

Zöld Cave and the Late Epigravettian in Eastern Central Europe

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Abstract

Zöld Cave is a recently discovered Late Epigravettian site in Hungary. It yielded a small archaeological collection dated to 17.0–14.9 ka cal BP. The findings consists of faunal remains of horse and reindeer bearing extensive marks of human activity, and lithic artifacts of hunting armature types, including curved backed points, backed truncated bladelets, and backed bladelet, typical for a Late Epigravettian tool inventory. The archeozoological results indicate the cave was used as a hunting–butchering site. The Late Epigravettian archaeological record of eastern Central Europe suggests that this human population of hunter-gatherers practiced a residentially mobile subsistence strategy. Our results indicate that the Late Epigravettian population of eastern Central Europe did not disappear without descendants but likely contributed to the formation of the Federmesser culture.

Keywords

Late Paleolithic, hunter-gatherer, mobility, subsistence strategy, backed points

1. Introduction

Borrowed from the taxonomy of the Mediterranean Late Upper Palaeolithic (LUP), the term Epigravettian describes an archaeological culture dated to and after the Last Glacial Maximum (LGM) in eastern Central Europe (ECE) (Kozłowski, 1986; Svoboda, 1991; Bánesz et al., 1992; Montet–White, 1990; Dobosi, 2000; Svoboda and Novák, 2004; Verpoorte, 2004). Other names of cultural entities dated to the LGM, such as the Ságvárian (Kozłowski, 1979; Dobosi, 2016), Kašovian (Svoboda and Novák, 2004), Grubgrabian (Terberger, 2013), and Epi-Aurignacian (Demidenko et al., 2019), also occur in debates of archaeological taxonomy.

In ECE, most of the Epigravettian sites were found in the Carpathian Basin (CB), especially in Hungary (Lengyel, 2018; Lengyel and Wilczyński, 2018). The Hungarian research previously recognized two chronological clusters of Epigravettian: (1) late LGM sites between 18 and and 16 ka uncal BP (Dobosi, 2000) featuring an expedient lithic technology (Dobosi, 2004, 2009), and (2) post LGM sites between 16 and 12 ka uncal BP called "Epigravettian rich in blunted blades" (Dobosi, 2004). This Epigravettian taxonomy and chronology in ECE was revised based on Hungarian archaeological data (Lengyel, 2016, 2018). The revision pointed out that the Epigravettian period indeed can be divided into two distinct chronological clusters, but the phase dated to the LGM cannot be subdivided into further cultural entities. All of the LGM human occupations, including Ságvárian, Grubgrabian, and Epi-Aurignacian, can be classified Early Epigravettian, while the post LGM phase was defined Late Epigravettian (Lengyel, 2016).

The prime lithic typological difference between Early and Late Epigravettian up to date is the presence of backed and curved backed points in the hunting armature tool kit in the latter group. Other lithic armature types, such as the retouched point, backed bladelet, and backed truncated bladelet, are regular components of both Epigravettian phases (Lengyel, 2018; Lengyel and Wilczyński, 2018). Another difference between the Early and the Late Epigravettian is that sites of the early phase yield lithic tools made of raw materials originally occurring in the CB, and sites of the late phase contain lithic assemblages made of flints procured from outside the CB (Lengyel, 2014a, 2018).

An insecure part of the results of the revision was the low number of sites reliably dated to the Late Epigravettian period (Lengyel, 2008-2009, 2016, 2018) including only two sites: Nadap (Dobosi et al., 1988) and Esztergom (Dobosi and Kövecses-Varga , 1991). Hence, any occurrence of Late Epigravettian has been awaited to better understand the Late Epigravettian population in the formation of the cultural diversity of the Late Pleistocene human population of ECE. The introduction of Zöld Cave, Pilis Mountains, Hungary, dated to the post LGM period, improves the balance between the quantity of Early and Late Epigravettian sites. This paper presents the archaeological data of Zöld Cave that consists of a small collection of lithic artifacts accompanied by abundant faunal remains. The Zöld Cave archaeological record allows defining the subsistence strategy of Late Epigravettian hunter-gatherers, and provides an alternative interpretation for the disappearance of this human population from the Western Carpathians and occurrence of the Federmesser culture in Central Europe.

2. Materials and Methods

2.1. Site location and stratigraphy

Zöld Cave is located in Pilis Mountains, western Hungary, on the north-eastern slope of the mount called Nagy-Kevély, at 367 m a.s.l. (Fig. 1). The cave consists of a chamber of 15 m long, 5 m wide, with a ceiling height of 5 m (Fig. 2). In the rear part of the cave, the solid bedrock steeply rises up till the end of the chamber. At the end of the chamber, there is vertical shaft that is approximately 9 m deep.

FIG. 1.

FIG. 2.

The cave was discovered in the 1930s and until 2001 solely speleological explorations were carried through the upper entrance of the cave situated 10 m from the lower entrance (Fig. 2). The lower entrance, originally 1 x 0.5 m wide, was unearthed in 2001–2003. This series of fieldworks recognized the cave is an archaeological site (Ézsiás et al., 2001; Ézsiás, 2002, 2003). These campaigns removed a large part of the sediment in the middle of the cave along the chamber's total length, and found shards of ceramic vessels, human skeletal remains, and Holocene fauna. A thicker portion of the original sediment remained intact by the eastern wall of the cave, and the bedrock also was not found. The stratigraphic sequence, as reported (Ézsiás et al., 2001; Ézsiás, 2002, 2003), consisted of four layers as follows.

Layer 1, the uppermost sediment in the sequence, was a blackish brown recent soil rich in humus, and contained stone boulders. The maximum thickness of this layer was 0.7 m in the entrance. Layer 1 gradually thinned to 0.3 m inwards the cave. Its color gradually browned towards its lower boundary. Layer 1 contained potshards mostly of Copper Age and a few of Medieval and Roman periods, and human skeletal remains.

Layer 2 was found solely outside the entrance, on the terrace of the cave. It was a yellow clayey sediment approximately 1.0 m thick that contained smaller stone boulders. This layer did not yield archaeological finds.

Layer 3 was a red/reddish-brown clay located inside the cave, and sporadically contained small stone boulders. It was 1.0 m thick. Layer 3 stratigraphically contemporaneous with layer 2. It yielded sub-fossilized animal remains, but none of them was identified as a Pleistocene species.

Layer 4 was a yellow clayey sediment found inside the cave under layer 3. Its thickness remained unknown because the bedrock was not reached in 2001–2003. This layer was empty in terms of archaeology.

2.2. Fieldwork 2018

The excavation in 2018 was a short season in winter. The aim of the excavation was to test the cave sediment for Pleistocene remains because the fauna retrieved in 2001–2003 indeed included some bones of Pleistocene species (reindeer and horse). Although the 2001–2003 excavation removed a large portion of the nearly 1.0 m thick layer 3, intact matrix was preserved by the left (eastern) cave wall near the entrance, which was promising to be tested. Eventually, nine square meters were excavated in the entrance of the cave (Fig. 2).

2.3. Lithic tools

Lithic raw materials were identified macroscopically following Přichystal (2013) and the Lithic Reference Collection of the Eötvös Loránd University of Budapest (Mester, 2013). A lithic tool here is defined as a knapped stone product with edges modified by retouching. The tools were further analyzed in terms of technological and typological features. The typological analysis followed the categories used to describe LUP assemblages in Hungary (Lengyel, 2016). This divides the toolkit into two broad categories: domestic tools (end-scraper, burin, edge retouched tool, perforator, truncation, splintered tool, combined tool, knife) and armatures. The category of armatures was subdivided into backed points, backed, and backed-truncated artifacts. No microscopic surface analyses were run on the artifacts.

2.4. Human remains

Human remains were comparatively studied at the Institute of Archaeology in Brno, Czech Academy of Sciences, Center for Palaeolithic and Palaeoanthropology in Dolní Věstonice with Mid-Upper Palaeolithic skeletons Dolní Věstonice 13-16.

2.5. Archaeozoology

The identification of bone remains from Zöld Cave was based on a comparative collection of the Institute of Systematics and Evolution of Animals, the Polish Academy of Sciences in Kraków, and publications (Schmid, 1972; Pales and Garcia, 1981; Hillson, 1992). Three quantification methods were used to calculate species proportions: NISP (Number of Identified Specimens), MNI (Minimum Number of Individual Animals), and MNE (Minimal Number of Skeletal Elements) (Klein and Cruz-Uribe, 1984; Lyman, 1994; Reitz and Wing, 1999). Bone remains lacking species specific characters were assigned to three size categories of mammals: large (bison/horse size), medium (reindeer size), and small (fox/hare size). Bone fragments without visible morphological features were classified as undetermined. All bone remains were subjected to identify taphonomic agents (Haynes, 1980, 1983; Binford, 1981; Shipman et al., 1984; Lyman, 1994; Stiner et al., 1995; Bennet, 1999; Villa et al., 2002; Fosse et al., 2012; Fernandez-Jalvo and Andrews, 2016). The age of animals was determined on the basis of teeth features (Reitz and Wing, 1999; Hillson, 2005).

2.6. Paleobotany

For anthracological analysis, a reflected light microscope with magnifications of 100x, 200x, and 500x (Zeiss Axio Lb.1) was used to observe three anatomical sections of wood on freshly broken charcoals: transverse, longitudinal radial, and longitudinal tangential. Taxonomical identifications applied a modern wood comparative collection of the Department of Palaeobotany at the W. Szafer Institute of Botany PAS, and atlases of wood anatomy (Greguss, 1955; Schweingruber, 1990). The taxonomical identification of woody flora of Central Europe was limited to genus level (*Juniperus* sp., *Picea* sp. and *Larix* sp.). The sample preservation obstructed to differentiate between *Picea* sp. and *Larix* sp.. It is likely that in cases of these genera, the taxa may correspond to *Picea abies* and *Larix decidua* since they represent the only native species in ECE. Coniferous wood was indicated when not all anatomical features were visible. Micrographs of charcoals were made by using a Hitachi S-4700 scanning electron microscope (SEM) at the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University (Kraków, Poland). Dendrological analysis focused on ring curvature observations was performed (Marguerie and Hunot, 2007), and the presence of decayed wood was noted (Moskal-del Hoyo et al., 2010).

