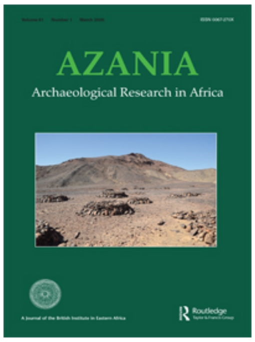

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New excavations at Nasera Rock (Tanzania): the Lemuta industry

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ABSTRACT

Nasera is a key site for understanding the Middle and Later Stone Age in northern Tanzania and East Africa, thanks to its nine-metre cultural sequence and 25 archaeological levels. Excavated previously by Louis Leakey (1932) and Michael Mehlman (1975–76), work resumed there in 2018. This paper presents the results of the excavation of Level 5, belonging to the Lemuta industry of the Later Stone Age, which is dated to 47.1 ± 4.5 kya. The faunal assemblage comprises species such as Alcelaphini, Antilopini and *Equus quagga*, which supports the existence of dry and open grasslands. The lithic assemblage consists of chert knapped using single-platform and prismatic blade/bladelet methods. Retouched blanks are scarce, but microliths (crescents and trapezes) predominate. These techno-typological characteristics and the site's chronology allow the assemblage to be related to the Naisiusu industry of Olduvai.

RÉSUMÉ

Nasera est un site clé pour comprendre le Middle et le Later Stone Age dans le nord de la Tanzanie et en Afrique de l'Est, grâce à sa séquence culturelle de neuf mètres et à ses 25 niveaux archéologiques. Précédemment fouillé par Louis Leakey (1932) et Michael Mehlman (1975–76), le travail a été repris depuis 2018. Cet article, présente les résultats des fouilles du niveau 5, appartenant à l'industrie Lemuta du Later Stone Age, daté de 47.1 ± 4.5 kya. L'assemblage faunique comprend des espèces telles qu'Alcelaphini, Antilopini et *Equus quagga*, ce qui confirme

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l'existence de prairies sèches et ouvertes. L'ensemble lithique est réalisé en chert. Les méthodes utilisées sont de type 'single platform' (à un plan de frappe) et prismatique pour obtenir des lames et des lamelles. Les supports retouchés sont rares, mais les microlithes (croissants et trapèzes) prédominent. Ces caractéristiques techno-typologiques et la chronologie nous permettent de relier cet ensemble à l'industrie Naisiusiu d'Olduvai.

Introduction

The beginning of the Later Stone Age (LSA) and its transition from the Middle Stone Age (MSA) are among the most complex topics in African archaeology. Far from a replacement model such as that which seems to exist in Europe, in Africa it appears that the distinctive features of the LSA date back several tens of thousands of years within the MSA and are more of a cumulative than an abrupt process (McBrearty and Brooks 2000; Scerri and Will 2023), at least in East Africa, blurring a clear starting point. The distinctive features that define the LSA can be summarised in the following cultural manifestations for East Africa: the systematic use of blade/bladelet methods and backed pieces, as well as personal adornment or the employment of a microlithic technology (Barham and Mitchell 2008; Tryon 2019). Furthermore, based on the archaeological record, the process appears to have been asynchronous and mosaic in nature, occurring over a time span of between 60 and 40 kya depending on the region (Tryon 2019).

We do not have a clear understanding of the nature of the changes brought about by the LSA. Several hypotheses have been proposed. The most popular, with different nuances, involve an increase in population and/or a lack of resources that triggered contact between groups (Ambrose 1998; McBrearty 2007; Powell *et al.* 2009) or caused pressure on their territorial arrangements (Mackay *et al.* 2014; Tryon and Faith 2016; Tryon 2019). It has also been proposed that a cognitive shift brought about the change (Klein 2019) or that it was simply due to internal evolution within populations (Villa *et al.* 2012).

Archaeological sequences are now beginning to emerge in East Africa that allow us to glimpse the processes involved in the formation of the LSA. This is why northern Tanzania, together with southern Kenya, plays an important role in this debate thanks to sequences such as Panga ya Saidi, Lukenya Hill (GvJm16 and GvJm22) and Enkapune ya Muto in Kenya and Magubike, Kisese II, Mumba and Nasera in Tanzania. These sites allow us to see this transition between the MSA and the LSA, as well as the early LSA in the region (Inskeep 1962; Mehlman 1989; Ambrose 1998; Kusimba 2001; Willoughby 2012; Tryon *et al.* 2015, 2018; Shipton *et al.* 2018, 2021).

This paper presents the results of work in the Lemuta industry-associated Level 5 at the site of Nasera, Tanzania, taken from the new excavations that we are currently conducting at the site.

Nasera Rockshelter

Nasera is situated on the northern face of a large quartz-feldspathic gneiss inselberg in the Angata Kiti region of northern Tanzania, approximately 35 km north of Olduvai

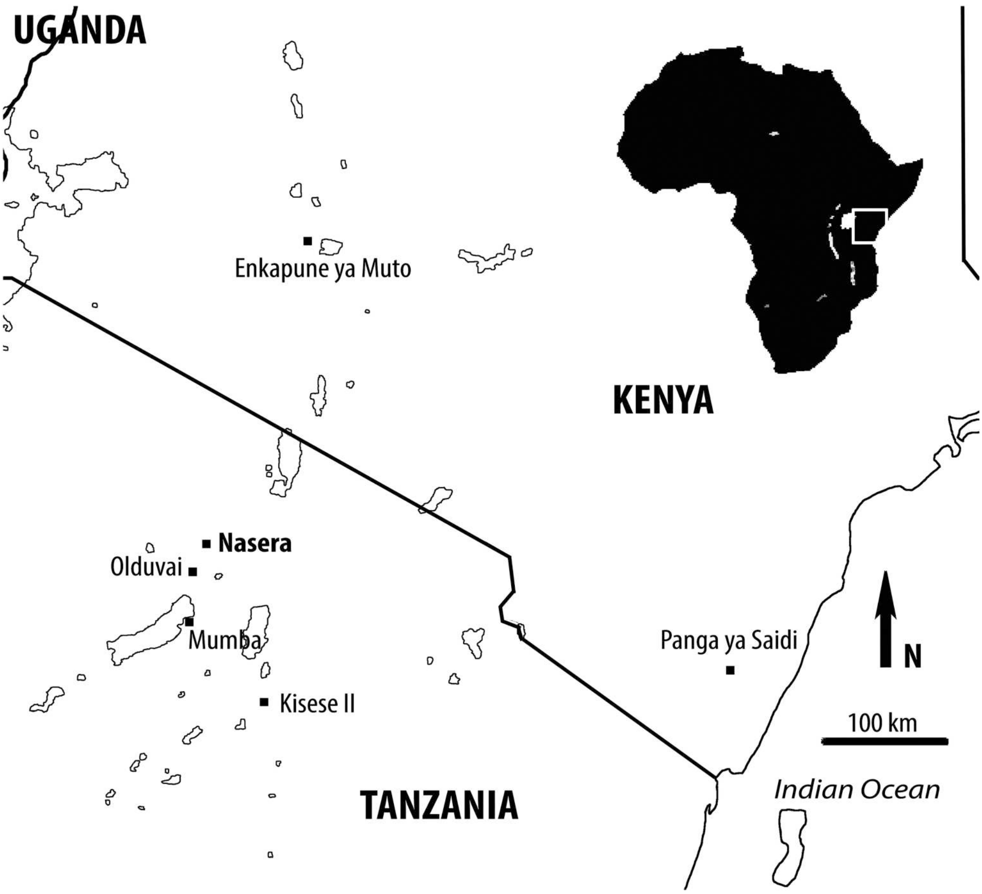

Figure 1. Map of East Africa showing the sites cited in the text.

Gorge (Figures 1 and 2a). The site was discovered and excavated by Louis Leakey in 1932 (Leakey 1936) and later by Mike Mehlman between 1975 and 1976 (Mehlman 1977, 1989). We have been working there ourselves since 2018, when samples were taken for dating and sedimentological analysis (Martín-Perea *et al.* 2020). In 2023, we began excavating the sequence, starting with Level 5.

