



## Middle Palaeolithic human occupation of the high altitude region of Hovk-1, Armenia

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### ARTICLE INFO

#### Article history:

Received 7 May 2011

Accepted 22 September 2011

Available online 22 October 2011

#### Keywords:

Middle Palaeolithic

Palaeoclimate

Palaeoenvironmental reconstruction

Caucasus

### ABSTRACT

Charting the timing of human occupation in the mountainous regions of the Caucasus during the Last Interglacial/Glacial periods is of particular interest to the understanding of past human adaptive and behavioural plasticity and capacity. In this paper we analyse palaeoenvironmental, faunal, and archaeological data gathered during 2006–2009 excavations of the Palaeolithic cave site of Hovk-1, Armenia, in order to address whether human presence in this cave correlates with episodes of mild climate and certain environmental and ecological conditions that were favourable to human occupation in such a region. In the second part of the paper we evaluate the implications of our results in understanding the nature of human presence in other mountainous regions such as the Alps and its potential implications for Palaeolithic research.

Our analysis demonstrates that hominins occupied Hovk-1 Cave during milder climatic phases of the Last Interglacial *sensu lato* (MIS 5d–c) and Last Glacial (late MIS 4/early MIS 3) periods when the area surrounding the cave was an open meadow environment. The stratigraphic Units with noticeable traces of hominin occupation (Units 4, 5 & 8) contrast with others in the lack of cave bear fauna and suggest an inverse correlation between human and cave bear occupational phases in Hovk-1. We speculate that human groups visited this region to hunt specific prey species that prevailed in this habitat (such as the bezoar goat). However, the assemblages of large mammals from Hovk-1 do not provide any clear anthropogenic signal and therefore highlight the difficulty of teasing apart natural and cultural formation processes.

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### 1. Introduction

The Caucasus is part of the Alpine-Himalayan mountainous belt that was created by the collision of the Arabian and Eurasian continental plates during the Neogene (Volodicheva, 2002). This tectonic activity resulted in the formation of both the Lesser Caucasus and Greater Caucasus ranges. The Lesser Caucasus and the associated Armenian Volcanic Highlands are located south of the Rioni-Kura depression and consist of a series of mountain ranges with altitudes between 2000 and 2800 m above sea level (asl) in the west and 2500 and 3300 m asl in the east.

The Early Middle Palaeolithic (EMP) spans between 250 and 128 kilo years before present (ka BP) and thus encompasses the penultimate glacial cycle [Marine Isotope Stages (MIS) 6–7]. The Mid Middle Palaeolithic (MMP) is coterminous with the Last Interglacial and Early Glacial periods (MIS 5) which span between 128 ± 71 ka BP. The onset of the Late Middle Palaeolithic (LMP) coincides with the beginning of MIS 4 and ends at or soon after ~47 ka BP, i.e. during MIS 3 and coincident with the first appearance of Early or Initial Upper Palaeolithic assemblages across Eurasia (Shea, 2003a).

Our knowledge of the EMP, MMP and LMP in the Caucasus is limited due to the paucity of radiometric determinations for the majority of the stratified sites. Only two caves, Mezmaiskaya in the northwestern Caucasus, and Ortvale Klde in Imereti, the southwestern Caucasus, provide an extensive chronometric record for

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human occupation in these regions and excavations of both have yielded chronological sequences which include occupational phases which span some sub-phases of the LMP and EUP (Golovanova et al., 1999, 2006, 2010; Golovanova and Doronichev, 2003; Adler et al., 2006; Pinhasi et al., 2008, 2011). While other caves such as Djruchula in Imereti, Georgia; Tsona, Kudaro I & III in South Ossetia; Myshtulagty Lagat ('Weasel Cave') in North Ossetia, and Azokh Cave in Nagorno-Karabagh, provide a clear indication of EMP and MMP human occupation in the form of typologically dated artefacts (and some such as Kudaro I, Azokh and Tsona also yielded Acheulean Lower Palaeolithic artefacts) (Liubin, 1984, 1989; Hoffecker and Cleghorn, 2000; Hidjrati et al., 2003; Fernandez-Jalvo et al., 2010) their chronologies are not based on reliable radiometric determinations and are therefore provisional at best. The lack of well-dated stratified sites from these periods is even more acute in the case of the Lesser Caucasus. Until recently, knowledge of Middle or Upper Palaeolithic human occupation in the Lesser Caucasus was based on surface finds and/or open-air sites with disturbed stratigraphy. Our 2006–2009 excavation at the high-elevation (2040 m asl) site of Hovk-1, located in the Ijevan range of the Lesser Caucasus, Armenia, has provided a chance to further explore and better date human presence in this region during the Middle Palaeolithic.

When discussing human occupation in the Caucasus during the Middle Palaeolithic it is necessary to consider the fossil record and assess which human species/subspecies utilised the various habitats in different regions and in different episodes. However, there is a paucity of Palaeolithic human remains from the Caucasus. Middle Palaeolithic human fossils have been recovered from the north-western slopes of the Greater Caucasus (from the sites of Mezmaiskaya, Barakaiskaya, Monasheskaya) and have been attributed to *Homo neanderthalensis* (Liubin, 1984, 1989). Additional human remains associated with Middle Palaeolithic Mousterian lithic assemblages were recovered from the southern slopes of the Greater Caucasus in the region of Imereti, western part of the Republic of Georgia. These included a small number of isolated teeth from the site of Djruchula, Bronze Cave, Ortvale and Ortvale Klde, and partial human maxillae from the site of Sakhajia. All these specimens have also been attributed to *H. neanderthalensis* (Gabunia et al., 1978; Liubin, 1984, 1989). While it has been suggested that Mousterian assemblages from sites in other regions of the southern Caucasus were also made by Neanderthals, we can in practice only speculate as to who were the makers of these assemblages. Moreover, as a long history of palaeoanthropological and archaeological research in the southern Levant has demonstrated (Shea, 2003b, 2005), it is possible to have lithic assemblages that share clear techno-typological affinities and yet were made by both anatomically modern humans and Neanderthals during different periods.

Human presence in high-elevation mountain environments during the Last Interglacial/Last Glacial period is of particular interest for several reasons. First, the anthropogenic signature of human visits (lithics, fire spots, butchering, cooking, etc.) is often limited in comparison to the palaeontological signal generated by activity of cave bears and other carnivores. In cases when the anthropogenic signal is not disturbed (cf. Henry, *in press*), such sites offer a unique glimpse into short-term occupation or what may have been a single visit of humans to the cave site. Second, the climatic conditions in high elevation environments are often harsh, even at present, and hence past human occupation of these regions is most likely coincident with episodes of relatively mild climate. Hence, palaeoenvironmental and palaeoclimatic studies of such sites offer the chance to test a potential correlation between specific climatic conditions, a particular faunal and floral spectrum, and human presence in these regions. Third, it is often assumed that the occupation of high elevation environments requires complex behavioural and technological capacities which characterised modern humans,

but which may have not been within the capacity of Neanderthals (e.g. Gamble, 1996). If this is the case then the study of these habitats can tell us something about the nature of human occupation and their utilisation of these unique environmental niches.

In this paper we analyse palaeoenvironmental, faunal, and archaeological data gathered during 2006–2009 excavations of the Middle Palaeolithic cave site of Hovk-1, Armenia, in order to address whether human presence in this cave correlates with particular episodes of mild climate and particular environmental and ecological conditions, and also in an attempt to assess when and why humans were present in this high-elevation region. After having addressed these questions, we evaluate the implications of our results in understanding the nature of human presence in other high-elevation regions.

## 2. Regional setting and geological context

Hovk-1 cave is located at 40°49'21"N 45°0'18"E in the north-easterly Tavush province of Armenia, 20 km east of Dilijan, the provincial capital and 100 km north-east of Yerevan (Fig. 1). The cave is at an elevation of 2040 m asl and is exposed in an east-west orientated cliff which has developed as a result of faulting on the southern flank of the Ijevan mountain range. The latter forms the northerly horst of the east-west trending Aghstev graben and is comprised of Jurassic and Cretaceous limestones and sandstones overlying Jurassic volcanic rocks (Dumitrashko, 1962; Nefedyeva, 1962). Pleistocene-Holocene alluvial deposits overlie Mesozoic rocks in the lower parts of the Aghstev graben. Hovk-1 cave itself developed in Jurassic dolomitic limestone as a result of karstic dissolution along a bounding plane between two limestone beds, and along a fault crack perpendicular to the cliff line. The net result is a hollow in the limestone measuring a maximum of 14 m in length, 2 m in width and 3 m height (Figs. 2 and 3) (Pinhasi et al., 2008). The cave is divided into three zones (Fig. 2): the main gallery which is exposed to light through the present cave entrance; a rear gallery that does not receive light from the cave mouth, but which is the location of a blocked karstic chimney, and a 1.5 m deep infilled karstic hollow (a 'karren') located immediately below the present cave entrance.

The site was excavated during five fieldwork seasons between 2005 and 2009. In 2005, a grid of 1 m squares was established inside the cave using a total station. A local coordinate system and datum were then associated with the grid and linked to the UTM (WGS 84) coordinate system and geoid elevation by surveying into the cave with a total station from permanent control points established with a differential GPS on the plateau below.

Excavation was carried out in separate 50–100 mm thick 'spits' within each depositional sedimentary unit ('Unit') and grid square, and all artifacts and faunal remains were recorded with respect to local grid coordinates and site datum using a total station. Articulated animal bone, such as a complete cave bear skeleton in Unit 6 encountered during the 2006 season, was recorded in vertical digital photographs taken on site, georeferenced by means of total station recorded control points and then the outlines of individual bones traced in the ArcGIS software package. Pre-medieval sediment was bagged separately by unit, spit, and grid square, removed from the cave, and then processed using a standard flotation machine and with meshes of 0.5 mm for both flot and residue, in order to recover micro-artifacts and biological remains.

