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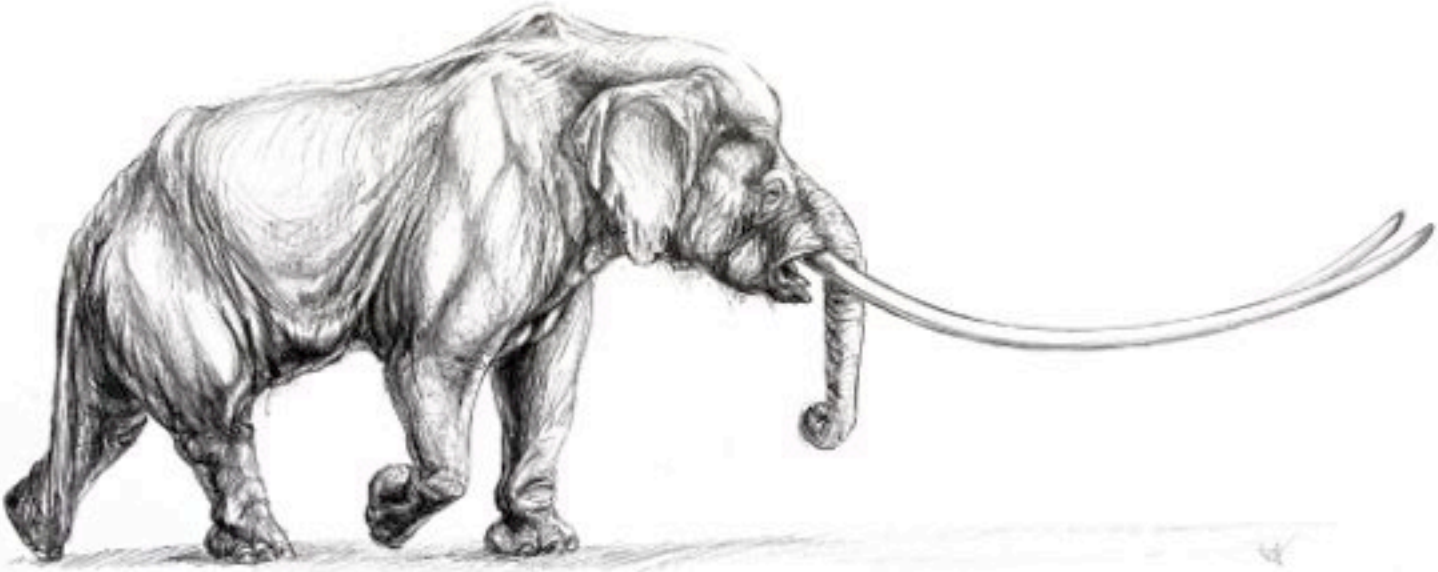

GREVENA
SIATISTA
GREECE 2014

VIth International Conference on Mammoths and their Relatives

ABSTRACT BOOK

Editors:
Dimitris S. KOSTOPOULOS, Evangelos VLACHOS, and Evangelia TSOUKALA

THESSALONIKI, MAY 2014

ARISTOTLE UNIVERSITY OF THESSALONIKI
FACULTY OF SCIENCES

ΑΡΙΣΤΟΤΕΛΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΟΝΙΚΗΣ
ΣΧΟΛΗ ΘΕΤΙΚΩΝ ΕΠΙΣΤΗΜΩΝ

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ABSTRACT BOOK

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ON MAMMOTHS AND THEIR RELATIVES

5-12 MAY 2014, GREVENA - SIATISTA

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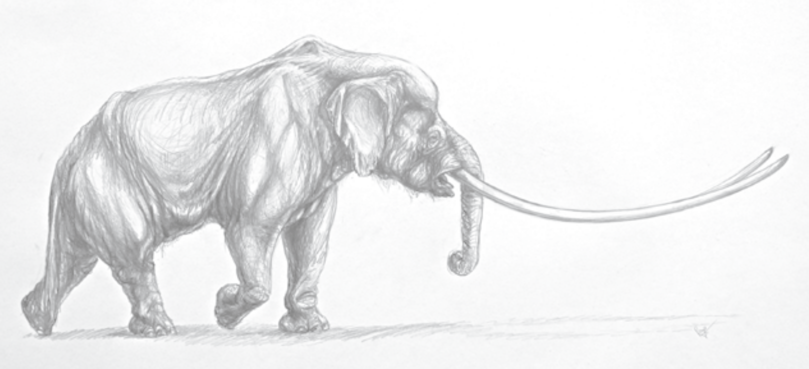

Cover:

The reconstruction of the Milia *Mammut borsoni*, based on the fossil record of the Paleontological Exhibition, Milia, Grevena, W. Macedonia, Greece.

Drawing by Remie Bakker (The Netherlands), under the supervision of Dick Mol (The Netherlands).

GREVENA
SIATISTA
GREECE 2014

VIth International
Conference
on Mammoths
and their Relatives

Abstract Book

Editors:
Dimitris S. KOSTOPOULOS, Evangelos VLACHOS, and Evangelia TSOUKALA

Organization

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The Exhibitions

Paleontological Exhibition of Milia, Municipality of Grevena. Photo: H. Wildschut.

Historical Paleontological Collection of Siatista, Municipality of Voion. Photo: H. Wildschut.

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Preface

Dear Participants,

On behalf of the Scientific Committee, I want to welcome all of you to the Conference. The International Conference on Mammoths and their Relatives (ICMR) provides a way to find out the results of research, world-wide, dealing with 'Mammoths and their Relatives'. These meetings are always informative, provide the most recent research results, and allow scientists, researchers, and others to meet, mix, mingle and propose cooperative ventures, research methods, and participate in interaction with colleagues.

The ICMR conferences had their beginning in St. Petersburg, Russia (ICMR I) in 1995; ICMR II was hosted in Rotterdam, Netherlands in 1999; ICMR III followed in Dawson City, Yukon Territory, Canada.; ICMR IV was held in Yakutsk, Siberia in 2007, followed by ICMR V in Puy-en-Velay, France. This conference (VIth ICMR) is being held in Grevena and Siatista, Greece (2014).

The ICMR conferences are always informative, educational, have some 'cutting edge' presentations. They allow introduction to, and cooperation with other researchers across the globe. The varied host locations provide an opportunity to experience a variety of field locations, exhibits, other cultures, and field trips.

The hosts of VIth ICMR are eager to share their discoveries, exhibits, and field trips with participants. Please enjoy their hospitality, scientific research and exciting locales.

May the VIth ICMR become a pleasant reality and long held memory for all participants.

Larry D. Agenbroad
Honorary President,
Scientific Committee

Editorial

The ICMR conferences originated as a partnership between the organizers of the International Mammoth Conferences (ICM) and the World of Elephants Congresses (WEC) to increase access to their overlapping fields of interest. The historic conferences of the ICM include 1995-Saint Petersburg, 1999-Rotterdam, 2003-Dawson City, and 2007-Jakutia, and those of the WEC include 2001-Rome and 2005-Hot Springs, South Dakota.

The last International Conference on Mammoths and their Relatives (named Vth ICMR) was held at Le Puy-en-Velay, France in 2010. At these world-class scientific meetings, the latest results of proboscidean research were presented, discussed and communicated among international specialists. The sites for the ICMR conferences are selected with preference for local communities that host mammoth and elephant study sites who can benefit by an exchange of knowledge with world-renowned scientists. Western Macedonia, Greece, is rich in proboscidean fossils, mastodons, mammoths and elephants, ranging in age from the Pliocene to the end of the Pleistocene. For this reason, the VIth ICMR was chosen to be held in the historic West Macedonian towns of Grevena and Siatista.

This Abstract Book presents the findings reported at the VIth conference, spanning the knowledge base of modern proboscidean research. The conference was attended by more than 170 scientists from all parts of the world; it continues in the scientific tradition of the previous conferences and displays a steady increase in the amount and quality of information presented, thus promoting the study of proboscideans on global scale. In total, 81 oral and 74 poster contributions were presented in the Cultural Center of Grevena and at the Trampantzeion Gymnasium in Siatista. The topics presented covered a wide variety of proboscidean-related subjects: new discoveries, application of new techniques, regional news and reviews, molecular studies, bone pathologies and dietary analyses, notes on the associated fauna, and information on the status of present-day elephants. We note with pride a significant increase in the participation of students and young scientists. The study of proboscideans has not only a glorious past, but a great future!

The present volume includes 155 extended abstracts of the VIth ICMR conference, published as a Special Volume of the Scientific Annals of the School of Geology, Aristotle University of Thessaloniki, Greece. This University series includes published conference proceedings and honorary volumes such as the 12th International Cave Bear Symposium (2006) and the 19th Conference of the Carpatho-Balkan Geological Association (2011).

All abstracts in the present volume are peer reviewed by the members of the Scientific Committee of the VIth International Conference on Mammoths and their Relatives. We sincerely thank the Members of the Organizing and Scientific Committees for their help and assistance in the submission, editing, and review process of the abstracts; their communication and co-operation over the past few months has been excellent. Thanks are also due to Dr Annie Rassios and Dina Ghikas for their linguistic editing. This book would not have been completed without the assistance of the School of Geology, Aristotle University of Thessaloniki and the numerous volunteers who gratefully read and commented on the final draft.

We hope that this Volume will be a valuable addition to your library and that the scientific results presented in the following pages will be a source of knowledge and inspiration for proboscidean enthusiasts all over the world.

The Editors

Dimitris S. Kostopoulos, Evangelos Vlachos, and Evangelia Tsoukala

Contents

The Early Villafranchian site of Milia

Abstracts of the VIth International Conference on Mammoths and their Relatives

The Early Villafranchian site of Milia

Excavations in the Early Villafranchian site Milia-5 (Grevena, Greece): a multidisciplinary approach

Georgios LAZARIDIS ✉, Nikolaos KANTIRANIS, Ioakeim IOAKEIMIDIS, and Vladimir BOZUKOV

Milia (Grevena, W. Macedonia), an Early Villafranchian fossiliferous locality is systematically excavated since 1996. Eleven different fossil spots have been located till nowadays with most characteristic findings that of incomplete Borson's mastodon partial skeletons including two pairs of the longest tusks in the world (4.39 m and 5.02 m). The Milia preliminarily faunal list includes the following species: *Mammut borsoni, Anancus arvernensis, Hipparion crassum* s.l., *Tapirus arvernensis arvernensis, Dicerorhinus jeanvireti, Sus arvernensis arvernensis, Gazella borbonica, Croizetoceros ramosus*, large bovid, *Homotherium crenatidens, Agriotherium* sp., *Ursus etruscus, Hystrix* cf. *refossa* and turtles (Tsoukala 2000; Tsoukala et al., 2010; Guerin and Tsoukala, 2013).

Among several fossil spots discovered, Milia-5 is of particular interest because:

1. Its stratigraphic position is less than two meters below an overlying lacustrine formation/horizon bearing plant and mollusk remains.

2. The fossil material includes specimens of *M. borsoni*, large bovid, and *Agriotherium*, verifying the co-occurrence of these taxa.

3. It can be correlated stratigraphically with the site of Priporos (included in the Milia fossil spots) with *Dicerorhinus jeanvireti* finds.

In August 2007, sediment samples, plant remains and mollusks as well as detailed taphonomical field notes were collected during the excavation of Milia-5 site. The analysis of these samples and data is presented in this study in order to provide a multidisciplinary interpretation for the paleoecology, taphonomy, sedimentology and stratigraphy of the locality.

Fossil plants of Milia-5 include the following nine species: *Acer pseudoplatanus* L. foss., *A. campestre* L. foss., *Carya denticulata* (C.O. Weber) Iljinsk., *Fagus sylvatica* L. foss., *Potamogeton natans* L. foss., *Pterocarya paradisiaca* (Unger) Iljinsk., *Quercus mediterranea* Unger, *Q. pseudocastanea* Goeppert, *Zelkova carpinifolia* (Pall.) K. Koch foss. Most of them are similar or identical to modern species common in Europe, apart from the Middle Oligocene - Upper Pliocene species *Carya denticulata*, allowing Milia flora to be dated close to the Pliocene/Pleistocene boundary. Due to relative abundance of mesoxerophytic species imprints, and mesophytic species representation by only one or two specimens, it is suggested that the vegetation has evolved under the influence of subarid climatic phase (Palamarev, 2004). This vegetation is represented by mesoxerophytic oak forests interspersed with wood species of mesophytic character. Moreover, the presence of hydrophytic and hygromesophytic species is related to the water basin, wherein the plant material was deposited.

Each sedimentary layer of the Milia-5 excavation site was sampled for detailed textural and lithological characterization; in total 12 sediment samples were collected. The majority of the sediment samples were classified as mud and silt, while the fossils are scattered in sand to muddy sand deposits.

Taphonomical analysis includes the spatial and directional distribution of the Milia-5 fossil finds and the fracture modification of the mastodon remains. Bone's transverse fractures are dominating. Many of them are complete segmental while other are oblique. Radiating fractures found to the flat ends of the bones, at the surface on which it was lying on the sediment. This may be a criterion in cases of re-deposition of fossils. The conditions that influenced the placement of the bones in their final deposition seem to vary from weak shallow current that acted to the anterior part of the skeleton and a stronger current that removed completely the hind leg elements and the pelvis and vertebras. The tusks are suggested to have been acted as a barrier that blocked the removal of the rest skeleton parts. A river-bank is suggested as death site of the mastodon. An E-W to NE-SW direction of paleoflow resulted in the entrapment of the fossils in the "shadow" of the tusks; whereas the posterior elements that were located far from the tusks were exposed to stronger flow and they were completely removed.

Biochronology of the Milia localities is compared with other Eurasian Pliocene faunas and found closely associated with Etouaires and Vialette in France, which are dated to MN16a biozone and less close to Kislàng, Hungary of MN16b and younger faunas.

Faunal similarity indices such as Simpson's Index, Pickford Index and a cluster analysis with Bray-Curtis coefficient suggest significant similarity between the Milia faunal assemblage and that of Etouaires confirming previous suggestions about the age of the Milia locality (Guerin and Tsoukala, 2013). Moreover, the composition of the fauna and the significant similarity with Etouaires suggest that the Milia area was a forested landscape underwent warm and humid climate.

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Bovidae and Cervidae of the Early Villafranchian site of Milia (Grevena, Macedonia, Greece)

Evelyne CRÉGUT-BONNOURE ✉, and Evangelia TSOUKALA

Since 1996 a large number of isolated skeletal elements of artiodactyls has been excavated from the Aliakmon River sand deposits in Milia fossil site (Grevena, Western Macedonia, Greece), known for the longest tusks of *Mammut borsoni* in the world (4.39 m and 5.02 m) (Tsoukala and Mol, 2010).

Two different families of Early Villafranchian artiodactyls are studied here: the Bovidae with large and small sized species, and the Cervidae. The preliminary study allows us to give a faunal list comprising nine taxa: a new large Boselaphini, *Alephis* sp., Bovini indet., cf. *Procamptoceras*, *Gazella borbonica, Gazella* sp. *Croizetoceros ramosus, Procapreolus cusanus* and a medium sized cervid.

The bovids are more abundant than cervids. The Milia new large Boselaphini is well-distinguished from *Alephis/Parabos* group (Gromolard, 1980; 1981). The fossil material consists of 234 specimens, teeth, postcranial bones and substantial portions of the cranium with left and right horn-cores (Fig. 1). The horn cores are long and slender, sub-triangular in cross-section, heavily built, and with bone thickness varying between 11 and 18 mm.

Gazella is a widespread genus in Greece (Koufos, 1986; Athanassiou, 1996; Kostopoulos 1996; Kostopoulos and Athanassiou, 1997). *Gazella borbonica* has been described from the MN15 and MN17 zones (Kostopoulos and Athanassiou, 1997; Koufos 2006).

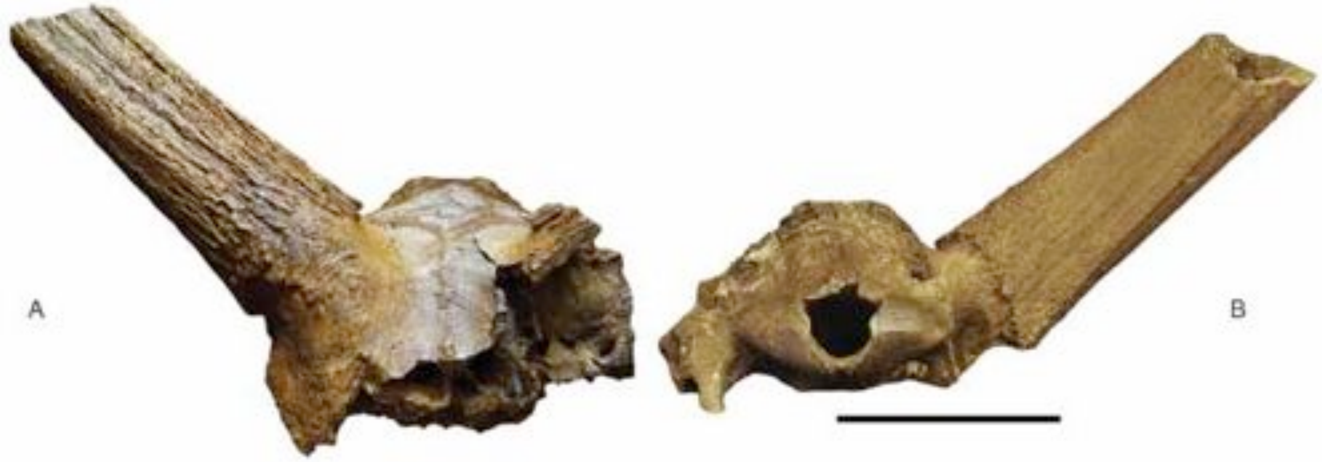

Fig. 1. Milia large boselaphini: Skull MIL 401, **a**, front view; **b**, posterior view. Scale bar equals 50 mm.

On the other hand, *Croizetoceros ramosus* has been described from Sesklo (MN17) (Athanassiou, 1996), Volakas (MN17), and with the new subspecies *C.r. gerakarensis* from Gerakarou (MN 18) (Kostopoulos, 1996) .

The Milia bovid and cervid association along with the proboscideans (*Mammut borsoni, Anancus arvernensis*), the tapirid (*Tapirus arvernensis arvernensis*), rhino (*Dicerorhinus jeanvireti*), suine (*Sus arvernensis arvernensis*) (Guérin and Tsoukala, 2013), *Agriotherium* sp., and *Hipparion* of *H. crassum* group allows us to date the site in the biozone MN 16 (Earlymost Villafranchian) and to correlate it with Les Etouaires, Vialette (France), Villaroya (Spain) and Montopoli (Italy) (Crégut-Bonnoure, 2007). It is the first time that this biozone is well-documented in Greece.

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The Proboscidea of the Early Villafranchian site of Milia (Grevena, Macedonia, Greece)

Evangelia TSOUKALA, and Dick MOL

Two different species of Early Villafranchian proboscideans were contemporaneous in Milia (Grevena, Western Macedonia, Greece): the large zygodont, Borson's mastodon, *Mammut borsoni* (Hays, 1834), and the smaller gomphothere, the mastodon of Auvergne, *Anancus arvernensis* (Croizet and Jobert, 1828), the former being predominant.

Since 1996 partial skeletons and a large number of isolated skeletal elements of the zygodonts have been excavated from Aliakmon River sand deposits in Milia (Tsoukala, 2000; 2005; Tsoukala et al. 2010). The skeletons include substantial portions of the cranium with left and right molars (M2, M3); two pairs of the longest upper tusks ever recorded in the world (4.39 m and 5.02 m) and the most complete mandible in Europe, with the two entire lower tusks in anatomical position, as well as three almost-complete mandibles with dentition (m2 + m3); and post-cranials. These partial skeletons represent very robust male individuals in the prime of their life at time of death (Mol and Tsoukala, 2010; Mol and van Logchem, 2009). In addition to the partial skeletons of Milia 5 (among the eleven MIL localities, Fig. 1) we present for the first time a deciduous tusk of *Mammut borsoni*. We also discuss the evolutionary position of the specimens among mammutids and the stratigraphy. The enriched Milia zygodont material is compared with other European specimens in order to get a better understanding of its extinction (Mol and Lacombat, 2010).

Fig. 1. *Mammut borsoni* Milia locality: view of the Milia 5 excavated area in 2007. Note the recovery position of the mandibles below the tusks. Upper right: map of Greece indicating the Milia (MIL) locality.

Fig. 2. *Mammut borsoni*: Right second lower deciduous incisor, di2 MIL1885, **a**) labial view, **b**) lingual view. Scale bar equals 10 mm.

Many discussions on the nature and development of the proboscidean tusks mainly on the Late Miocene elephantoid species have been presented by various researchers (Tassy, 1987; Göhlich, 2010 etc). On the other hand literature on the tusks of Pliocene elephantoid species is poor.

The new find presented here is a tiny delicate right second lower deciduous tusk (MIL 1885) and gives evidence to the study on the development of the growth and life of the earliest Villafranchian mastodons (Fig. 2). It is the first time that such a young mammutid individual is reported in the literature and there is no comparative material available. The animal died within the first year of its life, probably shortly after it was born.

Seven specimens are attributed to the Milia straight-tusked Auvergne mastodon. The preserved mandible consists of left and right medium worn second molars, of typical tetralophodont structure (Fig. 3). The main cone is characterizing the pretrites and posterior the posttrites are followed by a conule, with a small talonid bearing two combs. The left first and second lophids and the right first, second and third lophids of the teeth are worn on the pretrites, all the pretrite semilophids being confluent.

Conclusions regarding the relationship between the two proboscideans can be derived from the site of Dorkovo (4.5 Ma) where *Anancus* is fully predominant over *Mammut borsoni*, indicating a prevalence of open woodland environment about c. 4.5 Ma ago (Metz-Muller, 1995; Markov, 2004; Delson et al., 2005). Reverse analogies of Milia show that the favourable environmental conditions for *Mammut borsoni* continued in northern Greece up

Fig. 3. *Anancus arvernensis*: The occlusal views of mandible fragments of the same individual, **a**) left, MIL 410b with m2 and **b**) right, MIL 410a with m2 and m3 fragment. Scale bar equals 100 mm.

to the end of the Late Pliocene. The morphology of the Milia specimen (mainly large size) may be a response to favourable environments for browsing-adapted species.

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Carnivores of the Early Villafranchian site of Milia (Grevena, Macedonia, Greece)

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The Milia locality in Grevena, North Greece encompasses eleven excavation spots to date. It is well known as the source area of the two pairs of the longest fossil tusks yet found in the world: these measure 4.39 m and 5.02 m and belong to *Mammut borsoni* (Hays, 1834) (Tsoukala, 2000; 2005; Mol and Tsoukala, 2010; Guérin and Tsoukala, 2013). The associated fauna includes: *Anancus arvernensis* (Croizet & Jobert, 1828), *Tapirus arvernensis arvernensis* Croizet & Jobert, 1828, *Dicerorhinus jeanvireti* Guérin, 1972, *Sus arvernensis arvernensis* Croizet & Jobert, 1828, *Hipparion* cf. *crassum*, bovids and cervids, *Hystrix* cf. *refossa* and three species of turtles.

Carnivores identified among the Milia fossils are represented by *Homotherium crenatidens* Fabrini, 1890, *Ursus etruscus* Cuvier, 1823, *Agriotherium* sp. and possibly two other small to medium-sized unidentified carnivores.

A well-preserved, almost 16 centimeter - long left upper canine of the scimitar-toothed machairodont *Homotherium crenatidens* was found at the Milia 1 site that exhibits typical coarsely crenulated edges. Moreover a distal portion of left humerus, an almost complete right tibia, and the navicular have been unearthed. A typical adult *Homotherium* reached 110 cm at the shoulder, comparable to the size of a male African lion and would have weighed about 250 kg. Packs of these hypercarnivore animals (diet with more than 70% meat) could easily have overwhelmed a proboscidean juvenile, other medium-sized pachyderms, or juveniles of the larger hoofed animals (van Logchem et al., 2010).

Ursus etrucsus is identified at the Milia locality by the presence of a left lower canine with extreme gnawing marks of *Hystrix* (Fig. 1a), and a left humerus shaft with vestiges of the bar of bone enclosing the entepicondylar foramen in form of a rugosity at its proximal termination (Fig. 1b). This rugosity is more characteristic of *Agriotherium* humerus (Hendey, 1980). Additionally, a left caput femoris, two right proximal ulnae fragments, a right proximal portion of a radius and an eroded left metatarsal II of this species have been identified.

Agriotherium is an extinct genus of the Ursidae, represented by an almost complete calcaneus and a canine fragment. The canine preserves only the part of the base of the crown, where there is posteriorly a slight but well distinguished longitudinal crest. It also preserves a complete, robust and rather short root. The canine is large in size: according to Hendey's description (1980) the *Agriotherium* canines differ from the canines of Ursinae only in being less elongated anteroposteriorly, which fits well with the Milia specimen. The smaller dimensions may indicate that the Milia individual to be female. The calcaneus, which was discovered at the Milia 5 excavating site, is well preserved and almost complete, missing only a small part of the distal end (Fig. 2). Compared with that of the latest Miocene-Early Pliocene *Agriotherium africanum* Hendey, 1972, which is ursine-like, differing principally in having a relatively shorter, asymmetrical and much stouter tuber calcanei (Hendey, 1980).

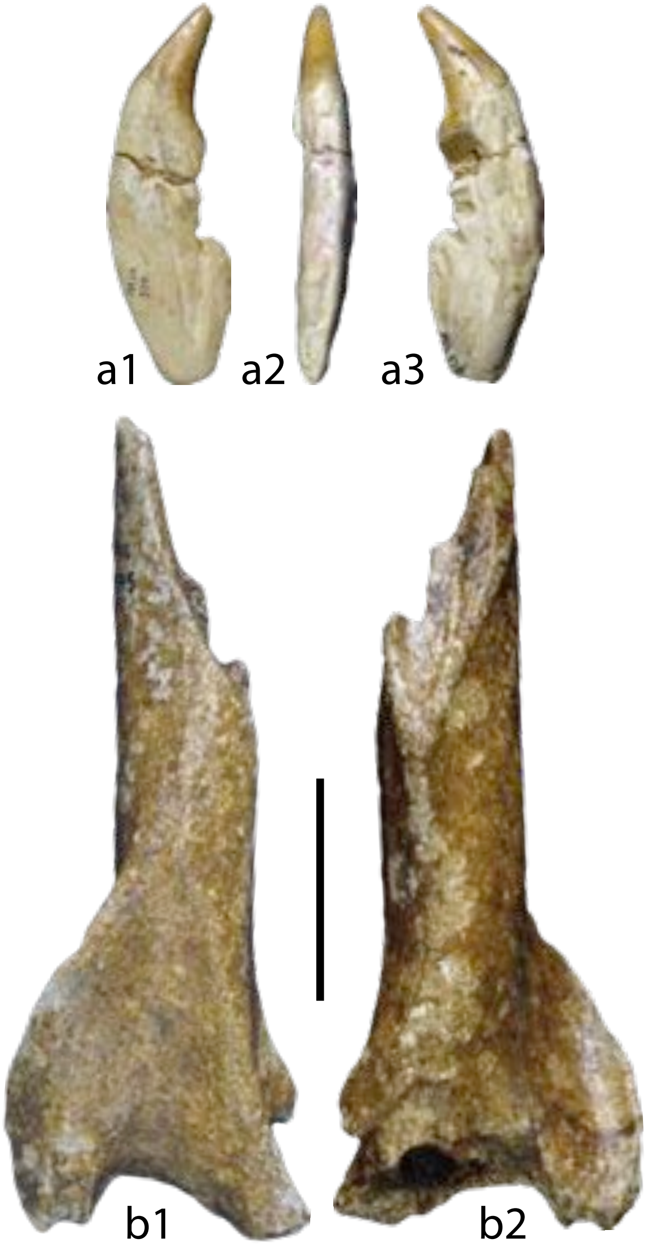

Fig. 1. *Ursus etruscus* Milia. **a**, Lower left canine MIL 510 with gnawing marks of *Hystrix,* a1, labial, a2, anterior; a3, lingual view; **b**, left humerus diaphysis MIL 1515, b1, posterior, b2, anterior view. Scale bar equals 50 mm.

The Milia carnivore remains represent almost 1.35% of the total specimens. Canids that dominated the Villafranchian have not been so far recovered in Milia. Early Villafranchian carnivores are poorly known in Greece due to absence of localities.

Fig. 2. *Agriotherium* sp. Milia, left calcaneus MIL 551. **a**, anterior, **b**, posterior, **c**, lateral, **d**, medial view. Scale bar equals 50 mm.

The Milia Pliocene assemblage of the two mastodonts *Mammut borsoni* and *Anancus arvernensis*, the perissodactyls *Dicerorhinus jeanvireti* and *Tapirus arvernensis* along with the carnivore *Agriotherium* sp. allows us to date the site to the biozone MNQ 16 (Early Villafranchian).

The Milia carnivore association has been compared to those of European sites of equivalent biozones, specifically Vialette and Etouaires in France and Hajnáčka in Slovakia. Our identification of *Agriotherium* marks its initial discovery in Greece. The carnivore assemblage of Milia requires a forested landscape in a warm, relatively wet climate.

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Short note on the Equidae of the Early Villafranchian site of Milia (Grevena, Macedonia, Greece)

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The Early Villafranchian fossiliferous site of Milia (Grevena) has been systematically excavated since 1996. It is characterized by the presence of incomplete Borson's mastodon skeletons. These include the longest tusks so far discovered in the world (4.39 m and 5.02 m) associated with the Auvergne's straight tusked mastodon. Fossil remains of rhinos, tapirs, suids, artiodactyls (cervids and bovids), carnivores, porcupine and turtles have also been excavated (Tsoukala 2000; Tsoukala et al., 2010; Guerin and Tsoukala, 2013).

The Milia hipparion collection consists of about one hundred specimens and includes: 21 isolated permanent upper cheek teeth and a single deciduous, 39 lower permanent cheek teeth and 2 deciduous either isolated or in mandible fragments and two isolated incisors. Postcranial specimens are rare and usually fragmented. Three complete metapodials and a talus comprise the best preserved specimens. Moreover, there are few rolled talus, fragments of lateral metapodials, femur, tibia, humerus, radius and ulna.

The Milia *Hipparion* s.l. is characterized by robust postcranial elements, highly plicated upper cheek teeth with isolated protocones; protocone index ranges between 20% and 30%; lingual side tends to be flat; hypoconal groove is mostly simple (without plications) and broad; mesostyle and parastyle often show grooves; enamel of lower cheek teeth appears to be crenulated; protostylids are commonly present with varying heights; metaconid is rounded to elliptical; metastylids are rounded to triangular; linguaflexids are mostly U-shaped. The highest values of hypsodonty index are 240 in lower, 207 in the upper premolars and 264 in the upper third molar. Tooth crowns reach 52 mm in the upper and 57 mm in the lower permanent cheek teeth. In the lower deciduous teeth the ectostylids are absent. The incisors are grooved.

Pliocene robust hipparions in Europe and Eastern Mediterranean are known by several specific names, among these: *H. gracile* Kaup, 1833; *H. gracile complicatum* Pirlot, 1956; *H. crassum* Gervais, 1859; *H. moriturum* Kretzoi 1954; *H. malustenense* Radulescu and Samson, 1967; *H. heintzi* Eisenmann and Sondaar 1998. These species and forms referred to as *H.* cf. *crassum* or *H.* ex. gr. *crassum* have been revised and united by Forstén (2002) as "the *Hipparion crassum* Group". This group corresponds to the *Hipparion* "morphotype" 4 according to Alberdi (1989). Moreover, Forstén concluded that at least two taxa within this group are recognized on the basis of dental morphology as well as the size and proportions of the limb bones. *H. crassum* has been identified at Late Ruscinian localities, including *H. moriturum* and *H. malustenense*. Forstén considered *H. heintzi* as "a geographic form". The second taxon, according to her revision, includes Early Ruscinian forms, dentally similar to *H. crassum* but showing a different postcranial morphology more similar to Turolian forms. Forstén also recognized a third heterogeneous *Hipparion* sp. but she did not name any taxon. Hipparions of the *H. crassum* Group are known from the Ruscinian, with a possible occurrence also in MN16 (Early Villafranchian) and succeeded by *Proboscidipparion rocinantis* in MN16-17.

In Greece, Pliocene hipparions are known from Maramena (MN13/14 boundary) with two species (Sondaar and Eisenmann 1995), Silata with *H.* cf. *mediterraneum* (MN13/14 boundary) (Koufos, 2006), Megalon Emvolon (MN15) with *H.* cf. *longipes*, Ptolemais lignites (MN15) (Koufos 1982) and Apolakkia in Rhodes (MN15) with *H. crassum* (Benda et al., 1977).

The Milia hipparion is a member of the *Hipparion crassum* group based on its dental characteristics. Its limb size and proportions are comparable to the Late Ruscinian forms and, thus, the typical *Hipparion crassum*. There are, however, some postcranial characteristics (ongoing study) that appear to be significantly different from *H. crassum* at 95% level of significance: these are the larger anteroposterior diameter of the distal articular keel in third metatarsal and the longer metacarpals. This variation falls within the observed range and the 95% confidence interval of *H. heintzi*. The metacarpal height is slightly higher than the mean value plus two standard deviations and the observed range. Other measurements are far less than the range of two standard deviations from the mean values of Perpignan (x±2sd), showing different proportions including small anteroposterior diameter of the proximal articular surface in the third metatarsal.

Further study of the Milia hipparion collection will enrich our knowledge about the terminal European hipparions due to the young age of the locality and the relative abundance of the fossil material.

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Between the feet of elephants: turtles as a common element of the associated fauna of proboscideans

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The Greek fossil chelonian record has been partly studied up to now, but preliminary studies have shown that the diversity of tortoises used to be much greater in the past. Interestingly, Testudines are a common element of the associated fauna of the proboscideans.

The most diverse Greek locality is the Late Pliocene site of Milia, where the zygodon *Mammut borsoni* (see Tsoukala, 2000) and the gomphothere *Anancus arvernensis* are found together with at least 3 different chelonian taxa, including terrestrial and aquatic forms. The most common is a small terrestrial tortoise, which is part of the *Testudo* s.s. group, with a partial carapace and plastral remains. The carapace preserves a posteriorly flared carapacial margin, which allows association with the *Testudo marginata* group, but is not elongated as in the present-day marginated tortoise. The second taxon is a geoemydid, preliminary attributed to the freshwater *Mauremys* sp. Finally, two specimens could be attributed to a giant terrestrial tortoise. These are a partial coracoid and a possible osteoderm that indicate the presence of '*Cheirogaster*'. The turtles and tortoises from Milia reveal that the environment of the area during Pliocene was diverse, with forested and open areas, with significant water bodies (lakes, ponds and rivers).

Other sites in Northern Greece with co-occurrences of turtles and proboscideans are Xerias, Gefira, Epanomi, Kryopigi, Platania, and Axios valley. In most cases, medium-sized to giant tortoises are found together with the proboscideans, in the humid environment of Epanomi (Pliocene, with *Mammuthus* cf. *meridionalis*, see Athanasiou and Kostopoulos, 2010) and the savannah-like environment of Axios valley (Late Miocene, with *Choerolophodon anatolicus* and *Ch. pentelici*, see Konidaris and Koufos, 2013). In other cases, Xerias (Pleistocene, with *Elephas antiquus*, see Tsoukala et al., 2011) and Platania (Late Miocene, with mastodons), small terrestrial tortoises of the *Testudo* s.s. group have been found. In southern Greece, at least three species of Testudinidae, including a giant tortoise, are found in the Late Miocene site of Pikermi, along with *Choerolophodon pentelici* (see Konidaris, 2013). These are the hinged *Testudo marmorum*, an un-hinged taxon, and the gigantic, up to 180 cm long, cf. *Cheirogaster* aff. *schafferi*. From the Pleistocene, the freshwater species *Mauremys caspica* has been documented, together with *Elephas antiquus* (see Melentis, 1961), in Megalopolis basin (Peloponnesus). In the Aegean region, giant tortoises co-occur with *Anancus arvenensis* in the Early Pleistocene site of Lesvos Island (see de Vos et al., 2002) and in the Pliocene of Rhodes Island (see Mueller-Töwe et al., 2011) and with choerolophodons in the Late Miocene sites from Samos (precise locality of the giant tortoise unknown). One of the most important co-occurrences of turtles and proboscideans is that of the Charkadio cave in Tilos Island. Along with many findings of dwarf elephants (*Elephas tiliensis*, see Theodorou et al., 2007), the preliminary study of the material revealed several postcranial remains of a small testudinid taxon (see Bachmayer and Symeonidis, 1975). The complete absence of shell remains raised questions of possible human interaction in the cave, but recent studies do not support this claim (see Michailidis et al., this volume).