2.7. Radiocarbon dating

Radiocarbon dates were measured at the Poznan Radiocarbon Laboratory in Poland, and at the Hertelendi Laboratory of Environmental Studies (HEKAL), in Debrecen, Hungary. Methods of bone and charcoal sample chemical pre-treatment of Poznan Laboratory (Czernik and Goslar, 2001; Piotrowska and Goslar, 2002; Goslar et al., 2004; Goslar, 2015) and HEKAL (Molnár et al., 2013a, 2013b; Major et al., 2019) are published. Radiocarbon dates were calibrated with OxCal (Reimer et al. 2013) indicating 95.4% probability.

3. Results

3.1. Stratigraphy

The 2001–2003 research left a stratigraphic column inside the cave (Fig. 2: 1), which was ruined during the years until 2018. In 2018, layer 1 was not found in situ in the cave and layer 3 was preserved with its lower portion. As a consequence, the 2018 excavation was able to recover the lower portion of layer 3.

Layer 3 was mainly preserved by the eastern wall of the cave near the entrance and towards the terrace (Fig. 3). It was a reddish–brown clayey sediment which gradually turned lighter towards its bottom. The uppermost 5–10 cm of layer 3 was the recent cave floor of dark brown color. It was mixed with modern materials and redeposited fragments of layer 1. The thickness of layer 3 in the northern line of the excavation area was 0.4 m, and at the eastern cave wall in square E0–1 a 0.6 m thick part was preserved. It included sharp-edged lime stone debris up to 4 cm large, and larger boulders near the eastern and western cave walls (Fig. 3). The interface between layer 3 and 4 was uneven at some parts of the cave (Fig. 4). It featured a zigzag line probably created by either bioturbation or cryoturbation, or channels of running water, displaying sediment reworking in a dynamic sedimentary environment. The lack of fine stratigraphic units also was an evidence of post-depositional admixtures. The freshness of the bones and the sharp edges of breakage surfaces (see the archaeozoology chapter) indicated a short term reworking activity. All the disturbances affecting layer 3 could have occurred in the Pleistocene because the fauna we recovered completely consisted of Pleistocene species. Most likely, the Holocene species reported from layer 3 from the 2001–2003 exploration (Ézsiás et al., 2001; Ézsiás, 2002, 2003) were mixed in from the overlying layer 1.

As it was described by the 2001–2003 exploration (Ézsiás et al., 2001; Ézsiás, 2002, 2003), the yellow clay layer 4 was situated beneath layer 3. Layer 4 did not yield archaeological remains, but a few bone remains partially were embedded within it through the interface with layer 3. The bedrock was not reached in 2018.

FIG. 3.
FIG. 4.

3.2. Lithic tools

A total of five lithic tools were found in the entrance of the cave in layer 3 (Fig. 5: 1–5). Each artifact preserved sharp edges except one made of radiolarite (Fig. 5: 2) that was exposed to heat. Each of them is a retouched tool, armature type, made of blade. Wet sieving of 20 L of sediment through 1 mm mesh did not provide lithic chips.

FIG. 5.

The first artifact is a curved backed point, made of a Cretaceous flint blade (Fig. 5: 1). This flint raw material is of Silesian/Moravian origin of erratic outcrops. The tip was formed at the proximal part of the blade. The distal end was broken off before retouching. The backing retouch is located on the left edge. On the ventral face, the tip on the right edge bears an impact fracture similar to burin spall removal. Another tiny scar of post retouching on the same side runs over the dorsal face.

The second artifact laid in the uppermost part of layer 3 that was disturbed by recent activities. It was made of a brown radiolarite, burnt to red, and it is a distal fragment of a blade that was retouched into a curved backed point (Fig. 5: 2). This raw material might have originated in the Lesser Carpathians of western Slovakia or in the Transdanubian mid mountain range in western Hungary. The backing retouch is located on the left edge. The point was partially damaged, and impact scars are located on both the ventral and dorsal faces of the tip.

The third artifact is a backed and truncated blade made also of Cretaceous flint (Fig. 5: 3). The backing retouch is located on the left edge and the truncation is on the proximal end. The proximal part was broken off with heavy fracturing. The fracture scars are located on the ventral face, which partially damaged the backed edge, too.

The fourth tool is a mesial fragment of a backed bladelet made of Cretaceous flint (Fig. 5: 4). The backing retouch is located on the right edge. It was fractured irregularly. The fracture scars are angular and partially damaged the backing retouch, too.

The fifth tool is also a backed and truncated blade made of Cretaceous blade (Fig. 5: 5). The proximal part was broken off. The backing retouch is located on the left edge and the truncation is on the distal part. The breakage surface is tonged shaped.

The shapes and the locations of the breakage surfaces on the lithic tools resemble impact fractures of throwing lithic tipped composite weapons (Fischer et al., 1984; Yaroshevich, 2010; Yaroshevich et al., 2010; Rots and Plisson, 2014; Rots, 2016; Sano et al., 2019). The most obvious impact damages are the burination on the tip of the first tool (Fig. 5: 1), and the heavy ventral fracturing of the backed truncated bladelet (Fig. 5: 3), but the damages of the backed edges (Fig. 5: 3, 4) parallel with the axis of the tools also indicate impact from the distal ends of the tools. These macroscopic features suggest this toolkit was used in hunting activities assembled into composite projectile weapons.

3.3. Human remains

A human skull piece was found lying on top of layer 3 in the admixed cave floor (Fig. 6). Its stratigraphic position suggested it could have belonged to the Pleistocene, but it was eventually dated to the Copper Age period (see details in the radiocarbon dating section). The stable isotope data of this bone, $\delta^{13}C$ = –20.2 vs. PDB (‰) (± 0.15‰) and $\delta^{15}N$ = 10.8 vs. air (‰) (± 0.1‰), indicate a diet based on C_3 ecosystem with high intake of animal protein (Richards, 2020).

FIG. 6.

The bone consists of three conjoining fragments of a human parietal bone (55.6 x 44.6 x 5.7–6.2 mm). Fragments A and C display remains of the irregular suture mostly resembling the lambdoid. The internal side of fragments A and B have imprints of the veins. The bone thickness and suture view without obliteration indicate a young (gracile) adult or adolescent. Fine and rounded porosity on the external surface of which the density increases in the suture direction may present a healed porotic hyperostosis with a moderate anemia during childhood (Ortner, 2003; Walker et al., 2009). The bone structure thins in internal parts of B and C fragments which causes a bone lesion with a preserved diameters 10.1 x 11.7 mm. If the suture display an irregular variation of the sagittal structure, the endocranial depression could be a small Pacchonian depression, which may normally occurs relatively anterior (close to the bregma).

3.4. Archaeozoology

The 2018 excavation season found nearly five hundred remains of different animal species in layer 3. Wet sieved sediment included only a few micromammal remains. The small to medium sized mammals belong to a minimum of seven species (Table 1). The bone preservation in layer 3 is generally good. Bones are compact, slightly sub-fossilized, and yellow or waxy in color. Only four cases of root etching impeded the archeozoological analysis.

TABLE 1.

The small mammal frequency is low but varied (Table 1). These are a single second phalanx of a beaver (*Castor fiber*), a mandible fragment, two molars, a humerus distal fragment and tibia of a hare (*Lepus* sp.), and a right maxilla fragment with P^4 of stoat (*Mustela erminea*)

(Fig. 7). A further fragment of a small carnivore canine may belong to this taxon, too. An additional crown fragment of canine belongs to red fox or Arctic fox.

FIG. 7.

The largest part of the faunal assemblage, making up 91.7% of the total (Table 1), represents two ungulate taxons: wild horse (*Equus ferus*) and reindeer (*Rangifer tarandus*). Horse (NISP = 44) represents skull, axial skeleton, long bones, carpal and tarsal bones, and a distal part of limbs. There is a noticeable lack of scapula and innominate. The most numerous skeletal parts are from the cranium including isolated teeth (N = 10), then phalanxes (N = 6), and femur fragments (N = 4). The horse remains belong to at least three individuals, two of which are sub-adults and one is an adult. Reindeer remains (NISP = 56) represent all skeletal elements including skull, flat and long bones, and distal limb parts. In the reindeer assemblage the most numerous are carpal and tarsal bones (N = 13), then cranial elements (N = 10), phalanges (N = 8), and metatarsal bone fragments (N = 5). The rest of reindeer elements are represented by single bones, such as humerus, ulna, radius, tibia, pelvis, and metacarpal bone. The reindeer bones represent minimum two adult individuals.

FIG. 8.

The ungulate mammal bones preserved traces of human activity (Table 1). The most common that generally indicate human activity is the green breakage pattern characteristic to freshly broken up bones (Fig. 8). This was most common on horse (44.5%) and reindeer long bones (73.7%). Green breakage surfaces are present on the skeletal parts of small mammals, too.

Further human impacts are the cut marks that reflect different stages of carcass processing. The transversal marks noted on trochlear ridges of horse astragalus indicate that cut marks were created during dismembering carcasses, and cut marks aligned transversally on a horse lumbar vertebra indicate filleting (Fig. 9).

FIG. 9.

The third trace of direct human action on bone is the puncture mark (N = 12). Among horse remains, a femur, a tibia, and a first phalanx longitudinally split bore puncture. Among reindeer bones, a calcaneus was punctured. Further long bones of large (N = 5) and medium size (N = 2) mammals also have puncture marks. A single bone flake created during splitting of bone was also noticed.