The results of the lithic analysis, the study of large fauna, and micromorphological examination of thin sections during the first three field seasons are described in Pinhasi et al. (2008). Macro and micro fauna recovered from the excavation were studied in Yerevan, and spot samples for preliminary pollen analysis were taken from Units 4, 5, 6, 7, and 8 (Fig. 3) during the 2005 season and then examined in Frankfurt (see below). Sub fossil plant remains were

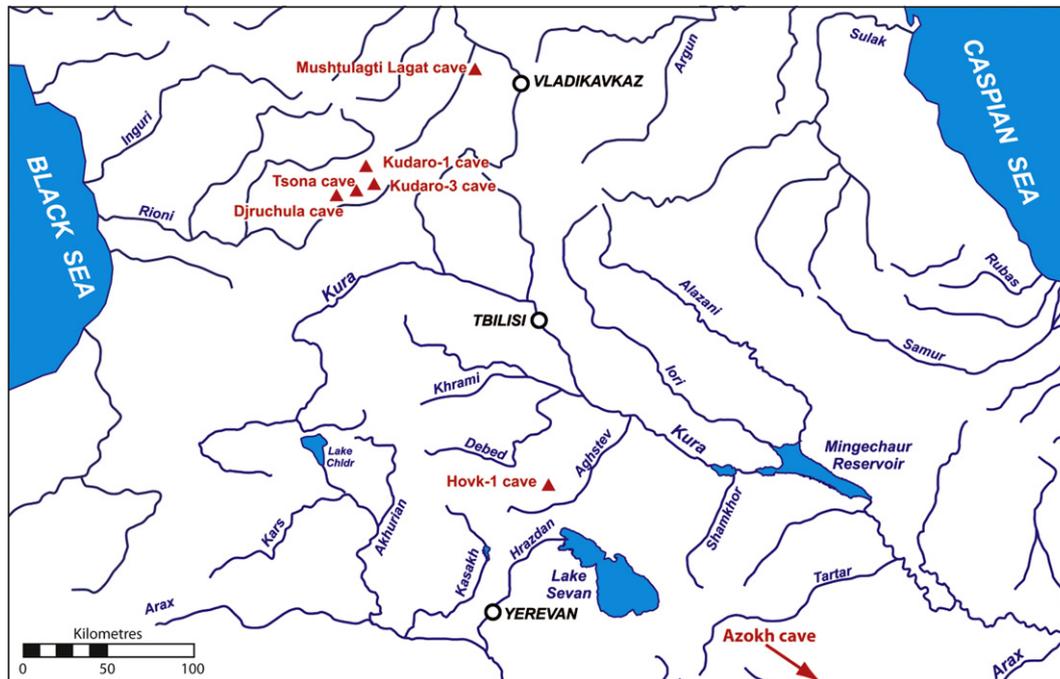


Fig. 1. Location of the Hovk-1 cave.

obtained from both flots and residues of samples taken from Units 1–8 (see below).

### 3. Stratigraphy and chronology

The stratigraphy and micromorphology of the main gallery of the Hovk-1 cave has been discussed in detail by Pinhasi et al. (2008). Here we expand on the data presented in that paper to describe all three zones the cave. The 0.80 and 4.40 m of infilling sediment that lie above the limestone platform forming the base of the cave have been divided into 13 sediment Units (Fig. 3) and their descriptions are provided in Table 1.

A combination of U-series, OSL and AMS  $^{14}\text{C}$  dating provides a chronology for the infilling events. Thus Unit 8 formed at and before  $104 \pm 9.8$  ka BP (OxL-1001), flowstone formation of Unit 6a ceased soon after  $94.2 \pm 4.9$  ka BP (BIG-UTH-A243) and was followed by a hiatus before Unit 6 accreted at  $54.6 \pm 5.7$  ka BP (OxL-1000) (Pinhasi et al., 2008). Unit 5 was originally dated to  $33.8 \pm 0.5$   $^{14}\text{C}$  ka BP (Poz 14674) (Pinhasi et al., 2008), but the *Capra aegagrus* (bezoar goat) astralogus originally used for AMS  $^{14}\text{C}$  dating was re-analysed using the ultrafiltration technique (Higham et al., 2006), and a bone age of  $>46$  ka BP was obtained (Poz-23097). An *Ursus* bone from Unit 4 was AMS dated by ultrafiltration to  $35.55 \pm 0.65$   $^{14}\text{C}$  ka BP (OxA 24504). Medieval ceramic fragments (1000–500 BP), as well two Iron Age beads (one made of cornelian and one made of glass) dated by cultural attributed to circ. 500 BC to AD 0, were found in Units 1 and 3 hence indicating that these Units are of Holocene age and therefore that an unconformity exists at the contact of Units 4 and 3.

### 4. Human occupation

The evidence for Middle Palaeolithic human presence at Hovk-1 is based on a small number ( $n = 50$ ) of Mousterian stone tools, flakes and lithic debris (debris is here defined as a flake  $<15$  mm), most of which were made from local limestone but some ( $n = 26$ ) were made of non-local obsidian and chert. In addition, several ash

spreads were excavated in Pleistocene Units 12, 10, 9, 8, 6, 5 and 4, although no burnt bones or burnt lithic artefacts were recovered.

Unit 12 contained one obsidian flake and one piece of obsidian debris. Unit 10 yielded two obsidian flakes and two pieces obsidian debris. Unit 9 contained one unretouched Levallois point, two limestone flakes one obsidian and one limestone debris. Unit 8 contained four unretouched limestone Levallois points, a limestone flake, a limestone tool fragment and three small debris (made of andesite and obsidian) (cf. Pinhasi et al., 2008). Unit 6 contained one piece of flint debris. Unit 5a contained one limestone Levallois flake (this more than likely appeared in this colluvial unit from the above plateau through the chimney). Unit 5 contained one obsidian flake and seven obsidian debris, and a limestone core or utilized nodule. Unit 4 contained one obsidian flake and one obsidian debris. Unit 3 contained one obsidian and one limestone debris. Unit 1 contained one obsidian flake and one small obsidian debris and one Middle Palaeolithic scraper made of limestone (the lithic artefacts in Unit 1 are likely to have been reworked by fluvial processes from the colluviums of Unit 5a in the rear gallery).

The karren yielded eight Middle Palaeolithic artefacts: two obsidian and two limestone flakes, three retouched elongated limestone Levallois points and one obsidian point. In addition two Middle Palaeolithic artefacts (one limestone flake and one limestone single scraper) and two obsidian flakes (both belong to later periods Units 5–3) were found inside of accumulated sediment in the front platform of the cave.

The techno-typological analysis of the Hovk-1 Unit 8 artifacts highlights some typological similarities with assemblages from the Kudaro-Djrchula group (cf. Meignen and Tushabramishvili, 2006), for example those from Djrchula Cave (Imereti, Republic of Georgia), Kudaro I and III, and Tsona (South Osetia). However, the absolute age of these assemblages is not known due to lack of reliable chronometric determinations for the relevant strata. The lithic assemblages from all these sites contain a high frequency of elongated Levallois points and blanks with low frequencies of debitage, cores, and other tool forms. The elongated Levallois points and blades share techno-typological similarities with Levantine

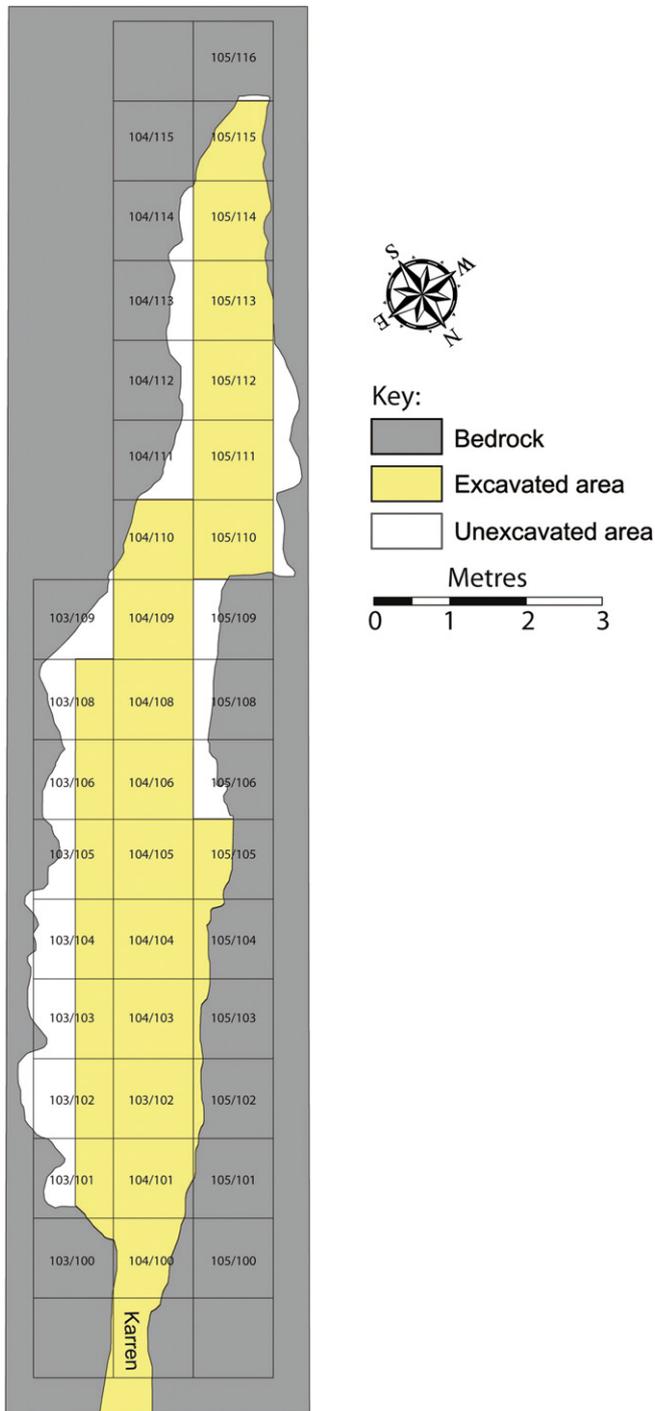


Fig. 2. Plan of the Hovk-1 cave showing the location of excavated squares.

and other Near Eastern early Middle Palaeolithic industries such as those from Tabun D, Hayonim E, Abu Sif, Rosh Ain Mor, Ain Difla, Doura, and Hummal and are dated between 90 and 250 ka BP (Liubin, 1984, 1989; Beliaeva and Liubin, 1998; Rink et al., 2004).

