

Oron, M., Roskin, J., Avni, Y., Porat, N., Aladjem, E., Yegorov, D., Vardi, J., Hovers, E., 2023. A conceptual model of multi-scale formation processes of open-air Middle Paleolithic sites in the arid Negev desert, Israel. Quatern. Res. 1–19. https://www.doi.org/10.1017/qua.2023.31

Pagli, M., 2013. Variabilité du Moustérien au Proche-Orient: approche géographique des dynamiques de changement en milieu méditerranéen et en milieu steppique. Ph.D. Dissertation. Université Paris Ouest Nanterre La Défense.

Perlès, C., 1992. In search of lithic strategies, a cognitive approach to prehistoric chipped stone assemblages. In: Gardin, J.C., Peebles, C.S. (Eds.), Representations in Archaeology. Indiana University Press, Bloomington, IN, pp. 223–247.

Picin, A., Peresani, M., Falgueres, C., Gruppioni, G., Bahain, J.-J., 2013. San Bernardino Cave (Italy) and the appearance of Levallois technology in Europe: results of a radiometric and technological reassessment. PloS One 8, e76182. https://www.doi.org/10.1371/journal.pone.0076182

Posth, C., Wißing, C., Kitagawa, K., Pagani, L., van Holstein, L., Racimo, F., Wehrberger, K., Conard, N.J., Kind, C.J., Bocherens, H., 2017. Deeply divergent archaic mitochondrial genome provides lower time boundary for African gene flow into Neanderthals. Nature Comm. 8, 16046. https://www.doi.org/10.1038/ncomms16046

Prévost, M., Centi, L., Zaidner, Y., 2022. The use of the lateral tranchet blow technique at Nesher Ramla (Israel): a new cultural marker in the Levantine Middle Paleolithic? Quatern. Int. 624, 128–147. https://www.doi.org/10.1016/j.quaint.2020.11.008

Prévost, M., Zaidner, Y., 2020. New insights into early MIS 5 lithic technological behavior in the Levant: Nesher Ramla, Israel as a case study. PloS One. 15, e0231109. https://www.doi.org/10.1371/ journal.pone.0231109

Rak, Y., 1993. Morphological variation in *Homo neanderthalensis* and *Homo sapiens* in the Levant: a biogeographic model. In: Kimbel, W.H., Martin, L.B. (Eds.), Species, Species Concepts and Primate Evolution. Plenum Press, New York, pp. 523–536.

Riel-Salvatore, J., Barton, C.M., 2004. Late Pleistocene technology, economic behavior, and land-use dynamics in southern Italy. Am. Antiq. 69, 257–274.

Roded, R., 1996. Geological map of Israel (1:50,000): Dimona sheet (19-I). The Geological Survey of Israel, Jerusalem.

Rolland, N., Dibble, H.L., 1990. A new synthesis of Middle Paleolithic variability. Am. Antiq. 55, 480–499.

Schiffer, M.B., Skibo, J.M., 1987. Theory and experiment in the study of technological change. Curr. Anthropol. 28, 595–622. https://www.doi.org/10.1086/203601

Shea, J.J., 2006. The Middle Paleolithic of the Levant: recursion or convergence? In: Hovers, E., Kuhn, S.L. (Eds.), Transitions Before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age., Interdisciplinary Contributions to Archaeology. Springer, New York, pp. 171–195.

Shea, J.J., 2008. The Middle Stone Age archaeology of the Lower Omo Valley Kibish Formation: excavations, lithic assemblages, and inferred patterns of early *Homo sapiens* behavior. J. Hum. Evol. 55, 448–485. https://www.doi.org/10.1016/j.jhevol.2008.05.014

Shimelmitz, R., Kuhn, S.L., 2013. Early Mousterian Levallois technology in Unit IX of Tabun Cave. PaleoAnthropology 2013, 1–27. https://paleoanthropology.org/ojs/index.php/paleo/article/view/698

Sivan, D., Potasman, M., Almogi-Labin, A., Mayer, D.B.-Y., Spanier, E., Boaretto, E., 2006. The *Glycymeris* query along the coast and shallow shelf of Israel, southeast Mediterranean. Palaeogeogr. Palaeoclimatol. Palaeoecol. 233, 134–148. https://www.doi.org/10.1016/j.palaeo.2005.09.018

Solecki, R.L., Solecki, R.S., 1970. A new secondary flaking technique at the Nahr Ibrahim Cave site, Lebanon. Bull. Musée Beyrouth 23, 137–142.

