*Du Big Dry à l'Holocène en Afrique de l'Est et au-delà*
*From the Big Dry to the Holocene in Eastern Africa and beyond*
Actes de la séance de la Société préhistorique française de Toulouse (septembre 2019)
Textes publiés sous la direction de Joséphine Lesur, Jessie Cauliez, Lamya Khalidi,
Laurent Bruxelles, Isabelle Crevecoeur, David Pleurdeau, Chantal Tribolo et François Bon
Paris, Société préhistorique française, 2023
(Séances de la Société préhistorique française, 20), p. 75-94
www.prehistoire.org
ISSN : 2263-3847 – ISBN : 2-913745-93-8

# Living the High Life? Prehistoric Occupation of High-Altitude Environments in Ethiopia

# *Une vie de haute volée ? L'utilisation des environnements de haute montagne en Éthiopie*

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**Abstract:** On the one hand, high-altitude mountain habitats are often regarded as unfavourable for sustained human occupation, due to the challenging environmental stress in these landscapes for the human body. On the other hand, tropical highlands in Africa are suggested as potential refugia during times of climate deterioration. However, archaeological surveys in these areas were virtually non-existent. Extensive archaeological research during the last decade in the high-altitude regions of Ethiopia has fundamentally changed our understanding of prehistoric occupations in these areas. It is now known that these ecozones had been part of the human habitat at least since the emergence of *Homo sapiens*. High altitude landscapes were used for short-term, task-specific trips of small groups. However, they have also been used for longer periods as regular settlement places. The advantages of high-altitude biomes are the relative abundance of water and compressed altitudinal ecozones offering a wide spectrum of natural resources. For these reasons, highlands have also been used as retreats during times of environmental stress. However, climatic deterioration was not the main trigger for the occupation of high-altitude regions. They were also used during favourable environmental conditions as part of larger settlement areas that also included lowland regions or were at least part of exchange networks.
**Keywords:** Ethiopia, high altitude environment, Early Stone Age, Middle Stone Age, Later Stone Age, refugium, landscape archaeology.

**Résumé :** Les habitats de haute montagne sont souvent considérés comme défavorables pour une installation permanente, à cause du stress subi par le corps humain dans ce type d'environnement. Cependant, les hautes terres tropicales africaines sont perçus comme des refuges potentiels pendant les périodes des détériorations climatiques. Par ailleurs, les prospections archéologiques dans ces régions sont quasiment inexistantes. Des recherches archéologiques extensives menées depuis une dizaine d'années dans les régions des hauts plateaux d'Éthiopie ont fondamentalement changé notre compréhension des occupations dans ces zones. On sait maintenant que ces domaines biogéographiques font partie des habitats humains au moins depuis l'apparition d'*Homo sapiens*. De petits groupes y faisaient des excursions de courte durée pour y pratiquer des activités spécifiques, mais, régulièrement, ils y effectuaient aussi des séjours de plus longue durée. Les avantages des biomes de haute altitude sont l'abondance relative d'eau et des étages biogéographiques compressés qui présentent une vaste gamme des ressources naturelles. Pour cette raison, les hautes terres étaient utilisées aussi comme lieux de repli pendant les périodes de stress environnemental. Cependant, elles ont été aussi utilisées pendant des périodes aux conditions environnementales plus favorables, uand elles faisaient partie soit de régions d'occupation plus vastes avec des plaines, soit de réseaux d'échanges..
**Mots-clés :** Éthiopie, environnement de haute altitude, Early Stone Age, Middle Stone Age, Later Stone Age, refuge, archéologie du paysage.

## INTRODUCTION: THE AFRICAN HIGHLAND DICHOTOMY

There is an interesting discrepancy regarding the occupation of high-altitude regions. On the one hand, high altitude mountain habitats are challenging for human physiology and therefore regarded as unfavourable for sustained human occupation (fig. 1, B). The most prominent phenomenon is the prevalence of high-altitude hypoxia. Other stresses and strains are increased solar radiation, water loss and metabolic rates (West et al., 2007). On the other hand, orographic rainfall, reaching a maximum at an altitude between 2,000 m and 2,500 m (Camberlin, 2019) and the ability to capture atmospheric water from fog and low-level clouds (Los et al., 2019) are the cause of higher precipitation rates in the tropical highlands of Africa in comparison to the surrounding lowlands. Due to the catchment of runoff water and high storage capacities, mountains act as important water reservoirs (fig. 1, C and fig. 2, C). Therefore, these regions are considered as favourable areas and potential refugia during arid periods such as the Last Glacial Maximum (LGM; Basell, 2008; Brandt et al., 2012; Steward and Stringer, 2012).

This discrepancy and the general character of prehistoric human occupations of Ethiopian high-altitude regions are the topics of this paper. In doing so, we will look at three major questions:

- What is the earliest evidence for human exploitation of the Ethiopian high-altitude environments?
- Is climate a trigger for sustained occupation and were highlands used as a retreat (refugium) during arid periods?
- Are high altitude regions only used for specific tasks, such as hunting and collecting of raw materials, plants and honey or are they regular settlement areas?

Prior to that, a definition of our understanding of two key-terms is necessary.

High altitude regions (highlands): the term "high altitude regions" can be defined using different parameters. For the purpose of this paper, the impact of high altitude on the human body is the salient factor and therefore, the term is used from A. J. Murray (2016): "The defining feature of the high altitude environments is sustained hypobaric hypoxia." Native lowlanders experience altitude oxygen starvation from an elevation of 2,500 m above sea level (m a.s.l.) onwards but altitude sickness and mild tissue hypoxia are already common at around 2,000 m a.s.l. (Dietz and Hackett, 2013). This is also in round terms the lower limit for our classification of archaeological sites as a high-altitude site(1).

Refugia: we use the term in its initial conception for "regions where elements of the modern flora and fauna might have survived glacial periods with greatly reduced numbers and distribution" (Bennet and Provan, 2008, p. 2450). Broadly synchronous to glacial periods at high latitudes and comparable in their effects on species distribution and abundance are arid to hyper-arid environmental conditions in tropical regions. Classical refugia are areas around the margins of an ecological region. One particular response to climatic change, which is of special importance for this paper, is altitudinal shifts in mountainous regions (Bennet and Provan, 2008, p. 2451).

The hypothesis of a Late Pleistocene human refugium in the south-west Ethiopian highlands was first formulated by S. Brandt and colleagues (2007) and discussed for the Greater East African Region by L. S. Basell (2008). Other related research examines the role of refugia in the human expansion out-of-Africa from an evolutionary biogeographical perspective (Stewart and Stringer, 2012).

## 1. WHEN DID HOMININS FIRST OCCUPY TROPICAL HIGHLANDS?

Due to the challenges of highlands for the human physiology, it is parsimonious to assume that humans would only be pushed into such conditions by decreasing terrestrial resources in the lowlands following rapid population increase or climate crisis. In general, the colonization of highlands is regarded as a recent phenomenon (e.g. Aldenderfer, 2014) and high-altitude ecosystems are perceived as natural environments, unaffected by human influence. Even recent global change synopses (Ellis et al., 2010) state low level and late human transformation for tropical highlands. This general assumption had first been contradicted by evidence from the site Gadeb (De La Torre, 2011) that is now supported by recent discoveries from Mount Dendi.

### 1.1 Stone Age occupation of Mount Dendi

Approximately 100 km west of Addis Ababa on the west central Ethiopian plateau rises Mount Dendi, a silicic volcanic complex with a maximum altitude of 3,270 m a.s.l (fig. 1, A1 and fig. 3, C). A notable feature of the almost elliptical caldera is the presence of two lakes formed within the central depression (fig. 3, A and B). A large number of springs in the steep slopes of the caldera drain into the lakes. The current aquatic abundance is recharged by the smaller "Belg" rains from February to April and the heavier "Keremt" rainy season from June to September with an annual mean precipitation of about 1,400 mm (Degefu et al., 2014).

An archaeological survey associated with coring activities in the crater lakes by the University of Cologne's CRC 806 research group in April 2012 (Wagner et al., 2018), led to the first discovery of Stone Age artefacts in the Dendi caldera and initiated further surveys in 2012 and 2015. The survey routes covered the western half of the caldera and the surrounding slopes, resulting in 82 archaeological sites ranging typologically from Early to Later Stone Age (fig. 3, B). In addition, three obsidian outcrops have been located, which have been exploited for the production of the prehistoric stone

