Journal of Paleolithic Archaeology (2025) 8:13
https://doi.org/10.1007/s41982-025-00212-7

RESEARCH

New Insights on an Old Excavation: Re-visiting the Late Middle Palaeolithic Site of Far'ah II, North-western Negev, Israel

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Accepted: 28 February 2025

Abstract

Revisiting collections from old excavations with new research objectives and analytical tools brings them to life and integrates them into evolving models of human-landscape interactions. This paper examines hominin behaviour and adaptations at the late Middle Palaeolithic open air camp site Far'ah II, dated to ~ 49 ka by analyzing the spatial patterning of assemblages from the 1976–1978 excavation seasons. This was facilitated by the large area excavated and the fact that all lithics and most bones larger than 2.5 mm were recorded using three dimensional coordinates. Examining the refitted flint sequences highlights the use of variable technological systems, including the Levallois unidirectional convergent method. Use wear on the ground stone tools suggests they were used for knapping as well as food processing, and the faunal assemblage reflects a wide range of species that were consumed on-site. By combining lithic refitting studies and spatial mapping of artefact and bone distribution using GIS, we have dissected the occupation history and demonstrate that the living floor defined during the excavations actually consists of at least two different occupation events, that partially overlap in the central area of the site. This analysis demonstrates that Far'ah II was probably a favoured locality, revisited by Middle Palaeolithic hominins due to its proximity to a rich mosaic of habitats.

Keywords Spatial analysis · GIS · Late Middle Palaeolithic · Open-air sites · Besor Basin

Introduction

Re-studying old excavations allows researchers to formulate new or additional research questions to those originally addressed without having to conduct new excavations since they have access to readily available data sets (Benito-Calvo & de la Torre, 2011; de la Torre & Benito-Calvo, 2013; Sánchez-Romero et al., 2016). Moreover, the use of such sources contributes to their digitation and preservation, often making the primary source information available for the first time. The late Middle Palaeolithic open-air site of Far'ah II, north-western Negev, Israel (Gilead, 1980, 1988; Gilead & Grigson, 1984), is a classic example of a site where novel methodologies have allowed us to test new research questions relating to hominin behaviour through the examination of on-site activities and their layout. This was achieved by integrating analysis of all finds and their spatial relationship. Such data enables a more nuanced understanding of how the site formed over time, hominin-environmental interactions as well as the complexities of societal dynamics (the social landscape) and lifeways in the past (such as the range of tasks undertaken, social organization, technological

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capabilities, hominin perceptions of space), information that contributes to broader discussions on human and cultural evolution (e.g., Binford, 1978, 1982; Clark, 2017, 2019; Henry et al., 2004; Maher & Conkey, 2019; Schiffer, 1987; Vaquero et al., 2017).

During the Middle Palaeolithic (250–49 ka) in the Levant, caves were intensively occupied and repeatedly used for habitation, socialization and food sharing (Hovers & Belfer-Cohen, 2013). Open-air sites, on the other hand, mostly represent ephemeral occupations and/or task-specific localities situated adjacent to particular subsistence resources such as water, food sources and/or raw materials (Ekshtain et al., 2014; Gilead & Grigson, 1984; Goren-Inbar, 1990; Malinsky-Buller et al., 2014; Munday, 1976; Sharon & Oron, 2014; Stahlschmidt et al., 2018). Even when a long and stratified sequence is identified at an open-air site, it is often characterized as an accumulation of short-term occupations (Hauck, 2011; Prévost & Zaidner, 2020; Zaidner et al., 2016, 2018).

Prior to reconstructing the arrangement of a site and use of space, issues such as site integrity and the nature of assemblage preservation should be addressed. Open-air sites offer an especially problematic setting for assessing spatial patterning since they often lack defined physical boundaries (Hovers, 2017), and when such localities are frequented repeatedly, flexible use of space makes it harder to separate between designated activity areas (Binford, 1978; Hovers, 2017; Staurset et al., 2023). Post-depositional processes may make it difficult to discern features given that a multitude of factors can influence assemblage coherence and affect our ability to differentiate between natural and human processes (Gifford-Gonzalez et al., 1985; Schiffer, 2010; Staurset et al., 2023; Villa & Courtin, 1983). Environmental processes pertinent to preservation of artefacts and site structure include, amongst many factors, local climatic and topographic conditions, rate and duration of site burial, weathering, bioturbation and perturbation (Bertran et al., 2019; Hofman, 1986; Hovers et al., 2014; McKey, 2024; Schiffer, 2010). Notably, humans and animals may also disturb the spatial scattering of objects by prolonged occupation and revisiting of a site, while influencing assemblage composition by lithic artefact curation (Binford, 1979, 1982; Camarós et al., 2013; Haynes, 2012; Henry, 2012; Kuhn, 1992, 1994, 1995; Malinsky-Buller et al., 2011, 2014; Schiffer, 2010). Spatial analysis of find scatters is one of several methods that are used to identify, for example, stratigraphic integrity, knapping events and latent structures such as phantom hearths (Aldeias, 2017; Alperson-Afil et al., 2009; Leroi-Gourhan & Brézillon, 1972; Mallol & Henry, 2017; Pop et al., 2016; Sánchez-Romero et al., 2020), while lithic artefact refitting and tracing the connecting lines between the refits is used to reconstruct on-site technological organization (Davidzon & Goring-Morris, 2003; Gilead & Fabian, 1990; Marder & Goring-Morris, 2020; Prévost & Zaidner, 2020; Slavinsky et al., 2016; Soressi & Geneste, 2011; Volkman, 1983). Spatial analysis combined with refitting studies also offers a method for deciphering post-depositional processes, site integrity and use of space (e.g. Coulson & Andreasen, 2020; Deschamps & Zilhão, 2018; Gabucio et al., 2023; Hietala, 1983; Staurset et al., 2023; Vaquero et al., 2019). Additionally, use-wear analysis of groundstone artefacts and zooarchaeological data, when available, contribute additional information on hominin behavioural practices as well as on-site use of space.

In this paper, we re-visit the finds recovered during excavation seasons 1976–1978 at the late Middle Palaeolithic site Far'ah II (Gilead, 1980, 1988; Gilead & Grigson, 1984). The study was structured to characterize the technological systems employed at the site and integrate them with a lithic refitting study and spatial analysis in order to model use of space within the site. Using the original documentation, we present a detailed techno-typological analysis of the lithic assemblage with additional data on refitting (Gilead, 1988; Gilead & Fabian, 1990). This is combined with a GIS spatial–temporal study using the original 3D coordinates retrieved during the excavation for lithics, groundstone artefacts and fauna. The research combines a *chaîne opératoire* approach to lithic analysis for sociotechnology. Using the combination of artefact refitting and GIS spatial statistics of lithic and groundstone artefacts and fauna, we address issues of defining activity areas within archaeological palimpsests as a means to interpret hominin behavioural practices.

The Far'ah II Site

Far'ah II is located within loess badlands on the east bank of the riverbed of Nahal Besor (Nahal meaning river in Hebrew) (Fig. 1). Nahal Besor and its tributaries are ephemeral nowadays, with flow events related primarily to winter frontal storms with several perennial springs known within the lower basin (Alexandrov et al., 2008). The accumulation and accretion of primary loess in the Negev began during the Middle Pleistocene (~ 200–180 ka), with fluvial deposition of reworked loess occurring between ~ 90 and ~ 12 ka along Nahal Besor and its tributaries (Amit et al., 2011; Ben Israel et al., 2015; Crouvi et al., 2008, 2009). For the last ~ 12,000 years, the loess badlands are being eroded by the Besor and its tributaries (Ben Israel et al., 2015). Far'ah II is embedded in the fluvially re-worked loess sediments that fill the lower section of the Besor Basin, forming deposits up to 25 m thick (Crouvi et al., 2017). The reworked loess sediment accumulation is consistent with an active, occasionally flooded plain (Sneh, 1983). The archaeological occupation layers are overlain by 2–3 m of loess sediments, the result of rapid sedimentation that protected the layers from ongoing erosive processes. The site was initially

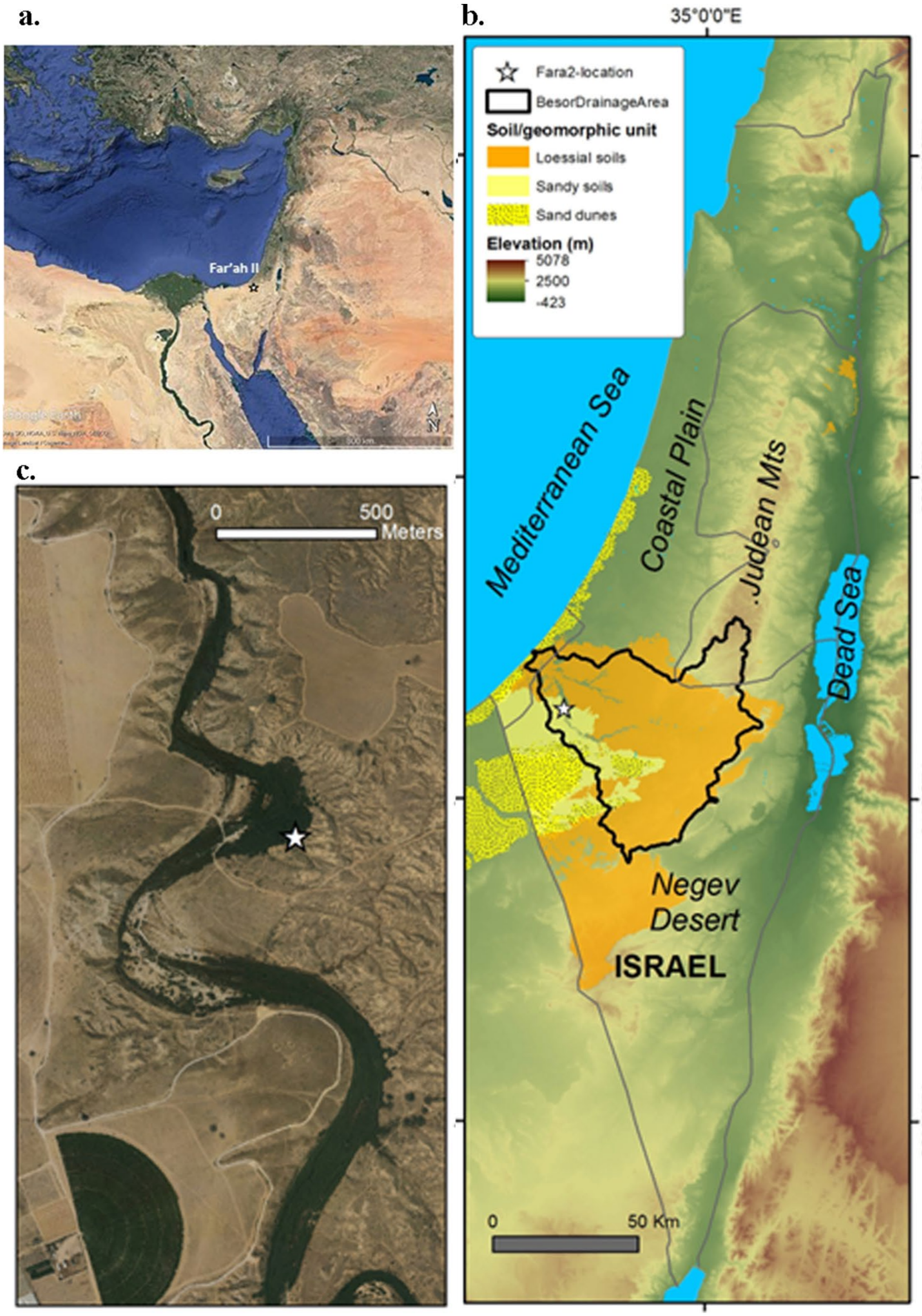


Fig. 1 **a** Location map of the study site in a regional context. **b** Digital elevation model of Israel and surroundings, showing the location of Far'ah II within the Negev desert and the Besor Basin (black line). Note the distribution of the loess that covers most of the northern and central Negev. Soil and geomorphic units are after Crouvi et al. (2008). **c** An aerial photo showing the location of Far'ah II along the eastern bank of Nahal Besor

discovered and explored by the British Western Negev Expedition during their 1972–1973 survey and named Fara-Site B (Price Williams, 1973a, b, 1975). An extensive excavation took place between 1976 and 1978 (Gilead, 1980, 1988; Gilead & Grigson, 1984) followed by an additional short excavation season in 2017 (Goder-Goldberger et al., 2020).

1976–1978 Excavations

During three excavation seasons between 1976 and 1978, two archaeological horizons were uncovered (Gilead, 1988; Gilead & Grigson, 1984). In the 1976–1977 seasons, a large scatter of artefacts, 40 m^2 in extent, was exposed over a continuous archaeological horizon and was named the living floor (Gilead, 1980). This layer sloped slightly from south-west to north-east, ca. 20–30 cm across 4 m (Gilead, 1980). During the subsequent 1978 season, the exposure of the living floor was expanded to cover a total area of 70 m^2, with a hearth identified in squares L-M 14–15 (Fig. 2a, b). The lower archaeological horizon (i.e. Layer 3) was identified some 20 cm below the living floor and was separated from it by an almost sterile layer of loess (Gilead, 1988; Gilead &

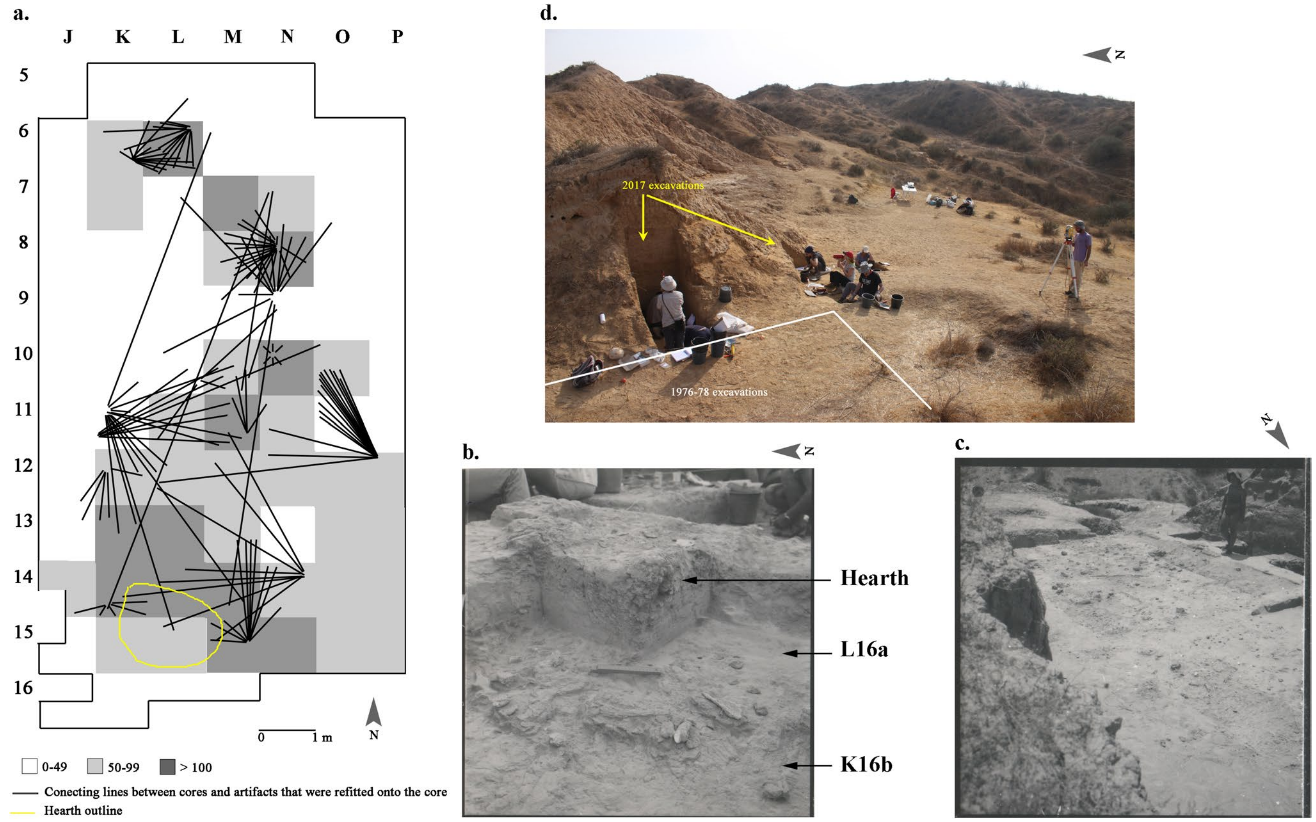


Fig. 2 Far'ah II 1976–78 excavations. **a** Density map of the living floor: artifacts > 2.5 mm superimposed with the refitted groups (modified after Gilead & Grigson, 1984, Gilead and Fabian, 1987). **b** Photo of the surface of the living floor before the artefacts were removed (photo by I. Gilead). **c** Photo of squares K-L 15,16 with the hearth from the living floor and artefacts from the lower layer (photo by I. Gilead). **d** Spatial association between the 2017 excavations and the 1976–78 excavation (photo by M. Goder-Goldberger)

Grigson, 1984). Layer 3 was exposed mostly in soundings and identified only in the southern section of the excavation along rows 15 and 16 (Gilead & Grigson, 1984). The two layers, composed of identical lithic assemblages, bone fragments, charcoal and ash, could not be differentiated by a change in sediment composition, rather the separation between them was based on the presence of the nearly sterile layer between the two (Fig. 2c). The only change in sediment colour was noted within the living floor and was the result of ash and charcoal tainting the sediment with a grey burnt shade (Gilead & Grigson, 1984).