Green breakage and puncture marks most often can be the result of marrow extraction. Moreover, smaller puncture marks on bones also might have originated also from hunting (Yeshurun and Yaroshevich, 2014). Noteworthy is the lack of burning and osseous artefacts.

Gnawing marks of carnivores were found on 5.8% (N = 29) of the bone assemblage (Table 1). They occur on 20.5% of horse and 7.1% of reindeer bones. Location and shape of the gnawing marks indicate that they were probably made by wolves (Haynes, 1980, 1983).

The number of small mammal remains in this assemblage is low, and clearly shows that accumulation of this fauna was probably created without human contribution. Contrary to small animals remains, the accumulation of the medium and large sized mammals was clearly a result of human hunting activity. This is indicated by faunal composition, the presence of only medium and large herbivorous species and the almost absence of carnivores, animal anatomical pattern, the presence of whole animal carcasses, and the signs of human activity (e.g. cut marks, impact fractures). Presence of gnawing marks on studied material, can be interpreted as carnivore activity that took place directly after the end of the human occupation, indicating rather short time of human presence at the cave.

3.5. Paleobotany

Altogether six hand collected charcoal samples were studied from layer 3. The samples were taken from the northern wall of square E0, where the only charcoal concentration was noticed during the excavation (Fig. 10). The samples have a stratigraphic order, starting from 40 cm below the datum line. No other area and plus the wet sieved sediment yielded charcoals. The charcoals were solely a few small fragments of coniferous wood, which is a very low taxonomic diversity: *Juniperus* sp., *Picea* sp. or *Larix* sp., and coniferous tree or shrub (Table 2).

TABLE 2.
FIG. 10.
FIG. 11.

Several charcoal fragments are characterized by the presence of fungal hyphae (Table 2, Fig. 11), which may indicate the use of deadwood. In the case of *Juniperus*, it was possible to determine that the wood come from small twig. In addition, branchwood was inferred due to the observation of a presence of compression wood (Table 2).

3.6. Radiocarbon dating

Radiocarbon samples were selected from the faunal collection and the charcoal assemblage of layer 3 (Table 3). Two different animal species were dated, horse and reindeer. Of the reindeer remains, a mandible fragment, and of the horse remains a humerus bearing green breakage surface and a vertebra that bore cutmarks were dated. All samples contained a sufficient amount of collagen (i.e. >1.0%) and the C/N atomic ratios were within the border of acceptance 2.7–3.5. The charcoal sample dated was a *Larix/Picea* charred wood from the third charcoal concentration in layer 3 situated 60 cm beneath the datum line (Fig. 10). The dated charcoal was a single piece. We also tested the age of the human skull piece.

TABLE 3.

The human parietal bone belongs to the human remains recovered in 2001–2003 together with the Copper Age (Ézsiás et al., 2001; Ézsiás, 2002, 2003). Its calibrated age between 6,200 and 5,950 kya fits to the end of the Early Copper Age in Hungary (Raczky and Siklósi, 2013).

Two of the bone dates, one horse 13,110 ± 90 BP (Poz–99669) and another reindeer 12,930 ± 50 BP (Poz–103229), overlap after calibration. The third bone date of horse 13,820 ± 70 BP (Poz–103176) falls out of the 2σ range of the other two dates, while the upper boundary of the charcoal date 12,700 ± 60 BP (DeA–19556) overlaps the lower third of the youngest bone date.

The vertical distribution of the samples does not accord with the aging of the dates. The oldest age (Poz–103176) is located in the middle of the sequence (Fig. 12). This also indicates that layer 3 might have been reworked in the Pleistocene.

FIG. 12.

The radiocarbon dates may indicate two occupational periods during the end of the Pleistocene, one between 17.0 kya and 16.4 kya, and another between 16.0 kya and 14.9 kya (Fig. 13), both falling within the GS–2.1 stadial period (Rasmussen et al. 2014). Since the aging of the samples does not follow a stratigraphic order, and the lithological features also designate post-depositional disturbance of the sediment embedding the animal remains and lithic artifacts, it is probable that the two occupational events we estimate is apparent.

4. Discussion

The results showed that at least three horses and two reindeers were hunted and processed at Zöld Cave during two distinct human visitations. According to the radiocarbon dates, the first visit involved the processing at least one horse, while the second visit processed at least one horse and one reindeer. Besides cutting off the meet, the bones were further damaged to access marrow.

The lack of lithic chips, bone tools, and lithic tool curation indicates an short term occupations at Zöld Cave. This is further supported by the lack of burnt bones and the rare presence of charcoals in the sediment. The remains of twigs and branches of trees and shrubs, and the preservation of fungi may specify the use of deadwood randomly collected around the site.

The archaeological literature generally distinguishes two basic hunter-gatherer subsistence systems that involve mobility: foragers and collectors (Binford, 1980). Foragers frequently move their residential base that includes remains of food processing and consuming, tool production, repair and discard, and camping features, such as hearths. Hunting trips do not take more than a day, therefore, satellite sites are uncommon, and if the capture was too far to deliver the complete animal, they process the meet and take only the dismembered animal parts to the residential base.

Collectors (Binford, 1980) create a residential base for longer duration and launch task groups to procure food into distances longer than a day. The task groups establish field camps while executing the task, which is a temporary base for the task group, where subsistence and maintenance occur. The archaeological consequences of the collector subsistence strategy is similar for the residential base but with more intensive accumulation of remains due to the longer duration of the occupation. Field camps create a composition of archaeological features similar to the residential camp, but with a low frequency of remains and probably with higher representation of tools used to accomplish the task.

Others (e.g. Barton and Riel-Salvatore, 2014) view the residential–logistical mobility as two extremities of a scale and claim that a hunter-gatherer group may practice both types of foraging strategy but biased towards to one of them. The retouched tool frequency negatively correlates with lithic density, and thus high retouch and low artifact ratio signify a short duration occupation of residentially mobile humans. Low retouch ratio paired with abundant debitage is the consequence of a basecamp establishment of logistically mobile foragers.

The Zöld Cave findings do not represent a residential base of any kind. The archaeological data proves the site was a butchering place of residentially mobile groups, rather than a field camp for logistically mobile hunter-gatherers.

In spite of the small number of archaeological finds, Zöld Cave shares all of its features with other Late Epigravettian sites in Hungary. The chronologically closest site to Zöld Cave is Nadap (Dobosi et al., 1988), dated to 15.9 and 15.3 kya (Verpoorte, 2004), located 50 km southwest of Zöld Cave. Nadap preserved hearths (Dobosi et al., 1988), a lithic assemblage (N = 1087) consisting of each element of the lithic reduction sequence (Lengyel, 2018), and lithic tool kit (N= 66) including three curved backed points, two backed points, backed bladelets (N=36), and backed-truncated bladelets (N=6) (Lengyel, 2018). The raw material of most artifacts was a Jurassic flint originated in Poland and Cretaceous flint of glacial moraines in Silesia or the Moravian Gate (Lengyel, 2018).

Another Late Epigravettian assemblage, Esztergom–Gyurgyalag (Dobosi and Kövecses-Varga , 1991), located 25 km of Zöld Cave, was dated to 18.1–17.1 kya (Hertelendi, 1991), mismatching the 17.0–14.9 kya occupational period of Zöld Cave. In spite of the age difference, Esztergom–Gyurgyalag yielded a toolkit that is composed of the same armatures as Zöld Cave (Lengyel, 2016, 2018), a lithic assemblage (N = 1072) made of a Cretaceous flint of Prut river or Podolian upland region, including the whole lithic reduction sequence (Lengyel, 2018), a high frequency of retouched tools (N = 344), hearths, and pendants made of fossil shells (Dobosi and Kövecses-Varga , 1991).

Among insecurely dated Late Epigravettian sites, the closest open-air site nearby Zöld Cave is Budapest-Csillaghegy, located 4.3 km southeast from the cave (Gábori–Csánk, 1986). The precise age of the site is unknown, but it is later than 19.2 kya as a radiocarbon date obtained from mollusc shells 20 cm below the archaeological layer indicates it (Lengyel, 2008-2009). The lithic assemblage was made mostly of Jurassic and Cretaceous flints of Silesian–Moravian Gate origin is small (N = 40), and it includes only domestic tools (N = 6) and unretouched lithics (Gábori–Csánk, 1986).

Based on lithic tool typology, the lithic assemblage (N = 26) of Jankovich cave uppermost Pleistocene level, located 33 km of Zöld Cave, could be Late Epigravettian with its one curved backed point and several backed bladelets (Hillebrand, 1935, Taf. V. 21; Vértes, 1965). However, it yielded one tanged point that is unfamiliar in Late Epigravettian context

(Hillebrand, 1935, Taf. V). No hearths were reported.

Another, yet undated, site that yielded curved backed points was recovered at Pécel, located 32 km southeast of Zöld Cave (Markó and Gasparik, 2018). The total lithic assemblage included four tools made of Jurassic chocolate flint of Polish origin and three unretouched pieces of obsidian, recovered together with the skeletal remains of one individual of a wholly rhino. The four flint tools are the backed points. Three of them are curved backed types, and the fourth tool is a straight–backed point whose distal end was symmetrically retouched inversely from both edges. This toolkit was estimated to be as old as the upper layer of Istállóskő cave ca. 30 ka uncal BP (Markó and Gasparik, 2018). In spite of that, we find the tools of Pécel fitting Late Epigravettian lithic typology.

The archaeological remains of larger sites (Nadap and Esztergom) show moderate features of base camps, indicating that Late Epigravettian hunter-gatherers were residentially mobile, and involved short duration butchering camps (Zöld Cave, Jankovich cave, and Pécel) used during hunting trips. This Hungarian archaeological record, although fragmented, shows that the human population did not disappear after the LGM from the CB as it was earlier suggested (Verpoorte 2004). The Late Epigravettian still foraged this territory.