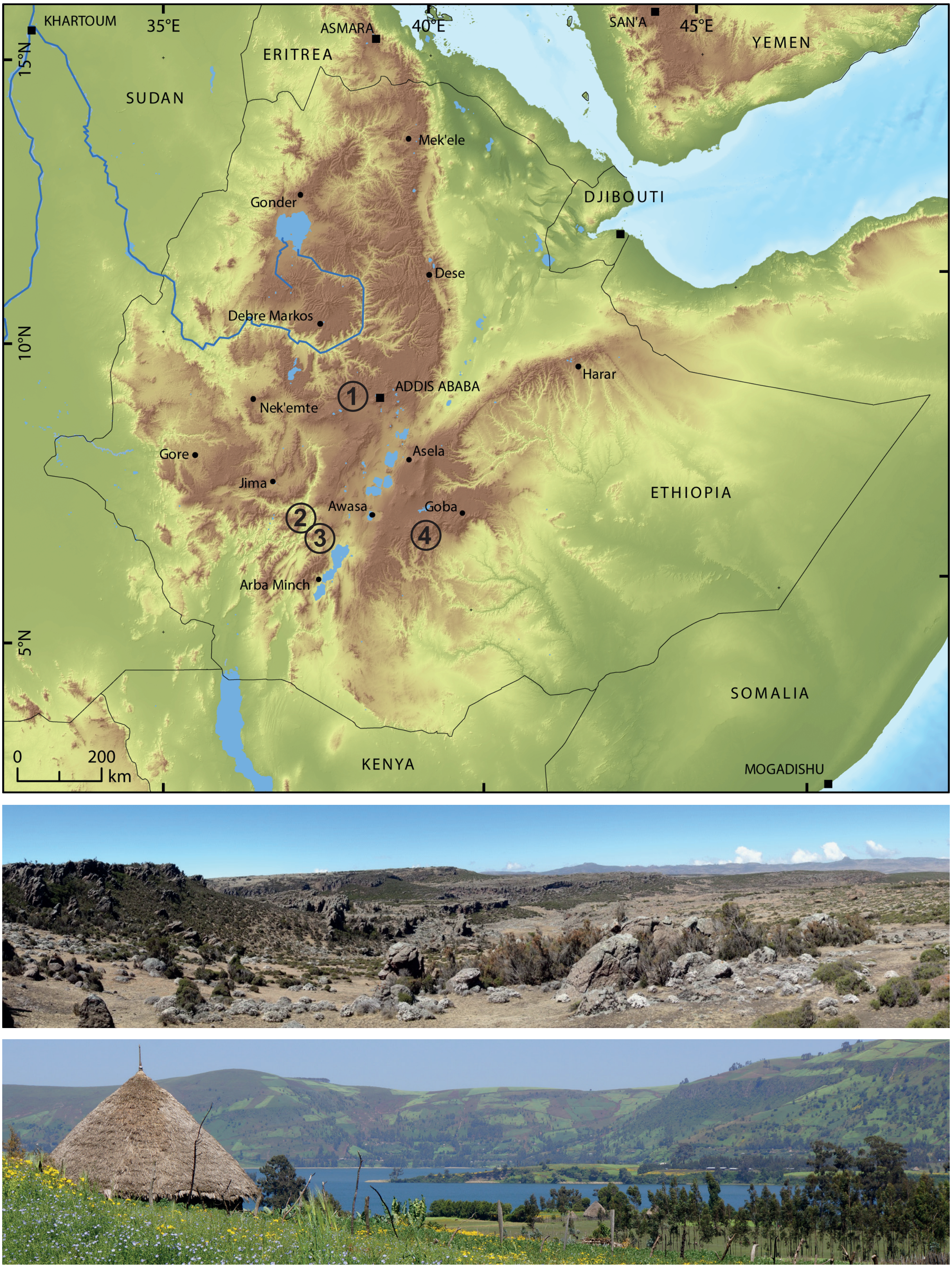


**Fig. 1** – Regional map with sites listed in text: Mount Dendi (A1), Mount Sodicho (A2), Mount Damota (A3), Bale Mountains (A4); the harsh environment of the Sanetti Plateau/Bale Mountains (B; ~ 4,000 m a.s.l.); flowering meadows at the shores of the Dendi lakes (C; ~ 3,000 m a.s.l.).

***Fig. 1*** *– Carte de la région avec les sites mentionnés dans le texte : mont Dendi (A1), mont Sodicho (A2), mont Damota (A3), montagnes du Bale (A4) ; l'environnement rude du plateau Sanetti, montagnes du Bale (B ; ~ 4 000 m d'altitude) ; prairies fleuries sur les rives des lacs de Dendi (C ; ~ 3 000 m d'altitude).*

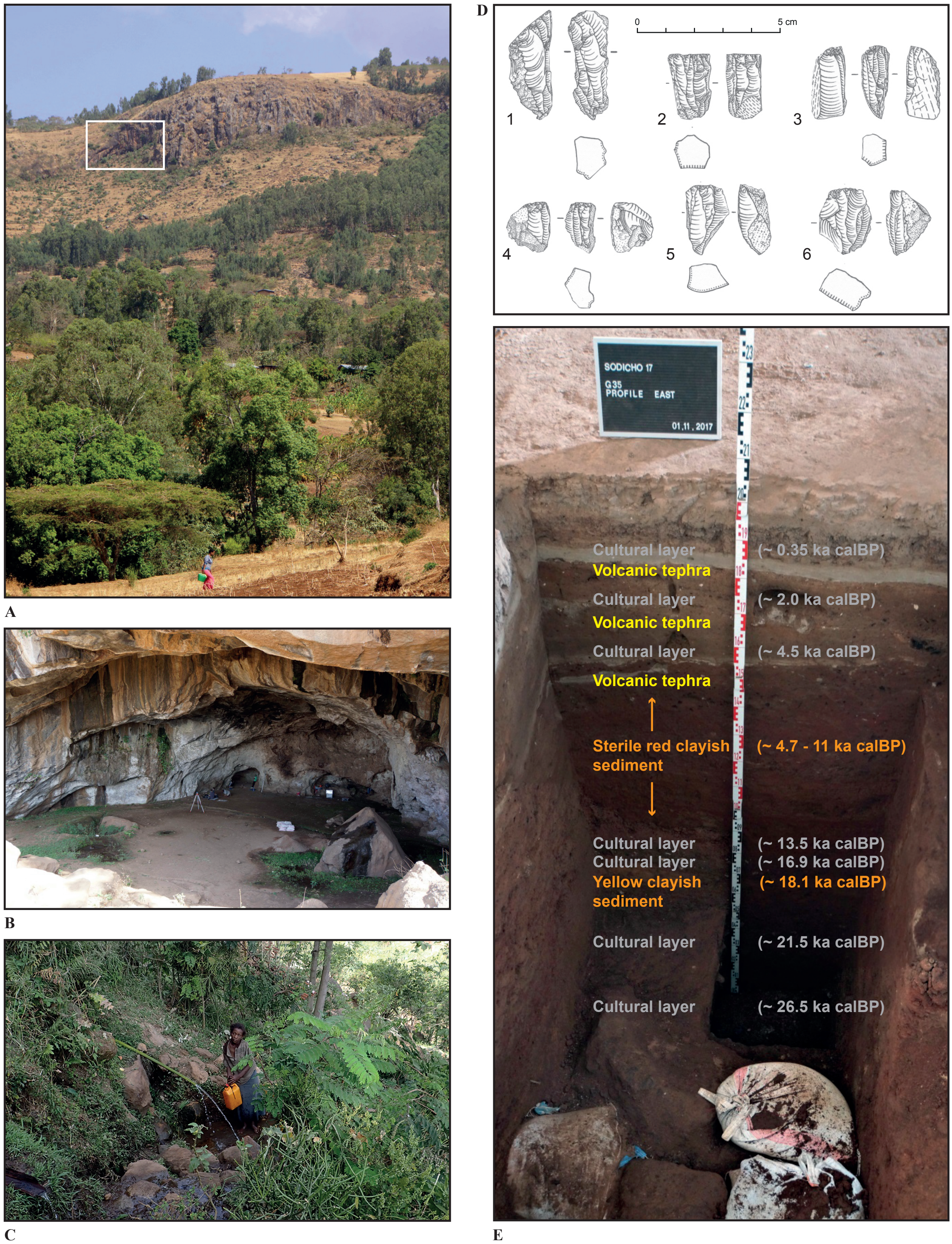


**Fig. 2** – Mount Sodicho: The rock shelter Sodicho (A; white rectangle); interior of the rock-shelter with excavation trench (B); one of the many springs of Mount Sodicho (C); bladelett cores from the Late Pleistocene layers (D); profile G35 east with a sequence of cultural layers, volcanic tephra and clayish sediments (E).

***Fig. 2** – Mont Sodicho : l'abri Sodicho (A ; rectangle blanc) ; intérieur de l'abri avec la coupe du secteur fouillé (B) ; une des nombreuses sources du mont Sodicho (C) ; nucléus à lamelles provenant des couches du Pléistocène supérieur (D) ; coupe G35 est avec une séquence de couches anthropiques, de tephra volcanique et de sédiments argileux (E).*

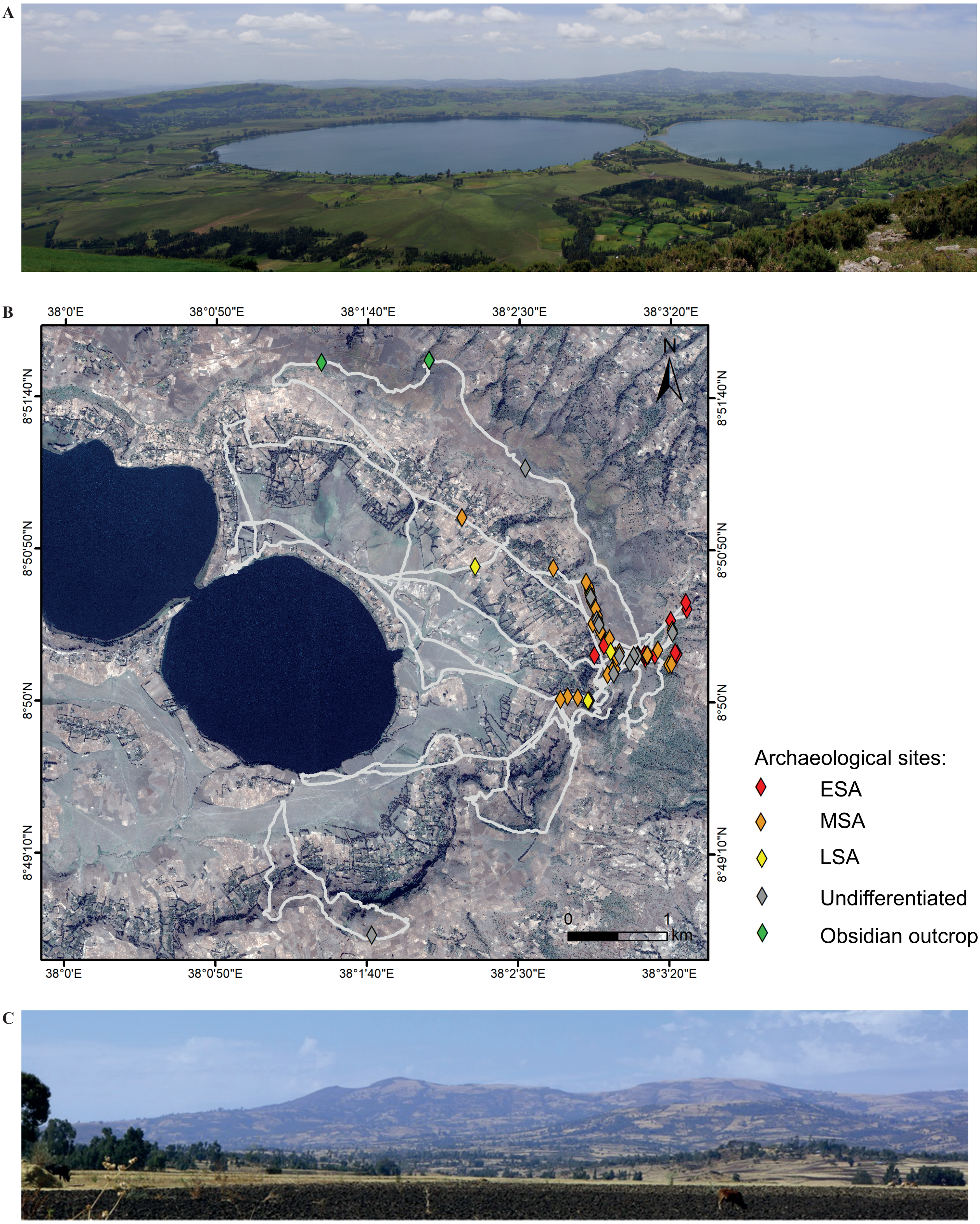


**Fig. 3** – Mount Dendi: View of the two crater lakes within the caldera (A); map showing the survey routes and the location of archaeological sites (B); view of Mount Dendi, looking west (C).