2017 Excavation

A small-scale excavation was conducted at the site aimed at better constraining its age and to collect data needed to reconstruct local paleoenvironmental conditions during site occupation. An area of 10 m^2 was excavated in 1 × 1 m squares bordering on the 1976–1978 excavated area. Contact between the new and old excavation areas was established (Fig. 2d) as well as contact with one of Price Williams' excavated squares (Goder-Goldberger et al., 2020). No hominin skeletal remains were recovered from Far'ah II; thus, we are unable to attribute the assemblage to either of the Middle Palaeolithic hominins known from the region, Neanderthals or *Homo sapiens*.

Dating

Based on the estimated sedimentation rate, the site's age was initially thought to be between 52 and 45 ka (Gilead & Grigson, 1984). Later, electron spin resonance (ESR) dated the site to ~ 60–50 ka (Schwarcz & Rink, 2002). A series of optically simulated luminesce (OSL) and ^{14}C dates sampled during the 2017 field season, coupled with δ^{18}O values from the sediment (-1.8 to -2.4‰), and wiggle matched with the Soreq Cave speleothem δ^{18}O curve, indicate an age younger than 49 ka for the living floor (Goder-Goldberger et al., 2020).

Material and Methods

In this study, we focus on the finds from the 1976–1978 excavations for two reasons: the finds from the smaller 2017 excavation season have already been published, including a comparison of the 2017 and the 1976–1978 lithic and faunal assemblages (Goder-Goldberger et al., 2020). Despite the fact that contact between the 2017 and 1976–1978 excavation areas was established, an exact alignment of the two grids was not possible (Goder-Goldberger et al., 2020). Additionally, during the 1976–1978 excavation, an extensive area was identified as a living floor offering an excellent opportunity to examine in more detail the nature of this occupation. Moreover, the find assemblages from the latter seasons are large and well documented providing an excellent database for robust statistical analyses.

Flint Artefacts

The flint artefacts were studied within the *chaîne opératoire* methodological framework (Geneste, 1991; Pelegrin et al., 1988; Soressi & Geneste, 2011; Tostevin, 2011). An attribute analysis was used to acquire primary quantitative information (e.g., artefact dimensions) and qualitative data (e.g. scar pattern and platform type), in order to characterize the assemblage and reconstruct the reduction sequences. The attribute list is based on Hovers (2009: appendices 2–4); the Levallois technological schemes on Boëda (1995), Delagnes (1995) and Meignen (1995); the typological list used is based on Bordes (1961). The few limestone artefacts were described using the same attributes as the flint artefacts.

Groundstone Artefacts

Use wear analysis was conducted on a sample of 30 limestone and sandy limestone artefacts using a multi-scale approach by combining the use of 3D scanning (HP 3D Structured Light Scanner Pro S3 DAVID SLS-3) to support the identification and characterization of the active areas and microscopy (ZEISS Stemi 305 and Dino-Lite Edge AM7915MZT) to analyse the traces at low and high magnification (Adams et al., 2009; Adams, 2014; Dubreuil et al., 2015; Dubreuil & Savage, 2014). The sample included all the complete or almost complete limestone and flint nodules, sandy limestone slabs and several of the limestone knapped artefacts.

Faunal Remains

The majority of the Far'ah II faunal assemblage from the 1976–1978 seasons were cleaned, curated and identified by C. Grigson (Gilead & Grigson, 1984). However, a sizeable portion of the collection, primarily comprising unidentified fragments, was not prepared or studied. For the current study, this portion of the assemblage was cleaned and additional diagnostic pieces identified to species or body class (large, medium, small mammal) and skeletal element. To assess post-depositional diagenetic processes and hominin activity, a detailed taphonomic study of the assemblage is being undertaken. For this analysis, four taphonomic markers were examined on a sample of bones comprising 50% of the studied assemblage: (i) bone size and shape—a sub-sample of 405 bones (that included bones classified by body-size as well as indeterminate bone fragments), were measured (length, breadth, depth), using a digital calliper (in mm). (ii) The fracture pattern of bone ends was scored for the same sample of 405 bones (Villa & Mahieu, 1991; Wheatley, 2008). (iii) The state of surface preservation was scored (Behrensmeyer, 1978). (iv) The presence of burning (based on visual assessment of colour Stiner et al., 1995) was scored for 76% of the assemblage ($N = 618$), i.e. for all bones that had 3D coordinates and could be plotted. A computerized catalogue was created of all the 1976–1978 fauna including their species and skeletal element identifications, provenance in the site (square and sub-quadrant, XYZ co-ordinates, heights) as well as metric data and information on burning. This information served as the basis for the spatial analyses presented here. As will be detailed below, the extremely poor preservation of the bones excluded undertaking bone refitting.

Spatial Analysis

The 1976–1978 excavated area was marked with a 1 × 1 m grid and excavated in quadrants and spits of 5 cm in depth, and all sediments were sifted through a 3 mm sieve (Gilead & Grigson, 1984). During excavation, the majority of larger-sized bones (identified to species/skeletal element, and unidentified fragments) and all lithic artefacts larger than 2.5 cm were recorded with three coordinates (X, Y and Z), and both the square and sub-square were recorded. Artefacts smaller than < 2.5 cm were collected in bags assigned to square quadrants and 5 cm spits. All elevations were recorded according to the datum. The original notebooks from the 1976–1978 excavations include all the data recorded during excavations for artefacts and bones > 2.5 cm.

One of the challenges of our renewed study was to use the 3D coordinates initially assigned to the finds, to visualize the assemblage spatially using ArcGIS 10.8.2. This included adapting the sub-square system used during excavations to one that could be imported into GIS. Originally, the sub-squares were numbered starting from the north-western corner of the square. The spatial data (XYZ coordinates) obtained from the excavation notebooks were merged with the assemblage spreadsheet using serial numbers, including descriptive and quantitative attributes used to acquire assemblage characteristics. Only artefacts and bones with an assigned elevation, either exact or within a designated spit, were used for spatial analysis (see supplementary information for a detailed record of how the data was used in the GIS).

The assemblage included in the GIS spatial analysis comprised 4708 flint artefacts (all the lithics > 2.5 cm), as well as 150 limestone and sandy limestone groundstone artifacts. The faunal sample analysed comprised 618 faunal remains for which 3D coordinates were available (76% of the faunal assemblage, made up of bones identified to species and body size as well as unidentified bone fragments). Statistical analyses were performed to evaluate clustering of the artefacts and confirm spatial patterning of the finds (see supplementary information for a detailed explanation). The average nearest neighbour (ANN) and Global Moran's tests were performed to evaluate if the finds were clustered, dispersed or randomly distributed (Getis, 1964). In the case of Global Moran's, this was calculated for the lithic artefacts considering "length" as a quantitative variable (Sánchez-Romero et al., 2022), as in the case of the application of Getis-Ord Gi* hotspot analysis (Getis and Ord, 1992). Length was selected as a representative attribute, as size rather than shape has a greater influence on artefact movement resulting from slope and water flow (Bertran et al., 2012; Marwick et al., 2017). ANN and Global Moran's tests were selected as the first stage of analysis to confirm the distributional pattern of the assemblage (Li et al., 2007; Sánchez-Romero et al., 2022). We also performed a density analysis using kernel density estimation (KDE) (Silverman, 2018) to calculate the areas where artifacts are mostly concentrated, as the previous tests do not indicate the location of the accumulations. For this, we applied a search radius of 0.5 for the maps and 0.10 m for the artifacts plotted by elevation (archaeo-stratigraphy) and refits. Once we evaluated the clustered nature of the assemblage, we proceed to the cluster identification by combining the Quadrat Method (Lee & Wong, 2001) with Getis-Ord Gi* (Getis & Ord, 1992). In this case, the quantitative variable was the number of artifacts contained in each quadrat (Getis, 1964; Lee & Wong, 2001), with a distance band of 0.075 m and a fixed spatial relationship. The Getis-Ord Gi* hotspot method was also applied to calculate statistically significant accumulation according to the length of each artifact in both levels. For this, we applied a distance band of 1 m and a fixed spatial relationship.

Results

The Lithic Assemblage

The raw material selected and used at the site includes variable flint types and limestone cobbles, as well as limestone and sandy limestone slabs. All types of raw material are available in the Besor riverbed and the sandy limestone outcrops adjacent to the site (Fig. S1 for spatial distribution of the flint types used for knapping). The site is embedded in fluvially reworked loess deposits that are composed of fine grain sediments (Goder-Goldberger et al., 2020); thus, all larger stone materials were introduced on-site from the riverbed including flint nodules used for artefact manufacture. Today, the site is ca. 200 m from the riverbed, and there is no evidence to suggest the situation was significantly different when the site was occupied. In presenting the results of the lithic analysis, we separate between the groundstone tools and the knapped lithic assemblage.

Groundstone Tools, Limestone Tools and Use-Wear Analysis

The artefacts within this group are mostly made of limestone and sandy limestone (Table 1) and include processing (i.e. pestles and anvils) and manufacturing (i.e. hammerstones) tools, manuports (i.e. large natural stones introduced to the site, with no signs of use) and knapped and retouched artefacts (Figs. 3 and 4). Other than the knapped flakes and tools, these artefacts generally preserve the original shape of the selected cobbles and slabs, with their use at the site attested to by use-wear marks (Fig. 3 (3, 5, 6, 9). Of the 30 artefacts selected for macro and micro-wear analysis (Table 2), 26 bear marks related to anthropogenic activities, including impact marks mostly associated with activities on hard materials (see Table S9 for all attributes). Several tools present a clear concentration of impact marks visible at low magnification. The abrasive features seen on two of the undefined fragmented sandy limestone slabs, characterized by the flattening of the surface high peaks (Fig. 3 (7, 8)), suggest that they may have been used for grinding activities (Paixão et al., 2021). This is also suggested by the polish observed on the pestle (Fig. 3 (6)). However, the identified micro-polish formations are not very developed, lacking enough diagnostic micro use-wear traces for a clear association with

Table 1 Composition of the groundstones and limestone tool assemblage (data presented as number counts)

Artefacts	Limestone	Sandy limestone	Flint
Single convex scraper	1		
Endscraper	1		
Flakes	41		
Flake fragments	33		
Hammerstones	13		19
Anvils	6	4	
Manuports	6		
Chopper	1		
Cobble fragments	42		
Cores	2		
Total N	146	4	19

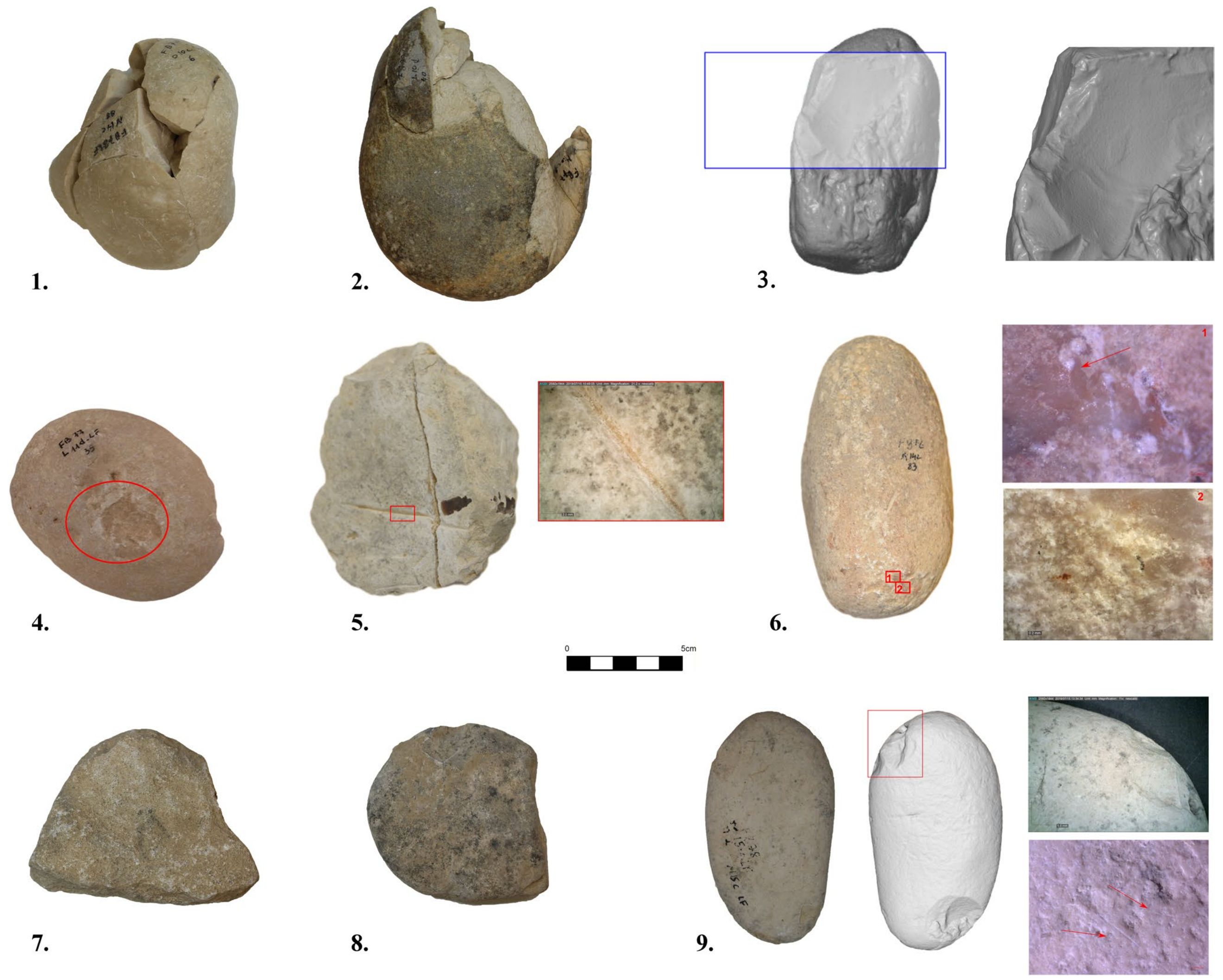


Fig. 3 Ground stone artifacts. (1,2) Refitted limestone hammerstones, (3) Limestone chopper with impact marks, (4) Limestone hammerstone with impact marks, (5) Soft limestone scraper with an incision on the ventral surface, (6) Limestone pestle with polish marks, (7, 8) Sandy limestone slabs, (9) Limestone pestle with impact marks and striations

a specific contact material (Paixão, 2021). Several of the hammerstones and one of the anvils studied for microwear display striations alongside highly crushed surfaces associated with percussive activities, such as knapping (Fig. 3 (3,4)). The knapped and retouched limestone artefacts include flakes and flake fragments as well as a side-scraper and an end scraper (Fig. 4); the latter is made of soft limestone and bears striations (Paixão, 2021). Limestone artefacts and cobble fragments ($N=30$; 20.5% of the assemblage) refit into nine groups, of which two cobbles were refitted from seven and eight fragments (Fig. 4 (1,2)). These two refitted limestone cobbles do not seem to have been knapped intentionally to produce blanks, rather the pounding marks on their outer surface indicate they were used as hammerstones.

The Flint Assemblage

The flint lithic assemblage consists of 11,433 artefacts of which 6670 are larger than < 2.5 cm (Table 3). Most artefacts are made on a versatile brown/grey flint; the remaining are made on semi-translucent, banded, black and brecciated flint (Fig. 5a, b). An attribute analysis of the artefacts larger than 2.5 cm provides several observations relating to artefact preservation, assemblage composition and general technological traits. The artefacts have fresh edges, and less than 1% of the assemblage shows any measure of patination. The percentage of breakage is 32% for debitage and tools. Distal and proximal breaks are present in similar proportions and account for 22% of the fragmented pieces. The remaining 10% of the debitage and tools have more than one broken edge. As

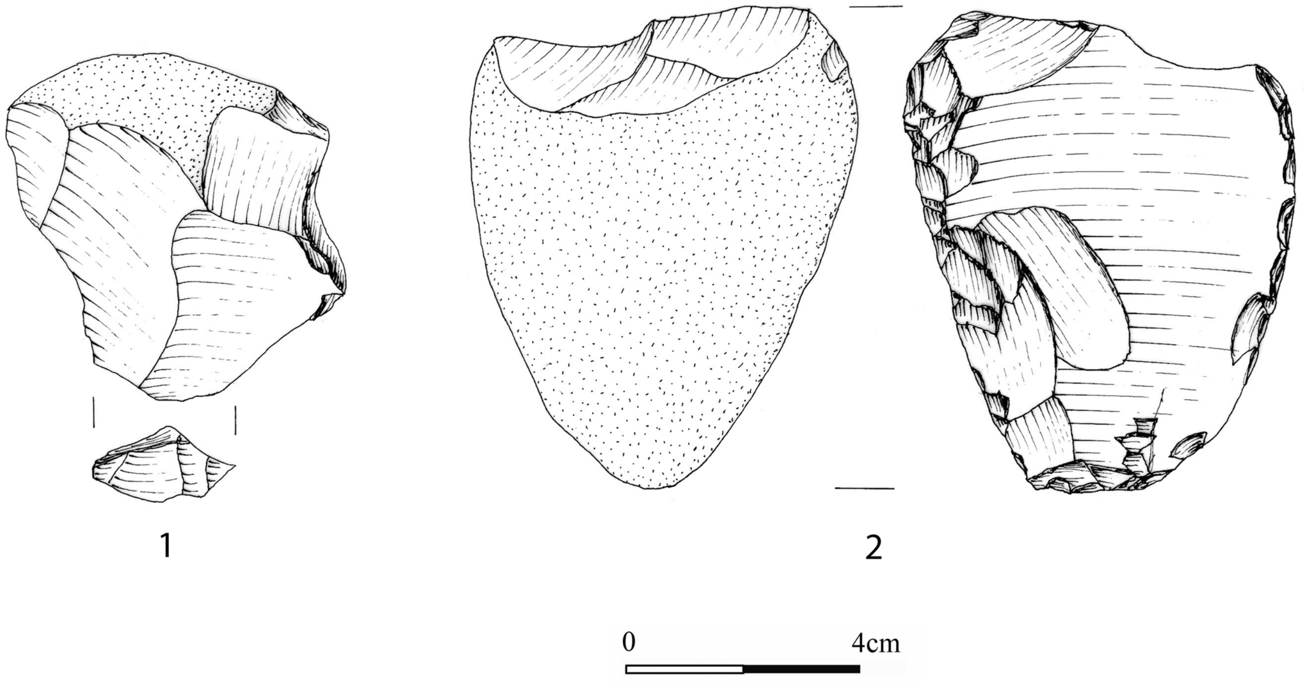


Fig. 4 Limestone artifacts. (1) flake; (2) single-convex side scraper

Table 2 Use-wear analysis of a sample of 30 artefacts

		Anvil	Chopper	Core	End scraper	Hammerstone		Manuport	Pestle	Undefined		Total *N*
Type of use wear		Impacts	Impacts	Impact	Striations	Impacts	Mix[a]		Mix[a]	Impacts	Polish	
Flint												
Pebble	Complete							1				1
	small scar		1									1
Limestone												
Block	Broken	1			1			4			2	8
	Complete	1								1		2
Pebble	Broken		1	1		6				1		9
	Complete					2	1	1	1			5
	Small scar					2						2
Sandy limestone												
Block	Broken	1								1		2

[a] A mix of polish and striations

for the cortex cover, 46.3% of the artefacts have no traces of cortex on their dorsal surface, 36.6% have a cortex cover of less than 50%, and 17.5% have over 50% cortex cover, of which just over half are entirely cortical. More flakes than blades were removed during the initial stages of core decortification (Fig. 5c). Variation in artefact size does not seem to relate to flint type, but rather results from the technology employed, as Levallois blanks are on average larger than non-Levallois blanks (Table S4). Overall, cortical flakes and blades tend to be slightly larger and thicker than non-cortical ones (Table S4). Levallois artefacts have the most prominent and thickest striking platform, while flakes have a larger and thicker platform compared to blades (Table S4).