Soressi, M., Geneste, J.-M., 2011. The history and efficacy of the chaîne opératoire approach to lithic analysis: studying techniques to reveal past societies in an evolutionary perspective. PaleoAnthropology 2011, 334–350.

Tostevin, G.B., 2000. The Middle to Upper Paleolithic transition from the Levant to Central Europe: in situ development or diffusion? In: Orschiedt, J., Weniger, G.C. (Eds.), Neanderthals and Modern Humans: Discussing the Transition. Central and Eastern Europe from 50,000-30,000 BP. Neanderthal Museum, Mettman, pp. 90–109.

Tostevin, G.B., 2012. Seeing Lithics: A Middle-Range Theory for Testing for Cultural Transmission in the Pleistocene. Oxbow Books, Oxford.

Tostevin, G.B., 2019. Content matters: the materiality of cultural transmission and the intersection of Paleolithic archaeology with cultural evolutionary theory. In: Love, A.C., Wimsatt, W.C. (Eds.), Beyond the Meme: Development and Structure in Cultural Evolution. University of Minnesota Press, Minneapolis, pp. 311–364.

Valladas, H., Mercier, N., Froget, L., Hovers, E., Joron, J.-L., Kimbel, W.H., Rak, Y., 1999. TL dates for the Neanderthal site of the Amud Cave, Israel. J. Archaeol. Sci. 26, 259–268.

Valladas, H., Reyss, J.-L., Joron, J.-L., Valladas, G., Bar-Yosef, O., Vandermeersch, B., 1988. Thermoluminescence dating of Mousterian Troto-Cro-Magnon' remains from Israel and the origin of modern man. Nature 331, 614–616. https://www.doi.org/10.1038/331614a0

White, M., Ashton, N., 2003. Lower Palaeolithic core technology and the origins of the Levallois method in north-western Europe. Curr. Anthropol. 44, 598–609. https://www.doi.org/10.1086/377653

Wintle, A.G., Murray, A.S., 2006. A review of quartz optically stimulated luminescence characteristics and their relevance in single-aliquot regeneration dating protocols. Radiat. Meas. 41, 369–391. https://www.doi.org/10.1016/j.radmeas.2005.11.001

Wojtczak, D., Malinsky-Buller, A., 2022. The Levantine Early Middle Palaeolithic in retrospect–reassessing the contribution of Abou-Sif to the understanding of Palaeolithic record. Archaeol. Res. Asia 30, 100366. https://www.doi.org/10.1016/j.ara.2022.100366

Zaidner, Y., Centi, L., Prévost, M., Mercier, N., Falguères, C., Guérin, G., Valladas, H., Richard, M., Galy, A., Pécheyran, C., Tombret, O., Pons-Branchu, E., Friesem, D.E., Yeshurun, R., Turgeman-Yaffe, Z., Frumkin, A., Herzlinger, G., Ekshtain, R., Shemer, M., Veroner, O., Sarig, R., May, H., Hershkovitz, I., 2021. Middle Pleistocene *Homo* behavior and culture at 140,000 to 120,000 years ago and interactions with *Homo sapiens*. Science 372, 1429–1433. https://www.doi.org/10.1126/science.abh3020

Zaidner, Y., Weinstein-Evron, M., 2012. Making a point: the Early Middle Palaeolithic tool assemblage of Misliya Cave, Mount Carmel, Israel. Before Farm. 2012, 1–23.