Since turtles and tortoises are adapted in a variety of ecosystems and are very sensitive to the environmental changes, their detailed study can provide additional information about the reconstruction of the paleoenvironment in which the proboscideans were also adapted. Specific interest is drawn upon the changes on the faunal composition of turtle assemblages since Late Miocene, which are compared with the information obtained by other well-studied mammal groups, such as proboscideans. Our data indicate that the changes in the proboscidean associations in Greece during the last 12 million years, were not followed by analogous changes in the chelonian faunas. This suggests that the various environmental and climate changes that affected the proboscidean assemblages did not cause extinction events in the more conservative turtle lineages, but rather affected their paleozoographical ranges. The only significant exception would be the extinction of the giant tortoises, which coincides with the last occurrence of *Anancus arvernensis* (in Lesvos Island, Earliest Pleistocene).

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Palaeoenvironmental information from isotopic fingerprints of the Early Villafranchian *Mammut borsoni* from Milia (Grevena, Macedonia, Greece)

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Skeleton and tooth remains of the zygodont *Mammut borsoni* (Hays, 1834) (Proboscidea) were identified at Milia in Grevena, W. Macedonia. The present study focussed on tooth remains of this proboscidean. Among the elephantoids, zygodon mammutids are the most conservative; however fossils were unearthed in a state of generally poor preservation with a high degree of post-mortem mineralization. The right M3 upper molar is better preserved than M2, and retains relatively unaltered enamel of about 5.8 mm to 7.6 mm in thickness. Roots on these molars appear to be well-developed and robust. The lower molar m3 is located in the middle of the mandible remnant, and along with m2, comprises less than a third of the total length of the jaw (Tsoukala, 2000). The third permanent molar is the last to erupt and show wear, and is considered to represent the natural limit of mammut's life (Arppe, 2009).

Tooth enamel structure is essentially non-porous and almost entirely inorganic. Additional enamel form during life by accretion, and is not altered in composition after the initial crystallization. Thus, we believe that the palaeoenvironment and palaeodiet of the mammutid are recorded within the enamel of these molar teeth; we analyzed the tooth enamel of these specimens to determine the carbon isotope composition of hydroxyapatite carbonate (Dotsika et al, 2011; Merceron et al, 2013; Pushkina et al, 2014).

About 100 mg of powered sample were used for isotopic analysis which carried out in Stable Isotope Unite of Institute for Advanced Materials, Physicochemical Processes, Nanotechnology & Microsystems of NCSR "Demokritos" in Greece. The external precision based on multiple sample measurements was about 0.1‰ for $\delta^{13}C$ results. Also elemental microanalysis spectrometer with energy dispersive X-ray (Energy Dispersive X-ray, EDX) in a scanning electron microscope (Scanning Electron Microscopy, SEM) were carried out, at the same institute, where results reflected the hydroxyapatite carbonate structure of enamel through the dominant presence of Ca, P.

The interpretation of isotopes concluded probably on the presence of C3 type of diet.

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Not the brain alone: the nutritional potential of elephant heads in Paleolithic sites

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The significant role of elephants in Paleolithic faunal assemblages is well demonstrated in many sites in Europe, Africa and Asia (e.g., Klein, 1988; Anzidei et al., 2011; Rabinovich et al., 2012). However, the dietary significance of these huge animals has not been thoroughly explored. We argue that during Paleolithic times elephants were a constant and significant source of calories for early hominins. The human use of the elephants for dietary purposes is still debated in some cases (e.g., Villa et al., 2005). Several Lower Paleolithic Acheulian sites, however, clearly demonstrate butchery of elephants (e.g., Goren-Inbar et al., 1994; Rabinovich et al., 2012). Post-Acheulian and Mousterian sites in Europe provide further evidence for the use of elephants for dietary purposes, such as meat and marrow consumption, (e.g., Yravedra et al., 2012).

The role of protein in human diet and subsistence in Lower Paleolithic sites has been demonstrated repeatedly (e.g., Milton, 2003; Bunn, 2006) and it is commonly accepted that Acheulian and even pre-Acheulian hominins extracted a significant portion of the calories they consumed from animal meat and fat, and were actually dependent on animals for their survival (e.g, Ben-Dor et al., 2011). Carnivory is thus a remarkable human trait accompanying humans from their earliest stages to this very day.

Many Paleolithic sites with elephant remains found in direct association with human activity have yielded elephants' head remains, including mandibles, skull fragments and teeth (e.g., Rabinovich et al., 2012; Yravedra et al., 2012). The presence of elephants' head parts in those sites should not be overlooked and needs to be explained.

This presentation deals with the nutritional potential of the elephant's head and its implications as follows:

1. An overview of elephant skull remains in selected Paleolithic sites.
2. The anatomy of the elephant's head and its nutritional potential.
3. Ethnographic evidence for the consumption of different head parts of elephants.
4. A re-evaluation of the nutritional potential of the elephant's head and its contribution to the understanding of Paleolithic human behavior.

Our research will provide accounts of archaeological sites with elephant remains including the numbers of those remains in the faunal assemblages, and the possible uses of those elephants' parts by early humans.

The anatomy of the elephant's head will be presented using zoological and biological literature, as well as ethnographic documentation on the hunting and consumption of elephants' heads. One example for such documentation can be found in an account by Cuthbert Christy, an elephant hunter. There he describes:

> *"The best way to secure a supply, when one has only a hunting knife, is to cut away the skin of the hollow over the eye. Here both meat and fat are easily obtainable, but should be cut out soon after death."* (Christy, 1922, pp. 292-293).

We suggest that the elephant's head, including all its parts, is rich in edible meat and fat. The tongue, for instance, can weigh up to 14 kilograms in modern African elephants, and the trunk can weigh over 110 kilograms in modern African elephants (Byers and Ugan, 2005). Another organ worth mentioning is the temporal gland, an organ located in the temporal depression, behind the eyes (Rasmussen et al., 1984). Visible oily secretion is discharged from this gland. Pleistocene elephants probably also possessed temporal glands, that most likely were larger than those of modern elephants (Buss et al., 1976).

The elephant's head is a particularly high-quality source of energy, and therefore could have been used by early hominids as an important dietary source. Thus, understanding the nutritional potential of elephant heads, combined with the remains of elephant skulls in Paleolithic sites, provides new insights concerning human behavior and subsistence in Paleolithic times.

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Occurrences of bone growth variations in Columbian mammoth, *Mammuthus columbi* at the Mammoth Site of Hot Springs, SD

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Since the discovery of the Mammoth Site in South Dakota in 1974, the remains of 61 mammoths, 59 Columbian and two Woolly mammoth were recorded after 35 years of excavations. The remains of mammoths trapped in the sinkhole about 26,000 years ago, are represented by over 1,200 in situ identifiable bones and fragments, and over 2,000 identifiable bones and fragments placed in the collections. The trapped animals accumulated in a very short geological time (about 200-700 years) representing result of selective (behavioral) deaths, and can be characterized by parameters of a single "population". The Mammoth Site collection is complete, and with the exception of the microfauna (the screen washing of the sediments began in 1990), none of the identified specimen was discarded.

The assemblage represents a thanatocoenosis of mammoth in unique circumstance of an untransported, or minimally transported accumulation in springfed pond within a karst depression (Agenbroad and Mead, 1994). Most of the bones (about 90%) in situ are not associated (or in articulated position with each other), and concentrated within three-six meters of the northeast, east, south and southwest edges of the former sinkhole.

Based on the cranial material retaining molars revealed age range of the trapped mammoths between 10 and 54 AEY (African Elephant Years), dominated by 10-19 and 20-29 AEY young adult animals (Agenbroad and Mead, 1987), with a mean age of 25 AEY (Agenbroad, 1994). Scarcity of juveniles and senile individuals, as well as predominance of males in the assemblage argues against a catastrophic event or a mass accumulation of a single heard (Agenbroad and Mead, 1994; Agenbroad and Lister, 1994).

The most complete specimens belong to Columbian mammoths and include 90% complete skeleton of the 49 AEY years old mammoth nicknamed "Napoleon", adult male mammoth nicknamed "Murray", the largest specimen so far found at the site (Agenbroad, 1994), and partial skeleton of two adult male mammoths, nicknamed "Swimmer" and "Dutchman". None of the mentioned above specimens revealed bone abnormalities.

Very few bones (0.01%) of the entire collection accumulated in 1974-2013 field seasons display signs of possible development of abnormal or excessive growth of bony tissues. The bones were not associated with any skeletons, and mammoth individual ages that yielded these specimens remain unknown.

The bones represent mostly stylohyoideum, sternum, vertebrae and rib. Among highly variable stylohyoidea observed among the specimens in the collection, two out of approximately two dozen of specimens in the collection, have extensions in the shelf area (Fig. 1).

Fig. 1. The Columbian mammoth, *Mammuthus columbi* stylohyoids. **A**, normal shape (dex; MSL 2308); **B**, extended shelf area (dex; MSL 938).

A single isolated mammoth presternum (MSL 725) displays a significant growth around the articulation facets of first pair of ribs, with some of the growth expanding towards the tip of the bone. The growth might have been stimulated by dislocation of the ribs from the sternum.

Originally identified as pathology (Mol & Agenbroad, 1994), we cannot over rule the possibility of interpreting this growth as a healed fracture caused by bull fighting. The sternum is in the anatomical position to be vulnerable to tusks damage, as in fighting between bulls.

Few frontal thoracic vertebrae display overdeveloped (or deep) cavities (not penetrating foramens) at the base of the neural arch with spinal process. Based on their rarity, we opt considering it as a morphological variation, or most likely, ontological changes due to aging. Whether this feature (cavity) corresponds to extreme cases of development of further penetrating through the bone foramens observed in woolly mammoth, *Mammuthus primigenius* recorded in few cases in European sites and southwestern Siberia (Krezminska, 1980; Musil 1983; Leschinsky, 2009), is unknown.

Although the hyoid apparatus is highly functional system on Proboscidea associated with feeding, sound production and water storage in pharyngeal pouch, the other bones, as vertebrae, ribs, and foot bones are cited as having most of the pathological changes (oseoblastoma, spondylosis, cancer, etc.) in mammoth skeleton (Krezminska, 2008), as in other mammals. It is obviously not a case at the Mammoth Site collection.

Within the entire collection, no specimens (except the presternum) revealed cases displaying healed fractures, malformations of the skeletal elements (furrows in the molar's cement, holes in bones due to abscess), vertebrae fusion, or additional molars in rami.

The Columbian mammoths from the Mammoth Site are represented by healthy individuals, with animals displaying a very small percentage of bones with unusual morphology, characterizing normal condition of a natural population.

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A partial skeleton of *Deinotherium* (Proboscidea, Mammalia) from the late Middle Miocene Gratkorn locality (Austria) and the discussion on taxonomy of late Middle and early Late Miocene Deinotheriidae

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The late Middle Miocene (Sarmatian sensu stricto; 12.2 - 12.0 Ma) Gratkorn locality (Austria) yielded a disarticulated, though still roughly associated partial *Deinotherium* skeleton (Fig. 1, E). It can be determined as a medium sized taxon of Deinotheriidae and clearly assigned to the genus *Deinotherium* due to dimensions and morphology of the dental and postcranial material. As typical for *Deinotherium* and different to *Prodeinotherium* the specimen's radius shows a weaker torsion, its corpus radii is generally more flattened, and its proximal diaphysis is mediodorsal-lateropalmar flattened; the distal articular surface of the os carpi ulnare with two concave facets (axes dorsopalmarly) is divided by a central convexity, the os tarsi centrale carries only three distal articulation facets but none for the articulation with the Mt I (Fig. 1, A-D). The specimen from Gratkorn thus confirms the osteological differences in the postcrania between *Prodeinotherium* and *Deinotherium*. The Gratkorn specimen is one of the few skeletons of a medium sized taxon of Deinotheriidae and one of the rare well dated late Middle Miocene occurrences in Central Europe with associated dental and postcranial material. As the diagnostically important p/3 is missing in the specimen its determination on species level is uncertain and it can only be assigned to *Deinotherium levius* vel *giganteum*.

Fig. 1. *Deinotherium levius* vel *giganteum* from Gratkorn, Austria. **A**, os carpi ulnare sin. in distal view; **B**, os tarsi centrale dex. in distal view; **C**, sketch of B with identified articulation facets; **D**, radius sin. in dorsal view; E, excavation of partial skeleton by the Universalmuseum Joanneum in 2006. Abbreviations: os t., os tarsale. Scale bar equals 5 cm.

With the taxonomic determination of the Gratkorn specimen and recent works discussing validities of different deinothere species (Böhme et al., 2012; Pickford and Pourabrishami, 2013), a taxonomic concept with two medium sized deinothere species (*Deinotherium giganteum* and *Deinotherium levius*) is reestablished. In contrast to this, other taxonomic concepts question the validity of the species *D. levius* (e.g., Gasparik, 2001; Markov, 2008). A discussion on the different concepts and the possible application for biostratigraphic and biochronologic considerations based on morphological and dimensional variabilities and differences among deinothere species will be presented. Comparable to the results of Böhme et al. (2012) and Pickford and Pourabrishami (2013) we propose that *Deinotherium levius* is present during the Middle Miocene, but seems to shows a wider biochronologic (MN6 to MN9) and chronostratigraphic range (late Early Badenian to Pannonian B) than assumed so far. *Deinotherium giganteum* in contrast most likely does not appear before the Late Miocene, while the genus *Prodeinotherium* is restricted to the Early and Middle Miocene in Central Europe.

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Primitive elephantid from Turkey

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In 2010, during road construction in Büyükyağlı, Kırıkkale, a tusk and a humerus of an elephantid were found in the locality called Kale Tepe-3, followed in 2011 by a complete mandible. The locality is in the south-west part of the Çankırı-Çorum Basin and stratigraphically fits within the upper levels of the Akkaşdağı Formation which has been thought to be dated to MN15, i.e. Early Pliocene, according to a small mammal fauna from Balışeyh, a locality close to Kale Tepe-3 (Karadenizli, 2011).

In the mandible, three teeth are exposed on the occlusal plane. To be sure of the form of the rearmost tooth, an X-ray image of the mandible from the left side was taken. According to the X-ray image, the posterior tooth has 10 plates and a talon in total, 5 of them exposed on the occlusal plane, 5 buried in the jaw (figure 1). In the X-ray image, the tooth tapers strongly at the back in side view as in a typical m3. So this suggests that the tooth is m3 with 10 plates which fits with Maglio's (1973) count of *Elephas planifrons* m3 (8-13). Although it seems strange that the posterior tooth extends so far toward the back end of the jaw, Osborn (1942, p. 1006, fig. 892 and 893) showed some examples of mandibles of *Elephas* (*Archidiskodon*) *imperator* and *E.* (*Parelephas*) *washingtonii* with m3 going far toward at the back of the mandible. In the Kale Tepe-3 specimen three teeth are exposed on the mandible; small remnant of m1 in front, m2 in the middle and m3 at the back.

All plates of m2 are at an advanced stage of wear, especially the anterior ones which are almost flat. Although the left m2 preserves ∞3x and the right one has ∞4x plates, according to the length of the crown the total number of plates is suggested to be about 6-7. Lamellar frequencies of m2s are very low. Enamel is thick and little-wrinkled on the center of the plate. Both left and right m3s are at very early stage of wear with small enamel rings in the first three plates, therefore it is not possible to comment on enamel figure.

The tusk is not twisted significantly as in *Mammuthus* but has a slight curve as seen in *Elephas*.

With the plate number and other measurements and also enamel figure of m2, Kale Tepe-3 specimen is very close to *M. rumanus* from Europe MN16 and specimens from Bethlehem. For *Mammuthus*, Maglio (1973) suggested a migration route from Africa via Gibraltar at c. 2.5 Ma, but with the earlier specimens of *M. rumanus*, migration via Levant at c. 3.5 Ma is more probable (Markov, 2012). As early mammoths and the Asian species *Elephas planifrons* have similar dental morphology, *E. planifrons* used to be included in the genus *Archidiskodon* which resulted the idea of *E. planifrons* occurence in several localities in Europe (Markov, 2012). But now it is assumed that *E. planifrons* did not occur in Europe or Africa (Maglio, 1973).

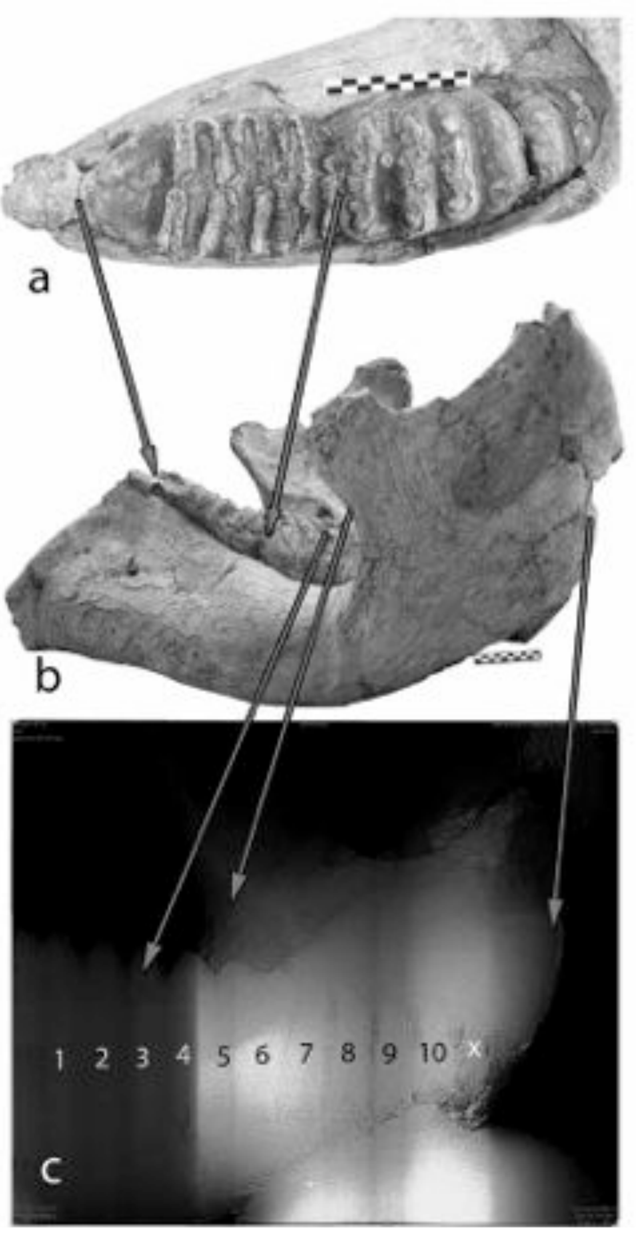

Fig. 1. Mandible of the elephantid from Kale-Tepe 3; **a**, Occlusal view of left tooth row; **b**, Lateral view of the mandible from the left side; **c**, X-ray image of the mandible from the left side, numbers and x indicate the numbers of the plates and talon. Scale bar equals 10 cm.

Because of its key position between Africa, Asia and Europe, Turkey has potential importance for elucidating the history of early Eurasian elephantids (Albayrak & Lister, 2012). Although the tusk is more similar to *Elephas*, with its gentle curve, the specimens from Kale Tepe-3 could be assigned to *E. planifrons* of Asia or *M. rumanus* of Europe according to features of the mandible and the teeth. There are many debates and questions on early mammoths (Lister et al., 2005, Markov, 2012). The material from Bethlehem has played an important part in these discussions; originally described by Hooijer (1958) as *E. planifrons*, Markov (2012) considered them as a possible *M. rumanus*, and further discussion is provided by Rabinovich and Lister (this volume). The specimens from Kale Tepe-3 may be similar to those from Bethlehem, and the same questions on their taxonomy pertain. Although the age of the Akkaşdağı Formation is MN15, according to new finds the age could be younger as early Late Pliocene, i.e. MN16a, (Levent Karadenizli, pers.comm.) and this age is very consistent with the earliest *M. rumanus* and Bethlehem specimens.

Primitive specimens from Turkey like Kale Tepe-3 or Yukarısöğütönü (Albayrak and Lister, 2012) are important pieces in this puzzle, and a step forward on understanding the migration and early evolution of elephants outside Africa.

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New discoveries of woolly mammoth and woolly rhinoceros from Northern Iberia

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Cold adapted large mammal faunas reached the Iberian Peninsula, which constituted the south-western boundary of their Eurasian distribution, during the coldest episodes of the Late Pleistocene (Álvarez-Lao and García, 2010, 2011a). Findings of woolly mammoth (*Mammuthus primigenius*) and woolly rhinoceros (*Coelodonta antiquitatis*), although they are not abundant, have been noticed in a number of Iberian sites, especially coming from the northern areas (Altuna, 1996; García and Arsuaga, 2003; Álvarez-Lao and García, 2011a, 2011b, 2012). In the last three years, two very interesting new discoveries have been added: Jou Puerta and Rexidora caves, both coming from the province of Asturias (NW Spain) and located 24 km away each other.

Jou Puerta site (Llanes, Asturias) corresponds to a cave placed under a sinkhole, discovered in April 2011 during the excavation works for a highway (Álvarez-Lao, 2014). An amount of 1064 fossil remains corresponding to 10 large-mammal species was recovered. The origin of the bone accumulation is related to a natural trap, so most of the fossils were unusually well preserved. The chronology of the fossils ranges from 36.6 to 30.2 Cal ka BP. The faunal association included one of the largest (n=105) and best preserved assemblages of woolly rhinoceros remains from the Iberian Peninsula, comprising an almost complete mandible, isolated teeth, scapulae, pelvis, vertebrae, limb bones, carpus, metacarpus, tarsus and phalanges; corresponding to a minimum of three individuals (Álvarez-Lao, 2014). Four teeth remains of a woolly mammoth calf (one small permanent tusk and three isolated plates of a dp4) were also recovered. The age at death of this individual was estimated on 1.5 to 2 years (Álvarez-Lao, 2014). Other ungulate species in the assemblage includes *Cervus elaphus* (red deer), *Megaloceros giganteus* (giant deer), *Capreolus capreolus* (roe deer), Bovini or *Bos/Bison* (aurochs/bison), *Capra pyrenaica* (ibex), *Rupicapra pyrenaica* (chamois) and *Equus ferus* (horse). Carnivores provided one single remain, a deciduous molar corresponding to a felid classified as cf. *Panthera pardus* (Álvarez-Lao, 2014).

Other interesting feature of the Jou Puerta assemblage is the faunal composition: while cold elements (as woolly rhinoceros and woolly mammoth) are present, temperate species (like red deer or roe deer) are predominant in the assemblage. Compared with other Iberian and Western European fossil assemblages where *C. antiquitatis* and/or *M. primigenius* occurred, results showed that temperate ungulate species are predominant at most of the Iberian assemblages whereas, by contrast, Western-Central European ungulate associations were dominated by cold-adapted taxa (especially reindeer *Rangifer tarandus*). This mixture of temperate and cold elements at Iberian sites (including Jou Puerta), which does not reflect the typical faunal composition of the Eurasian mammoth steppe, supports the idea that these cold taxa only reached the Peninsula occasionally, during the coldest episodes of the Pleistocene (Álvarez-Lao and García 2011b, 2012). Consequently, Iberian assemblages reflect a mixing of cold and temperate faunas instead of a faunal replacing, suggesting that the typical mammoth fauna was never completely established in Iberia as it was in mainland Europe and Siberia (Álvarez-Lao, 2014).

The Rexidora Cave (Ribadesella, Asturias), was discovered in 2012. The faunal assemblage is exceptionally well preserved and lacks any evidence of human or carnivore activity, suggesting that the cave was also in connection with a natural trap. The morphology of the cave, placed under a sinkhole, supports this idea. The ongoing excavation works provided, up to date, more than 300 fossil remains corresponding to *Coelodonta antiquitatis*, *Cervus elaphus*, *Rangifer tarandus*, *Bison priscus* (steppe bison), and *Crocuta crocuta* (cave hyena). The woolly rhinoceros assemblage includes numerous unusually well preserved elements as one mandible, one femur and one partially preserved skull from, at least, two subadult individuals. Other environmentally indicative species is the reindeer, which is also present in a number of Iberian sites (Altuna, 1996; Álvarez-Lao and García, 2010, 2011a; Gómez-Olivencia et al., in press), supporting the existence of cold environmental conditions at that time. The steppe bison is the dominant species in the assemblage (with a minimum number of five individuals) providing an outstanding collection of well-preserved elements, that comprises two skulls and numerous limb bones, and constituting one of the best bison assemblages from the Iberian Peninsula. Carnivores are represented by a partially preserved skeleton (including a complete skull) of a cave hyena, that was most probably another victim of the natural trap.

Occurrences of cold-adapted faunas from Iberian sites are becoming more and more frequent in recent years, in connection with the proliferation of road works and construction, evidencing that their presence in such southern areas is not as unusual as it was thought until some years ago.

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An old Mexican proboscidean studied with new techniques

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Víctor Adrián PÉREZ-CRESPO, Pedro MORALES-PUENTE, and Edith CIENFUEGOS ALVARADO**

During the Late Pleistocene, the Basin of México was inhabited by populations of large megaherbivores, being contemporaneous with the early humans. Although more than 100 mammoth localities have been found in the basin, very few of them present any trustable evidence of mammoth-human interactions (Arroyo-Cabrales et al., 2006). Most of those findings occurred in the eastern portion of what it used to be Texcoco Lake, in some of the lowest elevations in the region (2,200 masl). However, few of them have been found on the foothills of the mountains around the basin, and only last year, new mammoth remains were found in Milpa Alta at 2,800 masl., at the south easternmost portion of the Basin, in one of the few remaining rural areas, near one of the most populated cities of the World, México City.

Initial findings of upper and lower molars provided a starting point for proposing a paleontological research project in México that for the first time involved geophysical surveys combining three different methods: magnetic gradient, ground-penetrating radar (helpful in identifying location, depth and shape of anomaly), and electrical resistivity (helpful in defining bone concentration) (Barba et al., 2009, 2010). Based on the results from the collected geophysical data, one sample site was excavated to test the geophysical signals, but also because molars were found nearby.

Excavations were conducted in accordance to the usual square-grid method, which was followed as far as the nature of the sediments allowed, as they consisted mostly by loose dark volcanic ashes, and as such keeping the walls straight was quite difficult. Initial hypothesis pointed out towards a possible volcanic event causing the death of a mammoth, with late exposure of the animal bones, and a second event covering them again with volcanic ashes. During this time interval most of the limb bones moved down the hill, lower than the head and the girdles.

In order to test this hypothesis, samples from sediment in

Fig. 1. 3D-Laser scanned view of the Milpa Alta mammoth, head and pectoral girdle are in view. *Courtesy of Victor Takahashi.*

touch with the buried bones were secured for chemical analyses in order to figure out whether the bones had muscle remains still attached on due to a fast burial event.

The observed volcanic stratigraphy during the excavation suggests two different volcanic events: an ash layer identified as tutifruti produced by a first eruption event of the Popocatepetl Volcano is found right above the mammoth remains and has been dated to 14100 BP. During the burial process the soft tissue decayed and it seems that due to the tectonic and volcanic activity of the Chichinahutzin ridge, the bone remains were exposed again thousands of years later. Later on, a second eruption event covered the bones again with a lahar type layer composed of volcanic ash and water that slided down from the San Miguel volcano slopes and shifted some of the bones from their original position.

It is outstanding that a small concentration of fragmented bones was found on the side of one of the tusks, including a few bones with possible anthropic cuts. These have been studied using a SEM, and human modification seems a plausible scenario. However, dating the time of the supposed cutmarks will not be easy.

The mammoth specimen was an adult individual belonging to the species *Mammuthus columbi* (Proboscidea, Elephantidae), the Columbian mammoth. Based on the molar identification (permanent third molar), the specimen was assigned as 43 years old. The recovered skeleton was almost complete, lying on its side. Furthermore, the bones were quite weathered, probably due to the unusual conditions of the burial sediments (volcanic ashes). Also 3D-laser scanning was employed to understand the way that the deposit was formed (Fig. 1).

Molar dating is on-going, and carbon, nitrogen and oxygen stable isotopes analyses have been assayed in bone (apatite of bone and collagen), dentine and dental enamel. The obtained δ^{13}C values were -4.84‰ (enamel), -13.59‰ (dentine), -7.02‰ (apatite of bone), and -13.84‰ (collagen), which indicate that this mammoth had a mixed-diet with important intake of C_4 plants, and thus inhabiting in open habitats. In addition, δ^{15}N values were 9.82‰ for the dentine and 9.73‰ in the collagen, similar to those found in other mammoths (Pérez-Crespo et al., 2012). In contrast, oxygen isotopic values of apatite in enamel and bone were -6.16‰ and -6.26‰ respectively, which suggest that this mammoth possibly moved no more than 100 km. Further analyses are warranted to learn more on the biology of this individual.

Along with the scientific interest in learning more on this high-elevation individual, an exhibit has been planned. Certainly the community is quite interested in attracting visitors with a mammoth exhibit. They have made arrangements to purchase a piece of land nearby the area where the remains were found (Molina M., 2013; Olvera, 2013).

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Migratory movements of a population of Columbian mammoth (*Mammuthus columbi*) from Laguna de las Cruces, San Luis Potosí, México

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Proposing migratory patterns by Quaternary mammal species is a topic scarcely addressed in paleoecological studies. This is due to the lack of direct evidence that provides any information about those movements. However, in the last 20 years, the use of strontium isotopic ratios has turned into a useful tool for determining migration patterns for some species of herbivorous mammals from the United States and Europe (Hoppe and Koch, 2007; Julien et al., 2012). This technique is based on the following assumptions: the isotopic ratios of $^{87}Sr/^{86}Sr$ in a rock, depends upon its age, and initial content of ^{87}Rb (Faure, 1977). The rocks suffer diverse chemical, physical and biological alterations processes forming soil; however, those processes do not affect $^{87}Sr/^{86}Sr$ isotopic ratios, so that soil will have $^{87}Sr/^{86}Sr$ values similar to the rock that formed it (Capo et al., 1998). Plants incorporate the strontium from soil, and animals do it from plants, but strontium isotopic ratio remains the same (Feranec et al., 2009). Using strontium isotopic ratios from dental enamel, we inferred the distance that a Columbian mammoth population (*Mammuthus columbi*) migrated out of Laguna de las Cruces, San Luis Potosí, México. The dental enamel of three individuals was leached, while three samples from the same individual were not leached. The $^{87}Sr/^{86}Sr$ values were compared with those obtained for plants and soils collected at several localities in the state of San Luis Potosí following the technique proposed by Schaaf et al. (2012). One of the individuals has $^{87}Sr/^{86}Sr$ ratios similar to those shown by soils and plants from Laguna de las Cruces: while the other two individuals have quite different $^{87}Sr/^{86}Sr$ values from soil and plants from all sites (Fig. 1). In contrast, a fourth individual, whose sample was not leached, shows differences between its values, which suggest the presence of secondary Sr. This corroborates the need to use the leaching technique to remove secondary Sr from other sources. Finally, the assays suggest that two individuals may have moved more than 100 km from Laguna de las Cruces, but lack of enough soil and plant samples restricted us from determining where they moved to or from. Such results support other proposals (either using current mammal fauna or geomorphological studies), which point out that megaherbivores moved through the valleys in central Mexico feeding on the large food sources of the savannas and grasslands.

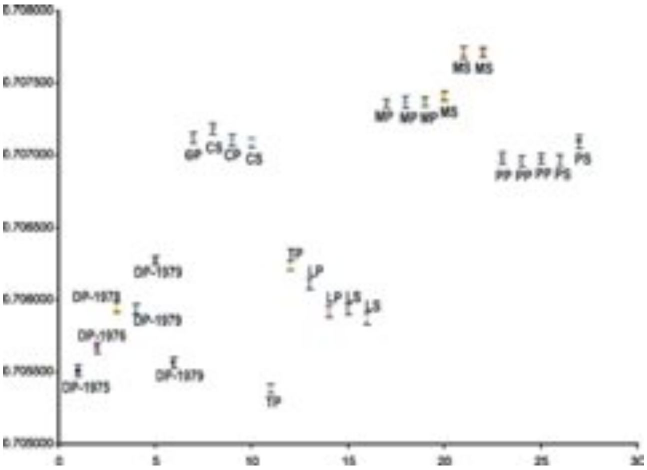

Fig. 1. Comparison between $^{87}Sr/^{86}Sr$ values of mammoths (DP) and plants and soil.

LS, Laguna de las Cruces, soil; **LP**, Laguna de las Cruces, plant; **CS**, Cedral, soil; **CP**, Cedral, plant; **MS**, Mina de San Antonio, soil; **MP**, Mina de San Antonio, plant; **PS**, Paso del Águila, soil; **PP**, Paso del Águila, plant; **TS**, El Tepetate, soil; **TP**, El Tepetate, plant.

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Anancus arvernensis (Proboscidea, Mammalia) from Kallíphytos (Dráma, E. Macedonia, Greece), with a revision of existing samples from Greece

Athanassios ATHANASSIOU ✉

Anancus, an advanced tetralophodont Old-World Gomphothere, is the most common non-elephantid proboscidean genus in Pliocene and Early Pleistocene localities of Greece (Doukas and Athanassiou, 2003), but it is known mostly from fragmentary or isolated dental specimens. A new site excavated in 2005 near Kallíphytos (Dráma, Eastern Macedonia) yielded an additional *Anancus* specimen, an almost complete mandible (Fig. 1). The find is brevirostrine, without any indication of tusk presence. It preserves both rami, but lacks its rostroventral part, which has been eroded away. The dentition comprises the left and right third molars (m3). Both consist of five lophids and a talonid, are rather low crowned and very worn anteriorly. The occlusal surface exhibits clear anancoidy, with alternating labial and lingual semilophids. Based on its morphological and metrical characters the specimen is referred to the species *A. arvernensis* (Croizet and Jobert, 1828). The specimen belongs to the collections of the Archaeological Museum of Dráma, where it is also exhibited.

Fig. 1. *Anancus arvernensis* mandible with both m3s from Kallíphytos, Dráma, Greece; occlusal view. Scale bar equals 100 mm.

A similar find of the same species was discovered in early ’70s during quarrying works in the Early Pleistocene locality of Sésklo (Magnesia, Thessaly) (Tataris, 1975). The specimen, a complete mandible with both m3s, was described and figured by Symeonidis and Tataris (1983) and it is redescribed here in comparison to the Kallíphytos find. The two specimens are very similar morphologically and metrically and belong to individuals of about the same ontogenetic age, as inferred by the similar dental wear stage.

The Sésklo mandible was found together with a toothless cranial part, which might belong to the same individual. This latter specimen, reconstructed from several broken parts, preserves the right half of the skull, including part of the occipital region and the right tusk alveolus. It is characterised by vaulted dorsal profile, relatively low position of the orbit, and flat occipital. Its large size, as well as the large diameter of the tusk alveolus, indicate that it belonged to a male individual. Both Sésklo specimens are kept in the Museum of Palaeontology and Geology, University of Athens.

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The endemic elephants of Cyprus: a reconsideration of their variation and taxonomy based on new fossil finds

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Cyprus, an oceanic island that remained isolated from the mainland since its emergence, is characterized by the presence of a highly impoverished, endemic mammalian fauna of Late Pleistocene to early Holocene age. The main element of this fauna is an extremely dwarfed hippo, *Phanourios minor* (Desmarest, 1822), abundantly found in many sites across the island (Boekschoten & Sondaar, 1972; Reese, 1995; Theodorou et al., 2004). Other known taxa include a rodent, bats, a genet (*Genetta plesictoides* Bate, 1903) and a dwarf elephant [*Palaeoloxodon cypriotes* (Bate, 1903)] (Bate, 1903, 1904; Reese, 1995; Theodorou et al., 2007a; van der Geer et al., 2010).