***Fig. 3** – Mont Dendi : vue des deux lacs de cratère à l'intérieur de la caldeira (A) ; carte montrant les itinéraires de prospection et l'emplacement des sites archéologiques (B) ; vue du mont Dendi, vers l'ouest (C).*

artefacts (pers. comm. B. Nash). Obsidian is nearly the exclusively used raw material to produce stone artefacts during all Prehistoric periods.

### *1.1.1 The Later Stone Age occupation of Mount Dendi*

The Later Stone Age (LSA) is the period of the most recent prehistoric occupation but is only represented by three surface sites. Although diagnostic LSA single finds have been hard to detect because they are generally small in size, the absence of larger scatters of artefacts from this period suggests only ephemeral human presence on the mountain. However, a test excavation in the small rock-shelter DEN12-A01 (fig. 4, A) proves repeated habitation in a high-altitude region from the Early Holocene until historical times in the uppermost layer A1 (fig. 4, B and D; Schepers et al., 2020). The basal, and up to now undated, horizon D has a probable *terminus post quem* of 10200 cal. BP. 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 rock shelter sediments, suggesting a later deposition of the preserved layers. The oldest date comes from horizon C (7360 years cal. BP) and is of special interest, because there is no published contemporaneous archaeological assemblage from the Ethiopian Rift-Valley or the southwest Ethiopian highlands (Foerster et al*.,* 2015). The date verifies the settlement of the shelter in between two drier spells of the AHP. Starting around 6000 years ago increasing aridification leads to the end of the African Humid Period (AHP). Two dates of 4720 and 5390 cal. BP classify horizon B in this phase. LSA horizon A2 has an age of about 900 years cal. BP, that also dates the earliest appearance of pottery at the site and is separated by a hiatus of 3000 years from the underlying occupations. Charcoal dates around 1800 years cal. BP from a fluvial channel indicate erosional activities around that time that might have destroyed archaeological evidence from the intermediate period.

The surface and the basal archaeological assemblages (A1 and D) are characterized by the virtual absence of formal tools but a high number of flakes and bladelets with edge damage that might be the result of use-wear. Typical for the other three archaeological horizons is a restricted spectrum of tool types with an emphasis on micro-points and segments (fig. 4, C), which were used as projectile insets and are indicative of hunting equipment (e.g. Clark, 1977; Lombard and Pargeter, 2008; Lombard, 2015). The restricted tool-spectrum points to short-term stays of small groups of hunters, as also suggested by the presence of only wild species among faunal remains. Hunting trips might have been combined with other activities, such as collecting honey and plants or the sourcing of obsidian from the raw material outcrops on top of the mountain. In this way, foragers may have exploited a wider spectrum of resources than the archaeological record suggests.

The correlation of the settlement phases with the general climatic model for south-western Ethiopia verifies the human presence at Mount Dendi during the phase of aridification at the end of the AHP (fig. 4, D). Climatic evidence from two cores from the Dendi crater lakes shows that the effect of this climatic deterioration seems to be less distinct on the local scale (Wagner et al., 2018). This is an interesting advantage of location and might explain the occupation of highlands if it is a general effect that could be confirmed from other high-altitude regions.

### *1.1.2 The Middle Stone Age occupation of Mount Dendi*

A total of 34 sites were classified as Middle Stone Age (MSA) based on stone tool typology especially different kinds of points (fig. 5, C1 to C3 and C5), and based on technological features, such as Levallois reduction strategy and blade production. Remarkable is the distribution of MSA sites in a row like pearls on a string along the 3,000 m contour line. If this connection reflects an old shoreline of the lake(s) has still to be clarified (fig. 5, A).

The characteristic tool category "points" can be subgrouped into bifacially retouched points (n = 10), unifacially retouched points (n = 9), edge-retouched points (n = 3) and unretouched Levallois-points (n = 5). Except for the edge-retouched points, the functionality of all other points as projectile armatures is suggested by a simple ballistics measure, the Tip Cross-Sectional Area (TCSA; see Shea, 2006, p. 224, fig. 1). The values for the facially retouched points and the Levallois-points are within the range of spearheads (Thomas, 1978; Sisk and Shea, 2011). A use as hunting equipment may be supported by the numerous single finds of points that might be evidence of unsuccessful throws. Comparable to the LSA period, the area seems to have been predominantly used for hunting expeditions. However, some larger clusters of MSA finds with a heterogenous spectrum of tool types, indicating diverse activities, might be the result of longer settlement events.

### *1.1.3. The Early Stone Age occupation of Mount Dendi*

The occurrence of large bifacially retouched tools, such as different forms of handaxes (fig. 5, E), but also cleavers, scrapers and bifacial knifes resulted in the classification of 21 sites to the Early Stone Age (ESA) period. ESA sites are especially abundant in areas affected by gully erosion (fig. 5, B and D). Of special importance is the site DEN12-A02 with large bifaces partly in stratigraphical context that is located at an altitude of 3,000 m a.s.l. (Vogelsang et al*.,* 2018). Road construction created three artificial terraces that cut the artefact bearing deposits (fig. 6, A). The provenience of the ESA stone tools from the wall of the middle terrace could be verified by the excavation of a test-trench that yielded several flakes and one handaxe (fig. 6, B and D). The spectrum of the standardised tool-types is heterogenous, with different forms

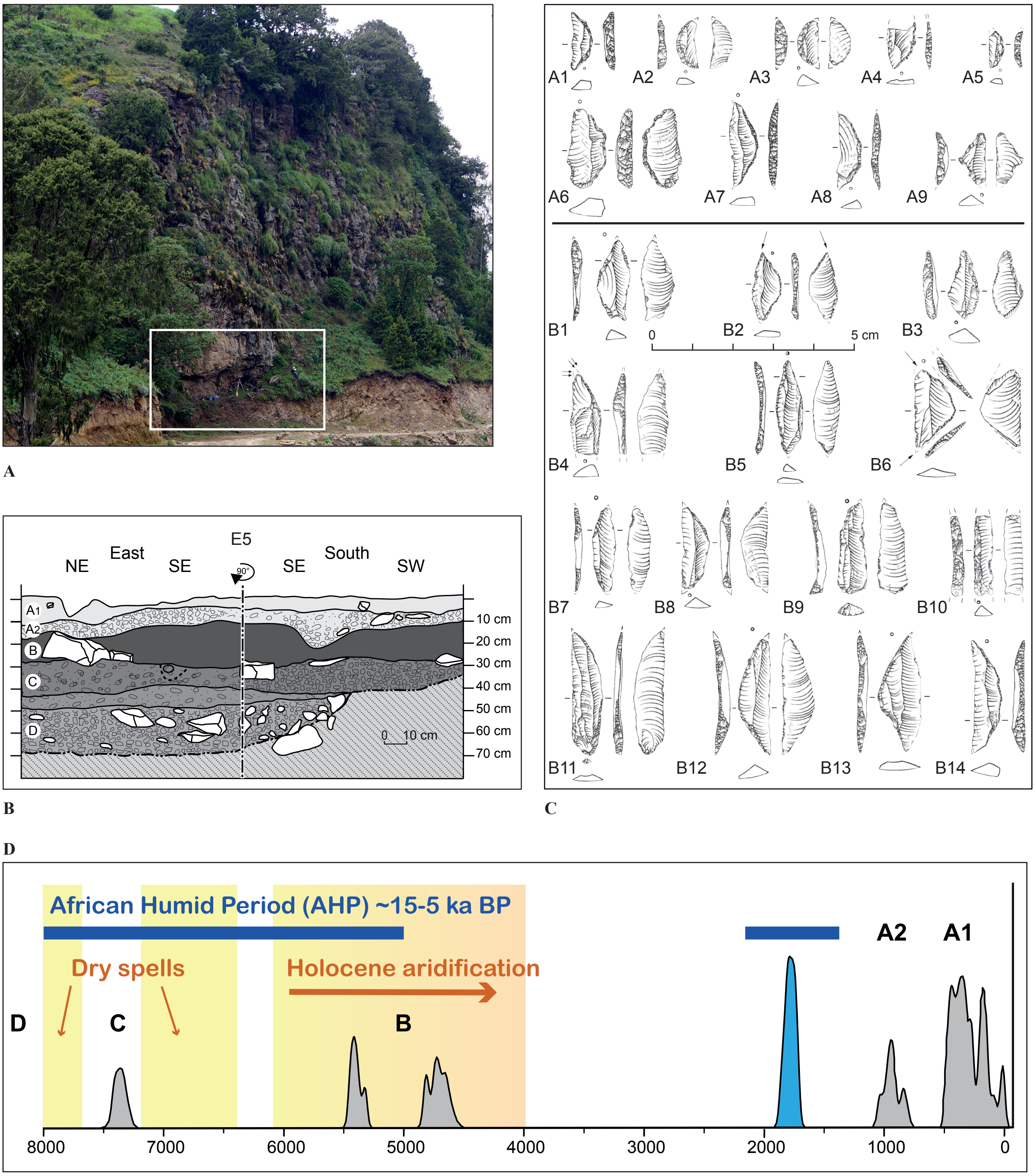


**Fig. 4** – Mount Dendi: A) the rock shelter DEN12-A01 (white rectangle); B) section drawing with cultural layers A1 to D; C) backed microliths horizon A and B: micro-segments (A1, A2 and A4), micro-segment with crossed backing (A3), very small segment (A5), large segment (A6), long micro-double-points, unilaterally retouched (A7, A8, B5, B12 and B14), isosceles triangles (A9, B6 and B13), elongated trapeze, isosceles with straight truncation (B1, B11 and B8), segment with curved end (B2), alternately, bilaterally retouched micro-point (B3), long micro-points, unilaterally retouched (B4, B7 and B9), (broken) backed blade (B10); D) distribution of AMS-dates and their correlation with climatic phases (graph with CalPal 2016.2: Weninger and Jöris, 2008; climatic data: Foerster et al., 2015).