The nature of the striking platform reflects the measure and nature of platform preparation prior to blank detachment, while the scar pattern retains the directionality of prior removals from the core. Less than 40% of the assemblage features faceted striking platforms, including

Table 3 Composition of the flint assemblage (data presented as number counts)

	Levallois	Non-Levallois	Maybe Levallois	Total *N*	%
Typical Levallois flakes	103			103	2.2
Atypical Levallois flakes	23			23	0.5
Levallois points	32			32	0.7
Retouched Levallois points	3			3	0.1
Pseudo Levallois points	5			5	0.1
Flakes		3050	173	3223	69.5
Blades	4	301	17	322	7.8
Bladelets		30		30	0.6
Blank fragments		398	1	399	9.5
Total blanks	*170*	*3779*	*191*	*4140*	*90.9*
Ridge blades		11		11	0.2
Core-tablets		14	3	17	0.4
Core shaping artefacts	15	194	2	211	4.5
Naturally backed knives		13		13	0.3
Burin spalls		1		1	0.0
Total core shaping artefacts	*15*	*233*	*5*	*240*	*5.3*
Retouched Levallois points	3			3	0.1
Retouched flakes	1	15	4	20	0.4
Retouched blades		1	1	2	0.0
Signs of use on blanks		14		14	0.3
Isolated removals on blanks		22		22	0.5
Single straight side-scrapers		5	1	6	0.1
End-scrapers		4		4	0.1
Burins		4		4	0.1
Borers		2		2	0.0
Truncations	1	4		5	0.1
Notches		12	5	17	0.4
Retouched blanks on ventral face		1		1	0.0
End-notch pieces		1		1	0.0
Choppers		3		3	0.1
Varia		3		3	0.1
Total N Tools	*5*	*104*	*11*	*120*	*2.2*
Cores	29	134	29	192	4.1
Total N	216	4265	227	4708	99.0
Chunks		55		55	
Chips (<2.5 mm)		6670		6670	
Total N				11433	

partially faceted and dihedral platforms. Punctiform platforms are most prominent on bladelets amounting to 28.6%, while 23.3% of the retouched artefacts had their platform removed by flaking or retouching (Fig. 6a; Table S5). The scar pattern on the dorsal face of the debitage and the final flaking surface of the cores indicate that unidirectional and unidirectional convergent flaking modes were commonly used in all knapping methods, both Levallois and non-Levallois (Fig. 6b).

Technological Reduction Sequences

The flint assemblage was produced using surficial and volumetric technological approaches to blank production (Carmignani & Soressi, 2023; Goder-Goldberger et al., 2023a). Components of all stages within the *chaîne opératoire* are represented in the assemblage, albeit with a low frequency of retouched artefacts (2.2%). The source of the flint was nodules of variable size and shape that were collected from the

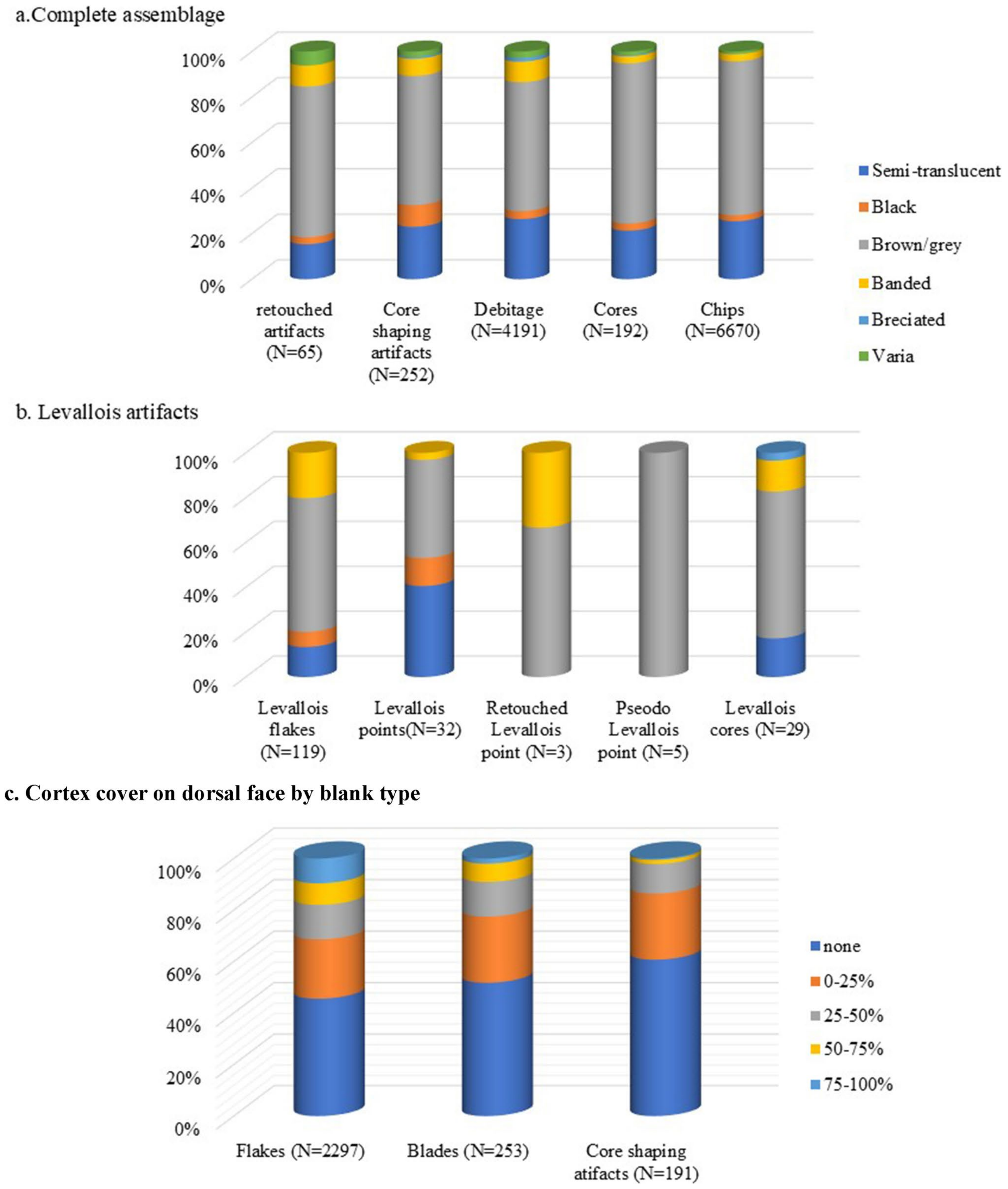
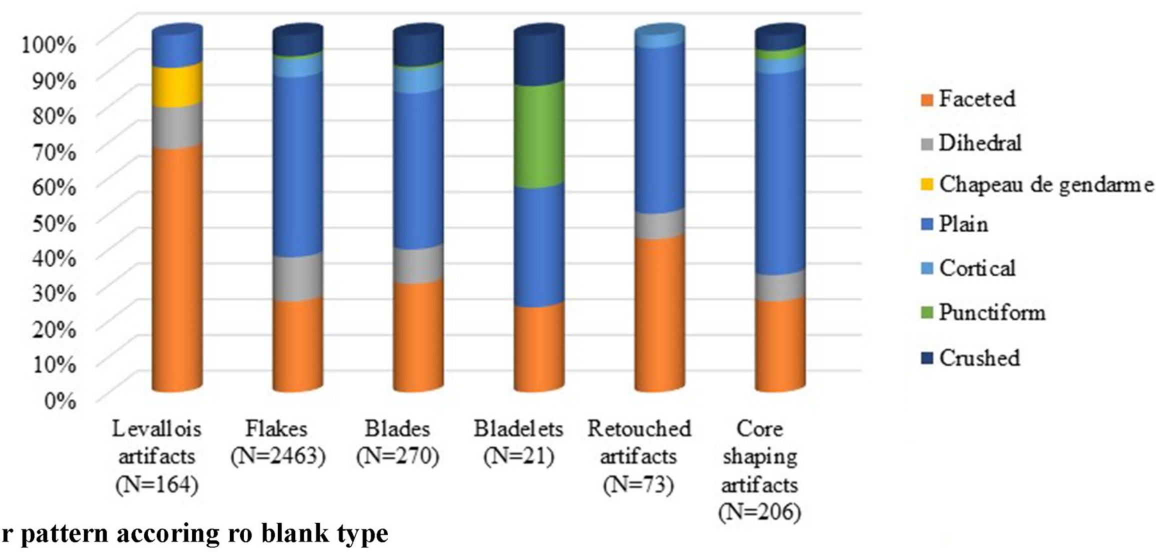


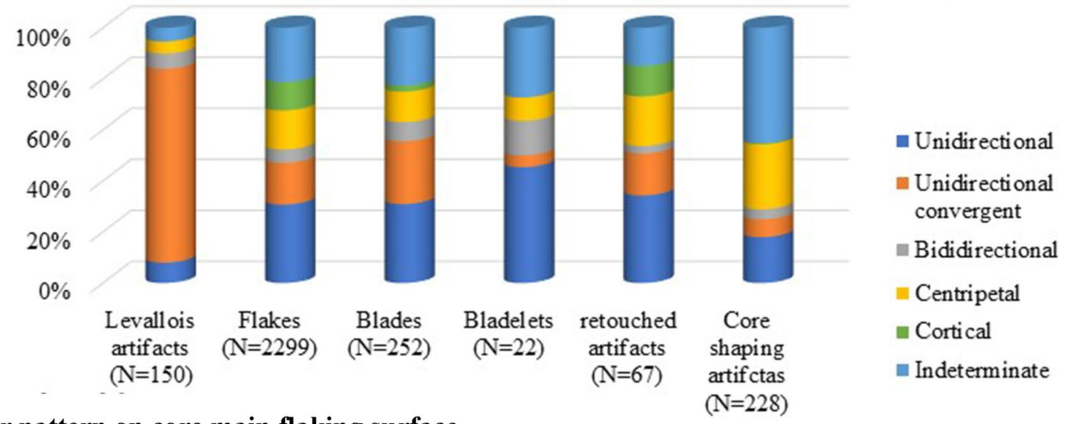
Fig. 5 Flint types used **a** complete assemblage, **b** Levallois artefacts, **c** cortex cover percentage by blank type

Besor riverbed, including rounded cobbles and orthogonal nodules (Gilead, 1988), each with their own set of preparatory debitage as evident in the refitted sequences that will be discussed below. Different modes of technological organization are seen in the assemblage; among the surficial modes, the most visible, albeit their low percentages (Table 4), are

a. Striking platform types



b. Scar pattern accoring ro blank type



c. Scar pattern on core main flaking surface

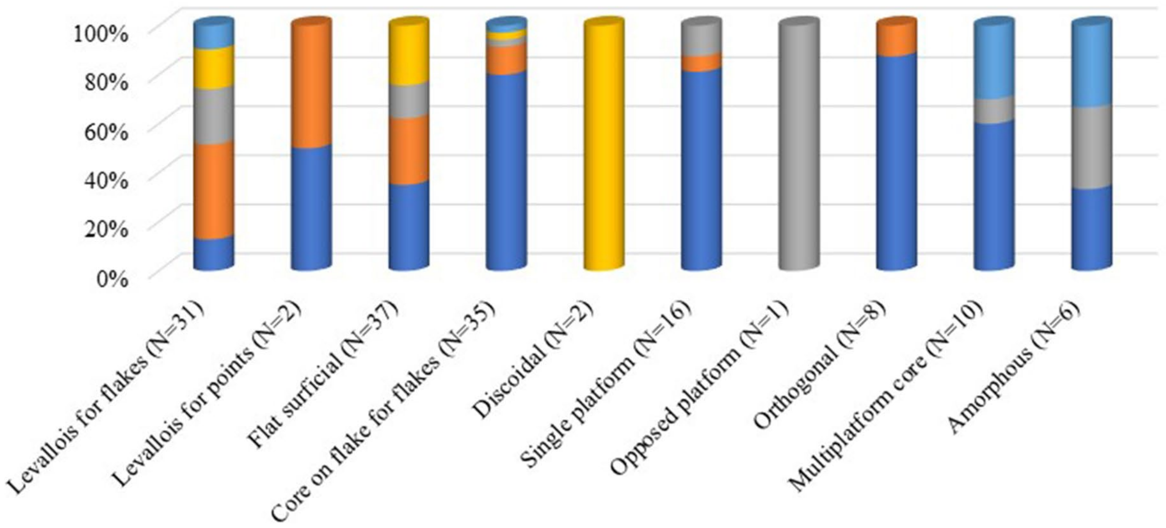


Fig. 6 **a** Types of striking platforms according to blank type. **b** Scar pattern on debitage, by blank type. **c** Main flaking surface of the cores

the Levallois and the truncated faceted exploitation of flakes as cores. Cores on flakes were exploited using the Levallois reduction sequence as well as a less formal mode of production (Goder-Goldberger, 2020; Goder-Goldberger et al., 2020; Goren-Inbar, 1988; Hovers, 2007). The volumetric mode is evident by the presence of single-platform cores. Knapping occurred onsite, as seen by the completeness of the reduction sequences and the refitted clusters.

Several of the refitted clusters are almost complete and only have a few artefacts missing, others include only two or three flakes. Initially, 224 artefacts were refitted onto 13 cores (Gilead & Fabian, 1990). Subsequent work has increased the number of refitted artefacts to 451, which conjoin into 90 clusters, accounting for 9.6% of the flint artefacts larger than 2.5 cm. The largest four clusters consist of between 17 and 48 refitted artefacts (Fig. 7). Two of the clusters are small flint nodules that were broken rather than knapped (Fig. 7 (3)). The marks on the outer cortex suggest they were used as pounders or hammerstones. When the original shape and size of the nodule could be inferred, the length of the refitted nodules ranges between 8.0 and 12.4 cm, the width 5.5–6.8 cm and thickness 3.3–3.5 cm. The original nodule sizes are almost double the average artefact length. The refitted clusters belong to a range of technological systems, including Levallois centripetal and unidirectional convergent (Figs. 7 (1,2) and 8 (3–4)), a volumetric sequence (Fig. 8 (2)) and tested nodules (Fig. 8 (1)). Several of the refitted sequences belong to more expedient exploitation practices resulting in artefacts and cores supporting a loose interpretation of the Levallois technological protocols (Fig. 8 (5)) as defined by Boëda (1995).