## 5. Palaeoclimate and palaeovegetation

### 5.1. Fossil plants and palynology

To our knowledge only scarce information about palynological or archaeobotanical macro botanical data from other Middle

Palaeolithic strata within high elevation caves above tree line and with stratified sedimentation are available for comparison with those from Hovk (cf. Coles and Gilbertson, 1994; Carrión et al., 1999; Navarro et al., 2001; Groner, 2004; Feurdean et al., 2011) and therefore the studies outlined below provide important documentation of such environmental information.

All sediments from Hovk-1 recovered during the 2006–2008 seasons have been processed by flotation and wet-sieving (smallest mesh size 1 mm) as discussed above and several hundred plant macrofossils recovered. Much of the uncharred and occasionally charred (e.g. one grain of emmer from Unit 2) material has accumulated in the cave during the Holocene mostly as a result of animal activity. However wet sieving resulted in the recovery of 227 calcified macrofossils of Pleistocene age from Units 6, 8, 10a, 10b and 12 (Supplementary information, Table A1).

While calcification benefits seed preservation, it also leads to significant deformation and distortion. As a result 85 of the recovered Pleistocene seeds (37.4%) are unidentifiable, and 5 (2.1%) are only identifiable to type. The remaining 137 seeds (60.4%) are assigned to 4 taxa (Supplementary information, Table A1, Fig. A1). The identified taxa are all herbaceous plants, although 10 fragments of mineralized charcoal were recovered. The highest concentrations of plant macro-remains were recorded in Units 10b (50.2%), 10a (19.4%) and 12 (8.8%) of square 103/108 and in unit 10a (6.2%) of square 104/108.

Representatives of *Centaurea* and *Chaerophyllum* still grow in the vicinity of the cave, and both are edible. Species of *Centaurea* are common components of meadows and *Chaerophyllum* is one of the main elements of sylvatic relatively moist and shadowy plant formations in northern Armenia. These taxa may document the presence of meadows but also some moist broadleaved forests in the vicinity of the cave.

Seven samples were taken from Hovk1 section N1 (Units 8–2) and seven samples from section N3 (Units 12–9) for palynological analysis (Supplementary information, Table A2). The analysed samples have low pollen contents. The assemblages are dominated by herbaceous pollen, mainly by Asteraceae (Chichorioideae and Asteroideae) and Caryophyllaceae. Occasionally, other herbaceous taxa occur, which are Apiaceae, Brassicaceae, Chaenopodiaceae, Dipsacae, Plumbaginaceae, Thymelaeaceae and Poaceae. Tree pollen are rare and mainly dominated by gymnosperm pollen of *Pinus* (in Units 4–9), with *Quercus*, *Betula*, *Corylus* and *Carpinus* occurring only in Units 4 and 5. Fern spores (*Asplendium*-type) are abundant in Unit 4, but occur occasionally also in older levels (Fig. 4). The occurrence of algal spores documents water availability inside the cave. In the text below we provide a description of the results for the stratigraphic Units 12 to 4. No environmental interpretation is possible for Units 3 and 2 due to very poor pollen preservation.

The pollen flora of Unit 12 is represented by two samples both of which are strongly dominated by Asteraceae – Chichorioideae (incl. *Centaurea*) (>87%). All other taxa in the assemblage are herbaceous plants as well: Asteraceae – Asteroideae, Apiaceae (incl. *Chaerophyllum*), Caryophyllaceae, and Dipsacaceae. The macro flora confirms this spectrum by ten calcified seeds of *Centaurea* sp. (Asteraceae), two other Asteraceae and one seed of Apiaceae. Macro and micro remains of the flora of Unit 12 indicate open vegetation. All determined taxa are herbaceous plants, however, some of them appear also in forests. Thus, the existence of forest in the vicinity of the cave cannot be totally excluded. Furthermore, the low abundance of charcoal gives no evidence of human activity.

Unit 10 has the highest concentration and diversity of plant macro remains. High numbers of *Centaurea* (Asteraceae) and *Chaerophyllum* (Apiaceae) plus various unidentifiable specimens are recovered together with a great variety of herbaceous pollen

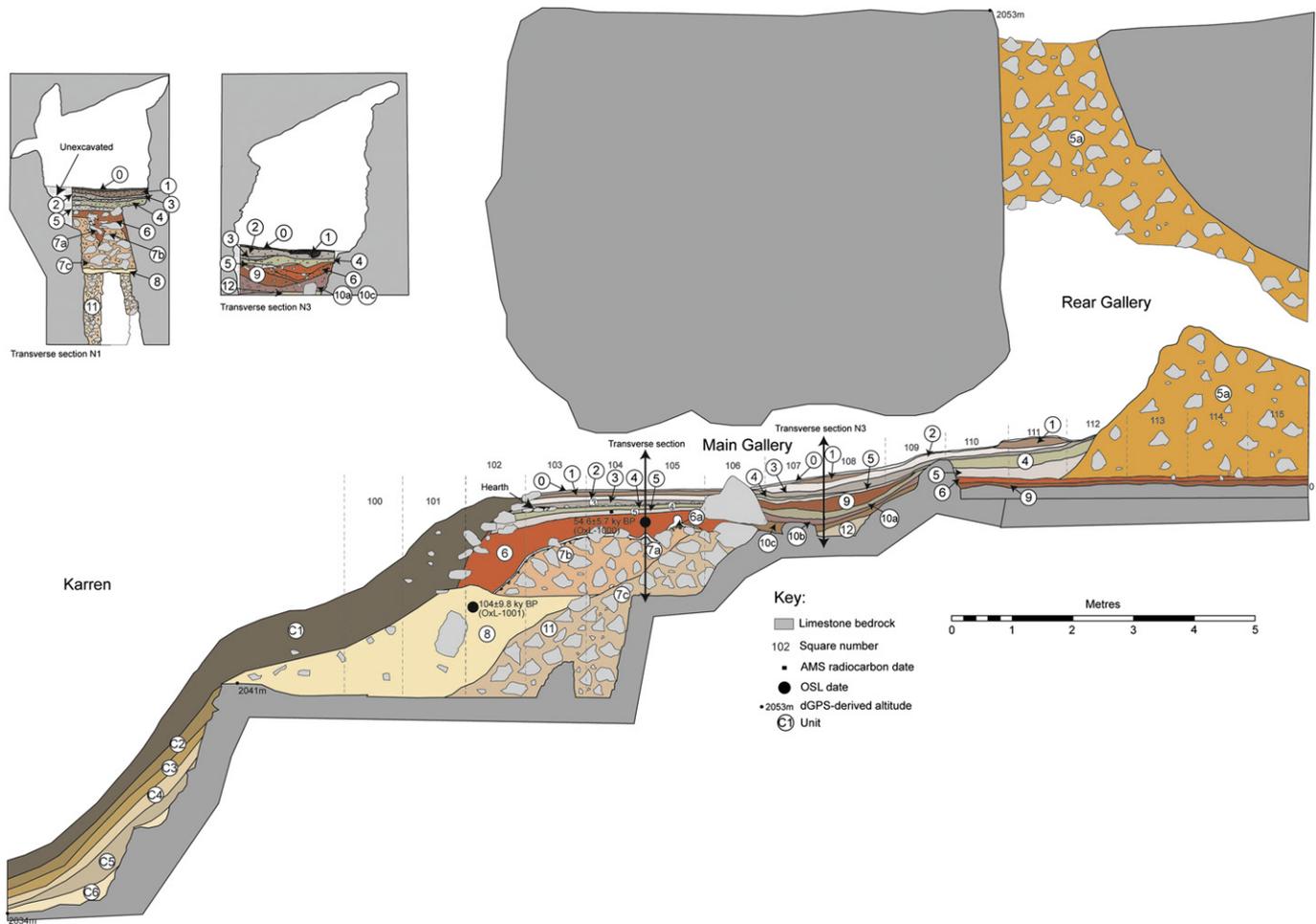


Fig. 3. Longitudinal and transverse sections through deposits infilling Hovk-1 cave. See Table 1 for descriptions of the infilling strata.

taxa. The flora of Unit 10 is very similar to Unit 12 and is characteristic of open vegetation. However, in contrast to Unit 12, Unit 10 includes increasing amounts of charcoal from Units 10c to 10a, which could be an indication of the onset of increasing human activity.

The flora of Unit 9 is only represented by pollen data. The assemblages are dominated by herbaceous taxa of Asteraceae – Cichorioideae (incl. *Centaurea*) (>97%), as well as Apiaceae, Brassicaceae, and Dipsacaceae. Single grains of pine (*Pinus*) and fern (*Asplenium*-type), respectively, occur for the first time. The pollen flora of Unit 9 also indicates a dominance of open vegetation and the abundance of charcoal is relatively high and may reflect human activity.

Unit 8 yielded no pollen but 11 calcified seeds of herbaceous *Centaurea* (Asteraceae) and 7 seeds of *Chaerophyllum* (Apiaceae). The flora of Unit 8 is poor in number of taxa and is too limited for an environmental interpretation.

A pollen flora of Asteraceae – Cichorioideae (incl. *Centaurea*) (94%) is dominant in Unit 6. All other taxa in this assemblage are also herbaceous plants: Asteraceae – Asteroideae, Caryophyllaceae, Chenopodiaceae, Poaceae. In the macro category only two calcified seeds of *Centaurea* sp. (Asteraceae) were recovered. Although pollen concentration in Unit 6 is low, the assemblage implies an open landscape.