***Fig. 4** – Mont Dendi : A) l'abri DEN12-A01 (rectangle blanc) ; B) coupe avec les couches anthropiques A1 à D ; C) pièces microlithiques à dos couches A et B : micro-segments de cercles (A1, A2 et A4), micro-segment de cercle à dos croisé (A3), très petit segment de cercle (A5), grand segment de cercle (A6), micro double pointes longues, retouchées unilatéralement (A7, A8, B5, B12 et B14), triangles isocèles (A9, B6 et B13), trapèzes allongés, isocèles avec troncature droite (B1, B11 et B8), micro-segment de cercle avec extrémité recourbée (B2), micro-pointe retouchée de façon alterne (B3), micro-pointes longues, retouchées unilatéralement (B4, B7 et B9), lamelle à bord abattu [brisée] (B10) ; D) distribution des dates AMS et leur corrélation avec les phases climatiques (graphique réalisé avec CalPal 2016.2 : Weninger et Jöris, 2008 ; données climatiques : Foerster* et al.*, 2015).*

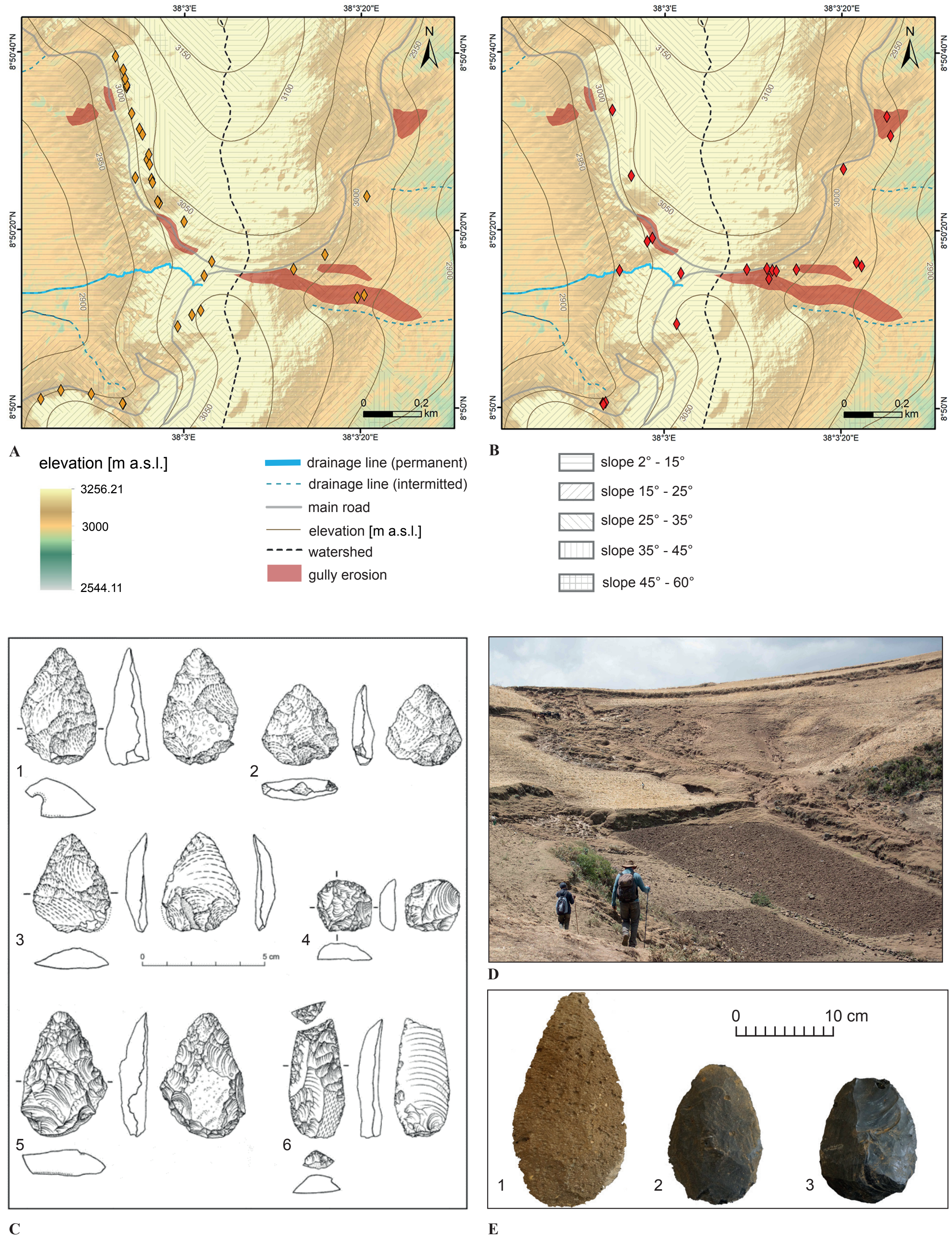


**Fig. 5** – Mount Dendi: Distribution of MSA sites (A); distribution of ESA sites (B); MSA stone tools (C): bifacially retouched points (1 to 3 and 5), Levallois core (4), double side-scraper with steep end-retouch (6); area affected by gully erosion (D); handaxes from surface sites in different states of preservation (E).

***Fig. 5** – Mont Dendi : distribution des sites MSA (A) ; distribution des sites ESA (B) ; industrie lithique du MSA (C) : pointes à retouche bifaciale (1 à 3 et 5), nucléus Levallois (4), racloir double à troncature abrupte (6) ; zone affectée d'une érosion par ravinement (D) ; bifaces provenant de la surface, en différents états de conservation (E).*

of handaxes, a cleaver, two leaf-shaped scrapers and one backed knife (fig. 6, C). However, the similar operational sequence (*chaînes opératoires*) of all modified tools indicates a closed association of the finds. Facial shaping was first finished on one face and then on the other. In a last step, lateral thinning and edge retouch were performed for the preparation of the working edges (Vogelsang et al., 2018, fig. 4). The technological similarity of the production process suggests a close temporal connection of the assemblage. The diversity of tools speaks against an interpretation as a task specific site, but is more in favour of a settlement site. In addition, the heterogeneous tool-type spectrum gives a first indication for the chronological classification of the assemblage to the Late Acheulean. This is supported by the high level of knapping skills and the comparatively small size of the artefacts (Vogelsang et al., 2018, p. 306-309). The most approximating assemblage in Ethiopia is the site Mieso 31 (De La Torre et al., 2014) that is dated around 212 ka ago and marks the latest evidence of the ESA in Eastern Africa. The earliest securely dated site is Hugub Bed with an age of 600 and 500 ka (Gilbert et al., 2016). DEN12-A02 can roughly be dated in the range between these two limits, which makes it the highest located Acheulean site worldwide and marks the beginning of the settlement of high-altitude regions. Consequently, hominins might have settled in high altitude regions already before the advance of *Homo sapiens sapiens*. This would question the concept of modern humans' superiority in a wide range of domains, such as subsistence strategies and hunting equipment in comparison to extinct hominins.

## 2. WERE HIGHLANDS USED AS A RETREAT (REFUGIUM) DURING ARID PERIODS?

Today, the south-west Ethiopian highlands are a region classified as humid with an annual precipitation of 1,189-1,711 mm, that is in some parts even higher (Berhanu et al., 2013, table 3, fig. 6). The south-west Ethiopian highlands refugium hypothesis is based on the assumption that the annual precipitation, which is the highest average amount in the Horn of Africa today and are significantly higher in this region than in the surrounding areas, had also been relatively higher during arid phases in the past. This supposition is supported by climate modelling (Willmes et al., 2017) and that would have made the highlands an ecologically favoured region into which humans could retreat. However, archaeological evidence for this hypothesis is only scarce and was up to now confined to the Holocene (Foerster et al., 2015). Contrarily, important Pleistocene archaeological sequences, such as the stratigraphies from Mochena Borago rock shelter (Brandt et al., 2012 and 2017) and Goda Buticha (Pleurdeau et al., 2014; Tribolo et al., 2017) document an occupational gap of about 20000 years roughly between 30000 and 9000 BP, which encompasses the hyper-arid phase of the LGM.

### 2.1. Sodicho rock shelter

First evidence of archaeological settlement layers closing this gap comes from Sodicho rock shelter. The site is located about 225 km southwest from the capital Addis Ababa at the margins of the southern Ethiopian plateau to the western central and southern main Ethiopian Rift (fig. 1, A2).

#### *2.1.1 Topography and research history*

Sodicho rock shelter is situated on the southern flanks of Mount Sodicho (max. altitude 2,025 m a.s.l.), a volcano belonging to the Wagebeta Caldera Complex, which is one of the major trachytic volcanic complexes formed along the Rift's margins during the Plio-Pleistocene (Corti et al., 2013; Abbate et al., 2015). The steep cliff at this side of the volcano was most probably formed by a lateral blast of the crater wall (pers. comm. O. Bödeker). At an elevation of 1,910 m a.s.l., the shelter is located only a few meters below the edge of the plateau (fig. 2, A) and offers an excellent view over the surrounding landscape (Hensel et al., 2019, p. 208). Mount Damota and the Omo River Valley can be seen from the opening of the shelter under good visibility conditions. The mountain is flanked by two streams that drain into the Omo River about 11 km to the southwest. The site is located only about 40 km north-west from Mount Damota with the important archaeological key-site Mochena Borago.

