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Hunter-gatherers of the high-altitude Afromontane forest – the Holocene occupation of Mount Dendi, Ethiopia

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ABSTRACT

Dendi Lake Rockshelter is situated about 100 km west of Addis Ababa on the west-central part of the Ethiopian Plateau in the Ginchi woreda of Ethiopia's Oromiya regional state. In October 2012, a team from the University of Cologne excavated a test-trench that revealed four archaeological complexes that could clearly be distinguished on a typological basis as well as by radiocarbon dates. This article focuses on the lithic artefacts recovered from the excavation and specifically the microliths that are one of the main characteristics of the Later Stone Age. Their high variability in this assemblage is a common feature of contemporaneous sites in the Horn of Africa. The rockshelter is situated in a high-altitude Afromontane forest and was most probably used for short-term stays by groups of hunters.

RÉSUMÉ

Le refuge de Dendi Lake Rock Shelter est situé à environ 100 km à l'ouest d'Addis Abeba, sur le plateau éthiopien du centre-ouest, dans le woreda de Ginchi de l'État régional d'Oromiya, en Éthiopie. En octobre 2012, une équipe de l'Université de Cologne a réalisé un sondage qui a révélé quatre complexes archéologiques clairement distingués par les modes typologiques ainsi que par les datations radiocarbone. L'article portera principalement sur l'industrie lithique, notamment les microlithes qui sont l'une des principales caractéristiques du Later Stone Age. Leur grande variabilité dans cet assemblage est une caractéristique commune aux sites contemporains de la Corne de l'Afrique. L'abri est situé dans une forêt afromontane de haute altitude et était très probablement utilisé par des groupes de chasseurs pour des séjours de courte durée.

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Introduction

Mount Dendi (3270 m a.s.l.) is located on the west-central portion of the Ethiopian Plateau, approximately 100 km west of Addis Ababa in the Ginchi woreda of the Oromiya regional state of Ethiopia (Figure 1). The volcano is part of the upper volcanic

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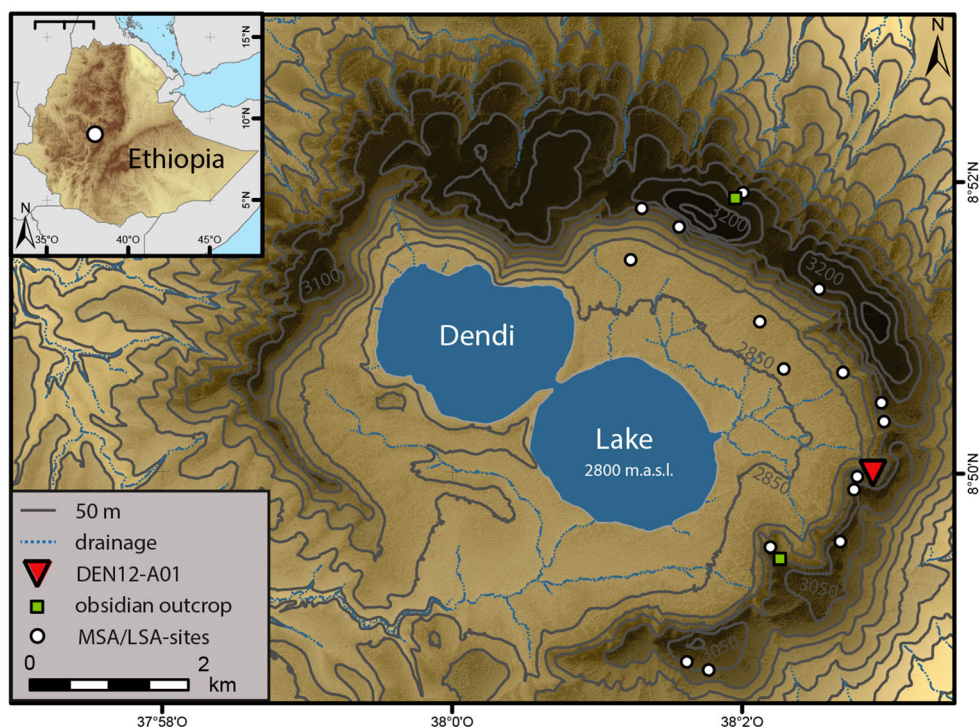


Figure 1. Location of Middle and Later Stone Age sites on the slopes of the Mount Dendi caldera enclosing the two crater lakes and the locations of the DEN12-A01 rock-shelter and a nearby obsidian outcrop. Archaeological survey was restricted to the eastern part of the mountain.

sequence of the Ethiopian Plateau, where volcanic activity started in the late Miocene and lasted until less than 1 mya (Abebe *et al.* 1998; Abbate *et al.* 2015). Mt Dendi is a large silicic volcanic complex constituted by both trachytic and rhyolitic lava flows and domes. Obsidian lava flows on top of these deposits are a potential raw material source to produce stone artefacts. The lava flows are overlain by younger pyroclastic deposits and volcanic ash that together constitute the floor of the caldera (Zinaye 2014).

The caldera itself has an almost elliptical shape with a diameter of about 8.5 km in its longest direction and 6.5 km in its shortest. A notable feature is the presence of two lakes formed within the central depression (Figure 2). A large number of springs in the steep slopes of the caldera drain into the lakes. The current abundance of water is recharged during two rainy seasons spanning from February to April and from June to September with an annual mean of about 1400 mm (Adimassu *et al.* 2014; Degefu *et al.* 2014).

Population pressure and intensive farming have impacted Mount Dendi's landscape to such an extent that the natural forest vegetation is only preserved in areas that are difficult to access. The potential natural vegetation is classified to the 'dry evergreen Afromontane forest and grassland complex', whereas that of the caldera rim above 3000 m a.s.l. belongs to the 'Ericaceous belt' (Friis *et al.* 2011).

Archaeological survey concomitant with coring activities in the crater lakes just mentioned was undertaken by the University of Cologne's CRC 806 research group in April 2012 (Wagner *et al.* 2018) and led to the first discovery of Stone Age artefacts in the



Figure 2. View of the Mount Dendi caldera with the two crater lakes.

Dendi caldera. Of special importance is the rockshelter Dendi12-A01 (DEN12-A01). Road construction had cut the deposits in front of a steep rock face and led to the erosion of numerous obsidian artefacts that attracted the attention of the survey team. The narrow overhang is located in a large trachytic cliff of the western flank of the caldera depression at an altitude of 2987 m a.s.l. (Figures 1 and 3).



Figure 3. The DEN12-A01 rockshelter (yellow oval) and surrounding landscape (top). Close-up of the shelter with scale (bottom).

The formation of rockshelters and caves is extremely rare in the volcanic lava flows and domes and up to now DEN12-A01 is the only recorded rockshelter with archaeological remains on Mt Dendi. The site's location offers two advantages: first, it is possible to overlook the caldera and the lakes and second the rock wall offers protection from the strong winds common in the area.

Research questions

As will be shown, blades and bladelets form a major group of the débitage in all Dendi assemblages and a significant amount of them have been transformed into backed microliths. Despite the early occurrence of backed tools during Marine Isotope Stage (MIS) 4, such as the southern African Howiesons Poort industry, backed microliths have until now been considered to be a main characteristic of the African Later Stone Age (LSA) (Clark 1985: 95; Ambrose 2002; Leplongeon 2014: 1). Moreover, assigning DEN12-A01 to the so-called Ethiopian Transitional Industries of the Late Pleistocene (Brandt 1986: 62) or to the Hargesian (Clark 1954; Guthertz *et al.* 2014) is not possible due to the absence of Middle Stone Age (MSA) elements. The general attribution of the DEN12-A01 assemblages to the Later Stone Age is therefore obvious.

However, a detailed description of the typo-technological development of lithic assemblages is still missing for the region, partly due to political instability in the Horn of Africa and discontinuous patterns of research. Indeed, not much progress has been made toward defining clear technocomplexes for this period since the fundamental work of J.D. Clark (1954) and S.A. Brandt (1986). Clark (1954) grouped the LSA into four lithic industries, namely the Magosian, Hargesian, Doian and Wilton, contextualising them with respect to the geology of the Horn of Africa. Brandt (1986) then synthesised the following thirty years of research, including chronometric and palaeoenvironmental data. He concluded that the stone tool complexes are in need of revision and that macro-regional studies are necessary to answer questions about hunter-gatherer adaptations to environmental change in the Horn of Africa, which is characterised by a high temporal and spatial diversity. Nelson (1976: 138) mentions similar conditions for technological variability in East Africa.

In the last 20 years, new research, especially by French colleagues, has significantly enhanced the available database. This has initiated new interpretations of cultural developments during the LSA (Bon *et al.* 2013; Assefa *et al.* 2014; Ménard *et al.* 2014; Pleurdeau *et al.* 2014). By giving a detailed description of the lithic artefacts from the DEN12-A01 rockshelter we want to enable high comparability with other LSA assemblages in the Horn of Africa. We thus focus here on the following three questions.

1. Is there a significant chronological change in technology and typology apparent in the DEN12-A01 sequence?
2. Are LSA sites from the southwestern Ethiopian highlands different from lowland sites in terms of their lithic assemblages?
3. Was the Dendi caldera a refugium for hunter-gatherer groups during arid periods?

Excavation methodology

In October 2012, a team from the University of Cologne directed by one of the authors (R. Vogelsang) excavated a test-trench measuring one square metre in the remaining sediments of the DEN12-A01 site. Most of the archaeological deposits had already been destroyed by road construction. The areas close to the back wall of the shelter and in front of the drip line, both of which are especially prone to disturbances by post-depositional processes, were avoided. The potential excavation trench was therefore restricted to a small area.

The trench was divided into quarter-metre squares and excavated in spits of 5 cm depth; spits were subdivided more finely when sediment changes in colour or texture were observed during excavation. Layers were differentiated based on those different sediments. Every spit or sub-spit was marked with a level number and every layer received a Roman number. The artificial units were used to document the spatial structure of the trench. Furthermore, they made it possible to reconstruct the position of the finds. All excavated material was sieved in three stages, using mesh widths of 10, 5 and 2.5 mm. All finds were separated according to material type (stone, pottery, bone, wood, charcoal and other botanical macro-remains) during the excavation process.