Table 4 Core types within the assemblage

Core type			Total	%
Levallois cores				
Centripetal		for flakes	5	2.6
Bidirectional		for flakes	2	1.0
Unidirectional-convergent		For flakes	9	4.7
		for points	2	1.0
	On flake	for flakes	1	0.5
Unidirectional		for flakes	1	0.5
	On flake	for flakes	1	0.5
Undefined		for flakes	8	4.2
Maybe Levallois		for flakes	7	3.6
		For points	11	5.7
	On flake	For flakes	11	0.5
Non-Levallois cores				
Cores on flake			28	14.6
Multiplatform			11	5.7
Pyramidal			5	2.6
Amorphous			15	2.8
Discoidal			2	1.0
Single platform			11	5.7
Opposed platform			1	0.5
Two platforms at 90°			13	6.8
Preferential surface			37	19.3
Preform			11	5.7
Fragment			10	5.2
Total			192	100.0

The Levallois Technology

The low frequency of Levallois products observed by Gilead and Grigson (1984) still stands (Table 2) and amounts to less than 6% of the assemblage, resulting in the assemblage being defined as a non-Levallois assemblage (Gilead & Grigson, 1984; Meignen et al., 2006). There are two aspects pertaining to the low percentage of Levallois products at the site:

1. Artefacts produced during initial stages of the reduction sequences, including Levallois products, do not retain traits of the Levallois technology. Cortical artefacts, belonging to the initial modification stages within the Levallois *chaîne opératoire*, are in effect excluded from the definition of Levallois (e.g. Boëda, 1995; Bordes, 1980; Van Peer, 1992). Thus, with cortex present on 50.8% of the artefacts at Far'ah II (Fig. 5c), this cuts by half the number of artefacts that may be defined as Levallois even though they were used within the Levallois *chaîne opératoire* to install the convexity needed for the next technological stages.
2. Middle Palaeolithic open-air sites are generally characterized by low Levallois indices (Gilead, 1995: Table 6.2) due to on-site knapping (Gilead & Grigson, 1984). The discrepancy between the percentage of Levallois cores (15.1%) and Levallois artefacts (3.6%) supports this claim. Additional support is found in the refitted groups, where the refitted Levallois cores display the removal of non-Levallois blanks during initial stages of knapping (Figs. 7 (1,2) and 8 (3–5)). For example, the CA refitted sequence (Fig. 7 (1)): the number of conjoined artifacts amounts to 48, yet when each of the blanks was analysed independently, only four flakes were defined as Levallois including a broken Levallois point. Although the core itself is missing, the series of refitted artefacts delineates a reduction sequence within which there are two hierarchical working surfaces, a preparation surface and a flaking surface. Platform shaping and core convexity were maintained by the removal of a series of small flakes, creating dihedral platforms, and partially faceted platforms on removed blanks.

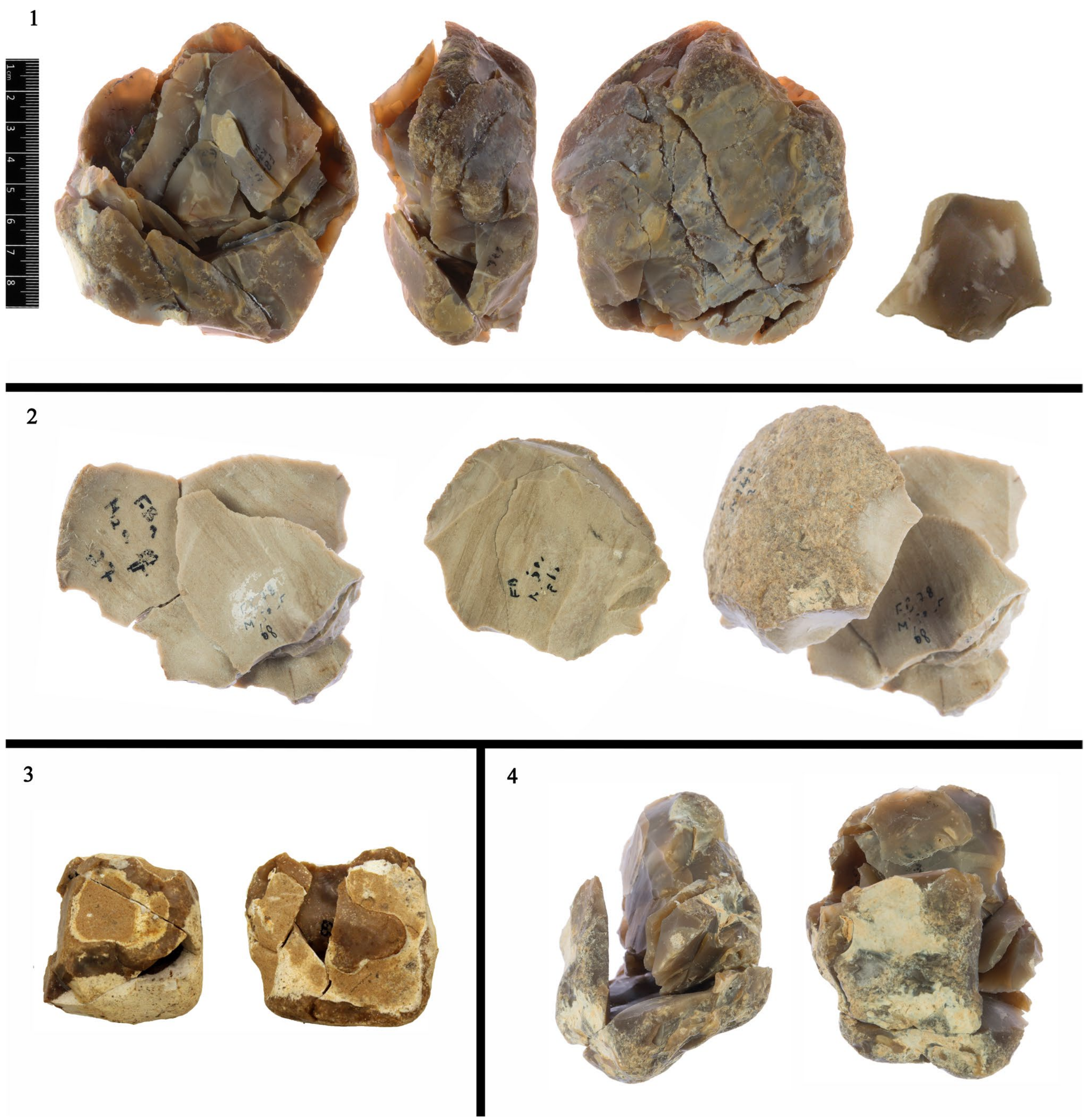


Fig. 7 Refitted groups. (1) CA group ($N=48$) Levallois unidirectional convergent, (2) core 10 ($N=22$) Levallois unidirectional convergent, (3) pebble 3 ($N=5$), (4) core CC ($N=15$) Levallois

The final scar pattern of the cores and artefacts indicates that the Levallois unidirectional convergent flaking mode dominates (Figs. 6 and 9 (2–4)), with both Levallois bidirectional flaking and centripetal flaking modes present (Figs. 6 and 9 (1, 5,6)). Wide and narrow Levallois points, often the last blank to be removed from the core, were produced using the unidirectional convergent flaking mode (Fig. 10 (1, 5–9)). All Levallois points are flakes (L/W < 2), and the points made on the brown/grey flint are the most elongated (Table S5b). The different average L/W noted for Levallois points by Gilead and Grigson (1984, see Table 4) reflects the difference of where the width was measured on the artefact. In the current study, the width measured is the maximum width perpendicular to the flaking axis while Gilead and Grison (1984) measured the width at half the length of the

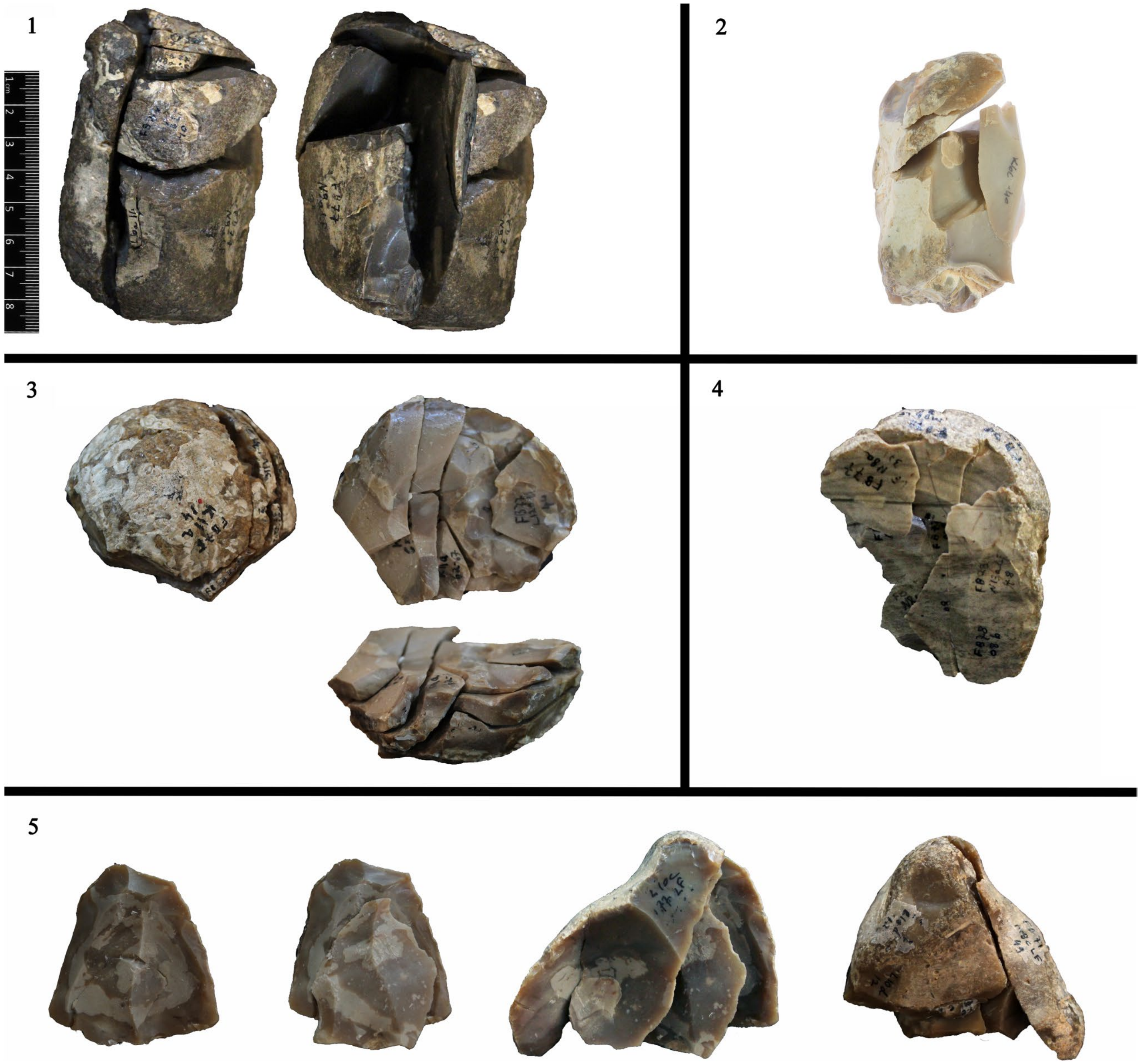


Fig. 8 Additional refitted groups. (1) Core 5 ($N=16$) broken nodule, (2) core CD ($N=4$) single platform core with refitted core tablet and blade, (3) core 2 ($N=15$) Levallois unidirectional convergent, (4) group 7 ($N=18$ core is missing), (5) core 9 ($N=10$) Levallois unidirectional convergent

artefact. *Débordant* flakes were used to form and maintain the convexity of the cores' flaking surface (Fig. 11 (2–6)). Faceted striking platforms were shaped in one of two ways: (1) by intensive faceting of the platforms before blank removal (Fig. 10 (1,9,10)), a type of platform preparation that was commonly used on the banded flint nodules (Fig. 7 (2)), or (2) by shaping the striking platform by means of flaking a series of small wide flakes, resulting in dihedral platforms on the removed flakes (Fig. 12 (8,9)). As seen on the refitted sequence (Fig. 10 (1)), this type of platform shaping was used throughout the knapping sequence. Reshaping of core striking platforms was maintained through the removal of flakes and blades, taking with them part of the striking platform (Fig. 11 (8–11)). The core preparation face often remained untouched and almost completely covered with cortex (Fig. 9). The Levallois products show some measure of bias in flint types; among the flakes, the bias is towards the banded flints, while among the Levallois points, it is towards the semi-translucent flint type (Table S4).

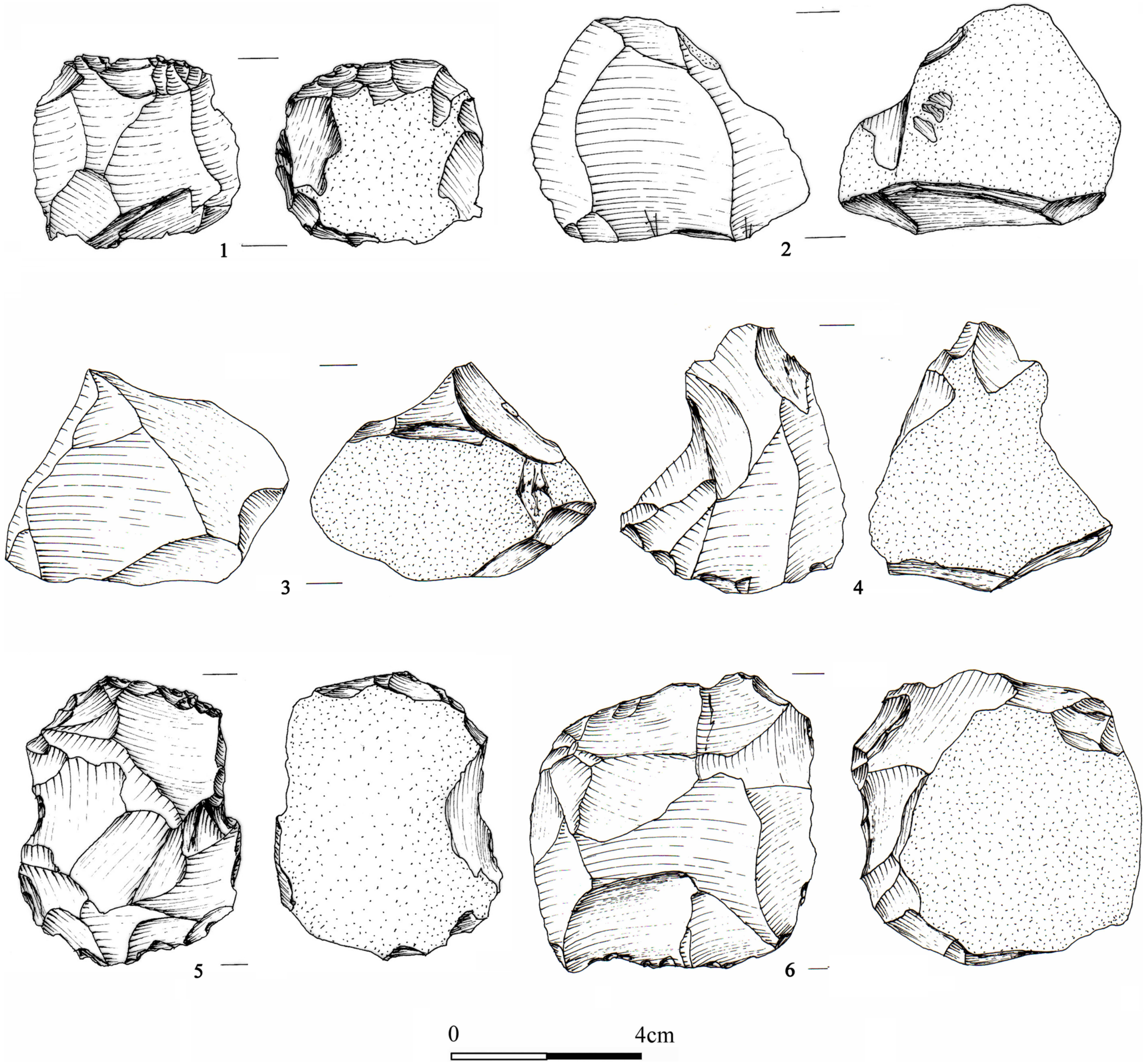


Fig. 9 Levallois cores. (1) Levallois bidirectional core for flakes, (2–4) Levallois unidirectional cores for preferential flakes, (5,6) Levallois centripetal cores for flakes

Surficial Preferential Surface

These cores were worked according to the surficial concept similar to the Levallois technology (Goder-Goldberger et al., 2023a) albeit they do not always maintain a hierarchy between the preparation and flaking surfaces (Fig. 13 (1,2)), a defining characteristic of the Levallois technology (Boëda, 1988, 1995). The overall production of blanks at the site is not highly standardized (Gilead, 1988; Gilead & Fabian, 1990) and reflects some measure of flexibility in the interchange between flaking modes. One example of such flexibility is a Levallois point core that in its final stage had a blade removed from its side (Fig. 14). A similar core is present at Ksar-Akil Level XXV, where it was described as a 'single platform prismatic core on a Levallois point core' (Ohnuma, 1988 p. 44). The cores on flake and truncated faceted pieces (Fig. 13 (5–7)) are included within the surficial cores as they display a flat flaking surface.