Zaidner, Y., Weinstein-Evron, M., 2020. The emergence of the Levallois technology in the Levant: a view from the Early Middle Paleolithic site of Misliya Cave, Israel. J. Hum. Evol. 144, 102785. https://www.doi.org/10.1016/j.jhevol.2020.102785

Ziaei, M., Schwarcz, H.P., Hall, C.M., Grün, R., 1990. Radiometric dating of the Mousterian site at Quneitra. In: Goren-Inbar, N. (Ed.), Quneitra: A Mousterian Site on the Golan Heights. Qedem. Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem, pp. 232–235.

Supplement 01: Occupation Duration and Identification of Technological Traditions: Insights from the Late Middle Paleolithic Site of Nahal Dimona 24 in the Negev Desert, Israel

MAYA ORON
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem; and, Israeli Antiquities Authority, Nahman Avigad 1, 9370726 Jerusalem, ISRAEL; ORCID 0000-0003-0213-2325; mayaoron@gmail.com

NAOMI PORAT
Geological Survey of Israel, 32 Yesha'ayahu LeibowitzSt., 9692100 Jerusalem, ISRAEL; ORCID 0000-0002-5900-2460; naomi.porat@gsi.gov.il

ERELLA HOVERS
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem, ISRAEL; and, Institute of Human Origins, Arizona State University, Tempe, AZ, USA; ORCID 0000-0002-7855-6573; hovers@mail.huji.ac.il

SUPPLEMENTARY MATERIAL 1: FAUNAL REMAINS
This file includes: text and Supplementary Material Figure S1.

Most of the faunal remains are ostrich eggshell fragments (n=344, Figure S1b), but the assemblage includes also some highly fragmented mammalian bones (n=92, only four of the which are larger than 2cm). Additionally, one fragment of *Glycymeris* sp. (Figure S1a), found in thanatological shell assemblages on the Mediterranean seashore (~75km northwest of ND24; Sivan et al. 2006), was found in unit 3. The study of the faunal remains is ongoing, with the hope that this will contribute additional environmental data.

The distribution of faunal remains within and between the archaeological horizons in ND24 is uneven. This may be a result of post-depositional processes or/and differential use of space. Thirty two percent (n=29) of the bone fragments originated from the small excavated area in unit 5. This may suggest a better preservation of faunal remains in unit 5. The majority of the ostrich eggshell fragments (n=337) are from unit 3, an additional five pieces are from unit 5, and three were collected from the surface in the rock shelter. Many of the ostrich eggshell fragments were concentrated in one area at the back of the rock shelter (Figure 4 in the main manuscript).

REFERENCE

Sivan, D., Potasman, M., Almogi-Labin, A., Mayer, D.B.-Y., Spanier, E., Boaretto, E., 2006. The *Glycymeris* query along the coast and shallow shelf of Israel, southeast Mediterranean. Palaeogeogr. Palaeoclimatol. Palaeoecol. 233, 134–148. https://www.doi.org/10.1016/j.palaeo.2005.09.018

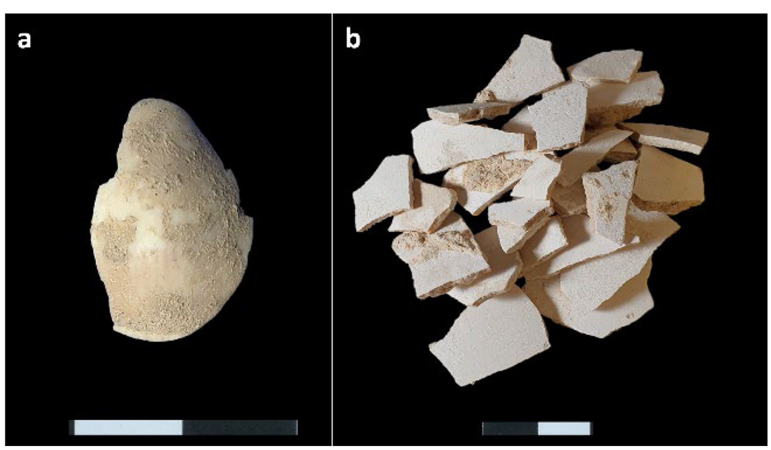

Figure S1. Finds from unit 3: a) marine shell, b) ostrich eggshell fragments (scale bars are 2cm).