Leakey focused his excavations at Nasera on the west side of the site, where he dug ten trenches to a maximum depth of about 5 m, uncovering Holocene, Later Stone Age and Middle Stone Age levels (Leakey 1936). Mehlman, meanwhile, focused his excavation on the site's eastern sector, where he excavated an area of 75 m^2 and also found levels from the same periods (Figure 2b). However, the two cultural sequences differ and are challenging to correlate (Mehlman 1989).

The stratigraphic sequence of Nasera currently employed and used here is that defined by Mehlman (1977, 1989). The following industries have been identified in the 25 levels of the site's 9 metres of stratigraphy: the Angata Kiti in Level 3a belonging to the Pastoral Neolithic; the Olmoti (LSA) in Level 3; the Sisale (LSA) in Level 3b; the Lemuta (LSA) in Levels 4 and 5; the Nasera (LSA) in Levels 6 and 7; the Mumba (LSA) in Levels 8/9–11 marking the beginning of the LSA; and the Kisele (MSA) in Levels 12–25.

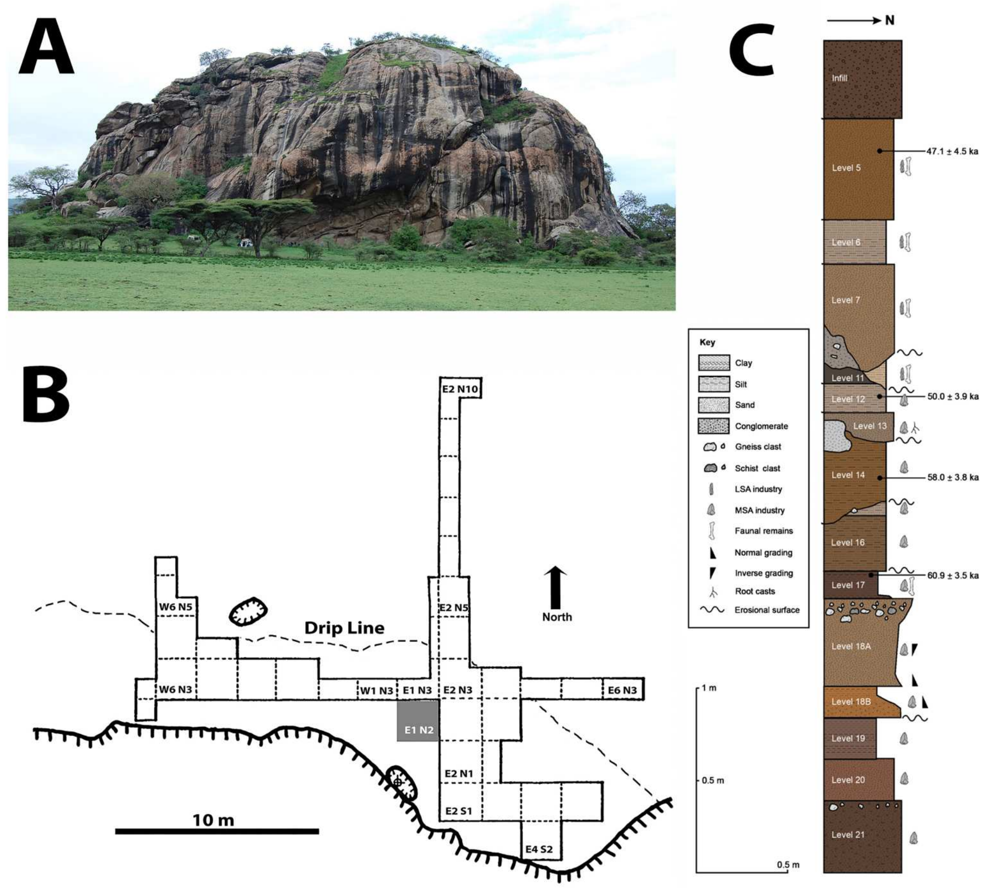

Figure 2. Nasera: a) Nasera soit; b) plan of Nasera rockshelter (modified from Mehlman 1989) with our fieldwork in 2023 in grey; c) Nasera's profile (after Martín-Perea 2020).

Our excavation in Level 5 was carried out in 2023 and was spatially very small (just over two square metres in area) in the corner of the CE-EWT profiles of Mehlman's excavation. The area corresponds to his grid E1N2 (Figure 2b). The first thing we were able to verify was that the first level *in situ* of Mehlman's stratigraphy was Level 5 and that the rest had been altered and removed both by bioturbation (roots) and by human factors, since the shelter has been inhabited until very recently. We also noted the existence of cracks affecting the entire profile, as well as bioturbation, possibly caused by roots that significantly alter the geometry of Level 5 (Figure 3). These bioturbations were clearly isolated during the excavation. Like Mehlman, we also identified three sub-levels in Level 5, which we have named from top to bottom 5a, 5b and 5c (Figure 4).

Level 5

In general, Level 5 is a 60-cm-thick unit. However, in the excavated area, its thickness was almost 50 cm (Figures 2c, 3 and 4). This unit is a light yellowish brown (10YR

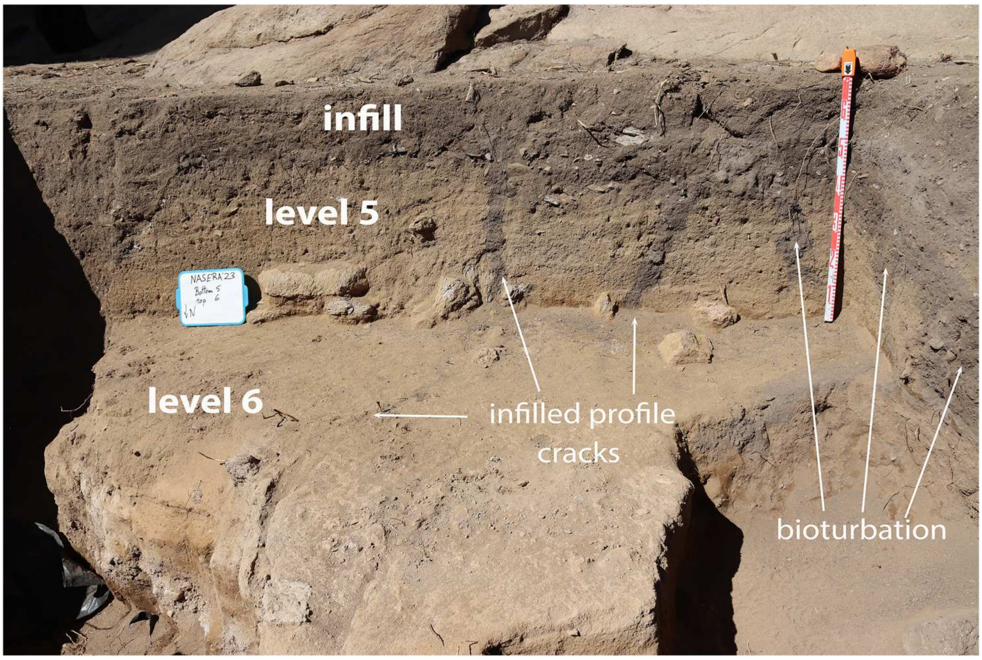

Figure 3. Nasera: excavation area of Level 5.

6/4), heterogeneous, very slightly gravelly, slightly muddy, coarse to fine tuffaceous sand. It contains a large and a medium-sized gneissic boulder, along with faunal remains and the Lemuta LSA industry. The deposit is likely the result of runoff and layer-washing processes, with a few gneissic boulders embedded due to the decomposition and colluvial weathering of the local gneiss bedrock. Previous studies placed this level between 21–22 kya (Mehlman, 1989) or >46–>50 ka BP (Ranhorn and Tryon 2018). New OSL techniques now date Level 5 to 47.1 ± 4.5 ka (Martín-Perea *et al.* 2020).