Stratigraphy

The square metre was excavated to a depth of 70 cm. This comprised 14 spits and seven layers (designated by Roman numbers). Most of the sediment units from the DEN12-A01 stratigraphy reflect a mixture of natural and anthropogenic deposition (Figure 4). The only exceptions are Layer IV, which is a fluvial channel that contains only redeposited, worn artefacts, and Layers I and VII, which seem to be predominantly naturally deposited with only minor input from human activities. The extreme abundance of lithic artefacts in the middle part of the stratigraphy (Layers IV and VI) might point to a compaction of cultural material through the erosion of fine-grained natural sediments, most probably by low energy fluvial activities. Such post-depositional processes are presumably also the reason for the high portion of small gravels in Layers II and VII. Nevertheless, a well-preserved hearth structure in Layer II, the preservation of charcoal in all layers, the radiometric dates, the presence of bones down to Layer VI and the high portion of chips in the stone artefact débitage all argue against a severe disturbance of the deposits and of the settlement layers within.

Radiocarbon dating

A total number of eleven AMS radiocarbon dates indicate repeated occupations of the shelter at least since the mid-Holocene (Table 1; Figure 5). For calibration we used CalPal 2016.2 (Weninger 1986; Weninger and Jöris 2008) and the IntCal13 curve (Reimer *et al.* 2013). All the dates derive from charcoal, but it was not possible to securely identify the exact nature of the charcoal material present due to poor preservation conditions. Based on observations by the excavators and later assessment of datable charcoal we assume that it is wood charcoal. As a result, it is not possible to rule out the old wood effect (Schiffer 1986). After comparing radiocarbon dates from wood with short-lived taxa

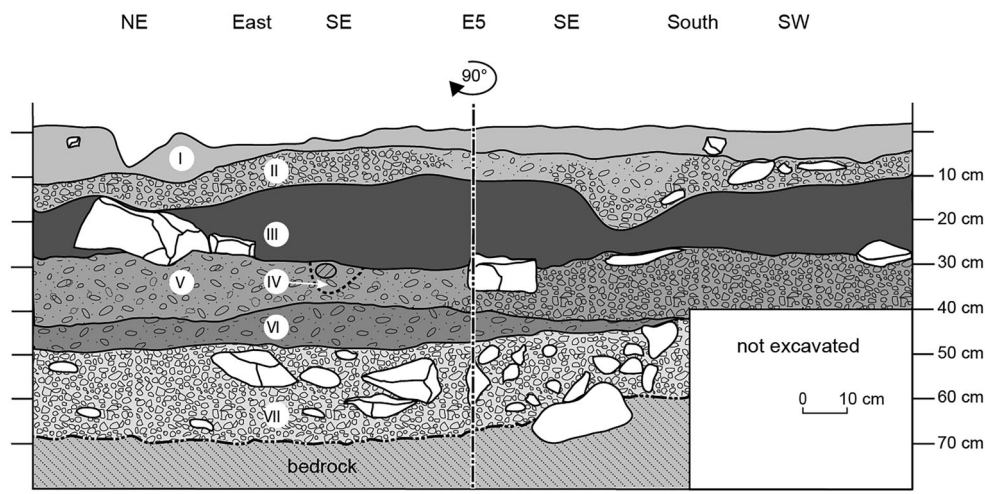


Figure 4. DEN12-A01: section drawing with sediment units I to VII. I: loose silty sediment of dark grey/ brown colour mixed with organic material. II: more compact, silty to fine-grained sediment of dark grey/ brown colour mixed with numerous small gravels (0.5–5 cm). III: ashy, greyish brown sediment with an increasing amount of small to medium sized gravels, interspersed with abundant charcoal flecks and small pieces of charcoal. A concentration of charcoal with patches of greyish-white ash indicates a hearth structure in the SE corner (not visible in the profile). IV: fluvial channel. Very loose sediment mixed with many gravels, worn artefacts and small roots. V: fine-grained, clayey sediment of reddish-brown colour interspersed with white calcareous rocks that are quite brittle. Some of them are relatively large (10–20 cm). Cut by a small fluvial channel (IV) in quarter-squares NW, SW and SE. VI: clayey sediment of brown colour with a very high content of small gravels (2–5 cm) and obsidian artefacts. There are some bigger rocks (up to 10 cm) in the southern part. VII: consolidated light brown sediment with high abundance of small gravel and big rocks. The number of obsidian artefacts decreases towards the base, where bedrock was reached.

Table 1. DEN12-A01 AMS radiocarbon dates calibrated with CalPal 2016.2 and the IntCal13 Curve.

Laboratory number	Excavation unit (Square-Quarter-Level)	Horizon	Sediment unit	δ^{13}	Date BP	Calibrated date (one-sigma)
COL-2015.1.1	E5-SE-3	A(1)	II	-24.5	183 $\pm$ 33	cal. AD 1775 $\pm$ 91
Beta-481341	E5-NW-4	A(1)	II	-23.8	190 $\pm$ 30	cal. AD 1752 $\pm$ 73
Beta-481340	E5-SW-3	?	II/III?	-24.9	350 $\pm$ 30	cal. AD 1553 $\pm$ 65
COL-2016.1.2	E5-SE-5	A(2)	III	-24.3	938 $\pm$ 34	cal. AD 1095 $\pm$ 49
Beta-481338	E5-NW-7	Fluvial channel	IV	-25.2	1860 $\pm$ 30	cal. AD 154 $\pm$ 50
Beta-481339	E5-SW-6	Fluvial channel	IV	-25.5	1840 $\pm$ 30	cal. AD 175 $\pm$ 45
COL-2024.1.1	E5-SW-8	B	V	-23.7	4182 $\pm$ 43	2771 $\pm$ 83 cal. BC
Beta-481342	E5-SW-7	B	V	-24.9	4650 $\pm$ 30	3437 $\pm$ 56 cal. BC
COL-2025.1.1	E5-SE-10	C	VII	-27.6	1066 $\pm$ 37	cal. AD 965 $\pm$ 42
COL-2026.1.1	E5-SE-10	C	VII	-32.0	6449 $\pm$ 50	5414 $\pm$ 50 cal. BC
COL-2017.1.1	E5-SE-12	D	VII	-26.5	327 $\pm$ 34	cal. AD 1563 $\pm$ 58

Kim *et al.* (2019) conclude that the old wood effect does not cause significant bias before the first millennium BC and depends on different factors. Research about the old wood effect in Ethiopia might clarify the issue.

Due to the lack of any datable material, the basal levels of sediment unit VII and of archaeological horizon D within it remain undated. A single measurement of cal. AD 1505–1621 (327 $\pm$ 34 BP, COL-2017.1.1) comes from charcoal that must have fallen

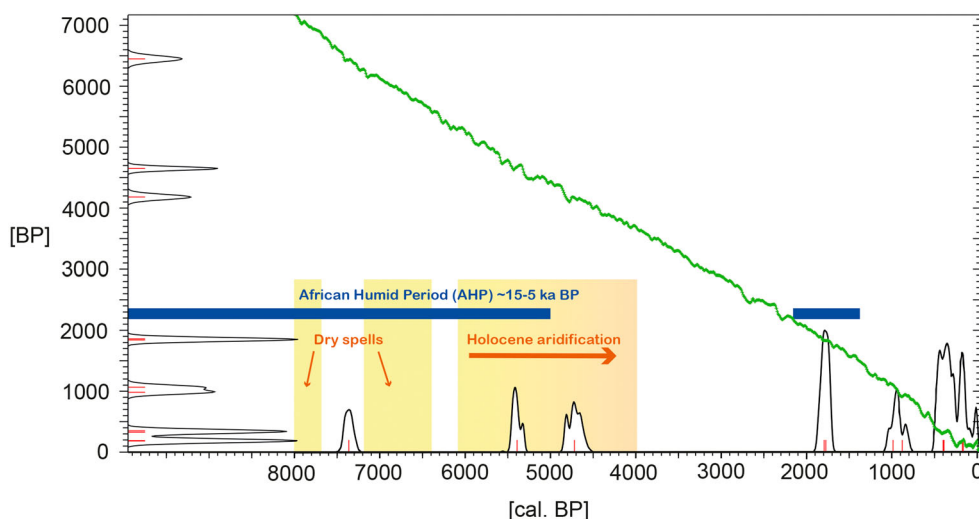


Figure 5. DEN12-A01: distribution of AMS-dates and their correlation with climatic phases. The graph was produced with CalPal 2016.2 (Weninger 1986; Weninger and Jöris 2008) using the IntCal13 calibration curve (Reimer *et al.* 2013) and climatic data from Foerster *et al.* (2015), Trauth *et al.* (2015) and Wagner *et al.* (2015).

from the uppermost parts of the profile. However, there is a probable *terminus post quem* of 8200 cal. BC for the basal layers. This is the age of a 2 m-thick tephra layer revealed in a sediment record from the Dendi lakes (Wagner *et al.* 2018). Evidence of this massive eruption is missing in the rockshelter's sediments, suggesting a later deposition of the preserved layers. This indicates that the shelter had been used since the early Holocene.

With an age of 5364–5464 cal. BC, the oldest date (6449 ± 50 BP, COL-2026.1.1), which comes from sediment unit VI, is of special interest because there is no published contemporaneous archaeological inventory from the Ethiopian Rift-Valley or the southwestern Ethiopian highlands (Foerster *et al.* 2015). This date verifies the settlement of the shelter (Archaeological Horizon C) between two drier spells of the African Humid Period (AHP). Starting around 3000 BC, increasing aridification led to the end of the AHP. Sediment unit V represents this phase and two dates of 2688–2854 cal. BC (4182 ± 43 BP, COL-2024.1.1) and 3381–3493 cal. BC (4650 ± 30 BP, Beta-481342) date the associated archaeological horizon B. A small fluvial channel within the stratigraphy from AD 170 contains only rolled, displaced artefacts. The local climate record from lake cores implies low lake level in combination with increased rainfall runoff between 650 BC and AD 450 (Wagner *et al.* 2018). Sediment unit A covers the last 900 years. The oldest date from this layer of cal. AD 1046–1144 (938 ± 34 BP, COL-2016.1.2) also dates the earliest appearance of pottery at DEN12-A01. The youngest date is cal. AD 1684–1866 (COL-2015.1.1, 183 ± 33 BP) and indicates that the site was used as a stopover until recent times.

Cultural sequence

Only the quarter-squares SE and NE were excavated down to bedrock. The stone artefact analysis therefore focused on the 10,214 lithic artefacts from these units. The exclusive raw

material used for stone artefact production was obsidian. Several raw material sources are available in the surroundings of the shelter, but specific provenances have not yet been checked by electron microprobe analysis. Retouched artefacts were differentiated into five major tool categories: backed microliths, scrapers, burins, denticulates/notched pieces and undiagnostic retouched pieces.