In 2015, two one square-metre test-trenches were excavated in the north-western part of the shelter. Trench E41 was situated in one of the chamber-like caves in the rear-wall of the shelter, but excavations where soon constricted by rocks, which are most probably part of the bedrock. Therefore, in the subsequent three years excavations focused on trench F35 that was expanded by three square-metres (F34, G34, G35) and reached a maximum depth of 2.1 metres below surface in quarter-square G35/SE without reaching bedrock (fig. 2, B).

#### *2.1.2 Settlement phases*

The stratigraphy can be divided in two large sediment packages containing archaeological layers, which are divided by a 60 cm thick sterile deposit of red clayish sediment (fig. 2, E). Despite few potsherds and bones from historical times, the main two settlement layers of the upper part date around 4500 and 2000 years cal. BP respectively and contain LSA lithic assemblages, characterized by microlithic backed tools. The main difference between the two assemblages is the emergence of pottery in the younger assemblage. The sterile layer of red clay is bracketed by radiocarbon ages of around 10900 cal. BP and 4700 cal. BP, which roughly corresponds to the AHP However, the nature and duration of deposition are still unclear, but it might indicate a period when parts of the highlands had been too moist for human occupation.

Repeated occupation of the shelter is testified between 27000 and 13500 cal. BP. Preliminary analysis of the lithic assemblages shows a surprising uniformity of the stone artefacts. All assemblages are dominated by the production of bladelets and the analysed sample completely lacks any retouched tools (fig. 6, D). Settlement phases dating around 13500, 16900 and 21500 cal. BP coincide with the arid or rather hyper-arid climatic phases of the Older Dryas, Heinrich-1-event and LGM This is the first evidence for the use of highlands as a refugium during times of severe environmental stress in the lowlands.

## 3. PREHISTORIC LAND USE PATTERNS AND SETTLEMENT SYSTEMS IN MOUNTAINOUS REGIONS

The example of Sodicho rock shelter testifies to the occupation during arid periods, but humans would not only be pushed into high altitude environmental conditions by decreasing land resources in the lowlands following ecological changes. Highlands seem to have been part of larger settlement systems also during periods of climatic favourable conditions. The Prehistoric occupation of Mount Damota is a good case-study to answer the question about the general advantages of including mountainous regions into a hunter-gatherer habitat.

### 3.1 Mount Damota and the Mochena Borago rock shelter

Mount Damota is located 320 km south of the capital Addis Ababa at the intersection of the southwest Ethiopian highlands with the main Ethiopian Rift Valley (fig. 1, A3). The dormant trachytic volcano rises steeply from its surrounding flanks and offers from its peak (2,908 m a.s.l.) striking views of the central and southern Ethiopian Rift Valley, the Gibe and Omo River valleys, Lake Abaya and the Wolaita/Hadiya highlands. The topography of Mount Damota is dominated by steep slopes and rocky gorges in the mountain ranges (Abbate et al., 2015) and by lower relief topography in the transitional zone descending to the Rift Valley floor. The orographic effect of increased mean annual rainfall also applies to Mount Damota and amounts to 2,000 mm p.a. (Viste and Sorteberg, 2013).

Mochena Borago rock shelter is situated on the southwestern flanks of Mount Damota at ~ 2,200 m a.s.l. The large shelter (almost 70 m wide, 12 m high and 20 m deep) is at the head of a steep ravine, into which a seasonally active waterfall flows over the shelter's mouth (fig. 7, A).

#### *3.1.1 The archaeology of Mochena Borago rock shelter*

Archaeological research by the Groupe pour l'Étude de la Protohistoire de la Corne de l'Afrique (Gepca) in the Wolaita region since 1995 involved extensive excavations of Mochena Borago rock shelter, directed by X. Gutherz, that focused on the Holocene occupation of the site, but also revealed Later Pleistocene deposits in a 1.5 m$^2$ test unit (Gutherz, 2000; Gutherz et al., 2002). Since 2006, the Southwest Ethiopian Archaeological Project (SWEAP) directed by S. Brandt and L. Hildebrand, and between 2009 and 2014, in co-operation with the University of Cologne's Collaborative Research Centre 806 (CRC 806), investigates the Pleistocene deposits of the site (Brandt et al., 2012).

Geomorphological analyses indicate a multiphase, polygenetic accumulation and erosion of sediments deposited through natural and anthropogenic processes (fig. 7, B). The sedimentological evidence points to multiple occupations of the shelter mainly during humid conditions. More than 60 radiocarbon dates on charcoal make Mochena Borago one of the best-dated archaeological sites in Africa (Brandt et al., 2017) and classify the Pleistocene layers to Marine Isotope Stage 3 (MIS 3). Layers older than the radiocarbon "dating barrier" (> 50000 years) most probably reach back to MIS 4. Only one of the two main excavation trenches is partly analysed up to now (Brandt et al., 2012). Remarkable is the continuity of technological and typological attributes of the lithic assemblages of the four occupational episodes, dating between ~ 49400 and 36600 cal. BP (Upper T-Group, S-Group and R-Group). Like all other assemblages presented in this paper, obsidian is the dominant raw-material for the production of stone artefacts. Less frequently used rocks, mainly rhyolite, are 7.5% more prominent only in the Lower T-Group assemblage that is older than 50000 years. The dominance of obsidian is not surprising, because it is an excellent material to produce stone tools (Rapp, 2009) and is available in the vicinity. The main source for the inhabitants of Mochena Borago rock shelter had been the rich obsidian sources at Baantu approx. 20 km south east of the shelter (Brandt et al., 2012), albeit it is an open question whether the intensity of the erosion processes, leading to the exposure of the raw-material had the same intensity during the Late Pleistocene compared with the Late Holocene (Hensel et al., 2019). Nevertheless, it seems highly unlikely that raw material availability was a limiting factor and the reason for the generally small size of the lithics in all assemblages. A further characteristic for the technological attributes of the lithic assemblages is the coexistence of different core reduction strategies, such as centripetal cores (Levallois- and radial cores; fig. 7, C5 and C6) and a heterogeneous spectrum of other flake- and blade cores (single-, double- and multiple platform cores, bipolar cores, irregular cores; fig. 7, C1 to C4). Blade and bladelet production is part of all assemblages and there is a proportional increase and improved technological capabilities over time, although the total blade proportions remain small (Parow-Souchon, 2013). Characteristic modes of secondary preparation are facial retouch and backing that are present in all assemblages. However, there is a clear change in proportion from a predominance of facial retouch in the older assemblages (Upper and Lower T-Group) to a predominance of backed pieces in the two younger stratigraphic units. Unifacial and bifacial points are representative tool types (fig. 7,