From a cultural perspective, Mehlman referred to the industry from Level 5 as Lemuta. In his study, the most used raw materials were quartz and, to a lesser extent, chert and obsidian. Techno-typologically, the industry is characterised by a high frequency of bipolar and single platform (unidirectional) methods. Among the retouched pieces, there is a balance between small scrapers (endscrapers) and backed pieces. Backed pieces are not very standardised, although pieces such as crescents and trapezoids are present (Mehlman 1989). This industry has been linked to the Naisiusiu type site industry in Olduvai Gorge (Leakey *et al.* 1974; Mehlman 1989; Ranhorn and Tryon 2018).

The faunal remains of these levels were originally interpreted as indicating an open savanna palaeoenvironment similar to that of today (Mehlman 1989). Based on radiocarbon dates provided by Mehlman (23–30,000 BP), this assemblage was initially assigned to the Last Glacial Maximum (LGM). Later, Tryon and Faith (2016) proposed a more arid and open environment based on the presence of oryx and *Equus grevyi*, taxa typically associated with dry open habitats. However, new dating now places this assemblage in the first half of Marine Isotope Stage (MIS) 3 rather than in the LGM.

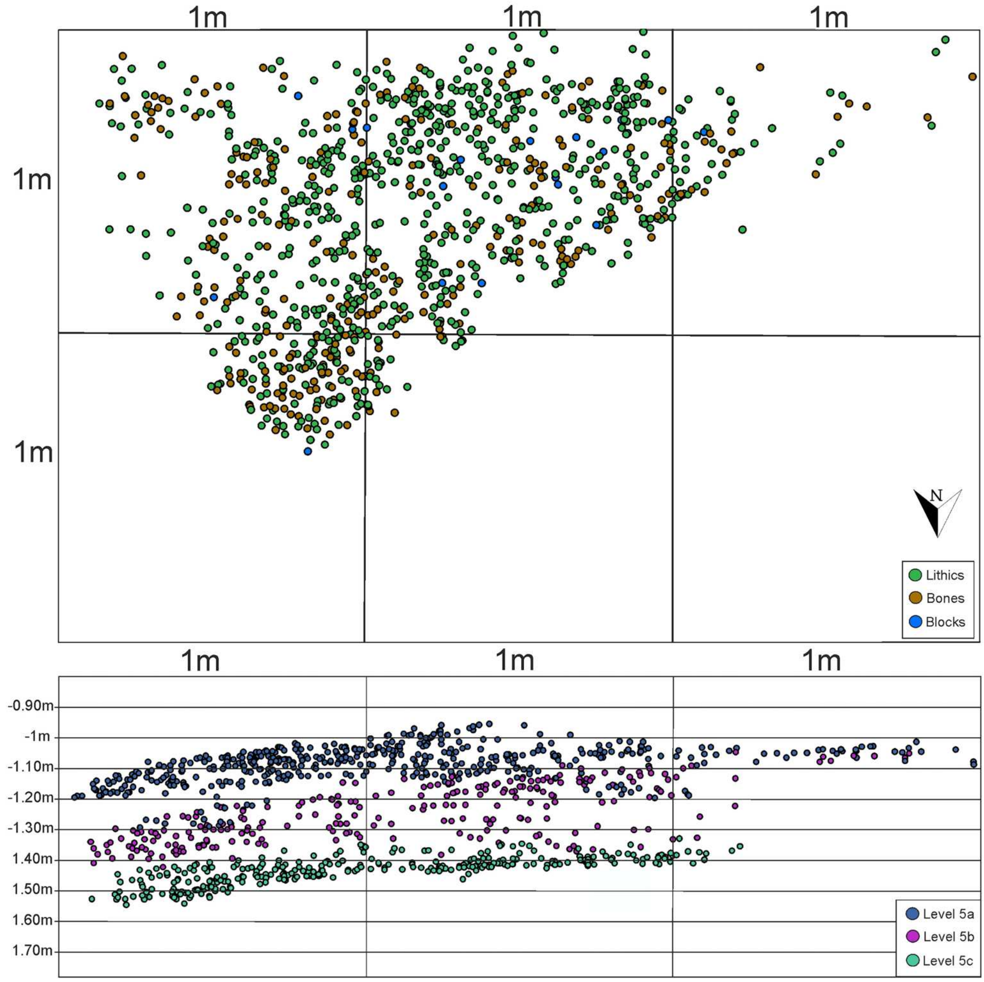

Figure 4. Nasera: distribution of archaeological materials, ground plan and profile.

Materials and methods

Materials

As we have already mentioned, the materials analysed in this paper come from the excavation we carried out in 2023 at the site. The excavated area was almost 3 m² in area and corresponds to part of grid E1N2 of Mehlman's grid. It was affected by a small collapse in the northeast corner of the grid and a large burrow in the northwest corner that removed Level 5 there (Figures 2b and 3). The excavation was carried out using sticks and brushes in layers of approximately 5 cm, following the geological levels. Previously bioturbated areas were isolated and excavated independently. The bioturbated material has not been studied. All sediment was dry-sieved using two sieves measuring 10.0 and 3.0 mm. For his part, Mehlman (1989: 11) used an intermediate screen of 5.0 mm width. Unlike Mehlman, we decided to analyse each sublevel independently (Figure 4).

Methods

Faunal analysis

The faunal remains were classified according to taxon, size category, anatomical element, side and portion whenever possible. To analyse the representation of anatomical elements, carcasses were divided into anatomical areas: cranial (skull, mandible and teeth), axial (vertebra, ribs, pelvis bone and scapula), and appendicular (limb bones). Four indices were used to estimate taxonomic and anatomical abundance: the number of identified specimens (NISP), the minimum number of elements (MNE), the minimum number of individuals (MNI) and the standardised minimum number of animal units (%MAU) (Binford 1984; Grayson 1984; Lyman 1994). To estimate MNE, the side, landmarks and age of each identifiable specimen were considered. The size of the specimens was established according to the categories described by Bunn (1982): size 5 (over 850 kg); size 4 (400–850 kg); size 3 (150–400 kg); size 2 (20–150 kg); size 1 (5–20 kg) (Assefa 2006).

Spearman's rank order was used to test the correlation between %MAU and bone mineral density (Lam *et al.* 1999). We assessed the visibility of the cortical bone surfaces based on how much surface could be studied as follows: 0 = none, 1 = one-third, 2 = two-thirds and 3 = whole surface.

We followed the method devised by Villa and Mahieu (1991) to establish the degree of fragmentation and the agents responsible for bone breakage. Bone cortical surfaces were examined with 10–20x hand lenses under a strong oblique light source (Blumenschine 1995). The type, delineation, location and positions of cut marks were described to identify butchering activities (Binford 1981; Domínguez-Rodrigo *et al.* 2009). We followed the criteria of Téllez *et al.* (2022) to describe the extent of burning damage. Percussion marks were made following the criteria of Blumenschine (1995), Blumenschine and Selvaggio (1988) and Pickering and Egeland (2006). Post-depositional modifications were identified as concretions and weathering (Behrensmeyer 1978).

Lithic analysis

Two factors were considered in the study of the lithic industry from Level 5: alterations and techno-typological composition. In the first case, we focused only on two alterations that we consider most relevant for interpreting the formation of the archaeological level: pseudo-retouching (Trigham *et al.* 1974; Stapert 1976; Courtin and Villa 1982) and rounding (Shackley 1978; Bustos-Pérez *et al.* 2019). For both, a distinction has been made between low, medium and heavy.

The study of the lithic industry follows the concept of the operational chain or *chaîne opératoire* (Lemonnier 1983; Inizan *et al.* 1995), which analyses the lithic collection through the stages of the production process, from the acquisition of raw materials to abandonment. Here, we pay special attention to raw materials, methods of knapping and retouched pieces.