The overall distribution and density of the stone artefacts together with the radiocarbon dates indicate several phases of human occupation that are separated by periods of abandonment. The phases can be roughly correlated with sediment units and represent, according to the distribution of the tool categories, different cultural horizons (A–D) (Tables 1 and 4). Flakes are defined by the existence of a ventral and a dorsal side. This is the case for blades as well. Additionally, blades are twice as long as they are wide with parallel edges and dorsal ridges. Bladelets are blades with a width smaller than 10 mm. The percentages in the following section represent complete and fragmented objects. For blades and bladelets we considered only blanks with a proximal-medial preservation in combination with aforementioned criteria.

The composition of the lithic débitage (Table 2) is quite similar in all the archaeological horizons and shows only slight changes in proportion. Small flakes (<25 mm) are the dominant débitage category. Their percentage varies between 50.1% and 30.9%. More pronounced is the decrease of large flakes from Horizon A (4.2%) towards the bottom Horizon D (2.0%). An opposite trend shows the distribution of bladelets with increasing portions from Horizon A (14.2%) to horizon D (19.0%). The median length, width and thickness of bladelets in Horizon A is bigger than in the other horizons, but their elongation (length divided by width) is the lowest. This means that bladelets in the lower three horizons are relatively longer (Figure 6). The quantity of blades is always under 10%. Their distribution is quite constant; only Horizon C shows a significant drop. Cores are always rare (less than 1.3%). Single platform cores are present in all horizons and represent about 60.5% of all cores. In Horizon A irregular cores dominate and point to an increase in opportunistic blank production. Cores with more than one platform (double platform, opposed platform and multiple platform) are only present in Horizons B, C and D and are missing from Horizon A (Table 3). Alternating exploitation of the same face from two platforms is the exception. Additional platforms were used for new flaking surfaces or modifications.

A total of 2573 flakes and flake fragments smaller than 10 mm (chips) verify the production and repair of stone tools at the site. In addition, they support the aforementioned assumption that post-depositional disturbances of the settlement layers were not too excessive and restricted to low-energy fluvial processes. However, they are certainly under-represented and their distribution is therefore insignificant for any chronological differentiation.

All in all, débitage proportion and core type distribution indicate a technological change between the youngest archaeological horizon (>AD 1000) and the three older assemblages (>2000 BC).

Backed microliths are the dominant tool category. They are only absent from the surface layer and the upper part of Horizon A, which seems to represent two different settlement phases (A1 and A2), as is also indicated by the radiocarbon dates. Backed microliths are the characteristic tool category in all the other horizons, except the basal Horizon D, where undiagnostic retouched pieces predominate. Scrapers are absent in

Table 2. DEN12-A01: Distribution of débitage per archaeological horizon.

Horizon	Chips <10mm		Flakes <25mm		Flakes >25mm		Bladelets		Blades		Angular waste		Cores		TOTAL	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
A	311	19.0	820	50.1	68	4.2	233	14.2	101	6.2	85	5.2	19	1.2	1637	16.0
Fluvial	246	26.8	364	39.6	13	1.4	204	22.2	72	7.8	18	2.0	2	0.2	919	9.0
B	565	19.7	1188	41.3	98	3.4	658	22.9	269	9.4	77	2.7	20	0.7	2875	28.1
C	857	27.2	1247	39.6	62	2.0	681	21.6	174	5.5	90	2.9	37	1.2	3148	30.8
D	594	36.3	505	30.9	33	2.0	311	19.0	73	4.5	103	6.3	16	1.0	1635	16.0
TOTAL	2573	25.2	4124	40.4	274	2.7	2087	20.4	689	6.7	373	3.7	94	0.9	10214	100.0

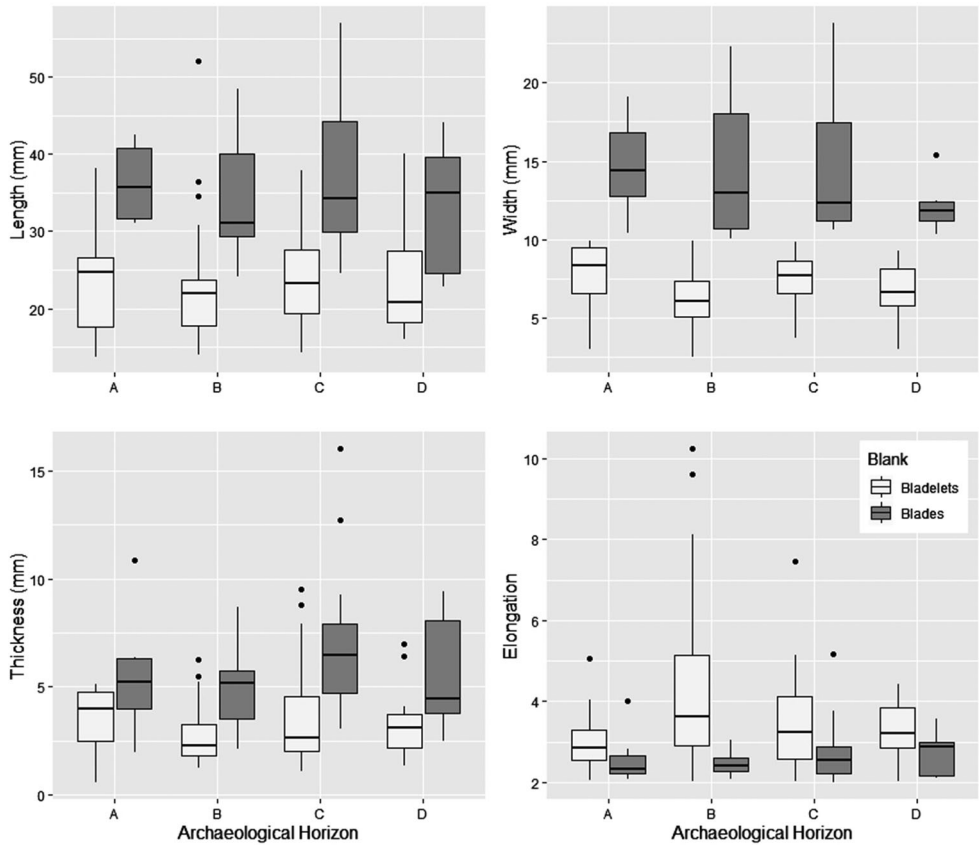


Figure 6. DEN12-A01: size of bladelets and blades throughout the stratigraphy. The graph was produced using R (R Core Team 2018) and package ggplot2 (Wickham 2016).

Table 3. DEN12-A01: distribution of complete cores per archaeological horizon.

Horizon		A	B	C	D	Fluvial	TOTAL
Single platform	N	9	10	22	9	2	52
	%	17.3	19.2	42.3	17.3	3.8	60.5
Multiple platforms	N	0	6	11	7	0	24
	%	0.0	25.0	45.8	29.2	0.0	27.9
Irregular	N	6	3	1	0	0	10
	%	60.0	30.0	10.0	0.0	0.0	11.6
TOTAL	N	15	19	34	16	2	86
	%	17.4	22.1	39.5	18.6	2.3	100.0

Horizons A and D and are represented by only two artefacts in Horizon B. All the other scrapers (N = 9) belong to Horizon C, where they account for 12.5% of the tool composition. Denticulates and notched pieces are present in all assemblages. Their number is especially high in Horizon A and they are the exclusive tool type in the upper part of this layer (A1). Burins are represented by single pieces in Horizons A2, B and D, but are the most common tools in Horizon C (Table 4).

Table 4. DEN12-A01: distribution of major tool types per archaeological horizon.

Horizon	Backed microliths		Scrapers		Retouched pieces (no formal tool types)		Denticulates/notched pieces		Burins		TOTAL	
	N	%	N	%	N	%	N	%	N	%	N	%
A	21	32.8	0	0.0	22	34.4	19	29.7	2	3.1	64	26.8
Fluvial	4	36.4	1	9.1	4	36.4	2	18.2	0	0.0	11	4.6
B	36	48.0	2	2.7	30	40.0	4	5.3	3	4.0	75	31.4
C	21	29.2	9	12.5	18	25.0	1	1.4	23	31.9	72	30.1
D	3	17.6	0	0.0	9	52.9	3	17.6	2	11.8	17	7.1
TOTAL	85	35.6	12	5.0	83	34.7	29	12.1	30	12.6	239	100.0

In summary it is possible to distinguish the four archaeological horizons through their stone tool composition. The basal Horizon D is characterised by a restricted range of formal tools, but single backed microliths are already present. Characteristic of this oldest horizon are artefacts without diagnostic retouch. In comparison, the overlying layer C is characterised by a higher number of backed microliths, scrapers and burins. The latter are most abundant here throughout the sequence. Horizon B is characterised by the highest number of retouched tools and the broadest tool-type range of all assemblages, with backed microliths, burins, denticulates, notched pieces and scrapers. The youngest horizon can be subdivided into a lower part, A2, with a tool range dominated by notched pieces and denticulates, but where a few backed microliths and burins still occur, and an upper part, A1, with notched pieces and denticulates as the only tool category.

Typology of backed tools

The stone tool assemblages from DEN12-A01 are hallmarked by backed microliths, which are a characteristic tool type of the Later Stone Age (Ambrose 2002; Phillipson 2005: 92–94, 109, 125, 137), although LSA sites without backed microliths do exist (e.g. Leplongeon 2014). Due to their high standardisation and commonness, they are well suitable for intra- and extra-site comparisons. However, most single types are not appropriate as type fossils for chronological classification due to their long-lasting nature. Types that are restricted to short periods seem to be the exception. More important therefore is the composition of larger assemblages. The classification used in our analysis is based on a typology compiled by B. Gehlen and colleagues (pers. comm., 12 March 1997) from the African Research Unit at the University of Cologne. The goal of this work was to standardise different typologies used for LSA assemblages from northeast and southwest Africa (Tixier 1963; Close 1977; Richter 1991). Additionally, some new types were identified. This common typology should avoid misunderstandings of typological designation and thereby allow trans-regional comparisons of stone tool assemblages.