ISSN 1545-0031
Paleoanthropology Society & European Society for the study of Human Evolution.
OPEN ACCESS
Early View available online 20 May 2024

Supplement 02: Occupation Duration and Identification of Technological Traditions: Insights from the Late Middle Paleolithic Site of Nahal Dimona 24 in the Negev Desert, Israel

MAYA ORON
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem; and, Israeli Antiquities Authority, Nahman Avigad 1, 9370726 Jerusalem, ISRAEL; ORCID 0000-0003-0213-2325; mayaoron@gmail.com

NAOMI PORAT
Geological Survey of Israel, 32 Yesha'ayahu LeibowitzSt., 9692100 Jerusalem, ISRAEL; ORCID 0000-0002-5900-2460; naomi.porat@gsi.gov.il

ERELLA HOVERS
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem, ISRAEL; and, Institute of Human Origins, Arizona State University, Tempe, AZ, USA; ORCID 0000-0002-7855-6573; hovers@mail.huji.ac.il

SUPPLEMENTARY MATERIAL 2: OSL ADDITIONAL DATA
This file includes: text and Supplementary Material Figure S2.

The dose recovery test over a range of preheat and cutheat temperatures shows that a recovery of 0.95 is obtained with a preheat of 10s at 260 °C and a test dose preheat of 5s at 240 °C (Figure S2a). These parameters were used for all further measurements. The OSL signal is very bright (Figure S2b), and the samples perform well with the criteria of the single aliquot regenerative dose (SAR) protocol (Wintle and Murray 2006). Dose distribution of individual measurements have a medium scatter (overdispersion; Figure S2c, d), indicating that the quartz grains were mostly well bleached at the time of deposition.

REFERENCE

Wintle, A.G., Murray, A.S., 2006. A review of quartz optically stimulated luminescence characteristics and their relevance in single-aliquot regeneration dating protocols. Radiat. Meas. 41, 369–391. https://www.doi.org/10.1016/j.radmeas.2005.11.001