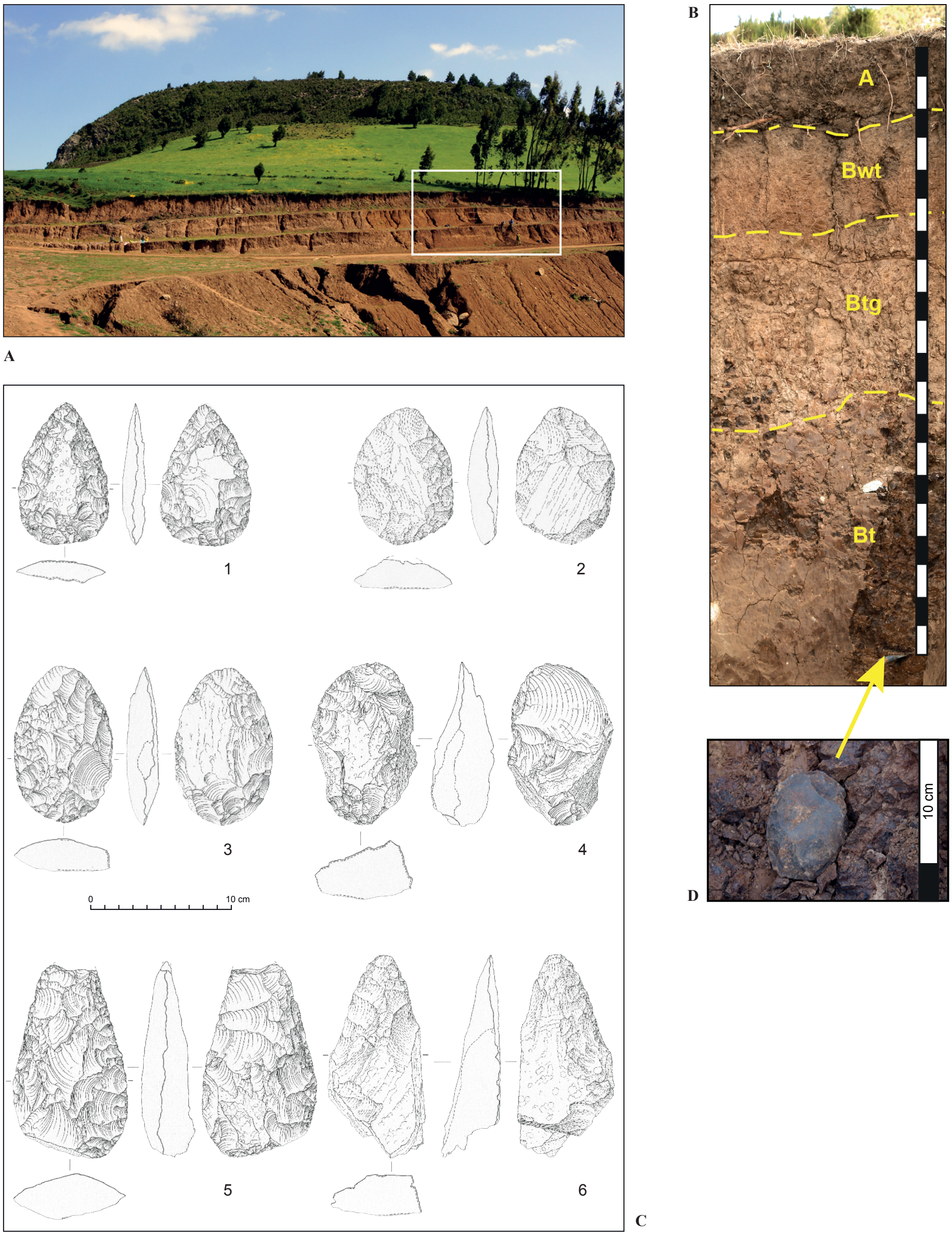


**Fig. 6** – Mount Dendi: The Acheulean site DEN12-A02. View of the three artificial terraces and location of profile B (A; white rectangle, humans as scale); profile DEN12-A02 with four different soil horizons (B). The in situ handaxe (D) was found in the Bt horizon. The surface horizon A is a silty clay loam containing roots and showing a high total organic content (TOC; 4%). TOC and grain size decrease with depth. The lower horizons Bwt, Btg and Bt all classify as clays and have TOC values < 1%. These horizons show blocky soil structure and firm soil consistence. Furthermore, strong accumulation of siliceous clay with voids of manganese-oxides and iron hydroxides in the matrix are evident, also in characteristic micromorphological features such as intact coatings and nodules; DEN12-A02 bifacial tools (C): Flat cordate handaxe (1), bifacial scraper (2), ovate handaxe (3), cleaver-like biface (4), elongated handaxe (5), bifacial knife ("Keilmesser"; 6).

***Fig. 6** – Mont Dendi : le site acheuléen DEN12-A02. Vue des trois terrasses artificielles et de l'emplacement de la coupe B (A ; rectangle blanc, humains servant d'échelle) ; coupe DEN12-A02 avec quatre horizons de sol différents (B). Le biface in situ (D) a été trouvé dans l'horizon Bt. L'horizon de surface A est un loam argileux limoneux contenant des racines et montrant un contenu organique total élevé (TOC ; 4 %). Le TOC et la taille des grains diminuent avec la profondeur. Les horizons inférieurs Bwt, Btg et Bt sont tous classés comme des argiles et ont des valeurs de TOC < 1 %. Ces horizons montrent une structure de sol en blocs et une consistance de sol ferme. De plus, une forte accumulation d'argile siliceuse avec des vides d'oxydes de manganèse et d'hydroxydes de fer dans la matrice sont visibles, ainsi que des traits micromorphologiques caractéristiques, tels que des revêtements intacts et des nodules ; outils bifaciaux DEN12-A02 (C) : biface cordiforme (1), racloir à retouche bifaciale (2), biface ovalaire (3), biface en forme de hachereau (4), biface allongé (5), couteau bifacial (« Keilmesser » ; 6).*

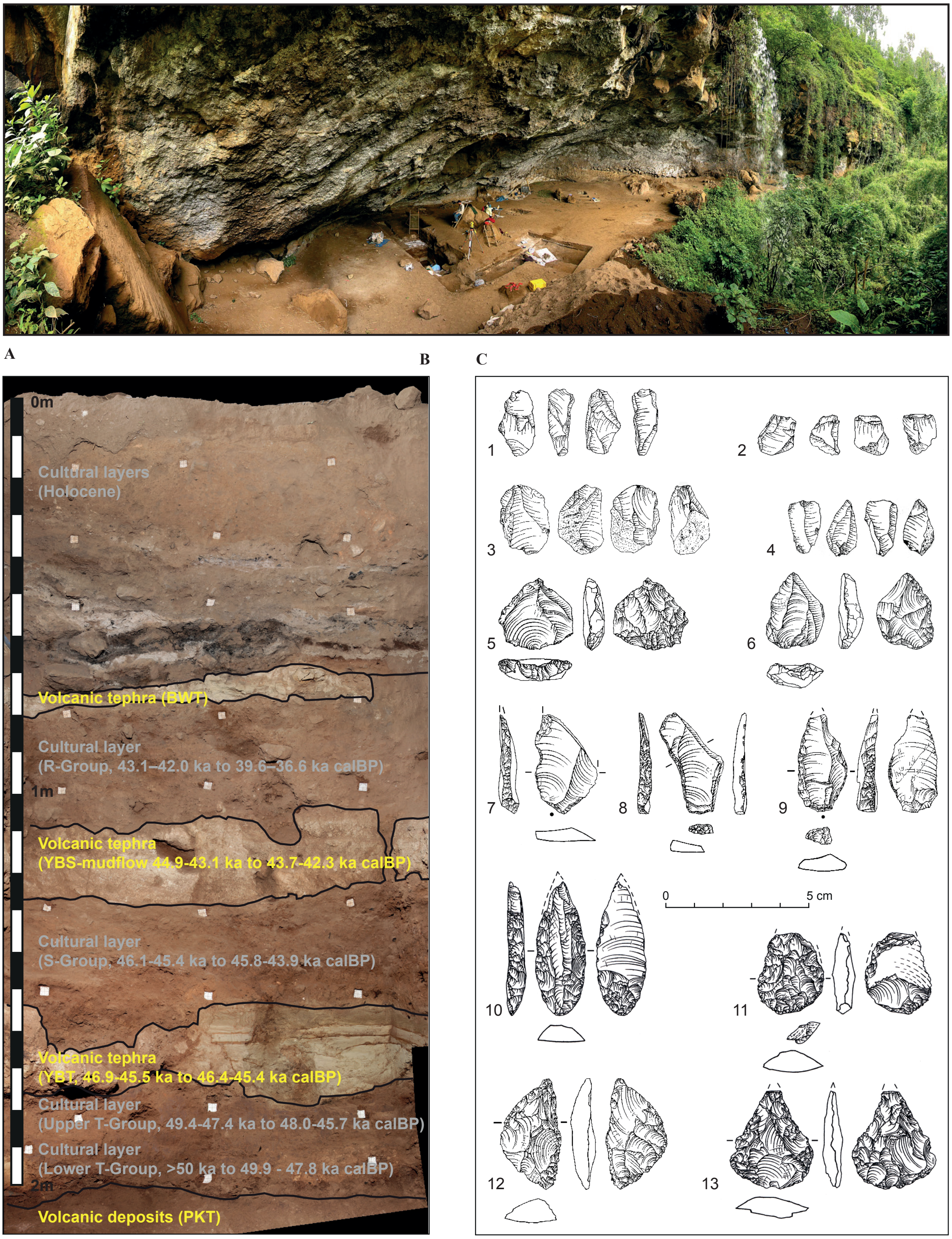


**Fig. 7** – Mochena Borago: View of the rockshelter, with the "Block Excavation Area" (BXA) in the foreground (A); profile H9 West with a sequence of cultural layers and volcanic deposits (B); C) small flake and blade cores (1 to 4), Levallois cores (5 and 6), backed pieces (7 to 9), bifacially retouched tools (10 to 13).

***Fig. 7** – Mochena Borago : vue de l'abri, avec la « Block Excavation Area » (BXA) au premier plan (A) ; coupe H9 ouest avec une séquence de couches anthropiques et de dépôts volcaniques (B) ; C) petits nucléus à lamelles et à lames (1 à 4), nucléus Levallois (5 et 6), pièces à dos (7 à 9), outils à retouche bifaciale (10 à 13).*

C10 and C13), but not all facially retouched pieces can be classified as points. Especially in the T-Group assemblages, there is a broad spectrum of facially retouched tool types that needs further investigation (fig. 7, C11 and C12). The typological variety of backed pieces is also heterogeneous and unstandardized (fig. 7, C7 to C10). There are pieces with tips formed by backing that might have been used as perforators, small backed sidescrapers, flake fragments with basal or terminal truncation and backed flakes and blades with use-wear on the opposite edge, which suggest that hafting was practiced in SW Ethiopia since the early MIS 3.

### *3.1.2 Mount Damota settlement patterns*

Accompanying the excavations in Mochena Borago, extensive pedestrian surveys covering a total distance of 130 km were conducted in the surrounding of the rock shelter. While Mochena Borago provides a stratified sequence with preservation of charcoal, bones and macrobotanical remains, open-air sites offer a complementary record of human behaviour. In general, open-air sites are more numerous than rock shelters and they represent distinct specific activities, such as settlement, hunting/butchering and raw material procurement. Whereas Mochena Borago's sequence provides crucial benchmarks for the chronological classification of the open-air sites, these, in turn, are the base for a landscape archaeological approach and permit the reconstruction of settlement- and land-use patterns.

The archaeological surveys on Mount Damota attempted to include all different landforms of the area, such as slopes, steep valleys and plateaus, in different altitudes from the foot of the mountain (~ 1,900 m a.s.l.) to the summit (2,900 m a.s.l). For this reason, survey routes followed not only currently used pathways that are often along ridges. Some routes also crossed the flanks of the mountain horizontally, thus covering steep slopes and gorges. Sixty-three archaeological sites were located and classified on the basis of characteristic tool-types to three rough chronological classes, namely MSA (fig. 8, A), LSA and historical period. Data on topographic features and archaeological site attributes aimed to assist reconstruction of settlement systems for different time periods. A detailed description of the methods and results, especially regarding the creation of settlement areas, is presented in Vogelsang and Wendt (2018). The quintessence of the analysis was an intensification of settlement activities from the MSA to the LSA and a different organization of the settlement clusters along the mountain slopes. The LSA sites form one large cluster with interconnected smaller sub-groups. In contrast, the reconstructed MSA settlement areas show a linear, vertical orientation, including different altitudinal belts in a close distance (fig. 8, B). This is interpreted as a land use model that offered short access to numerous elevations-bound ecozones. Small hunter-gatherer groups could exploit a wide spectrum of resources by taking advantage of the different altitudinal biotopes or move in annual cycles to exploit specific resources over a longer period (fig. 8, C). A historical example for the latter case were the Okiek (Huntingford, 1929), who lived in the forested highlands of the Mau escarpment in west central Kenya until deforestation and the change of the land tenure system by government intervention changed the demographics of the area (Blackburn, 1982; Kratz, 1999). The settlement area of an Okiek group consisted of one mountain ridge, on which they move to different forest zones according to three main honey seasons (Dale et al., 2004). The compression of numerous vertical ecozones within a small distance renders long distance annual migration unnecessary. In this respect, tropical highland zones in Africa, such as Mount Damota are an attractive environment even during periods of climatic favourable conditions.