The types are mainly defined by position, morphology and method of backing. If types are differentiated by size, we used length (e.g. micro-segment and large segment) and elongation (length divided by width, e.g. for all segments and double-points). The Shapiro-Wilk test (Royston 1982a, 1982b, 1995) shows that in the case of length and elongation some types are normally distributed while others are not. When the number

of artefacts within one group was too small for the Shapiro-Wilk test we used the Jarque-Bera test with skewness and kurtosis (Jarque and Bera 1987). The p-value is then computed by Monte Carlo simulation. Overall, we cannot expect normality for the two variables (length p-value = 0.003; elongation p-value = 0.0001). Due to the data not being normally distributed and the presence of multiple groups (eighteen types), differences in length and elongation are tested with the Kruskal-Wallis test (Hollander and Wolfe 1973). For length the p-value is equal to 0.0001 and for elongation to 0.00003. As the p-values are less than the 0.05 significance level, it is possible to conclude that there are significant differences in length and elongation between the types. To calculate comparisons between types, a pairwise two-sample permutation test with matrix output was used (Mangiafico 2019). The applied adjustment method for p-values by Benjamin and Yekutieli (2001) controls the false discovery rate. Only sixteen pairs of types are significantly different from each other. For further statistical testing of the typology an increase of sample size is necessary. Nevertheless, taking the other attributes like retouch into account it seems feasible to use the types for the DEN12-A01 assemblage. For this data analysis R was used (R Core Team 2018) with the packages normtest (Gavrilov and Pusev 2014) and rcompanion (Mangiafico 2019). Backed tool types appearing in the DEN12-A01 assemblages are illustrated in Figure 7 and defined in Table 5.

Backed microliths as chronological markers

With 239 artefacts (used pieces not included), backed microliths represent 35.6% of the total number of tools in the Dendi assemblage and the major tool category present.

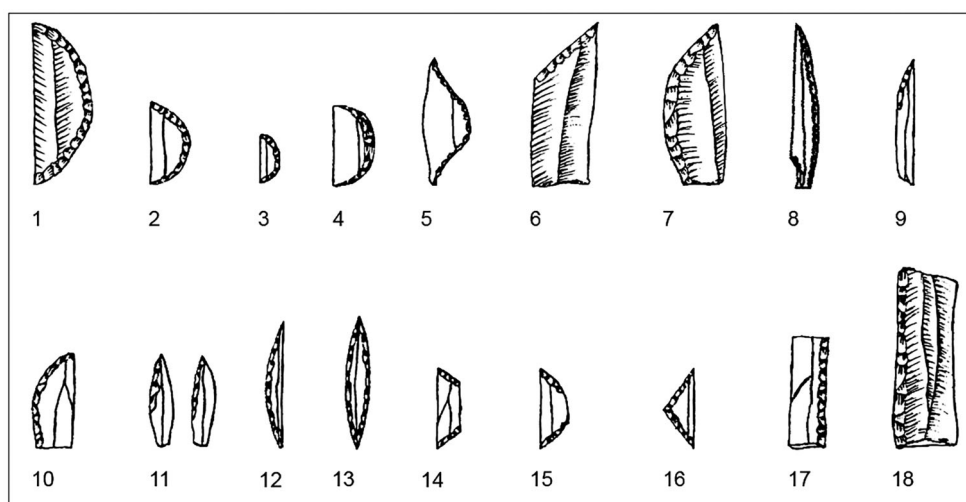


Figure 7. DEN12-A01: backed tools typology: 1) large segment; 2) micro-segment; 3) very small segment; 4) micro-segment with crossed backing; 5) segment with curved ends; 6) backed point with oblique truncation; 7) convex backed point; 8) backed point with notch; 9) long unilaterally retouched micro-point; 10) short unilaterally retouched micro-point; 11) alternately retouched micro-point; 12) long unilaterally retouched micro-doublepoint; 13) long symmetrical bilaterally retouched micro-doublepoint; 14) elongated isosceles trapeze with straight truncation; 15) segment-like isosceles trapeze with convex truncation; 16) isosceles triangle; 17) backed bladelet; 18) (broken) backed blade.

Table 5. DEN12-A01 backed tool-types and their definition.

No.	Name	Description	References
	Segment	Geometric microliths with the arc of a circle forming the backed edge and the sharp edge forming the chord. Segments always have two opposed points, formed by the back and the sharp edge. Retouch on the back is in general continuous. Regular morphology and no bulb.	Tixier (1963) subsumes all segments under his type 82
1	large segment	length >25 mm, length/breadth >2:1	Richter (1991) type 48
2	micro-segment	length <25 mm, length/breadth >2:1	Richter (1991) type 1
3	very small segment	length <14 mm, length/breadth >2:1	Richter (1991) type 3
4	micro-segment with crossed backing	length <25 mm, length/breadth >2:1	Richter (1991) type 2
5	segment with curved ends	length <25 mm, length/breadth >2:1	Gehlen (1997)
	Backed point		
6	backed point with oblique truncation	length >25 mm	Richter (1991) type 45
7	backed point, convex	length >25 mm	Tixier (1963) type 56; Richter (1991) type 47
8	backed point with notch		Tixier (1963) type 61
9	long micro-point, unilaterally retouched	length/breadth >3:1	Richter (1991) type 10
10	short micro-point, unilaterally retouched		Richter (1991) type 12
11	alternately (bilaterally) retouched micro-point		Richter (1991) type 21
12	long micro-double-point, unilaterally retouched	length/breadth >3:1	Richter (1991,) type 11
13	long micro-double-point, bilaterally retouched, symmetrical	length/breadth >3:1	Richter (1991) type 15
	Trapeze	Trapezes are characterised by two convergent, retouched sides positioned opposite to each other and separated by one longer and one shorter sharp edge. The sharp edges are the edges of the former blank	
14	elongated trapeze, isosceles, with straight truncations	length/breadth >2:1	Tixier (1963) type 83; Richter (1991) type 8
15	segment-like trapeze, isosceles, with convex truncations		Tixier (1963) type 88; Richter (1991) type 9
	Triangle	Triangles are characterised by two retouched legs meeting in a specific angle. The third and longest side is in general not retouched	
16	isosceles triangle		Tixier (1963) type 89 Richter (1991) type 5
	Others		
17	backed bladelet	length <25 mm	Richter (1991) type 25
18	(broken) backed blade	length >25 mm	Richter (1991) type 44

Due to their large number and their relevance for the Holocene LSA, this section focuses on their different types and their occurrence in the different archaeological horizons (Table 6).

Segments

Segments (Figure 7: 1–5) account for 11.8% of all the microlithic tools present. With five sub-types they are the most heterogeneous group. Most pieces are complete (80%) and their assignment is therefore unambiguous. Only one segment from Horizon A exceeds 25 mm in length. There are nine micro-segments, of which one has crossed backing,

Table 6. DEN12-A01: distribution of backed microliths per archaeological horizon.

	A		Fluvial		B		C		D		TOTAL	
	N	%	N	%	N	%	N	%	N	%	N	%
Micropoint	7	22.6	3	9.7	15	48.4	5	16.1	1	3.2	31	36.5
Micro-double-point	3	14.3	0	0.0	7	33.3	10	47.6	1	4.8	21	24.7
Segment	8	80.0	0	0.0	2	20.0	0	0.0	0	0.0	10	11.8
Backed bladelet	2	25.0	0	0.0	4	50.0	1	12.5	1	12.5	8	9.4
Backed blade	0	0.0	1	33.3	1	33.3	1	33.3	0	0.0	3	3.5
Triangle	1	33.3	0	0.0	2	66.7	0	0.0	0	0.0	3	3.5
Trapezoid	0	0.0	0	0.0	4	80.0	1	20.0	0	0.0	5	5.9
Backed point	0	0.0	0	0.0	1	25.0	3	75.0	0	0.0	4	4.7
TOTAL	21	24.7	4	4.7	36	42.4	21	24.7	3	3.5	85	100.0

one has curved ends and one is very small (Figure 8: A5). With the exception of the extraordinary piece with the curved end (Figure 8: B2) and one simple micro-segment from Horizon B, all the other pieces belong to Horizon A2. They are therefore characteristic of the younger settlement phases of the rockshelter.

Micro-points

Micro-points (Figure 7: 8–13) represent 61.2% of all the microliths at Dendi. Their high number might partly be due to the fact that nearly all (69.2%) are broken. The high fragmentation of this tool type also complicates their identification and definite classification to one of the possible sub-types. In all, 21.2% of the micro-points could not be classified to a specific sub-type. The majority of the distinct pieces are long, unilaterally retouched micro-points, followed by double-points. With the exception of one symmetrical, bilaterally retouched double-point and one alternately, bilaterally retouched micro-point, all the remaining 50 pieces are only retouched on one edge. Less common are short micro-points.

Almost all micro-points with a distinct designation can be assigned to Horizon B and they are therefore a type-fossil for this period. The only exceptions are double-points, which occur in all the archaeological horizons. However, their main distribution is in Horizon C, where their percentage exceeds that of the long micro-points. Double-points from Horizon C are, in general, slightly longer and more elongated than in Horizon B (Figure 9).

Trapezes

Trapezes (Figure 7: 14–15) are a small but highly variable group. Besides three elongated trapezes and one segment-like piece, one did not fit into any of these groups. Four of five trapezes belong to Horizon B, while the only segment-like trapeze is from Horizon C.

Triangles

Triangles (Figure 7: 16) form the smallest and most homogenous group of microlithic tools. All three pieces are isosceles triangles. Like the segments, they occur in Horizons A2 and B. The single piece from Horizon A2 (Figure 8: A9) is smaller and thicker than the two pieces from Horizon B (Figure 8: B6 and B13). Like the very small segment from the same assemblage, this might point to a chronological trend of miniaturisation in the younger assemblage.