Endemic elephants are a common element of insular faunas. *Palaeoloxodon cypriotes* is a very small elephant species, roughly comparable in size with the Maltese–Sicilian *P. falconeri*, as it is inferred by dental dimensions. It quite probably derived from a *P. antiquus* founder population that reached the island during the Late Pleistocene. The species is known from more than fifteen sites but the available material is scanty (Bate, 1904; Reese, 1995; Herridge, 2010; Filippidi et al., 2013), particularly with respect to the hippo finds.

The possibility of the existence of a second endemic elephant in Cyprus, larger than *P. cypriotes*, has been already expressed quite early (Vaufrey, 1929), and subsequently discussed by several authors, but the available remains were insufficient for an adequate description. New material from SE Cyprus (Achna, Ormideia and Xylophagou areas) accumulated during the last decades by private collectors and excavations (Boekschoten & Sondaar, 1972; Reese, 1995; Theodorou et al., 2005, Iliopoulos et al., 2011) corroborates this. The available material includes a partial skull, mandibles, long bones, and isolated tusk and molars. The finds indicate an animal quite larger than *P. cypriotes*, of a size comparable to that of Tilos elephant, *P. tiliensis* (Theodorou et al., 2007b).

The cranial and dental morphology (wide frontoparietal area, diverging tusk alveoli, occlusal shape and enamel pattern) offers evidence of close phylogenetic affinities with *P. antiquus*. Though some of the new sites are dated in the early Late Pleistocene (Poole and Robertson, 1998; Theodorou et al., 2005), the stratigraphic range of the larger Cypriot elephant is presently not well known, especially with respect to the range of *P. cypriotes*. Some *P. cypriotes* - bearing sites have been dated to the latest Pleistocene – early Holocene, but methodological issues limit the reliability of these dates (Herridge, 2010). It is probable that the larger Cypriot form is more ancient than *P. cypriotes*, but this has to be corroborated by new datings.

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Feeding habits of South American gomphotheres (Proboscidea, Gomphotheriidae): a comparative study of proboscidean's paleodiet diversity in the Quaternary

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The study of paleodiet can elucidate dietary patterns of ancient organisms as well as their occupied niche, ecological plasticity, and the paleoclimatic/paleoenvironmental aspects of their former habitat. Currently there are few published studies that focus on reconstructing the paleodiet of South American gomphotheres. Therefore, this contribution aims to: (i) recognize the feeding habits of *Cuvieronius hyodon* (Fischer, 1814) and *Notiomastodon platensis* (Ameghino, 1888) from low magnification of tooth enamel microwear features, and (ii) compare the dietary diversity between Quaternary proboscideans of South America with those from North America and Europe.

We have selected 21 teeth of *C. hyodon* and *N. platensis*. All specimens were upper and lower second permanent molars with wear stages 2-4 (Simpson and Paula-Couto, 1957). N. platensis specimens are from Brazil (Itaboraí/Rio de Janeiro [IR] and Toca do Garrincho/Piauí [TP]) and Argentina (Buenos Aires and Santiago del Estero). While, *C. hyodon* is from Bolivia (Tarija). This material is housed at the main paleontological collections in the Americas.

The microwear analysis was performed following Solounias and Semprebon (2002) and Green et al. (2005). The analyzed teeth were free of taphonomic damage to the enamel of the metaloph/metalophid occlusal surfaces of both postrite

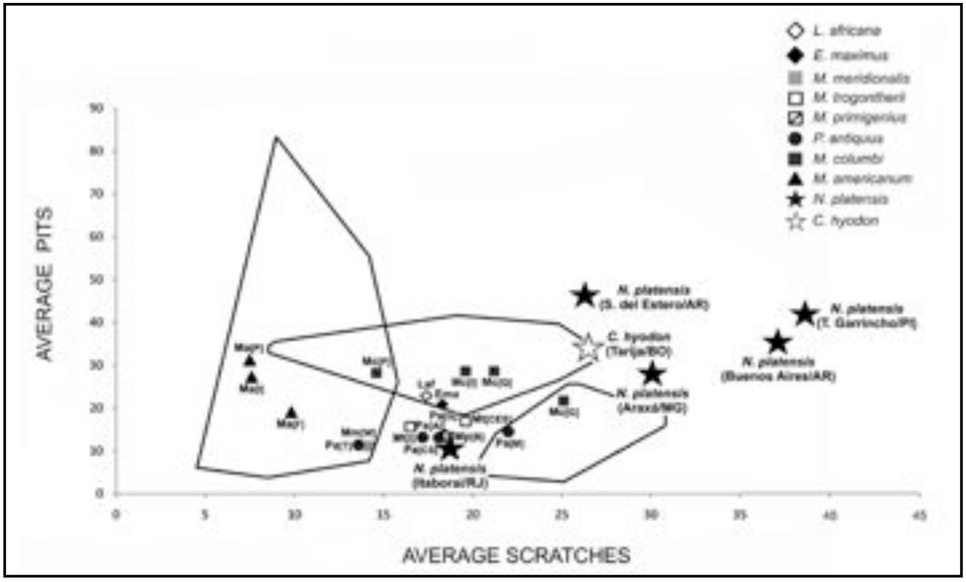

Fig. 1. Scatter plot of average scratches and pits of the South American gomphotheres compared with modern and extinct proboscideans from North America and Europe (Green et al., 2005; Rivals et al., 2012).

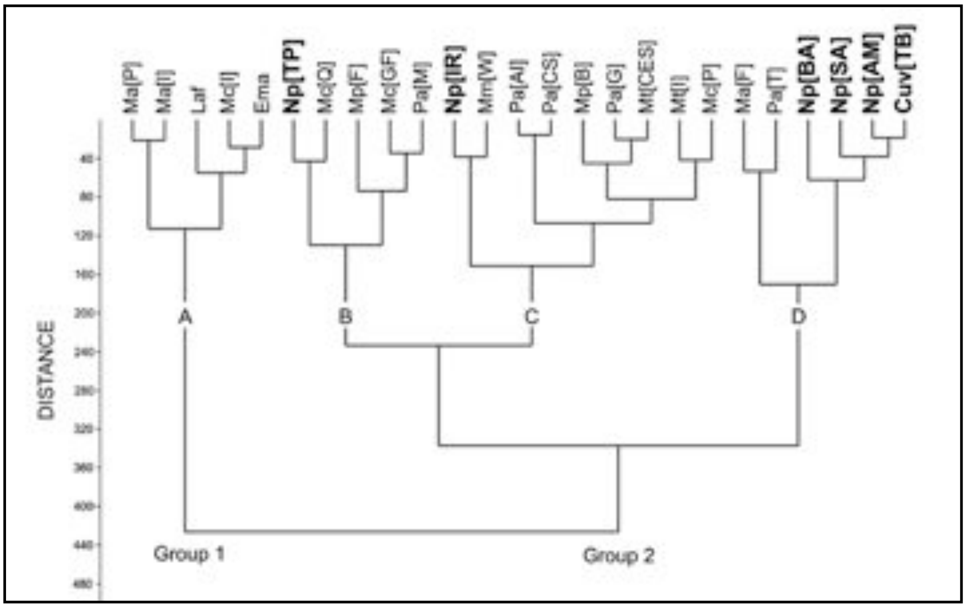

Fig. 2. Hierarchical cluster analysis using all microwear variables of the South American gomphotheres compared with modern and extinct proboscideans from North America and Europe (Green et al., 2005; Rivals et al., 2012).

Abbreviations: Gomphotheres: **Npl** = *Notiomastodon platensis* ([TP] = Toca do Garrincho/PI, [IR] = Itaboraí/RJ, [AM] = Araxá/MG, [BA] = Buenos Aires/AR, [SA] = Santiago del Estero/AR), **Cuv** = *Cuvieronius hyodon* ([TB] = Tarija/BO). Modern: **Laf** = *Loxodonta africana*, **Ema** = *Elephas maximus*. Extinct: **Mm** = *Mammuthus meridionalis*, **Mt** = *Mammuthus trogontherii*, **Mp** = *Mammuthus primigenius*, **Pa** = *Palaeoloxodon antiquus*, **Mc** = *Mammuthus columbi*, **Ma** = *Mammut americanum*.

Additional letters in the acronyms refer to the localities abbreviations (see Green et al., 2005; Rivals et al., 2012, pp. 3).

and pretrite cusps. For each tooth, these areas were cleaned before casting. The casts were examined under an area of 0.16 mm^2 using a stereomicroscope with 35x magnification. The following microwear scars were observed: scratches (fine, coarse and hypercoarse), pits (small and large), cross scratches, gouges and punctures. The observed patterns were compared to the microwear patterns previously described in the literature for extant ungulates (Solounias and Semprebon, 2002), and modern and Pleistocene proboscideans (Green et al., 2005; Rivals et al., 2012; Asevedo et al., 2012) through scatter plots, hierarchical clusters, ANOVA and Tukey HSD statistical tests.

South American gomphotheres from all the analyzed localities demonstrated generalist feeding habits which may characterize opportunistic behavior (Fig. 1). The specimens of *Notiomastodon platensis* from IR were possibly generalists consuming mainly woody plants. On the other hand, the specimens from the other three localities were especially consuming grasses, possibly complemented with other food items on a daily basis. And *Cuvieronius hyodon* were a generalist whose diet varied seasonally or regionally, similar to some extant and Pleistocene proboscideans.

Significant differences were observed between the generalist paleodiets (ANOVA, p = 0.000629). *N. platensis* from Argentina and from TP differs from the IR and the European elephantid *Palaeoloxodon antiquus* (Aguirre, 1969) specimens. The TP *N. platensis* also differs their diet from other European elephantids such as *Mammuthus trogontherii* (Pohlig, 1885) and *Mammuthus primigenius* (Blumenbach, 1799). These differences were evidenced by the high average of scratches and pits present on the teeth enamel of these gomphotheres as a result of great consumption of grasses.

The cluster analysis allowed the recognition of a group having high frequency of pits and scratches plus other mixed textures (Fig. 2, cluster D). On this group, *C. hyodon* and *N. platensis* have similar mixed diets. According to Mothé et al. (2013) both were probably sympatric only in Peru, suggesting a competitive exclusion between them. However, further studies are necessary to corroborate this hypothesis.

The mixed feeder *N. platensis* from TP clustered together with grazers and mixed feeders predominantly grazers. This is supported by the high frequency of pits and scratches with textures ranging from fine to mixed (Fig. 2, cluster B). There is a high similarity of diet between TP *N. platensis* and the North American grazer *Mammuthus columbi* (Falconer, 1857). This supports the idea that elephantid and gomphothere lineages could have competed for food resources. This corroborates the proposal of Lucas et al. (2011) that a possible competition occurred between *M. columbi* and gomphotheres during the Early Pleistocene of North America.

N. platensis from IR grouped with browsers and mixed feeders predominantly browsers. Their microwear scars showed a median frequency of pits and scratches (Fig. 2, cluster C). This is similar to the browsing diet of *Mammuthus meridionalis* (Nesti, 1825) from the Early Pleistocene of Europe. Both specimens apparently had a broad consumption of foliage from woody plants, as evidenced by scratches with mixed textures on dental enamel.

Competition between other sympatric Pleistocene proboscideans for food resources was also identified in our analysis, and corroborates previous studies. The present study shows that the Late Pleistocene South American gomphotheres of the selected localities were generalists that varied their diets according to the available food resources. Also, a possible sympatric competition occurred between species. This behavior was also observed in most species of different proboscidean lineages, except for *Mammut americanum* (Kerr, 1792) that fed only on leafs. Our analysis corroborates previous studies of competitive interactions in the Pleistocene between the North American gomphotheres, elephantids and mammutids, the European elephantids and the South American gomphotheres.

The continuity of this study will allow further inferences for understanding the ecological interactions between the gomphotheres *C. hyodon* and *N. platensis*, and will also provide more detailed data to allow the reconstruction of paleoenvironmental aspects of the Pleistocene of South America.

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About the lower tusks of *Cuvieronius hyodon* (Gomphotheriidae, Proboscidea, Mammalia) from South America

Leonardo dos Santos AVILLA ✉, Marco FERRETTI, Dimila MOTHÉ, and Beatriz GUIMARÃES BONFIM

Proposed phylogenies of American gomphotheres are mainly based on adult characters (Shoshani, 1996; Prado & Alberdi, 2008; Ferretti, 2010; Mothé et al., 2013). However, juvenile features are known to be potentially useful in providing information on character polarity, by preserving plesiomorphic states, unknown in adult stages. Among New World proboscideans, the origin and evolution of South American Gomphotheriidae (SAG) are highly debated issues. Increase knowledge on morphology of SAG deciduous dentition may help to elucidate those issues. SAG are trilophodont, whose dentition consists of three deciduous premolars, three molars and a pair of upper tusks. Adult mandibles lack lower tusks. However, the presence of lower tushes (LT) was reported in juvenile mandibles of *Cuvieronius hyodon* from Tarija, Bolivia (Liendo, 1946; Ferretti, 2008). No detailed study of the LT and premolars of SAG have been made to date. We present the results of an analysis of the ontogenetic and evolutionary patterns of the deciduous dentition of *C. hyodon*, with special focus on LT. Despite *C. hyodon* occurs also in North America, we analyzed exclusively specimens from Tarija, Bolivia, because this is the only locality that provided statistically important and most complete juvenile jaws. We analyzed 34 mandibles, housed in various paleontological collections in the Americas and Europe. The age group of each individual was based on the deciduous tooth in use (dp2 to dp4) and its wear stage (Green & Hulbert, 2005). Each tooth wear class was then related to the age groups proposed for extant elephants (Laws, 1966). In order to recognize mandible development patterns, we compared relative change during growth of the mandibular depth measures in *C. hyodon* with that of the longirostrine gomphothere *Gomphotherium angustidens* and of the brevirostrine mammutid Mammut americanum (data from Tassy, 1996 and Green & Hulbert, 2005). The age classes recognized in our sample were from Juvenile 1 to 5 (J1-J5) of Green & Hulbert (2005), which includes individuals from 0.5 to 3.5 years.

Nine individuals securely bear lower tusk alveoli (LTA; Fig. 1) and only two had a portion of the LT preserved in situ. Differently from the upper permanent tusk, LT of *C. hyodon* are not twisted (Liendo, 1946). With exception of one fetal mandible, all studied *C. hyodon* mandibles from J1 on (0.5 year old) presented LTA. One-year-old individuals show

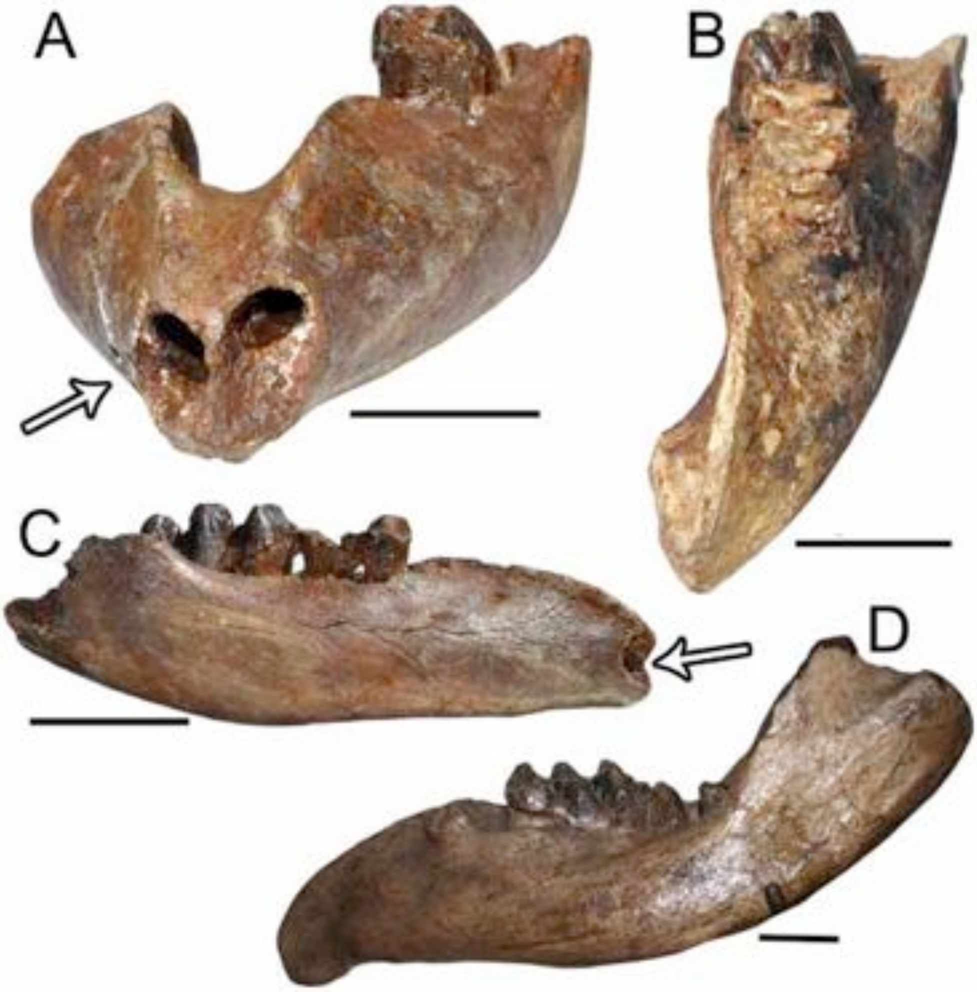

Fig. 1. *Cuvieronius hyodon* juvenile specimens from Tarija, Bolivia. **A**, Specimen MNPA-V 005888 with lower tusk alveoli; **B**, Specimen MNPA-V 92 without lower tusk alveoli; **C**, Same specimen of “A” in lateral view, with straight profile; **D**, Specimen TAR 806, with downturned profile. The arrows indicate the lower tusk alveoli. Scale bar = 5 cm.

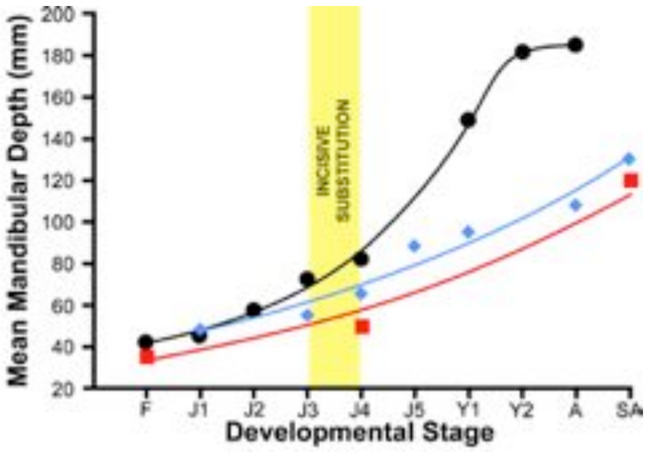

Fig. 2. Mean mandibular depth at posterior mental foramen for age classes of *Cuvieronius hyodon, Mammut americanum* (mean mandibular depth values from Green & Hulbert, 2005) and *Gomphotherium angustidens* (mean mandibular depth values from Tassy, 1996). *Cuvieronius hyodon* curve (blue line) and *G. angustidens* curve (red line) indicate a proportional growth from Juvenile to Adult classes, in contrast with *M. americanum* curve (black line), which presents an high increase between the Juvenile 4 and Adult classes. Graphic modified from Green & Hulbert (2005).

well-developed LTA (figure 1A), while all J3 and most of J4 but one, the oldest, lack LTA. Individuals from J5 on, with preserved symphysis, also lack LTA (Fig. 1B). Concluding, in *C. hyodon* the LT is reabsorbed, and LTA closes, at approximately one year of age (J4). A similar pattern was documented for *M. americanum* (Green & Hulbert, 2005).

A change in the lateral profile of the symphysis of *C. hyodon* is recognized during growth; It is straight in J1-4 (Fig. 1C), and the downturned profile, typical of most adults, appears from J5 on (Fig. 1D). An exception is specimen MNPA-V 005869, which groups with J4, but has a downturned symphysis profile, probably because of a delayed dental substitution.

Lack of LT is a derived feature among Gomphotheriidae (Shoshani, 1996) and it is commonly associated with brevirostry. In order to document the structural rearrangements related to the evolution of brevirostry among SAG, we compared the growth pattern of the mandible of *C. hyodon*, the only brevirostrine Gomphotheriidae possessing LT and lacking lower permanent tusks (LPT), with that of the longirostrine *G. angustidens* and the brevirostrine *M. americanum*. The three taxa show similar growth pattern at early developmental stages, from Fetus to J4 (Fig. 2). Since this latter stage on, the rate of growth of the mandibular depth in *M. americanum* markedly increases, producing a very deep mandible at adult stages. Conversely, the growth rate remains substantially constant in the two gomphothere taxa, untill adult size is reached. Interestingly, the time of more rapid mandibular growth observed in the American mastodon coincides with the LT substitution (Fig. 2), occurring around J4. This is possibly a result of a selective pressure caused by the presence of LPT associated with the brevirostrine (derived) condition in *M. americanum*, in which the roots of both LPT and permanent molariforms possibly compete for space in the mandible. On the contrary, in the longirostrine *G. angustidens*, the lower teeth roots do not compete for space (plesiomorphy). Although *M. americanum* and *C. hyodon* share brevirostry, they responded in a different way to this issue. *C. hyodon* responded in a distinct way to the same selective pressure, by repressing the development of LPT and the maintenance of a relatively shallow mandible. Thus, *C. hyodon* represents an important (intermediate) stage in Gomphotheriidae evolution in the Americas, and may provide clues about how the fully brevirostrine condition in *Notiomastodon* and *Stegomastodon* evolved from such longirostrine taxa as *Gomphotherium* and *Rhynchotherium*.

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The "Tell Tale" Tusk: acid rain at the onset of the Younger Dryas?

Joanne BALLARD ✉, Dick MOL, Andre BIJKERK, and Jelle REUMER

A female mammoth tusk from Yakutia, Siberia, exhibits a remarkable dissolution pattern on the part of the tusk that was exposed to the atmosphere. The section of the tusk that was hidden up in the alveolus is pristine. The pitting of the emerged portion of the tusk took place while the animal was alive, as evidenced by subsequent polishing of the damaged ivory. The hypothesis we will test is that this dissolution was the result of a nitric acid rain event.

An acid of pH 2.0, the equivalent of lemon juice, can indeed dissolve tusks, antlers and even exposed bones. One possible source of nitric acid rain is an extraterrestrial event. Thermal shock waves resulting from a bolide impacting earth atmosphere would cause dissociation of O2 and N2; chemical reactions between NOx and water then lead to production of nitric acid precipitation lasting a year or longer (Prinn and Fegley 1987). Nitric acid rain is documented for the Tunguska extraterrestrial event of 1908 evidenced by nitrogen isotope research on a peat core near the impact site (Kolesnikov et al. 1998, 2003).

Our research has two objectives: to replicate the dissolution pattern on the ivory, and to radiocarbon date this unusual tusk specimen. We predict that the age of the tusk is the Bolling-Allerod/Younger Dryas Boundary ca. 10,900 14C years BP, or ca. 12,800 cal yrs BP. If we are correct, then this mammoth most likely witnessed the extraterrestrial event at the beginning of the Younger Dryas as hypothesized by Firestone et al. (2007), and she survived the impact.

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Fig. 1. **A**, Pitting of the ivory where tusk emerges from the alveolus. Lateral interior view. **B**, Dorsal view of the dissolution of the tusk, and polishing of dissolved surface. Pitting occurs where the tusk emerges from the alveolus. **C**, Ventral view of the dissolution of the tusk, and polishing of dissolved surface. Pitting occurs where the tusk emerges from the alveolus. **D**, The Tell-Tale Tusk, in the center, has a reduced diameter for the portion of the tusk exposed to the atmosphere and the hypothesized nitric acid rain.

Postcranial skeleton of *Deinotherium* from Lower Don Area (Rostov Region, Russia)

Vera BAYGUSHEVA ✉, Vadim TITOV, and Galina TIMONINA

In 1982 the employees of the Azov local museum excavated an almost complete skeleton of a large deinothere in the Obukhov sand pit near Novocherkassk town (Bajgusheva, 1998; Bajgusheva, Tishkov, 1998). The find comes from the fluvial or deltaic Upper Miocene deposits of the Yanov Formation. This thick sequence of continental deposits occurs between the upper Sarmatian and the lower Pontian marine layers. In these strata of the adjacent Yanov sand pit the remains of *Mammut* cf. *praetypicum*, *M.* cf. *borsoni*, Rhinocerotidae gen. and «*Palaeoryx*» *longicephalus* were found (Bajgusheva et al., 2001). These deposits are correlated with the Late Meotian and the fauna corresponds with the Late Turolian, zone MN 12/13 (Titov, Tesakov, 2013). Originally the deinothere from Obukhovka was determined as *Deinotherium giganteum* Kaup, 1829. But there was noted its rather large size intermediate between *D. giganteum* and *D. gigantissimum* (Bajgusheva, Titov, 2006). Based on the latest revisions they proposed to refer all huge Turolian deinotheres (zones MN11- 13 and partly MN 14) to *D. gigantissimum* Stefanescu, 1892 (Markov, 2008) or to major synonym *D. proavum* (Eichwald), 1831 (Pickford, Pourabrishami, 2013).

The most of bones of *D. proavum* skeleton from the Obukhov sand pit are preserved. In collection of the Azov museum-reserve there are 172 bones and fragments (collections No. AMZ - KP 26579, 29352, 27402). The skull, lower jaws and left scapula were destroyed before excavations during working in the sand pit. The right scapula, cervical and thoracic vertebrae, ribs were considerably damaged. The most part of the II and III phalanges are absent. This skeleton is one of the most complete. After the mounting the following skeletal dimensions were restored: the shoulder height is 370 cm, the length from tusks to the end of the sacrum is 4.2 m. The restored weight of the animal is about 8 tons.

Morpho-functional features and lifestyle of the deinotheres are still controversial. Therefore, the study and analysis of postcranial skeletons of these animals are important. The comparison of the lengths of the long limb bones of the deinotheres indicates a general similarity to other large proboscids, particularly to representatives of Elephantidae. However Deinotheriidae differ markedly by massiveness of the limb bones, especially the bones of the forearm and crus (Fig. 1). The metapodials and phalanges of the deinotheres are comparatively longer than the one of the elephants (Svistun, 1974; Kovachev, Nikolov, 2006).

As noted by V.I. Svistun (1974), a foothold in thoracic limbs rests on the lateral parts, mainly. And the forelimbs were adapted to move not only in the sagittal plane, but could perform more diverse movements in comparison with the elephants. In addition, the manus and pes of these animals were more elongated with well developed muscles; it allowed the animals to expand significantly its carrying surface. This gave them an advantage when driving the movement over a swampy ground.

During assembling of the skeleton in 2009 (under the guidance of E.N. Maschenko, PIN RAS, Moscow), we also drew attention to the fact that a vertebral column of the deinotheres is more direct in comparison with the elephants and a position of pelvis is more vertical. The femoral bone has limited mobility in forward direction, but a greater mobility degree in caudal direction. The forelimb has a considerable mobility in shoulder joint, as compared to the elephants. Probably, it was able to make rake movements inwards and backwards. Apparently, all of these features suggest that the deinotheres were good swimmers. The differences in the morphological characteristics of the deinotheres and the representatives of the Elephantinae indicate a greater adaptability of the elephants for mobility over the land.

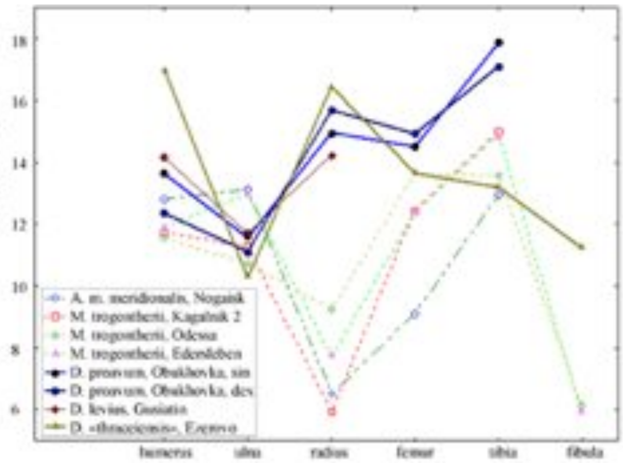

Fig. 1. The comparison of limb bones massiveness of some representatives of *Archidiskodon, Mammuthus* and *Deinotherium*.

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Quaternary sites in Central Yakutia, containing remains of mammoth fauna

Innokenty BELOLUBSKY ✉, Pavel NIKOLSKIY, Alexander BASILYAN,
Anatoly SERGEENKO, and Gennady BOESKOROV

Mamontova Gora outcrop, stretching for about 12 km, is located at the left bank of Aldan river (325 km upstream from its mouth, figure). Blanket loams and sandy loams with lenses of humic material and scattered plants remains occur at the 80-, 50- and 30- meter terraces. Layers are saturated with vein ice. Strata thickness is of 10-12 m. Remains of mammal fauna are represented by *Mammuthus primigenius* (Blum.), *Rangifer tarandus* (L.), *Coelodonta antiquitatis* (Blum.), *Equus lenensis* Rusanov and other representatives of the Upper Paleolithic faunal complex. Fresh water mollusks *Gyraulux gredleri* (Gred.), and *Valvata aliens* (West.) are also found. An absolute age of 35300 + 1500 years (MGU-IOAN-123) is estimated for timber from the lower half of the strata.

Steppe species (*Spermophilus undulates* Pall., *Microtus gregalis* Pall.) and tundra species (*Lemmus sibiricus* Kerr, *Dicrostonyx torquatus* Pall, *Microtus hyperboreus* Vinogradov), do not co-exist here at present time, whereas intrazonal meadow species (*Microtus oeconomus* Pall.), that live today in the area, are also found among rodents in Late Neopleistocene (=late Latest Pleistocene) of Mamontova Gora.

It is noteworthy that, fruits of *Trapa natans* L., 1758 were found in beaver dam remains. This suggests significantly more favorable climatic conditions than at present time (Boeskorov & Agadjanyan, 2004). Beaver bones were also found in Neopleistocene deposits of Mamontova Gora (Vangengeim, 1977) .

Part of a bighorn sheep skull found in Tandinskoe outcrop (figure), located in a small distance from Mamontova Gora suggests that this species was possibly present in the studied area.

Peschanaya Gora outcrop is located 60 km upstream from Aldan river mouth (62053’41”NL, 129048’07”EL; Fig. 1), and extends for 7 km along the right bank up Lena river. The outcrop is confined to the scarp of Lena river Bestyakh terrace, 20-30 m high.

Peschanaya Gora outcrop was previously described in detail by Alexeev et al. (1990). According to their data, the following formations occur within the frame of the outcrop: the Middle Neopleistocene Bestyakhskaya formation (sands with pebble, of a thickness of 1-7 m), the Mavrinskaya formation (14-16 m thick sands), and the Late Neopleistocene Diolkuminskaya formation, represented by sands with plant remains and buried soils, and with a thickness of 5-20 m. According to radiocarbon data, the age of Diolkuminskaya formation is 17200+500 yr BP (IM-759) 2 meters above the brink, and -14000+500 yr BP (IM-760) at 8 meters above the brink is. An age of 11850+150 yr BP (GIN-2461) is also estimated from soil samples at the top of the section consisted of fine-grained sand layers with horizontal lamination. Alternation of eolian, lacustrine and soil layers, belonging to Holocene, occurs in the uppermost part of the section. The total thickness of the Holocene deposits is about 3 m. According to several researchers (Alexeev et al., 1990, Péwé & Hournaux, 1983, Grinenko et al., 1993), the sands of Diolkuminskaya formation are of eolian origin. Proof of this is the observed unidirectional cross-lamination in sections, with dip 25-300, close to angles of natural slope. Deposits of Diolkuminskaya formation close to Peschanaya Gora,– namely the Sullar Myran site (at about 60 km from Peschanaya Gora upstream the Lena river; figure) includes rather numerous mammal remains of mammoth fauna. Bone remains of *Mammuthus primigenius, Coelodonta antiquitatis, Equus lenensis, Bison priscus*, and *Saiga tatarica borealis* were found here. The presence of saiga, indicator of steppe habitats, further suggests cryoarid conditions during the formation of Diolkuminskaya strata. A single radiocarbon dating on rhino bone from Sullar Myran, give an age of 20530+440 yr BP (GIN-14410), indicating a Sartanian period of inhabitation for this extinct species. The combinations of species found in Sullar Myran, is generally typical for Late Neopleistocene of the Siberian

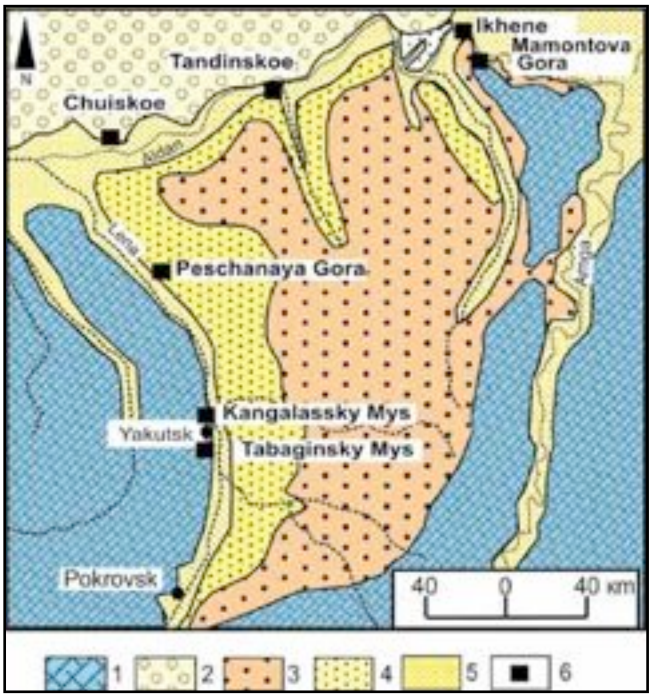

Fig. 1. Geomorphologic diagram of the Central Yakutia (by P.A.Soloviev, 1959).
1, denyfation plateau; **2**, accumulation glacial-fluvioglacial plain; **3**, Abalakhskaya accumulation plain; **4-5**, terraces: 4, tuyngulunskaya and bestyakhskaya;5, II (sergelyakhskaya) and I (yakutskaya) terraces above flood-plain, high and low flood-plain terraces; **6**, exposured

platform, including its Sartanian cryochron, characterized by tundra-steppe, cryo- and xerophyte type of vegetation.

Based on palynological data analysis, it can be concluded that, open landscapes prevailed during the sand accumulation in the lower part of the section. Vegetation cover is treeless, very sparse, and fragmentary, indicating severe climatic conditions, extremely unfavorable for the existence even of shrubby and herbaceous associations.

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A study of a frozen mummy of a horse from the Holocene of Yakutia, Russia

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In July 2010 the Yukagir tribe members found remains of the partial frozen carcass of a Pleistocene horse (the so-called "Yukagir" horse; Boeskorov et al., 2013) on the northern slope of the Oyagosskii Yar, at the coast of the Dmitry Laptev Strait in northern Yakutia (72°42´16´´N, 142°50´15´´E). The horse was found 50 meters far from the Yuka mammoth, which had AMS radiocarbon date 34,300 yr BP. However, despite the vicinity of the sites, the horse age appeared to be much younger, about 4,630±35 yr BP (GrA-540209; Boeskorov et al., 2013). This date falls at the end of the second half of the Atlantic period, the warmest period during the Holocene that lasted from about 6,0 to 4,5 kyr BP, just before a significant cooling recorded in many sites of northern Eurasia (Velichko et al., 1997).

The carcass was preserved in two large pieces: the head with the neck, and a part of the torso with inner organs, hind limbs and tail (Fig. 1). The missing part of the snout, ripped off (and missing) fore limbs with frontal part of the torso and numerous torn holes, gaps and stripes on the hide indicate that the horse was hunted and/or scavenged by a large predator, like bear or wolf.