The pollen flora from Unit 5 includes generally the same herbaceous taxa as Unit 6, which account for 86% of the assemblage. However, 10% of the pollen belong to arboreal plants, mainly

pine (*Pinus*, 9%) and lesser amounts of hazel and hornbeam (*Corylus* and *Carpinus*, 1%). Thus, the flora of Unit 5 indicates the existence of trees in the vicinity of the cave and may imply a spread of forest, especially compared to Units 9 to 12. This could be due to higher temperatures and a rise of tree line or increased humidity and a general spread of forests in the wider region. The latter is also supported by the occurrence of algal spores in the palynoflora that indicates humid conditions inside the cave.

The pollen flora of Unit 4 shows even less herbaceous plant taxa (64%) than Unit 5, but the highest abundances of pine pollen (ca 13%), fern spores (*Asplenium*-type, 16%) and algal spores of all samples. A few grains of birch and oak (*Betula* and *Quercus*) occur as well. It thus shows a further increase in trees and since fern spores generally are not transported over considerable distances, the forest may have been relatively close to the cave. However, ferns of *Asplenium* also grow at the entrances of caves and could indicate humid conditions in the cave itself. This interpretation is supported by the occurrence of high numbers of algal remains in the palynofloras. Generally, Units 5 and 4 show increased evidence for humidity than in the case of all other Units but nonetheless the vast majority of plant remains is characteristic of a herbaceous open vegetation.

## 5.2. Microfauna

Table 2 presents the taxonomic composition of the micro-mammalian assemblage and the numbers of molar specimens that

**Table 1**  
Summary descriptions of strata infilling Hovk1 cave. Modified from Pinhasi et al., (2008), Fig. 3.

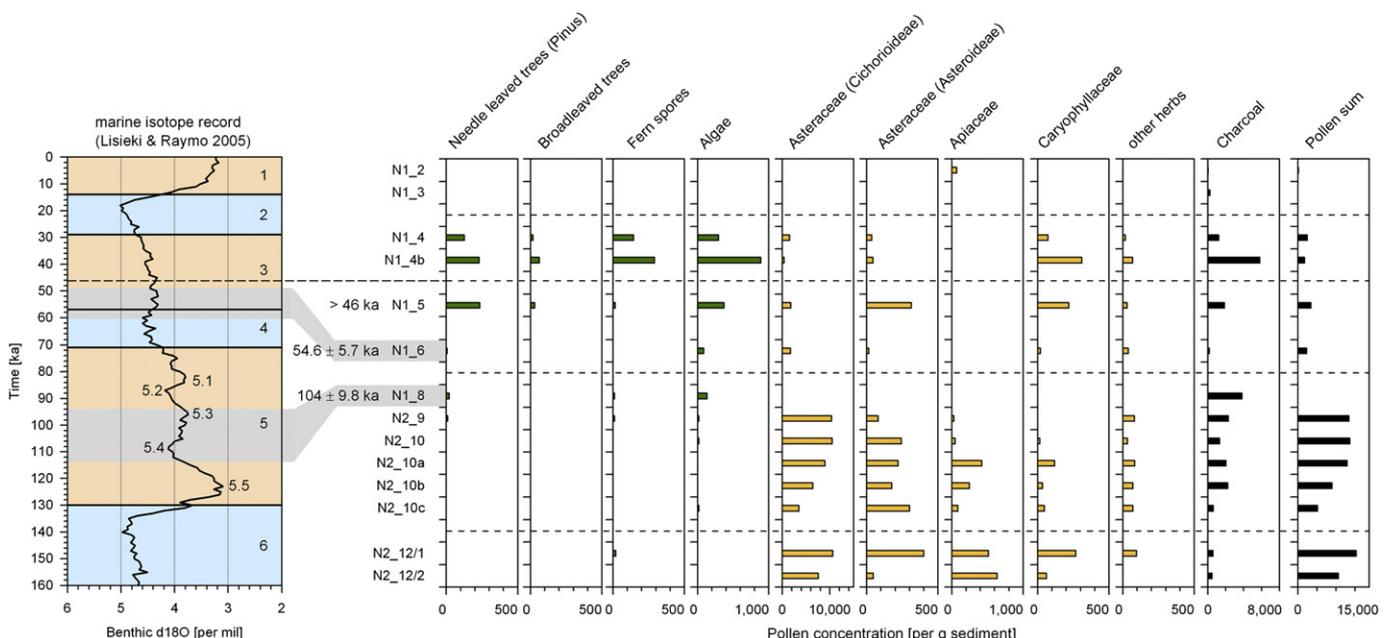
Unit	Description	Interpretation
0	10 YR 3/2 Dark brown humic and fibrous fine sand/silt	Recent animal dung
1	10 YR 6/3 Pale brown poorly sorted matrix-supported fine gravel of sub-angular to sub-rounded granules and fine pebbles in a silt/fine sand matrix	Holocene cave earth
2	10 YR 4/3 Brown fine poorly sorted matrix-supported fine gravel of sub-angular to sub-rounded granules and fine pebbles in a silt/fine sand matrix	Holocene cave earth
3	10 YR 6/3 Pale brown poorly sorted matrix-supported fine gravel of sub-angular to sub-rounded granules and fine pebbles in a silt/fine sand matrix and interbedded with fine pebble to silt-size charcoal concentration (hearth)	Holocene cave earth
4	10 YR 5/3 Brown silt/fine sand with occasional fine pebble to granular sub-angular to sub-rounded limestone clasts	Pleistocene cave earth
5	10 YR 4/3 Brown poorly sorted matrix-supported gravel of sub-angular to sub-rounded granules and fine pebbles in a humic silt/clay matrix	Pleistocene cave earth
6	10 YR 6/4 Light yellowish brown well sorted fine sand with very occasional sub-angular limestone granules	Pleistocene fluvial deposit
6a	Flowstone and stalactite	Pleistocene speleothem
7	10 YR 6/4 Light yellowish brown poorly sorted matrix and clast-supported gravel of sub-angular limestone boulders and cobbles in fine sand/silt matrix	Pleistocene roof collapse
8	10 YR 6/3 Pale brown poorly to moderately sorted medium sand with occasional granular to pebble-sized sub-rounded limestone clasts	Pleistocene cave earth
9	7.5 YR 5/4 Brown moderately sorted medium sand with occasional fine pebble-sized sub-angular to sub-rounded limestone clasts	Pleistocene fluvial deposit
10	10 YR 5/3 Brown moderately sorted medium sand with occasional fine pebble-sized limestone clasts	Pleistocene fluvial deposit
11	Poorly sorted clast- and matrix-supported gravel of sub-angular limestone boulders in a matrix of sand- and granular-sized limestone clasts	Pleistocene roof collapse
12	10 YR 6/4 Light yellowish brown poorly sorted matrix-supported gravel of sub-angular limestone boulder to pebble-sized clasts in a fine sand/silt matrix	Pleistocene colluvium

were examined from each taxon by stratigraphic unit. The samples from the sequence of Units 8–1 include 18 different taxa of small rodents, shrews and bats.

Digestion marks on molar teeth of micromammals resulting from predation were noted on specimens from all of the stratigraphic units of Hovk-1. The frequency of digestion marks in the sample of lower M1 teeth of the genus *Microtus* ( $N = 361$ ), by stratigraphic Unit is presented in Supplementary information, Table A3. A striking two-fold difference in the frequency of digestion can be noted between the Unit 8 sample (75%) and the samples from Units 6–1 (28–42%). This observation could indicate that different types of predators were responsible for depositing the micromammalian remains in the two separate parts of the Hovk-1 stratigraphic sequence (Andrews, 1990). It could also indicate the contribution of other processes of accumulation of

micromammalian remains such as by pitfalls through the chimney. More detailed taphonomic analysis will be required for establishing the precise role of predators and of other processes in formation of the assemblage, how these processes may have changed through time, and a firmer basis for interpretations of the paleoenvironment (e.g., Fernández-Jalvo, 1995; Fernandez-Jalvo et al., 2011).

The overall composition of the micromammalian species (Table 2) shows a strong biogeographic affiliation with southern provinces, i.e. mainly the Eastern Mediterranean and Asia Minor. Data on the present distribution of species of rodents and shrews in Table 2 show that 16 of the 17 species from Hovk-1 are extant in Armenia and that 14 inhabit the region of Hovk-1 in northern Armenia. Distribution areas of two of the species (mole rats and mole voles) do not include northern Armenia at present and indicate relatively minor alterations in micromammalian species



**Fig. 4.** Simplified pollen diagram with correlation to the global isotope record. green - humid indicators: trees, ferns, algae; yellow – open vegetation: herbs.