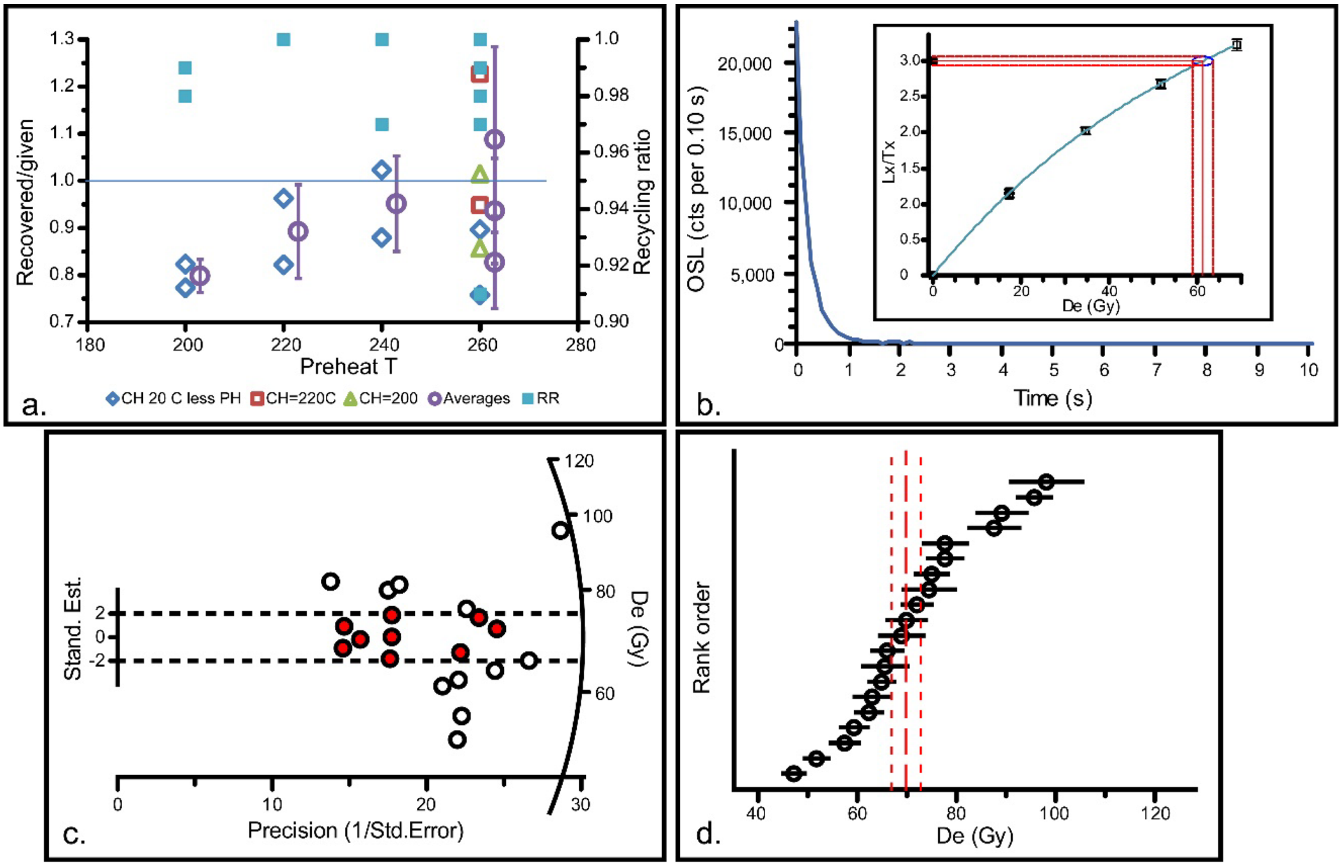

Figure S2. OSL results for sample MSD-4. a) Results of a dose recovery test over a range of preheats (10s) and cutheats (5s). Note that the best recoveries (recovered/given ratios closest to 1) are under a preheat of 260o C and cutheats of 200o C or 240o C. The latter was chosen for all subsequent measurements. Recycling ratios are mostly >0.95. b) The natural OSL signal (10s of 40s measurement) from an aliquot of sample MSD-4. Note the rapid decay of the signal to background levels within less than 2 seconds. Inset: a dose response curve for the same aliquot, De=62.1±2.5 Gy. Note recycling points at ~20 Gy, which are indistinguishable. c) Radial plot for the sample showing the distribution of all measured aliquots, average De (calculated using the central age model) =69.8±3.0 Gy. Note medium scatter (OD=18%). d) A probability density function for the same data as c, showing the normal dose distribution.

Supplement 3: Occupation Duration and Identification of Technological Traditions: Insights from the Late Middle Paleolithic Site of Nahal Dimona 24 in the Negev Desert, Israel

MAYA ORON
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem; and, Israeli Antiquities Authority, Nahman Avigad 1, 9370726 Jerusalem, ISRAEL; ORCID 0000-0003-0213-2325; mayaoron@gmail.com

NAOMI PORAT
Geological Survey of Israel, 32 Yesha'ayahu LeibowitzSt., 9692100 Jerusalem, ISRAEL; ORCID 0000-0002-5900-2460; naomi.porat@gsi.gov.il

ERELLA HOVERS
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem, ISRAEL; and, Institute of Human Origins, Arizona State University, Tempe, AZ, USA; ORCID 0000-0002-7855-6573; hovers@mail.huji.ac.il

SUPPLEMENTARY MATERIAL 3: SIZE DISTRIBUTION OF LEVALLOIS ITEMS
This file includes: Supplementary Material Figure S3.