The frozen mummy had intact skin on the hind limbs, on the large part on the head, on the back of the neck and on the sides of the torso. The predominant color of the skin was dark brown; the skin was mummified and very hard. It was 1-5.1 mm thick, as in the domestic horse. Short (45 - 70 mm), dark-brown and, in some places, black hair was preserved only on the distal pats of the limbs, below the tarsal-phalanx joint. Mammoth, bison, and horse carcasses frozen in permafrost usually have most of the body hair detached from the skin, but often retain the hair in distal parts of the limbs.

The horse is an adult female: the canines are absent and the state of the incisors' wear corresponds to that of a 5-years old domestic horse.

We managed to estimate some of parameters of the horse's skull by measuring the un-skinned and un-fleshed horse head. Most of the Yukagir horse skull measurements fall within the variation range of *Equus lenensis* Rusanov, 1968, which was studied by Lazarev (1980) and Kuzmina (1997). However, the Yukagir horse was relatively large-headed and possessed a relatively large dentition.

The Yukagir horse ear was shorter (length 14 cm) that that in *E. przewalskii* (14-18 cm). The tail was preserved intact, but had missing hair. It was relatively short (36.3 cm) in comparison to Przewalski's horse (38-60 cm).

The left hoof was 19 cm long and 15 cm wide, i.e., larger (wider) than hoofs of the Late Pleistocene horse (*E. lenensis*) and of the domestic Yakutian breed (Vereschagin, Lazarev, 1977). Wide hoofs would reduce weight load and allow the animal moving comfortably in lowland wetlands and boggy tundra, as well as enhance their ability digging out the grass from under snow during snowy winters.

The estimated height in hips is 132 cm. It is slightly shorter than that of the Selerikan horse mummy, *E. lenensis* (136 cm) from the Upper Indigirka River basin (about 38,000 yr BP) and comparable to the height of the modern Yakutian breed (Lazarev, 1980). The size of the distal parts of the hind legs was relatively large.

There are several records of the extinct Pleistocene horse remains (possibly *E. lenensis*) from the Holocene (ca. 4.6 – 2 kyr BP) of the Central and Eastern Siberia indicating that this species inhabited the wide area from Western Taymyr Peninsula to Indigirka River in the east and from Bolshoi Lyakhovsky Island in the north to Verkhoyansky Range in the south (Lazarev, 1980; Lazarev et al., 2011; Kuznetsova et al., 2001; Sulerzhitsky, Romanenko, 1997). The Pleistocene horse remains have never been dominant in the Holocene assemblages, and this likely indicates that the species survived through the Late Holocene in small populations

Fig. 1. Remains of the Yukagir horse partial frozen carcass.

in scattered and isolated steppe refugia.

The Yukagir horse lived in a period characterized by moister climate due to the ongoing marine transgression. The annual precipitation level was 200 mm more than present precipitation in Yakutia, which caused an expansion of moisture-demanding conifers (*Pinus sibirica, Abies sibirica, Picea obovata*) to the north, where currently only drought-resistant conifers (*Larix* spp.) exist (Monserud et al., 1998, Pisaric et al., 2001). The local vegetation consisted of open larch woodland with shrub alder alternating with dwarf birch and dwarf willow growths (Kaplina, Lozhkin, 1982; Velichko et al., 1997; Andreev et al., 2011). A significant cooling at the end of this period (4.0-3.0 kyr BP), implied the southern shift of vegetation zones and a retreat of the forest vegetation (*Picea, Larix, Pinus*) to the south (McDonald et al., 2000).

In contrast to the composition of the vegetation, the palynological spectrum of the samples from the Yukagir horse colon shows predominance of grass (97.4%), with low percentage of trees (1.9%) pollen, and spores (0.6%). The grass is represented by true grasses (91.6%), sedges (4.5%) and others. The analyses of macro-remains, which included fragments of leaves and stems of monocots, with rare remains of mosses (genus *Bryales*) and grass seeds (family Poaceae), confirmed that the Yukagir horse strongly preferred grasses for its diet.

The Yukagir horse diet included more "grasses" than the diet of the early Holocene Yukagir and "Chukotka" Bison (Boeskorov et al., this volume; Kirillova et al., 2013), which lived in unfavorably changing landscapes and vegetation shifting towards forest and swampy tundra. However, morphological adaptations (small body size, and large hoofs), and possibly smaller than *Bison priscus* size herds, were important factors for the survival of the Pleistocene horse during the late Holocene.

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The Yukagir Bison: initial analysis of a complete frozen mummy of *Bison priscus* from the Early Holocene of Northern Eurasia

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A frozen mummy of bison (the so-called "Yukagir Bison") was discovered in 2011, thawing out from the northern slope of Chukchalakh Lake (Fig. 1) in the Yana-Indigirka Lowland of northern Yakutia, Eastern Siberia, Russia. The find represents the second complete (or almost complete) mummy of an adult steppe bison with preserved inner organs, recovered from the permafrost of Siberia. The AMS radiocarbon dates fall within 9,295 +/-45 yr BP (hair, GrA-53292) – 9,310 +/- 45 yr BP (horn core, GrA-53290) (Boeskorov et al., 2013).

Mitochondrial DNA analysis confirmed that the specimen belongs to the steppe bison, *Bison priscus*. The wear stage of the Yukagir Bison dentition correspond to 4-4.5 year-old animal, based on the comparisons with the modern prairie bison, B. bison (Boeskorov et al., 2013). The height in withers of the animal was about 170 cm with an estimated weight of 500-600 kg.

The body size of the Yukagir Bison was compared with that of the modern European and American bison. The results showed that its body was shorter than that of same-aged American bison, and closer to the average European bison size. The withers height of the studied specimen is closer to the grown bulls than to a 4-years old animal of the modern species. In addition, the Yukagir Bison appeared to be larger in hip height and chest girth than a 4 year-old European and American bison, but its hind foot length falls within the lower limits of both modern species. The hoofs appeared to be relatively large, with bearing surface of about 665 cm^2, which might indicate adaptation to support weight on softer (marshy) substrate. With its estimated weight of 500-600 kg, the hoof weight load would be 752-902 g/cm^2, which is considerably lower than in European bison (1,000-1,300 g/cm^2; Flerov, 1932). The Yukagir Bison tail is relatively short, which is also typical for the Canadian Wood bison, *B. bison athabascae*.

The young Yukagir Bison width in horn core tips is close to the maximum size of the fully grown modern bison, and falls within the range of *B. priscus occidentalis* (67–80 мм) recorded from the late Pleistocene of Eastern Siberia (Flerov, 1977). Having reached already a relatively large size for the 4 year-old animal, the Yukagir Bison would have reached withers height of about 200 cm and a weight of 1,000 kg in adulthood.

The mummy's digestive tract content along with palynological spectra of the sediments at the Yukagir bison site, were analyzed as well. The spore-pollen spectrum of the sediments reflects dominance of the sparse deciduous woodlands (birch, alder, willow, spruce) over steppe-grass vegetation. In contrast, the bison rumen

Fig. 1. The Yukagir bison *in situ*. Chukchalakh Lake bank slope, northern Yakutia, Russia.

and stomach samples mostly contained the pollen of herbs and grasses. The rumen contained 86.2% of grass and herb palynomorphs, while trees accounted only to 8.9%, with relatively high percentage (4.9%) of spores. The herbaceous vegetation was dominated by grasses (72%), accompanied by 6.5% of sedges. Low percentages of dwarf birch, Apiacea, and legumes (Fabaceae) were also present. Few other taxa comprising a fraction of percent were also identified. Non-pollen palynomorphs (except single spores of peat-moss) were absent in the analyzed rich organic material. Scarce fern spores were most likely consumed by the animal with water.

The 50 ml sample of the macro-remains collected from the stomach consisted of shredded vegetative plant parts: stems and leaves of grasses and herbs, free from bark crushed and split bush branches, along with rare remains of mosses (Bryales) grass seeds. Recovered single finds of bison hair, bird feather fragment, planktonic crustacean Daphina (Cladocera) and quartz grains were probably accidently swallowed by the animal while grazing and drinking.

The grass seeds from the stomach were well preserved and included Poaceae, Cyperaceae (*Carex* sp.), *Eriophorum* sp., Rosaceae (*Comarum palustre*); Menyanthaceae (*Menyanthes trifoliata*), and Apiaceae. All the plants identified from the seeds sampled from the bison stomach belong to typical grass-herbaceous species and genera found in the modern tundra zone of Yakutia.

Similar data on the gastric content were obtained from the analysis of the plant remains, biomorphs and pollen from the partial mummy of the steppe bison (*B. priscus*) discovered in the Holocene deposits of Rauchua River in vicinity of Bilibino, western Chukotka (Kirillova et al., 2013). Slightly younger in geological age (about 8,3 kyr BP) than the Yukagir Bison, the "Chukotka" bison also preferred feeding mostly on grasses, particularly Graminoids (Poacea), with significant ratios of sedges and forbs.

The beginning of the Holocene or Preboreal chronozone in Eastern Siberia was manifested by the climate warming about 10,300 years ago (Khotinsky, 1977). As a result, the favorable conditions that existed about 9,5 – 8,0 kyr BP, led to the expansion of tree and bush vegetation that reached their northernmost boundary ever recorded in Siberia since the last (Eemian) interglacial, with birch species reaching the New Siberian Islands (Kaplina et al., 1979; Sher, 1997; Wetterich et al., 2009).

Similarly to the Yukagir Bison site, the shrub- and forest-tundra landscapes with the lowest representation of steppe-grass vegetation were reconstructed for the Taymyr Peninsula around 10,000 yr BP (Klimanov et al., 2002), the Laptev Sea shelf about 9,300 yr BP (core samples PZ-2 and PZ-3; Naidina, 2006), the Oyagosskii Yar on the Laptev Sea arctic coast, which was particularly dominated by Alnaster fruticosa, Betula nana, and Salix about 11,500 – 8,400 yr BP (Wetterich et al., 2009; Andreev et al., 2011), and the northern Eastern Siberia (El'gygytgyn Lake) about 10,500 – 8,000 yr BP (Tarasov et al., 2013).

The comparison of pollen data from the bison digestive tract with those of sediment data directly confirmed that the steppe bison was a selective grazer species. Between 11,500 – 8,000 yr BP the species persisted in habitats that were dominated by vegetation largely unfavorable to the bison. Our data may indicate that the dramatic decrease of the suitable habitats and pastures in the high Arctic of Eastern Siberia during the early Holocene climatic optimum was a major factor of irreversible population fragmentation and decline leading to the species' extinction.

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Coexistence between mammoth and Palaeolithic people approved – To the 150th anniversary

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In the first half of the 15th century the first mammoth bones were reported in Europe. The majority of these bones of mammoths were regarded as the remains of giants. Finally the skeleton which was discovered in Tonna near Gotha (Thuringia, Germany) in 1696 was analyzed by a historian and was described as an extinguished elephant. However, the scholars at that time were not able to explain the existence of elephants in Europe, because they were only known in warmer regions as south Asia and Africa. One idea was that they were brought to Central Europe by the Romans. Another explanation was that they were flushed to Europe by the deluge which at that time was equivalent to the diluvium – the former term for the Pleistocene (Lister and Bahn, 2005).

In 1796, however, the French anatomist Georges Cuvier postulated that these elephants are clearly different from recent ones and that they are remains of fossil elephants. This is the reason why J.F. Blumenbach attributed them in his book "Handbuch der Naturgeschichte" in 1799 to the *Elephas primigenius*. (Joger and Pohl, 2005; Lister and Bahn, 2005; Reich et al. 2007). In 1799 the first carcass of a mammoth was discovered in the area of the mouth of the Lena River in Siberia. In 1806 these remains were recovered by Michail Adams and were exhibited in St. Petersburg in 1808. This mammoth is nowadays known as Adams' Mammoth (Joger and Pohl, 2005; Lister and Bahn, 2005; Tassy, 2004). Regarding the place of discovery G. Cuvier concluded that it was an extinct species which had lived in this region and had not died in the deluge (Lister and Bahn, 2005). Finally in 1828 the English anatomist and naturalist Joshua Brookes attributed the remains of these fossil elephants to a species of its own and named it *Mammuthus* (Joger and Pohl, 2005).

Another important question asked by savants during the first half of the 19th century was if human beings had already existed during the diluvium and - if yes - whether they had coexisted with the extinguished animals. In 1847 the former customs officer Jacques Boucher de Perthes found bones of different extinguished animals associated with stone artefacts in the gravels of the Somme River near Abbeville in northern France (Lister and Bahn, 2005; Züchner, 2005).

As numerous remains of fossil animals were found in caves, scientists started to explore the caves to look for relicts from our ancestors (Züchner, 2005). In 1860 the French lawyer and palaeontologist Edouard Lartet and the English banker and explorer Henry Christy began with excavations in the rock shelter of Aurignac (Dép. Haute-Garonne, France), where they found abundant animal remains and implements made of stone and organic materials such as ivory, bone and antler (Rouquerol, 2007). After Aurignac they continued with excavations in caves and rock shelters in the Périgord (Dép. Dordogne) close to Les Eyzies where they also discovered engravings of animals on bone and antler. In May 1864 – thus 150 years ago – in the Abri de La Madeleine they finally found a mammoth tusk with an engraving of a mammoth. The depicted details prove that the person who made this engraving saw mammoths with his own eyes and thus it was the explicit first proof that people had been living at the same time as mammoths (Lartet and Christy, 1875):

Fig. 1. The first discovered representation of a mammoth on a fragment of mammoth tusk found in the year 1864 in the Abri de La Madeleine (Dép. Dordogne, France) by Lartet and Christy (1875). The length of the object is 24.8 cm.

> "This new fact will not, indeed, add any thing to already acquired convictions as to the coexistence of Man with the fossil Elephant (*Elephas primigenius*) and other great Herbivores and Carnivores which geologists regard as having lived together in the earlier phases of the Quaternary Period. This truth of retroperspective evidence is deduced now-a-days from so great a number of concordant observations, and of material facts of so clear a significance, that minds the least prepared to admit it are not slow to accept it in all its reality, when they will but take the trouble to look and then judge conscientiously" (Lartet and Christy, 1875:207-208).

After this most important first finding of a representation of a mammoth of the Ice Age numerous figures of mammoths were found in the Ice Age portable and cave art all over Europe (see Braun and Palombo, 2012).

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New findings about the Akhalkalaki site (Southern Georgia, Caucasus; 0.98-0.78 Ma)

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The early Galerian fauna from Akhalkalaki (Georgia, Caucasus, 0.98-0.78 Ma) was organized, revised and the ecological structure of the large mammal community was examined on a quantitative basis. Furthermore, survey, mapping and palynological sampling of the lacustrine sediments contemporaneous with the Akhalkalaki site were undertaken.

The following taxa were identified in the fossil collection: *Bison* sp., *Capra* sp., *Pontoceros ambiguus, Eucladoceros* sp., *Hippopotamus amphibius antiquus, Stephanorhinus* aff. *hundsheimensis*, *Equus suessenbornensis*, *E. hipparionoides, Mammuthus (Mammuthus)* aff. *trogontherii*, *Panthera onca gombaszoegensis, Pachycrocuta brevirostris, Meles* sp., *Vormela* cf. *peregusna*, *Lutra* sp., *Ursus* sp., *Xenocyon lycaonoides, Canis mosbachensis, Hystrix* sp. (gnaw marks), and *Erinaceus* sp.

We were unable to confirm the presence of some taxa mentioned in previous works (Vekua, 1962, 1986, Sokolov&Vekua, 1966, Hemmer et al., 2001, Tappen et al., 2002) such as *Bos* sp., *Cervus* cf. *Dama*, *Mammuthus (Archidiscodon)* sp., *Vulpes vulpes, Felis silvestris, Homotherium crenatidens, Lepus europaeus, Spermophilus* sp.

The paleoecological part of our study focused on the specialized herbivore community. A suite of ecological variables (body mass and diet) was assessed. The sample is dominated by high abundances (NISP) of *E. suessenbornensis* and provides a strong specialized grazing signal. However, the diversity among the fresh grass grazers is higher than the diversity among specialized grazers because five (vs. a single) species contribute to the signal. A quantitative comparison of the ecological structure and diversity of the specialized herbivore community in the Akhalkalaki assemblage distinguishing six ecological categories of specialized herbivore taxa illustrates that similar faunas are presently found in temperate latitudes and are associated with the temperate mixed broadleaf forest rather than temperate coniferous forests, forest steppe, alpine tundra or other systems at high altitudes. Our reference dataset includes a variety of vegetation densities (based on leaf area indices and/or greenness as proxies).

A rather similar picture is indicated by the palynological studies. Palynological samples were taken from the whitish sandy-clays of the site (site was formed in the fluvio-lacustrine sediments with admixture of colluviual deposits). These samples contained pollen of *Zelkova*, Vitaceae, Poaceae and Apiaceae; among the NPPs large amounts of bone salt crystals, freshwater microalgae – *Geiselodinium*, starch, hairs of aquatic insects, wood remains, and *Glomus* spores were found. Pollen of *Picea* and *Cedrus* were found in the samples from the sediments adjacent to the Akhalkalaki site. NPPs contained: wood remains, aquatic insects, algae, and phytoliths. Samples from the contemporaneous profiles at some distance from the site also confirmed presence of mixed deciduous forest. Pollen of *Cedrus, Fagus, Carya, Juniperus,* Vitacea, *Picea, Betulla, Tilia, Quercus, Alnus* and spores of the deciduous broadleaf forest ferns: *Dryopteris, Asplenium, Pteridium* were found here. Especially rich was the palynological and NPP spectra of the Baraleti profile (North of the Akhalkalaki site): alongside of freshwater algae, a large quantity of tracheal cells of wood was found, indicating the presence of forest. Among the arboreal pollen, pine predominates, the spectrum contains the pollen of cedar, spruce, birch, beech, oak and alder. The amount of pollen of arboreal species is three times higher than that of the herbaceous plants. Poaceae were the dominant grasses among herbaceous species, followed by Asteraceae. In general this vegetation spectrum is similar to temperate mixed forest now found in the Taurus Mountains of the Southern Anatolia and indicates warm and mild climatic conditions.

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Tusks of woolly mammoth (*Mammuthus primigenius*) with abnormal growth found in Yakutia

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Woolly mammoth tusks with abnormal proliferative growth are extremely rare – even more rare than descriptions of them in the scientific literature. From the territory of Yakutia, only two mammoth tusks with such abnormalities have been reported previously; one (ZIN, Nr. 30) is from Bolshoi Lyakhovsky Island, and the other is from from Kotelnyi Island, collected on 02.16.1916 by V.V. Artamonov and now exhibited in the Yakutsk State Museum of History and Culture of the People of the North, named after Em. Yaroslavskiy (MYar, Nr. KP 7433, P 167).

Both discoveries were briefly described in prior articles (Vereschagin, 1960; Vereschagin and Tikhonov, 1986; Boeskorov, 2010). The specimen in the Yaroslavskiy Museum in Yakutsk is probably a left tusk. Wear that developed during the life of the animal is present on the tip of this tusk, and several convex areas of nodular growths occur on both upper and lower sides of the tusk. On the lateral side, near the base, there is a "digi-form-microtusk" with length 38.9 mm and width 15.7 mm. Surface colors range from beige to brown, and are mostly pale. Virtually the entire surface is smooth and covered with micro-cracks.

In 2013, on the middle branch of the Kolyma River near Irilyah-Siene, a Museum of Mammoth employee found a third abnormal woolly mammoth tusk (MM, Nr 1662) associated with remains of the mammoth fauna. Compared to the other tusks, this one is intermediate in mass and shorter in length, but its maximum width and height are greater (Table 1). Apparently, this new specimen is also a left tusk. Its surface is rough and covered with an irregular network of cracks. Wear that developed during life is present on the tip of the tusk. When viewed from above, the tusk has an irregular shape, similar in profile to an equilateral triangle, with its mass produced through extensive proliferative growth. In other views, the specimen remains highly irregular. Its surface color is mainly yellowish with light brown and brown shades (especially near the base of the tusk).

Such abnormal proliferative growth is associated with a disease condition known as an odontoma. An odontoma is composed of wildly contorted, bulging and radially structured masses of dental tissues, sometimes including both enamel and dentine (Van Essen, 2004). Odontomas are a category of lesions that are united in their origin from cellular tissues related to tooth formation (Hunter and Langston, 1964).

Concerning abnormal conditions in bones and teeth, many researchers associate such diseases with influence of the environment (Musil, 1968; Garutt, 1990; Niven and Wojtal, 2003). Other potential causes of such pathologies include anomalies of individual development (Maschenko and Spansky, 2005), mineral starvation (Leshchinskiy, 2009) and adverse changes in the available nutrients (Kirillova, 2009). We conducted 3D scanning of the tusks from museum collections in Yakutsk (Fig. 1). We also plan a computed tomography scan of these tusks to determine their internal structure.

Table1. Size and weight of abnormal tusks from the territory of Yakutia

Specimen	Weight (gm)	Straight Length (mm)	Maximal width at the base (mm)	Height of the tusk (mm)
ZIN, Nr. 30	2100	370.0	140.0	75.0
MYar, Nr. KP 7433, P 167	4280	401.7	200.0	109.2
MM, Nr.1662	2920	245.4	216.9	113.9

Fig. 1. 3D scans of abnormal tusks. A: MYar, Nr. KP 7433, P 167; B: MM, Nr.1662.

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MicroCT analysis of mandibular tusks from the Ziegler Reservoir mastodons

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Ever-growing proboscidean tusks provide remarkable opportunities to investigate life histories of fossil individuals. X-ray computed tomography (CT) of tusks shows seasonal variability in dentin density and expands our ability to characterize tusk growth at annual and subannual scales. Complete microCT scans of twenty mastodon mandibular tusks from male and female adults as well as adolescents and juveniles from the Ziegler Reservoir fossil site (ZR; ranging from 130,000 to 80,000 yrBP) show distinct, regularly repeating radiodensity cycles over extended growth intervals (Fig. 1A). We interpret these as annual growth increments based on correspondence to patterns of structural and compositional variation that they share with annual increments documented in premaxillary tusks (e.g. Fisher, 1987, 2001; Koch et al., 1989), and we use them to compare dentin growth rates through life and between individuals.

In some ZR tusks density features are clear enough to enable direct volume measurement of annual increments in dentin growth (Fig. 1B). To streamline the process and incorporate specimens for which increment volumes are more difficult to measure directly, we used increment

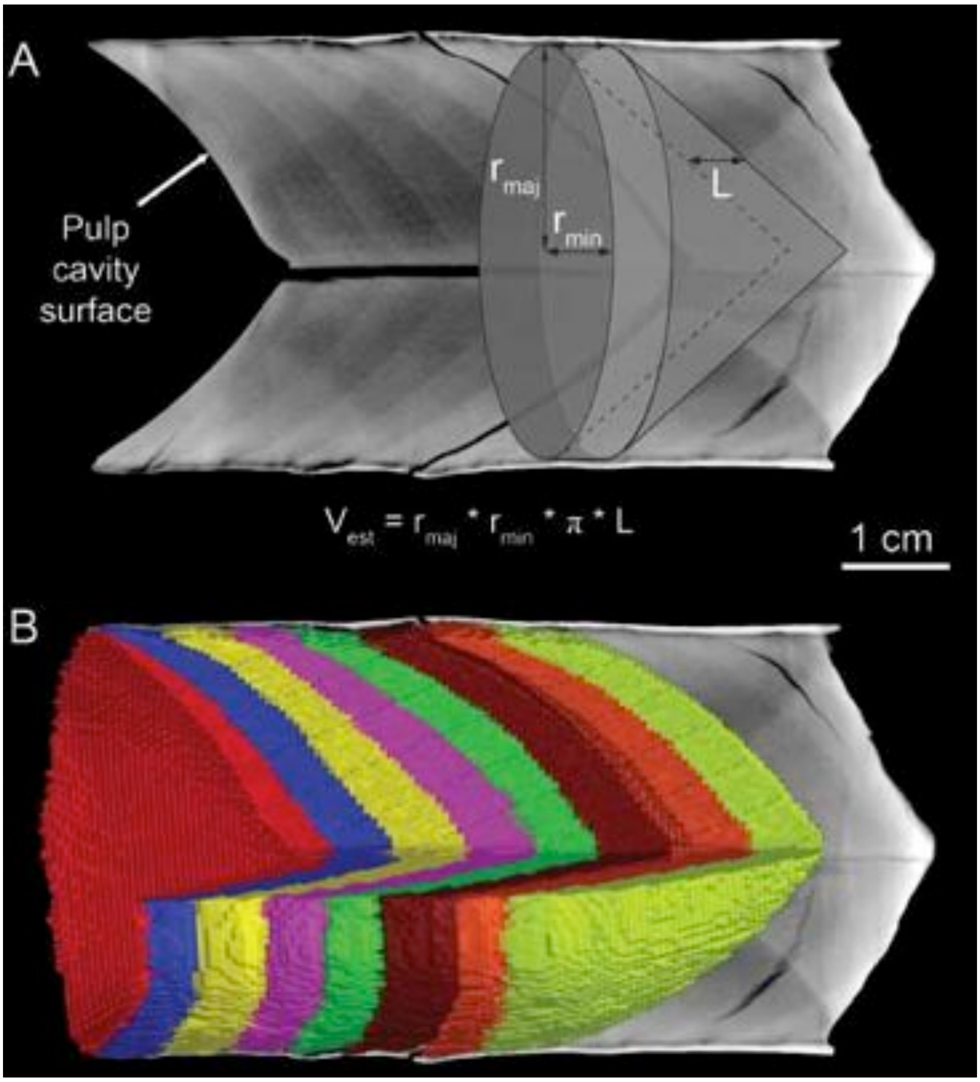

Fig. 1. *Mammut americanum* mandibular tusk from Ziegler Reservoir site in Colorado, USA; field no. 60.057 (Denver Museum of Nature & Science). **A**, virtual 2D longitudinal slice through the tusk axis projected from 3D microCT data showing radiodensity variation. Each gradual transition from dark (low radiodensity) to light (high radiodensity) defines a zone that parallels the pulp cavity surface and represents a year of growth. Linear measurements taken from 2D projections of CT data provide a close approximation of increment volumes. **B**, segmentation of microCT data enables direct volumetric measurement of annual growth increments (years distinguished by color).

V_{est}, estimated increment volume; **L**, increment length measured along a line half-way between axis and CDJ; **r_{maj}**, half the major diameter (usually dorsoventral) of the tusk at location of increment length measurement; **r_{min}**, half the minor diameter (usually mediolateral) of the tusk at location of increment length measurement.

volume estimates to compare growth series between individuals. Estimates were calculated using linear measurements from two-dimensional virtual slices of CT data and closely approximated measured volumes when comparisons were possible (Fig. 1A). The relatively simple curvature and regular cone-in-cone geometry of mastodon mandibular tusks contribute to the precision of volume estimates in our study, but we see potential for this metric as an alternative to linear increment measurements in large tusks and others for which we do not have complete three-dimensional CT data.

Comparisons between CT scans and thin-sections demonstrate that first-order (annual) CT increments and first-order thin-section increments are roughly equivalent for ZR mandibular tusks. Scans of premaxillary tusks and molars of proboscideans from various other sites also show density features that parallel other first-order features in the tusks. In addition to first-order features, some CT scans of ZR and other tusks display distinct changes in density within annual increments. In some cases, year-to-year consistency in these subannual variations likely reflects variation related to seasonal climatic and/or migratory patterns. In other cases, intra-annual variation is less consistent and is more likely a result of climatic perturbations, life history events (such as pregnancy in females and musth in males), or pathological conditions that could alter parameters of tusk growth.

Extended series of estimated first-order CT increment volumes in ZR mandibular tusks, which in some cases cover more than twenty years of growth, show sexual differences, ontogenetic patterns, year-to-year variability, and intra-annual timing of death. These series also present an opportunity to quantify growth variability using mean sensitivity (MS), a metric that has been employed in dendrochronology to assess environmental stress in tree populations (Fritts, 1976; Laxson, 2011). Further research is needed to determine if MS thresholds for recognizing stress in trees provide useful guidelines for interpreting variation in proboscidean tusks, but differences in MS between ZR individuals at least indicate relative levels of environmental stress within the sample population.

Recent advances in CT technology have made it more accessible, leading to increased use by paleontologists, but we are just beginning to realize its potential contributions to studies of fossils. Further work is necessary to establish mechanistic models detailing the causes of common patterns of radiodensity variation in tusks, but our extensive CT work on ZR mastodon mandibular tusks demonstrates that analysis of variation in dentin X-ray attenuation is a useful addition to existing modes of tusk analysis.

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Reconstruction of the Late Pleistocene soil-vegetation cover of the Yana-Indigirka Lowland mammoth fauna

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The studied region is situated in the north of the Republic of Sakha (Yakutia), representing tundra-bog landscapes of the Yana-Indigirka Lowland (N=70°43´, E=135°24´). According to the permafrost landscape map of Yakutia (Fedorov et al., 1989), the region belongs to the Lower Yana lake thermokarst province.

There are numerous finds of the mammoth fauna remains in the territory of the Yana-Indigirka Lowland. Recently, an early man-site has been discovered there (Basilyan et al., 2011) dated to the Late Pleistocene. A study of buried soils is performed in order to refine the evolution of the soil-vegetation cover of that time. The studied buried ancient soils represent the frozen loess-like sandy loams alternating with organogenic horizons of various origin (humus, black mold, peat).

The paper describes the results of the study of similar strata in the "Mus-Khaya" locality (Fig. 1). The studied pedocomplexes are as follows:

- Sartan "peat-gley" pedocomplex (PR-3 T);
- Kargin (№1) "sod-gley" pedocomplex (PR-6 A);
- Kargin (№2) "sod (forest)" pedocomplex (PR-7 A);
- Kargin (№3) "peat-gley" pedocomplex (PR-7 T);
- Kargin (№4) "sod (forest)" pedocomplex (PR-11 A).

The Sartan pedocomplex (PR-3 T) is as deep as ~215(217)-275 cm from the modern surface. Morphologically, it represents a profile of "peat-gley" soils. The organogenic horizon of this pedocomplex lacks palinological material, up to 100 grains in 4 samples. The pollen of tree-shrub plants makes up 46.0%, herbs and dwarf shrubs – 50.0%, and spores – 4.0%. Spore-pollen spectrum shows intrinsic changes of vegetation during the formation period of this pedocomplex. Abrupt climate cooling resulted in reducing tree-shrub vegetation and developing grass-forb associations with minor participation of larch and shrubs. The basic trend of soil formation at that time was rather peat formation.

The other four revealed pedocomplexes are situated in the Kargin stratum. At its basement the cultural layer is confined, studied by a number of specialists (Basilyan et al., 2011).

The first discerned (top down the soil profile) Kargin pedocomplex (PR-6 A) is situated as deep as ~ 436(453)-484(514) cm. According to morphological parameters, it is represented by a profile of "sod-gley" soils.

At a depth of ~ 484(514) cm, it is followed by the second Kargin pedocomplex (PR-7 A ~484(514)-514(554)). Morphologically, it represents a profile of "forest" soils, though with more developed organogenic horizon (~20 cm). This horizon is enriched with plant root remains representing a slightly decomposed humus soil layer. The spore-pollen spectrum of this horizon shows high pollen productivity, the pollen content reaching up to 904 in one sample. Generally, the spectrum shows increased content

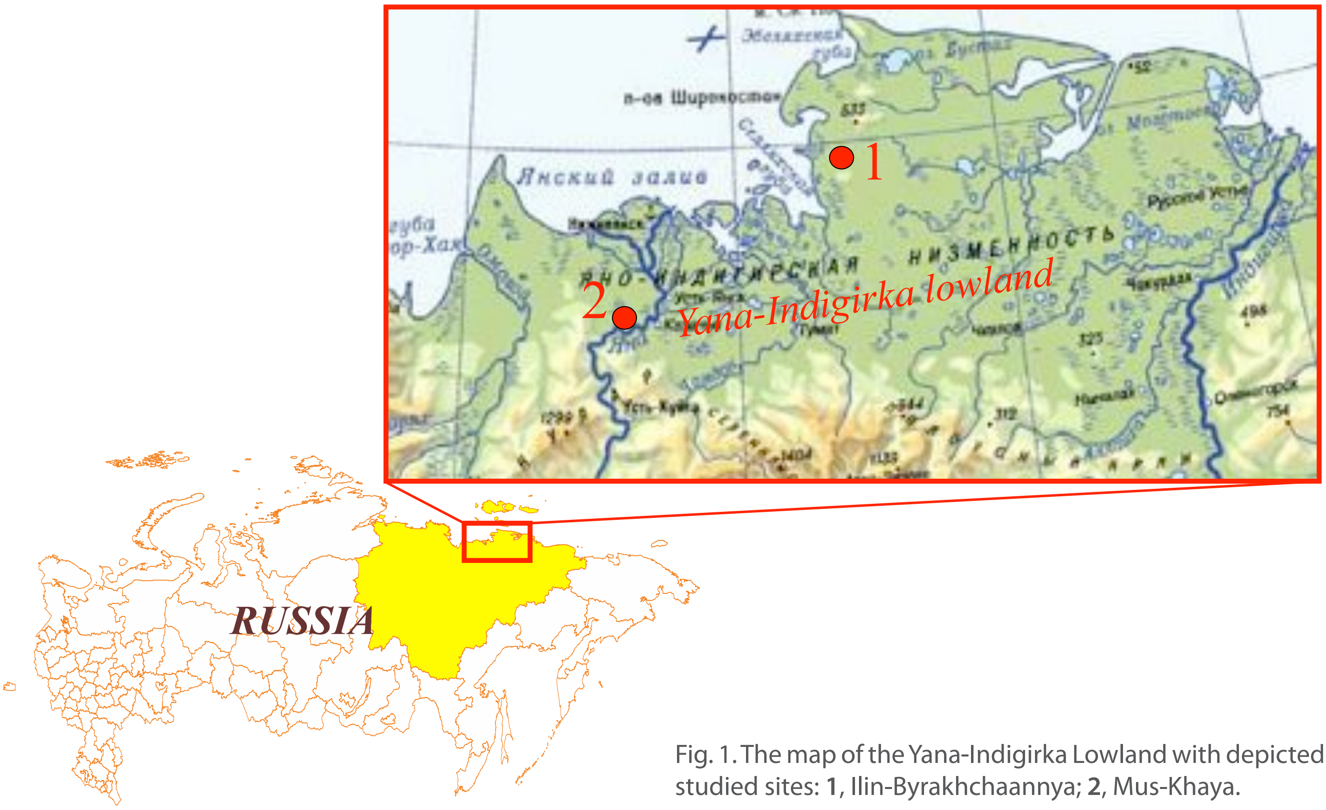

Fig. 1. The map of the Yana-Indigirka Lowland with depicted studied sites: **1**, Ilin-Byrakhchaannya; **2**, Mus-Khaya.

of tree-shrub plant pollen (74.6%) and dependency of herb-dwarf shrub (23.8%) and spore (1.6%) plants. The spectrum composition apparently indicates that during the period of sedimentation, larch thin forests occured with participation of tree-like birches, and properly developed shrub and herb layers. The main trend of soil formation was humus formation.

The third pedocomplex (PR-7 T) was discerned at a depth of ~514(534)-570 representing the profile of "peat-gley" soils. As compared to the horizon PR-7 A, the content of micro-grains here is somewhat decreased (211 in two samples). The spectrum contains almost equal portions of tree-shrub (48.3%) and herb-dwarf shrub (49.2%) plants. The spores make up 2.5%. The spore-pollen composition of two horizons indicates predominance of poorly forested landscapes during that period of sedimentation.

Beneath the abovementioned cyclites (pedocomplex alternation), a well preserved pedocomplex (PR-11 A) was discerned at a depth of ~ 864(872)-950cm. It represents a profile of "forest" soils. The spore-pollen spectrum of the organic horizon of this pedocomplex is characterized by a very low content of spores and pollen (164 grains in three samples). Despite the small amount of pollen grains the spectrum is prevailed by the pollen of tree-shrub species (50.7%). The pollen of herbs and dwarf shrubs makes up 43.1% of the association, whereas the spores represents only 7.2 %.

Thus, in the studied profile 1 Sartan and 4 Kargin pedocomplexes have been discerned reflecting the soil-vegetation cover succession. The gained results allow to state that the Kargin pedocomplex consists of three warm and one cold stages, their signs being clearly traced in the studied pedocomplexes. According to the published data, those changes in coastal lowlands are related to the drastic change in geochemical landscapes (Tomirdiaro, 1980) expressed by gleization of subhorizons and other soil properties (Zykina et al., 2010).