**Table 2**  
Numbers of identified micromammalian molar teeth by taxa and stratigraphic units.

Taxa	Common name	Unit 8		Unit 6 <sup>a</sup>		Unit 5		Unit 4		Unit 2		Unit 1		Preent distribution includes Northern Armenia <sup>e</sup>	Distribution type <sup>f</sup>
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI		
Chiroptera		–	–	1	1	2	2	–	–	–	–	2	2	–	–
Rodenfia															
<i>Dryomys nitedula</i> <sup>b</sup>	Forst dormouse	–	–	–	1	–	–	–	–	–	–	–	–	✓	East Mediterranean
<i>Sciurus anomalus</i>	Persian squirrel	–	–	–	–	1	1	–	–	–	–	1	1	✓	East Mediterranean
Cricetinae															
<i>Cricetulus migratorius</i>	Migratory hamster	–	–	–	–	1	1	–	–	1	1	1	2	✓	East Mediterranean
<i>Mesocricetus brandti</i>	Brandt's hamster	–	–	–	–	4	3	1	1	1	1	–	–	✓	East Mediterranean
<i>Cricetus cricetus</i>	Common hamster	93	28	1	1	8	5	–	–	1	1	1	1	Northern Caucasus	European
Arvicolinae															
<i>Ellobius llutescens</i>	Tra re Caucasian mole vole	–	–	–	–	–	–	3	2	1	1	1	1	Southern Armenia	East Mediterranean
<i>Arvicola amphibius</i>	Water vole	4	3	–	–	5	3	–	–	1	1	1	1	✓	East Mediterranean
<i>Microtus</i> spp. <sup>c,d</sup>	Field voles	757	84	21	2	279	24	94	16	157	16	193	19	✓	Eurasian
<i>Chionomys nivailis</i>	Snow vole	32	20	2	1	39	26	14	10	14	10	27	22	✓	East Mediterranean
<i>Spalax nehringi</i>	Leser mole rat	2	2	1	1	–	–	–	–	–	–	–	–	Western Armenia	East Mediterranean
<i>Allactaga</i> sp.	Jerboa	–	–	–	–	–	–	–	–	1	1	2	2	✓	Central Asia
<i>Apodemus witherbi</i>	Field mouse	3	3	–	–	–	–	–	–	–	–	1	1	✓	East Mediterranean
Lipotyphla (Insectivora)															
Soricinae															
<i>Sorex minutus</i>	Lesser shrew	1	1	–	–	–	–	–	–	–	–	1	1	✓	Eurasian
<i>Sorex satunini</i>	Common shrew	2	2	1	1	4	4	–	–	–	–	–	–	✓	Aisa Minor
<i>Neomys teres</i>	Water shrew	1	1	–	–	–	–	–	–	–	–	–	–	✓	East Mediterranean
Crocidurinae															
<i>Suncus etruscus</i>	Etruscan shrew	3	3	–	–	1	1	–	–	–	–	2	2	✓	Eurasian
<i>Crocidura</i> sp.	Whle-toothed shrew	2	2	–	–	1	1	–	–	–	–	–	–	✓	Eurasian
Total		900	149	27	7	345	71	112	29	177	32	234	55		

<sup>a</sup> 15 specimens from un differentiated samples between Units 5–6 not included in the table.

<sup>b</sup> A single specimen of *D. nitedula* derived from Unit 5–6.

<sup>c</sup> NISPs include *Microtus* spp. and *C.nivalis* M2-M3 teeth. MNI's for both taxa based on M1's only.

<sup>d</sup> *Microtus* voles include common voles *M. arvalis* and social voles *M. socialis*.

<sup>e</sup> Distribution data based on Vereschagin (1967); Harrison and Bates (1991); Wilson and Reeder (1993); Panteleyev (1998).

<sup>f</sup> Distribution data based on Vereschagin (1967); Wilson and Reeder (1993).

distribution within the territory of Armenia. Such alterations have also been recorded during the Holocene (e.g. Vereschagin, 1967 for mole rats in Armenia). Of particular interest is the presence of the common hamster. *Hovk-1* is well outside the present day distribution of this species which extends across the Eastern European Plains and is truncated within the Northern Caucasus (Panteleyev, 1998). The majority of the remains of common hamsters are from Units 8, 6 and 5. The few specimens of common hamsters in Holocene strata may be derived from erosion of older deposits within deeper parts of the cave.

The samples show a significant presence of species of small rodents and shrews which are typical of the European high-altitude Alpine complex (see Allainé and Yoccoz, 2003; Fomin et al., 2004). This includes common and snow voles and the common and lesser shrews (Table 2) which prevail in high-altitude mountainous regions. The voles (*arvicolines*) together with hamsters of the *cricetine* subfamily comprise the two most dominant groups throughout the sequence and strongly indicate widespread and persistent presence of open vegetation most likely of high-altitude steppe or meadow formations. Snow voles, unlike other species of voles, are not well-adapted for digging burrows and depend on the microclimate of rocky areas such as the scree of mountain slopes (Janeau and Aulagnier, 1997) and indicate the presence of rocky habitats. The water vole and shrew are characteristic of water biotopes such as floodplain meadows and marshy areas. Species indicating forested environments (Persian squirrel, forest dormouse and field mouse) are relatively few and rare and suggest that tree cover was sparse in the region during MIS4-MIS2.

Given the relatively large sample size (Number of Individual Specimens [NISP] based on molars = 2138) quantitative change in the abundance of species can be assessed from NISPs and Minimum

Number of Individuals (MNI) in Table 2. Occurrence of species through the stratigraphic sequence provides few indications of faunal change as disjunct distributions mainly relate to small numbers of specimens (Table 2). Taxonomic proportions based on both NISPs and MNIs are presented in Supplementary information, Table A3. The proportions of common hamsters show a clear trend of decrease in Units 8–5 and are especially low in Units 4–1. Diminishing prevalence of common hamsters may indicate refuge populations cut off from their centre of distribution due to glaciation in northern latitudes. The importance of glacial refugia in the phylogeography of common hamsters has been documented through paleontological (Markova et al., 1995) and DNA research (Neumann et al., 2005). Microfaunal records indicate that common hamster was fairly frequent in Upper Pleistocene layers in archaeological sites in the Northern Caucasus and that they occur in a wide altitudinal range (Vereschagin, 1967; Gromov and Fokanov, 1980). They are absent, however, from lower altitude sites of this period in Armenia (L. Weissbrod pers. obs.).

Snow vole proportions increase through in Units 8–1 (Supplementary information, Table A3). The increase is particularly evident between Units 6 and 5. Snow voles became especially widespread in western Eurasia during the last glacial period (Janeau and Aulagnier, 1997). This indicates the persistence of cold and possibly dry climatic conditions in Units 6 and 5 although the increase in snow vole proportion could be related in part to the collapse of the chimney. At present fragmented populations of snow voles persist mainly in high-altitude areas surrounding the Mediterranean. Upper Units (6–1) are also characterised by the appearance and gradual increase in abundance of other hamster species including Brandt's and migratory hamsters with distinctly southern centres of distribution and adaptation to dry conditions.

**Table 3**  
Numbers of identified specimens (NISP) and minimum numbers of individual (MNI) by taxa and stratigraphic units.

Taxa	Karren		Colluvium		Unit 8		Unit 7		Unit 6		Unit 5		Unit 4		Unit 3		Unit 2		Unit 1	
	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP
Ungulate	90	44.1	145	79.7	38	60.3	13	40.6%	9	9.9%	60	47.2%	109	66.1%	39	66.1%	45	56.3%	60	65.9%
<i>Capra aegagrus</i>	31	15.2	10	5.5	10	15.9	2	6.3%	2	2.7	3	2.4%	10	6.1%	4	6.8%	3	3.8%	5	5.5%
<i>Cervus elaphus</i>	1	0.5	4	2.2	1	1.6	—	—	1	1.4	1	0.8%	—	—	2	3.4%	1	1.3%	—	—
<i>Sus scrofa</i>	—	—	2	1.1	1	1.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Bison caucasicus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Capreolus capreolus</i>	69	33.8	6	3.3	5	7.9	13	40.6%	53	71.6	29	22.8%	11	6.7%	5	8.5%	21	26.3%	3	3.3%
<i>Ursus deningeri</i>	8	3.9	1	0.5	1	1.6	—	—	1	1.4	—	0.0%	1	0.6%	—	—	1	1.3%	2	2.2%
<i>Canis lupus</i>	4	2.0	9	4.9	2	3.2	—	—	4	5.4	8	6.3%	12	7.3%	6	10.2%	3	3.8%	11	12.1%
<i>Vulpes vulpes</i>	—	—	—	—	2	3.2	—	—	1	1.4	1	0.8%	2	1.2%	2	2.5%	2	2.5%	3	3.3%
<i>Meles meles</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Martes foina</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Vormela peregusna</i>	1	0.5	1	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Felis lynx</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Other mammals	—	—	—	—	3	4.8	2	6.3%	2	2.7	22	17.3%	9	5.5%	2	3.4%	1	1.3%	2	2.2%
<i>Lepus europaeus</i>	—	—	—	—	—	—	—	—	—	—	1	0.8%	4	2.4%	—	—	2	2.5%	5	5.5%
<i>Tetragalus caspius</i>	—	—	1	0.5	—	—	—	—	1	1.4	1	0.8%	1	0.6%	—	—	—	—	—	—
Birds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Fulica atra</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Pelecanus onocrotalus</i>	—	—	1	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Bubo bubo</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unid. Medium birds	—	—	2	1.1	—	—	2	6.3%	—	—	—	—	—	—	1	1.7%	—	—	—	—
Total	204	—	182	—	63	—	32	—	74	—	127	—	165	—	59	—	80	—	91	—

**6. The macro faunal record**

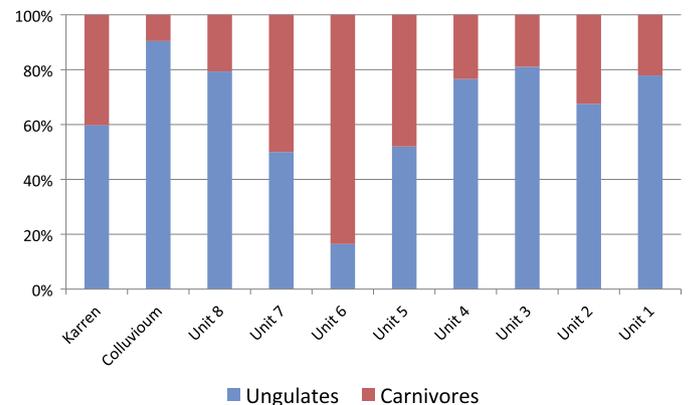
The taxonomic composition of Hovk-1 large faunal assemblage is rich and diverse. The bone assemblage includes a total of 1090 complete and fragmentary bone specimens that were identified to taxon. Taxonomic identifications were carried out in the field using a virtual comparative collection of recent skeletons and osteological catalogues (Schmid, 1972; Hillson, 1998). Finer taxonomic identifications of closely related species were achieved with the assistance of Nina Manaseryan from Yerevan Zoological Institute and the comparative collection of the Institute. Taxonomic identification of bears was based on size criteria of selected bones (following Stiner, 1998; Stiner et al., 1998).