The lithic features of the assemblages indicate that a common feature of the Late Epigravettian are the curved backed points, backed points, and backed truncated bladelets, and the dominance of distant lithic raw material use in making the hunting weaponry in the CB. The correlation between distant lithic raw material procurement and numerous presence of backed artifacts, especially the curved backed points (Lengyel, 2018), also relates the Late Epigravettian type lithic assemblages with the archaeological record of highly mobile hunters crossing frequently the Carpathians (Lengyel, 2014b).

The lithic raw material composition of Zöld Cave showed contacts through the Moravian Gate towards Poland. Although there are a few traces of an earlier occupation of Late Epigravettian in Moravia, Brno Štýřice III dated to 19.0–17.3 kya (Nerudová 2016), and in Poland, Targowisko 10 dated to 18.2 and 16.3 kya (Wilczyński, 2009), the only contemporaneous and typologically similar Late Epigravettian sites with Zöld Cave in the northern lithic raw material source area is the lower layer of Sowin 7 in Lower Silesia, dated to 17.1–14.6 kya with OSL (Wiśniewski et al., 2012, 2017, in press), and Święte 9 at San River valley at the Przemyśl Gate in East Poland dated to later than 15.5 kya by OSL (Łanczont et al 2020). After these two sites, no other Epigravettian occupation can be found in Poland. Thus, both the CB and Polish archaeological record indicate that the Epigravettian disappeared near the 14.7 kya onset of the GI–1 warming (Rasmussen et al., 2014). This suggests that the last

Late Epigravettian hunter-gatherers were subsisting on the taiga biome in the CB, which composed of reindeers, horses, and coniferous forest (Vörös, 2000; Pazonyi, 2004; Magyari et al., 2019). The only archaeological collection in the CB dated to the GI–1, Lovas (Sajó et al., 2015), lacks the features of the Late Epigravettian, and its fauna is composed of elk (Patou-Mathis, 2002). This indicates a dwindling in human population in the CB not after the LGM (Verpoorte, 2004), but in GI–1, which eventually coincides with the disappearance of the Pleistocene megafauna from this territory (Magyari et al., 2019). In Southern Poland, after the Late Epigravettian, the Late Magdalenian spread over (Wiśniewski et al., 2017). However, further north, a Late Palaeolithic culture characterized by curved backed points, the Federmesser, begun dispersing, chronologically close to the disappearance of the Late Epigravettian (Sobkowiak–Tabaka, 2017). The typological similarity between Late Epigravettian and Federmesser by the curved backed points, and the coincidence of the Late Epigravettian end date and Federmesser start date suggest that the Late Epigravettian hunter-gatherers contributed to the formation of the Late Glacial archaeological record of Central Europe.

This discussion showed that lithic tool typology still can be a powerful tool to classify and date archaeological cultures. However, the Budapest-Csillaghegy archaeological record already suggests that the Late Epigravettian typologically might not always be fully uniform, which is probably in relation with the subsistence strategy of hunter-gatherers. The only way to resolve this issue is to perform further radiocarbon dating for sites yet undated. This will raise the accuracy of the relative chronology of the archaeological record of the CB and opens a wider perspective to understand hunter-gatherer ecology and cultural evolution.

5. Conclusion

Our paper demonstrated that the late phase of the Epigravettian that is dated after the LGM and ends with the GI–1 interstadial at 14.7 kya has a growing archaeological evidence in the CB. The archaeological assemblage from Zöld Cave supported that the Late Epigravettian characterized by curved backed points and the abundance of other backed tools used in composite hunting weaponry, very often made of distant lithic raw materials. The Late Epigravettian archaeological assemblages often were accumulated at hunting and butchering sites, composed of a low number of lithics including a high proportion of armatures, and small base camps of residentially highly mobile hunter-gatherers. Their subsistence strategy was engaged with the Late Pleistocene fauna, and as soon as it left the CB, the Late Gravettian population did not return from the north. We suppose, on the basis of the curved backed points that the Late Epigravettian contributed to the formation of the Federmesser culture in Eastern Central Europe.

Acknowledgment

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Figure 1. Location of Zöld cave and Late Upper Palaeolithic sites. 1) Szob, 2) Pilismarót site cluster, 3) Esztergom–Gyurgyalag, 4) Dömös, 5) Mogyorósbánya, 6) Jankovich cave, 7) Pilisszántó I rock shelter, 8) Kiskevély cave, 9) Budapest–Csillaghegy, 10) Budapest–Corvin-tér, 11) Pécel, 12) Nadap. Circle indicate radiocarbon dated Early Epigravettian (LGM) sites; squares indicate radiocarbon dated Late Epigravettian (post–LGM) sites; triangles indicate sites with relative chronological data.

Figure 2. The map of Zöld cave. Upper part shows the cross section of the cave. Lower part shows the plan of the cave with the excavation grid in 2018 (modified after Ézsiás 2003).

Figure 3. The eastern end of the excavation grid (looking north) at the wall of the cave with layer 3 including boulders of rocks. (Red-white scale on the rigth represents 30 cm.)

Figure 4. The irregular interface line between layer 3 and 4 in the northern wall of square D0. (Yellow-white strips on scale represent 10 cm.)

Figure 5. Lithic tools of Zöld cave (1–5). 1 and 2 are curved backed points; 3 and 5 are backed truncated bladelets; 4 is a backed bladelet.

Figure 6. The human parietal bone of Zöld cave.

Figure 7. Zöld cave. Right maxilla with preserved P4 tooth of stoat (*Mustela erminea*). Scale is 3 cm.

Figure 8. Horse (*Equus ferus*) distal part of metapodium (A) and reindeer (*Rangifer tarandus*) femur shaft (B) with visible breaks created during direct human action. Scale is 10 cm.

Figure 9. Zöld cave. Cut marks described on horse (*Equus ferus*) astragalus. Scale is 10 cm.

Figure 10. The sampling location of the charcoals in the north wall of square E0. Note the irregularity of the interface between layer 3 and 4. (Yellow-white strips on scale represent 10 cm.)

Figure 11. Wood charcoal of *Picea* sp. or *Larix* sp. from Zöld Cave. A-B. transverse section, C-D. longitudinal radial section. The arrows indicate fungal hyphae.

Figure 12. The distribution of finds in the excavation unit. A: plan view. B: vertical distribution of the finds in the north section.

Figure 13. Calibrated radiocarbon dates of Zöld cave.

Table 1. Zöld cave. Mammalian remains expressed by NISP (Number of Identified Specimens) and MNI (Minimal Number of Individual), with information concerns to human and carnivores activity.

Table 2. Results of anthracological analysis from Zöld Cave.

Table 3. Radiocarbon dating results of Zöld cave arranged by their elevation layer 3 measured from the datum line.

Figure1

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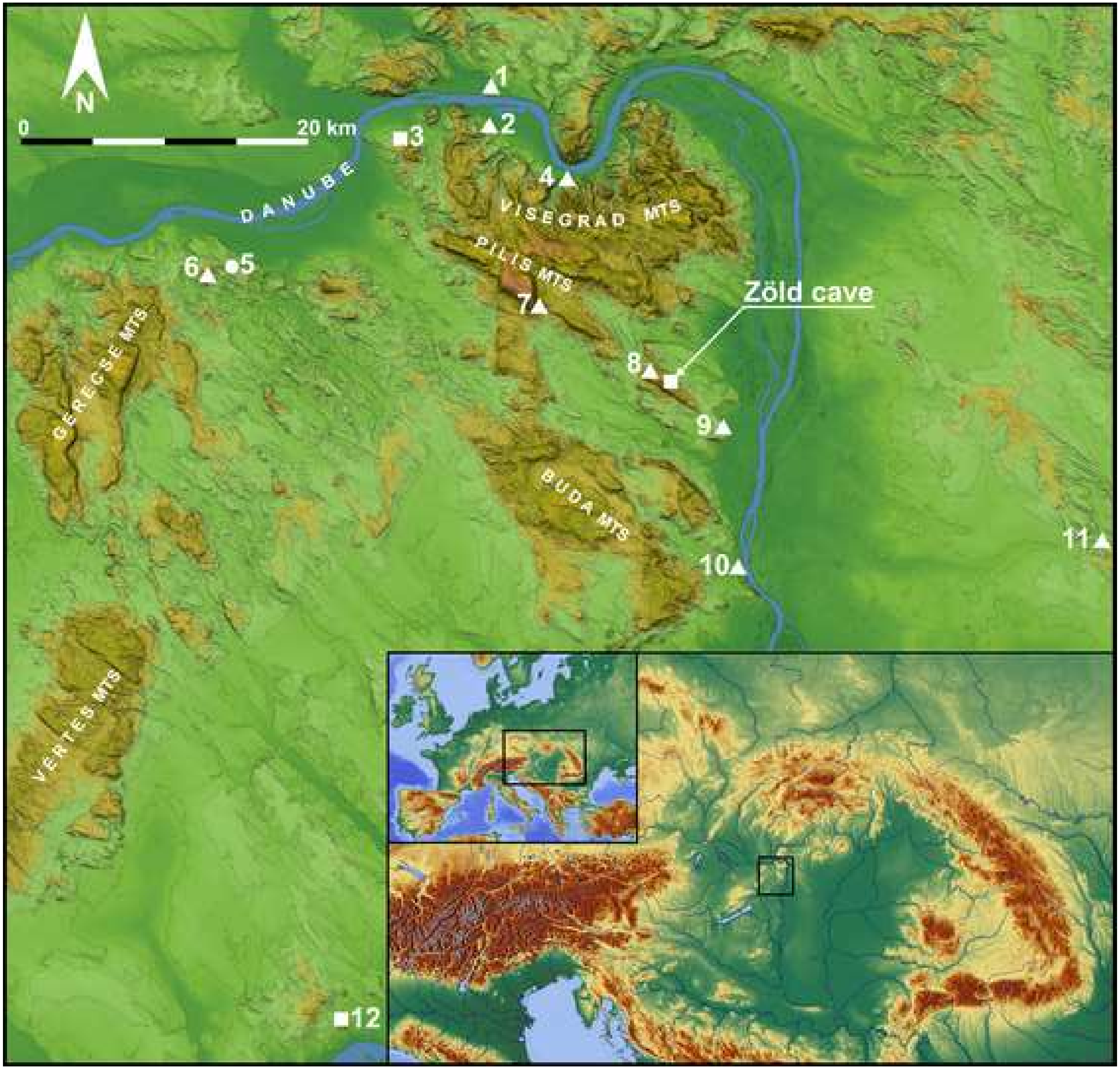