As a whole, the results of the soil evolution study testify five drastic changes in habitats of the Late Pleistocene mammoth fauna in the Yana-Indigirka Lowland due to climate fluctuations.

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High-latitude steppe vegetation and the mineral nutrition of herbivores of the mammoth fauna

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High-latitude steppes were widespread and zonal in the Late Pleistocene and formed a landscape basis for the Mammoth Biome. Now the patches of these steppes survived on steep slopes with S, SW and SE expositions. These refugia serve as unique information source on the Late Pleistocene "Mammoth" steppe. Numerous data obtained by palynological, carpological, and DNA analysis of plant remains from feces and stomach contents of herbivore mummies, as well as from buried soils and enclosing deposits show that they are similar to modern xerophytic -steppe plant assemblage in taxa composition and structure of the vegetation cover. This is typical for Late Pleistocene vegetation in the studied area (Yurtsev, 1982; Berman et al., 2001). Plant's nutrient concentrations are of fundamental importance across Pleistocene grass-rich ecosystems because of their role in the support of large herbivores of the mammoth fauna complex. The average weight of an adult mammoth skeleton (about 0.5 tons) and of a woolly rhinoceros (about 0.2 tons) clearly suggests this. Detailed studies on fossil bone remains showed mineral deficiency in large Pleistocene herbivores (our data; Leschinskiy, 2012). Most often it was manifested as an osteodystrophy of bone tissue, especially in mammoths from South Siberia (Leschinskiy, 2009; 2012).

A two-year study of ash and mineral contents of two types of relict cold steppe vegetation at the Kolyma Lowland, Arctic Siberia has been carried out. During the Late Pleistocene vast steppes were stretching in this region. Petrophytic steppes (Fig. 1A; more than 60 vascular plant species) and thermophitic steppes (Fig. 1B; more than 30 species) were dominating amongst these steppe communities (Davydov et al., 2009a). Nowadays refugia of similar vegetation are located not far (1 - 15km) from the outcrops of Ice Complex permafrost deposits were abundant remains of fossil mammals are found (Davydov et al., 2009b). For example, a site of a mummy woolly rhinoceros (Kolyma rhino) (Boeskorov et al., 2009) was located 5km from the sampling sites of steppe vegetation. Dominant species of the steppe vegetation were sampled throughout different phenological phases. Analysis of ash and nutrients of vegetation were carried out using standard methods (Grishina, Samoilova, 1971; Miller, 1998).

Preliminary studies indicate that the ash-content varied 1.5-2 times in species of steppe herbs of Compositae, Caryophylláceae, and Rosaceae families. Ash-content for steppe-habitat grasses and sedges were insignificantly higher or similar to non-steppe grasslands at the peak of growing season. Fabaceae and Equisetaceae taxa which are usually characterized by high ash-content were insignificantly different between the steppe and non-steppe herbs. Nevertheless, the latter differences notably increased at the end of the growing periods. The Ca, P, Mg, K macroelement contents was higher for most steppe species than in the local herbaceous vegetation, especially in calcium and phosphorus. One of the most important elements of the mineral nutrition of animals, the phosphorus, was always found in higher concentrations in the steppe vegetation than in plants of recently dominant landscapes of the Kolyma lowlands. At the same time, the Na content was low and insignificantly different between steppe habitats and the non-steppe vegetation. We also noted an increase of mineral nutrients in steppe plants in years with dry warm summers. It should be noted that the mineral nutrient content of the modern steppe vegetation

Fig. 1. **A**, Petrophytic steppe. North-East Kolyma Lowland, Arctic Siberia. **B**, Thermophytic steppe. North-East Kolyma Lowland, Arctic Siberia.

of Siberian Arctic is comparable to that of the recent zonal steppe of Transbaikal Region. This study supports the hypothesis that aboveground mineral concentrations of late Pleistocene grass-rich ecosystem were consistently higher than that of the recent common species of Siberian Arctic grassland. The source of mineral nutrients in the Pleistocene high-latitude steppe vegetation served as one of the reasons for the existence and survival of large herbivores in the Mammoth Biome.

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Zooarchaeological study of an Upper Palaeolithic site with mammoth remains, Pushkari I - excavations VII (Chernigov oblast, Ukraine)

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Pushkari archaeological complex was discovered in 1930's by Rudinsky (1947), on the right bank of the Desna river. Our work focuses on Pushkari I, one of the sites of the complex of Pushkari. Stratigraphic and geographic studies showed that the archaeological layer is located -0.70 meter deep. As it is located above the Briansk soil (Pidoplichko, 1947 ; Boriskovsky, 1953; Velichko, Gribchenko, Kurenkova, 1997) it can be correlated to the beginning of the Upper Pleniglacial. The radiocarbon datings gave an age between 19 010 ± 220 BP (AA1389) and 21 100±40 BP (GIN3382). During the Upper Pleniglacial, between 23,000-20,000 years BP, the climate of the area got colder and more arid. In the region, the remains of human occupations recovered for this age are scarce, with less dense concentrations than during the other Upper Palaeolithic periods. Pushkari is one of the few archaeological complexes giving information about this time.

The lithic material is characterized by an unusual Gravettian assemblage including Pushkarian points. It is different from the contemporaneous lithic industries of Kostienki and other sites of the Dnieper region and corresponds to an original cultural type (Rudinsky, 1947; Boriskovsky, 1953; Otte et al., 1996; Belyaeva, 1997b, 2000, 2002; Nuzhnyi, 2009). Species of the local fauna, identified in different excavations, include mammoths, horses, reindeer, red deer, wolves, polar foxes, brown bears and lemmings (Boriskovski, 1953; Sablin, 1997).

In order to understand acquisition modalities and treatment of large mammals, and to test the hypothesis of the use of woolly mammoth as a source of food and building material, we studied the faunal remains from the subdivision VII of Pushkari I (42 m^2 excavated, Fig. 1). Our methodology includes paleontological, paleoenvironmental and taphonomical approaches.

The faunal spectrum is made of *Mammuthus primigenius*, the predominant species, *Equus* sp., Cervidae, *Canis lupus* and *Vulpes vulpes/Alopex lagopus*. Bones of the upper and lower extremities of canids are well preserved, and more or less in their anatomical position indicating that bone deposition is little disturbed. All anatomical parts of woolly mammoths are represented, suggesting that the individuals died near the site. The high representation of tusk material may indicate anthropogenic influence. Concerning the age classes of mammoths, we identified juveniles, young adults and a predominance of adults. This type of mortality profile does not result from a natural process. The taphonomic study allowed us to suggest that the bone remains lied in open-air for a long time before they were buried and affected by sandy deposits. Moreover alteration on bone surfaces allows implying a more humid climate than expected. Concerning biological agents, carnivores were in no case responsible for the origin of the assemblage. In contrast, we observed human cutmarks on bones of large mammals. Human groups came to Pushkari I to use local flint, to hunt, butcher large mammals, and get supplies of carnivore furs.

This study provides new data to understand the particular status of the woolly mammoth within the Upper Palaeolithic human groups in the russo-ukrainian plain.

Fig. 1. View of the excavations VII of Pushkari I, Ukraine.

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Contamination study: a possibly Holocene mammoth tooth appears to be from just another old mammoth

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As part of a larger research project, fourteen mammoth molars from the Naturalis Biodiversity Center collection (Leiden, Netherlands) were radiocarbon dated at the Centre for Isotope Research (Groningen University, Netherlands). These molars were all collected from the North Sea near the Dutch west coast. Thirteen molars yielded ^{14}C dates between 30 and >45 ka BP, which was within the expected age range for fossils from the North Sea. However, the fourteenth specimen [registration number RGM.338276] dated to 9,005±45 BP (GrA-50857). In the literature, the youngest dates from Western Europe are around 12,000 BP (Stuart et al., 2002). If correct, RGM.338276 would have been the youngest woolly mammoth ever discovered in Western Europe. In such cases a closer investigation is required.

Due to its peculiar Holocene ^{14}C age the molar was thus redated and geochemically investigated to test two hypotheses: (1) the 9005 ±45 BP (uncal.) date is correct or (2) the ^{14}C age is too young and resulted from post mortem contamination of the tooth with young carbon, due to either diagenetic processes and/or contamination with allochtonous carbon.

In order to remove any preservatives, new molar samples were subjected to an acetone ultrasonic bath and the so-called soxhlet procedure. The extracted collagen was re-dated to 18,750±70 BP and 21,650±90 BP, respectively. Clearly younger carbon has been removed by both pretreatment procedures resulting in Late Pleistocene ages.

Phosphate oxygen isotope composition ($\delta^{18}O_{PO4}$) of the enamel was analysed to determine whether the mammoth ingested drinking water during interglacial (i.e. Holocene) or glacial periods. These results were then compared to the values obtained from a mammoth molar dated to 42,690 +550/-470 BP from the same locality. The $\delta^{18}O_{PO4}$ values are around 16‰ for both bulk and serial sampled enamel of the RGM.338276 tooth. This is also the case for a 42,690 +550/-470 BP-old mammoth molar. In very general terms, one can argue that these ^{18}O values show similar climatic regimes for both specimens, the 42.7 kBP and the 21.7 kBP. The temporal resolution of both calibration of ^{14}C dates and the rapid climate changes (D/O events) during the glacial however make firm conclusions impossible.

In situ elemental analysis using XRF was performed on both enamel and dentine of the molar to investigate the degree of diagenetic alteration. These results were compared to XRF data of teeth from four other woolly mammoths from the North Sea, a modern, diagenetically unaltered, Asian elephant and a ±1 Mya-old *Stegodon trigonocephalus* from Java as an outgroup. According to statistical PCA analysis of the dentine XRF data the RGM.338276 specimen is slightly closer to the modern Asian elephant in comparison to the other woolly mammoths and *Stegodon*. Thus no exceptionally intense diagenesis could be detected for this molar which could account as cause for the >10ka offset of the radiocarbon date. However, contamination by young carbon from preservatives remains a possibility.

All analyses combined did not provide a well-supported date for this molar. It is possible that the soxhlet procedure did not remove all contaminating organic carbon. Therefore, bio-apatite ^{14}C-dating and applying ultrafiltration during collagen extraction will be applied in the near future to test this.

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Remains of mammoths, horses and deer from the Late Middle Pleistocene loess deposits at Nosak (Drmno coal pit), Kostolac Basin, NE Serbia

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In 2009, an almost complete steppe mammoth (*Mammuthus trogontherii*) skeleton was discovered in Kostolac Basin (Lister et al., 2012). In 2012, several hundred metres to the north and few dozen metres above the previous find, mammoth bones and tusks were seen sticking out of a section made by a large backhoe excavating the overburden at the Drmno coal mine.

Drmno is an open-pit coal mine in the Kostolac Basin in operation since 1870. Containing Late Miocene to Quaternary sediments, the basin sits between three large rivers, the Danube on the north, the Velika Morava on the east, and the Mlava on the west. The Quaternary units comprise Pleistocene alluvial sediments and a later Pleistocene loess sequence with intercallated paleosols, topped by Holocene sediment. In 2009, the first Kostolac mammoth skeleton was found in alluvial deposits, but the

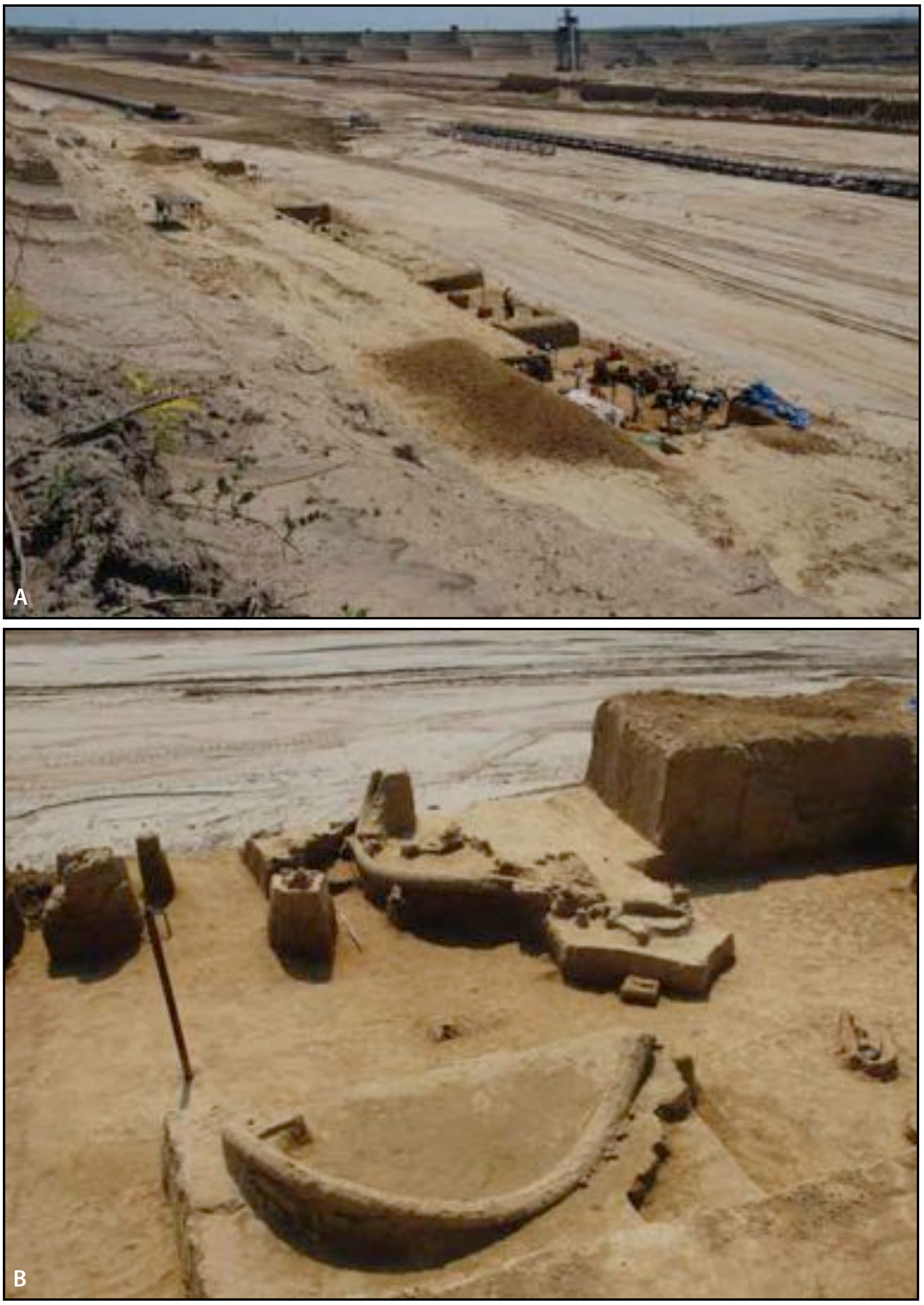

Fig. 1. **A**, Excavations in course, 21th August 2012, view from southwest. **B**, Skull, tusks and postcranial bones of a steppe mammoth in the Trench Kl 97. Photos: Nemanja Mrđić.

2012 finds from the Kostolac Basin occurred in the later Pleistocene loess sequence.

The coal exploitation required the removal of the Quaternary overburden above the Miocene coal. Large backhoes removed the sediment by making cuts approximately 6-7 m deep revealing furrowed, subvertical profiles. The archaeological field survey discovered the mammoth bones and teeth in one profile, at 19 m below the land surface. Palaeontological excavations started in July, 2012 in trenches approximately 10 m wide positioned in a line approximately 150 m long (Fig. 1A).

Skeletal remains from large mammals were scattered over an area up to 10 m wide and 130 m long. Individual bones and teeth were encased within thick carbonate concretions. From their composition, morphology, and manner of formation, these carbonate concretions resemble the characteristic "loess dolls" that form in loess. The brittle, fully mineralized, white bones are difficult to separate from the carbonate coatings.

For many bones and teeth covered with this thick carbonate cover, it was impossible to identify the skeletal element and taxon before their conservation and preparation, which still remains to be completed. Exceptions were some large bones and teeth that were identified according to their size and shape. In Trench KI 97, spirally curved tusks suggested the presence of a mammoth (Fig. 1B). The identification of a steppe mammoth, *Mammuthus trogontherii*, was based on the enamel thickness and lamellar frequency of the molars in the lower mandible, M2-1, found in Trench 99. The enamel is 3 mm thick, and the lamellar frequency 6,6. These values are approximate, since they were calculated on molar fragments less than 10 cm long. Although coated in carbonate, horse remains (*Equus* sp.) were identified by the morphology of a femur recognized by a third trochanter, and by a few bones from the hind limb, including the phalanges. The presence of a cervid was confirmed by a tooth fragment protruding from a carbonate concretion and by a few long, curved antler-shaped carbonate concretions.

Preliminary analyses indicate remains from at least three mammoths, one horse, and one cervid. A fragmented skull, complete left and right tusks, at least five vertebrae, several ribs, a scapula, radius, ulna, femur, tibia, and several short bones from the extremities originated from an adult mammoth (Fig. 1B). The remains from another mammoth include a fragmented skull, a mandible, and one tusk. Between these two mammoths' remains, mixed bones from mammoths and other large mammals occurred. The third mammoth is evidenced by a fragmented skull and a tusk. The equid remains included two vertebrae, a femur, tibia, metatarsus, and third phalanx. The cervid remains included antlers and teeth.

Most likely hyaenas scattered some bones and teeth. In Trench 97, a mammoth vertebra, a scapula, and an ulna display characteristic damage most likely of biogenic origin. Breakage on the bones is irregular and serrated, while the spongiose tissue has been furrowed. Given the bones' massive size, obviously a large predator must have produced such damage. Only hyenas have jaw strengths powerful enough to leave such marks.

The bones and teeth accumulated at a single level within the loess sitting just above the upper of two paleosols. Given the sedimentological and faunal analyses, the paleosols most likely were formed during MIS 7, while the loess likely was deposited in MIS 6 (Marković et al., 2013). Accordingly, the age for the Nosak mammoths falls near the last appearance of steppe mammoths within Europe (Lister et al., 2005). Therefore, precise dating of the Nosak finds by is critical. Samples for ESR dating were taken from a mammoth molar from Mandible M2-K1 found in Trench 99. Two sediment samples were collected from the loess. Eight enamel subsamples from the molar fragment have been dated by standard ESR enamel and isochron protocols, using time-averaged cosmic and sedimentary dose rates. While the molar postdates 180 ka, preliminary isochron analyses indicate that it has experienced multiple U uptake events.

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Final years of life and seasons of death of woolly mammoths from Wrangel Island

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By the onset of the Holocene, many large terrestrial mammal species that had characterized the Pleistocene had gone extinct worldwide, including the majority of proboscidean taxa. However, Wrangel Island, off the northern coast of the Chukchi Peninsula in Siberia, provided a small refugium for the last remaining population of woolly mammoths (*Mammuthus primigenius*). This population of mammoths survived for much of the Holocene, until their extinction at approximately 4,000 rcybp (Vartanyan et al., 2006). Initially, it was hypothesized that Wrangel Island supported a relict community of glacial vegetation throughout much of the Holocene (Vartanyan et al., 1993), but palynological data suggest that a modern flora and climate was in place by 10,000 ybp (Lozhkin et al., 2001). Regardless, few hypotheses on the extinction of Wrangel Island mammoths have been well tested.

The tusks of proboscideans have the potential to contain a continuous record of growth throughout an individual's life. This record can be accessed through analysis of structural and compositional variation in tusk growth increments (Fisher, 2001). In mammoths, these increments have been interpreted to form on annual (first-order), weekly (second-order), and daily (third-order) intervals, with sets of lower-order increments nested within increments of higher-order. Life histories of the Wrangel Island mammoth population, as documented in the record of their tusks, have the potential to yield critical data on effects of extrinsic factors on individuals. Thus, with a large enough sample across a broad temporal scale, life history information provides a test for different hypotheses of extinction (Fisher, 2009). We present here partial life histories and seasons of death of three Wrangel Island mammoths using new techniques for tusk analysis.

Proximal portions of isolated tusks from three individuals (39M, 41M, and 42M) of *Mammuthus primigenius* were analyzed in this study. These individuals are all interpreted as female due to the relatively small diameter of their tusks. All three females are identified as adults based on the shallowness of the pulp cavity and the reverse-taper of the tusks proximal to the gingival margin. However, based on these features, 39M appears to be significantly older than 41M or 42M. Radiocarbon dating of these specimens yields absolute ages ranging from approximately 5,000 to 7,500 rcybp.

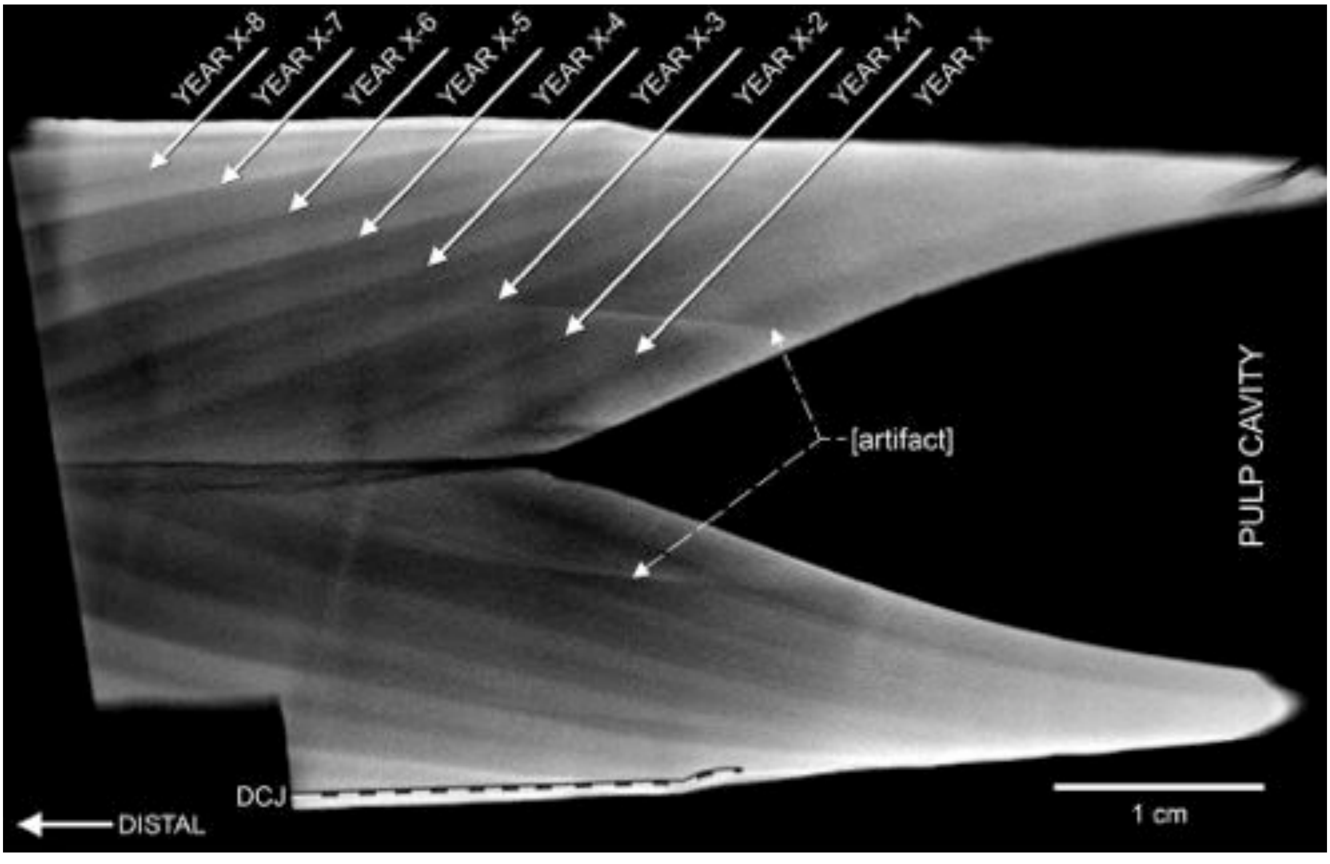

Fig. 1. Micro-computed tomographic slice of tusk 39M in longitudinal section showing annual variations in density. White arrows mark hypothetisized winter-spring boundaries with hypothetisized years labeled in between.

DCJ, dentin-cementum junction (marked by black and white dashed line); small white arrows with dashed lines mark the outer edges of a cylindrical CT artifact (= **[artifact]**).

The samples were scanned using microtomography to observe changes in density throughout the last few years of life. Annual variations in density observed throughout the tusks provide a basis for determining locations of boundaries between years (Fig. 1). These boundaries are observable in microCT as sharply contrasting contacts between zones of high x-ray attenuation leading into zones of low attenuation, which have been suggested to correlate to the boundary between winter and spring (Fisher et al., in review). Using these contacts as markers for year boundaries, the three Wrangel Island mammoth tusk samples each contain a record of approximately 5 to 9 years. Among these tusks, one specimen (39M) shows a relatively constant annual appositional thickness, while the other two specimens (41M and 42M) show greater variability. This variation is potentially due to calving events in the two younger individuals.

Thin sections of each tusk are used to measure appositional thickness of weekly (second-order) growth increments throughout the last few years of life to observe variations in growth patterns. These variations have been hypothesized to relate to nutritional status of the individual and in the context of seasonal patterns of growth, are used to corroborate the identification of winter-spring boundaries. Furthermore, deviations from a background annual growth pattern allow for interpretation of life history events (e.g., calving, injury, etc.) and provide potential clues for cause of death.

Carbon and oxygen isotopes are serially sampled from collagen and carbonate along a path perpendicular to the appositional surface. The isotopic composition of tusks shifts based on the composition of available food and water sources. Therefore, recovered patterns in isotopic composition reflect seasonal changes in vegetation and water source throughout the year. Patterns of seasonal isotopic change can thus be used to further assist in the assignment of annual boundaries and corroborate the interpretation of zones of low x-ray attenuation as early spring growth.

Based on the patterns observed in dentin density, all three individuals appear to have died within a zone of high x-ray attenuation. Based on comparison with previous years, the thicknesses of these high-density zones appear to be near the expected maximum thickness for that year. Therefore, we interpret all three individuals as having late winter deaths, which is consistent with a natural cause of death. Consistent rates of growth in years prior to death suggest that these individuals were relatively healthy, despite a warmer Holocene climate. Further analyses of tusk samples from approximately 50 other individuals from Wrangel Island will allow for an increased understanding of shifts in the patterns of life histories within the mammoth population through time, and will ultimately allow for greater interpretative power in deducing the cause of their extinction.

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Tomographic study and 3D-reconstruction of mummified Pleistocene dog from North-Eastern Siberia

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The mummified carcass of a young specimen of medium-size predator (Fig. 1) was found in the north of Yakutia by local residents of Tumat settlement (Ust'-Yanskiy district) on the high bank of the old bed of the River Syalakh in 2011. The find was frozen in the permafrost together with mammoth bones next to the broken skull of a mammoth and deposited in a peat lens which was around 16 m^2 by size. Definition of the geological age was done in the University of Groningen in 2012 with the result 12460±50 years BP (GrA-52435).A preliminary visual external examination of the carcass by some zoologists have made the assumption that it can be a young specimen of the domestic dog (*Canis familiaris*). The carcass of the animal is kept in a freezer at the Mammoth Museum at the temperature -18ºC. The study of the wool in Centre for GeoGenetics (Copenhagen, Denmark) gave the preliminary results which can presented as "more dog than wolf". The additional studies will be done quite soon.

Tomographic studies are planned in advanced medical imaging and high spatial resolution (computed tomography (CT) and magnetic resonance imaging (MRI) without breaking the anatomic integrity of the animal. Based on the CT study 3D-reconstruction of the skeleton was received. Additionally, an attempt was done for topographic and anatomical assessment of the mummified internal organs and soft tissues, including the brain, by MRI studies.

For the first time the computed tomography and laser scanning according to carcasses of fossil animal is 3D-reconstruction of the animal body with wool, and recreated the appearance of the Pleistocene dogs of North-Eastern Siberia (Ovodov et al, 2011), that will make substantial contributions to the study of ancient domestic animals and the development of advanced technology in the form of 3D museum exhibits.

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Fig. 1. General view of an ancient dog.

New material of *Mammuthus primigenius* (Proboscidea, Elephantidae) from the Late Pleistocene of Niederweningen, Canton Zurich, Switzerland

Mirjam FEHLMANN ✉, and Winand BRINKMANN

Since the 19th century, Niederweningen, 20 km northwest of Zurich, has been known as the most important woolly mammoth (*Mammuthus primigenius*) site of Switzerland. Over 100 fossil specimens comprising bones, teeth and tusks of at least seven mammoth individuals, including a very young calf, were excavated there in 1890-91 (Lang, 1892). In 2003, another partial *M. primigenius* skeleton was unearthed at a construction site close to the original locality of 1890/91 (Furrer et al., 2007). Previous studies of the mammoth site have revealed an age of about 45 ka for the layers containing the mammoth material (Hajdas et al., 2007; Preusser & Degering, 2007) and enabled the reconstruction of the environment and the climatic conditions during the middle part of the last glacial cycle (Middle Würmian) (Coope, 2007; Drescher-Schneider et al., 2007; Tütken et al., 2007).

The newly discovered, largely articulated material belongs to an adult and includes the mandible, molars, tusk fragments, hyoid bones, some vertebrae and ribs, a humerus, an ulna, one radius, an almost complete manus, a small portion of the pelvis, a rather fragmentary femur, one tibia and fibula, a patella, tarsal bones, metatarsals, phalanges and sesamoids.

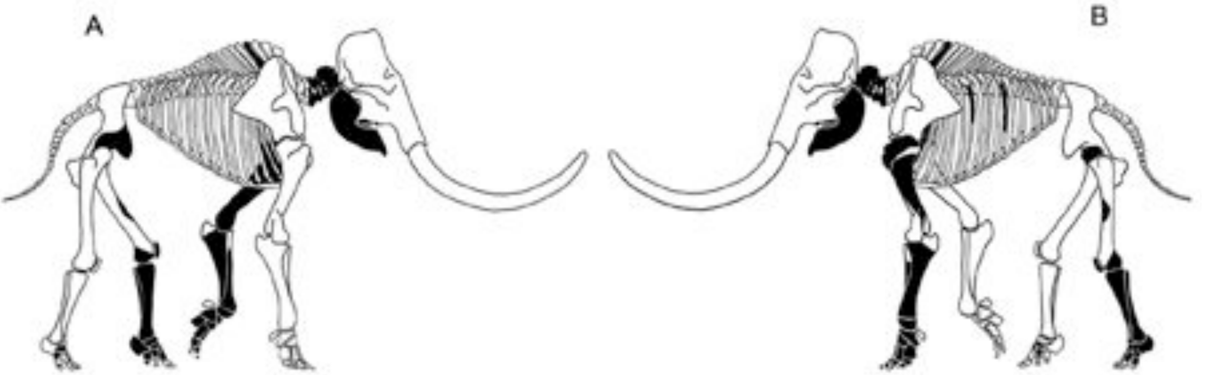

Fig. 1. Schematic drawing of a mammoth skeleton indicating the available skeletal elements of the specimen found at Niederweningen in 2003; **A**, right side; **B**, left side. Modified drawing of *Mammuthus* by S. Hartmann (available at www.skeletaldrawing.com). Based on our study the mammoth was thumbless. Thus, in contrast to the original drawing the phalanges of the first digit were removed.

Most of the collected limb remains are derived from the left side of the animal's body. We confirm that it was a large male individual (Furrer et al., 2007) and suggest a shoulder height of approximately 3.0-3.3 m. Based on the wear pattern of the molars, the mammoth died at an age of about 35-38 years.

For work on this new specimen, special emphasis was placed on the extraordinarily well-preserved carpals, metacarpals, phalanges and sesamoids of the almost complete left manus. Besides the missing pisiform and a third phalanx, all bones are preserved. Properly documented feet are extremely rare in the fossil record of *M. primigenius*, therefore this left manus reveals new insights into the morphology of the anterior autopodium of the species. Up to now the study clearly demonstrates, among other results, that our specimen was thumbless. No contact facet is observable at the lower side of the first metacarpal of its first digit. Moreover, two well-developed large sesamoids can be rearticulated laterodistally to its first metacarpal. Comparing the correspondent sesamoids of extant elephants, which are relatively small (Hutchinson et al., 2011), to the ones of the Niederwenigen mammoth, these elements clearly differ in their proportions. Regarding our mammoth individual we assume that the lack of the first digit in its manus is related to the increased size of the distal sesamoids of its first metacarpal. However, further investigations and more fossils are needed to support this hypothesis. Additional important observations obtained with our material are the identification of small bones of the left manus as third phalanges of the digits II to V. Finally, the aserial order of the carpal bones is also clearly visible in the left manus of the new partial skeleton whereby the magnum and trapezoid are overlapped by the lunar.