## 4. THE BALE MOUNTAINS AS AN EXAMPLE OF EARLY OCCUPATION OF ALPINE HIGHLANDS

The last section offers a short outlook on further approaches by ongoing fieldwork in the alpine environment of the Bale Mountains. The Ethio-German interdisciplinary Research Unit FOR2358, granted by the Deutsche Forschungsgemeinschaft, was established in 2016 to investigate the hypothesis of an early afro-alpine occupation. The afro-alpine region, also referred to as the African Mountain Archipelago, encompasses the high mountains of Ethiopia and tropical East Africa and is defined by its flora to the altitudinal zone above 3,500 meters (Hedberg, 1951). The Bale Mountains in south-eastern Ethiopia form the largest area of afro-alpine ecosystems in this region (fig. 1, B; fig. 9, A and B). The area was widely perceived as minimally disturbed with only minor and quite recent human impact (Umer et al., 2007; Yohannes et al., 2012) and is characterized by a large number of endemic species.

### 4.1 The Stone Age occupation of the Bale Mountains. First results

A first survey on the Bale Mountain plateau resulted in the location of 331 rock shelters (fig. 9, C), of which 56 were classified as potential archaeological sites (Reber et al., 2018). Up to now, 21 of these sites have been tested by small scale excavations of which three were extended to larger excavation trenches.

More than 37 radiocarbon dates from nine sites, located between altitudes of 3,430 and 4,123 m a.s.l., verify intensive settlement activities during the Holocene with a short gap between 7000 to 5000 years cal. BP. Up to now, there is again the hiatus between 30000 to 10000 cal. BP, which encompasses the period of the Big Dry. However, the sites Weyib and Simbero have an age of about 14000 years cal. BP and are two exceptions to this rule and may indicate that the missing evidence is based on the still preliminary research status. An early

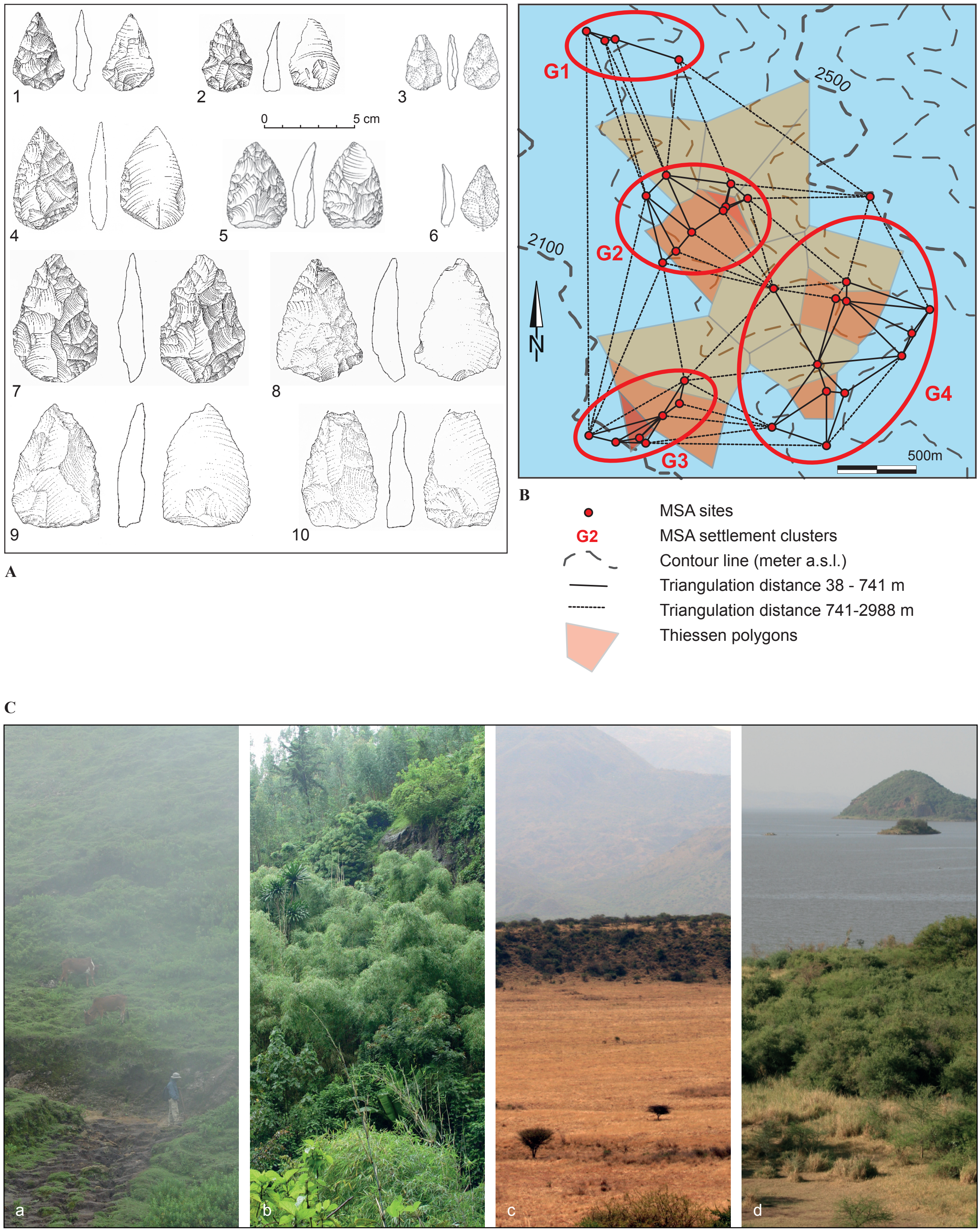


**Fig. 8** – Mount Damota: A) facially retouched points from MSA surface sites; B) MSA settlement cluster (G1-G4); C) ecological zones on and around Mount Damota: a = highland zone (dega; ~ 2,900-2,600 m a.s.l.), cool and moist with Afromontane vegetation (shrubs and grassland), b = mid-altitude zone (woyna dega, < 2,600-1,500 m a.s.l.), warmer and slightly drier, bamboo thickets and woodlands, c = lowland zone (kolla, below 1,500 m a.s.l.), hot and arid, open woodland and grassy savanna, d = Lake Abaya (1,169 m a.s.l.) hot, savanna forest and swamps.

***Fig. 8** – Mont Damota : A) pointes foliacées des sites de surface du MSA ; B) groupement de règlement du MSA (G1-G4) ; C) zones écologiques sur et autour du mont Damota : a = zone de hautes terres (dega ; ~ 2 900-2 600 m a.s.l.), fraîche et humide avec une végétation afro-montagnarde (arbustes et prairies), b = zone de moyenne altitude (woyna dega ; < 2 600-1 500 m a.s.l.), plus chaude et légèrement plus sèche, bosquets de bambous et forêts, c = zone de basse altitude (kolla ; en dessous de 1 500 m d'altitude), chaude et aride, forêts ouvertes et savane herbeuse, d = lac Abaya (1 169 m d'altitude), chaud, savane forestière et marécages.*