Figure2

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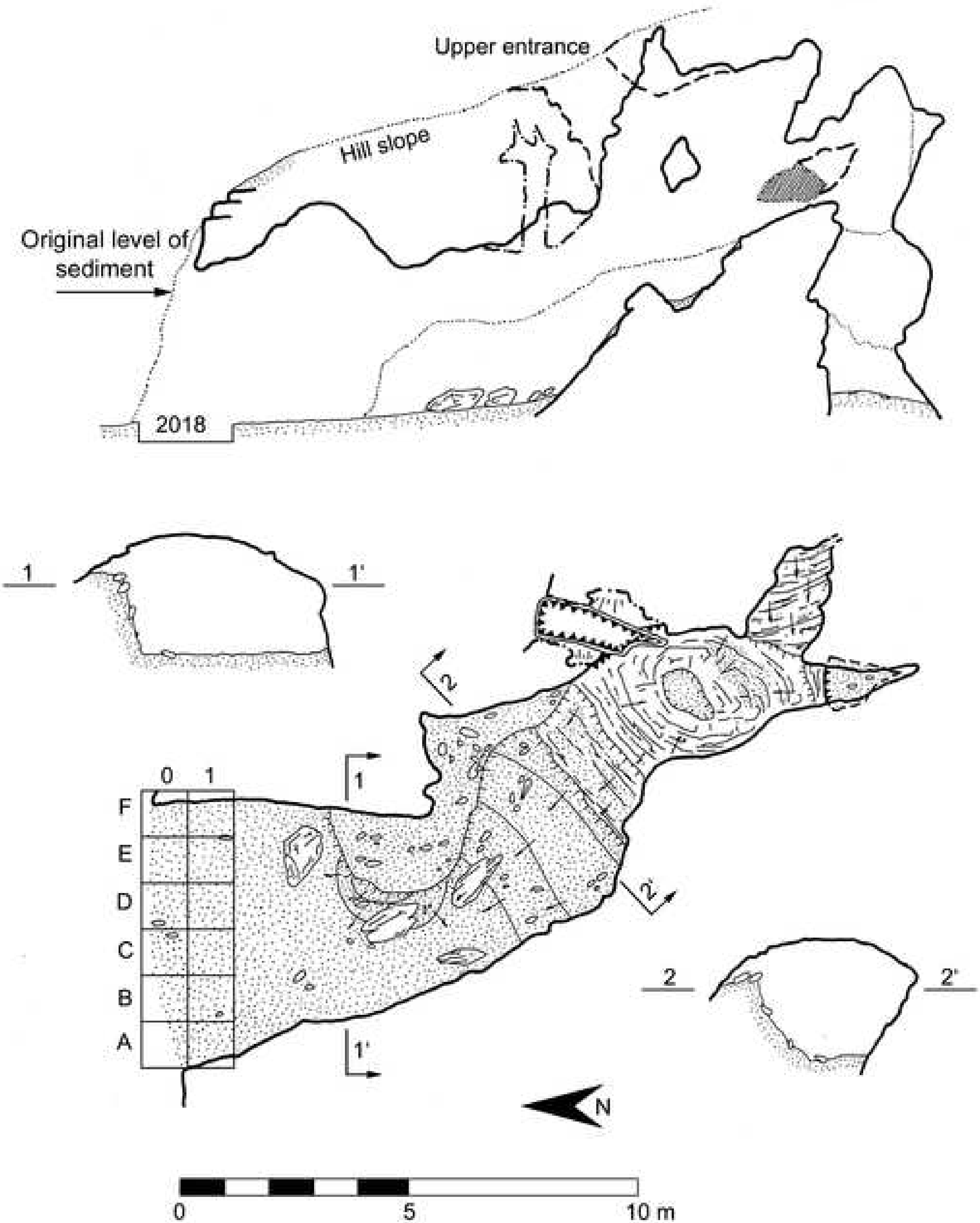