The knapping methods identified in this analysis are common for this period and have been extensively analysed in the literature. The methods discussed here are Levallois/discoid (Boëda 1993, 1994; Terradas 2003); bipolar (de la Peña 2015a), single platform (Clark and Kleindienst 2001), prismatic and laminar (Inizan *et al.* 1995; Maíllo-Fernández 2023). In relation to typology, several typological classifications exist for East Africa, something that hinders a coherent, basic comparison (Merrick 1975; Mehlman 1989;

Clark and Kleindienst 2001; Shea 2020). For this reason, we have grouped the pieces into basic categories (scrapers, burins, points, etc.). For microlithic blanks, we use the classification proposed by Mehlman (1989), which allows for a suitable comparison of this type of tool with other regional sites.

Results

Fauna

A total of 326 faunal remains were recovered during the excavation of Level 5 at Nasera, distributed across the sub-levels as follows: 165 in Level 5a, 71 in Level 5b and 90 in Level 5c (Table 1). All identified taxa and individuals, grouped by weight category, are listed in Table 2. The most common taxa are Alcelaphini and *Equus* sp., while by weight size categories the most common remains belong to sizes 2 and 1 (Supplementary Online Material 1). The only measurable equid tooth recovered from this level was identified as an M3 of *Equus quagga* (DMD: 21.75 mm; DVL: 19.59 mm; P: 12.19 mm).

The number of remains at the taxonomic level is limited and does not allow for the construction of a meaningful anatomical profile (Supplementary Online Material 2). The representation of anatomical parts across the three levels was compared with bone mineral density values, revealing a significant positive correlation between anatomical representation and mineral density ($rs = 0.226$; $p = 0.023$) that suggests the operation of differential preservation processes.

Across the three levels, almost all the long bones had less than a third of their total circumference and a quarter of their total length (Supplementary Online Material 3). Breakage patterns are also very similar, with the most common combination of fracture types being curved, oblique and smooth and longitudinal, oblique and smooth fractures (Supplementary Online Material 3).

Skeletal elements from all anatomical parts are represented (Supplementary Online Material 1). Specimens from the axial, cranial and postcranial skeletons were recovered.

Table 1. Nasera: number of remains by taxa and weight size categories in each level.

Taxon	Size	Level 5a	Level 5b	Level 5c
Alcelaphini	3	2		
Antilopini	1		1	1
	2			1
Bovinae	1	8	4	8
	2	11	4	7
	3	5	1	6
	4			2
Equidae	4	5	3	5
Felidae	1		1	
	2			1
Rodentia		1		
Weight size class	1	22	9	11
	2	34	17	13
	3	15	4	12
	4	17	8	8
	5	5		
Indeterminate		40	19	15
Total		165	71	90

Table 2. Nasera Level 5: number of elements by anatomical identification, taxon and weight size category at each level.

	Level 5a												
NISP	Alcelaphini	Bovinae			Equidae	Weight size							
Weight category	3	1	2	3	4	1	2	3	4	5	Indet.	Rodentia	**Total 5a**
Skull													
Mandible							1						**1**
Isolated teeth	2				4							1	**5**
Vertebra			1			2	2	2	2				**4**
Scapula													
Coxa							1						**1**
Rib						4	1	1	1				**7**
Humerus		2		2		1		1					**6**
Radius			1			1							**2**
Radius/Ulna													
Ulna			2				1						**1**
Femur		1											**1**
Tibia		1	3		1								**5**
Fibula													
Metapodial		2	1	2		1							**5**
Carpal		1		1									**1**
Astragalus		1	1										**1**
Articular			1				1						**1**
Phalange			2										**1**
Long bone						12	25	8	14	5			**58**
Flat bone						1	2	3					**5**
Indeterminate											40		**40**
Total	**2**	**8**	**11**	**5**	**5**	**22**	**34**	**15**	**17**	**5**	**40**	**1**	**165**

Table 2. Nasera Level 5: number of elements by anatomical identification, taxon and weight size category at each level.

							Level 5b					
NISP	Antilopini	Bovinae			Equidae	Felidae	Weight size					
Weight category	1	1	2	3	4	1	1	2	3	4	Indet.	**Total 5b**
Skull									1			**1**
Mandible												
Isolated teeth			1		3							**4**
Vertebra								1				**1**
Scapula												
Coxa												
Rib			1									**1**
Humerus		2										**2**
Radius	1						1					**2**
Radius/Ulna												
Ulna												
Femur		1										**1**
Tibia		1	1	1				1				**4**
Fibula						1						**1**
Metapodial												
Carpal												
Astragalus												
Articular			1									**1**
Phalange												
Long bone							7	10	3	6		**26**
Flat bone							1	5		2		**8**
Indeterminate											19	**19**
Total	**1**	**4**	**4**	**1**	**3**	**1**	**9**	**17**	**4**	**8**	**15**	**71**

							Level 5c							
NISP	Antilopini		Bovinae				Equidae	Felidae	Weight size					
Weight category	1	2	1	2	3	4	4	2	1	2	3	4	Indet.	**Total 5c**
Skull														
Mandible														
Isolated teeth	1	1					2							**4**
Vertebra			1		2						1			**4**
Scapula			1											**1**
Coxa														
Rib											1			**1**
Humerus			1	1	1		1							**4**
Radius				1										**1**
Radius/Ulna				1										**1**

Ulna							1							**1**
Femur			3	1										**4**
Tibia				1	1									**2**
Fibula														
Metapodial				2	1	1								**5**
Carpal														
Astragalus			1											**1**
Articular														
Phalange			1		1			1						**3**
Long bone									10	13	10	8		**41**
Flat bone									1					**1**
Indeterminate													15	**15**
Total	**1**	**1**	**8**	**7**	**6**	**1**	**5**	**1**	**11**	**13**	**11**	**8**	**15**	**90**

Nonetheless, the assemblage is dominated by appendicular elements, particularly shaft fragments of long bones. Of the remains identified as isolated teeth, only three were complete enough to allow for approximate taxonomic identification; the rest consisted of fragmented incisors, molars and premolars that could only be identified by family. Long bones of both the forelimb and hindlimb are represented in roughly equal proportions across all three levels, with tibia and humerus fragments the most common, occurring across multiple body size categories. Articular bones and phalanges are also represented, but in very low proportion.

The preservation of bone surfaces is moderate. Only 52.5% of the remains in Level 5a, 56.4% of those in Level 5b and 61.1% of those in Level 5c retain two-thirds or more of their surface in good condition. The most common post-depositional taphonomic agents identifiable are manganese oxide concretions, which affect more than 70% of the material in all levels, and sediment cementations on fossil surfaces (Supplementary Online Material 4; Figure 5a–b). Additionally, although less frequent, fissures consistent with sediment hydration/dehydration cycles were observed. These affect 6.3% of the remains in Level 5a and 8.9% of those in Level 5c.

Evidence of anthropogenic activity was identified in the form of cut marks, percussion pits resulting from intentional human breakage and fire-related modifications. A total of two specimens bearing cut marks were recovered from Level 5a, with seven more from Level 5c (Table 3). All were located on elements of the appendicular skeleton, specifically, long bone fragments and one articular bone (Figure 5). Most cut marks correspond to slicing actions, with a single instance of a scraping mark. The characteristics of these modifications suggest butchery activities involving defleshing, disarticulation and periosteum removal before bone breakage. Two further elements show diagnostic percussion pits as a result of bone fracturing: a size 1 bovid femur and a size 3 bovid tibia, both recovered from Level 5c.

A total of 19 specimens have evidence of thermal alteration, including nine in Level 5a and five each in Levels 5b and 5c (Figure 5). Among the isolated (simple) burn stages, the most frequent was degree 4 (calcined grey), followed by degree 5 (calcined white/blue) and then degree 2 (rubified brown/red) (SI5). Among combined burn stages, the combination of degree 3 (charred/black) and degree 4 (calcined grey) was identified on one specimen each from Levels 5a and 5c. The combination of degree 2 (rubified brown/red) and degree 4 (calcined grey) was found on one specimen from Level 5a, while the combination of degree 3 (charred/black) and degree 5 (calcined white/blue) was observed on a specimen from Level 5c.