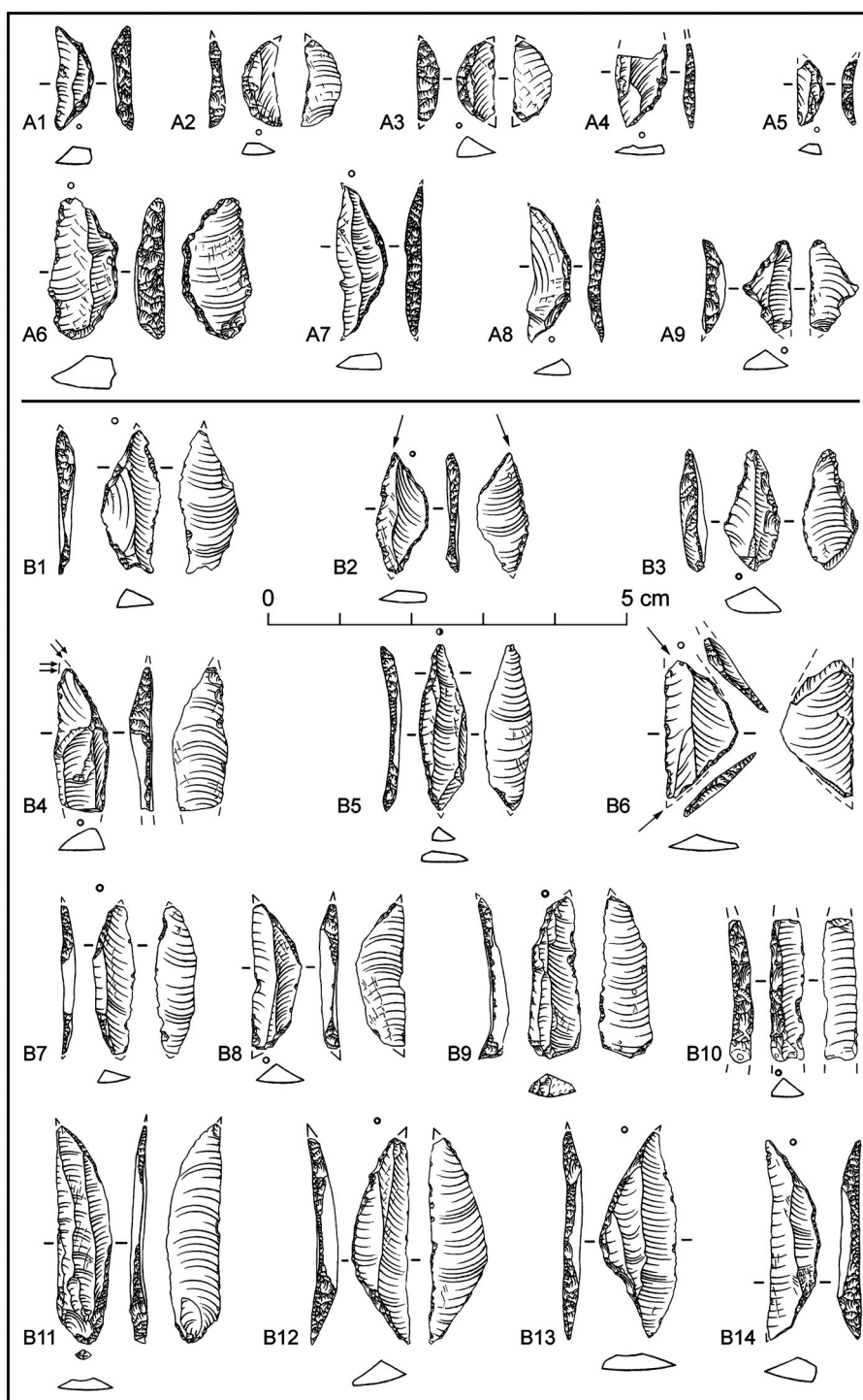


Figure 8. DEN12-A01: backed microliths from Horizons A and B: micro-segments (A1, A2, A4); micro-segment with crossed backing (A3); very small segment (A5); large segment (A6); long micro-double-points, unilaterally retouched (A7, A8, B5, B12, B14); isosceles triangles (A9, B6, B13); elongated trapezes, isosceles with straight truncation (B1, B11, B8); segment with curved end (B2); alternately, bilaterally retouched micro-point (B3); long micro-points, unilaterally retouched (B4, B7, B9); (broken) backed blade (B10).

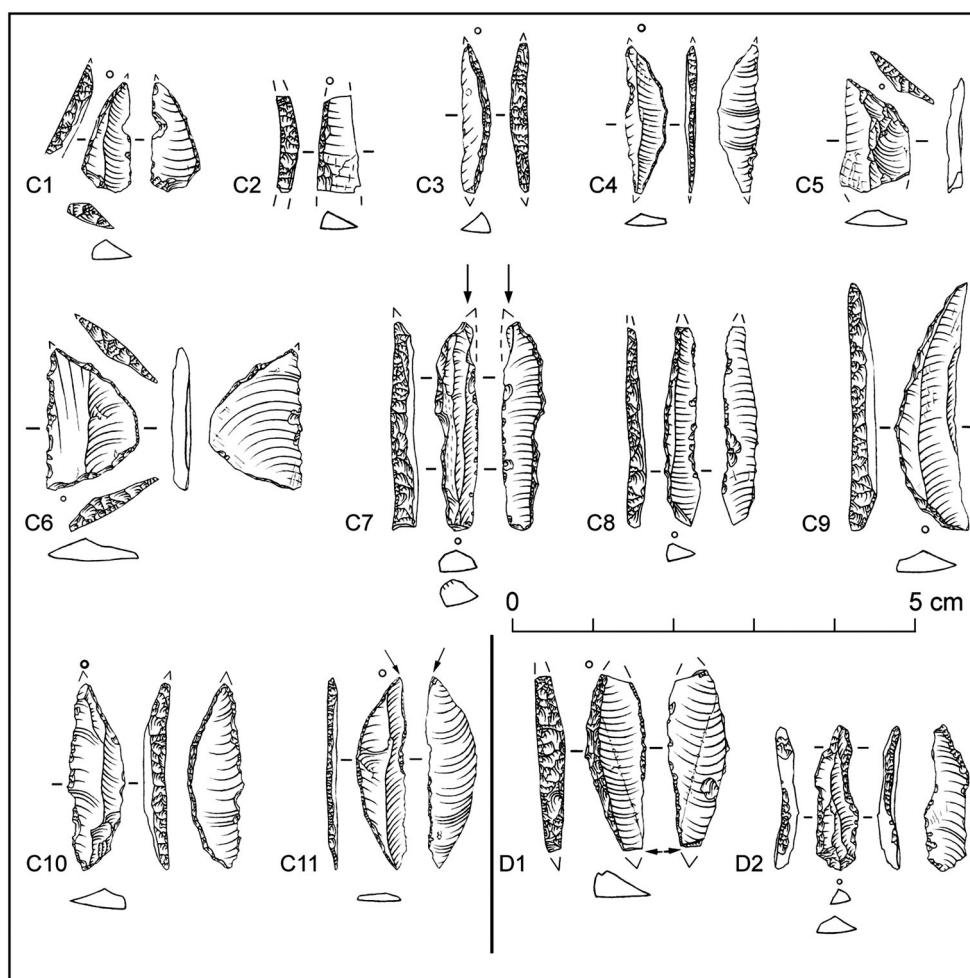


Figure 9. DEN12-A01: backed microliths from Horizons C and D: long micro-point, unilaterally retouched (C1, C5, D2); backed bladelet (C2); long micro-double-point, unilaterally retouched (C3, C4, C9, C10, C11, D1); segment-like trapeze, isosceles with convex truncation (C6); backed point with notch (C7, C8).

Backed bladelets

Backed bladelets (Figure 7: 17) occur in all horizons, but mainly in Horizons A2 and B. However, some of these pieces may be fragments of other microlithic tool-types and thus not have been intentionally produced. Their chronological informative value is therefore low.

Backed blades

Backed blades (Figure 7: 18) from Horizons B and C might, as in the case of the backed bladelets, be fragments of other tool-types, for example, of backed points. Due to their dimensions (>2.5 cm), they are not microliths in the narrow sense, but are closely related by reason of their backed retouch.

Backed points

This is also true of backed points (Figure 7: 6–7), which are likewise longer than 2.5 cm. With the exception of a convex backed point from Horizon B, two backed points with notches and one backed point with oblique retouch all come from Horizon C.

To sum up, the oldest horizon, Horizon D, is characterised by the rarity of any formal tools. However, two micro-points and a backed bladelet verify the production of microlithic backed tools already at this early stage of the site's history. Backed microliths, especially double micro-points but also one trapeze, are a common element of Horizon C, but non-microlithic tool types, such as scrapers, burins and large backed points, play a more prominent role. The largest number of microlithic tools occurs in Horizon B, dating to between 3381–3493 and 2688–2854 cal. BC. This horizon also sees the greatest range in backed microlith types (segments, triangles, trapezes and, in particular, different forms of micro-points) and is separated by a hiatus of 3000 years from the overlying horizon, Horizon A. Backed microliths are restricted to a few segments in Horizon A2 and are absent in Horizon A1 above this.

Although our analysis of the dimensions of backed microliths as a chronological marker was hampered by the low number of complete pieces and our results are not therefore statistically solid, as a general impression backed microliths from Horizon A are shorter than those from the lower three horizons (Figure 10).

Core reduction

Despite the presence of outcrops in the vicinity of the site raw material was used economically in all the assemblages at DEN12-A01. Cores were knapped until it was impossible to maintain convexities. Opportunistic reduction is present throughout the sequence, either on irregular pieces of raw material without further modification or on otherwise finished cores in order to obtain one last flake.

Core preparation started in all cases with the removal of cortex. In the case of cores with one flaking surface, the adjacent faces could be fully cortical at an early stage. The back side opposed to the flaking surface is usually unprepared. Core exploitation focused on the production of bladelets in all horizons as shown by the elongated negatives on both cores and blanks. The flaking surface is convex. Convexity was maintained by overshots, preparation flakes opposed to the main flaking direction, preparations perpendicular to the flaking surface or blanks struck from the core edge. Core tablets, blanks from the edge of the platform and flakes for preparing the core flanks are signs of further core rejuvenation between knapping sequences.

In Horizon A, cores have similar lengths and widths are not as thick. This resulted in flat, rounded artefacts. The platform was prepared laterally and blanks detached unidirectionally. A second platform was prepared opposite to the other for modifications of the flaking surface. The other side of the core remained cortical. The cross section is plano-convex (Figure 11).