Distribution of taxa for each of the stratigraphic units is detailed in Table 3. Mammals consist predominantly of ungulate and carnivore taxa. The ratio of ungulate to carnivore fluctuates according to stratigraphic unit (Fig. 5). In Units 8, 4–1, the frequencies of ungulates outnumber carnivores and constitute more than 60% of total identified bones. In contrast other units, and in particular Units 5, 6, 7 and the karren, frequencies of carnivores outnumber ungulates. The highest ratio of carnivores is observed in Unit 6 (84% of total identified bones).

The ungulate assemblages of Hovk-1 are dominated by Bezoar goat (*C. aegagrus*) which constitutes over 70% of total ungulates in each of the stratigraphic units (Supplementary information, Fig. A2). Red deer (*Cervus elaphus*) is the second most abundant ungulate taxa, their proportion ranges between 20% in Units 8, 6 and the karren and 10% or less in other units. Other ungulate species are represented by isolated bones and include wild boar (*Sus scrofa*), Caucasian bison (*Bison caucasicus*) and roe deer (*Capreolus capreolus*).

The ratio of carnivores also varies according to stratigraphic unit (Supplementary information, Fig. A3). Cave bear (*Ursus spelaeus*) is the most abundant carnivore taxon in Units 7, 6, 2 and karren (>70%). In all other units the proportions of cave bears are <50% and the assemblages also include high proportions of small carnivores and wolves (*Canis lupus*). Among the small carnivores foxes (*Vulpes vulpes*) are the main taxon. Other small carnivores represented are common badger (*Meles meles*), pine marten (*Martes foina*), marbled polecat (*Vormela peregusna*) and lynx (*Felis lynx*). The remains of small carnivores also include deciduous teeth and unfused bones of neonatal specimens which could not be identified to species. However, their presence indicates that the cave was in use by small carnivores as a den during certain periods.

Age data of the cave bear remains show dominance of prime-age individuals in most units. Wolverton (2006) described a similar pattern of a prime-age dominated assemblage of North American



**Fig. 5.** Ratio of ungulate to carnivore in each of the stratigraphic units at Hovk-1 Cave.

black bears (*Ursus americanus*) that were trapped in shaft caves. Such shaft caves are often pitfall traps for other animals and are frequented by bears attracted to the carcasses. Wolverson (2006) argued that prime-age individuals are the most susceptible age category for such entrapment due to intense competition for food resources. Such a mortality profile is strikingly different from patterns of attritional mortality which are dominated by young and old individuals (i.e., a U-shaped profile) and characterize die-off in wild populations or hibernation deaths of bears (e.g., Stiner et al., 1998).

Among the ungulates wild goat is the only species with sufficient sample size for reconstructing its mortality profile. Their remains include juvenile and prime-aged individuals in nearly equal proportions. This pattern corresponds to an attritional (U-shaped) mortality profile. Attritional profiles are the most common pattern of mortality in nature and can result also from numerous age-dependent causes. Among them are predation, natural death and accidental falls into pits (Stiner, 1990 and references therein). Among other ungulates there were two prime-aged specimens of red deer, two roe deer (one juvenile and one prime-aged) and a single prime-aged individual of wild boar. The combined data on age and mortality patterns of ungulates also suggest attritional mortality.

The bone assemblage of Hovk-1 exhibits exceptional preservation conditions which do not vary considerably among stratigraphic Units or taxa. Evidence for low rates of *in situ* bone attrition includes the presence of porous and low-density skeletal parts of both immature and adult animals and the fresh appearance of most bone surfaces. The majority of bones of all taxa exhibit few signs of surface weathering. Furthermore, evidence for other types of post-depositional modifications including striations caused by trampling and root etching are also rare in all stratigraphic units indicating little impact of such processes on assemblage formation. Overall, there is little evidence for differential preservation of skeletal elements due to post-depositional attrition processes.

Rates of fragmentation in the assemblage as a whole are low. Many of the long bones, of both ungulates and cave bears were found complete and many other specimens retained their full shaft circumference. In addition, many of the bones were found in vertical positions (Supplementary information, Fig. A4). These patterns do not vary among units. Additionally, there is no evidence for spatial segregation within the cave among the remains of carnivores, including all bear remains and the remains of ungulate taxa. Anatomical articulations of skeletal parts either complete or partial were not noted during excavation.

In spite of the high quality of bone surface preservation there is no evidence for human modification by hammerstone percussion marks, butchery or consumption marks with the exception of two modified bear sacra with evidence of percussion marks and several modified bear canines (Pinhasi et al., forthcoming). The completeness of bones also indicates little if any human breakage for marrow extraction and there are also no signs of burning. The limited evidence for human modifications of bones together with the remarkable state of preservation is strong evidence that the assemblages represent natural accumulations with minimal anthropogenic influence.

The assemblages also show few signs of carnivore modification and no gnawing marks of rodents. A few of the ungulate and cave bear specimens were gnawed by carnivores and the sizes of tooth punctures and overall characteristics of the marks indicate that they were made by both large carnivores such as wolves and small carnivores such as foxes. The limited prevalence of carnivore gnaws and the fact bones with such evidence were recovered from all stratigraphic units means that at this stage it is not possible to explain the inter-Unit differences in ungulate–predator ratios.

It is likely that most of the animals accumulated in the cave as a result of pitfalls through a chimney located in the roof of the second gallery of the cave. The high abundance of cave bear remains in Unit 6 correlates well with the geomorphological evidence that the chimney was open until after the deposition of Unit 6 (Fig. 3).

## 7. Discussion

### 7.1. How does human presence correlate with the cave's palaeoclimatic and palaeoenvironmental data?

Both the pollen (Fig. 4) and the micro fauna (Table 2) show some notable shifts which indicate significant palaeoenvironmental variations. Table 4 provides a summary of the anthropogenic, palynological, micro and macro-faunal data sets by Unit in an attempt to compare environments during episodes of human presence and absence from the cave. Since there are no microfaunal or macro faunal data for Units 12–9, while Units 1–3 are of Holocene date, we focus our attention here on comparing data for Units 8 to 4.

Unit 8 was formed during the Last Interglacial and contains field voles, snow voles, and common hamsters, i.e. typical species of open, high-elevation steppe or meadow environments. The microfaunal analysis of Unit 6, which formed during late MIS 4/early MIS 3, suggests an environment of a high-altitude steppe meadow and this is further supported by the pollen analysis which indicates a predominance of herbaceous plants that are characteristic of open vegetation. Unit 5 has a relatively high concentration of tree pollen (10%) and *Asplendium*-type fern spores, both indicating increased humid conditions. As spores of ferns are more resistant to corrosion than most of the pollen types, this signal seems reliable. The microfaunal assemblage, however, indicate cold, possibly dry conditions as *Cricetus* decreases from numbers seen in Unit 6, *Chionomys* increases, while there is a gradual appearance through the Unit of southern cricetines. It is worth noting that the frequency of pine tree pollen is rather low and hence that the environment was still for the most part an open steppe. It is therefore possible that during the formation of Unit 5 the climate fluctuated with cold and dry episodes as well as more humid conditions – a finding that is in agreement with what is known of the middle phase of MIS 3. The chronometric data for Unit 5 is limited to a single ultrafiltered radiocarbon date (>46 ka BP) which if accepted as a reliable determination indicates that sedimentation of the Unit must have started during the early part of MIS 3. However, more radiometric determinations and further micromorphological analysis are required in order to shed more light on the time span over which the Unit developed. Unit 4 reflects generally more humid conditions than in Unit 5 with an increase in the percent of arboreal (pine and fern) pollen from 10 to 29%. The microfaunal record sees a further trend for the replacement of relict *Cricetus* by southern cricetines. While there is no absolute date for Unit 4, lithological data indicate that it is probably of Pleistocene age. The appearance of the jerboa, a genus originated in the steppe and desert regions of Central Asia, in Units 2 and 1 provides the only indication for warming during the Holocene.

The large mammal fauna of Hovk reflects the high elevation environment of the cave and is indicative of general continuity in the composition of large-animal communities in this region throughout the Upper Pleistocene. Wild goats, boars, bears and wolves are among the most common species in mountain environments above the tree line (Ivanenko et al., 2004). Other species such as roe deer, red deer, bison, fox and marten typically inhabit forested areas of lower altitudes and occur in high-elevation environments on a more sporadic basis.

**Table 4**  
Hovk 1, summary of chronology, fauna, anthropology and palaeoenvironment (by Unit).

Unit	Chronology	Macrofauna			Anthropogenic	Palaeoenvironmental	
		Ung.	Car.	Ung.: car.		Palaeobotany	Microfauna
1–3	Holocene (Iron Age and Medieval)	159	63	2.52	Hearth, pottery, 1 flake, 1 debris, 1 scraper	Poor pollen preservation	Warming (appearance of gerboa <i>Allactaga</i> )
4	35.55 ± 0.65	121	37	3.27	Fire spots, 1 flake, 1 debris	29% arboreal, pine and fern: forest steppe	Increased replacement of relict <i>Cricetus</i> by southern cricetines
5	>48 ka BP	64	51	1.25	Fire spots, 1 flake, 7 debris, 1 core	10% arboreal plants, mainly pine: forest steppe	Colder, possibly drier conditions ( <i>Cricetus</i> decreases, <i>Chionomys</i> increases, appearance of southern cricetines)
5a		–	–	–	One Levallois flake	–	–
6	54.6 ± 7 ka BP	12	59	0.20	Charcoal	Herbaceous plants: open vegetation	High-altitude steppe meadow
7	No dates	15	15	1.00	One retouched fragment	None	N/A
8	104 ± 9.8 ka BP	50	14	3.57	Fire spots, 4 Levallois points, tool frag debris	Asteraceae and Apiaceae seeds:unspecific	Rocky, high-altitude steppe meadow: mainly arvicolines, cricetines, few forest taxa
9	–	–	–	–	Charcoal, 1 Levallois point, flakes, debris	Herbaceous plants: open vegetation	–
10	–	–	–	–	Charcoal. 2 obsidian flakes + 2 obsidian debris	Herbaceous plants: open vegetation	–
11	–	–	–	–	–	No data	–
12	–	–	–	–	1 Obsidian flake + 1 obsidian debris	Herbaceous plants: open vegetation	–
Karren	–	90	69	1.3	3 Levallois points, flakes, scraper	–	–