Three specimens in total, all from Level 5b, were recovered with carnivore tooth marks: two with pits and one with scores. These correspond to a size 1 bovid tibia fragment, a size 2 bovid long bone fragment and a size 3 bovid metatarsal fragment, respectively.

Lithic assemblages

Level 5c

The lithic assemblage from Level 5c consists of 198 pieces, nine of which have been retouched, representing 4.5% of the collection. The most used raw materials were quartz (52.5%), hyaline quartz (43.9%) and chert (3.1%) (Table 4).

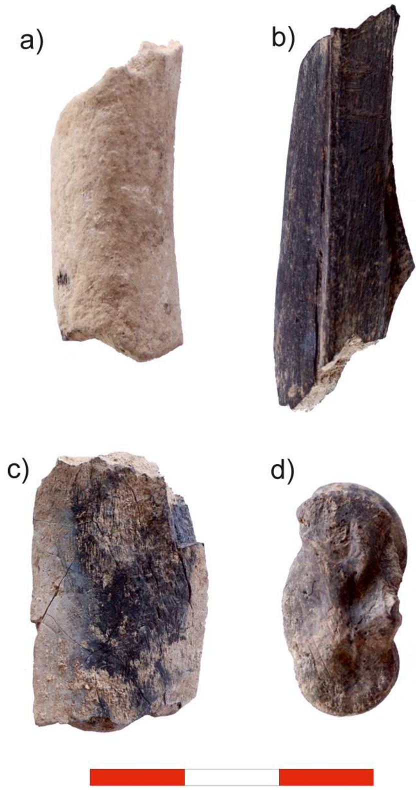

Figure 5. Examples of faunal remains from Nasera Level 5: a) long bone shaft of a bovid size 1 with sediment cementation which covered the entire surface; b) radius/ulna of a bovid of size 2 with manganese oxides over all the surface and scraping marks; c) long bone fragment of a size 3 bovid with cremation damage by fire action; d) astragalus of a size 1 bovid with slice marks.

Table 3. Nasera: skeletal elements in Level 5 with cut marks by taxa, element, type of mark, location on the bone, and butchering activity related to it.

Level	Taxon	Weight size class	Element	Type of mark	Location	Butchering activity
5a	Bovinae	3	Humerus	Slice	Epycondylar crest	Desfleshing
5a	Equidae	4	Tibia	Slice	Popliteum line	Desfleshing
5c	Bovinae	2	Radius/Ulna	Scrape	Posterior face	Periosteum
5c	Bovinae	1	Femur	Slice	Shaft	Desfleshing
5c	Bovinae	1	Astragalus	Slice	Lateral face	Disarticulation
5c	Indeterminate	4	long	Slice	Cortical surface	Desfleshing
5c	Bovinae	3	Humerus	Slice	Deltoid tuberosity	Desfleshing
5c	Indeterminate	2	long	Slice	Cortical surface	Desfleshing
5c	Indeterminate	4	long	Slice	Cortical surface	Desfleshing

The collection has a high percentage of fractured pieces (71.7%), primarily composed of quartz and hyaline quartz. In terms of alterations, pseudo-retouching is present in 43.9% of the blanks, with 70% of these instances being low and having little effect on the piece. Rounding affects only 13.6% of the collection, with almost all instances being low rounding, which is more prevalent in quartz and hyaline quartz (Supplementary Online Material 6). Although the sediment deposition at the level was lateral, it does not appear to have significantly affected the lithic industry, as the alterations associated with possible displacement, rounding and trampling are marginal.

Pieces related to a specific method account for 47.6% of the lithic collection. The most commonly used method is the single platform, followed by the bipolar and laminar methods (prismatic or carinated burin type) and finally, the discoid and centripetal methods (Table 5; Supplementary Online Material 7). In addition, flakes were obtained from opportunistic and polyhedral cores (Supplementary Online Material 8). No cores or pieces can be assigned to Levallois methods.

Level 5b

The collection from this sub-level comprises 253 pieces, of which 22 have been retouched (8.7%). Hyaline quartz is the most abundant raw material (41.1%), followed by quartz. Together, they account for more than 78% of the total number of blanks. Chert accounts for 19.3% and obsidian only 2% (Table 4).

The percentage of fractured pieces is 58.9%, with almost 75% corresponding to pieces made of quartz and hyaline quartz. In terms of alterations, 42.3% of the pieces exhibit pseudo-retouch, with 90% of these being composed of quartz and hyaline quartz. Rounding affects 16% of the pieces, all but one of which have low rounding and are also quartz and hyaline quartz (Supplementary Online Material 6).

Around half of the pieces have been assigned to a débitage method. Although the single platform method is the most common (17.2%), the bipolar and laminar methods feature at around 14% each. Radial methods (Levallois/discoid) are only present in 4% of the pieces (Table 5; Supplementary Online Material 7 and 8).

Level 5a

The lithic assemblage from Level 5a consists of a total of 346 pieces, of which 26 are retouched (7.5%). The most used raw materials are quartz (42.7%) and hyaline quartz (39.6%). Chert accounts for 12.1% and obsidian for 2.3%. Other raw materials are only marginally present (Table 4).

Sixty-three per cent of the pieces are fractured. Of these, 83.5% are in quartz or hyaline quartz. Pseudo-retouch affects 49.4% of the pieces, of which 83.6% takes a low form. Rounding affects 15.6% of the pieces, almost all of low rounding (Supplementary Online Material 6).

Slightly more than 47% of the débitage could be attributed to a knapping method (Table 5). The single platform method is the most common (21.7%), followed by the laminar method (10.4%). Both, as we will see below, are related to the production objective. The

Table 4. Nasera: raw material by levels. Percentages are shown in parentheses.

Raw material	Level 5a	Level 5b	Level 5c
Quartz	148 (42.7)	94 (37.2)	104 (52.5)
Hyaline quartz	137 (39.6)	104 (41.1)	87 (43.9)
Chert	42 (12.1)	49 (19.3)	6 (3.1)
Obsidian	8 (2.3)	5 (2)	
Sandstone	2 (0.6)		
Rhyolite	3 (0.9)		
Basalt	3 (0.9)		
Feldespate	1 (0.3)	1 (0.4)	1 (0.5)
Granite	2 (0.6)		
Total	**346**	**253**	**198**

Table 5. Nasera: percentage of débitage methods and main tool types in Level 5. * The Mehlman (1989) excavation industry reviewed by us (unpublished work). ** Crescents not included. *** Laminar included. The percentages are shown in brackets. The percentage of flaking methods is obtained from the total number of flaked blanks.

Level/item	Discoid/ Levallois	Single platform	Bipolar	Laminar	Backed**	Crescents/ trapezes	Points	Beads	N (Retouched/unretouched)	Reference
Nasera 5a	26 (8.2)	69 (21.7)	22 (6.9)	33 (10.4)	3 (11.5)	3 (11.5)	3 (11.5)		26/346	This study
Nasera 5b	9 (4)	38 (17.2)	32 (14.4)	31 (14)	4 (18)	2 (9)	1 (4.5)		22/253	This study
Nasera 5c	17 (9.5)	39 (20.2)	23 12.9	9 (5)	2 (22)	0	1 (11.1)		9/198	This study
Nasera 6/7	135 (20.2)	108 (16.2***)	319 (47.8)		1 (1.9)	1 (1.9)	52 (14.6)	yes	355/1023	Mehlman 1989
Nasera 8/9	11 (25.3)	8 (17.3)	15 (33)	9 (20)	8 (17.8)	-	3 (10.7)	-	28/148	Solano-Megías *et al.* 2021
Nasera 10	4 (9.4)	-	13 (66)	5 (23.8)	-	-	1 (14.2)	-	7/41	Solano-Megías *et al.* 2021
Nasera 11	3 (8.3)	-	22 (61.1)	11 (30.6)	-	-	1 (12.5)	-	8/65	Solano-Megías *et al.* 2021
Nasera 12*	8 (21)	6 (15.7)	4 (10.5)	1 (2,6)	2 (10)	-	-	-	20/38	Revised from Mehlman 1989
Nasera 13*	13 (25.4)	6 (11.7)	1 (1.9)	-	-	-	-	-	11/51	Revised from Mehlman 1989
Nasera 16*	12 (20.9)	2 (3,5)	3 (5.2)	1 (1.75)	-	-	-	-	8/57	Revised from Mehlman 1989

presence of the discoid and Levallois methods is noteworthy (8.2%), while the bipolar method is scarce and only accounts for 6.9% (Supplementary Online Material 7 and 8).