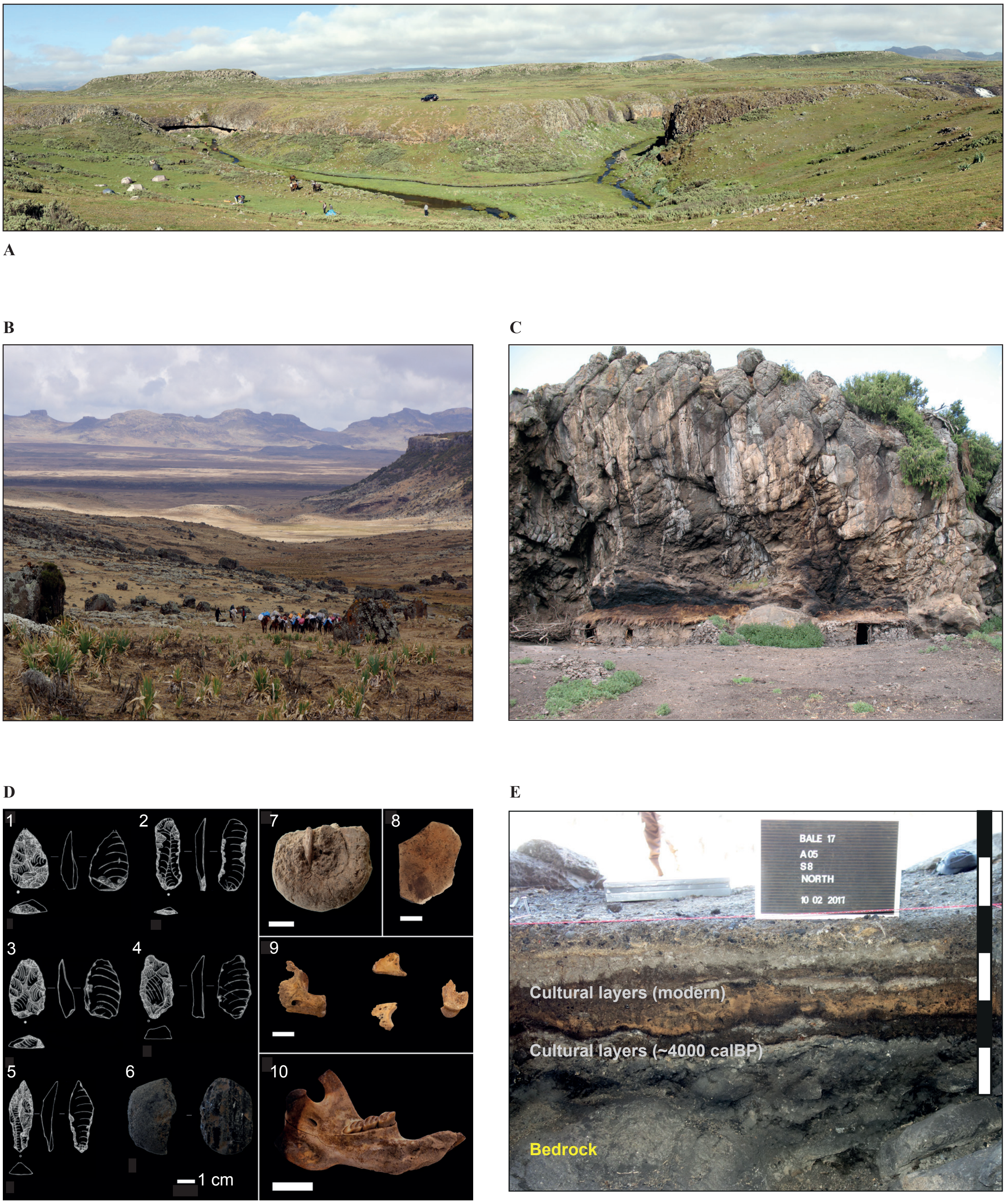


**Fig. 9** – Bale Mountains: The Web Valley with the rock shelter Fincha Habera on the left and the waterfall on the right (A); the Sanetti Plateau (~ 4,000 m a.s.l.; A); seasonally inhabited rock shelter (C); selected finds from the MSA deposits (D, scale bars = 1 cm): unifacial points (1 and 3), laterally retouched blade with alternate retouch (2), scraper (4), point with basal thinning (5), photograph of a tested cortical nodule (6), spotted Hyena (*Crocuta crocuta*) coprolite with included rodent bone fragment (7), ostrich eggshell fragment (8), digested bovid phalanges (9), left mandible from a giant mole-rat (Tachyoryctes macrocephalus) that presents extremity burning marks (10); Holocene stratigraphy with typical thick accumulation of ash and charcoal (E).

***Fig. 9** – Montagnes du Bale : vallée de Web avec l'abri Fincha Habera à gauche et la cascade à droite (A) ; plateau de Sanetti (~ 4 000 m d'altitude ; B) ; abri habité de façon saisonnière (C) ; échantillon de mobilier provenant des dépôts MSA (D ; barres d'échelle = 1 cm) : pointes unifaciales (1 et 3), lame retouchée latéralement avec retouche alternante (2), grattoir (4), pointe avec aménagement basal (5), photographie d'un nodule cortical testé (6), coprolithe d'hyène tachetée (*Crocuta crocuta*) avec fragment d'os de rongeur inclus (7), fragment de coquille d'œuf d'autruche (8), phalanges de bovidés digérés (9), mandibule gauche d'un rat-taupe géant (Tachyoryctes macrocephalus) présentant des marques de brûlure aux extrémités (10) ; D) ; stratigraphie holocène avec une épaisse accumulation typique de cendres et de charbon de bois (E).*

occupation of the Bale Mountains is verified at the site Fincha Habera between 47000 to 31000 years cal. BP (Ossendorf et al., 2019).

The stone tool spectrum of the Holocene sites is characterized by backed microliths, such as segments and micro-points. A special feature of the region is the high number of borers that might indicate specific tasks, perhaps hide working. It seems plausible that the harsh and cold conditions of this high-altitude environment required warm clothing and perhaps dwelling structures made of hide (Chu, 2009). Another way of protecting against the cold was fire and exceptional massive accumulations of ash and charcoal are evidence of large fires in the inhabited rock shelters (fig. 9, E).

A remarkable site is the rock shelter Fincha Habera (fig. 9, A) that proves the Pleistocene occupation of the Bale Mountains (Ossendorf et al., 2019). All stages of the stone artefact reduction sequence, from acquisition, production of cores, blanks and tools to utilization and discard are present, which points to the use of the shelter as a settlement site. Characteristic tool types are small facially retouched points (fig. 9, D1, D3 and D5). The almost exclusive raw material for the production of stone artefacts is local obsidian. The main raw material source is the Wasama Ridge outcrop at an altitude of more than 4,200 meters a.s.l. and the passage to this source most probably passed along glaciers.

Surprising is the faunal spectrum of Fincha Habera with 93.5% of the identified bones belonging to the giant mole rat (*Tachyoryctes macrocephalus*). The high number of burnt bones and specific burn marks at the extremities indicate roasting of the animals and their consumption by humans (fig. 9, D10).

Despite the extreme environment and hunting specialization, the tool types from Fincha Habera are comparable to contemporaneous sites in the lowlands. Direct evidence of contact to these regions is an ostrich eggshell fragment (fig. 9, D8), because these birds never lived in such high altitudes (Stewart et al., 2020). It seems that the inhabitants of Fincha Habera used the Bale Mountains as one specific part of a larger settlement system.

Constant access to fresh water sources, such as meltwater from the Harcha and Wasama glaciers, might have been the initial impetus to occupy the alpine environment of the Bale Mountains. The focus on the endemic giant mole rat as a food source, which is available year-round, easy to catch and occurs in large numbers, comply with the higher metabolism and reduced physical ability in high altitudes. The availability of high-quality obsidian outcrops was an additional motivation to exploit these demanding ecozones.

## CONCLUSION

Extensive archaeological research during the last decade in the high-altitude regions of Ethiopia has fundamentally changed our understanding of Prehistoric occupations in high altitude regions. We now know that despite the challenging environmental stress in high altitudes for the human body, these regions had been part of the human habitat at least since the emergence of modern *Homo sapiens*[(2)].

High altitude regions were used for specific tasks, such as hunting, collecting of raw-materials, plants and honey that might have been finished by expeditions of small groups during few days. However, they have also been used for longer periods as regular settlement areas. A major benefit of moving into high altitude regions is the relative abundance of water, which is one of the most limiting factors for human survival. The surroundings of all sites are characterized by numerous springs. Additional sources of water are in case of Mount Dendi the two crater lakes and in the Bale Mountains glacial melting water. A further advantage of mountainous regions are the altitudinal ecozones that permit the exploitation of a wide spectrum of natural resources in a small distance. The seasonal altitudinal shifting of ecozones extends the temporary availability of specific plants and the movement at a small scale in annual cycles renders long distance annual migration unnecessary.

Because of these advantages, highlands have also been used as retreats during times of environmental stress in the lowlands of Ethiopia. Although the species richness in plants and animals decreases under present climatic conditions between 1,000 m to 4,000 m altitude (Peters et al., 2019), the compressed altitudinal ecozones in combination are offering a broader spectrum in relation to the distances of logistical mobility (*senso* Binford, 1980) of foragers.

Thus, the occupation of high-altitude regions helped to overcome short periods of drought, but long-term climate changes might overstrain this settlement strategy. Climatic deterioration was not the main trigger for the occupation of high-altitude regions. Obviously, climate is an important limiting component, but human agency seems to be the more decisive factor. This also means that the occupants of high-altitude regions have not been marginalized people pushed into remote areas and living there in isolation. High altitude areas were most probably in all cases part of larger settlement areas that also included lowland regions or were at least part of larger exchange networks.

**Acknowledgements:** This review of Stone Age occupations in the highlands of Ethiopia is mainly based on the results of two projects: first, subproject A1, affiliated to the CRC 806 "Our way to Europe" (funded by the Deutsche Forschungsgemeinschaft [DFG, German Research Foundation] - Project-ID: 5744011 – SFB 806) and second, subproject P1 of the DFG Research Unit 2358 "The Mountain Exile Hypothesis: How humans benefited from and re-shaped African high altitude ecosystems during Quaternary climatic changes".

The Ethiopian Authority for Research and Conservation of Cultural Heritage (ARCCH) and regional and zonal cultural bureaus facilitated fieldwork and museum studies.

Special thanks to all the colleagues who contributed to the archaeological and geo-archaeological results of the projects, mentioned here in alphabetical order: A. Beldados, O. Bödeker, S.A. Brandt, O. Bubenzer, E.C. Fisher, E. Hensel, E. Hildebrand, T.H. Kahsay, M. Kehl, J. Lesur, S. Meyer, B.P. Nash, A. Negash, G. Ossendorf, H. Parow-Souchon, C. Schepers, M.G. Tekelemariam, K.P. Wendt, B. Zinaye.

I thank the local residents of the research areas for their support and participation in field research. I also thank the many Ethiopian, German and American students and colleagues who participated in the fieldwork or provided assistance in laboratory work. I am grateful to I. Koch for the lithic drawings, W. Chu for proofreading and many helpful comments and the University of Cologne for administrative support, especially Dr. W. Schuck. I thank the two anonymous reviewers for their very helpful comments and suggestions that significantly improved the manuscript. Finally, I want to thank the organizing committee of the conference in Toulouse for an absolutely amazing event and for their effort to publish the proceedings of this meeting.

## NOTES

(1) In earlier publications, we spoke of tropical highlands. The term tropical was used according to the Köppen-Geiger climate classification that is based on five vegetation groups, precipitation and air temperature. Published over a hundred years ago (Köppen, 1900), it is still the most frequently used climate classification and has been updated in recent years (e.g. Kottek et al., 2006; Peel et al., 2007). Regarding M. C. Peel and colleagues (2007, p. 1638), the research area in the southwestern highlands belongs today to the Tropical Savanna climate. However, climate changed and in the paleoclimate simulation by C. Willmes and colleagues (2017), the region is part of the Warm Temperate Savanna zone during the Last Glacial Maximum. Therefore, the use of the term "tropical" is avoided in this text, because it may imply a diachronic analogy.

(2) The large bifacial tools from the site Dendi12-A02 might also have been made by *Homo heidelbergensis*, a possible antecessor of *Homo sapiens* (Rightmire, 1998; Stringer, 2016). In Ethiopia, the skull from Bodo, classified as *Homo heidelbergensis*, has an age of 600000 years (Clark et al., 1994). However, the correlation of cultural evolution, represented by archaeological groups defined by stone tool types and technology, with anatomical hominin evolution, namely distinct species, is problematic and the production of the DEN12-A02 assemblage by *Homo sapiens* is not completely out of question (e.g. Sahle et al., 2019).

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