In the three lower archaeological horizons, three concepts of core reduction are present. In the first concept, cores have two sides, one flaking surface and one striking platform surface. The latter was prepared with centripetal flaking. These negatives were then used as platforms for flaking the other side. When the flaking surface was used up, the core was discarded. The main flaking direction was unidirectional with modifications

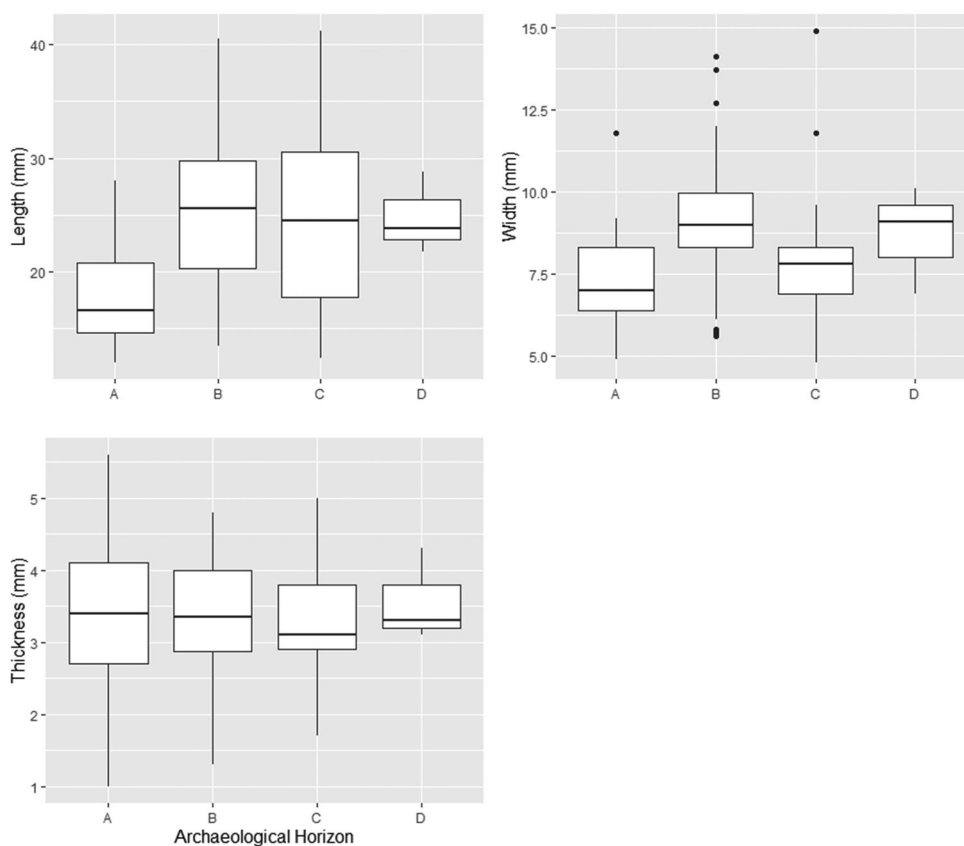


Figure 10. DEN12-A01: length, width and thickness of all backed microliths. The graph was produced using R (R Core Team 2018) and package ggplot2 (Wickham 2016).

from other directions. The flaking surface was less convex than the striking platform face, which resulted in plano-convex cores.

The cores of the second concept were prepared in a centripetal way and were plano-convex as well. The relatively flat side was used as a platform and bladelets were detached along the ridges of the centripetal flaking. A unidirectional, convergent configuration was used. After one flaking surface was finished, another was started. This resulted in circumferential cores, but the circumference was not knapped in one sequence (Figure 11).

The third concept encompasses a wide range of different core types, all of them with one primary platform and, in some cases, an opposed secondary one for modifications. The types are cores with one unidirectional parallel flaking surface, adjacent flanks and an unprepared back or semi-circumferential cores with one flank and an unprepared back. Cores with mixtures between these patterns show that they are all part of one continuous reduction. They are polyhedrons with a variable number of faces. The back-sides and bases were usually unmodified at the beginning. In some cases the flaking surface extends towards the flanks in later stages. The result was to produce cores with a convex flaking surface and an unmodified backside rectangular to the platform (Figure 12).

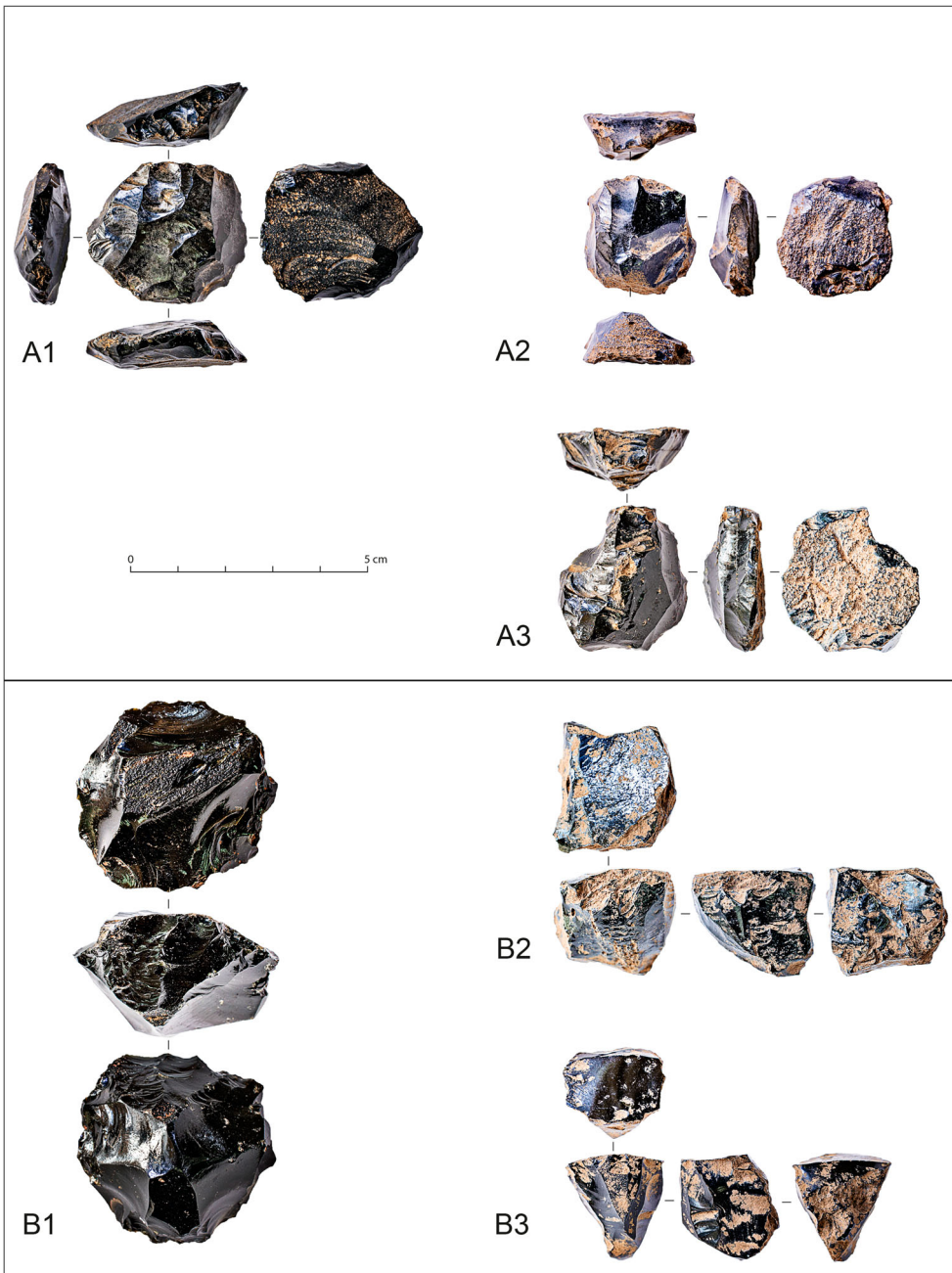


Figure 11. DEN12-A01: cores from Horizons A and B: all of the same concept (A1–A3); second concept of the three lower horizons (B1); third concept of the three lower horizons (B2, B3).

Pottery

Thirteen potsherds were found in the uppermost layers of the rockshelter (Horizons A1 and A2). Two fragments in Horizon B have the same temper and colour as the sherds in A; we assume that they were moved by bioturbation. Two pieces are fragments of a

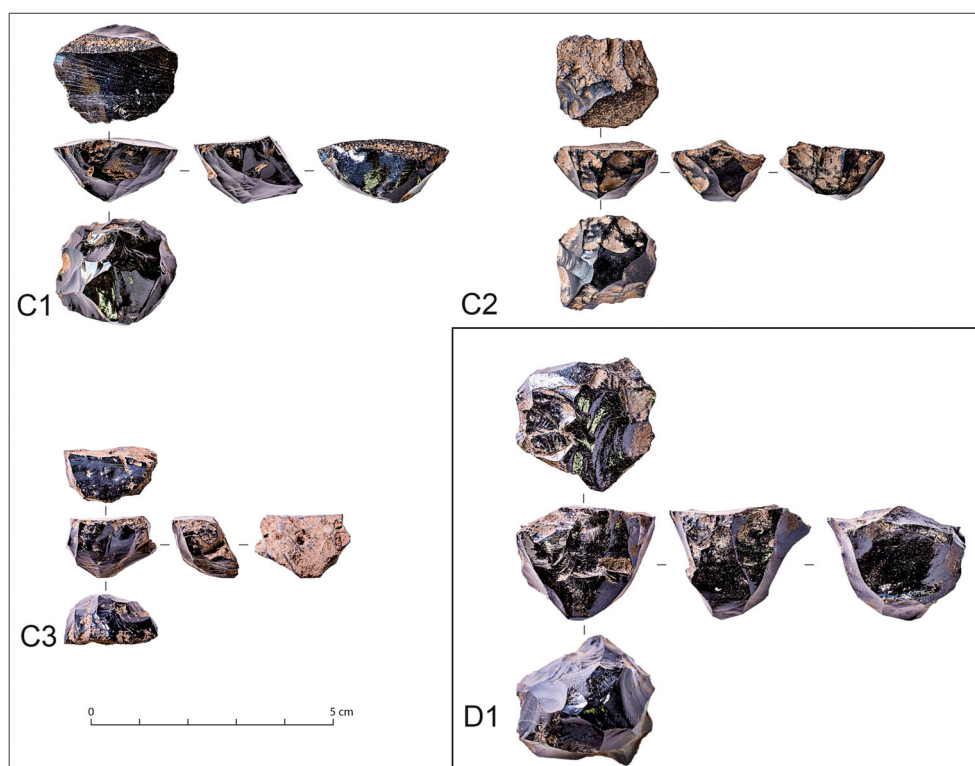


Figure 12. DEN12-A01: cores from Horizons C and D: third concept of the three lower horizons (all).

rounded rim, while others are from the body. No decoration is visible and the sherds are always sand-tempered. Core colour is mostly brown or light red, but in one case white. Red slip was applied to the inner and outer surfaces and its use is also reported from Mota and Tuwatey Caves in the Gamo Highlands of southwestern Ethiopia (Arthur *et al.* 2019).