Figure3

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Figure4

Figure5

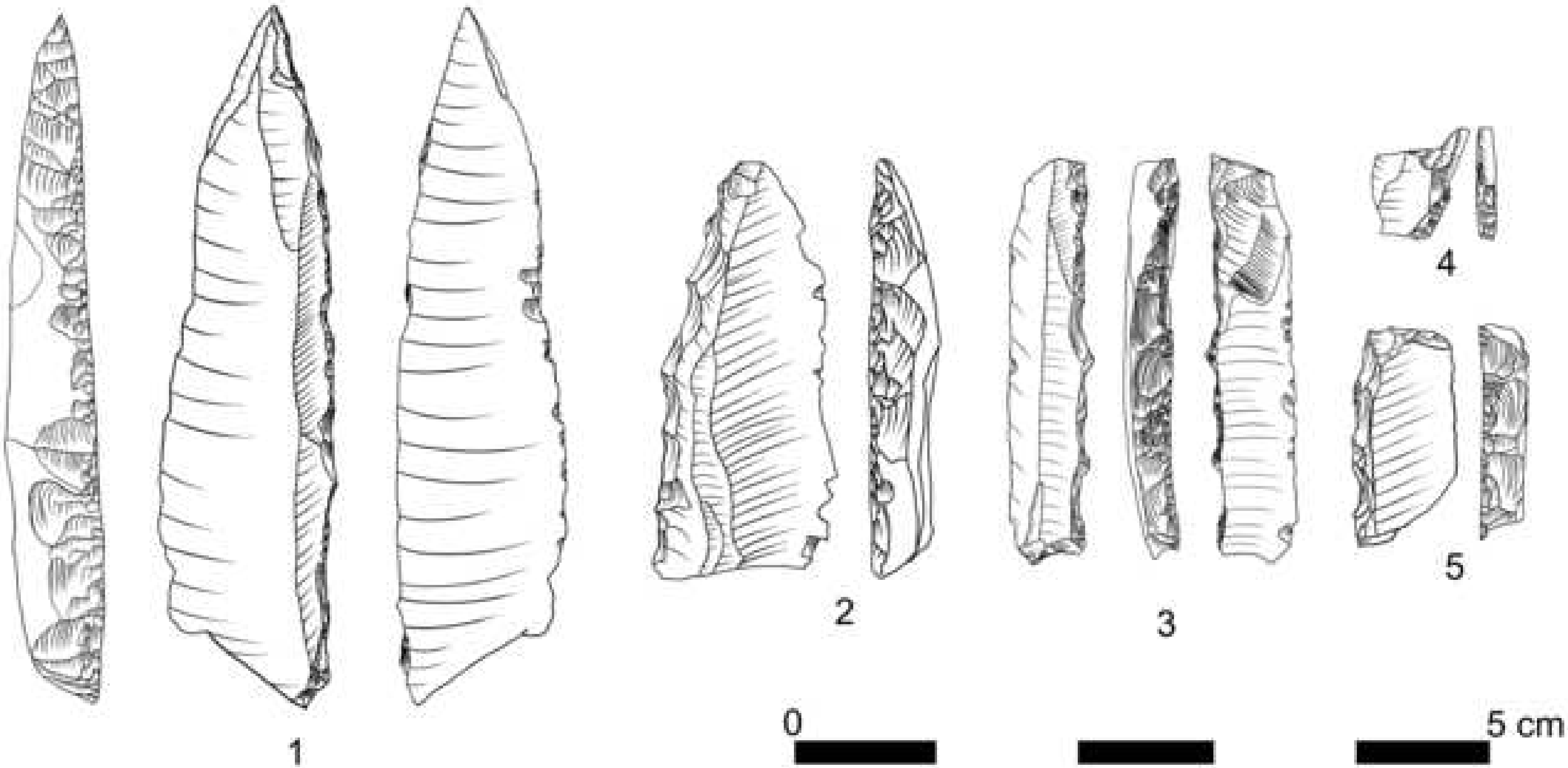

Figure6

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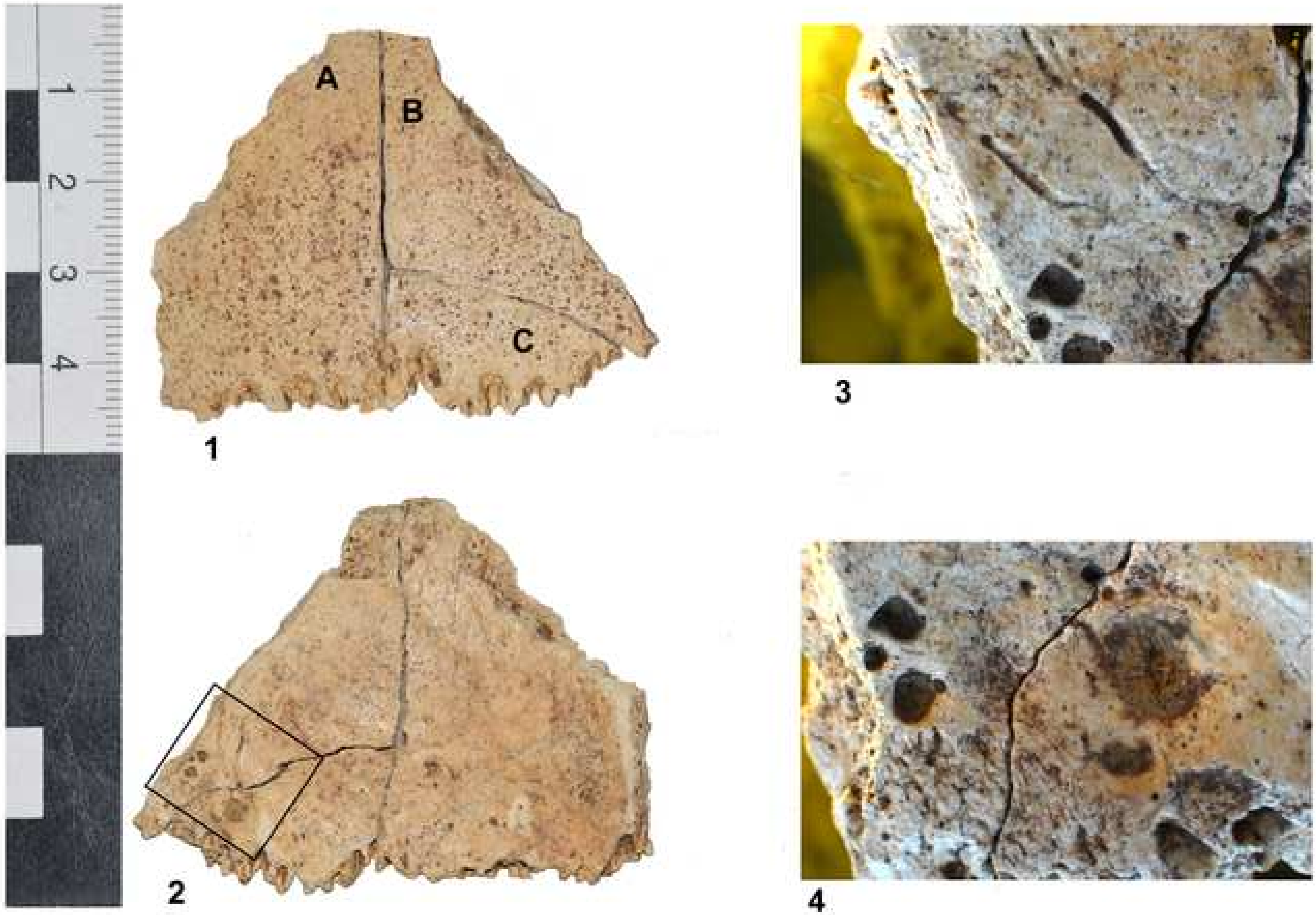

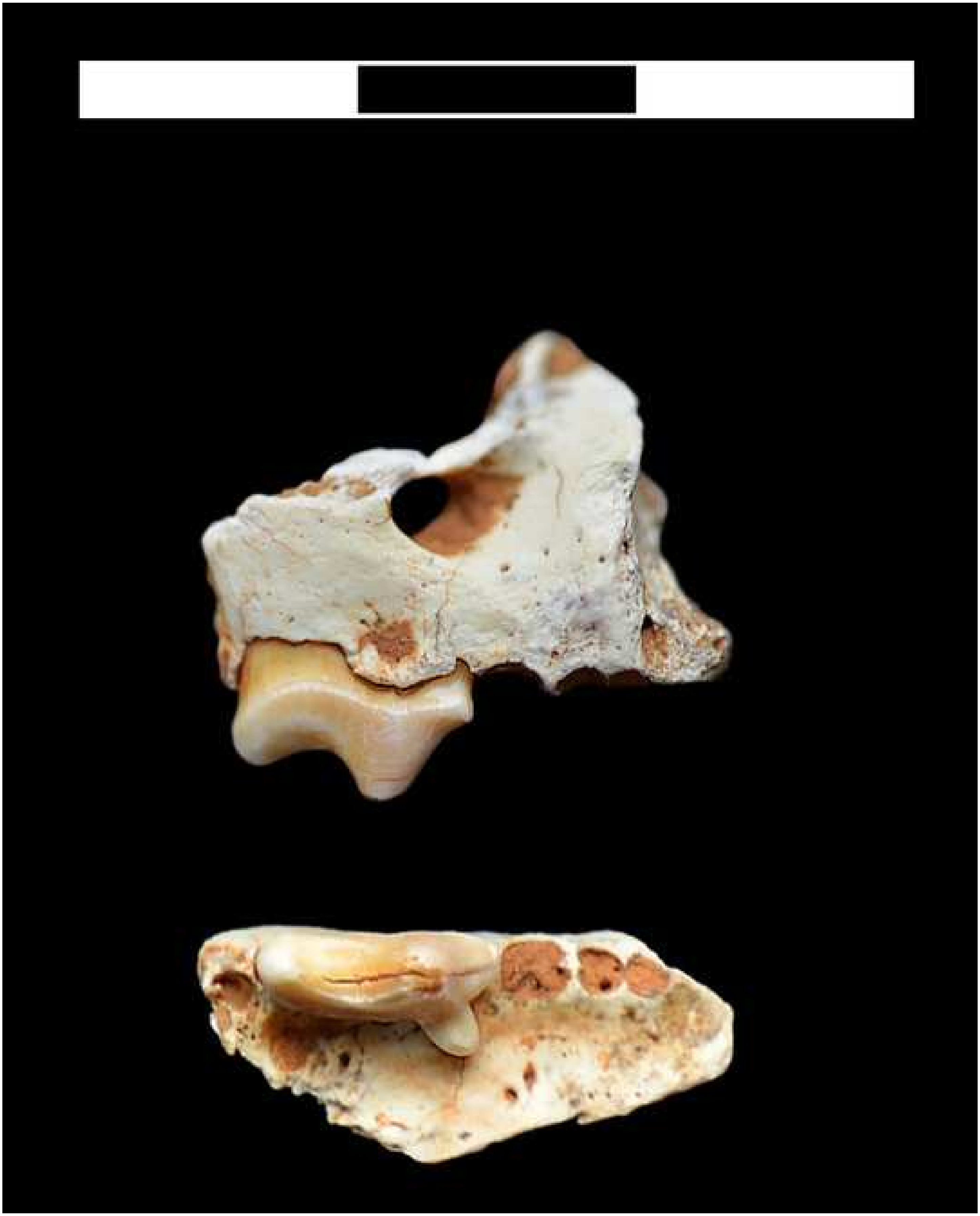

Figure8

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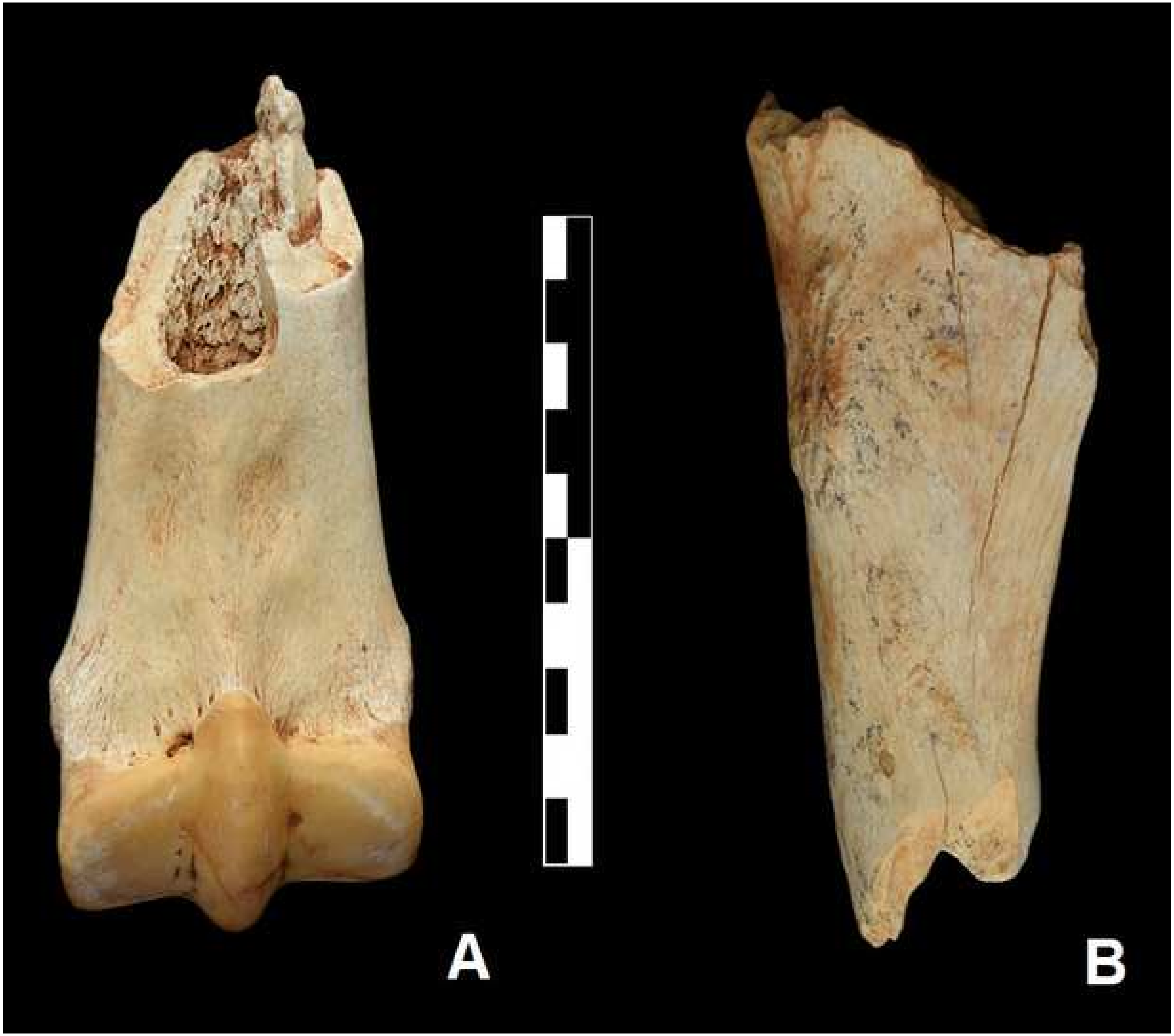