Volumetric Sequence

The volumetric reduction sequences found in the Far'ah II assemblage result in the final core having two or three flaking surfaces along the core's perimeter that result from one

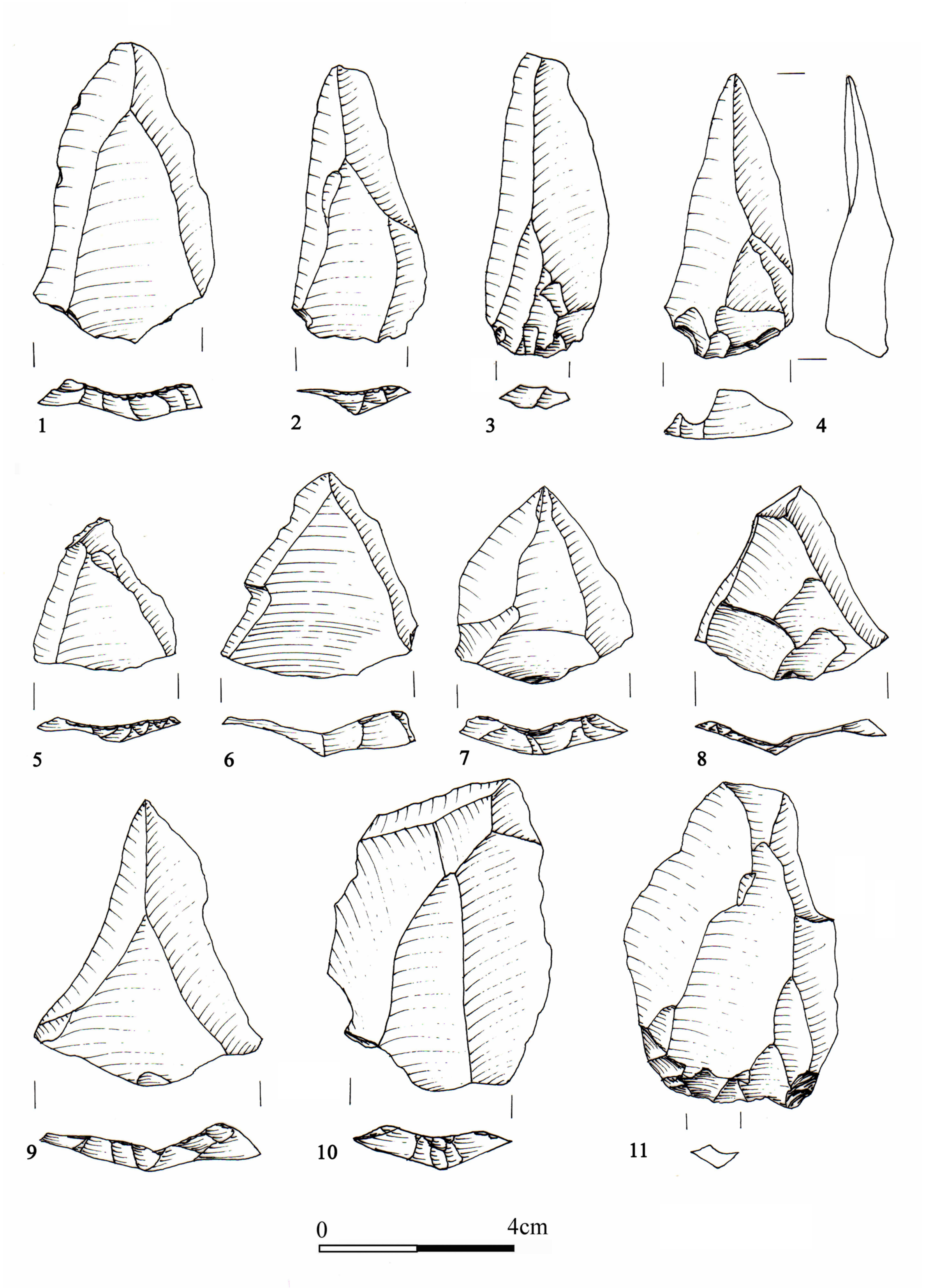


Fig. 10 Levallois Tools. (1, 5–9) Levallois points; (2,3) Levallois blades, (4) Levallois blade?, (10, 11) Levallois flakes

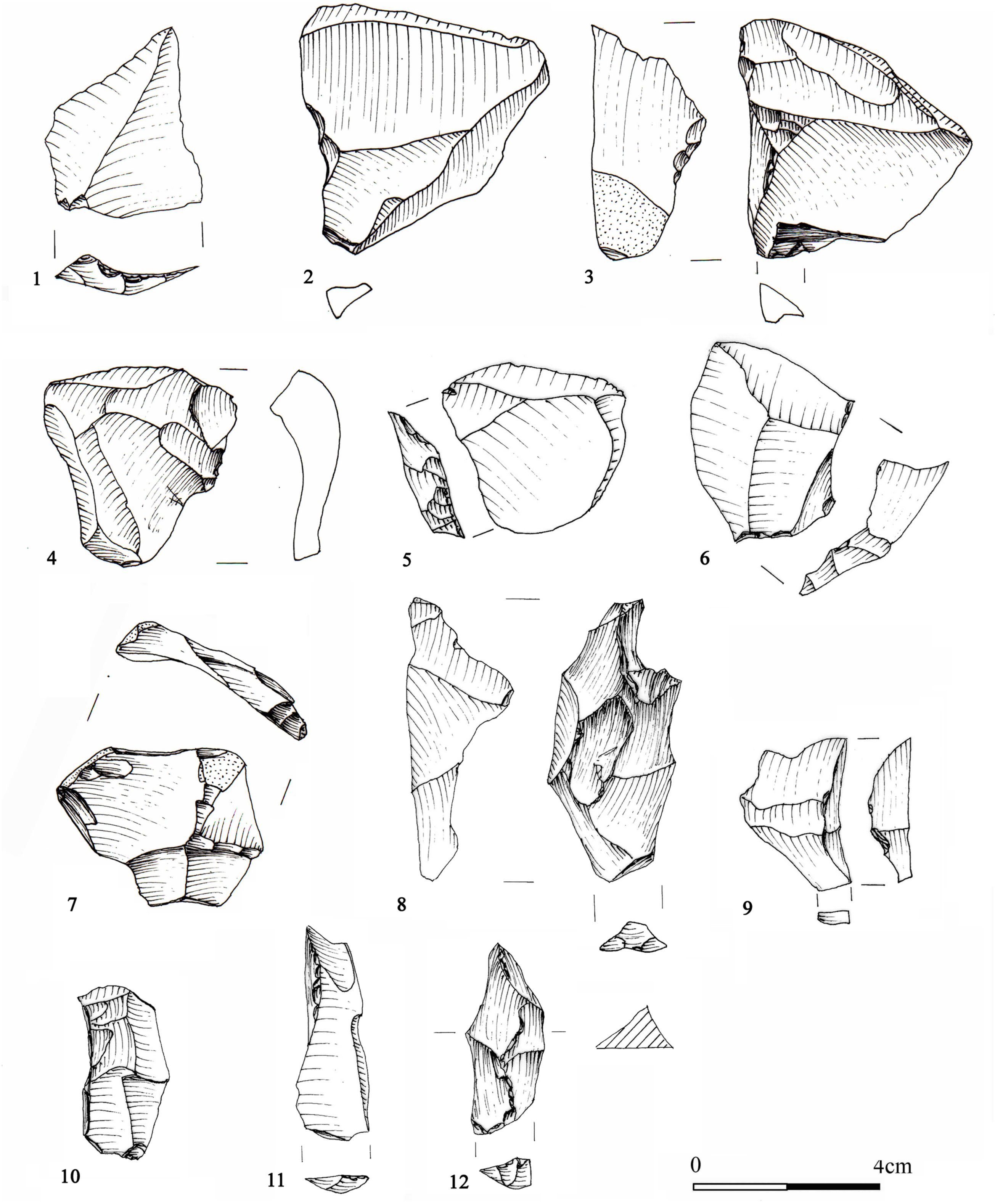


Fig. 11 Core shaping artifacts. (1) Pseudo-Levallois point, (2–6) débordant flakes, (7) overshot shaping flake, (8–10) platform rejuvenation flakes, (11) platform rejuvenation blade, (12) rejuvenation ridge

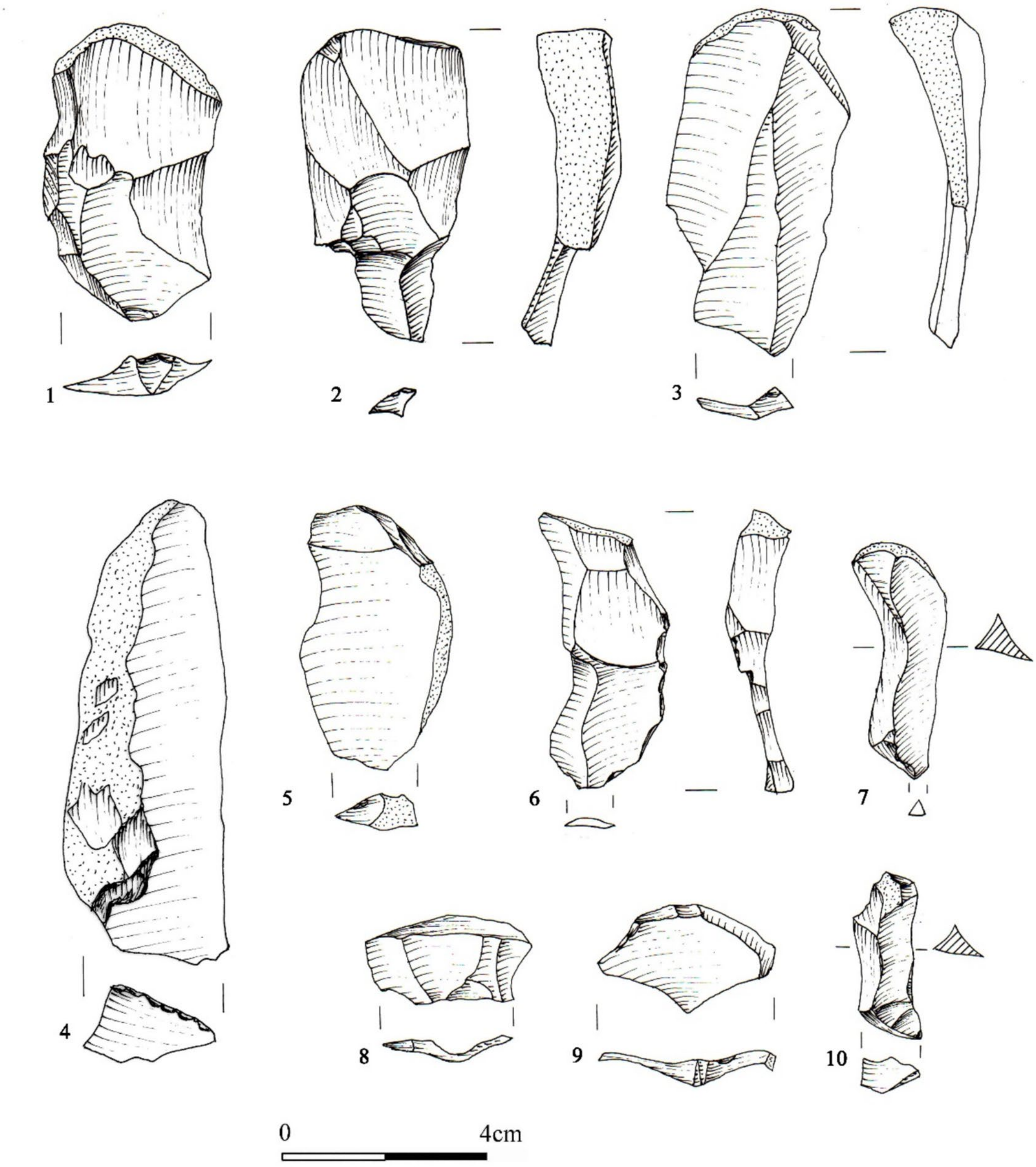


Fig. 12 Shaping artifacts. (1) Flake acting as core tablet, (2–3) overshot blades, (4, 5) naturally backed knife, (6) débordant blade, (7) core edge removal blade, (8,9) platform shaping flakes, (10) platform shaping blade

or two main striking platforms (Fig. 13 (4,5)). The flaking surfaces are either on the narrow or wide face of the core or on both and have an acute angle between the striking platform and flaking surface. When there are two striking platforms, they are at times offset from each other, or at opposite ends of the core. Rejuvenation of core shape and convexity resulted in over-shot flakes and blades removing the core's edge (Fig. 12 (1–3)). Core platforms are shaped and maintained by removing the edge of the striking platforms (Figs. 8 (2) and 12 (6–10)).

Tools

The tools in the lithic assemblage account for less than 3% (Table 2). Sidescrapers were made on limestone (Figs. 3 (5) and 4 (2)) and flint (Fig. 14 (1)). Also present are burins, endscrapers (Fig. 14 (2)), retouched flakes and blades (Fig. 14 (3,4)) and retouched Levallois points (Fig. 14 (5,6)).

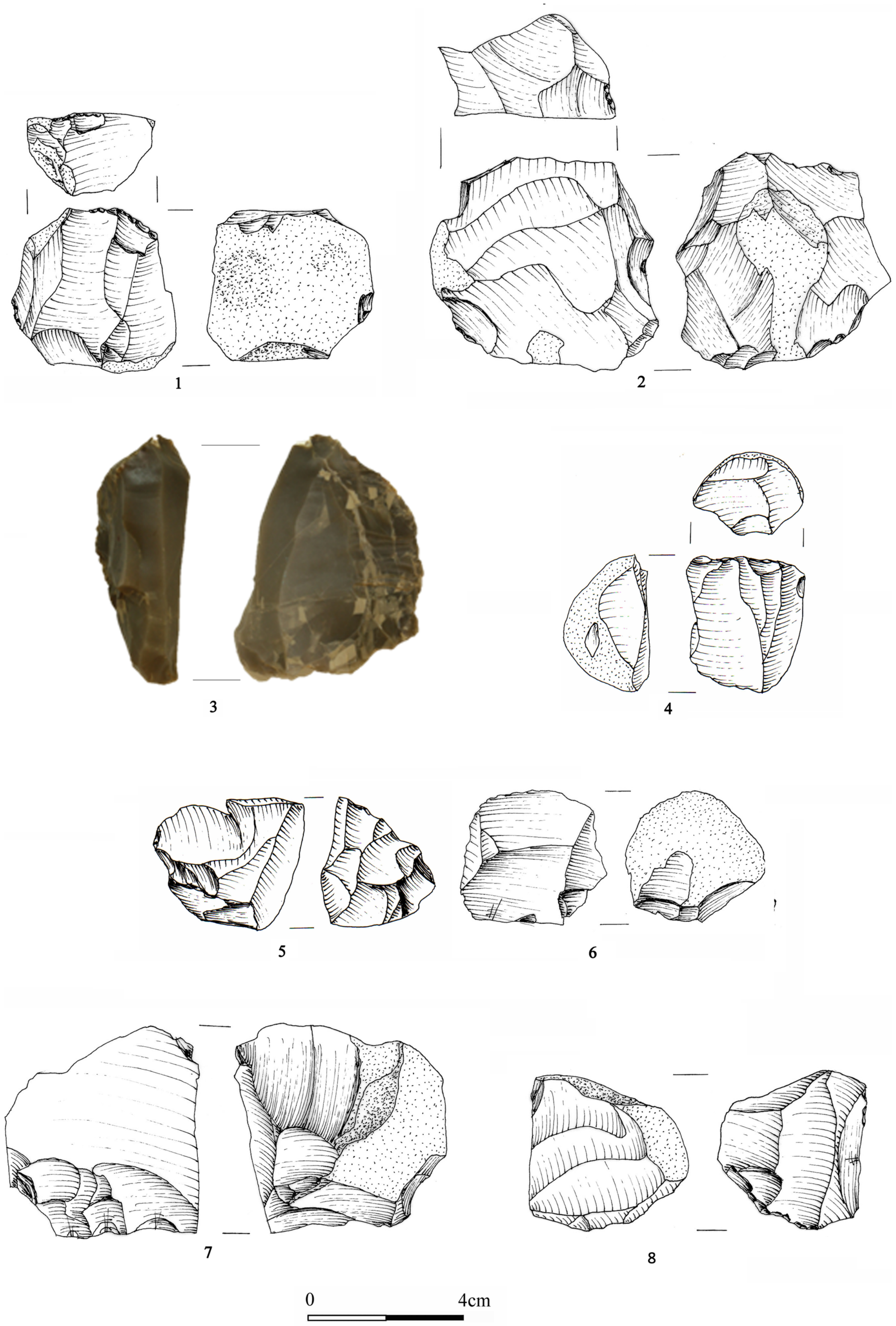


Fig. 13 Cores. (1–3) Surficial cores for flakes, (4) single-platform core for blades and bladelets, (5) multifaceted core, (6) core on flake, (7,8) truncated faceted core on flake