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Special Volume 102 55-56 Thessaloniki, 2014

3D models of proboscidean osteology

Daniel FISHER ✉, Joseph EL ADLI, Michael CHERNEY, and Adam ROUNTREY

Many studies that are essential for our understanding of both evolutionary and paleoecological problems require detailed considerations of skeletal and dental anatomy, taphonomically relevant aspects of site structure, or postmortem modifications of skeletal elements. Such investigations are fundamentally three-dimensional (3D), and we have always struggled to represent critical spatial and configurational relationships in two- dimensional (2D) media. Relatively successful examples drawn from current literature offer a sufficient number of 2D views to convey significant aspects of 3D form (e.g., Göhlich, 1998), but subtle features that show up in only certain views are inevitably under- represented. For mammutids in particular, the most widely cited reference on osteology (Olson, 1972) is not a comprehensive treatment of the skeleton, nor is it entirely consistent and accurate in its labeling. Fortunately, new developments in digital technology have begun to allow us to work and communicate in ways that more nearly approximate the 3D experience of interacting directly with specimens. In cases where demand is sufficient (e.g., human osteology), commercial software has been developed to allow 3D exploration of skeletal anatomy (<http://www.anatronica.com/anatomy-data/skeletal-system-full.html>). To bring these capabilities to studies of proboscidean evolution and paleoecology, we are developing a growing "library" of 3D models of proboscidean osteology and odontology. As a step toward wider use of 3D data, we have developed a complete, articulated, 3D model of an adult male American mastodon (*Mammut americanum*) skeleton (Fig. 1), based principally on a single individual from a late Pleistocene site in northeast Indiana, USA. This model and all its component elements are part of a larger digital resource on proboscidean osteology. Separate skeletal and dental elements of this individual, plus others that are regularly being added, were digitized using several techniques – a point digitizer, a laser scanning digitizer, x-ray computed tomography, and photogrammetry – to capture data on form. While surface models suffice for many purposes, model information content can be significantly enhanced

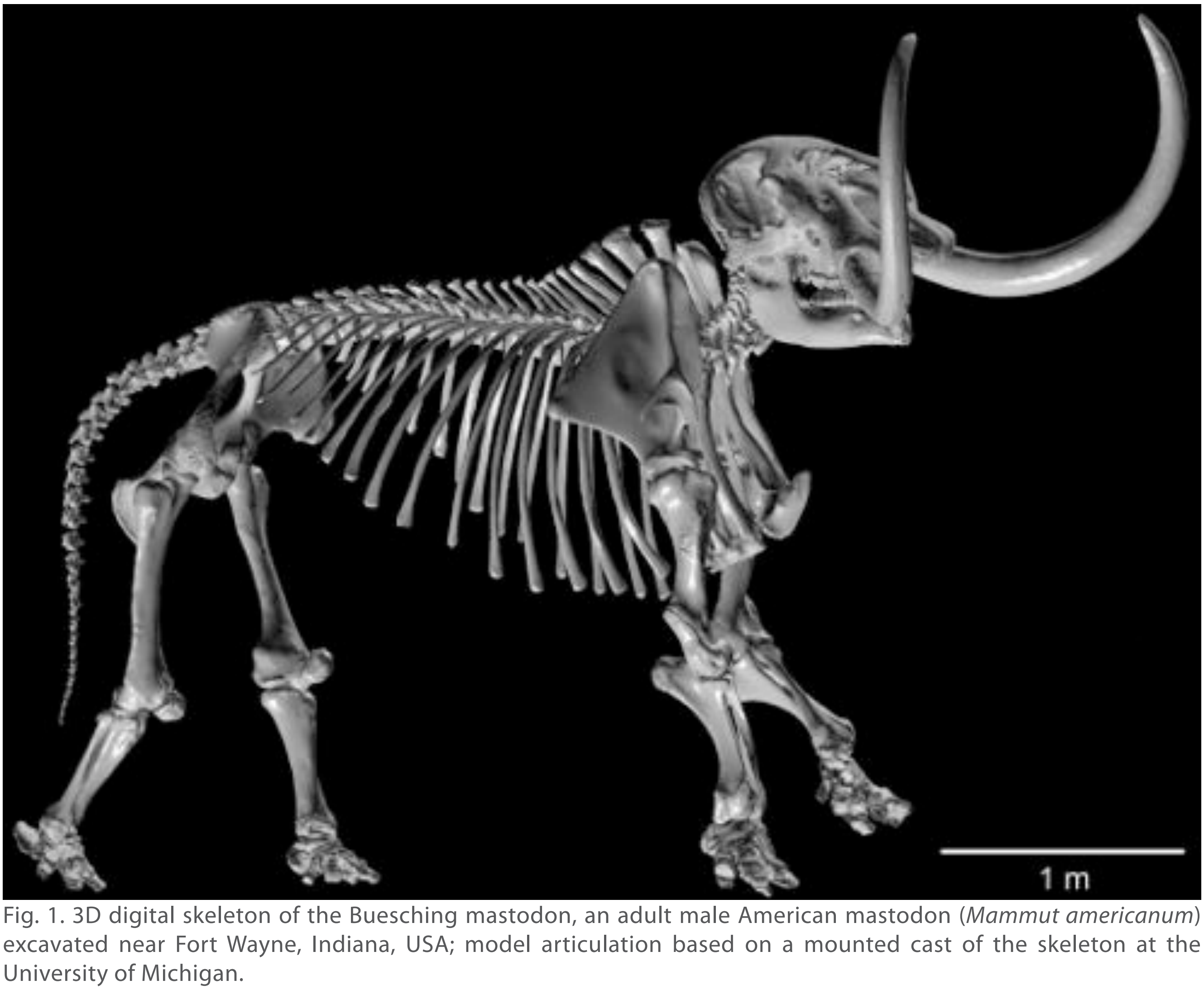

Fig. 1. 3D digital skeleton of the Buesching mastodon, an adult male American mastodon (*Mammut americanum*) excavated near Fort Wayne, Indiana, USA; model articulation based on a mounted cast of the skeleton at the University of Michigan.

through image-based texture mapping. We created texture-mapped models using specialized software (3DSOM Pro, recently upgraded to BOB Capture; <https://bobcapture.bigobjectbase.com/3dsom>) that allowed us to map multiple overlapping images of a skeletal element onto a corresponding surface model. The resulting models are photorealistic and can also be made available through an online interface that allows users to freely rotate, pan, and zoom, exploring morphology as one would with access to a comprehensive comparative collection. Our articulated model skeleton will be used in development of a graphical user interface for selecting individual bones for detailed viewing, supporting both comparative studies and precise identifications of material recovered at additional sites. Bone models, texture-mapped or not, have been articulated to portray anatomical configurations on scales ranging from pair-wise articular relationships to the proportions of entire skeletons. The digital format of models makes it easy to invert symmetry, compute stereo pairs, generate virtual sections, compile animations, or support 3D printing at real or transformed scales. Bone models have also been placed in a 3D reference frame to build an interactive digital replica of site structure. Implementation of an online repository for models of proboscidean osteology is a step in development of tools for digitally mapping sites as they are being excavated. Our models are currently being re-exported from the former 3DSOM standard format, dependent on FlashPlayer, to a more secure and flexible WebGL format. Surface models can also be exported as "live" (i.e., rotatable, zoomable) 3D pdfs, of which an example is available at <http://www.lsa.umich.edu/paleontology/research/danielfisher> (our WebGL models will also be accessible from this location). Future expansion of this project will continue to incorporate scans of additional specimens and taxa, leading to a range of research and educational applications within both academic and museum settings.

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The fat of the land: tales from a Gravettian hearth (27,000 years BP) at Krems-Wachtberg (Lower Austria)

Florian A. FLADERER ✉, Tina SALCHER-JEDRASIAK, and Marc HÄNDEL

The last two decades provided a number of publications using mammalian bone element abundances and breakage patterns to approach the reconstruction of fat yields from prey bodies (e.g. Blumenschine & Madrigal 1993, Outram 2003, Morin 2007). Apparently these were all inspired by the "palaeonutritional" pioneer study by Speth & Spielmann (1983), which had largely been influenced by John D. Speth's own archaeozoological research. At the same time, on a more public level amusing debates took place between proponents of a fat-rich, low-carbohydrate "palaeodiet," allegedly approved by millions of years of hominin history, and another party propagating a rather designed high-protein life-style based on a decisively low-fat diet. The important role of amino acids or more generally speaking, protein, at least, has been strongly emphasized by the studies of physical anthropologists (e.g. Milton 1999).

This presentation is mainly based on the recent analysis of bone fragments, which are mainly from mammoth, wild horse and reindeer, and their spatial distribution inside and around a 1.5 m diameter fireplace at a 27,000 BP Gravettian camp site by the Danube (Fladerer et al. 2012). The title is inspired by the archaeologist and ethnographer Vilhjalmur Stefansson (1961) who demonstrated in a laboratory setting that he could live on a 100% meat diet for several months based on his observation that Inuit eat only meat and fish for six to nine months. This represents a low-carbohydrate diet based on ca. 60 % of total calories from animal fat and max. 30% from proteins. "Carnivorous" ethnicities traditionally gather wild fruits and seeds, if available in their landscapes but the main supply of plant micro-nutrients is also consumed via the stomach contents of the herbivorous prey (e.g. Eidlitz 1999). These observations serve as models for the reconstruction of butchering practices of the mammoth steppe people. Archaeological evidence indicates some nutritional role of seeds, fruits and roots in the diversified palaeolandscapes of Central Europe (e.g. Revedin et al. 2010), but results establishing these to be a substantial source of carbohydrate or fat are not available.

Archaeozoology has a long tradition documenting bone destruction and marrow extraction from ungulate bones as an important subsistence activity for ice age people, but only a few reports have been published considering Proboscideans (e.g. Yravedra et al. 2012). Two incorrect arguments have been repeatedly used even in the scientific literature, namely that the interior of elephant limb bones lacks marrow cavities (Fig. 1) and secondly that elephant limb bone is too thick to be broken without modern tools. References and detailed observations (e.g. Haynes 1991, pp. 290) were likewise ignored.

We detected heavy breakage of marrow-bearing mammoth limb bones into small pieces and we ask why the majority of these greasy bones were left unburned around the hearth (Fig. 3). Artefacts from these bones are very rare in regional sites and thus tool manufacturing can be broadly excluded, as can the primary use of bone for fuel, a conclusion supported by the abundance of charcoal. We rather argue that compact and spongy bone were reduced to smaller pieces on the spot around the hearth (Fig. 2) in order to render the marrow more liquid by use of the heat allowing the fat to be slurped from the fragments in a manner similar to reports from Central Africa (Fisher 1992). We further suppose that the Gravettians were aware of the core of pure marrow present in some limb bones (compare Fig. 1) as well as its seasonal oscillations in fat content and taste. Grease-rendering is not testified from the actual data, but, incidentally, grease-rendering without using heated stones is quite feasible in bark, hide and stomach containers, though obviously almost impossible to prove (Speth 2012). Archaeological signatures of subcutaneous and visceral mammoth fat exploitation are not available, too, but ethnographic analogy (e.g. Duffy 1986, Bailey 1989) suggests highest probability also for Palaeolithic people.

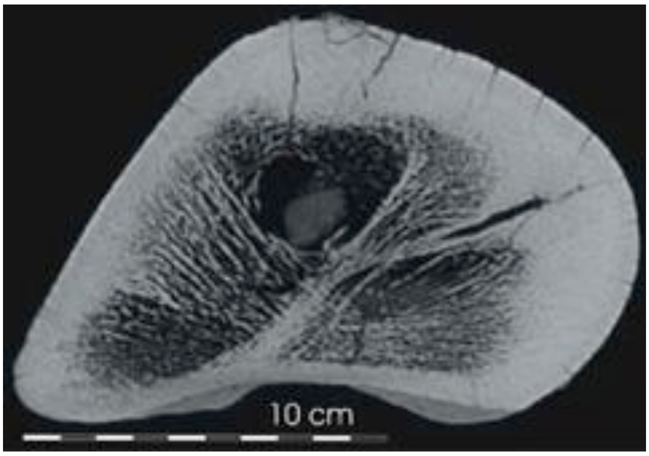

Fig. 1. Radiography of a *Mammuthus primigenius* humerus (mid shaft position) from Krems-Hundssteig (Hu 76/1; Fladerer & Salcher-Jedrasiak 2008), Lower Austria. Please note the marrow cavity without spongy tissue.

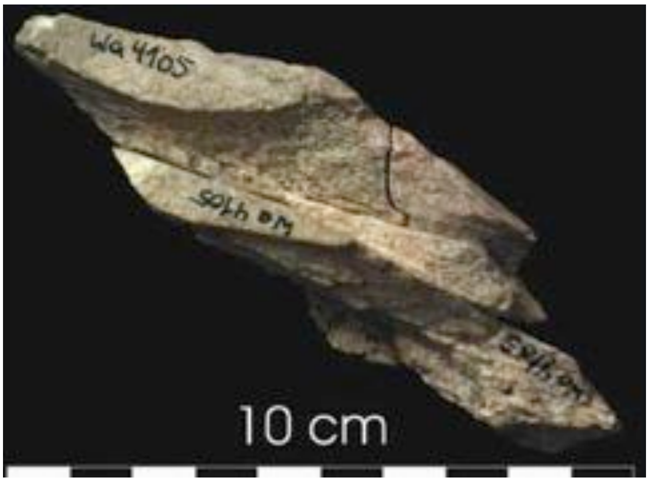

Fig. 2. Example of refitted compact limb bone fragments (bone flakes) with impact scar from Woolly mammoth, archaeological layer AH 4.4, living floor around the hearth 1 at Krems-Wachtberg (Wa 4105 refitted). Position see red circle in Fig. 3.

Mammoths played an important role by providing life-supporting oleic acid and other fatty acids in the Gravettian nutrition, at least for the Middle Danube region. The targeting of proboscidean marrow has probably been a vital activity, at a minimum, during bottlenecks caused by seasonal or periodic food shortage.

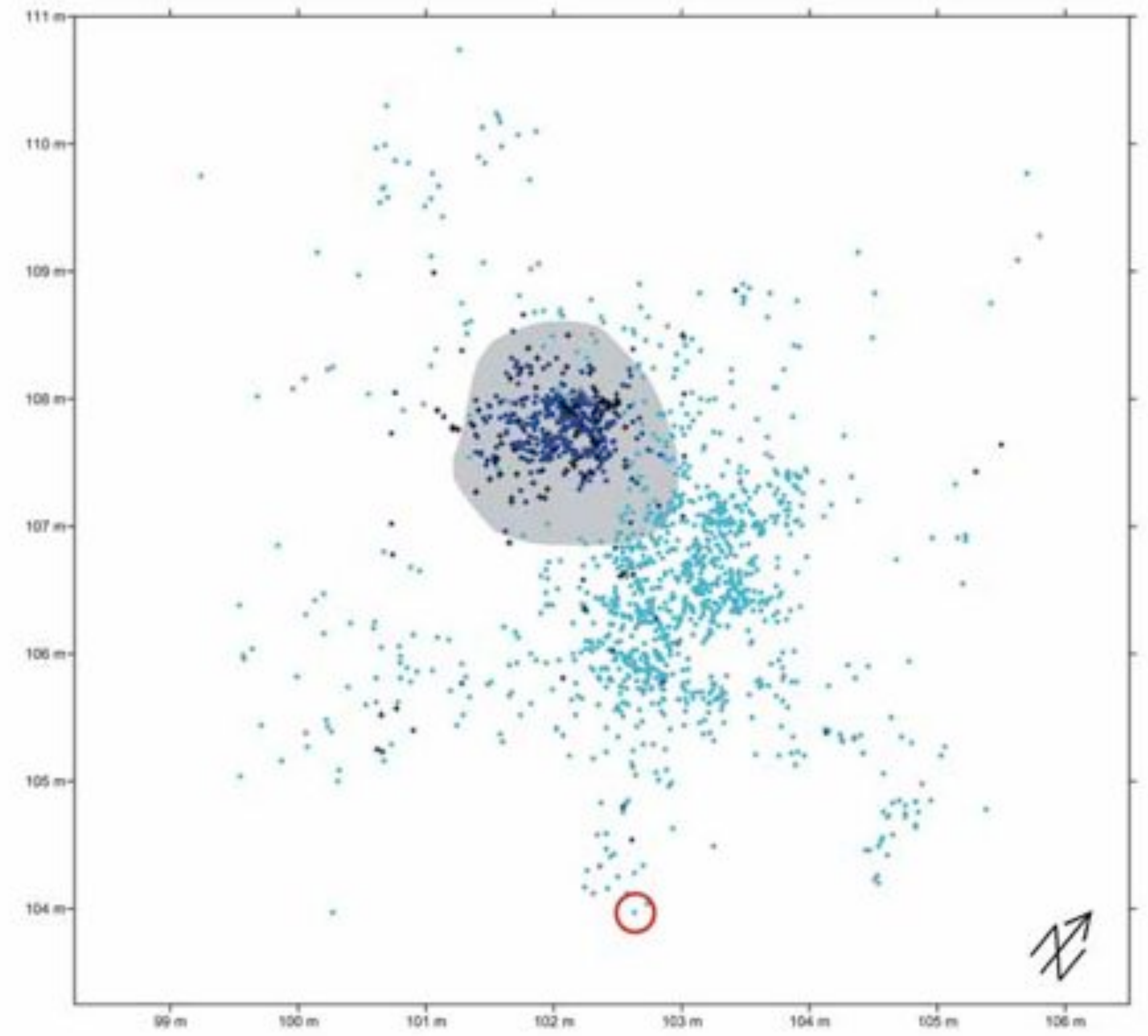

Fig. 3. Spatial distribution of Woolly mammoth bone fragments (including "very probably mammoth bone") within the hearth and archaeological layer AH 4.4 at Krems-Wachtberg.

Legend: **++**: axial elements (rib, vertebra, sternum); **dots**: limb bones, coxae, compact bone; **thin/light blue**: unburned to slighly scorched; **bold/dark blue**: fully burned, shaded area: maximum extension of the fire place in the second of three chronological hearth use phases; **red circle**: position of refitted limb bone example (Fig. 2). Please note the unburned - potentially greasy - bone fragments outside the fire place indicating that bones were not used as fuel.

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Palaeoloxodon Elephant from the Pleistocene of Southwestern Siberia (Russia)

Irina FORONOVA ✉

During the Pleistocene, representatives of the mammoth lineage occurred extremely widely all over the territory of Eurasia. Elephants of the genus *Palaeoloxodon* Matsumoto, 1924 were not as numerous, but their distribution covered most part of Eurasia as well. Abundant finds of these so-called «forest elephants» have been recorded in Europe (Italy, France, Spain, England, etc.) as well as in India, Japan, and China.

Individual fossils of these elephants have been described from Early(?) and Middle Pleistocene localities of Eastern Europe (south-west of Russia, Moldova, Ukraine), Kazakhstan and Turkmenistan as the species *Palaeoloxodon antiquus* (Falconer et Cautley), with several subspecies (Garutt, Vangengeim, 1982). These finds correspond to deposits of the Likhvin Interglacial (Singilian fauna) which is synchronous to the Holsteinian Interglacial (North-European Scale) or the end of Late Galerian — beginning of Aurelian (Italy), the time of acme of paleoloxodont elephants in Western Europe.

As for Siberia, the finds of *Palaeoloxodon* are very rare. Isolated molars and their fragments were found on Aldan river (Lena river basin, Eastern Siberia) and on Irtysh and Ob' rivers (Ob' Plateau, Western Siberia). They were referred to *Palaeoloxodon namadicus* (Falconer et Cautley) and dated as Early and Middle Pleistocene by (Vangengeim, Zazhigin, 1969).

Recently, a fragment of a skull with three molars (M^3 dex, M_3 dex and M^2 sin) has been found in the supposedly Middle Pleistocene deposits on the Sharap river (one of the Ob' river feeders) in southwestern Siberia. The M2 is heavily worn out, while both last molars are in good condition: they are in the initial stage of wear (each molar has 1-2 broken plates in the rear part of the crown). Parameters of upper and lower third molars (respectively) are as follows: molar length: 280 and 330 mm; crown height: 250 and 200 mm; width: 80 and 85 mm; plate number: 16 and 17; average plate frequency 5.5-6.0 and 4.0-5.0 per 100 mm; highly folded enamel, average plate thickness: 2.0-2.5 mm (Fig. 1).

These morphometric data, proportions of crown, high hypsodonty and low plate width differentiate these molars from the ones of the mammoth lineage, allowing to attribute them to the genus *Palaeoloxodon*. Important fact is that in length and height the crowns of these molars are similar to *Palaeoloxodon namadicus*, while the crown width, the plate frequency and the antiquoid incipient wear figures correspond to *Palaeoloxodon antiquus*.

Rare finds of paleoloxodont elephants in Siberia indicate that their expansion to the East and North of Eurasia were impeded by continentality of the climate and environmental conditions that were drastically different from West-European environments. During cold epochs (when open landscaped were predominant in most part of the Eurasia) these elephants survived only in the warm and moist forests of Southern Europe. In warm epochs paleoloxodonts were expanding to Middle and Eastern Europe and partly to Siberia, following the advancement of the forest zone. In this territory they could inhabit softwoods of moderate type with pine, larch, birch, alder and osier.

Fig. 1. *Palaeoloxodon* aff. *antiquus* (Falconer et Cautley), #21748(2), lower right third molar from Ob' River basin, Novosibirsk region, South of Western Siberia, Russia. (Collection of Novosibirsk State Museum of Local History and Nature). A, occlusal view; B, buccal view.

The findings of elephants of the genus *Palaeoloxodon* in Siberia, although extremely rare, indicate that we should pay closer attention to the expansion and the habitat of this branch of proboscideans in Asia.

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Woolly mammoth (*Mammuthus primigenius*) carcasses from European great plain mass death sites as an important food resource of the cave hyaenas (*Crocuta crocuta spelaea*) during the Late Pleistocene

Philippe FOSSE ✉, Mietje GERMONPRÉ, and Dick MOL

Taphonomic studies on Late Pleistocene large carnivores are common in Europe and occur mainly in deposits in karstic contexts; their sedimentary sequences have frequently recorded the nature and chronology of animal activities (multi-carnivore occupations and ungulate-carnivore relationships). The many cavities formed natural traps for ungulates and/or were used as dens by carnivores, especially the fossil spotted hyaena (*Crocuta crocuta spelaea*). Medium- and large-sized ungulates (cervids, equids and large bovids) provided the main prey found in the caves, along with megaherbivore (i.e. > 1000 kg) remains. Woolly rhinoceros (*Coelodonta antiquitatis*) and woolly mammoth (*Mammuthus primigenius*) are usually represented by milk teeth, and small unfused bones, shaft fragments, isolated carpals, tarsals and phalanges; their remains rarely exceed 100 bones/den, although Camiac, Perick and Teufelslucken are exceptions. The taphonomic signature of the cave hyaena-megaherbivore interaction is thus difficult to determine in karstic sites.

In order to estimate cave hyaena consumption patterns, such as the intensity of breakage and tooth marks, on very large bones, a taphonomic study was undertaken on two open air sites which had yielded numerous adult mammoth remains. Although the contexts of these discoveries, from early 20th century excavations and dredging in the North Sea, preclude many of the taphonomic observations usually made on in situ carnivore samples, such as articulations, the presence of coprolites, etc., the excellent preservation of bone surfaces and the quantity of available remains has enabled us to conduct a survey of cave hyaena activity on mammoth carcasses.

In Belgium, the site of Hofstade was recently the object of a palaeontological revision and a first taphonomic analysis (Germonpré, 1993). This rich fluviatile deposit is dominated by the woolly rhinoceros (NISP=444, MNI=34 (Germonpré, 1993: 278, table 2 and Germonpré, 2003: 175, table 2) and also by the woolly mammoth (NISP=508, MNI=30 (Germonpré, ibid). These two species comprise almost 75 % of the bone sample. Large carnivores, although very rare, are present in the bone assemblage with only one bone belonging to the cave hyaena and three of the brown bear, *Ursus arctos* (Germonpré, ibid).

In the South Holland Province of the Netherlands offshore economic and industrial activities in the harbour area and natural erosion of the coastal sandy sediments, allowed large quantities of palaeontological remains to be collected over several years. On-going geo-location of palaeontological discoveries has identified two main occurrences which yield bones: on the sea bottom at Eurogeul and on the coast at Maasvlakte 2 (Mol et al., 2006). The samples present an interesting taxonomic diversity, ranging from rodents to proboscideans and highlight the biochronology of sites over climatic sequences: the last interglacial, with hippopotamus and straight-tusked elephant and, particularly the last glacial, with woolly rhinoceros and woolly mammoth. The relatively frequent large carnivores, are dominated by cave lions (Panthera spelaea) followed by cave hyaenas, the latter identified by bones and, more recently, by coprolites (Reumer et al., 2010).

Our study describes a survey of skeletal elements from adult mammoth carcasses consumed by hyaenas at the two palaeontological sites. The location of hyaena tooth marks on bones, their morphotypes (scores, pits, punctures) and their size are presented to establish the taphonomic characteristics of this major predator/scavenger on proboscidean carcasses. Mass death sites can provide unique information on carnivore activities and taphonomic studies on such primary feeding places are necessary to reconstruct the diets of these predator/scavengers.

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Proboscideans (*Palaeoloxodon antiquus, Mammuthus meridionalis/trogontherii*) and first human settlements in France: taphonomic consideration from Soleilhac (Haute-Loire)

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The site of Soleilhac in the Massif Central (Haute-Loire) is one of the oldest archaeological sites in France. Interesting paleontological remains were found in the first half of the XIXth century at the site called « Soleilhac-ferme », with more than 500 bones, ascribed (according to a recent revision by Lacombat, 2005) to *Praemegaceros solilhacus, Cervus acoronatus, Dama clactonia, Hemitragus bonali, Bison schoetensacki, Hippopotamus antiquus, Equus altidens, Equus süssenbornensis, Stephanorhinus hundsheimensis, Mammuthus trogontherii, Ursus deningeri*.

At the beginning of 1970s, geological research in this geographical area allowed E. Bonifay to discover new paleontological remains of straight tusked elephant, P. antiquus in a similar fluviatile context. This new site was called "Soleilhac-centre". Although this new deposit cannot be stratigraphically correlated to the "historic" paleontological records between both localities seem similar from a biochronological point of view and are supposed to be contemporaneous.

In Soleilhac-centre, an area of 400m2 approximately was excavated and allowed to find a paleosurface (Bonifay, 1989, 1991, 2002) yielding paleontological remains (NT=3000; NISP=724) and lithic artefacts (N=500) of mode I (Turq & Fosse, 2012). The paleontological sample is extremely fragmented due to weathering and diagenetic compression.

Identified species (Bonifay & Bonifay, 1981 ; Aouadi, 2001) belong mainly to Cervus acoronatus and Praemegaceros solihacus (NISP =558) and then to Proboscideans (NISP = 134 ; MNI = 8). Most of the remains have been attributed to Palaeoloxodon antiquus but some teeth belong clearly to a mammoth group (*M.meridionalis/ ? M. trogontherii*). Other species of Ungulates (bison, rhino, horse) or Carnivores (*Canis etruscus*, cf. *Lynx* and *Vulpes* sp.) are very rare (< 5 bones/species). This paleontological record is correlated, according to the magnetostratigraphic (Thouveny & Bonifay, 1984) and biochronological comparison with other European sites, to the Jaramillo subchron. Recent biochronological revisions of main European archaeological records allow to correct this age, during the Brunhes episode, between 0.6 and 0.78 m.a..

From a taphonomic point of view, if skeletal elements of cervids seem to result from a human exploitation (no cutmarks on bones but postcranial elements are highly fractured), the anthropogenic intervention on Proboscidean bones is not evident. The sample includes isolated teeth (NISP=38), vertebrae (NISP=32) and ribs (NISP=25), then tusks and some isolated appendicular elements. The mortality profile raised from teeth shows that 12-24, 24-36 and 0-12 years (sensu Haynes, 1991) age classes respectively are, represented the best. The frequency of skeletal elements, correlated with the standardized disarticulation sequence (sensu Hill, 1979) suggests a relatively long time of exposure (abundance of ribs, vertebrae and presence of innominates). Bones also present taphonomic modification produced by water (erosion, dissolution). All of these taphonomic indications/evidences suggest that Proboscidean remains are of natural origin. By these paleontological (presence of Proboscideans) and taphonomic (none-low exploitation of Megaherbivore carcasses) characteristics, the sample from Soleilhac appears to be similar to that of other European and African sites yielding evidence of human occupation and confirm that natural death sites in fluviatile contexts were systematically occupied by Lower/Middle Pleistocene hominids.

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Woolly mammoths (*Mammuthus primigenius*) in southern France during the Late Palaeolithic: a geo-chronological assessment based on the palaeontological, rock art and portable art records

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Woolly mammoths (*Mammuthus primigenius*) are characteristic components of the cold Pleistocene fauna of Western Europe. Found mostly in sites from the North European great plain, their geo-chronological distribution further south is less-precisely known due to the paucity of direct dating and palaeontological surveys.

Evidence for the presence of woolly mammoths during Marine Isotopic Stages MIS 4, MIS 3 MIS 2 and, possibly, MIS 1 is derived mainly from karstic contexts. The goal of our contribution is to survey the implications of their spatial and chronological occurrence in natural traps and anthropological sites; based on undoubted palaeontological and artistic evidence, we consider symbolism in the parietal and portable art of the main Late Palaeolithic cultures of southern France.

From a paleontological point of view, the woolly mammoth is present in faunal records during isotopic stages 4 and 3, in anthropological sites (rock shelters, caves) but this species does not constitute an important part of the food resources. The woolly mammoth is also identified in hyena dens and natural traps, with other tundra steppe Megaherbivores, in particular, the woolly rhinoceros (*Coelodonta antiquitatis*), especially during late MIS 3 and beginning of MIS 2. During MIS 2, the mammoth is still present locally but in a few archeological sites (eg: Solutrean of Laugerie Haute in Dordogne) then the question of its presence in the Southwest of France arises for all the Tardiglacial cultures (Magdalenians). Indeed, from the end of Solutrean, the mammoth is identified only from some (small) pieces of ivory and these paleontological elements were able to be transported from other geographical regions (Bahn, 1984; Clot & Duranthon, 1990; Delpech, 1983; Guérin, 1980). From the Dordogne to Pyrenees, there does not seem to be a convincing information on the presence of the mammoth from the stratigraphical, archaeological contexts and the radiocarbon dates after 15000 ky BP approximately.

In the rock Art and portable Art records, the geo-chronological distribution of the species is different. If the number of representations is approximately the same since Aurignacian until the Magdalenian (250 paintings and engravings for Aurignacian, Gravettian and Solutrean; 260 for the Magdalenian), differences are to be noted concerning the frequency of sites yielding paintings and engravings of mammoth (29 for Early Upper Palaeolithic against 14 for the Magdalenian: Gély & Azéma, 2005). During the Aurignacian and/or Gravettian, the mammoth is common in several caves (Arcy/Cure, Chauvet Pont d'Arc, Baume Latrone, Pech-Merle) and become rare from the Solutrean. In the Magdalenian, only some caves of Dordogne (Bernifal, Combarelles, Rouffignac) contain important representations of mammoth (Gély & Azéma, 2005). In all other geographical areas, the mammoth is poorly represented in rock art. In the Magdalenian, there is a clear change, with an increase of representations on portable art (bone and ivory of mammoth engraved). The figuration of mammoths on portable supports could be explained by exchanges between Palaeolithics or by geographical movements by these human groups.

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Histological evaluation of tissue structure preservation in the Malolyakhovski mammoth

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Success in the comprehensive research on mammoth and accompanying fauna largely depends on the degree of preservation of soft tissue in cadavers of these ancient animals, which are unique finds of great value to science.

In order to determine the state of cellular and tissue structures, we conducted a histomorphological study of fragments of a carcass of an adult female mammoth found on the Malyi Lyakhovsky Island (New Siberian archipelago) in August, 2012.

Results of the first histological studies of the tissues of the Malolyakhovski mammoth trunk demonstrated varying degrees of preservation of tissues. Histological sections obtained in the imaging of tissue fragments show striated muscles, dense unformed connective tissue, and fragments of adipose tissue in the form of large clusters of fat cells (white adipocytes) with an optically empty cytoplasm, surrounded by a rough thin shell (Fig. 1).

Blood vessels of muscle type were found on the histological slices of tissue samples from the distal part of the mammoth's trunk. In this case, the vessel lumen is filled with a homogeneous mass of yellowish- pink color, probably a well-preserved clot of hemolyzed blood (Fig. 2). Under a light microscope it is possible to distinguish the rough form blood cells membrane. Moreover, in the walls of small blood vessels blue-violet nuclear elements were revealed of unevenly shaped undifferentiated cells, probably endothelial cells.

Thus, the results of the first histological researches of the tissue fragment of the Malolyakhovski mammoth trunk show the relative preservation of cellular and tissue structures. For the first time, histological samples of the mammoth trunk revealed soft tissues, a blood vessel of muscle type with a homogeneous mass, more like the hemolyzed blood clot. In earlier reports from studies of mammoth soft tissues only histologically differentiated and empty vessel lumens were described, which is typical for tissues exposed to severe mummification. Further histological studies of the soft tissue and internal organs of the Malolyakhovski mammoth will continue after the remains of the carcass are delivered to Yakutsk.

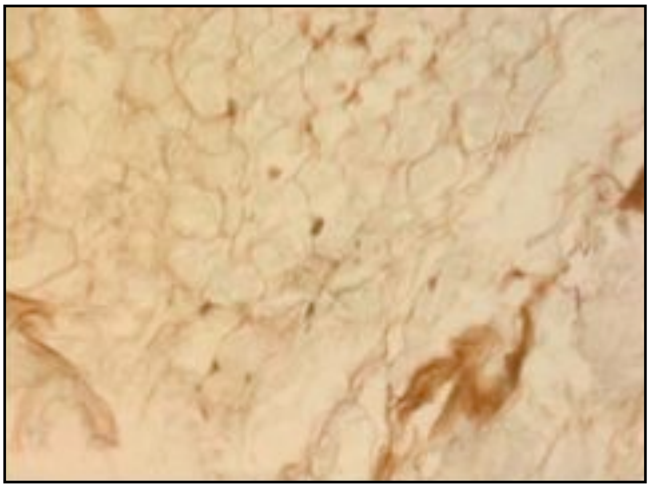

Fig. 1. Fragments of adipose tissue in the form of clusters of irregular shapes of white fat cells with clear cytoplasm in the soft tissues of the mammoth trunk (Inverted microscope Carl Zeiss, Axio. X 400).

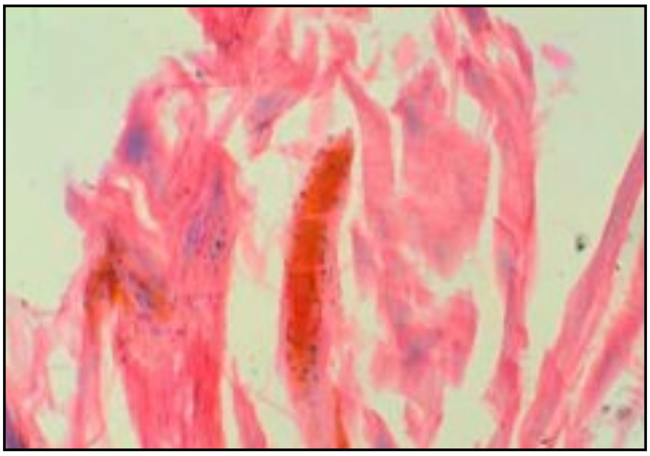

Fig. 2. Soft tissue of the distal part of the adult female mammoth's trunk. In the center of the blood vessel is a muscle-type small-caliber lumen, filled with hemolyzed blood. Hematoxylin and eosin. X 200.

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Discovery of a woolly mammoth (*Mammuthus primigenius*) carcass from Malyi Lyakhovski Island (New Siberian Islands)

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Grigoriy SAVVINOV, Gavril NOVGORODOV, Maksim CHEPRASOV, Sergei FEDOROV, and Evgeniy IVANOV**

A partial carcass of an adult woolly mammoth (*Mammuthus primigenius*) was found on Malyi Lyakhovsky Island in mid-August 2012 by mammoth tusk collectors. This island is located in the Laptev Sea and is one of the New Siberian Islands. The remains were found 200 m from the northeast coast of the island, on a low hill. Originally exposed material included several bones, skull fragments, and the trunk, which lay on the left tusk.

Excavation of this mammoth was undertaken in May 2013, by staff of the Institute of Applied Ecology of the North, North-Eastern Federal University. Only the lower half of the mammoth carcass remained intact (Fig. 1); this was removed from the permafrost and delivered to the settlement of Kazachie (Ust'-Yanskiy district). In August, 2013 an international group of scientists (the authors of this article and the South Korean biotechnology research group Sooam) conducted a preliminary examination of the carcass with sampling for different types of analysis.

The following parts of the body were preserved with soft tissues covered by skin: the lower part of the head, part of the trunk (Fig. 2A), the lower neck and belly, the front legs, and the distal half of the right hind leg. In its visual impact, the best-preserved region is the trunk, where muscle tissues even have a natural, red color. Forelimb muscle tissues are less well preserved and are brownish in color. Much of the remaining skin, especially around the mouth, retains its elasticity.

Remaining upper parts of the body – the skull, vertebrae, dorsal parts of ribs, right innominate, right femur, and the left hind leg – recovered from the surface of the tundra, were gnawed by predators or scavengers and are represented only by separate bones. During the excavation, most of the vertebrae and about half of the ribs were not recovered, suggesting that they were removed by scavengers. The left innominate is also absent, and the skull is broken into several pieces. In the hind portion of the carcass, the left leg was in anatomical association, pulled back in a horizontal position, with wool and fat tissue preserved around the knee and foot.