Technological analysis of the lithic assemblages

Due to the technological similarity of the three levels, we have decided to provide a joint description of the technological processes. The most used raw materials were quartz and hyaline quartz, followed by chert and obsidian (Table 4). The raw materials were sourced locally for quartz and hyaline quartz, which can be obtained in the immediate vicinity of Nasera, including on the inselberg itself. The chert mostly comes from Olduvai, 32 km south of Nasera. To a lesser extent, another type of reddish chert was also used, the origin of which has been suggested to be Lake Natron (Mehlman 1989), but this has not been confirmed. The obsidian analysed from Mehlman's excavations comes from Sonanchi in the Lake Naivasha basin in Kenya, 250 km north of the site (Mehlman 1989). We assume that the obsidian found in our excavation has the same origin.

From the presence of cortex in the pieces, we can infer that raw materials such as quartz and hyaline quartz were introduced into the site either in whole or almost whole nodules. The other two fine-grained raw materials were already knapped or in cores, such as chert, or in knapped blanks, such as obsidian (Supplementary Online Material 9).

With regard to the raw materials economy (*sensu* Pèrles 1991), quartz and hyaline quartz were generally knapped using the bipolar on an anvil method (Figure 6:13) with unidirectional or bidirectional exploitation, some of which is rotary (de la Peña 2015b). The blanks obtained were flakes and, to a lesser extent, laminar flakes (Figure 6:10). On the other hand, chert and, to a lesser extent, hyaline quartz were knapped using unidirectional (single platform) and prismatic laminar methods (Figure 6:1–2, 9). Obsidian was introduced already knapped at the site (Figure 7: 5, 15-16); flakes from re-sharpening/retouching indicate a resharpening of the obsidian pieces, very much in line with the treatment of pieces of distant or exotic origin (Kuhn 2020).

The single platform and prismatic methods, both unidirectional and bidirectional, are sometimes combined,and we consider them to be part of the same objective of débitage: the production of elongated pieces such as laminar flakes, blades and bladelets (Figure 6:1–2, 4–7, 9, 11, 14, 18–19, 22). The nodules used as cores in both methods have a morphology adapted to the type of débitage (Table 5; Supplementary Online Material 8). The most common start to the débitage process was from cortical flakes that open the débitage surface. However, some prismatic cores began their débitage using crests and the cores were reconditioned using neo-crests or core flanks to maintain their curvature (Figure 6:20). For the striking platforms of the cores, natural surfaces were used or large flakes were knapped to form core tablets (Figure 6:21).

The objective of the débitage was to produce elongated blanks, specifically blades/bladelets that were regular and rectilinear in their longitudinal profile. In both methods, especially in the unidirectional ones, laminar flakes are abundant, both in the blanks and in the last negatives of the core (Figure 6:3, 14, 18, 22). Both unidirectional and prismatic chert cores were intensively exploited distorting the original morphology of the core (Figure 6:15). Discoid and/or Levallois methods, generally in quartz, are very scarce in number (Figure 6:16). Similarly, we also found burin-type flake cores in hyaline quartz and obsidian, the latter exploited from the crest to begin the knapping (Figure 6:12, 17). The blanks

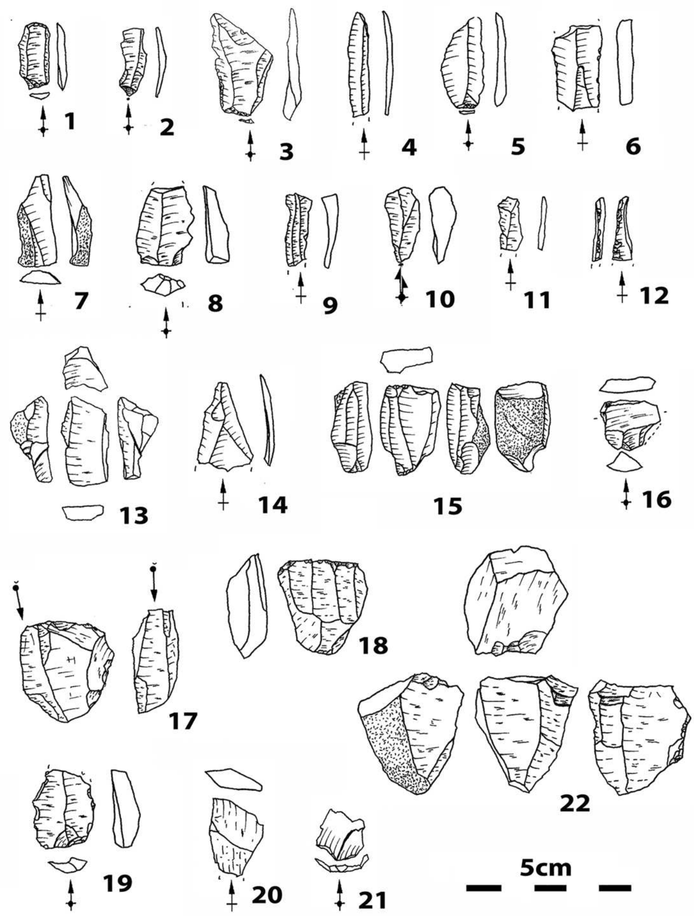

Figure 6. Nasera: stone artefacts from Levels 5a–c. Prismatic blades/bladelets: 1–2, 4–7, 9, 11; prismatic core: 15; unipolar blanks: 3, 8, 14, 19; unipolar cores: 18, 22; bipolar core: 13; bipolar bladelet: 10; burin core: 17; burin crest spall: 12; discoid flake: 16; prismatic core's rejuvenation flakes: 20–21. Raw materials: hyaline quartz: 1-3, 8-11, 13, 16-20; Chert: 4-7, 14-15, 21; obsidian: 12; quartz: 22. Level 5a: 1–3, 13 and 20; Level 5b: 4–7, 11–12, 14–15 and 21; Level 5c: 8–10, 16–19 and 22.

obtained are small, ranging from 19 to 24 mm in median length, although the number of whole pieces is low. The elongation index, the length divided by the width of the whole blanks, is also low, ranging from 1.29 to 1.47 mm (Supplementary Online Material 10).

Retouched lithic assemblage

Retouched pieces are relatively scarce, with only nine in Level 5c, 22 in Level 5b and 26 in Level 5a, representing 4.5%, 8.7%, and 7.5% of the total for each level, respectively. They can be divided into two large groups: sidescrapers, endscrapers and burin pieces and 'backed pieces *sensu lato*' (Table 6; Supplementary Online Material 11). The former includes endscrapers and burins (Figure 7:10–11), while the latter includes backed pieces, oblique truncations and geometric pieces such as crescents and trapezes

Table 6. Nasera: retouched pieces from Levels 5a-5c.