The oldest date in association with pottery from DEN12-A01 of cal. AD 1046–1144 is in accordance with others for the late appearance of ceramics in other highland regions, for example at Kafa (Hildebrand and Brandt 2010), Mochena Borago (Gutherz *et al.* 2002) and Sodicho (pers. obs.), making it significantly later than in the northern lowlands of the country. The low number of pottery sherds, even in the youngest layers, might be an indication for the ephemeral use of the shelter for short-term stays rather than as a base-camp for long-term occupations.

Faunal remains

A total of 658 faunal remains were found during the excavations. Due to high fragmentation and heavy soil corrosion, only 107 bones and one tooth fragment could be identified (Table 7). Most of these remains (N = 80) come from Horizon A and include a large number of rodent bones, which are better preserved than the other faunal remains. This may suggest a recent intrusion not linked with anthropogenic activities. The rest of the fauna from this horizon includes mainly wild bovids, especially three

Table 7. DEN12-A01: faunal remains (NISP).

	Surface	A	Fluvial	B	C	D	TOTAL
Cercopithecidae		1			1		2
<i>Procavia capensis</i> (rock hyrax)		9			1		10
Alcelaphini			1				1
<i>Phacochoerus</i> sp. (warthog)				1			1
<i>Syncerus caffer</i> (Cape buffalo)		1					1
Antilopini		3	2				5
Bovid small		6		1			7
Bovid medium	1	7	2	3	7	1	21
Bovid large	1	2	1				4
Rodent	1	42			1		44
Small mammal	2						2
Middle-sized mammal				1			1
Amphibian		9					9
Total	5	80	6	6	10	1	108
Unidentified	6	221	103	75	109	36	550
TOTAL	11	301	109	81	119	37	658

fragments from Antilopini and one tooth fragment probably coming from a Cape buffalo (*Syncerus caffer*). We also notice the presence of one primate bone (from a small cercopithecoid) and nine fragments of rock hyrax (*Procavia capensis*). The older horizons (Horizons B, C and D) delivered only six, ten and one identified remains respectively, mainly of bovids. Horizon C also produced a single fragment of warthog (*Phacochoerus* sp.).

The few species that could be identified can all live in the Afromontane forest and grassland that was present in the vicinity of the site. The assemblages from the different horizons are too small, however, to be indicative of the climatic changes that occurred during the Holocene. The only noteworthy result is the absence of domesticates through the entire sequence, even during the very recent occupations of the site. Although difficult to assert with such small collection, this fits with the hypothesis of a very late introduction of domesticates in the highlands, at least in communities of settled farmers (Lesur *et al.* 2014).

Discussion

A comparison with other Holocene hunter-gatherer assemblages from the Horn of Africa might clarify whether the changes in the range of tool types in the assemblages from DEN12-A01 reflect a local development or if they are representative of a regional trend. For this purpose, we use the tripartite division of the Holocene into 'early', 'middle' or 'mid-' and 'late' as chronological stages. While the beginning of the Holocene is dated to 9700 cal. BC (Walker *et al.* 2009), we follow Walker *et al.* (2014) and Cohen *et al.* (2013) in using the 8.2 ka event (6200 BC) as the early to middle Holocene boundary and the 4.2 ka event (2200 BC) for the middle to late Holocene boundary (which is, however, still contested; see Voosen 2018). Unfortunately the number of well-dated sites is very small, many assemblages come from old excavations and the material has not been studied in detail or well published. The first part of the discussion compares the temporal and environmental context of DEN12-A01 with other sites from the Horn of Africa.

The oldest assemblage from DEN12-A01 — that from Horizon D — is undated, but there are indications that it dates to the early Holocene. Comparable inventories are rare in the Horn of Africa and seem to represent a phase of re-settlement after the arid phase of the Younger Dryas stadial (Foerster *et al.* 2015). This arid interruption of the African Humid Period (AHP) separates late Pleistocene from early Holocene assemblages. Regionally, they concentrate in the Ziway-Shalla Basin in Ethiopia, with sites like Deka Wede DW2s1 and DW2s2 (Bon *et al.* 2013; Ménard *et al.* 2014), Deka Wede B20 (Street 1979) and Macho Hill (Haynes and Haas 1974). Occupations along the lake margins just before the last main transgression are a common feature of both these sites and the DEN12-A01 rockshelter. Attachment to an aquatic environment is not so obvious at other Ethiopian sites from this period, such as Aladi Springs (Williams *et al.* 1977; Gossa *et al.* 2012), Laga Oda (Kurashina 1978: 446) and Baahti Nebait (Finneran 2001). However, the first site was a mound spring (Clark and Williams 1978), the second is located close to fresh water sources (Cervicek 1971) and the latter rockshelter is linked to seasonal watercourses (Finneran 2000). In Somalia, other sites, like the complex of Laas Geel, are situated in the vicinity of wadis (Gutherz *et al.* 2014) or, as with the Rifle Range Site (Jones *et al.* 2018) and Gogoshiis Qabe (Brandt 1988), are at inselbergs that provide favourable ecological conditions due to their increased water catchment (Jones *et al.* 2018 after Jürgens and Burke 2000; Porembski and Barthlott 2000; Burke 2003; Müller 2007).

The mid-Holocene, which in general was a relatively humid phase in the Horn of Africa, is marked by a slight increase in the number of dated archaeological sites (early Holocene nine sites; mid-Holocene 15 sites; after Ménard 2015: Table 2). With the inventories from Horizons C and B, DEN12-A01 includes one assemblage from the beginning and one from the end of this period.

Contemporaneous assemblages for Horizon C include the LSA inventory from the upper dark clay layer at K'one (Williamson *et al.* 1977), the 'Bardaale' Industry from Gogoshiis Qabe in Somalia (Brandt 1977) and Goda Buticha Layer IIC in southeastern Ethiopia (Pleurdeau *et al.* 2014). K'one is a complex of calderas too, while the other sites are rockshelters. All resemble the environmental context of Dendi.

The most important comparative inventory for Horizon B comes from the rockshelter of Mochena Borago in the southwestern Ethiopian highlands, which is situated on the slopes of Mount Damota (Ménard 2015). This inactive volcano is visible from the entrance to Sodicho Cave, another site with the same environmental context (Hensel *et al.* 2019). Further sites in the region are Mota, Tuwatey and Gulo Cave (Arthur *et al.* 2019). Their assemblages date from the middle and late Holocene. Of the same age and character are most probably different sites from Lake Besaka with younger assemblages of the Besaka Industry grouped under the term 'Abadir phase' (e.g. FeJx2 and FeJx2 East; Brandt 1982). Furthermore, during the end of the mid-Holocene, humans added pottery to their material culture. An example of this in Ethiopia is K'urk'umu (Fernández *et al.* 2007). While food-producing societies settled in large parts of the Horn of Africa in late Holocene times, the highlands of Ethiopia seem to have offered a retreat for hunter-gatherer-groups. Dendi12-A01 Horizon A represents the last millennium of this phenomenon. Even the Ziway-Shalla Basin sites are close together but very variable in means of lithic typology and technology (Ménard *et al.* 2014). Therefore, it comes as no surprise that the inventories we have mentioned from the Horn of Africa with their diverse environmental settings do not form homogenous groups.

Although southern Africa is not the geographical focus of this paper it should be mentioned that there the uKhahlamba-Drakensberg Escarpment and Maloti-Drakensberg Mountains offered similar conditions to foragers as the Ethiopian highlands. One example of a dynamic change of subsistence strategies in that region comes from the open-air site Likoaeng in Lesotho (Mitchell *et al.* 2011). Lodder *et al.* (2018) show that the environment of Cathedral Peak remained relatively stable in the last 5000 years, suggesting that high altitude areas could have served as refugia. For the Maloti-Drakensberg region a synthesis of palaeoclimatic and palaeoenvironmental data also suggests that it was a refugium for humans during unstable, arid periods (Stewart and Mitchell 2018). For the Dendi caldera, climatic data from the local lake cores point towards a similar scenario (Figure 5; Wagner *et al.* 2015).

The second part of our discussion compares the lithic typology and technology of DEN12-A01 with other assemblages from the Horn of Africa. As a tentative impression, it seems that backed microliths were an element of most assemblages since the beginning of the early Holocene, mainly in the shape of pieces classified by us as micro-points. From this time Laas Geel is the only site in the region with numerous segments. However, the radiocarbon dates here derive from ostrich eggshell and are problematic as mentioned by Guthertz *et al.* (2014). Apart from that, geometric microliths seem to be a feature of mid-Holocene assemblages.

Micro-points form a common component of the assemblage from DEN12-A01's Horizon C, but they are outnumbered by larger tools, such as scrapers and burins. A new feature is the first occurrence of geometric microliths, although they are only documented by a single trapeze. The mid-Holocene inventory from Layer IIC at Goda Buticha in southeastern Ethiopia dates to the same period (Pleurdeau *et al.* 2014). Comparable to DEN12-A01 is the dominance of larger tools in proportion to backed microliths, which are represented by curved backed microliths (Leplongeon 2014). Two differences are the occurrence of 'typical' MSA elements at Goda Buticha, namely facially retouched points and a significant blade component. K'one (Williamson *et al.* 1977) and the 'Bardaale' Industry from Gogoshiis Qabe Rockshelter in Somalia (Brandt 1988) are not, however, adequately published for further comparison.