The upper teeth (Fig. 2B) are deeply worn (anterior plates worn to the roots) and are smaller (length ≈ 15 cm) than would be expected for M3s. Both are abnormally curved (concave toward the midline). Curvature of the left is more extreme, but the right is additionally affected by resorption along its lingual margin. In contrast, both lower teeth are m3s with normal configurations and lamellar frequencies of about 9.0 (Fig. 2C). The wear stage of the left m3 matches Laws' (1966) age group XXV (the right is slightly more advanced), suggesting an

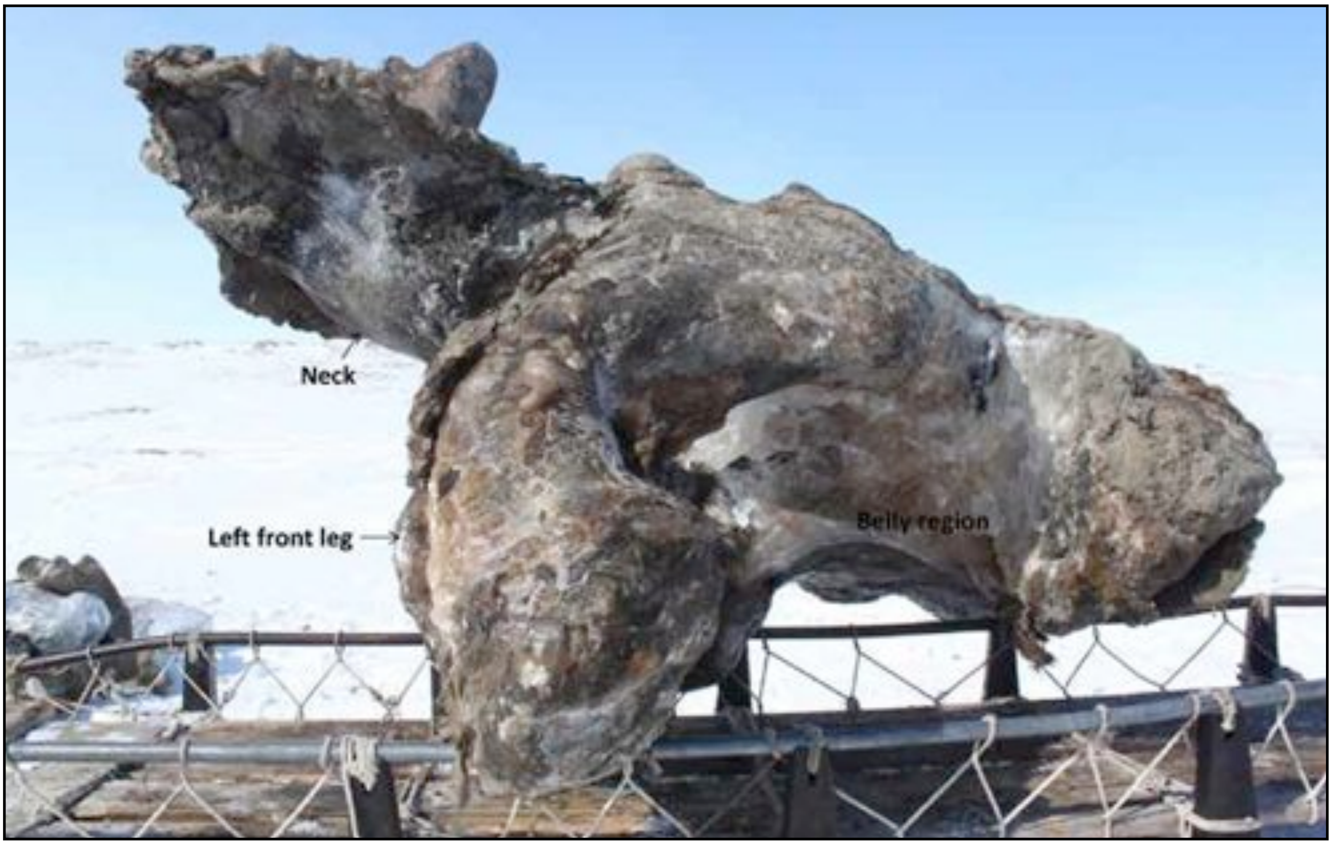

Fig. 1. Side view of mammoth carcass from Malyi Lyakhovski Island (New Siberian Islands).

Fig. 2. **A**, trunk; **B**, maxilla; **C**, left m3 of the woolly mammoth carcass from Malyi Lyakhovski Island (New Siberian Islands).

age of about 47 yr. If the uppers are M3s, it is unusual for them to be more advanced in wear than the lowers (normally, lowers are more advanced). The uppers may therefore be M2s that did not progress anteriorly in the normal fashion because of their contorted form, inhibiting development of the M3s. Occlusion of the uppers, first with m2s and then with m3s, would explain their advanced attrition.

The size and shape of the tusks, the small size of the body of this fully adult individual, and discovery of well-developed nipples and mammae on the anteroventral aspect of the thorax all imply that this was a female. The right tusk weighs 17.6 kg and is 207.5 cm long on its outside curve, with a basal circumference of 26.8 cm and a circumference of 27.9 cm at mid-length. The left tusk weighs 16.6 kg and is 223 cm long on its outside curve, with a basal circumference of 25.4 cm and a circumference of 29.7 cm at mid-length. The length from the anterior edge of the sole of left hind foot to the knee joint is 54 cm. Anteroposterior length of the sole of the left front foot is 34 cm. The right rear foot is 31 cm long, with a maximum width of 27.5 cm.

The height of this mammoth, computed following the method of Dubrovo (1982), was 230 cm. Adding 5% to account for missing soft tissues, height at the shoulders was about 240-250 cm.

During excavation in ice cavities below the belly and underarm area in two places, there was an accumulation of small amounts of dark-brown liquid, 3 ml of which were transferred to two tubes. Speculation that this is blood has not yet been confirmed, but erythrocytes from blood vessels in the trunk have been detected. The remaining part of the visceral cavity is still mostly covered by permafrost; for this reason, we cannot yet judge the condition of remaining internal organs. Wool samples from different parts of the body were collected. Although the wool coat from most parts of the skin is preserved, hairs have separated from the skin surface as a result of destruction of the epithelial layer and subsequent freezing in water.

This carcass of a mammoth from Malyi Lyakhovsky Island is the best-preserved specimen of an adult female woolly mammoth. The animal appears to have been trapped in a depression that accommodated about half the body volume. Water later filled the depression and froze, preserving part of the carcass. The carcass remained in excellent condition for thousands of years because the severe climatic conditions of the Arctic islands kept it locked inside almost pure ice, which never melted.

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Diet and habitat of *Mammuthus columbi* (Falconer, 1857) from two Late Pleistocene localities in Central Western México

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In México, there are few studies with stable isotopes of carbon and oxygen and dental microwear for inferring diets and the habitat of fossil mammal populations, while in the World there are some studies assaying together the two methods. It is considered that it could be important to apply both two methods to complement the information obtained in each case.

This study aims to infer the diet and the habitat of mammoths from La Cinta-Portalitos (LC-PT) and La Piedad-Santa Ana (LP-SA) (Michoacán-Guanajuato, Mexico), using those two methods.

La Cinta-Portalitos is located on the northern side of Cuitzeo Lake within the coordinates 20 ° 05 '09 "N. and 101 ° 09 ' 31 "W. La Piedad-Santa Ana is located on the banks of the Lerma River, within the coordinates 102 ° 02'-102 ° 54 ' N and 20 ° 23' -20 ° 19 ' W. The distance between each other is approximately of 94.33 km (Fig. 1)

For the isotopic analysis, of *M. columbi*, 6 from LC-PT and 5 from LP–SA were used. A sample of 40 to 50 mg of enamel per molar was extracted and were treated using the method proposed by Pérez-Crespo et al. (2011) Finally samples were sent to the Institute of Geophysics (UNAM) to obtain the isotope ratios. A Chi square test (X2) was performed to compare values between localities. An analysis of variance (ANOVA) and a Tukey-Kramer test were assayed to compare the values with populations of *M. columbi* from localities in the USA (Koch et al., 1998; 2004) and Mexico (Pérez-Crespo et al., 2012). To infer habitat preferences, it was used a model proposed by Feranec and MacFadden (2006).

For samples of dental microwear, epoxy molds of 3 M3 from LP-SA and 3 M3 of LC-PT were made, following the methodology proposed by Solounias and Semprebon (2002) and Rivals et al. (2012).

Stable Isotopes: It is observed two individuals as grazers and four as mixed feeders in LC –PT and the five from LP -SA as mixed feeders (Table 1). The Chi square test (X2) with $\delta^{13}C$ showed no significant differences between populations (X2=0.9924, DF=1, Prob> X2=0.3191). However, for the values of $\delta^{18}O$ there are significant differences (X2=6.9736, DF=1, Prob> X2=0.0083).

Table 1. Isotopic ratios for Mexican *Mammuthus columbi* from LP-SA and LP-SA

Catalog number	Locality	δ^{13}CVPDB (‰)	δ^{18}OVPDB (‰)	%C4
CPOEI 282	LP- SA	-5.752281275	-7.735903393	44.9847915
CPOEI 283	LP- SA	-4.266389308	-5.955051537	54.89073794
CPOEI 284	LP- SA	-4.23427621	-6.506577877	55.10482527
CPOEI 285	LP- SA	-4.089704299	-5.796894178	56.06863801
CPOEI 286	LP- SA	-3.765321602	-6.029544624	58.23118932
UM 725	LC-PT	-4.600491469	-4.233540322	45.07462422
UM 726	LC-PT	-4.351646437	-5.491840265	52.66339021
UM 52	LC-PT	-3.359162787	-5.634308414	54.32235709
UM 8	LC-PT	-4.117273635	-3.814803036	60.93891475
UM 9	LC-PT	-1.050066658	-4.804263072	55.88484243
UM 148	LC-PT	-2.131919215	-4.245966467	76.33288895

Fig. 1. Location of LC-PT and LP-SA.

The ANOVA and Tukey-Kramer showed no significant differences in $\delta^{13}C$ values between populations from localities in the USA and Mexico (ANOVA Prob>F=0.00161) and it was observed significant differences in $\delta^{18}O$ values (ANOVA Prob>F=0.0001). The results shows that both LC–PT and LP-SA populations preferred open habitat areas (Fig. 2). Dental microwear analysis shows that the populations of M. columbi are grazers in both sites (Table 2; Fig. 3)

The results of isotopic analyses show both grazers and mixed organisms. Grazers individuals have a high percentage consumption of C4 plants at 69% and 76% for LC–PT and LP-SA, respectively. In addition, no significant differences in diet between populations of *M.columbi* in both study areas were observed, showing on average a mixed diet and a habitat preference for open areas. However, the $\delta^{18}O$ values show significant differences between both study areas and localities of Mexico and the United States, perhaps this may be because the source of water supply and weather conditions were different.

Analysis of dental microwear reveals that populations were grazers, with not differences between them. When comparing the results of both techniques it is observed that the isotopic ratios also reveal a high percentage of consumption of C4 plants so we can conclude that these populations of M. columbi were mixed feeders with a tendency to be grazers, since the dental microwear shows the characteristics of the last meal of the animal (Rivals et al., 2012)

The populations of *Mammuthus columbi* from La Piedad -Santa Ana and La Cinta- Portalitos were mixed feeders with a tendency for grazing, and an habitat preference for open areas, so both localities had both grassland and forested areas during the late Pleistocene.

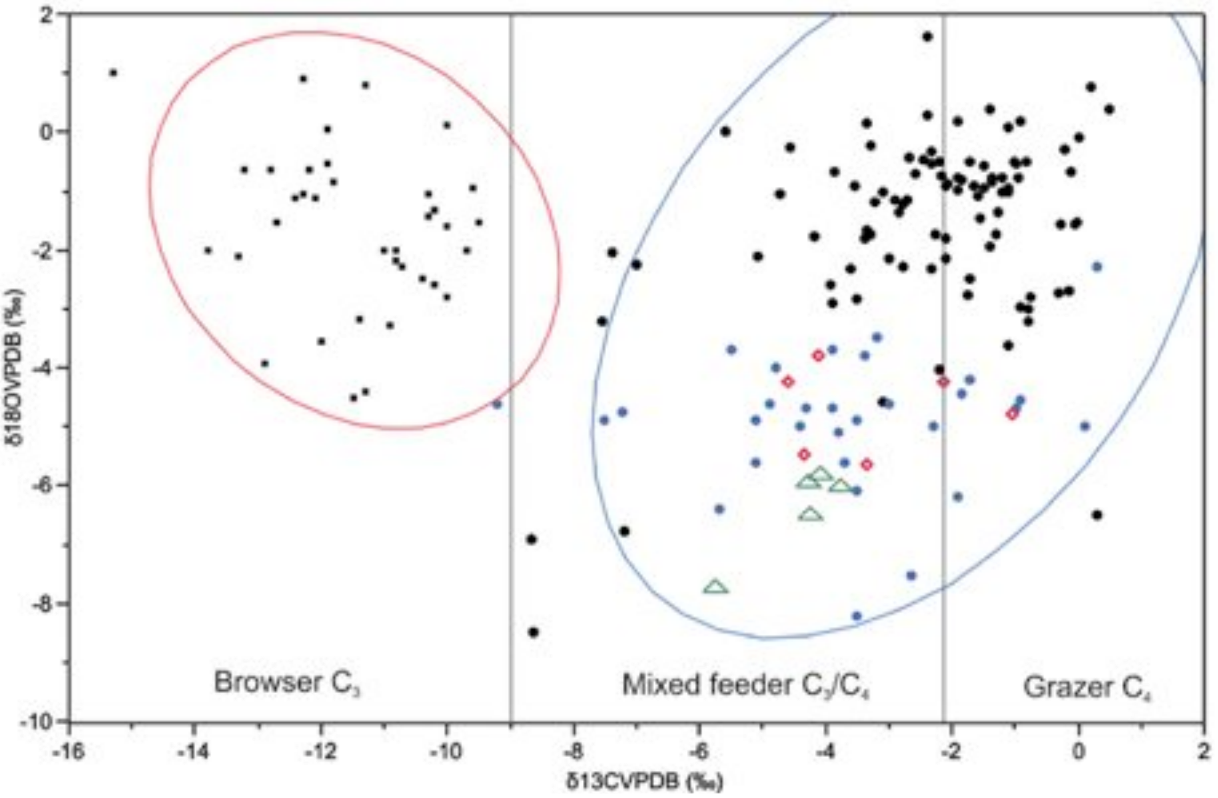

Fig. 2. Isotopic ratios of *M. columbi* from LC-PT (red diamond), LP-SA (green triangle), USA (black circle), and México (blue circle); and organisms that lived in closed areas (black square) (*Mylohyus, Mammut, Tapirus,* and *Odocoileus*).

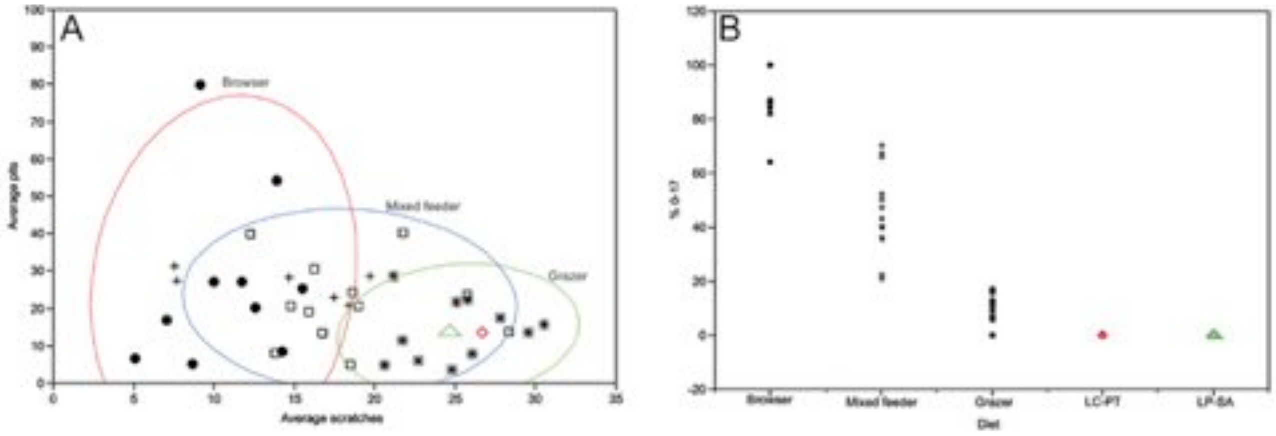

Fig. 3. **A**, Average pits and scratches of browser, Mixed feeder and grazer organisms (Solounias and Semprebon 2002; Rivals et al.2012). **B**, Percentages of organisms within 0 and 17 scratches per area.

Table 2. Average values of the populations of each locality.

Locality	N	Average pits	Average scratches	% Cross scratches	% Large Pits	% Gouges	% Fine Scratches	% coarse Scratches	% Mixed scratches	% 0-17
LC-PT	3	13.67	26.67	100	0	100	43.75	16.25	40.00	0
LP-SA	3	14	24.67	100	0	0	48.65	18.92	32.43	0

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Trauma, injury, and bone lesions in an African elephant population

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A number of pathological or abnormal specimens of bones, tusks, and teeth have been observed in a sample of nearly a thousand African elephant skeletons examined during three decades of actualistic fieldwork in Zimbabwe's wildlife reserves (Fig. 1). This presentation describes some specimens and compares them to similar prehistoric examples seen in mammoth and mastodon assemblages.

The most common traumatic injury to *Loxodonta* osseous tissue is tusk-fracturing from head-on fighting or aggressive jostling at water sources. Elephants in different regions of Africa break tusks to different degrees, depending on annual rainfall variations that affect competitive feeding and drinking behavior (Steenkamp et al. 2007). In Zimbabwe, the breaks do not result from the use of tusks in digging or lifting, but from direct percussive impact of the tips against the bodies or tusks of other individuals.

Loxodonta ribs are frequently broken. This sort of injury is not uncommon in very large animals. The famous *Tyrannosaurus rex* dinosaur skeleton nicknamed "Sue" has three fractured ribs of unknown cause, one of which did not form a union of the broken segments, and marine megamammals such as Fin and Humpback whales also suffer rib fractures from (presumably) killer whale attacks (Hellier et al. 2011), similar to what has been recorded on North American Mosasaur skeletons of the Late Cretaceous (Everhart 2001-2012; http://www.oceansofkansas.com/mosapath.html). *Loxodonta* has no predators capable of inflicting such injuries; their traumatic fractures result most likely from aggressive shoving, although accidental falls or deliberate rolling in dust or mud also may account for the blunt trauma. Fully or imperfectly healed rib fractures are surprisingly common in male and female *Loxodonta* in Zimbabwe's game reserves, occurring at a very roughly estimated frequency of 10% of individuals, based on observations of skeletons from drought/starvation deaths and culling operations. Instances of incomplete healing and complete repair of broken ribs also have been noted with mammoths (e.g., Kirillova et al. 2012).

Traumatic spiral-fracturing of *Loxodonta* limb bones are known from a few cases that led to death before callus-formation or in the first stage of it, probably 1-3 weeks or less after the injury was suffered. Such fracturing produces rounding and polishing of fracture edges. No healed fractured limb elements have been seen in *Loxodonta*, but a fractured and completely healed mammoth fibula from Krakow-Spadzista B site was described by Krzemińska (2008). The traumatic fracturing in *Loxodonta* may result from torsion breaks when individuals move

Fig. 1. **A**, Two thoracic vertebrae (which articulate) from an old female elephant; note the sharp bone growths and the extreme asymmetry of the left and right articular facets. **B**, a broken and nearly completely healed rib of an adult female elephant. **C**, a broken but healing half-mandible of an elephant calf in Laws age class III (~1 year old), possibly broken during birth; the M1/dp2 has very light wear. **D**, a normal mandible of an elephant calf in Laws age class III, ~ 1 year old, next to a fragment of a half-mandible of a similarly aged calf showing a supernumerary first tooth, a duplicate M1/dp2. **E**, a thoracic vertebra from an old male elephant, showing calcified ligaments and 'lipping' on articular facets.

across rough ground and one leg becomes twisted, or from heavy falls down hills or inclines, or from some other as-yet unknown events. Complete healing of the largest limb elements has been recorded for large terrestrial ungulates such as Pleistocene bison (Kierdorf et al. 2012) and modern cattle, but apparently proboscideans do not survive such major trauma.

Probable arthritic bone lipping on limb elements and vertebrae has been recorded in very old *Loxodonta* individuals. Two thoracic vertebrae from a young adult *Loxodonta* (possibly male) present lesions (abscesses) where interspinous ligaments attach, similar to what has been recorded on Krakow-Spadzista Street B mammoths (Krzemińska 2008). The cause may be disease organism (IVD, intervertebral disc disease?) or, equally likely, severe reaction to strain on the spine, perhaps caused by chronic head-to-head fighting (Krzemińska 2013, pers. comm.).

Tooth abnormalities or extreme wear have been seen in a few *Loxodonta* individuals. In one case, a lower M3 appeared to have broken medio-laterally, interfering with occlusion and the normal progression of forward movement in the bone. Extreme dental wear, showing complete loss of enamel from tooth surfaces, has been recorded, although not frequently, possibly because the region's recurring droughts may have removed older and hence more vulnerable animals from populations before they reach an advanced age. Several cases are known of supernumerary teeth, notably of the first molariform tooth (called M1 by biologists, or dp2 by paleontologists).

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A new chronology for Spinagallo Cave (Sicily): Implications for the evolution of the insular dwarf elephant *Palaeoloxodon falconeri*

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The mid-19th century to early-20th century saw the discovery of remarkable palaeontological specimens, such as 1m-tall dwarf elephants, in Pleistocene sediments of Mediterranean coastal caves (e.g. Spratt 1867; Falconer, 1868; Bate, 1907). However, after more than a century of study, spatial and temporal patterns and rates of mammalian evolution in island settings remain poorly constrained. Current chronology relies on (a) biostratigraphic correlations using the island endemic taxa themselves, raising the possibility of circular reasoning in our evolutionary interpretations; or (b) now discredited chronological techniques (e.g. amino acid racemisation of teeth and bones: Blackwell et al, 1990). With ever-increasing interest in Mediterranean island faunas, it is imperative that we find ways of building a robust chronology for the region and the ex situ fossil specimens housed in collections around the world. Here we present the first absolute-age chronology for one of the most important dwarf elephant sites: Spinagallo Cave, Sicily.

Located 116 - 130 m above present sea level in a Miocene limestone scarp, 15 km SW of Siracusa, Sicily, Spinagallo Cave (Grotta Spinagallo) was excavated in 1958 and 1960 (Accordi and Colacicchi, 1962). More than 2000 bones of the 1m-tall dwarf elephant *Paleoloxodon falconeri* were uncovered from the sandy 'red earth', and these are now housed in museum collections. No detailed excavation notes remain and the cave was much altered during the 1960 phase by breaking through the lower passage roof, but from published reports we do know: (i) that the cave was excavated in two phases, and the approximate extent of the excavations in each of these field season; and (ii) the approximate position of some key specimens, such as a well-preserved adult skull.

Following new field investigations, we have identified a few fossil specimens in situ within the 'red earth' sediments adhering to the cave walls. Intercalated within the red earth are sheets (> 5 cm) of flowstone, similar to those described in the scientific reports. At the base of the cave passage there is evidence of marine incursion and deposition of beach material ('panchina'), also in line with the published cave stratigraphy.

In this talk, we will present the first comprehensive overview of our 40 U-Th ages from speleothems above and below in situ fossil remains, and Optically Stimulated Luminescence (OSL) ages of the fossiliferous red earth. For most locations in the cave, we have obtained multiple age determinations, to demonstrate stratigraphic consistency within an individual layer. In addition, a comprehensive search of bone specimens from Spinagallo Cave housed at Catania University revealed 4 bones with calcite coatings >2 mm thickness, and these were also sampled to give a robust minumum age for *P. falconeri*. Our results provide a vital first step in establishing a robust chronology of Mediterranean island dwarfism to further our understanding of the causes and mechanisms of island evolution and body-size change in mammalian species.

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The five mammoth bone huts of the Upper Palaeolithic camp-site of Gontsy (Ukraine)

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The 1993-2013 excavations at the Palaeolithic settlement of Gontsy allow discovering for the first time the spatial organization of a settlement of mammoth bone huts of Upper Palaeolithic within their environment (Fig. 1). At first, it was highlighted that the installation of the Gontsy settlement is directly linked to the existence of wide mammoth bone beds intensively exploited by the hunter - gatherer groups, and provided particularly large quantity of mammoth bones for the construction of huts, the manufacture of tools and weapons and fuel for hearths.

The mammoth bone huts are located on a promontory of the river slope, along a North-South line. These are four circular or oval large huts of variable dimensions (from 4 to 7.5 meters in diameter), made by mammoth skulls and a small hut.

Many pits surrounding the mammoth bone huts were used for extraction of the loess to plug in and protect from the cold the walls of the huts, for storing food during summer upon the permafrost of the bottom of the pit, for storing bone building materials and for dumping.

The architecture of mammoth bone huts of Gontsy reveals that the largest bones of the skeletons of mammoths (skull, jaw, tusk, long bone, scapula and pelvis) are the main material for construction. Yet each hut in Gontsy has its own architectural feature. Comparison of the huts of Gontsy with huts of Mezine, Dobranichevka, Mejiriche, Ioudinovo, Kostenki 11 reveals individual features and common features that differentiate them, reflecting multiple functions: vital protection, social and spiritual life, cultural identification of the extended family, as well as the group and the intergroup relations within their geographic territory.

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Fig. 1. The mammoth bone dwellings n°3 and n°4 of the upper palaeolithic camp-site of Gontsy (Ukraine).

An almost complete skeleton of a large *Deinotherium* (Proboscidea, Mammalia) from the Late Miocene of Aghia Photia, Siteia (Crete Island, Greece)

George ILIOPOULOS ✉, Charalampos FASSOULAS, and Marianthi TZORTZI

A significant number of fossiliferous land mammal localities from the Miocene of continental Greece and Eastern Aegean Sea Islands have been well known for decades. Nevertheless, until a decade ago the Miocene of Crete Island had been represented by just five land mammal localities (van der Made 1996), three of them from the central part of the island (Kastelios Hill, in de Bruijn et al., 1971), Plakias (de Bruijn and Meulankamp, 1972), Melambes (Bonneau and Ginsburg, 1974), one from the western part (Vrysses, in Benda et al., 1968) and one from the eastern (Petras Siteia, in Leinders and Meulankamp, 1978). During the last decade, the Cretan Miocene land mammal localities have been doubled in number, with four new localities from the eastern part of the island (Maronia, in Athanassiou, 2004; Gela Aghia Photia, in Poulakakis et al., 2005, Fassoulas and Iliopoulos, 2011; Aghia Photia and Zakros, in Fassoulas and Iliopoulos, 2011), and an ichnofossil locality from the western part (Iliopoulos et al., 2012). The determined taxa and stratigraphic data indicate that the age of the respective faunas ranges from the Middle (Astaracian) to the Late Miocene (Tourolian) (van der Made 1996; Fassoulas and Iliopoulos, 2011).

Fig. 1. The complete right mandible of *D. proavum* from Gela, Aghia Photia with toothrow (p3-m3) and tusk in place.

Maximum anteroposterior diameter of the mandible = 1040 mm.

From 2002 to 2010, the Natural History Museum of Crete (NHMC) conducted systematic excavations at the locality of Gela, in Aghia Photia (Siteia eastern Crete, Greece), where the remains of a large proboscidean were revealed. The fossil assemblage was found within the fluviatile sediments of the Skopi formation, and more specifically in red brown clays which are overlaid by grey sandstones of subtidal origin. 115 bone and teeth specimens have been recovered, including 21 out of a total of 22 teeth, a complete right mandible with all teeth in place and a left tusk. Taphonomic analysis of the recovered specimens indicates that they all came from a single individual. The study of the collected material showed that they belong to an exceptionally large *Deinotherium* (Fassoulas and Iliopoulos, 2011; Iliopoulos et al., in press; Poulakakis et al., 2005). This is evident from the size of the complete right mandible with an anteroposterior length of 1040 mm and a maximum length (perimeter) of the attached tusk of 1470 mm (figure 1). The size of the mandible can be correlated with the equally large specimens of *D. thraceiensis* from Ezerovo (1120 mm, Kovachev and Nikolov, 2006) and *D. gigantissimum* from Romania (1200 mm, Stefanescu, 1910). Furthermore, the Gela tusk is considerably longer than the longest known Deinotherium tusk from Montredon (1240 mm, Tobien 1988). Originally, based on the view of Harris (1973) and Huttunen (2002) that all large sized deinotheres belong to one species the material had been determined as *D. giganteum* (Poulakakis et al., 2005; Fassoulas and Iliopoulos, 2011; Iliopoulos et al., in press). Nevertheless, taking in mind the metrical similarities and recently published works on the taxonomy and chronology of deinotheriidae (Pickford and Pourabrishami, 2013; Markov, 2008; Böhme et al., 2012; Aiglstorfer et al., published on line), the studied material can be attributed to *D. proavum* (Eichwald 1831), a species which stands for the group that includes the synonymised taxa *D. gigantissimum, D. thraceiensis* and *D. indicum* (Pickford and Pourabrishami, 2013). Therefore, the age of the assemblage can be considered as Late Miocene and more specifically as early MN11 (Early Turolian).

The presence of *D. proavum* on Eastern Crete cannot be considered as coincidental, as two more localities have recently yielded *Deinotherium* remains. In 2004, Athanasiou described a *D. giganteum* mandibular part with m1 from the locality of Maronia, located close to Siteia, and some *D. giganteum* bone and teeth fragments were reported from a new locality near Zakros (Fassoulas and Iliopoulos, 2011). In both cases, the determinations should be reconsidered and thus the respective material should be attributed also to *D. proavum*. In addition, tooth specimens of *Microstonyx* cf. *major* have been discovered from nearby localities such as Petras (Leinders and Meulenkamp, 1978), Aghia Photia (Fassoulas and Iliopoulos, 2011), as well as a lower m3 of *M.* cf. *major* has been found in the actual locality of Gela.

Therefore, it can be concluded that during the Late Miocene well established terrestrial environments could be found on Eastern Crete, and a connection with Anatolia can be inferred. Despite the fact that a small number of Middle and Late Miocene localities were already known from the Central and Western part of the island, these findings shed light on the paleogeography of the Miocene of Crete which still is not well known.

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Stratigraphical interpretation of rare earth element signatures in fossil bones from the Pleistocene fauna site Kharabai, Central Yakutia

Varvara IVANOVA, and Pavel NIKOLSKIY ✉

Most palaeontological remains are found in disturbed sedimentary contexts where bones and teeth may be secondarily mixed from a number of primary burial sources. Post-depositional movement and reworking of bone increases the spatial and temporal averaging of any bone accumulation and causes significant problems for the interpretation of palaeontological sites. In most palaeontological situations no method exists to date bone remains directly, and no alternative methods to assess the relative age of bone remains. Many studies reported already the use of REE (Rare Earth Elements) in fossil biogenic apatite as taphonomic and palaeoenvironmental tracers and as the "fingerprints" for testing stratigraphic provenance and the stratigraphic integrity of a site (Trueman et al., 2006; Suarez et al., 2010 and references therein). Fossil bone REE concentrations and patterns, thus, reflect pore-water chemistries specific to different depositional and burial environments.

Results of our studies of bone remains from different paleontological sites of Eastern and Central Yakutia (Ivanova, Nikolskiy, 2005, 2007; Ivanova, Nikolskiy, Basilyan, 2011; Ivanova, 2012) allow to propose an additional feature in the distribution patterns of the REEs - the tetrad effect - as criteria of the stratigrafic provenance. This effect can cause a split of chondrite-normalized REE patterns into four rounded segments called tetrads (first tetrad, La-Ce-Pr-Nd; second tetrad, (Pm)-Sm-Eu-Gd; third tetrad, Gd-Tb-Dy-Ho; fourth tetrad, Er-Tm-Yb-Lu). The rounded segments are either convex or concave and form M-shaped and W-shaped lanthanide distribution patterns, respectively (Masuda et al., 1987).

This work presents the results of studying rare earth element (REE) fractionation trends in Quaternary mammal bones for testing stratigraphic provenance. The field works were carried out at the Pleistocene fauna site Kharabai

Fig. 1. Teeth of the Pleistocene elephants *Archidiskodon trogontherii trogontherii* (bottom two samples) and the tooth of a woolly mammoth with very thin enamel (*Mammuthus primigenius*, top), found at Kharabali site (Yakutia).

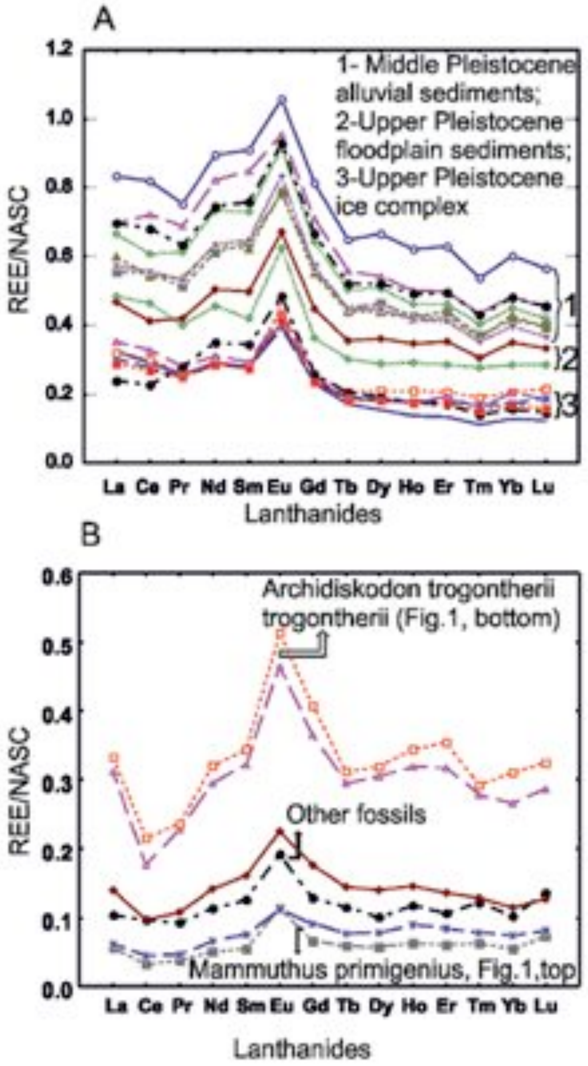

Fig. 2. NASC-normalized REE signatures in sediments from individual stratigraphic units (A) and fossil bones (B).

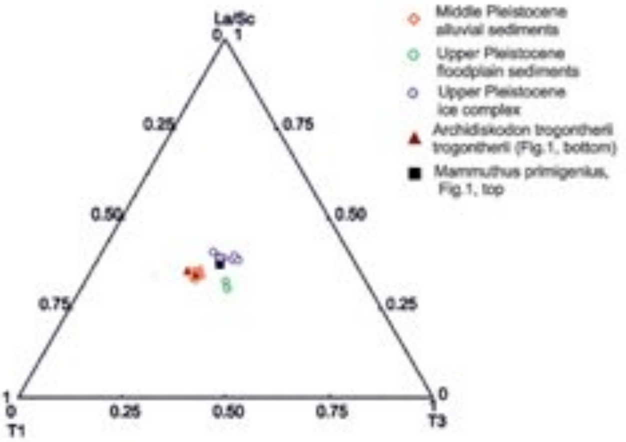

Fig. 3. Ternary diagram T1 (tetrad effect for La-Ce-Pr-Nd)-T3 (tetrad effect for Gd-Tb-Dy-Ho)- La/Sc (sediment composition) indicates the REE fractionation in bones and sediments.

(63.77 ° N, 121.10 ° E, lower reaches of the Vilyuy river, 20 km upstream Viljujsk, Central Yakutia , East Siberia) . The Kharabai outcrop is famous because there in the 1950s, a tooth of the Lower-Pleistocene mammoth-like elephant Archidiskodon trogontherii was found for the first time in East Siberia.

At this site in coastal cliffs Cretaceous and Quaternary sediments are exposed, which differ in lithology, the composition of fauna and flora and cryolithological features: (upward) Upper Cretaceous tephra, layer of the end of the Middle Pleistocene alluvial sediments, floodplain sediments of the beginning of the Upper Pleistocene age, upper Pleistocene ice complex in which alas complexes are embedded (Alekseev et al, 1978).

The Middle Pleistocene age of the basal alluvium is defined by the presence of *Archidiskodon trogontherii* and *Cervalces latifrons* remains (Alekseev 1978). Floodplain sediments and ice complex are dated by a mammoth fauna assemblage with Radiocarbone dates about 40 ka (Alekseev 1978).

To investigate REE composition the REE concentration was determined (ICP MS) in 42 bones of Pleistocene mammals (42 samples related to 7 species) and in sediments collected at Kharabai site. Some mammal remains are important for biostratigraphy, such as the mammoth-like form with thick enamel close to the standard form *Archidiskodon trogontherii trogontherii* (Fig. 1, 2 bottom pieces) and the woolly mammoths with very thin enamel *Mammuthus primigenius* (Fig. 1, top). These remains were found on the beach and it is important to assign it to the correct depositional unit.

-All investigated samples, such as rocks or bones-have a W-type tetrad effect.

-Bones and sediment layers can be correctly differentiated based on their trace element content.

-REE signatures are distinguished from each stratigraphic unit; therefore, fossils eroded from their stratigraphic context may be assigned to their proper depositional unit based on REE signature comparisons.