Figure9

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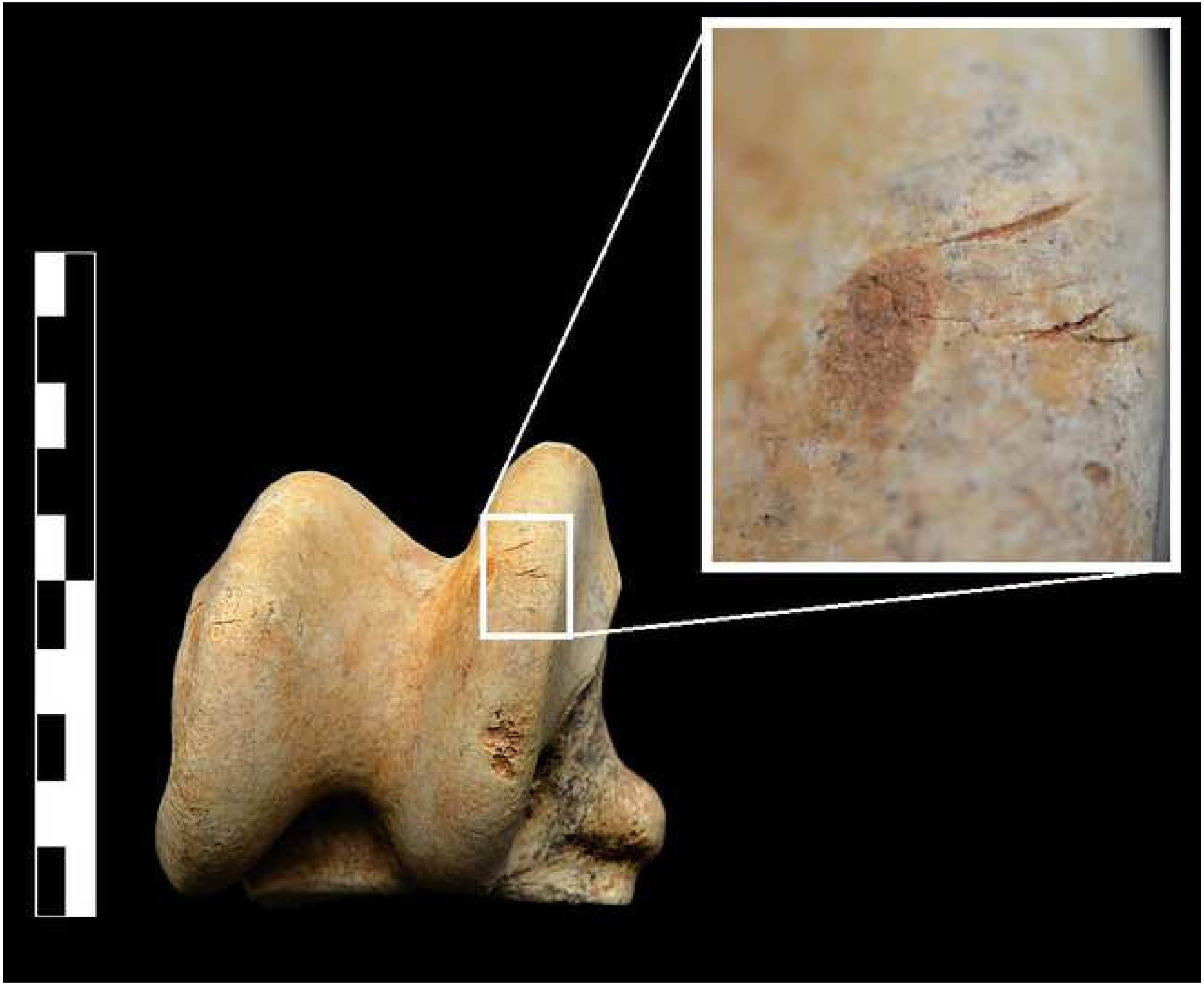

Figure

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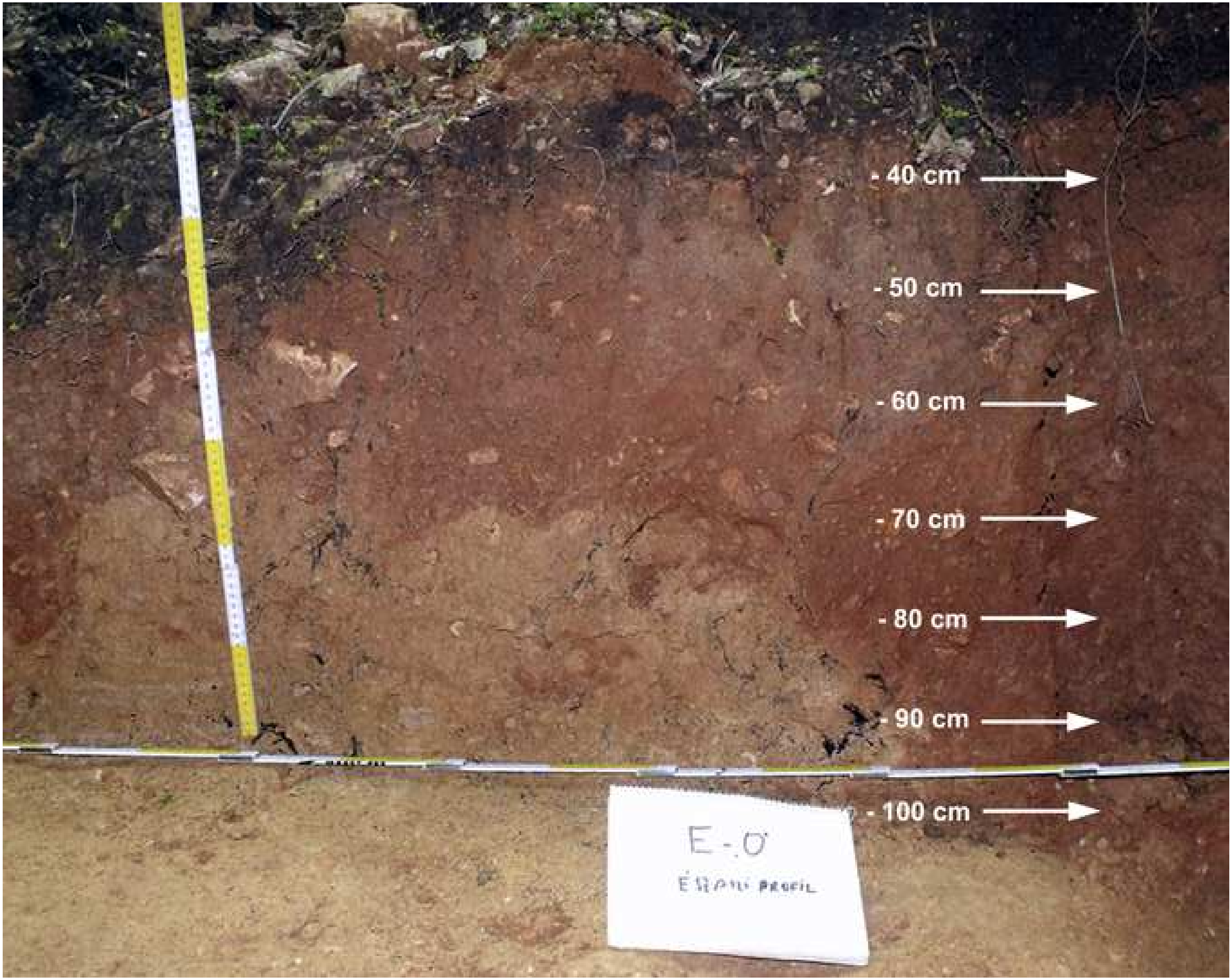

Figure11

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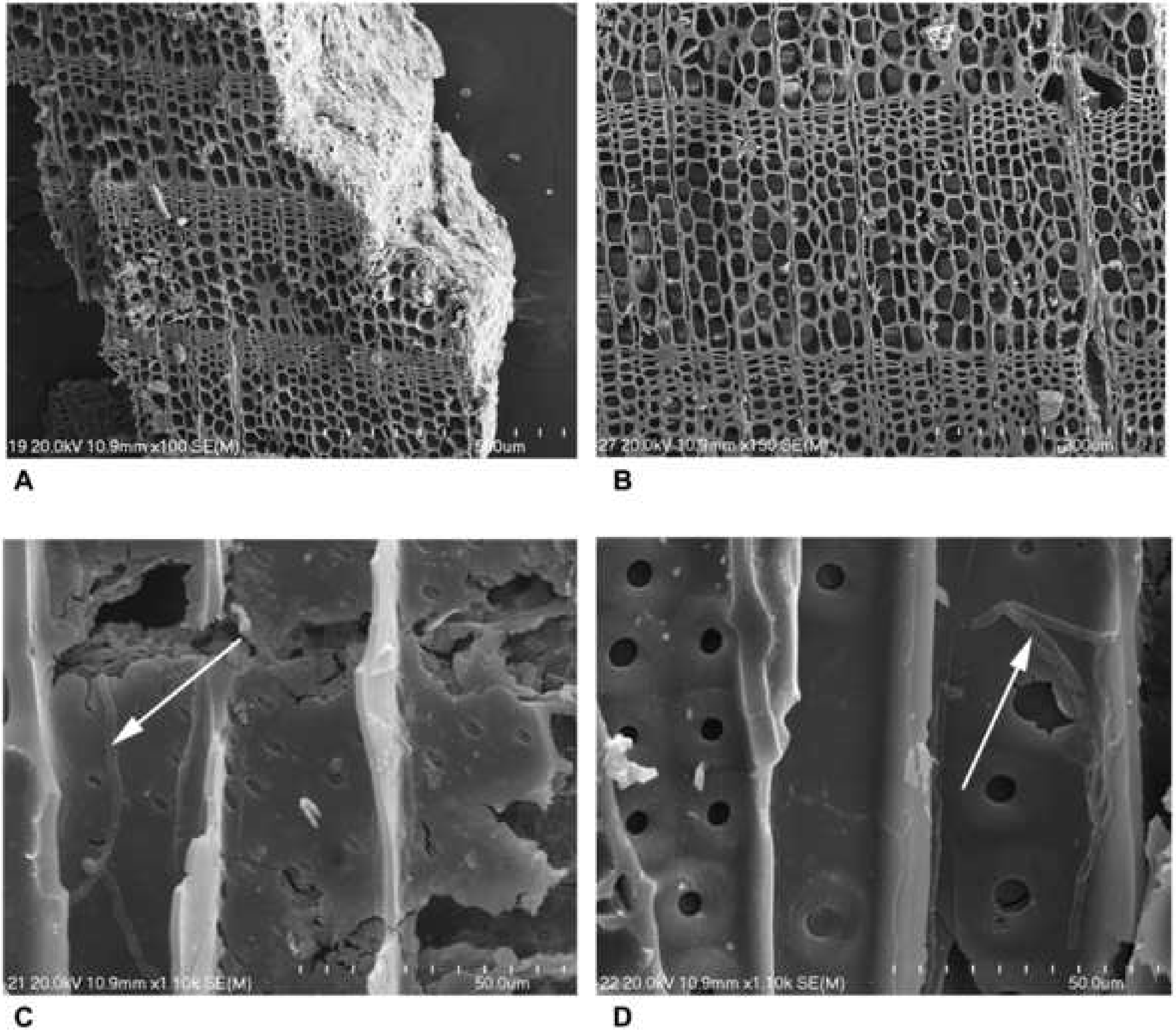