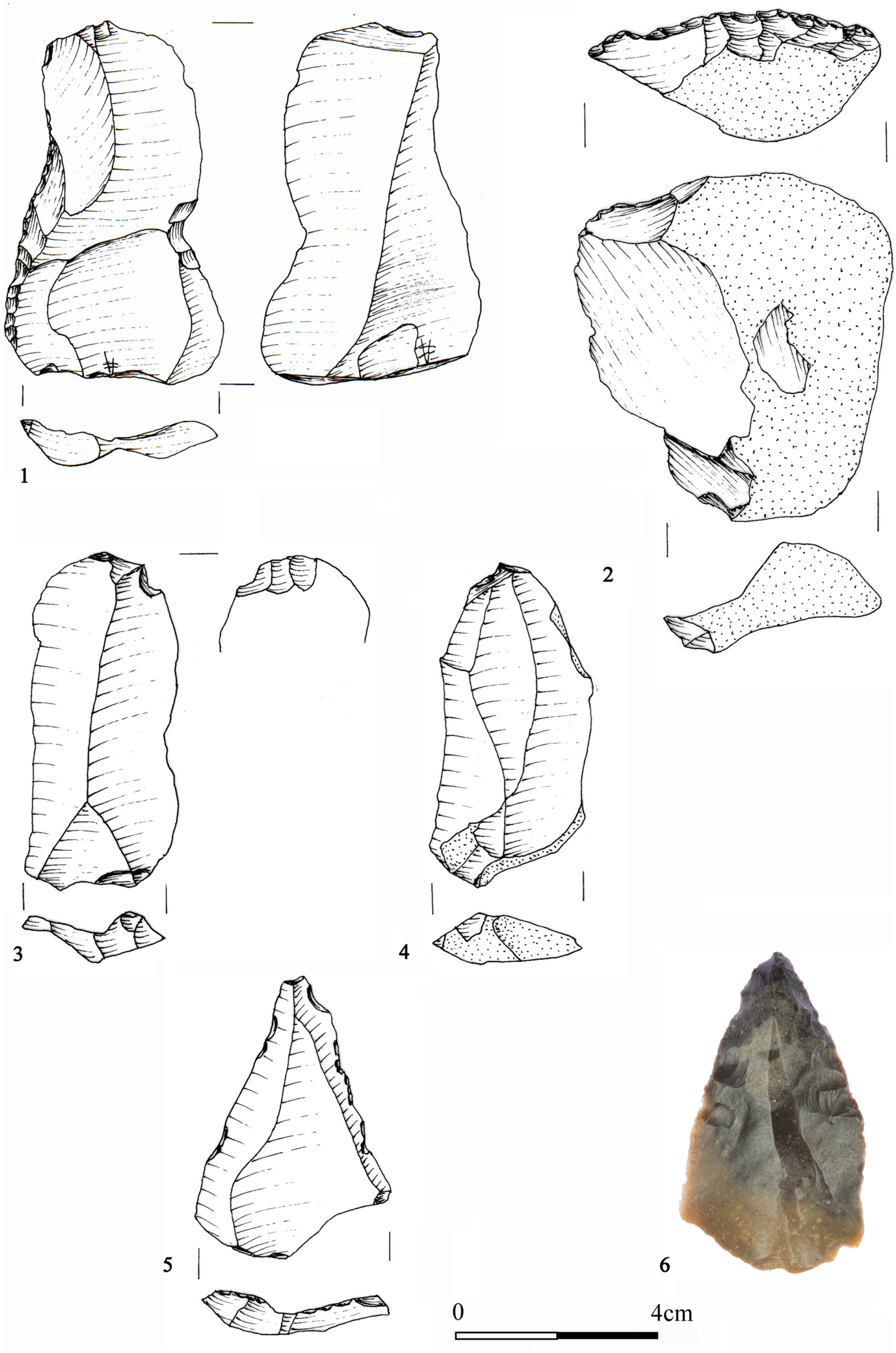


Fig. 14 Retouched artifacts. (1) Sidescraper on truncated flake, (2) endscraper on massive cortical flake, (3, 4) retouched blade, (5, 6) retouched Levallois point

The Faunal Assemblage

The faunal assemblage comprises almost exclusively of medium to large herbivores (Table 4; Gilead & Grigson, 1984), indicative of a semi-arid, open environment as attested by the two most common taxa in the assemblage, *Equus* spp. and *Alcelaphus*. Indeed, most of the indeterminate remains of large and medium-sized mammals can probably be attributed to these taxa. Both are indicative of dry grassland environments, as are the few remains of gazelle (*Gazella* sp.) and ibex (*Capra ibex*) identified at the site (Table 4). Scanty camel remains were found and initially identified as *Camelus thomasi* (Grigson, 1983). However, when compared to the measurements of the *Camelus thomasi* from the Pleistocene type-locality Tighennif (Ternifine) in Algeria, the Far'ah II remains are much larger but fall within the range reported from Palaeolithic sites in the Syrian desert (Martini & Geraads, 2018; Martini, 2017). Thus, the specific attribution of the camel remains from Far'ah are currently being revised.

In Syrian and Jordanian Middle Palaeolithic sites, camel co-occurs with gazelle and wild goat (probably ibex), indicating a dry steppe environment (Griggo, 2004). In contrast, at Far'ah II, these two arid adapted species co-occur at the site with grassland species, namely hartebeest and at least two species of equid, evidence for the presence of a steppe environment in proximity to the site (Bauer et al., 1994; Estes, 2012). However, aurochs (*Bos primigenius*), the third most common taxon at the site, is considered to be a species adapted to more humid, moister habitats (Hall, 2008; Van Vuure, 2005). It is likely that the perennial freshwater springs in the Besor Basin, would have provided a suitable biotope for this species.

The bulk of the diagnostic assemblage comprises bone fragments that could not be attributed to species but only to body-size classes (Tables 5 and 6). Of the assemblage that could be identified to species (NISP = 156), 68% are teeth (NISP = 107), with the remainder representing the most robust limb elements preserved, enabling identification (e.g. epiphyses and/or shafts of humeri, tibia, metapodial). It is suggested that these trends in skeletal element representation are not related to hominin selection but relate to post-depositional preservation biases that include extreme fluctuations in temperature and moisture (e.g. Conard et al., 2008) augmented by compaction due to the site overburden of 2–3 m of loess.

Table 5 Faunal species (NISP counts) from the 1976–1978 excavation at Far'ah II

Species	NISP	%
Alcelaphus cf. *bucelaphus* (hartebeest)	50	9.94
Bos primigenius (aurochs)	32	6.36
Camelus sp. (camel)	12	2.38
Equus spp. (equid)	57	11.33
cf. *Hippopotamus amphibius* (hippopotamus)	1	0.19
Capra cf. *nubiana nubiana* (ibex)	3	0.59
Gazella sp. (gazelle)	1	0.19
Large-sized mammal	212	42.14
Medium-sized mammal	123	24.45
Small-sized mammal	12	9.94
Total Identified	503	100
Undetermined fragments[a]	311	
Total	814	

[a] This is a sub-sample of available fragments that was analysed for this study

Triplots were made showing the relationship of measurements (length, breadth, depth) for a sample of bones that could be classified only by body size as well as a sample of unidentified bone fragments (Fig. 15). The triplot and table illustrate that there is no significant difference between the three categories of fragments and that irrespective of the class they belong to, all the fragments cluster in the top left-hand corner of the graph indicating that they are longer than wider but quite narrow and flat. The type of end fracture (dry versus green fracture) was also recorded for the same measured sample. Over 50% of bones had flat ends indicating dry fracture, 20% had green fractures on at least one end of the bone indicative of fresh bone fracturing, and 30% had mixed dry and green fractures on at least one bone end. Together, these data suggest that the bone assemblage has undergone post-depositional processes resulting in relatively homogeneous size and shape. Unfortunately, since the outer surfaces of the vast majority of bones in the assemblage are severely exfoliated, deeply cracked and split (Behrensmeyer weathering stage 5), the specific agent/s responsible cannot be clearly defined. However, the breakage patterns suggest that non-anthropogenic factors such as sediment compaction and/or trampling are probably the major factors responsible.

Spatial Analysis

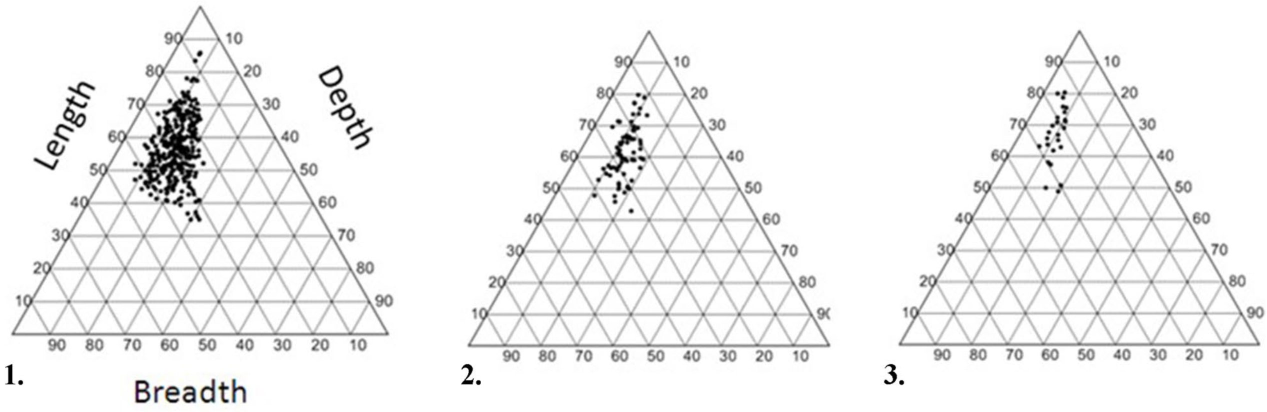
In the initial excavation (Gilead & Grigson, 1984), a visual separation was recorded between the lower layer 3 and the upper living floor (Gilead, 1988; Gilead & Grigson, 1984). Moreover, in their study, density and refitted cluster maps for the upper layer were produced based on entire meter square information. These maps depict two main concentrations of lithic artefacts in the south and north of the excavated area, with a dividing line formed by a low density of artefacts in squares J-8-L8 and M9-O9 (Gilead & Grigson, 1984 see Fig. 4a).

Our new analysis, with additional refitted clusters using only items with 3D coordinates, enabled us to statistically test and verify these two observations and extract additional

Table 6 Mean size of unidentified bone fragments (in mm)

	Unidentified fragments		Large mammal		Medium mammal	
N	311		69		25	
	Mean	SD	Mean	SD	Mean	SD
Length	16.8	7.6	61.6	35.7	50.9	34.5
Breadth	8.3	3.9	19.8	11.2	19.6	11.1
Depth	4.4	2.3	9.5	5.3	8.4	4.7

a. Triplots of fragment size (1) unidentified freagments (2) large mammal (3) medium mammal



b. Percent of burnt and unburnt fragments

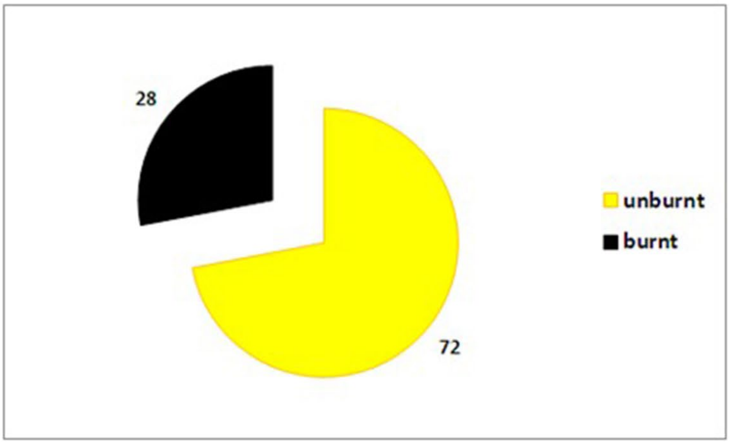


Fig. 15 **a** Triplots of fragment size (*N* = 405). (1) Unidentified fragments, (2) large-sized mammal, (3) medium-sized mammal. **b** Frequency of burnt and unburnt identified bones and fragments (*N* = 618)

information. The vertical distribution of artefacts ranges between 45 cm below the datum, with the main concentration of artefacts found at a depth between 60 and 90 cm. An additional group of artefacts assigned to the lower occupation layer (layer 3) were found at a depth of 91 to 100 cm only in the southernmost section of the site. Once all the artefacts were mapped and the refitted sequences were highlighted, a pattern emerged suggesting that the archaeological living floor may represent at least two separate occupation events. Once the refitted sequences were added and each of the refitted groups mapped individually, a clear dividing line emerged at an elevation of ~ 75 cm across the excavated area.

Of the 86 groups integrated into the artefact spreadsheet, 34 groups refitted above the 75 cm line; of these, only three clusters have one artefact below the line. Of the 43 groups that refit below the 75 cm line, two groups have one artefact that refits from above the line. Only three groups of two artefacts crossed the 75 cm line (Fig. S3). Six groups are associated with layer 3 and are spatially separate from the groups that refit higher up. To verify the vertical segregation of the living floor into two sub-units, we projected all the artefacts by elevation and performed a KDE analysis (Fig. 16). This analysis showed a notable difference in density between the top and bottom sub-units, while the latter appears to contain a lower density of items.

To quantify what we observed in KDE, we applied the Quadrat Method and then Getis-Ord Gi* (Fig. 16C, D) considering the variable number of points in each square. The results show that two levels were clearly identifiable: one much denser in the upper part and another less dense in the lower section. A clear accumulation of artefacts is visible towards the north (Fig. 16E). Considering these results, we projected the refitting lines. With these results, we used the elevation of 75 cm to separate the two sub-levels of the Living Floor (hence named upper and lower sub-units). We are aware that this may be considered an arbitrary line, but we find that the results presented permit the use of this line to divide between the top and bottom sub-units. One possible explanation for the discrepancy between this subdivision and the slope noted in the original publication (Gilead, 1980; Gilead & Grigson, 1984) is that no difference in the sediment was identified between the sub-units, neither was a sterile layer separating them identified during excavation, nor is there a sterile level evident in the vertical dispersal of artefacts. The palimpsest of the two sub-units resulted in them forming,

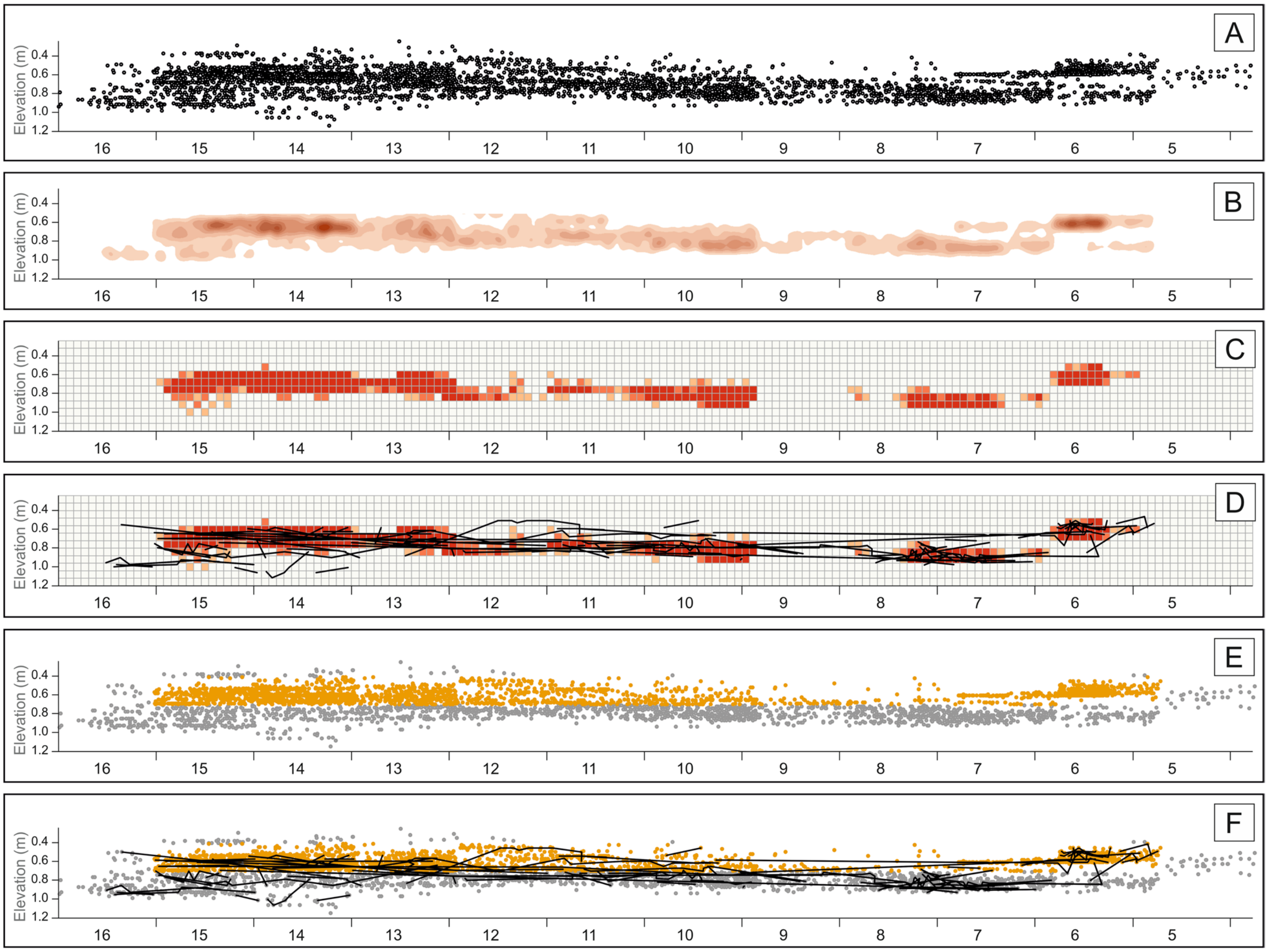


Fig. 16 Vertical analysis of the lithic assemblage. **A** Vertical plot of the complete lithic assemblage; **B** KDE map of the complete lithic assemblage; **C** Quadrat Method and Getis-Ord Gi* hotspot method; **D** Quadrat Method and Getis-Ord Gi* with lines marked between refitted artifacts; **E** plot of the complete assemblage: in yellow, the artifacts above the 75 mm line (top sub-unit) and in gray below the 75 mm line (bottom sub-unit)

what appeared to be in the field, one continuous slightly sloping layer.

Following the division of the lithic assemblage associated with the living floor into two sub-units based on the vertical data, the next step was to see if there is also a horizontal spatial segregation. The assemblage was split into two groups, the upper group included all artefacts above the 75 cm line (top sub-unit) and a second group of those below the line (bottom sub-unit). The same was done with the bone assemblage. Artefacts and bones assigned to the lowermost layer 3 were omitted from the analysis given that the research question related to the nature of the living floor. The two groups of artefacts and bones were projected independently, and the pattern that emerged showed a clear spatial difference between the two sub-levels. Average nearest neighbour (ANN) and Global Moran's were applied to evaluate whether the artefacts and bones were clustered, dispersed or randomly distributed. Both tests indicate that the distributional pattern for both units is clustered (Table S10). The top sub-unit is distributed across the western excavated area, and the bottom sub-unit is mostly found along the eastern area. KDE was performed for both sub-units, and the zones of maximum concentration of materials did not overlap between the two (Figs. 17 and 18).