The presence and dominance of the Bezoar goat throughout the stratigraphic sequence, however, shows a distinct difference from Upper Pleistocene assemblages in northern areas of the Greater Caucasus where the predominant ungulate is typically the Caucasian goat (*Capra caucasica*) (see Bar-Oz and Adler, 2005; Adler et al., 2006; Bar-Oz et al., 2008). The Bezoar goat commonly inhabits rocky high-elevation areas in relatively dry regions and its present distribution suggests a distinct association with southern zoogeographic provinces (Vereschagin, 1967). It therefore appears that humans occupied Hovk-1 during periods of varied vegetation and fauna which correlated with warm episodes of the Late Pleistocene (MIS 5d-c and early MIS 3). If lithic density is taken as an indicator of the frequency and intensity of human occupation, then evidence for human use of the cave is more noticeable in Unit 8, i.e. during MIS 5d-c, than in any of the other units. However, it is important to emphasise the very low lithic density in Hovk, which taken together with the complex set of processes forming the stratigraphic sequence mean that this is an hypothesis rather than a well-founded statement. While the faunal and floral record cannot offer a more detailed reconstruction of the habitat, it does suggest that the cave and its environs were of interest to human groups during periods of different climates.

## 7.2. Why were humans present in this high-elevation region?

It is possible to provide at least two explanations for human presence in Hovk-1 and its environs. Mountains provide a diversity of biotopes that change rapidly with elevation (Lomolino, 2001). Mountain plateaus and ragged terrains can be advantageous to capable hunters who rely on ambushing, trapping and hunting of game which is abundant in such region, such as the Bezoar goat.

Humans may have exploited this habitat during relatively regular short-term incursions (and during relatively mild climatic periods), possibly for seasonal hunting of game at and below the plateaux in the vicinity of the cave. The advantage of the Hovk mountainous habitats (and others) is that the steep terrain provided relatively easy means to hunt mountain animals such as the mountain goat, by ambushing and trapping. The plateau above Hovk-1 cave provides an ideal terrain for

this activity. The zooarchaeological study of fauna from Ortvale Klde cave indicates that both LMP Neanderthals and EUP modern humans (who occupied the cave after the disappearance of Neanderthals from this region) placed a strong emphasis on the hunting of prime age Caucasian tur and hence applied similar procurement strategies. As Adler et al. (2006) suggest, both human populations exploited a wide range of eco-logical niches, which imply that they had an understanding of the local environment and the permanent and seasonal distribution of key resources. In the northern Caucasus, Neanderthal hunting strategy focused on bison procurement at the open air sites of Il'skaya I and Il'skaya II, and Middle Palaeolithic phases in sites of the Borisovskoe Gorge, the Gubs River region (Barakaevskaya and Mezmaiskaya caves) (Baryshnikov and Hoffecker, 1994). This choice may reflect the availability of bison in sites which are located in lower to middle altitudes while Caucasian tur and to a lesser extent red deer were the main prey in higher altitude localities.

However, the Hovk-1 assemblage differs from those mentioned above as the ungulate bones do not display any cut marks or fresh fractures which characterise anthropogenic assemblages. Nevertheless, absence of cut-marked bones and of fresh fractures does not necessarily rule out the possibility that some of these bones were food refuse remains of consumed prey.

Another scenario is that the use of Hovk-1 by humans indicates rare and infrequent incursions by humans to high altitude regions, perhaps following their expansion to new habitats. The two scenarios are not mutually exclusive and it is not at present possible to test which of these is the most plausible one.

Some parallels can be drawn between Mousterian sites in the Caucasus, and those in the Alpine regions. In the Alpine regions, presence and intensity (i.e. number and density of artefacts, processed animal bones, fire spots, etc.) of human (Neanderthal) occupation signals decrease with elevation, while above 1500 m asl, human presence (predominantly based on the number of artefacts) is reported only for Jiboui (Vercors, 1620 m), Wildenmanlisloch (Appenzell, 1628 m), Chiffon (Vercors), Tanay (Chablais, 1810 m), Ramesch-Knochenhöhle (Austrian Alps, 1960 m) and Salzofenhöhle (Austrian Alps, 2068 m). Bernard-Guelle and Tillet (Tillet and Bernard-Guelle,

1996; Bernard-Guelle, 2002) discuss seasonal (Mousterian) Middle Palaeolithic human occupation in mid and high altitude alpine regions of the Vercors, the Austrian and Appenzeller Fore-Alps, the Swiss Jura, the Julienne Alps, and the Dolomites. They state that Alpine Mousterian sites fall into one of the following categories: (1) cave sites and rock shelters with a rather intensive anthropogenic signal, (2) caves which show a strong palaeontological signal and limited evidence for human short-term occupation, and (3) open-air high-altitude sites that were predominantly utilized for the obtainment of raw material. Hovk-1 clearly fits into the second of these categories.

An intriguing aspect of Hovk-1 is the presence of elongated Levallois points in Unit 8 and the karren which are made from low quality local limestone. The lack of raw material sources in the Hovk region (based on our 2006 and 2007 surveys) suggests that unlike some of the sites in the Vercors and other Alpine regions (cf. Tillet and Bernard-Guelle, 1996; Bernard-Guelle, 2002) human occupation in Hovk-1 was not associated with the utilization of raw material sources. In fact, the production of highly standardized Levallois points from local coarse-grained raw material shows ingenuity and flexibility.

Climate is not the only limiting ecological factor to human occupation in Hovk-1. A study by Torres et al. (2008) on the timing and duration of cave bear occupation at Amutxate Cave, Spain shows that hominid group expansion and exploitation of the environment during the period spanning between 39 and 48 ka BP was likely to be severely limited. Cave bears occupied caves for hibernation during the period from the beginning of winter until the beginning of spring. Humans could therefore only occupy the same caves after bears (and often their cubs) abandoned the cave during the period from the beginning of spring to the end of fall. However, wandering bears will occasionally occupy the caves during their mating period and during other intervals. Cave bears are the most abundant carnivore taxon in Units 7, 6, 2 and the karren (>70%) at Hovk-1 while in all other units the proportions of cave bears are <50% of the total mammalian assemblage. The assemblages also include high proportions of small carnivores and wolves. In contrast, the human occupational signature (albeit based on limited evidence) is most noticeable in Units 8, and 5 although charcoal and fire spots suggests visits to the cave during the formation of Units 10a, 10b (undated), Unit 6 ( $54.6 \pm 7$  ka BP) and Unit 4 ( $35.55 \pm 0.65$  ka BP). It is therefore clear that there is an inverse correlation between the frequency of bear bones and human occupation in the cave.

A recent study of Neanderthal occupation in Payre, France (MIS 8–7), and Taubach/Weimar, Germany (MIS 5) (Moncel and Rivals, 2011), suggests variability in the type and nature of subsistence activity in each location perhaps in response to variations in the environmental conditions. It indicates that Neanderthals were flexible enough to modify their adaptive subsistence strategies to variable geographic and climatic conditions and questions models which assume a direct correlation between mobility strategy, length of occupation, raw material availability and tool types (Binford, 1981a, 1981b; Kuhn, 1995).

## 8. Conclusions

Our case study demonstrates that humans occupied the distinctive high-altitude environment of Hovk-1 and environs, during MIS 5d-c and possibly MIS 3. The biogeographic isolation of the Lesser Caucasus from ecotones of more northerly latitudes began during the last glacial period and hence the mountains were a glacial refugium for several species during this time. Human groups are likely to have visited this region to hunt specific prey species which prevailed in this habitat (such as the Bezoar goat) but human occupation of caves in the region was constrained by the

use of the same habitat by cave bears, climatic fluctuations and variations in the suitability of the cave for human habitation (dryness, temperature, slope, sedimentation, and other factors). This study can only provide a limited glimpse into the nature and timing of human occupation in this high-altitude region, but it clearly demonstrates the need to critically examine similar habitats and in the context of understanding Neanderthal and modern human behaviour, subsistence and mobility.

## Acknowledgments

We thank Dimitri Arkelyan (Institute of Archaeology and Ethnology, National Academy of Sciences of the Republic of Armenia) for Figs. 1–3, Pavel Avetisyan (Institute of Archaeology and Ethnography, National Academy of Sciences of the Republic of Armenia) for his help during the 2006 season in Hovk and Nina Manaseryan (Yerevan Zoological Institute, National Academy of Sciences of the Republic of Armenia) for her assistance in taxonomic identifications. The Hovk project was supported by Roehampton University UK (2005–2007), the Armenian branch of the Gfoeller Foundation, and Science Foundation of Ireland (SFI) Research Frontiers Programme grant (Grant No. 08/RFP/EOB1478).

## Appendix. Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.quascirev.2011.09.020.

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Table A1. List of paleocarpological finds (mineralized, calcified seeds) from Hovk-1 cave (2005-2008 seasons).