Representing the younger part of the mid-Holocene, Horizon B at DEN12-A01 is characterised by a broad type range and numerous non-geometric and geometric backed microliths. The inventory from Mochena Borago (Ménard 2015) is likewise dominated by segments, in particular, as well as by some other geometric types. The same is true for the lithic artefacts from Sodicho Cave (pers. obs.), although its analysis is still in progress. Again, at all three sites it was mainly obsidian that people used. In addition, assemblages from the Abadir phase of the Besaka Industry are absolutely dominated by segments and already contain pottery (Brandt 1982). According to Leplongeon (2014), curved backed microliths that might be segments are also found in the ashy layers at Goda Buticha and this whole unit could be comparable to the later phases from Besaka. The lower levels from the site of K'urk'umu, situated in the Central Ethiopian Escarpment close to the Sudanese border, date to the same period and prove the advance of Sudanese pottery in the region (Fernández *et al.* 2007). The rarity of backed tools in this assemblage (a single segment) might be due to the use of 'poor-quality quartz' (Fernández *et al.* 2007: 107) as the predominant raw material. Despite our focus on hunter-gatherer sites, it is nevertheless interesting to note that contemporary Neolithic sites, such as Wakrita

(Gutherz *et al.* 2015) and Asa Koma (Gutherz 2017) in Djibouti, are also dominated by segments in their tool-type range. To sum up, the dominance of segments seems to be the common feature of most assemblages dating to the younger phase of the mid-Holocene. The earliest occupation of Mota Cave starts at 2570 cal. BC and lasts until 1390 cal. BC. The use of unifacial points sets it apart from Dendi. Similar, however, is the presence of geometric microliths, among them crescents, trapezoids and triangles. At both sites blades and bladelets are part of the débitage. The cores are at least morphologically similar and a technological similarity is possible. The assemblages also share a preference for obsidian (Arthur *et al.* 2019). Although activities were limited at Tuwatey Cave (3570 cal. BC – cal. AD 1650), the use of geometric microliths and obsidian as the raw material employed are the same. In addition, Arthur *et al.* (2019) mention similar features for Gulo Cave (3430 cal. BC – cal. AD 260).

In the late Holocene of Dendi, backed microliths became much less important and quite unstandardised tool types, such as denticulates and notched pieces, characterise the tool range found. This is in contrast to the contemporaneous assemblages from Ajilak 6 (González-Ruibal *et al.* 2014) and Akirsa (Bouakaze and Poisblaud 2000 as quoted in Ménard 2015: 155, Figure 86) that include larger numbers of different types of geometric microliths. Mota and Tuwatey Cave is an example from the Ethiopian highlands with geometric microliths in use until cal. AD 1650. At the same time humans consumed domesticated plants and animals (Arthur *et al.* 2019). In the Dendi Lake Rockshelter, there is no evidence for domestication. The low number of formal tools in Horizon A from DEN12-A01 is comparable to the younger layers of Bel K'urk'umu (Fernández *et al.* 2007) and some of the younger sites in the highlands of Kaffa (Hildebrand and Brandt 2010; Hildebrand *et al.* 2010).

Besides the chronological indication of formal tool types, their range can also be task-specific (Laplace 1972; Odell 1981). It seems plausible that different stone tool categories are linked to different activities. In this sense, inventories with a single primary tool class represent a specific activity range and are also likely to indicate a shorter duration of stay. Complicating issues here, however, are that a single type could have served several tasks or that different types might have been used for the same activity (Odell 1981). Use wear analysis could solve this problem. With the exception of the youngest and the oldest horizons, i.e. Horizons A1 and D, all the archaeological phases at DEN12-A01 are characterised by a similar tool type range, one that is dominated by backed microliths, especially micro-points and segments. Such assemblages are representative of typical hunting equipment (Lombard 2008; Lombard and Pargeter 2008; Mazzucco *et al.* 2012). We presume that the DEN12-A01 rockshelter was never a long-term settlement site, but rather a hunting camp used by a small group of hunters for repeated short-term stays (Figure 13).

Conclusion

The DEN12-A01 rockshelter shows evidence of repeated habitation in a high-altitude region since the (later) early Holocene. To answer the first research question that we posed above, the four archaeological horizons that we differentiated show distinct characteristics in their stone artefact inventories. Stone tools were used until recent times, but, with the exception of notched pieces and denticulates, formal retouched tools are absent in the uppermost horizon, Horizon A1. Segments are characteristic of Horizon

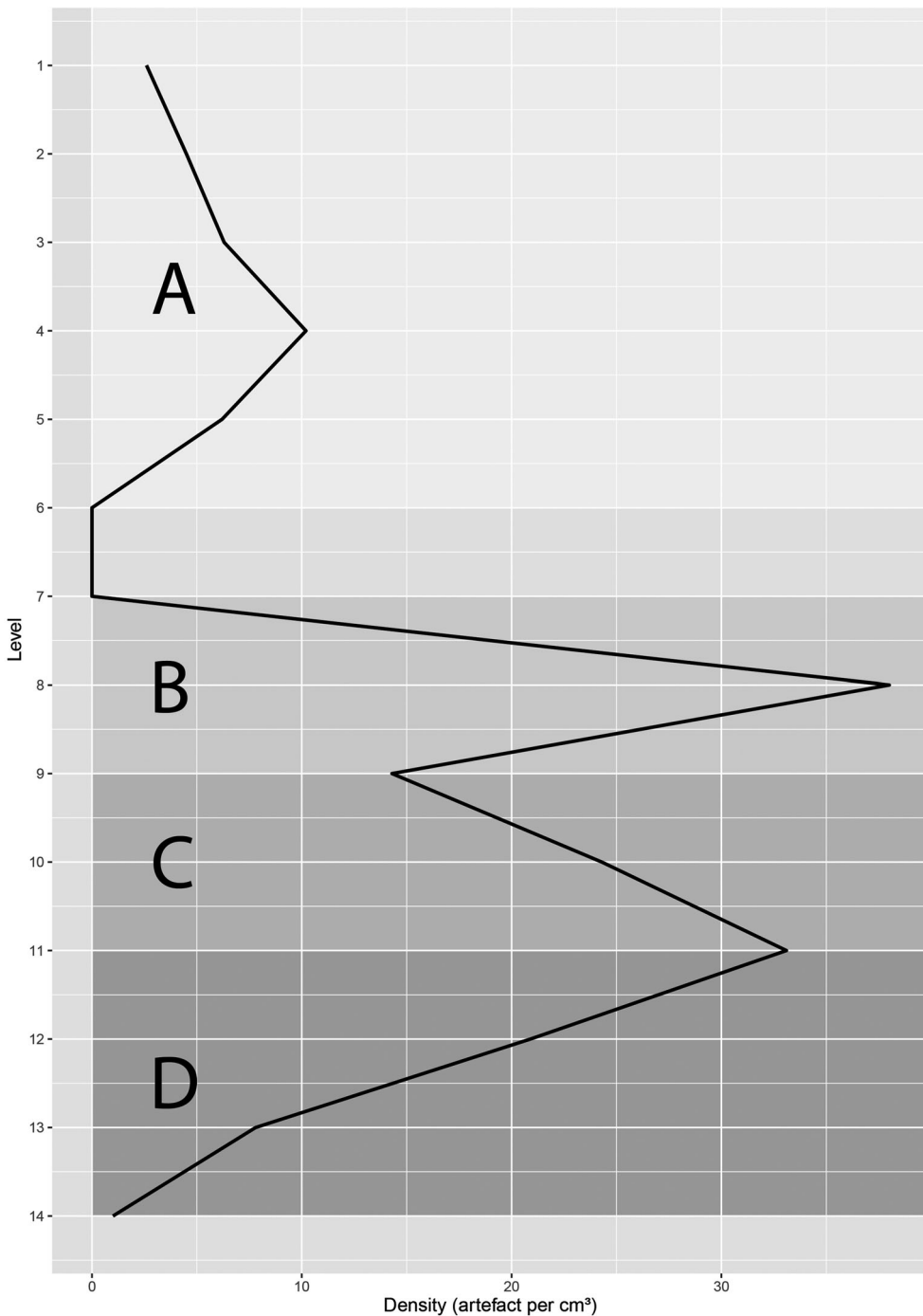


Figure 13. DEN12-A01: artefact density (artefacts per cm³) per excavation level. Capital letters refer to Horizons. The graph was produced using R (R Core Team 2018) and package ggplot2 (Wickham 2016).

A2, which has an age of about cal. AD 1095. These youngest settlement phases are separated by a hiatus of 3000 years from the underlying occupations. Charcoal dating to around cal. AD 170 from a fluvial channel indicates erosional activities around that time, which

may have destroyed archaeological evidences from the intermediate period (2000–1 BC). Horizon B has the broadest range of backed microliths with segments, triangles, trapezes and micro-points. The latter, in particular, characterise the approximately 3000 cal. BC assemblage. The only exceptions are double-micro-points, which are typical of the underlying layer, Horizon C. The relatively high occurrence of burins and fewer scrapers besides backed tools in Horizon C might be a chronological marker or an indication of a broader activity range. The basal, and, up to now, undated, Horizon D is characterised by the virtual absence of formal tools, but has a high number of flakes and bladelets with edge damage that might be use-wear. These patterns are not applicable to a bigger geographical scale.

While a lack of backed microliths is no reason to exclude a site from the Later Stone Age, their presence in combination with blade production is an indicator for the LSA. Geometric backed microliths are abundant within Holocene LSA assemblages. In the Pleistocene Later Stone Age, they are not present. These changes might be valid for the Horn of Africa, but the database is still too weak for well-grounded conclusions.

The comparison with other stone tool assemblages shows a high inter- and intra-site variability throughout the Holocene. Concerning our second research question, characteristics specific to the highlands are not visible in terms of the lithic artefacts found. The restricted range of tool types with an emphasis on micro-points and segments nevertheless points to short-term stays by small groups of hunters, as is also suggested by the fact that only wild species are present among the faunal remains recovered. Hunting trips might have been combined with other activities, such as the procurement of obsidian. Collecting honey and plants is also at least conceivable. In this way, foragers would have exploited a wide range of resources by taking advantage of different nearby altitudinal ecozones. A corresponding pattern has been proposed for Mount Damota, located in the southwestern highlands of Ethiopia (Vogelsang and Wendt 2018). In terms of animal exploitation, herding seems to have reached this area very late, as has already been highlighted in Kaffa and Wolayta, areas where the incorporation of livestock and ceramic production took place in longstanding and highly conservative systems (Lesur *et al.* 2014).

Finally, the correlation of the settlement phases with palaeoclimatic data for Ethiopia (Foerster *et al.* 2015; Trauth *et al.* 2015) verifies human presence at Mount Dendi during the phase of aridification at the end of the African Human Period. Climatic evidence from two cores from the Dendi crater lakes shows that the effect of this climatic deterioration seems to have been less distinct on the local scale (Wagner *et al.* 2018). Considering our third research question, this therefore implies that the Dendi caldera was indeed a refugium. It would be interesting to check if this is a special case or more broadly characteristic of high-altitude areas in the region. A new Ethiopian-European research project ‘The mountain exile hypothesis — How humans benefited from and re-shaped African high-altitude ecosystems during Quaternary climate changes’ (DFG FOR 2358) is currently dealing with this question using the example of the Bale Mountains (Reber *et al.* 2018).

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