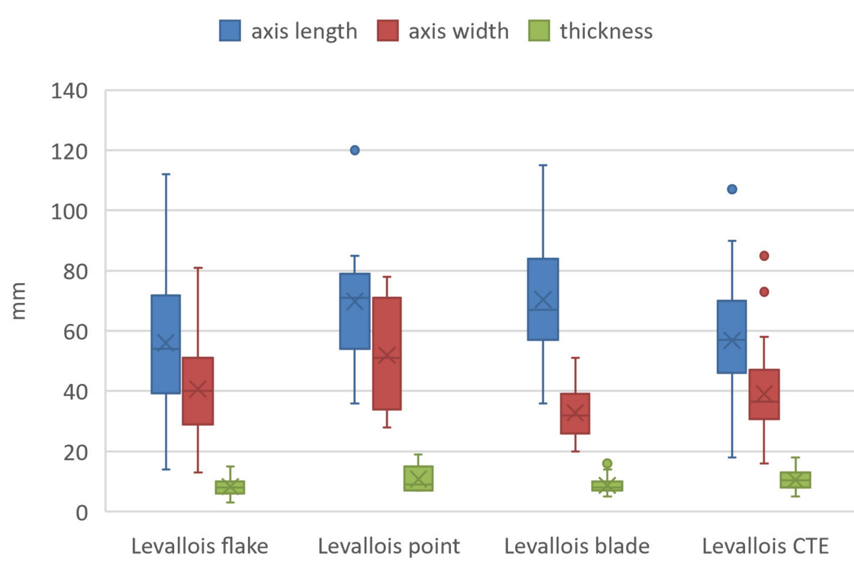

Figure S3. Size distribution of Levallois Items in Unit 3 assemblage.

ISSN 1545-0031
Paleoanthropology Society & European Society for the study of Human Evolution.
OPEN ACCESS
Early View available online 20 May 2024

Supplement 4: Occupation Duration and Identification of Technological Traditions: Insights from the Late Middle Paleolithic Site of Nahal Dimona 24 in the Negev Desert, Israel

MAYA ORON
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem; and, Israeli Antiquities Authority, Nahman Avigad 1, 9370726 Jerusalem, ISRAEL; ORCID 0000-0003-0213-2325; mayaoron@gmail.com

NAOMI PORAT
Geological Survey of Israel, 32 Yesha'ayahu LeibowitzSt., 9692100 Jerusalem, ISRAEL; ORCID 0000-0002-5900-2460; naomi.porat@gsi.gov.il

ERELLA HOVERS
Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus 91905, Jerusalem, ISRAEL; and, Institute of Human Origins, Arizona State University, Tempe, AZ, USA; ORCID 0000-0002-7855-6573; hovers@mail.huji.ac.il

SUPPLEMENTARY MATERIAL 4: LEVALLOIS DORSAL SCAR PATTERNS IN LEVANTINE MIDDLE PALEOLITHIC SITES

This file includes: supporting information for Figure 16 in the main text and Supplementary Material Tables S1 and S2.

PaleoAnthropology 202x:x supplement to Oron et al. 202x:x ISSN 1545-0031
Paleoanthropology Society & European Society for the study of Human Evolution.
OPEN ACCESS
Early View available online 20 May 2024

TABLE S1. PERCENTAGE OF DIFFERENT DORSAL SCAR PATTERNS ON LEVALLOIS CORES FREOM DATED ASSEMBLAGES IN THE LEVANT.

	Site	Centripetal	Convergent	Unidirectional	Bidirectional	Other/not reported
Mid MP	Geula	65.0	0.0	10.0	25.0	0.0
	Qafzeh VIIa	73.9	8.7	4.4	8.7	4.3
	Qafzeh IX	85.7	2.9	0	11.4	0.0
	Qafzeh XI	88.9	0	5.6	2.8	2.7
	Qafzeh XII	84.1	0	0	5.9	10.0
	Qafzeh XIII	82.7	5.8	3.9	5.8	1.8
	Qafzeh IV	75	2.7	5.6	16.7	0.0
	Qafzeh XV	58.5	8.2	15.3	16.9	1.1
	Qafzeh XVII	84.9	0	12.1	0	3.0
	Nesher Ramla I	60.4	15.1	15.1	9.4	0.0
	Nesher Ramla IIA	72.7	9.2	4.5	13.6	0.0
	Nesher Ramla IIB	69.1	13.2	8	9.7	0.0
	Nesher Ramla III	84	2.5	7	5	1.5
	N.Aqev (unit 11)	85.7	0	0	14.3	0.0
	N.Aqev (unit 7)	50	28.6	21.4	0	0.0
	N.Aqev (Lev3)	25.1	1.6	69.2	4.11	0.0
Late MP	Umm el Tlel V2 βa	6.7	24.4	48.9	20	0.0
	Umm el Tlel V2 \`a p.	54.2	4.2	16.6	25	0.0
	Amud B1	28.0	25.0	33.0	7.0	7.0
	Amud B2	20.0	23.0	28.0	21.0	8.0
	Amud B4	36.0	8.0	16.0	20.0	20.0
	Kebara VI	38.1	16.7	32.1	13.1	0.0
	Kebara VII	24.4	26.7	41.3	7.6	0.0
	Kebara IX	19.0	37.3	33.8	9.9	0.0
	Kebara X	17.3	38.5	31.3	12.8	0.0
	Kebara XI	21.7	36.7	31.3	10.2	0.0
	Qunietra A	40.0	46.0	0.0	6.0	8.0
	Qunietra B	43.0	40.0	0.0	6.0	11.0
	E.Qashish	41	0	0	22	37.0
	E.Qashish C	36.5	8.2	30.6	10.6	14.1
	N. Dimona 24	80	0	0	20	0.0