Tool	Level 5a	Level 5b	Level 5c
Burins	1	1	
Burins on truncature	2		
Endscrapers	2	1	
Sidescrapers	2	4	1
Denticulates	2	2	1
Microdenticulates	2		
Notches	2	2	
Pièces écaillés	1	1	1
Retouched flakes	3	1	3
Bifacial pieces		2	
Alternate retouched bladelets		1	
Points	2		1
Unifacial points	1	1	
Trapezes	2		
Crescents	1	2	
Backed points			1
Curved backed pieces		1	
Backed bladelets	1	2	
Backed bladelets (partial)	1		
Truncations		1	
Oblique truncations	1		1
Total	**26**	**22**	**9**

(Figure 7:4–9, 12, 14, 20). The latter are considered the most decisive tools for defining the Lemuta industry (Mehlman 1989). These pieces are more common in Levels 5a and 5b (Table 6). It should be noted that unifacial points are present in all levels (Figure 7:1–3) as, to a lesser extent, are sidescrapers, denticulates and retouched blades/flakes (Figure 7:13, 17–19, 21).

There is an evident economy of raw materials in their management, as backed microliths were made from fine-grained materials such as chert, hyaline quartz and obsidian (Figures 8:4–9, 14; Supplementary Online Material 11). On the other hand, obsidian also shows differential management in bifacial pieces that have undergone intense resharpening processes (Figure 7:15–16).

Discussion

The study of our Nasera Level 5 collection allows us to confirm some of the issues raised by Mehlman, clarify others and draw new conclusions regarding both the stone industry and the fauna.

Firstly, our work has indeed yielded significant material in the lower part of Level 5, contrary to Mehlman's (1989) statement that it contained almost no archaeological material. Post-depositional processes do not appear to have affected the original composition of the levels. The deposition of the level is lateral and rainwater runoff may have caused the rounding (Bustos-Pérez *et al.* 2019; Scancacello *et al.* 2025). For its part, the use of the rockshelter up to the present day may have caused pseudo-retouching both on the surface and buried in sandy sediment (Courtin and Villa 1982; McBrearty *et al.* 1998).

From a lithic industry perspective, the most used raw materials were quartz, hyaline quartz, and chert. To these we must add obsidian due to its qualitative role, as it comes from southern Kenya. In addition, we confirm the importance of geometric

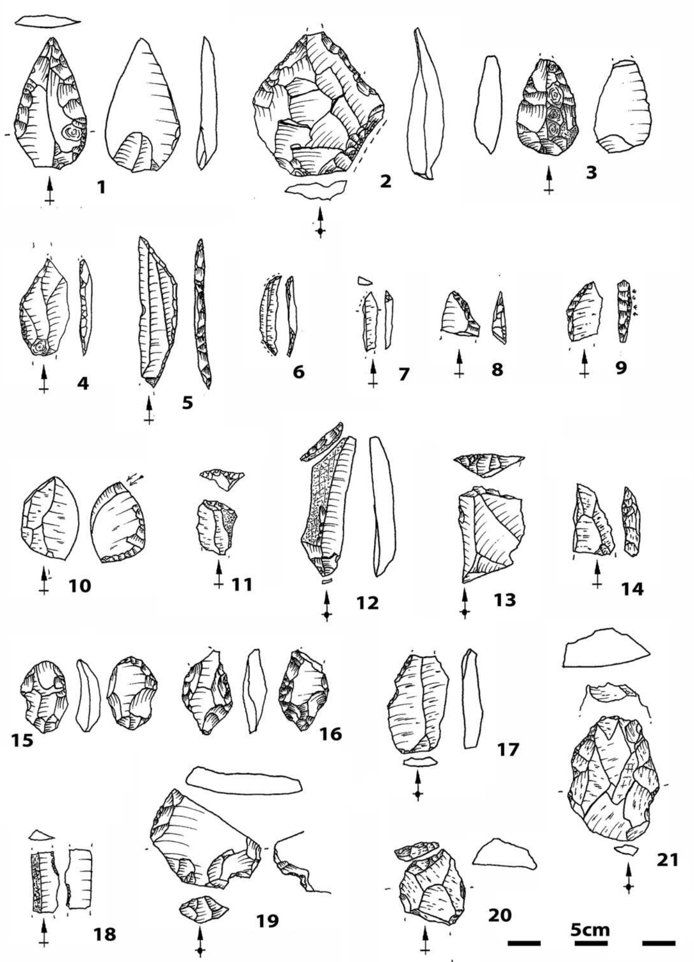

Figure 7. Nasera; retouched stone artefacts from Levels 5a–c. Unifacial points: 1–3; trapezes: 4–5; curve backed pieces: 6–7; crescents: 8–9; burin: 10; endscraper: 11; oblique truncation: 12, 20; denticulate: 13; backed point: 14; bifacial pieces: 15–16; retouched flaked/bladelets: 17–18; sidescraper: 19, 21. Raw material: hyaline quartz: 6–7, 9–11, 17, 21; chert: 1–4, 8, 12–13, 18–19; obsidian: 5, 15–16; quartz: 14, 20. Level 5a: 1–2, 4–5 and 10–13; Level 5b: 3, 6–9, 15–16 and 18; Level 5c: 14, 17 and 19–21.

pieces, especially crescents and trapezes, and the balance between endscrapers and burins. These characteristics are essential to the Lemuta industry and are found both in Mehlman's (1989) original work and our own.

With regard to the raw material economy practised (*sensu* Pèrles 1991), we note that fine-grained materials such as chert and some hyaline quartz, which have fewer diaclases, were used to produce elongated blanks (laminar flakes, blades and bladelets) using single platform and unidirectional and bidirectional prismatic methods. Bipolar and discoid methods, on the other hand, were carried out on quartz, a raw material that generally has diaclases. Lower quality hyaline quartz was also used for bipolar methods. We also identified an economy of débitage in the retouched blanks, as backed pieces are made from hyaline quartz, chert and obsidian.

Neither in our collection nor in Mehlman's excavations were any beads or decorated fragments of ostrich eggshell or other organic or mineral material recovered that could be interpreted as decorative or symbolic elements (Mehlman 1989).

Mehlman's (1989) faunal collection noted a broader range of taxa in the assemblage from the Lemuta 5/4 industry levels at Nasera. These data suggest the presence of an open savanna ecosystem, similar to that found in the region today. Species identified in those levels include Reduncini, *Damaliscus* sp., *Cephalophus* sp., *Equus grevyi* and *E. quagga*. In contrast, the present study did not yield such a high taxonomic diversity given that the number of taxa in Mehlman's excavation was 25, whereas in our study it was only six. The values of the diversity index for Mehlman's faunal collection support these assumptions (Lemuta 5/4: Simpson diversity index: 0.9; Shannon evenness index: 0.5 compared to Level 5: Simpson diversity index: 0.4; Shannon evenness index: 0.4). This discrepancy is likely attributable to the difference in excavation area: while Mehlman excavated approximately 28–30 m^2, our excavation covered no more than 3 m^2. Nonetheless, the taxa identified in this study are all included in the faunal list reported by Mehlman (1989), which allows us to confirm that at the time Level 5 the local environment could have been that of an open savanna ecosystem.

Importantly, the majority of remains recovered in the current assemblage consist of post-cranial elements, particularly fragments of long bones and limb elements. This contrasts with Mehlman's collection, as revised by our team, which includes almost exclusively dental remains. Consequently, our study provides the first taphonomic analysis of the Nasera site. The overall preservation of the assemblage can be considered moderate. Although some fragments of low-survivability elements, such as ribs, were recovered, the assemblage is dominated by high-survivability elements. This observation is supported by the statistically significant correlation between anatomical representation and bone mineral density, which suggests differential destruction of skeletal elements. The assemblage also shows a great degree of fragmentation and bone surface preservation is moderate. Post-depositional modifications, especially the formation of manganese oxides and sediment cementation, have obscured bone surfaces in many cases, limiting the extent of detailed taphonomic analysis. Despite these challenges, anthropogenic modifications have been identified. Cut marks are primarily associated with defleshing activities and, in some cases, disarticulation. Evidence of burning is primarily represented by calcined bones, with other thermal alterations, such as rubifaction, nearly absent. This pattern may partially be explained by the heavy presence of manganese oxide staining and sediment encrustation, which could mask subtler thermal modifications. However, the presence of bones in the early stages of calcination indicates direct exposure to fire, when bones still contained organic material (Téllez *et al.* 2020), which is typically associated with cleaning labour and more intense occupation of the site. Tryon and Faith (2016) suggest that, despite environmental variations (from more open and arid in the MSA/LSA to the Lemuta industry and then to a more humid environment in the Holocene), population density increased, contributing to a decline in residential mobility among foragers during that period. Anthropogenic modifications have been identified in the main weight categories represented in the assemblage, indicating that

LSA groups exploited most ungulates in the surrounding ecosystem, which is consistent with lower rates of mobility.