Figure12

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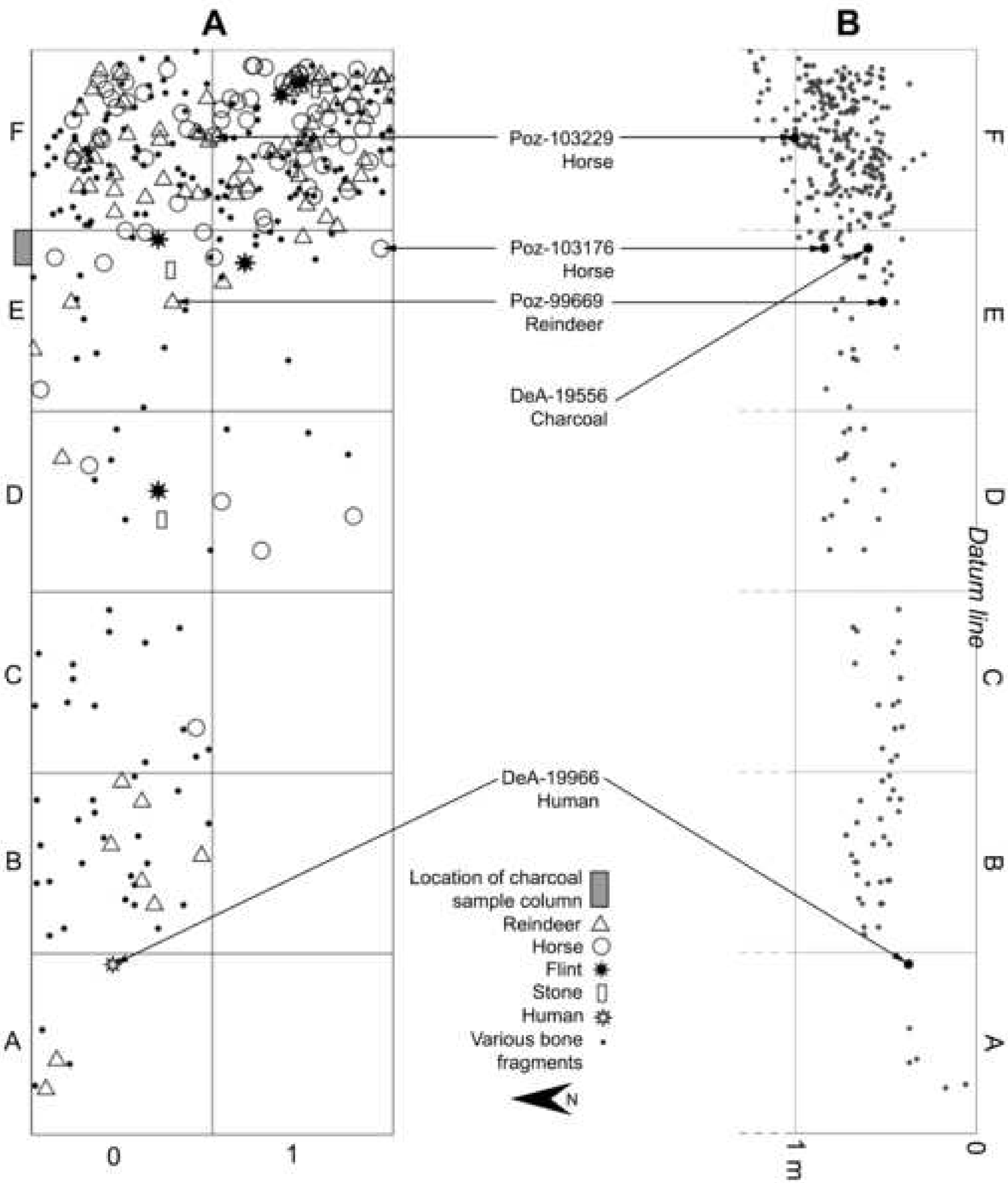

Figure13

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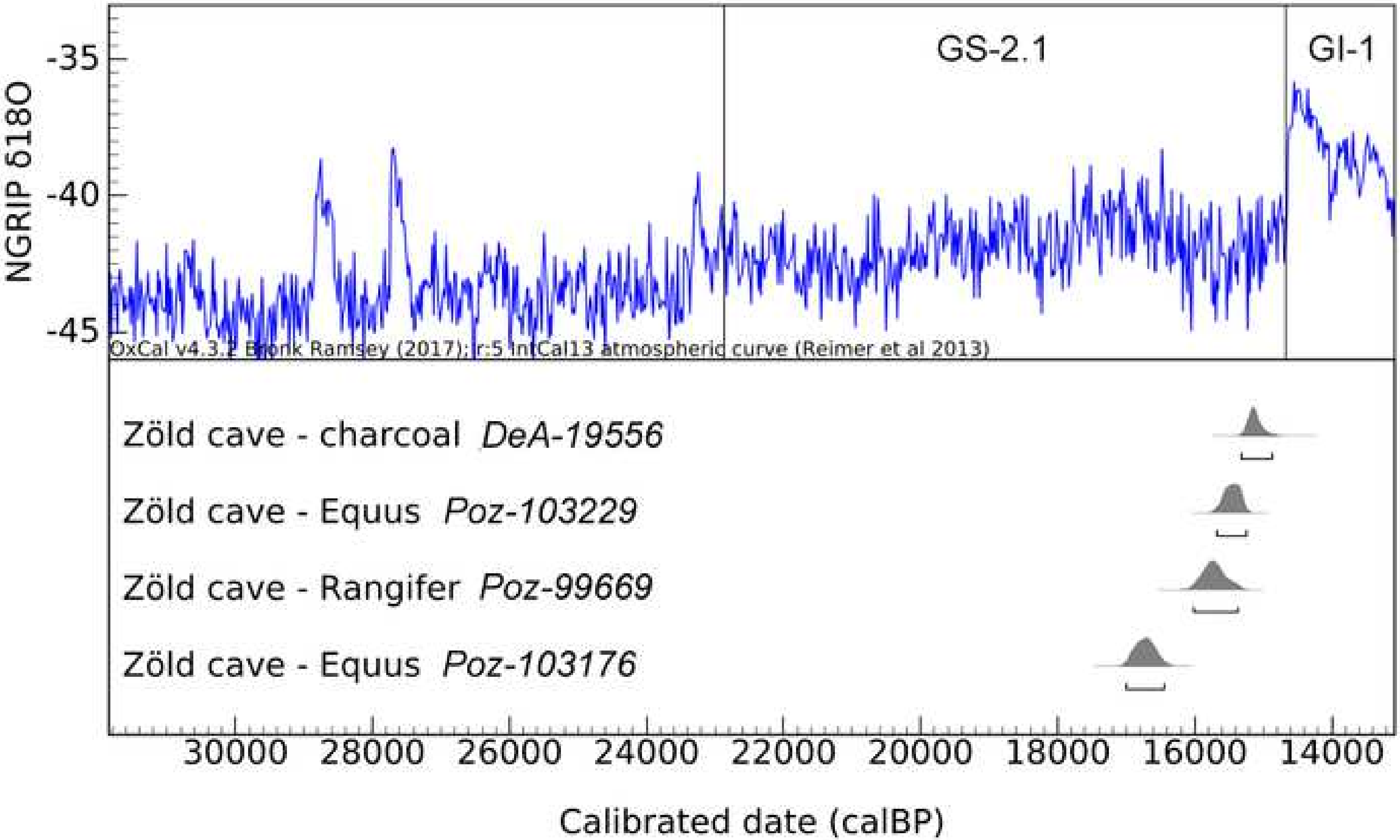

Table1

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Table2

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Table3

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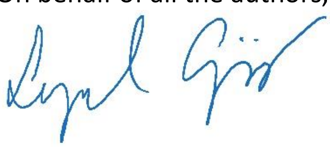
☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

On behalf of all the authors,



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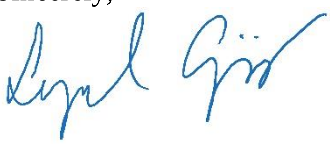
Sincerely,



György Lengyel

On behalf of all authors