TABLE S2. PERCENTAGE OF DIFFERENT DORSAL SCAR PATTERNS ON LEVALLOIS BLANKS FROM DATED ASSEMBLAGES IN THE LEVANT.

	Site	Centripetal	Convergent	Unidirectional	Bidirectional	Other/not reported
Early MP	Tabun EMP	11.5	60.8	12.8	14.9	0
	Abou-Sif B	5.1	25.6	57.7	11.5	0.1
	Abou-Sif C	8.8	27.4	38.8	25	0
	Mislya L10	6. 2	45.2	28.8	19.9	0
Mid MP	Geula	31.3	20.3	6.6	41.8	0
	Qafzeh VIIa	40.3	22.5	3.1	34.1	0
	Qafzeh IX	46.1	9.6	0.7	42.6	1
	Qafzeh XI	66.7	6.6	2.5	23.5	0.7
	Qafzeh XII	66.6	6.4	2.2	22.8	2
	Qafzeh XIII	71.9	4.7	1.4	20.9	1.1
	Qafzeh IV	59.4	15.9	1.1	23.6	0
	Qafzeh XV	36.6	30.2	2.8	29.1	1.3
	Qafzeh XVII	71.6	6.7	4.6	16	1.1
	Nesher Ramla I	46.2	38.6	12.3	2.9	0
	Nesher Ramla IIA	51.6	33	11	4.4	0
	Nesher Ramla IIB	54	28.4	11	6.6	0
	Nesher Ramla III	67	9.8	3.6	7.9	11.7
	N.Aqev (unit 11)	62.4	7.9	7.9	21.8	0
	N.Aqev (unit 7)	56.8	21.1	10.8	11.3	0
	N.Aqev (Lev3)	30.9	32.1	23.4	8.3	5.3
Late MP	Umm el Tlel V2 βa	2.7	34.9	28.1	12.3	22
	Umm el Tlel V2 `a p.	28.2	3.2	46.2	10.3	12.1
	Amud B1	14	51	19	14	2
	Amud B2	11	12	57	11	9
	Amud B4	20	31	14	30	5
	Kebara V	31	25.4	12.6	31	0
	Kebara VI	28.6	34.6	24.7	12.1	0
	Kebara VII	31	45.2	11.5	12.3	0
	Kebara VIII	28.8	49.1	13.1	9	0
	Kebara IX	20.2	56.2	10.7	12	0.9
	Kebara X	24.8	53.9	8.1	13.2	0
	Kebara XI	19.1	46.5	15.5	18.9	0
	Kebara XII	13.7	56.6	9.1	20.6	0
	E.Qashish C	26.7	13.8	28.3	14.1	17.1
	NMO	23	35.8	32.7	6.7	1.8
	Farah II 1976	0	88	0	0	12
	Farah II 2007	20	62	12	4	2
	Rosh ein mor	9.6	63	8.2	17.8	1.4
	N. Dimona 24	55	5.9	4.5	33.2	1.4