The top sub-unit has two main lithic artefact concentrations, one to the north and another one to the south of the excavated area. The bones in the top sub-unit seem to surround the limits of the identified hearth. The lithics tend to concentrate to the north of the hearth limits, with some lithics located within the limits (Fig. 17). The burnt lithic artefacts amount to 1% of the assemblage and were randomly scattered, while the burnt bones amount to 7% of all bones and were found clustered adjacent to the hearth limit (Fig. 17). The bottom sub-unit has several high-density concentrations of artefacts, all of them scattered along the eastern side of the excavation. In the bottom sub-unit, while no hearth was detected, burnt bones (that amounts to 20.5% of all bones analysed) were found very concentrated in a specific spot (Fig. 18). In this sub-unit, the burnt lithics comprise only 1% of the assemblage, as in the top sub-unit, but seem to cluster in the same location as the burnt bones.

Next, we applied the Getis-Ord Gi* hotspot analysis method using the "length" data as a quantitative variable. The objective of applying this method with this variable is to check whether the assemblage has been affected by post-depositional processes that may have sorted the artifacts by size. Likewise, this analysis is intended to improve the resolution of differences between the sub-levels and their comparison. The hotspot analysis was conducted for those artefacts for which we had recorded artefact length (i.e. 68.5%). For the top sub-unit, three clusters were identified, one coldspot and two hotspots. The two hotspots may belong to the same cluster but were separated due to the distance between them. The items within the coldspot cluster are notably more numerous than the rest of the identified clusters and consists of 267 items with an average length of 3.32 cm (Table 7). On the other hand, the one hotspot cluster contains 153 items, with an average length of 4.29 cm, while the second hotspot cluster is made up of 60 items with an average length of 4.11 cm.

In the bottom sub-unit, two main clusters were identified (Fig. 19), one coldspot and another hotspot. The coldspot cluster includes 217 items, with an average length of 4.17 cm (Table 7), while the hotspot cluster is made up of 235 items with an average length of 3.39 cm (Table 7). In both sub-units, the difference between the hotspot and coldspot clusters is significant, with a great similarity in the average length of items in clusters identified in both sub-units.

The application of the Quadrat Method combined with Getis-Ord Gi* for the spatial distribution by elevation and the spatial distribution of the refitted clusters (Fig. 20) shows that most clusters are aggregations of artefacts within one square meter. Other clusters represent larger spatial distributions with two and four artefacts spread over a distance of up to 2 m from the cluster's centre. The aggregation of clusters reflects isolated knapping episodes.

Discussion

The late Middle Palaeolithic site of Far'ah II, located within the loess badlands of the lower Besor Basin, with an age of ~ 49 ka, is at present one of the latest MP sites known from the Levant (Goder-Goldberger et al., 2020). This semi-arid region is part of the north-western Negev ecotone, a rich intermediate ecozone with high biodiversity (Kark & van Rensburg, 2006; Kark et al., 2005). The faunal assemblage reflects a mosaic environment with a range of large mammals typical of dry grasslands-steppe (*Camelus*, *Alcelaphus*, *Equus*, *Gazella*) and more rugged terrain (*Capra ibex*), while *Bos primigenius* is commonly associated with a flat terrain and a more humid environment (Bauer et al., 1994; Estes, 2012; Hall, 2008; Van Vuure, 2005) and probably relates to the Nahal Besor perennial springs along its riverbed. A similar environmental picture is formed by the pollen and charcoal data from the site, depicting a typical Irano-Turanian landscape. The woody species identified from the charcoals found at the site include *Tamarix* sp., *Juniperus phoenicea*, *Pistacia atlantica* and *Hammada* (Gilead & Grigson, 1984; Goder-Goldberger et al., 2020, 2023b).

The technological variability seen at Far'ah II is similar to that recorded at other Levantine Late Middle Palaeolithic sites including those from caves in the Mediterranean region (Crew, 1976; Demidenko & Usik, 1993, 2003; Ekshtain et al., 2019; Goder-Goldberger et al., 2023b; Goder-Goldberger & Bar-Matthews, 2019; Goren-Inbar, 1990; Hovers,

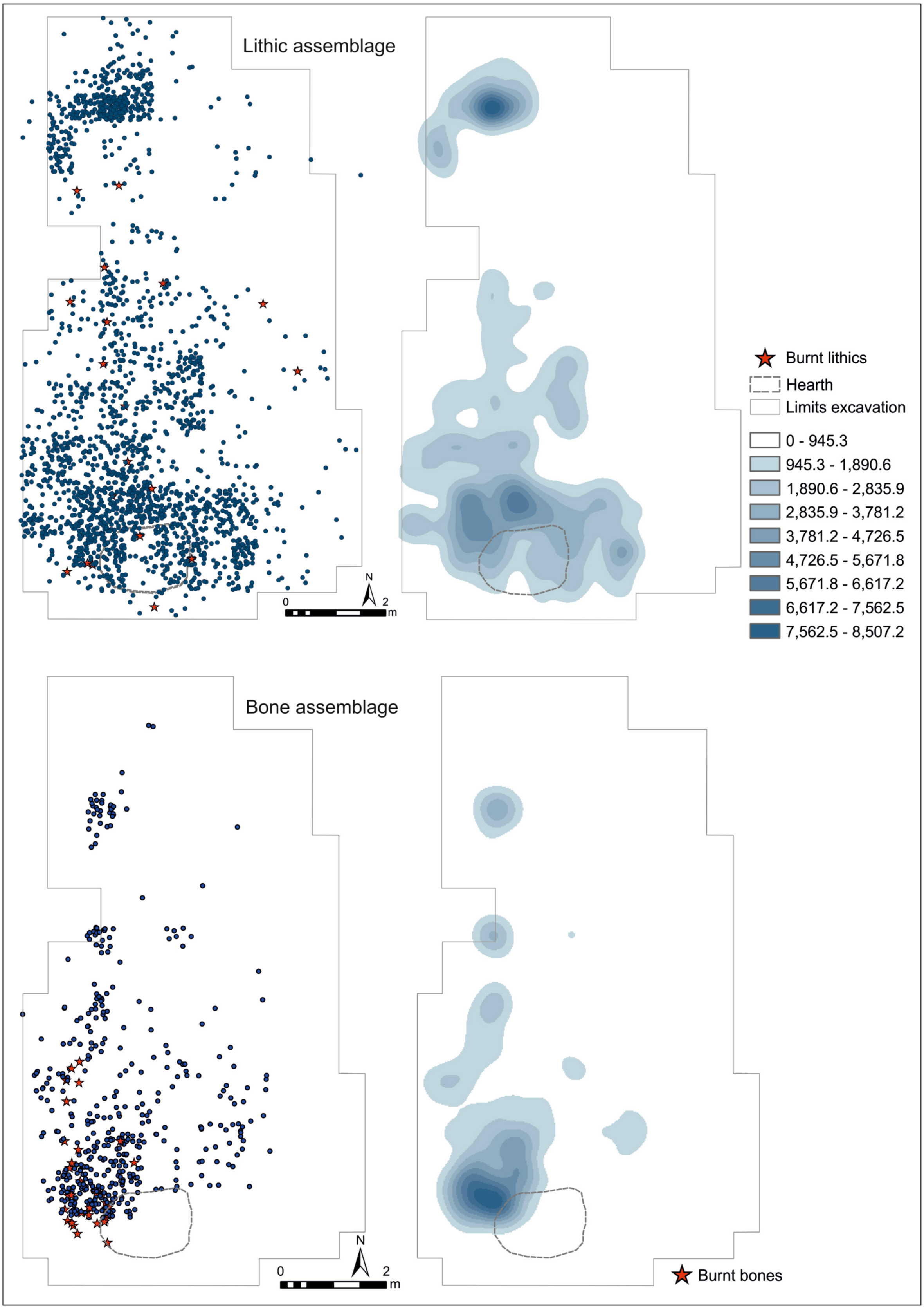


Fig. 17 Top sub-unit KDE maps of the lithic assemblage ($N = 2109$) and the bone assemblage ($N = 496$), with burnt lithics and bones marked as red stars

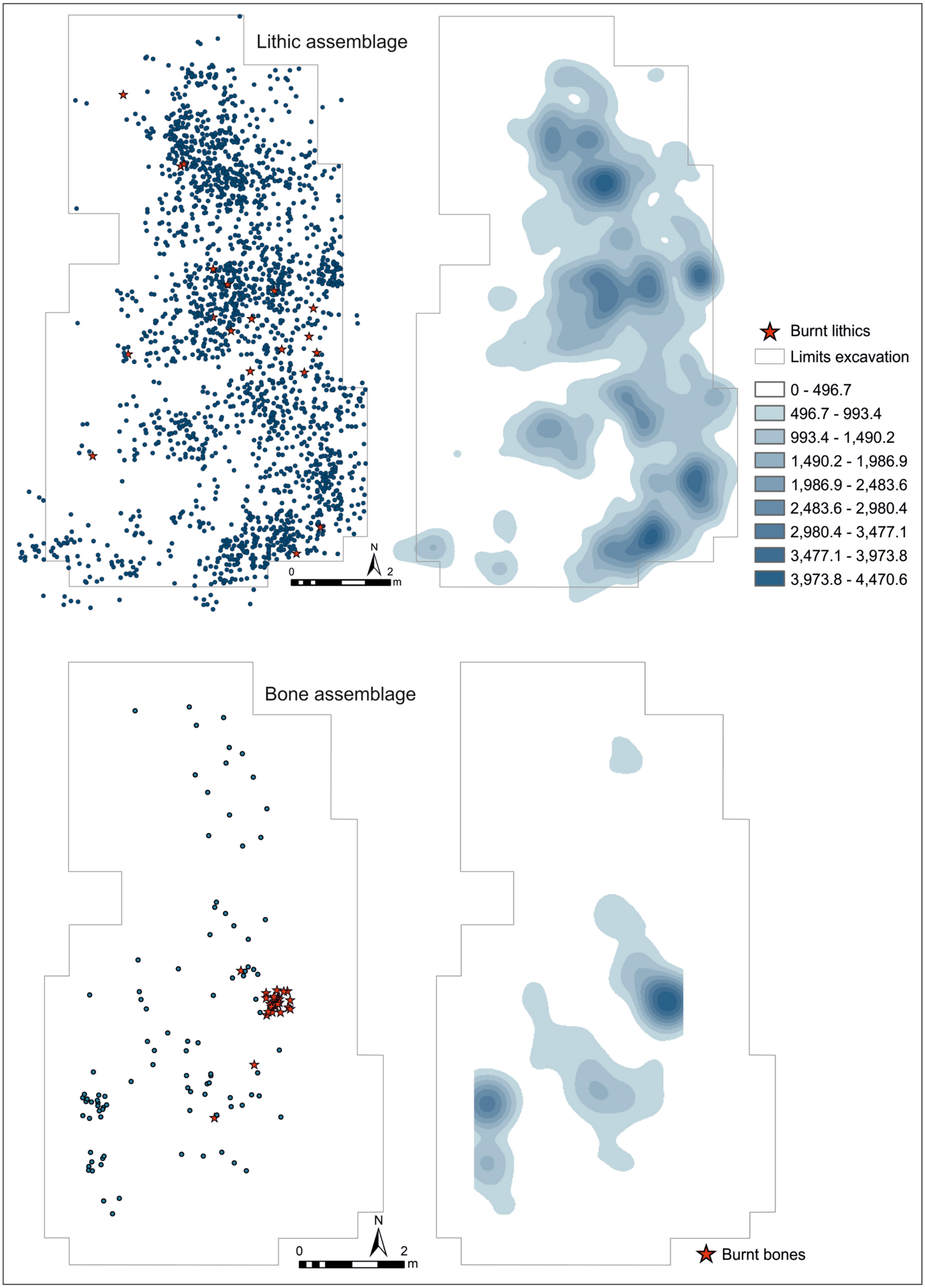


Fig. 18 Bottom sub-unit KDE maps of the lithic assemblage ($N = 1874$) and the bone assemblage ($N = 122$), with burnt lithics and bones marked as red stars

Table 7 Number of items and descriptive statistics of the statistically significant clusters identified in the lithic assemblage of the two subunits identified in the Far'ah II Living Floor. All length values are in mm

		n	avg	min	max
Top subunit	Hotspot	235	41.7	11.2	90.77
	Coldspot	217	33.9	8.71	101.29
Bottom subunit	Hotspot 1	153	42.9	14.1	109.2
	Hotspot 2	60	41.1	15	83.3
	Coldspot	267	33.2	11.7	83.1

1998, 2007; Malinsky-Buller et al., 2014; Marks & Monigal, 1995; Meignen & Bar-Yosef, 2019; Sharon & Oron, 2014). The assemblage depicts extensive on-site knapping activities represented by the presence of hammerstones, knapping waste (i.e. chips and debitage) and the refitted groups. On the other hand, the scarcity of tools at Far'ah II (compared to cave sites in the Mediterranean zone) may indicate they were taken off-site as part of the mobile tool kit (Kuhn, 1992, 1994). This hypothesis fits our reconstruction of the Far'ah II hunter-gatherer's lifestyle. Readily available flint nodules and limestone cobbles were collected from the Besor riverbed and brought back to be used at the site. In at least one instance, the nodule brought back was flawed and, after initial knapping, was abandoned (Fig. 11; Gilead, 1988). A flexible technological organization is evident, with the Levallois technology used alongside less formal ones. In several instances, the knappers took advantage of the nodule's natural curvature for surficial flaking. Just over 70% of all surficially exploited cores, including Levallois cores and cores on flakes, have a cortex cover of > 50% on the preparatory surface, and the percentage of core shaping flakes is low (Table 2). The unidirectional and unidirectional convergent flaking modes are delineated on 62.1% of the cores, followed by the centripetal (24.3%) and bidirectional (13.5%) flaking modes. Levallois points were knapped from both carefully faceted cores (Figs. 7 (2) and 8(3)) resulting in broad-based points with intensively faceted striking platforms, and from less standardized cores resulting in broad-based