Our analysis of the fauna aligns with the description of the Lemuta industry context by Tryon and Faith (2016), which proposes that during the Pleistocene and the Last Glacial Maximum, dry open grasslands predominated. With the new dates, this climate with a tendency towards aridity must be located in a range of 50-40 kya, as seems to be indicated by the work of Blome and colleagues (2012) and Beverly and colleagues (2017) on the drying up of Lakes Nyanza and Naivasha, which could have favoured the migratory routes of herbivores (Beverly *et al.* 2017).

From a cultural perspective, the Nasera Level 5 collection has been linked to Naisiusiu in Olduvai. The lithic industry, although more laminar in Naisiusiu due to the predominant use there of chert in lithic production, does show significant similarities in the production of blades and bladelets and in the presence of crescents among the retouched blanks. Furthermore, new dating places the archaeological levels of Naisiusiu in a range between 65.3 and 45.3 kya (Martín-Perea *et al.* 2025), comparable to the dating of Level 5 at Nasera of 47.1 kya (Martín-Perea *et al.* 2020). These data reinforce the similarities between the two collections and the designation of the Lemuta industry proposed by Mehlman (1989).

At the regional level, the Later Stone Age, as has already been pointed out on several occasions, appears to be a mosaic and gradual phenomenon not only in East Africa (Tryon 2019; McBrearty and Brooks 2000) but also in other regions such as the Horn of Africa (Leplongeon *et al.* 2020) and the south of the continent (Villa *et al.* 2012). Thus, in our study region, we find at Panga ya Saidi near the coast of Kenya that the process of LSA formation can be traced back to 60 ka BP. We observe there that Levels 11–12, dated to 54-48 kya, exhibit technology characterised by radial/Levallois methods, backed pieces, around 10% bipolar flaking and the absence of blade/bladelet cores (Shipton *et al.* 2021). On the other hand, at Enkapune ya Muto in the Rift Valley, the Nasampolai industry, dated between 50 and 40 kya, is composed almost entirely of large backed pieces with a small proportion of burins, *pièces ecaillées* and scrapers (Ambrose 2002). Meanwhile, the Sakutiek industry from the same site, dated to between 35 and 40 kya, is dominated by thumbnail endscrapers and *pièces ecaillées*, but has a low percentage of backed pieces and maintains a Levallois technology (Ambrose 1998: 383). For its part, the beginning of the LSA at Mumba V in Tanzania has been placed around 60 kya with a higher proportion of bipolar methods (Díez-Martín *et al.* 2009; Gliganic *et al.* 2012). To this varied scenario, we must add the survival of the MSA in Lake Nyanza until 36 kya (Blegen *et al.* 2017).

We can also observe this kind of mosaic formation at Nasera, which is at least partly inconsistent with linear models based on cumulative processes. Thus, the break between the MSA and the LSA a is verified to be in Levels 12 (MSA) and 11 (LSA). From Level 11 onwards, dated to less than 50 kya (Martín-Perea *et al.* 2020), we find 30% laminar elements and a decline in discoid/Levallois technology. However, these elements fluctuate in Levels 8/9–11 during the Mumba industry and Levels 6/7 in the Nasera industry (Mehlman 1989; Solano-Megías *et al.* 2021). It is in Levels 5a–5c that the blanks most related to the MSA decrease in presence (Table 5).

On the other hand, bipolar methods, one of the markers of the LSA in the region (Díez-Martín *et al.* 2009; Shipton *et al.* 2018, 2021), are widespread in the early stages of the LSA (Levels 11–8/9), but become less frequent as the LSA progresses. Meanwhile, single-platform and laminar methods, which are not significant during the MSA, account for one-third of lithic production during the LSA (Table 5). Discoid/Levallois methods continue to be present throughout the sequence of Levels 10–5, corresponding to the LSA, in percentages of less than 10%, except in Level 8/9, where the presence of these types of methods is similar to that in the MSA (Table 5; Mehlman 1989; Solano-Megías *et al.* 2021). This techno-typological variability shows that there is no linear implementation of the LSA and that this variability may be due to different factors such as the use of the site, the intensity or recurrence of use, different groups, technological traditions etc. We repeat that this variability is not unique to Nasera but can also be traced in other sequences such as Enkapune ya Muto, Panga ya Saidi or Kisese II (Ambrose 1998; Shipton *et al.* 2018; Tryon *et al.* 2018).

Another question that qualifies Mehlman's (1989) conclusions is the time span of LSA formation in Nasera. While Mehlman placed Level 5 at the Last Glacial Maximum around 21 kya, current dating of the site compresses this LSA formation range to about three millennia, since Level 5, which is clearly LSA, is dated to 47.1 ± 4.5 kya and Level 11, the last of the MSA, is dated to 50 ± 3.9 kya (Martín-Perea *et al.* 2020). The dates from Nasera, although more recent, are consistent with the beginnings of the LSA at other regional sites, such as 67 kya at Panga ya Saidi or 60 kya at Mumba V, and more recently around 50–40 kya at Enkapune ya Muto or Kisese II (Ambrose 1998; Gliganic *et al.* 2012; Shipton *et al.* 2018; Tryon *et al.* 2018).

Conclusions

The new excavations of Level 5 at Nasera confirm the vital role that the site plays in understanding the LSA in East Africa. Despite the limited excavation area, they have allowed us to discover three archaeological sub-levels with fauna and lithic industries dating back to around 47.1 kya. Analysis of the fauna allows us to conclude that the identified mammal species (Alcelaphini, Antilopini, and *E. quagga*) support previous interpretations of predominantly dry and open grassland (Mehlman 1989; Tryon and Faith 2016) and provide the first taphonomic analysis of the site's fauna. Thanks to this, we can observe anthropic activity on the bones, including defleshing, disarticulation and thermoalteration by the use of fire.

From a techno-typological point of view, Level 5 at Nasera corresponds to a clearly defined LSA assemblage characterised by laminar/single platform débitage and the prominent role of geometric blanks (crescents and trapezoids) among the retouched pieces. Finer-grained raw materials such as chert, obsidian and hyaline quartz are oriented towards this type of piece.

The beginning of the LSA at Nasera is located in Level 11, characterised by a high percentage of bipolar débitage and a laminar industry, but with a discreet use of backed pieces (Mehlman 1989; Solano-Megías *et al.* 2021). It is fully formed three millennia later with the Lemuta industry of Level 5. A certain degree of variability can be observed throughout the site's levels in the techno-typological compositions of the beginning of the LSA. This variability can also be observed at the regional level, both in the Tanzanian sequences of Mumba and Kisese II (Mehlman 1989; Díez-Martín *et al.* 2009), as well as in the most significant Kenyan sequences of the LSA, such as at Enkapune ya Muto and

Panga ya Saidi (Ambrose 1998; Shipton *et al.* 2018). We can therefore confirm that this was a mosaic, cumulative process with different chronologies both intra-site and from a regional point of view (McBrearty and Brooks 2000; Tryon 2019). It would thus be appropriate to speak of several transitions with specific cultural expressions, rather than of one single MSA/LSA transition alone (Leplongeon *et al.* 2019). Finally, we can confirm that the Level 5 assemblage, which Mehlman (1989) referred to as the Lemuta industry, is related both chronologically and techno-typologically to Naisiusiu in Olduvai, confirming the settlement of a former LSA in the area between 45 and 50 kya (Martín-Perea *et al.* 2025) based on the use of both a laminar technology and geometric microlithic pieces.

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