	Square	-	104/108	104/10 6	104/10 6	104/10 2	104/100- 101	103- 4/100	103/10 1	103/10 1	103/10 8	104/10 8	103/10 8	104/10 8	103/10 8	103/10 8
	Unit	-	-	6	6	8	8	8	8	8	10a	10a	10b	10b	12/1	12/2
		N1-3, mixed	mixed (5/2)	loc.027	b.73	b.98	-	b.100	b.102	b.105	-	-	-	-	-	-
Plant taxa		7	2	1	1	9	2	4	1	5	44	14	114	1	20	2
TOTAL	N= 227	3.1%	0.9%	0.4%	0.4%	4.0%	0.9%	1.8%	0.4%	2.2%	19.4%	6.2%	50.2%	0.4%	8.8%	0.9%
Centaurea sp. (Asteraceae)	10 45.8 4 %	2	2	1	1	6	1	2	-	2	24	13	39	1	9	1
Asteraceae gen. sp.	14 6.2%	1	-	-	-	-	-	-	-	-	5	1	5	-	1	1
Chaerophyllum sp. (Apiaceae)	14 6.2%	2	-	-	-	3	-	2	-	2	2	-	3	-	-	-
Apiaceae gen. sp.	5 2.2%	1	-	-	-	-	-	-	-	1	2	-	-	-	1	-
type 1 - Dicotyledones fam. gen. sp.	3 1.3%	-	-	-	-	-	1	-	1	-	-	-	1	-	-	-
type 2 - cf. Juniperus sp.	1 0.4%	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-

(?)

type 3 - cf.

Rubiaceae gen. 1 0.4%

sp. (?)

Unidentifiable species 85 37.4%

Charcoal fragments 11 -

-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
1	-	-	-	-	-	-	-	-	-	-	11	-	64	-	9	-	-
1	1	-	-	-	-	-	-	-	-	-	4	3	2	-	-	-	-

	N1_2			N1_3			N1_4			N1_4b			N1_5		
Unit	counts	%	conc./g	counts	%	conc./g	counts	%	conc./g	counts	%	conc./g	counts	%	conc./g
<b>Sum of Palynomorphs counted</b>	<b>5</b>			<b>14</b>			<b>208</b>			<b>1415</b>			<b>728</b>		
<b>Sum of Pollen counted</b>	<b>4</b>			<b>0</b>			<b>109</b>			<b>227</b>			<b>348</b>		
Pinus							7	6.4%	127	37	16.3%	229	30	8.6%	235
Corylus													3	0.9%	23
Carpinus													1	0.3%	8
Betula										2	0.9%	12			
Quercus							1	0.9%	18	8	3.5%	50			
Asteraceae, Cichorioideae							86	78.9%	1,562	61	26.9%	378	229	65.8%	1,792
Asteraceae, Centhaurea type 1										4	1.8%	25			
Asteraceae, Centhaurea type 2										1	0.4%	6	2	0.6%	16
Asteraceae, Centhaurea type 3										1	0.4%	6			
Asteraceae, Artemisia										2	1.8%	36	1	0.4%	6
Asteraceae, Asteroideae										1	0.4%	6	38	10.9%	297
Apiaceae, Chaerophyllum-type	2	50.0%	69												
Brassicaceae															
Caryophyllaceae							4	3.7%	73	50	22.0%	310	28	8.0%	219
Chenopodiaceae							1	0.9%	18	3	1.3%	19	1	0.3%	8
Dipsacaceae, Cephalaria-type															
Plumbaginaceae															
Thymelaeaceae, Daphne-type										1	0.4%	6			
Poaceae										6	2.6%	37	3	0.9%	23
Fern spores, Asplenium-type							8	7.3%	145	47	20.7%	291	2	0.6%	16
Unidentified										1	0.4%	6	11	3.2%	86
Unidentifiable	2	50.0%	69							4	1.8%	25			
<b>Charcoal fragments</b>	<b>1</b>	<b>20.0%</b>	<b>34</b>	<b>14</b>	<b>100.0%</b>	<b>223</b>	<b>66</b>	<b>57.4%</b>	<b>1,199</b>	<b>936</b>	<b>66.1%</b>	<b>5,798</b>	<b>238</b>	<b>32.7%</b>	<b>1,862</b>
Algae							16	13.9%	291	24	1.7%	892	47	6.5%	368
Fungi							17	14.8%	309	228	16.1%	8,474	95	13.0%	743
Counted Lycopodium spores	24			53			66			120			95		
Analyzed sediment mass [g]	45			44			31			50			50		
Total pollen per 1 g sediment	138			0			1980			1,406			2,723		

N1_6			N1_8			N2_9			N2_10			N2_10a			N2_10b			N2_10c
counts	%	conc./g	counts															
481			410			1,317			766			819			543			613
391			4			1,069			677			615			407			523
1	0.3%	5	2	50.0%	21	1	0.1%	10							+			
367	93.9%	1727	1	0.4%	10	1,034	96.7%	10,366	650	96.0%	10,482	532	86.5%	8,952	364	89.4%	6,416	442
						8	0.7%	80	15	2.2%	242	12	2.0%	202	10	2.5%	176	3
									+			1	0.2%	17	+			8
						+			+			+						+
3	0.8%	14																27
						3	0.3%	30	3	0.4%	48	25	4.1%	421	14	3.4%	247	11
						7	0.7%	70				2	0.3%	34	2	0.5%	35	4
4	1.0%	19							1	0.1%	16	7	1.1%	118	2	0.5%	35	6
1	0.3%	5																2
						1	0.1%	10				1	0.2%	17	1	0.2%	18	1
																		+
7	1.8%	33							2	0.3%	32	2	0.3%	34	1	0.2%	18	2
			1	0.4%	10	1	0.1%	10										
						10	0.9%	100	4	0.6%	65	22	3.6%	370	9	2.2%	159	3
8	2.0%	38				4	0.4%	40	2	0.3%	32	11	1.8%	185	4	1.0%	71	14
36	7.5%	169	370	90.2%	3,820	227	17.2%	2,276	82	10.7%	1,322	120	14.7%	2,019	127	23.4%	2,239	74
18	3.7%	85	13	3.2%	134	2	0.2%	20	1	0.1%	16							2
36	7.5%	169	23	5.6%	237	19	1.4%	190	6	0.8%	97	84	10.3%	1,413	9	1.7%	159	14
158			72			37			23			22			21			47
50			50			100.2			100.2			100.4			100.4			100.2
1,839			41			10,717			10,918			10,348			7,174			4,127

		N2_12/1			N2_12/2		
%	conc./g	counts	%	conc./g	counts	%	conc./g
		683			585		
		646			549		
		+					
84.5%	3,488	559	86.5%	10,616	491	89.4%	7,604
0.6%	24	1	0.2%	19	2	0.4%	31
1.5%	63	2	0.3%	38			
5.2%	213	18	2.8%	342	1	0.2%	15
2.1%	87	27	4.2%	513	41	7.5%	635
0.8%	32	1	0.2%	19			
1.1%	47	14	2.2%	266	4	0.7%	62
0.4%	16						
0.2%	8	3	0.5%	57			
0.4%	16	1	0.2%	19			
		1	0.2%	19			
0.6%	24	7	1.1%	133	4	0.7%	62
2.7%	110	12	1.9%	228	6	1.1%	93
12.1%	584	30	4.4%	570	29	5.0%	449
0.3%	16						
2.3%	110	7	1.0%	133	7	1.2%	108
		19			24		
		103.0			100.0		
		12,268			8,502		

Table A3. Proportions of identified micromammalian molar teeth by taxa and stratigraphic units and proportions of digested lower M1 molars of *Microtus*.

Taxa	Common name	Unit 8		Unit 6 <sup>a</sup>		Unit 5		Unit 4		Unit 2		Unit 1	
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Chiroptera		-	-	4	14	1	3	-	-	-	-	1	4
Rodentia													
<i>Dryomys nitedula</i> <sup>b</sup>	Forest dormouse	-	-		1			-	-	-	-	-	-
<i>Sciurus anomalus</i>	Persian squirrel	-	-	-	-	0	1	-	-	-	-	0	2
Cricetinae													
<i>Cricetulus migratorius</i>	Migratory hamster	-	-	-	-	0	1	-	-	1	3	1	4
<i>Mesocricetus brandti</i>	Brandt's hamster	-	-	-	-	1	4	1	3	1	3	-	-
<i>Cricetus cricetus</i>	Common hamster	10	19	4	14	2	7	-	-	1	3	0	2
Arvicolinae													
<i>Ellobius lutescens</i>	Transcaucasian mole vole	-	-	-	-	-	-	3	7	1	3	0	2
<i>Arvicola amphibius</i>	Water vole	0	2	-	-	1	4	-	-	1	3	0	2
<i>Microtus</i> spp. <sup>c, d</sup>	Field voles	84	56	78	29	81	34	84	55	89	50	82	35
<i>Chionomys nivalis</i>	Snow vole	4	13	7	14	11	37	13	34	8	31	12	40
<i>Spalax nehringi</i>	Lesser mole rat	0	1	4	14	-	-	-	-	-	-	-	-
<i>Allactaga</i> sp.	Jerboa	-	-	-	-	-	-	-	-	1	3	1	4
<i>Apodemus witherbi</i>	Field mouse	0	2	-	-	-	-	-	-	-	-	0	2
Lipotyphla (Insectivora)													
Soricinae													
<i>Sorex minutus</i>	Lesser shrew	0	1	-	-	-	-	-	-	-	-	0	2
<i>Sorex satunini</i>	Common shrew	0	1	4	14	1	6	-	-	-	-	-	-
<i>Neomys teres</i>	Water shrew	0	1	-	-	-	-	-	-	-	-	-	-
Crocidurinae													
<i>Suncus etruscus</i>	Etruscan shrew	0	2	-	-	0	1	-	-	-	-	1	4
<i>Crocidura</i> sp.	White-toothed shrew	0	1	-	-	0	1	-	-	-	-	-	-
Total		100	100	100	100	100	100	100	100	100	100	100	100
%Digested <i>Microtus</i> molars		75		33				42				28	

<sup>a</sup> 15 specimens from undifferentiated samples between Units 5-6 not included in the table.

<sup>b</sup> A single specimen of *D. nitedula* derived from Units 5-6.

<sup>c</sup> NISPs include *Microtus* spp. and *C. nivalis* M2-M3 teeth. MNIs for both taxa based on M1's only.

<sup>d</sup> *Microtus* voles include common voles *M. arvalis* and social voles *M. socialis*.