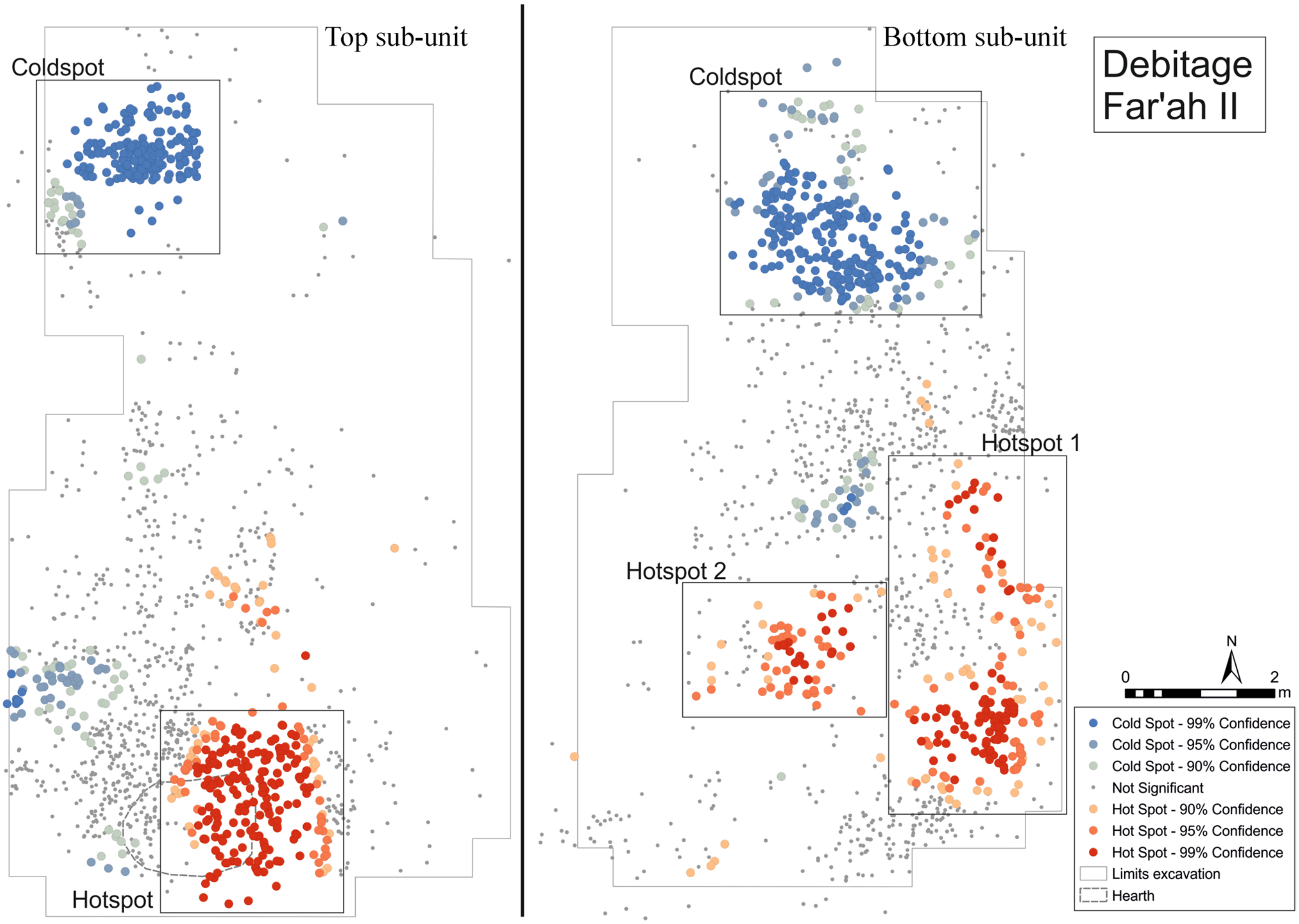
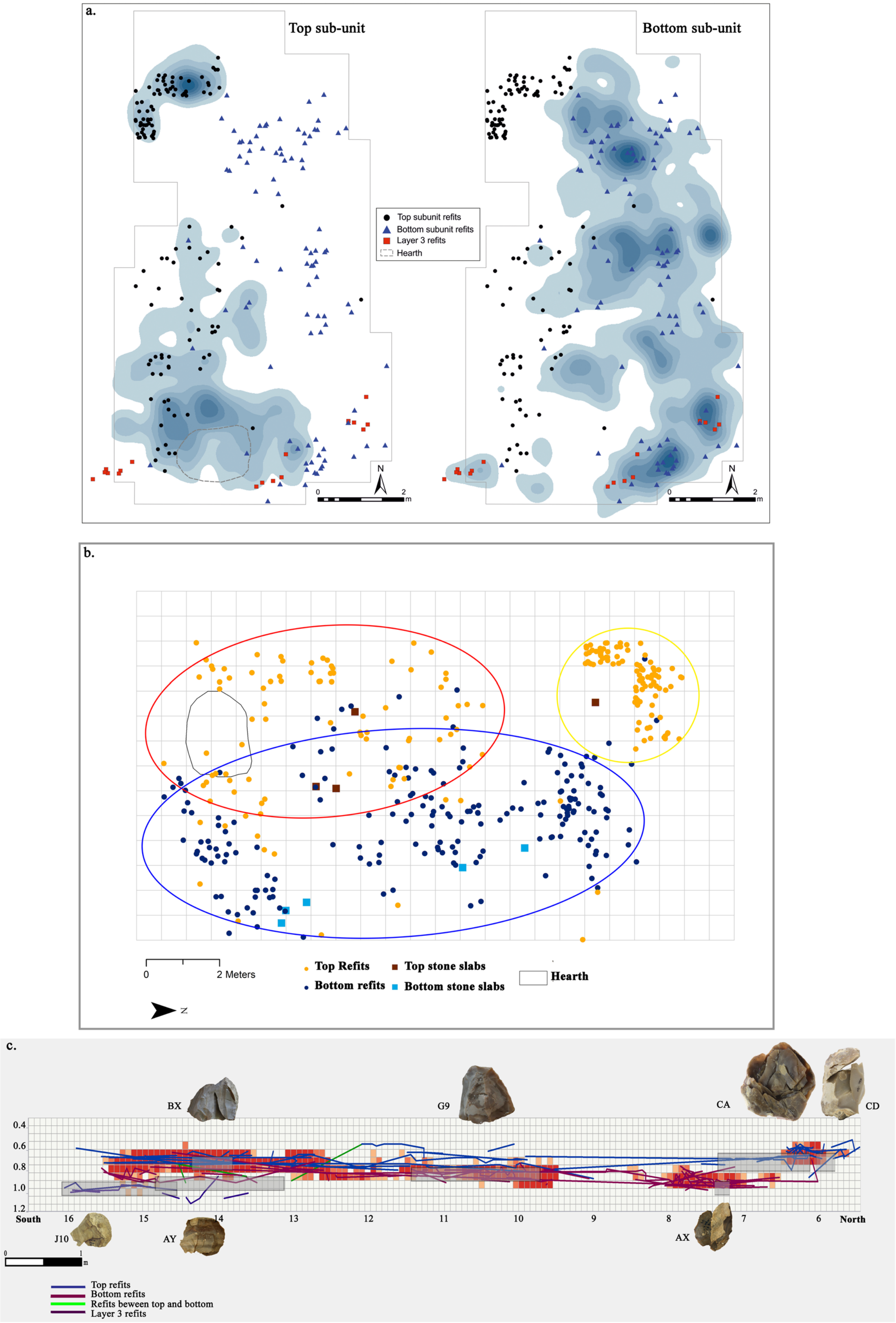


Fig. 19 Map with the statistically significant clusters identified by Getis-Ord Gi* applied to the variable of maximum length in the debitage lithic materials of the two sub-units identified in Far'ah II


a.
Top sub-unit
Bottom sub-unit
Top subunit refits
Bottom subunit refits
Layer 3 refits
Hearth
N
0
2
m
b.
0
2 Meters
Top Refits
Bottom refits
Top stone slabs
Bottom stone slabs
Hearth
N
c.
BX
G9
CA
CD
0.4
0.6
0.8
1.0
1.2
South
16
15
14
13
12
11
10
9
8
7
6
North
J10
AY
AX
0
1
m
Top refits
Bottom refits
Refits beween top and bottom
Layer 3 refits

◂**Fig. 20** Spatial representation of the sub-units of the Living Floor. In order to align the site map with the vertical profile, it is oriented differently than the previous figures. **a** Refitting sets distinguished by sub-units (see Fig s4) and the KDE map corresponding to each of them. **b** Map of refitted artifacts aligned with the vertical distribution below. The blue ellipse marks the bottom sub-unit, the red and yellow ellipses mark the top sub-unit possibly two separated events as there is almost no overlap in the refitted artefact scatter. **c** Vertical depiction of the sub-units with several of the refitted groups

points and elongated points that were not always faceted or have dihedral faceting platforms (Figs. 7 (1) and 8 (5)). The refitted Levallois groups suggest that faceting intensity of the platforms may relate to the type of flint selected. The banded flint (also known as "imported flint"), which is brittle (Tzibulsky & Frid, 2023), was intensely faceted, while the platforms of the semi-translucent block were shaped using small flakes, resulting in dihedral platforms (Fig. 10 (1,2)). The volumetric approach, accounting for 23.6% of all cores (Table S7), was used to produce flakes, blades and bladelets (Figs. 11 (2) and 16 (4,5)). All tools were made from flint, except for sidescapers which were made on both flint and soft limestone. For hammerstones, rounded cobbles of hard limestone and flint were selected, while elongated limestone cobbles were used as pestles. The presence of sandy limestone and limestone slabs with abrasive features, as well as polish marks on the pestles, implies they were used for grinding or pounding soft material.

At cave sites and rockshelters, use of space often reflects a repeated association between specific activities and their location within the place's physical boundaries (e.g. Alperson-Afil & Hovers, 2005; Henry, 2012). At open-air sites, the lack of these boundaries often results in a shift in activity location with each visit to the site, and the palimpsest nature of accumulation makes it harder to separate between them (Bailey, 2007; Hovers, 2017; Malinsky-Buller et al., 2011). As open-air sites are exposed to elements, such as overbank water flow, sediment accumulation, bioturbation and perturbation (Bertran et al., 2019), if we are to relate detected spatial patterning to anthropogenic causality, we must first elucidate the influence of post-depositional processes (Dibble et al., 1997; Malinsky-Buller et al., 2011; Méndez-Quintas et al., 2022; Stahlschmidt et al., 2018). Sediment compaction and/or trampling, which could have occurred after initial burial of the assemblage, may have caused the rate of breakage seen amongst lithics and bones and may have caused some vertical distribution (Villa, 1982; Villa & Courtin, 1983). In sandy sediments, beyond a depth of ~ 20 cm, trampling has little or no effect on artefact breakage (Forssman & Pargeter, 2014; Marwick et al., 2017). At Far'ah II, where the loess sediments are finer grained and more compact, the effective depth is most probably shallower. The fine grain size of the sediments within which the site was embedded is the result of slow water overflow and lack of soil development (Bertran et al., 2012; Goder-Goldberger et al., 2020; Sneh, 1983). Fast burial and minimal exposure of the assemblage is indicated by the fresh and sharp edges (found on 99.8% of all artefacts), lack of patinated artefacts (evident on less than 0.5%) and the presence of faunal remains, albeit highly fragmented (Staurset et al., 2023). Minimal spatial movement of artefacts is suggested by the lithic assemblage composition (58.3% of the artefacts are < 2.5 cm,) low breakage percentages (32.7% of artefacts > 2.5 cm and 66.7% of artefacts < 2.5 cm), artefact refit percentages (9.6% of the artefacts refit into 90 groups) and lack of size sorting of lithics and fauna (Fig. 19). Some measure of movement and size sorting would have been expected if the slope initially identified during excavation had any influence on the scatter of the lithics (Phillips et al., 2019). When the lithic clusters are analysed, there is a noticeable difference between the coldspot and hotspot clusters. The coldspots representing a concentration of smaller artefacts are found mostly in the northern section of both the top and bottom sub-units (Fig. 20). Considering the slope of the deposit identified during excavations (Gilead, 1980; Gilead & Grigson, 1984), we would have expected that the smaller remains would be displaced downslope, where in fact the largest remains identified by Getis-Ord Gi* are located (Table 7). The formation of coldspot and hotspot clusters could be explained by differing knapping activities, i.e. size of original nodules knapped and the reduction sequence used. For example, when a nodule was knapped, and the larger artefacts were removed for use, the resulting debitage concentration will include along with the larger cortical artefacts a concentration of the small-sized fraction of artefacts, mostly shaping flakes. The scatter of cores across each of the sub-units, rather than their concentration at the bottom of the slope (Fig s3), supports the observation that the slope had little post-depositional effect on the spatial distribution of artifacts.

The refitted sequences at Far'ah II enabled us to vertically group the living floor assemblage into two sub-units, albeit with a small number of refitted artefacts crossing between the two sub-units (Fig. 20). The spatial offset of the two sub-units hints at reoccurring visits to the same location within the landscape. The coherence in cultural material and fauna between the two sub-units and the lack of a sterile layer dividing the two indicate that only a short period of time, perhaps on a scale of months or years, separated the two events. The low percentage of artefacts refitting over a distance that exceeds 2 m (Fig. S3) strengthens the integrity of the stratigraphic division of the upper archaeological horizon into two subunits (Clark, 2017; Forssman & Pargeter, 2014).

The lowermost archaeological horizon (layer 3) was exposed only in the southernmost part of the excavation (Gilead, 1980; Gilead & Grigson, 1984). Two refitting clusters each consist of a series of refitted flakes. A sterile layer was noted between this layer and the bottom sub-unit of the living floor (Gilead & Grigson, 1984) indicative of a lengthy activity hiatus at the site.

In the bottom sub-unit, there seems to be two concentrations of refitted lithic sequences, one across the centre and to the north and the other at the southern edge of the excavation (Figs. 20 and s3). The faunal remains appear to form concentrations, with all the burnt remains grouped together in the central concentration, similar to the grouping of the burnt flint artefacts (Fig. 18), suggesting there may have been a hearth in close vicinity, possibly beyond the eastern limits of the excavation. The spatial overlap between the refitted clusters in the central part is notable and may be associated with spatial dispersal due to trampling (Forssman & Pargeter, 2014; Marwick et al., 2017). Limestone hammerstones, cobbles and cobble fragments were found across the central and southern sections, as well as four limestone and sandy limestone slabs. It would seem that the main activity in the bottom sub-unit focused on flint knapping, with less evidence of meat and food processing.

In the top sub-unit of the living floor, two activity areas are visible:

1. The northern section includes five refitted clusters (Figs. 20 and S3) within an area of 4 m^2, with each of the clusters mostly confined to an area of ~ 0.5 m^2. These clusters include Levallois, surficial and single-platform sequences, as well as broken flint nodules with impact marks. The low frequency of bones and the lithic coldspot cluster in this area (7.1%) implies that flint knapping was the main activity that took place. The clustering of the refitted sequences attests to fast burial, preventing dispersal of artefacts due to trampling. This clustering also attests to the short duration of occupation, as the longer an occupation lasts, people would have moved within and across the site, inevitably causing movement of artefacts.
2. In the southern section, several of the refitted clusters are in proximity to the hearth (Fig. 20). Also evident around the hearth, there is an overlap between the lithic and faunal scatters as well as a concentration of burnt bones (Fig. 17). Many of the cores are found around the northern rim of the hearth, while the Levallois artifacts do not seem to form a distinct clustering (Fig. S3). The density of artefacts and faunal remains supports our interpretation that flint knapping and meat processing took place adjacent to the hearth, with no clear separation between the two activities. Several limestone cobbles used as hammerstones and sandy-limestone slabs were also found around the hearth, indicating that they were an integral part of the various activities that took place here. Use wear analysis of the ground stone artefacts suggests that both knapping and pounding of hard materials occurred, as well as possibly grinding activities as indicated by the abrasion and polish. However, this requires further investigation with a special focus on the micro-surface features. This hypothesis should be further tested and supported by dedicated experiments.

The patterns emerging from both sub-units suggest that a similar range of activities were practiced at both. Occupation intensity may have been slightly higher in the top sub-unit, but if this results from a larger group size or longer occupation time cannot be determined from the results. The spatial scatter of Levallois cores, flakes and points does not seem to present any observed clustering (Fig. S3).

Ethnoarchaeological studies of hunter-gatherer use of space centre on two main resolutions: the camp and household spacing within the camp versus the use of space within a specific household (Binford, 1979, 1980, 1982; Gould & Yellen, 1987; Kroll & Douglas Price, 1991). Camps vary in size according to the type of occupation (e.g. basecamp, task-specific camp), seasonality and mobility and tend to exceed several hundred square meters in extent (Binford, 1978, 1980, 1982; Gould & Yellen, 1987; Mitchell et al., 2006). The makeup of the household, on the other hand, is fairly uniform in that the hearth is identified as the centre of activity, with storage facilities and refuse piles in variable locations (Binford, 1978; Gould & Yellen, 1987; Kroll & Douglas Price, 1991). While it is plausible that a similar pattern at Far'ah II may be used to imply that household activities took place round the hearth, we acknowledge that using ethnographically identified patterns of household use to interpret archaeological data is complex. Aside from the well-documented limitations innate in such analogues due to variability and distinctiveness of hunter-gatherer communities referenced (e.g. Bird & Bird, 1997; Johnson, 2014; Kelly, 2013; Lavi & Friesem, 2019), more specific agents such as occupation surface disturbance, repetitive use of the same location and the formations of palimpsests that effect the emerging patterns in archaeological sites must be considered (Mitchell et al., 2006; Sossa-Ríos et al., 2024). Fast burial of occupation surfaces, 3D recording of the finds during excavation and refitting of lithics all contribute to our ability to dissect palimpsests, map the scatter of finds and deduce patterns in camp sites (e.g. Karlin & Julien, 2019; Nadel et al., 2019) and activity areas within them (e.g. Alperson-Afil & Hovers, 2005; Henry, 2012; Speth et al., 2012). The most probably represents a camp site which results of our analyses at Far'ah II suggest that the location was repeatedly visited and that the exposed area of 70 m^2 represents only a segment of the site. The favourable ecological nature of the locality adjacent to a water source (seasonal and/or perennial) and availability of riverine and grassland vegetation made this an attractive spot for both fauna and hominins (Gilead & Grigson, 1984; Goder-Goldberger et al., 2020, 2023b). While presenting a similar array of activities, each of the occupations depicts a spatial shift in the occupation and hearth location, suggesting that on arrival to the site, the remains of the previous occupation were only minimally visible on the surface. Alternately, it may indicate that the newcomers chose to utilise a 'fresh' space for their activities, uncluttered by debris of their previous visits or by refuse left by other groups. Either scenario implies a seasonal or yearly cycle of visitation events to a favoured locality.

Concluding Remarks

Re-visiting the finds from the 1976–1978 excavation seasons at Far'ah II, we have demonstrated that the site was repeatedly visited and settled for short periods of time at ~ 49 ka. In this study, we have demonstrated how refitting and spatial analysis of finds have enabled us to untangle the living floor palimpsest into at least two repeated occupation events and several activity areas within each occupational level. During each of these occupational events, flint knapping and food processing occurred, activities which were similar in their repertoire and find composition. The results of this study demonstrate that well-documented old excavations can be re-studied resulting in new insights.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41982-025-00212-7.

Acknowledgements The article is dedicated to Isaac Gilead who passed away in April 2023. The project would not have materialised without his support and dedication, and the first drafts benefited greatly from his insight. The research was funded by The Fritz-Thyssen Foundation, a grant awarded to Gilead and Goder-Goldberger. L.S.-R is beneficiary of a Lady Davis Postdoctoral Fellowship at the Human-Environment Dynamics Laboratory at the Institute of Archaeology of the Hebrew University of Jerusalem (HUJI). Artefacts were drawn by P. Kaminsky and artefact photos by E. Ostrovski. We thank Kobi Vardi for sharing an excel sheet he formulated of all the data from the original excavation notebooks. We thank the three reviewers for their constructive comments.

Author Contribution M.G-G. and I.G. Designed the research and acquired the funding, M.G-G., L.K.H., L.S-R. E.P. analyzed the data and conducted the research, M.G-G., I.G., L.K.H., E.P and L.S-R. contributed to writing the manuscript. M.G-G., L.K.H., E.P, and L.S-R reviewed the final draft.

Funding Open access funding provided by Hebrew University of Jerusalem. The research was funded by The Fritz-Thyssen Foundation, a grant awarded to Gilead and Goder-Goldberger in 2017 for the project 'Out of Africa and the Middle to Upper Palaeolithic transition at the margins of the Levantine corridor: new perspectives from the sites of Far'ah II and Boker Tachtit'.

Data Availability No datasets were generated or analysed during the current study.

Declarations

Consent to Participate Not applicable.

Competing Interests The authors declare no competing interests.

Approval from Relatives of Deceased Author We have received approval from Dr. Yulia Ustinova, Prof. I. Gilead's wife, to have him as a co-author on the paper.

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