Results of REE analyses of fossil bones show that REE signatures of fossils and sediments are similar. Fig. 2 shows REE signatures (NASC normalized concentration vs. atomic number). These REE signatures are light rare earth (LREE) enriched with small negative cerium anomalies and strong negative europium anomalies. However, sediments from different stratigraphic unit yield different REE content. REE signatures in bones from the studied units vary from strong (LREE) and middle REE (MREE) enriched in the Middle Pleistocene alluvial sediments, to low (LREE) and middle REE (MREE) enriched in the Upper Pleistocene ice complex. REE signatures in fossils are generally similar in HREE content to surrounding sediments.

The ternary diagram (Fig.3) T1 (tetrad effect for La-Ce-Pr-Nd)-T3 (tetrad effect for Gd-Tb-Dy-Ho)- La/Sc (sediment composition) indicates that REE data shows accurate isolation of bone remains: assigned to the Middle Pleistocene alluvial sediments; assigned to upper Pleistocene ice complex. Stratigraphically, the REE spectrum becomes enriched by light REEs. Within the set of aleurite samples the tendency to enrichment with heavy REEs is observed. This trend can be caused by adsorption of light REEs by colloidal particles, or mixing of various types of soil and surface water.

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The Soyons mammoth: a Late Palaeolithic butchered woolly mammoth associated with lithic artefacts in the Rhône valley, Ardèche, France

Elodie-Laure JIMENEZ ✉

An incomplete skeleton of a mature male mammoth *Mammuthus primigenius* (Blumenbach, 1799) was found in 1985 on the right side of the present-day Rhône river. This find was discovered in the loess of an ancient terrace of the «Vallée Morte de Toulaud», where the palaeo-Rhône ran until the second half of the Middle Pleistocene. The mammoth remains were found in a house basement and were unfortunately highly damaged during the construction work. However, the recovered material includes the maxilla and the mandible each with the sixth molar, fragmented parts of the tusks, atlas, axis, and seven other cervical vertebrae in anatomical connection, six dorsal vertebrae also in anatomical connection, nine fragments of ribs and eight carpals and tarsals (Fig. 1A). All these elements have fused epiphyses and certainly belong to the same individual. The nature and patterns of the wear of the molars show that it is a mature mammoth, and its age at death was probably about 45-50 AEY (Laws 1966; Haynes 1991). Based on the tusk diameter at the alveoli (172 mm), it is probably a male individual (Vereschagin & Tichonov in Lister 2009).

The main interest of this skeleton resides in the fact that several clear cut marks have been identified on two of its ribs (Fig. 1B). This shows that the pachyderm was butchered. However, it is not possible to assert whether it was actively hunted, killed while dying or scavenged.

It is very interesting to note that five flint artefacts were discovered in strict association with the remains: one scraper, one laminar flake, two blade fragments, and one bladelet, all attributable to a Late Palaeolithic industry, and probably to the Gravettian or Solutrean local industry (Onoratini et al. 1995). Since no other piece of lithic were found on the site, « finished products » are over-represented and the chaîne-opératoire is clearly incomplete. This may suggest that the finished tools were imported from elsewhere, implying a possible high degree of planning of this butchery event.

The Soyons mammoth is the only Western European example of an isolated butchered Proboscidian carcass for the gravetto-solutrean period found in association with lithic artefacts. It helps us to better understand the «opportunistic» Proboscidean exploitation during the Late Pleistocene.

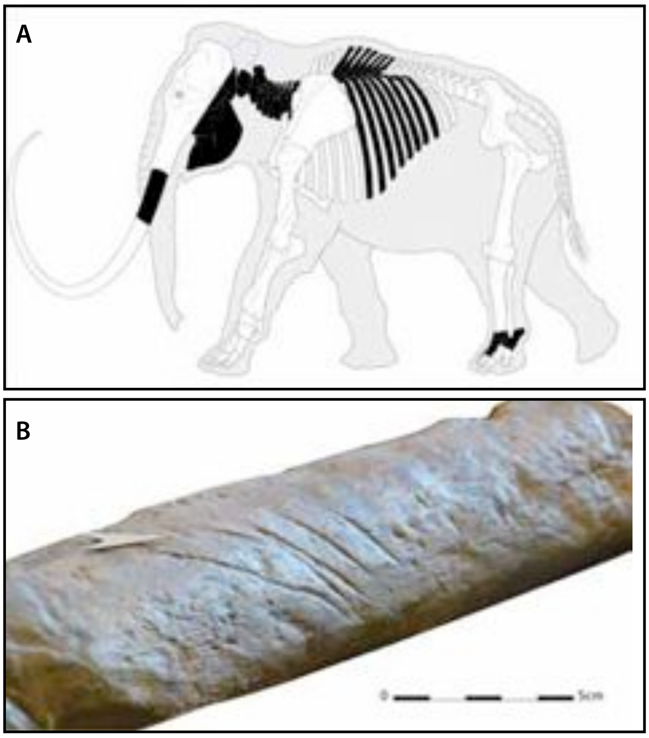

Fig. 1. **A**, Skeletal element representation of the Soyons mammoth. **B**, the documented cut marks on the rib.

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Maximum geographic extension of Holarctic *Mammuthus primigenius* during the Late Pleistocene

Ralf-Dietrich KAHLKE ✉

From 900 ka onwards the global climatic cyclicity was dominated by a clear 100 ka periodicity. Correspondingly, prolonged climatic cycles, which appeared as extended glacial and interglacial phases, caused drastic changes in the faunistic structure of the Northern hemisphere (Kahlke et al., 2011). The first (pan-Eurasian) Mammoth Fauna formed about 460 ka BP during MIS 12 (Kahlke, 2013). This new type of mammal assemblage expanded and contracted its geographic extension, parallel to alternating environmental conditions of the subsequent late Middle to late Pleistocene period.

Mammuthus primigenius as a key species of Holarctic Mammoth Faunas reached its maximum distribution during the Late Pleistocene (MIS 5d - 2). Its habitats stretched from the Iberian Peninsula, North Western Europe, the southern bight of the North Sea and Scandinavia via Central, Southern and South Eastern Europe, the Russian Plain, the Ukraine as far as the Black Sea, Transcaucasia, the Urals and Bashkiria to south-eastern Kazakhstan, Xinjiang in westernmost China, northern Outer Mongolia, East Siberia, north-eastern China, the northernmost part of South Korea, Sakhalin and Hokkaido, to Yakutia and Kamchatka, as well as to Alaska and coastal British Columbia, the western part of the Canadian Arctic, across Northern Canada to the Great Lake region and the Northern Plains of the US. The Holarctic extension of Late Pleistocene woolly mammoths covered an area of up to 305 degrees of longitude and 44 degrees of latitude, thus comprising approximately 32.82 million km^2 (Fig. 1).

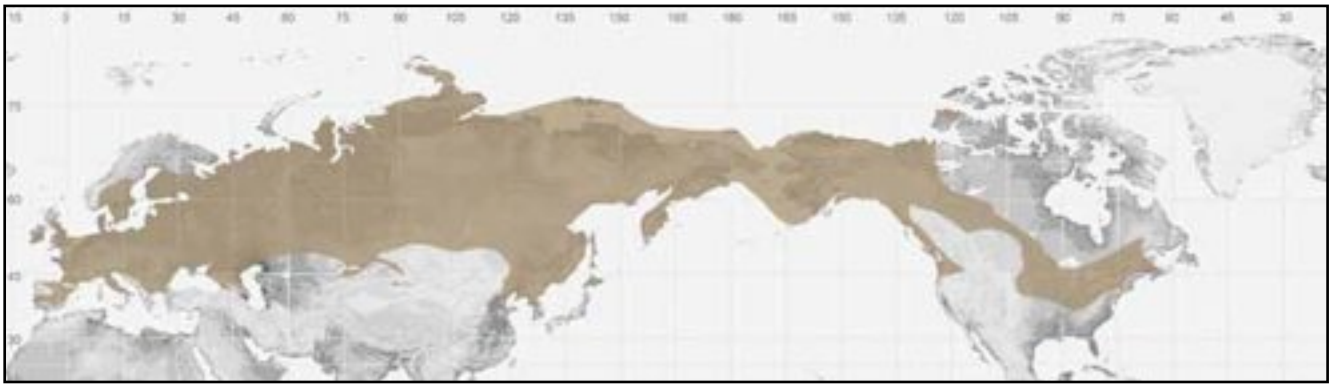

Fig. 1. Sketch of Holarctic maximum extension of *Mammuthus primigenius* during the Late Pleistocene (after Kahlke, 1999, 2013; Kahlke in Alvarez-Lao et al., 2009; additions concerning North America after Cooke et al., 1993; Burns, 1996; Hoyle et al., 2004 and Fisher in Larmer, 2013).

The maximum spread of the populations was primarily controlled by the following factors:

(1) The replacement of tundra-steppe by other types of biomes, less suitable for *M. primigenius* (Central Asian core steppe, North American grasslands);

(2) The exposure of continental shelf regions (e.g., Beringia, North Sea);

(3) The configuration of marine shore lines on year round open water surfaces (e.g., Mediterranean, Black and Caspian Sea);

(4) The configuration of semideserts and deserts (e.g., Hunger Steppe, Kysylkum, Taklamakan and Gobi deserts);

(5) The configuration of high mountain chains without passable valleys (e.g., ridges of the Pyrenees, Alps, Altai, Transili- and Dzungarian Alatau); and

(6) The configuration of inland glaciers (Eurasian, Laurentide and Cordilleran ice sheets).

Independent to the successively evolving *M. primigenius* of northern latitudes, *M. trogontherii* survived in Central Asia probably until the Late Pleistocene (Tong, 2010). A corresponding phenomenon of coexisting mammoth species is known from the New World, where woolly mammoth was replaced by *M. columbi* (inclusive of *M. jeffersonii*) from the Southern Plains southwards. In both cases the separate evolution of sister taxa indicate significant ecological differences between inner continental steppe and tundra-steppe of more northern altitudes. Parallel advances of *M. primigenius* detected in Western Europe and Eastern Asia during the Late Pleistocene, were controlled by connected climatic processes in marine (North Atlantic, North Pacific) influenced areas.

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A partial skeleton of *Elephas antiquus* Falconer & Cautley, 1847 from Eordaia, Macedonia, Greece

Charalampos KEVREKIDIS ✉, and Dick MOL

In this paper we present new data on the straight-tusked elephant, *Elephas antiquus*, Falconer & Cautley 1847 from the collections of the Paleontological & Historical Museum of Ptolemaida, Macedonia, Greece, collected in the basin of Eordaia. *E. antiquus* was quite common in Greece during the Middle Pleistocene, well-represented by fossil remains in the area of Florina-Ptolemais basin (Tsoukala et al. 2011; Kevrekidis 2012).

The partial skeleton presented in this paper was discovered in 2005 in the lignite mines of Amyntaio (coordinates: width 40°38´6.63´´ N, length 21°37´36.56´´ E) at a depth of 30 m below the surface and was heavily damaged by a bucket excavator. The remains have been deposited in coarse sand and are well preserved and heavily mineralized. The lithology, the color of the sediments and the species of the elephant indicate that this specimen was part of the Perdikka's Formation.

All the fusions of the epiphyses in the postcranials indicate that we are dealing with an aged individual. Since many of the bones have been found in anatomical connection and cemented together they indicate that the remains are of one and the same individual.

It represents an old and large sized male individual of *E. antiquus*. The recovered material consists of the heavily build skeletal elements described briefly in Table 1. Molar morphology allows ascribing the complete skeleton to *E. antiquus*. The lower m3s have all but one lamella in use. Consequently it should be placed in Laws' (1966) age group XXV, representing 47 +/- 2 AEY (African Equivalent Years) at the time of death.

The maximum length of the heavily built ulna of the Amyntaio elephant indicates a very large individual which stood at least 3500 mm at shoulder when compared with e.g. mammoths from the Late Pleistocene (Mol et al. 2006). The rough weight estimation for the Amyntaio straight-tusked elephant should be between 5 and 7 tons.

The fifth right metacarpal of this individual is deformed due to extreme extra bone growth around the shaft. The articular surface for the first phalanx of this metacarpal is missing due to the deformation. This deformation indicates that the individual was suffering much pain

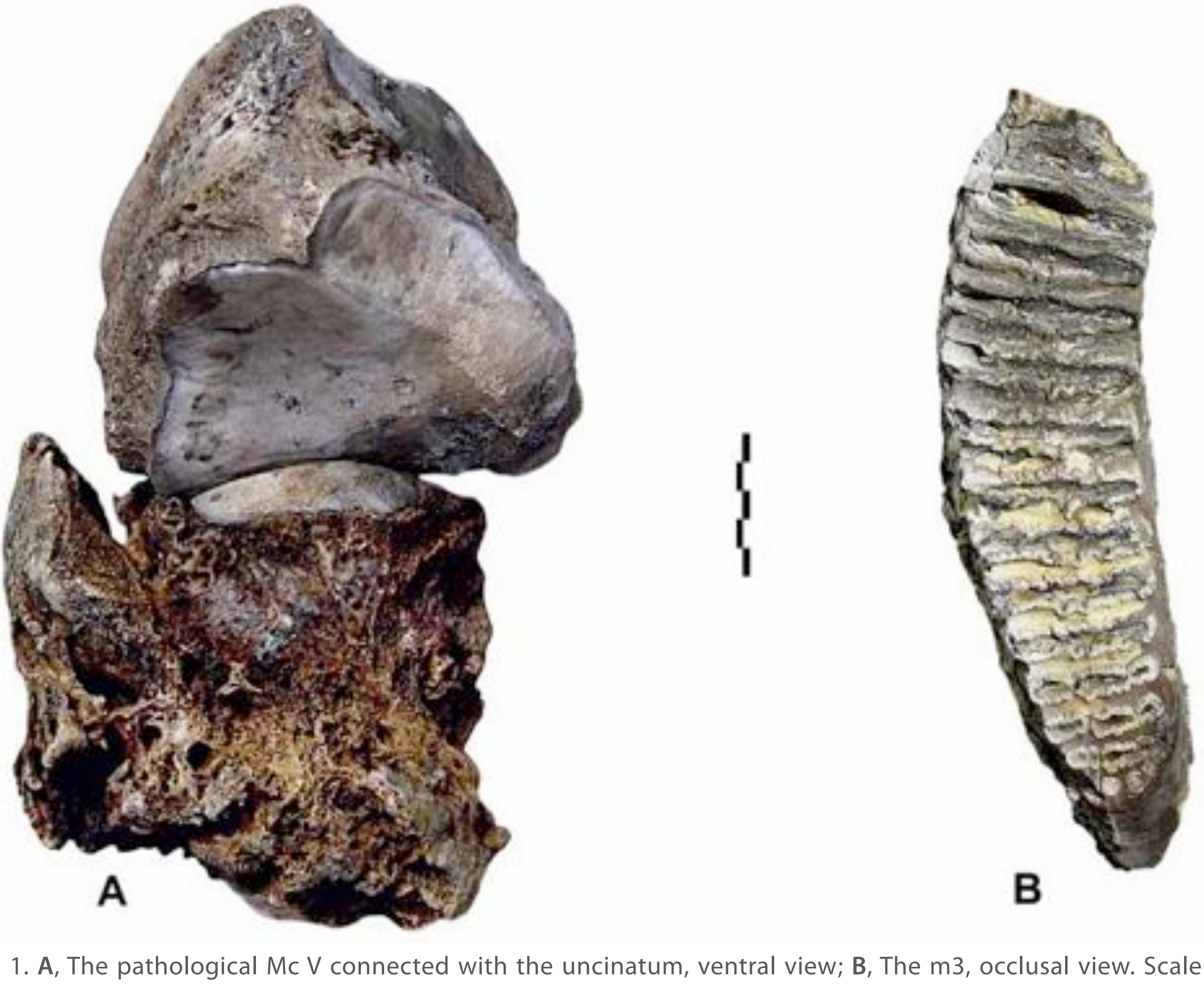

Fig. 1. **A**, The pathological Mc V connected with the uncinatum, ventral view; **B**, The m3, occlusal view. Scale bar equals 50 mm.

Table 1. The recovered skeletal material of Amyntaio elephant.

Skeletal element	Remarks
Cranium	Identifiable fragments including: - Maxilla with left and right M3 (dental formula ∞16x for left and right). - Mandible with left and right m3 with almost all plates in use (dental formula ∞14x for the left and ∞15x for the right). - Left and right alveolus with tusk fragments in anatomical position. The maximum diameter of tusks is 203 mm. - A complete basihyoid bone. To our knowledge, this is the first time a basihyoid bone of an *E. antiquus* is reported.
Vertebral column	- Axis, third, fourth and fifth cervical vertebrae. - 5 thoracic vertebrae, two of which are cemented together - 5 sacral vertebrae (see also Pelvic girdle) - 2 caudal vertebrae; one of them being the first caudal vertebra connecting with the sacrum.
Rib cage	- Praesternum with attachments for the first and second pair of ribs; the caudal end is damaged. 35 fragments of ribs from the left and right side of the rib cage; the capitulae are fused.
Front legs	- Left and right scapulae heavily damaged during excavation. Amongst others glenoid and the scapula necks are preserved. - Left front leg: humerus, radius and ulna are in anatomical position and cemented together. The distal epiphysis of the radius and ulna are completely fused. - The humerus shows at the exterior lateral side of the diaphysis a deep groove (deltoid fossa) of which the bone structure is extremely rough for the attachment of muscles. This morphology is characteristic for the humeri of *E. antiquus* (Kroll, 1991). - Right front leg: humerus, ulna and radius. - Left front foot: trapezoid and Mc I completely preserved. Mc I is showing at the distal end an articular surface for the connexion with the first phalanx as well as two articular surfaces at the caudal side for one pair of sesamoids. The Mc I articular surface indicates at least one phalanx was attached which is not always the case in Pleistocene Proboscideans as has been shown by Mol et al. (2006). - Right foot: triquetrum, uncinatum, magnum, Mc III, Mc IV and the pathological Mc V are completely preserved. The maximum length of Mc IV is 202 mm being the longest metacarpal of this series
Pelvic girdle	- Both pelvic halves are completely fused; the sacrum is fused with both halves. The pelvic girdle has been heavily damaged by the bucket excavator.
Hind legs	- Left hind leg: proximal portion of the femur is preserved of which the caput femoris is completely fused. It was found in anatomical position and cemented with the left acetabulum of the pelvis. From the distal end of the left femur only the interior condyle has been preserved showing that it was completely fused with the diaphysis. - Right hind leg: Distal part of the tibia is preserved. The complete calcaneum and an almost complete astragalus were cemented with the navicular, the cuboid, the third cuneiform and Mt III and Mt IV.

during its lifetime and it should be limping. The cause of this deformity could be attributed either to a trauma of the foot or to a bone tumor.

During the Conference field trip to Ptolemaida area, the remains of this discovery will be displayed and discussed in the Museum of Ptolemaida.

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Preserved brain of the woolly mammoth *Mammuthus primigenius* (Blum. 1799) from the Yakutian Permafrost

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The mummified carcass of a Woolly mammoth (*Mammuthus primigenius* (Blumenbach 1799)) nicknamed "Yuka" was found in August 2010 in nothern Yakutia, Russia (for details see Maschenko et al. 2012). It was dated by 14C at 39,440 - 38,850 cal. BP (Boeskorov et al. 2013). This specimen represents an individual 6-9 years old and is unique in possessing a preserved brain with well-defined gross anatomical features. We provide data on Yuka's brain morphology obtained with computed tomography (CT), magnetic resonance imaging (MRI), and classical anatomical methods.

Yuka's brain was revealed by a CT scan of the whole cranium done in Yakutsk in May 2012. The brain was then fixed with formalin solution inside the cranium. We applied the "flowing fixation" method over the course of three weeks during February 2013. The brain with meninges was removed from the neurocranium at the end of February 2013. A second CT

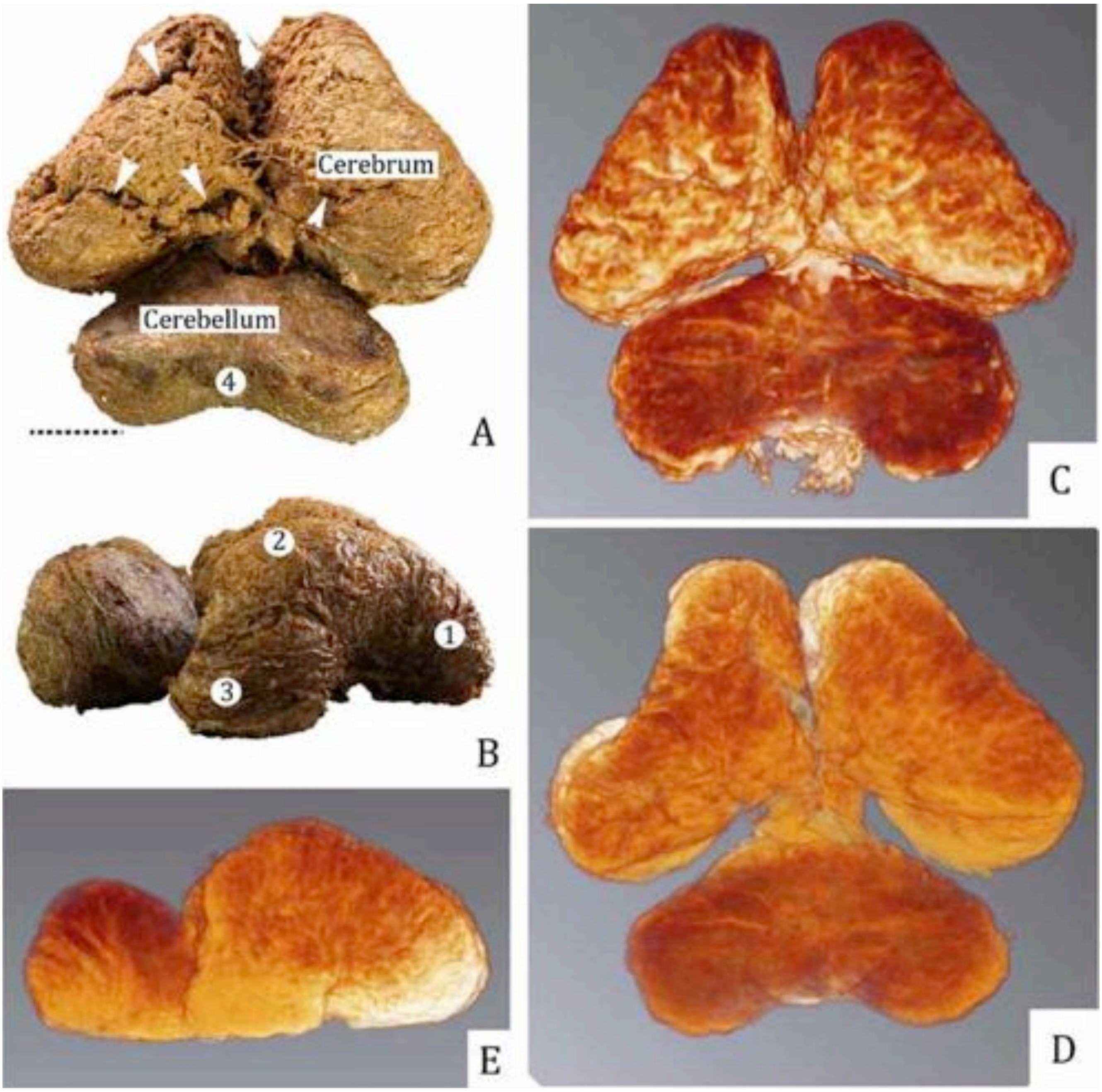

Fig. 1. **A-B**, The Yuka's brain from dorsal (bar=5cm), and lateral view. The 3D reconstructions of the Yuka's brain from dorsal view according to Yakutsk CT (**C**) and Moscow CT (**D**) and from lateral view (**E**, Moscow CT). The damages of the cerebrum surface: the left hemisphere had two large splits and right hemisphere had small one (arrows).

1, *lobus frontalis telencephali*; **2**, *lobus parietalis telencephali*; **3**, *lobus temporalis telencephali*; **4**, *cerebellar vermis*.

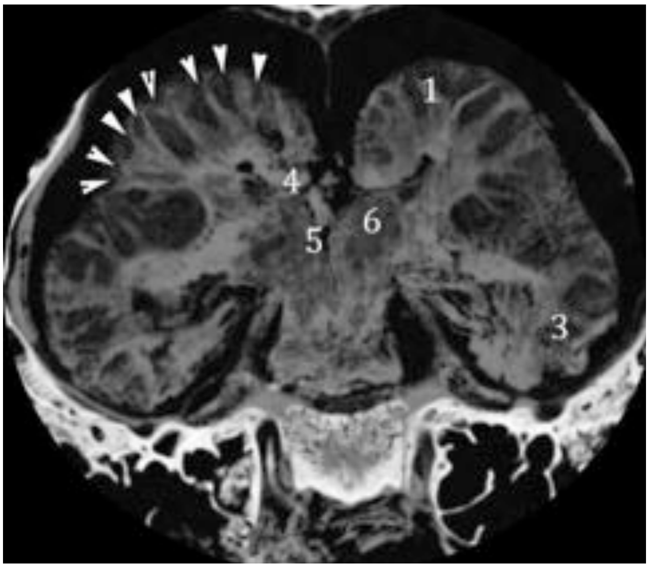

Fig. 2. The frontal (coronal) CT-scan (Yakutsk CT): structure of the white-gray matter reflects the gyri and sulci patterns of the cerebrum, as a result the position of sulcus can be reconstructed (arrows).

1, *lobus frontalis telencephali*; **3**, *lobus temporalis telensephali*; **4**, *corpus callosum* (damaged); **5**, *ventriculus tertius*; **6**, *thalamus*.

Table 1. Brain volumes for Yuka and modern elephants.

Volume/ Specimen	Brain	Cerebellum	Intact brain
M. primigenius (Yuka)	**2755** (Yakutsk)/ **2060** (Moscow) cm^3	**812** (Yakutsk)/ **630** (Moscow) cm^3	**4674 - 4774** cm^3 (appr. from endocast)
L. africana[1, 2]	**3886.7** cm^3	**946.6** cm^3	**4091 – 4319** cm^3
E. maximus (Iki)[3]	**4569 l**		
E. maximus (Tulsa)[3]	**4900 l**		

1, from Hakeem et al. 2005; 2, approximation of the intact brain volume was corrected for long-term formalin fixation shrinkage (storing time unknown); 3, from Shoshani et al. 1982.

and the MRI were performed in March 2013, in Moscow. After all noninvasive data collection, the dura matter was removed, and the brain was anatomically sliced. Yuka's brain was preserved as a whole morphological structure (Fig. 1A-B) but was in poor condition due to shrinkage and oxidation processes. The caudal part of the brainstem including the medulla oblongata was not preserved. The cerebrum had several surface ruptures (Fig. 1A). The olfactory region, including the olfactory bulbs, was also partly damaged. The remnants of the basal part of the olfactory bulbs and the olfactory nerves remained in the bulbus olfactorius cavity above the lamina cribrosa after the brain was removed.

The external morphology of Yuka's brain was described. The general brain morphology of this specimen resembles that observed in modern elephants. Data suitable for anatomical description of internal brain structures and for volumetric procedures were obtained with CT and MRI. A three-dimentional model of Yuka's brain was made (Fig. 1C-E). The detailed structure of the gyri and sulci of the cerebrum was not clear in external view but was reconstructed manually from serial CT scans (Fig. 2).

The volume of Yuka's brain is 2755.42 cm3 (the volume of the cerebellum was 812.28 cm3) based on the Yakutsk CT. Yuka's brain volume as calculated from the Moscow CT appeared to be 25% smaller. In the same manner, the difference in volume under the dura mater, between the Yakutsk and Moscow CT scans, was 23%. This volume difference is caused by the fixation procedure. Formalin fixation causes initial tissue swelling and subsequent shrinkage (Bahr et al. 1957). Formalin solution with added mercuric chloride causes additional shrinkage of the tissue (Romeis 1948). Yuka's brain also might have shrunk somewhat during multiple thawing and freezing cycles. The research team is aware of at least three thawing episodes to which the brain was exposed before the Yakutsk CT was done.

Yuka's brain also shrank due to the long-term mummification process. The brain volume measured from the Yakutsk CT is 45% smaller than the endocast volume (5025.4 cm3). In the same manner, the volume under the dura mater was 19% smaller. Volumetric data for modern elephant brains are available for three specimens. Volume of a formalin-fixed brain of an adult female African elephant (*Loxodonta africana*) was measured using an MRI-scan. Two other brain volumes (adult female, *Elephas maximus*) were measured by the the method of water displacement (Table 1).

Histology research on Yuka's brain was performed. Tissue sampled from deep parts of the cerebrum and cerebellum differs from tissues sampled from the surface due to the preservational condition of the samples. In spite of the cell nucleus remnants being revealed, The condition of the Yuka's brain is acceptable for anatomical study, but despite the presence of remnants of some cell nuclei, its condition is not adequate for standard histology and cytology.

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Diet of Late Pleistocene mammoths of northeastern Russia

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Coprolites are an independent source of information on extinct animals' diet and habitat. Strictly speaking, samples of ancient animal dung found frozen in permafrost soils are not coprolites, since the material is not mineralized. Nevertheless, it is remarkably well preserved due to the permafrost.

End products of a large mammal's digestive process were found in the Terekhtyakh River Basin, right tributary of the Indigirka River (Northern Yakutia, Russia). By their size and shape they most closely correspond to those of a modern elephant.

The specimen F-552 from the Terekhtyakh River represented two undamaged well preserved dung heaps (100-115 mm high, 160 mm of maximum diameter, 426 and 439 grams of weight) and crumbled feces fragments that consisted of half-digested plant remains. ^{14}C-age of the sample is 25300 ± 1000 BP (SPb-490), calBC: 28113 ± 1099.

Carbon isotope composition (δ^{13}C) of two fragments analyzed ranged from -28.0 to -27.2‰ which corresponds fully to the carbon isotope composition of vascular plants in the boreal zone. Two fragments differed strongly in the isotope composition of nitrogen (δ^{15}N 1.6-1.8‰ in the first specimen, 7.6-7.8‰ in the second). Nevertheless, the observed range of δ^{15}N values does not exceed the scope of values typical for the manure of large herbivores.

A sample weighing 11 grams was taken from the very middle of the undamaged specimen for the pollen analysis. Pollen grains found in the coprolite were mainly from herbs typical for an open landscape. They were largely dominated by pollen grains of grass with several species of Poaceae which could not be identified to species. The second most abundant group was *Artemisia* (15,8%) represented by at least two species. Caryophyllaceae (5.0%), Rosaceae (*Potentilla* and *Dryas*, 2,8% and 0,33%, respectively), Fabaceae (2,3%), Cyperaceae (1%) were also found. Pollen of other herbaceous plants had a low occurrence (<1%). A single spore of fern was found.

A few taxa found suggest the presence of wet habitats: Polygonum amphibium type, *Ranunculus aquatilis* type, *Thalictrum*, and two Rosaceae, *Sanguisorba officinalis* and *Filipendula*, the former growing on grassy banks, the latter in damp meadows. Cyperaceae were probably also associated with wetlands. The pollen spectrum of the Mammoth coprolite was overwhelmingly dominated by light-demanding taxa, without any pollen of trees.

The presence of spores of coprophilous fungi inside the core of the coprolite may confirm the assertion (Van Geel et al., 2008) about Mammoth coprophagy as a purposeful behavior.

The specimen of feces weighing 332 grams with a volume of one liter included 2608 macro-remains of herbaceous plants belonging to 38 taxa, 14 of which were identified to species, 19 – to genus and 4 – to family level. A few fragments of woody plants (twigs of deciduous shrubs) were found, but monocotyledons – Cyperaceae and Poaceae were strongly dominating. Seeds of the following plants were abundant: goosefoot (*Chenopodium prostratum*), cinquefoil (*Potentilla cf. stipularis*), different Polygonaceae (*Polygonum humifusum* Merk. ex C. Koch, *Rumex lapponicus* (Hiitonen) Czernov, *Rumex sibiricus* Hult., *Rumex* spp.) and Caryophyllaceae (*Cerastium* spp., *Dianthus* sp., cf. *Minuartia* sp., *Silene* spp., *Stellaria* cf. *crassifolia* Ehrh., Caryophyllaceae gen. indet.). The majority of these plants are currently abundant in habitats along the Terekhtyakh River. Mesophytes were dominant; xeromesophytes, hygro- and hydrophytes were also present. This suggests that mammoth used for grazing areas of different wetness. Fruits and seeds were fully ripe and well preserved, which suggests that the sample was formed at the end of the growing season.

For the phytolith analysis a specimen of 1.46 grams was taken. In total, 14 morphotypes were identified. The size of the majority of phytoliths was 50 -100 microns. Poaceae prevailed in the spectrum (more than 70%, with a dominance of meadow grass *Poa* sp., reed grass *Calamagrostis* sp. and wild rye *Elymus* sp.), along with other wild grasses, mostly dicotyledons. Lignified tissues of shrubs were also found.

In total, 22 insect remains were found, 14 of them were identified to genus or species. These included Coleoptera: *Harpalus* sp. - 1 (Carabidae); *Aphodius* spp. - 6 (Scarabaeidae); Lathridiidae - 2; *Stephanocleonus* sp. - 1 and *Notaris aethiops* - 1 (Curculionidae), and 2 fragments of puparia (Diptera). This association is typical for Northeast Russia in the present time as well as in the Pleistocene. Fragile remains of *Aphodius* and flies' puparia suggest that the insects were attracted by (fresh) feces, while others could have been eaten by the mammoth together with plants. The manure was likely frozen relatively soon after it was populated by coprophages and was not unfrozen until the river eroded the shore.

Apart from plants and insects remains the following components were found in the feces: reindeer's and mammoth's fur, fragments of the intestinal tissues, daphnia ephippia.

According to the data obtained in this study, the landscape where the mammoth was grazing can be reconstructed as a treeless steppe or a meadow with mesophytic vegetation. The main plant species were *Artemisia*, Poaceae and Cyperaceae. Remains of Chenopodiaceae, Polygonaceae, Caryophyllaceae imply the presence of areas with weakly developed soil (gravel, stony and sand slopes). Dwarf birches and willows were growing nearby. Overall, this description corresponds well to the so-called "Mammoth Steppe".

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Cave lion skeleton from the Maly Anyuy River (Chukotka, Russia)

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Fiona BERTUCH, and Fedor K. SHIDLOVSKIY**

Cave lion (*Panthera spelaea*) remains, like skeletons, skulls and individual bones, have been discovered all over the mammoth fauna range from Iberian Peninsula to North America. In Russia these finds are scattered and seldom.

In summer 2008 a compact cluster of cave lion remains belonging to a single specimen, a tuft of visually unidentified ginger-coloured hair and a horse vertebra were found in the water under the bank outcrop of Maly Anuy River (68.18 N, 161.44 E), Chukotka, Russia. The find included 36 vertebrae, 20 ribs, limbs bones: scapula, humerus, pelvic, femur, tibia, fibula, patellae, talus, metatarsal, and third phalanx with cover. In 2009 on the same spot the cave lion mandibular bones were found. Their age, sex and features support the probability of belonging to the same specimen as the skeleton prior. Bone sizes (mandible length: 255.7-262.0 mm; P3-M1 mean alveolar length: 80.2 mm; mean LxB of M1: 29.5x14.9 mm; M1 mean height (buccal): 53.5 mm; length of humerus: 386.1 mm, of femur: 431.5 mm, of tibia: 362.0 mm) fell within the range of other cave lion finds.

Some bones display deformities and age-related changes, e.g. an asymmetry of thoracic and sacral vertebrae, a notch on the scapula, sclerotized ligaments on the femur and tibia, osteophytes on the ribs. Vertebrae asymmetry is probably a result of young age trauma. Sclerotized ligaments are likely a sign of myositis – common for musculoskeletal overloads. The mandibles bear traces of age-related changes and pathological cortex transformation due to periostitis, usually from traumatic injuries. The noted features are not a sign of systemic illness though. The bone cortex, apart from the mandible outer surface, is dense and healthy; joint surfaces show no traces of degradation; muscle origins and insertions are clearly pronounced on the bones that testifies a high motor activity of the animal. The skeleton evidently belonged to a mature but not old male. The age, from counting the annual layers in canine cementum, was about 12 years. The claw sheath on the third phalanx and fur sample are of particular interest, since the cave lion skin derivatives have not been discovered previously.

Stable isotope analyses of samples taken from a few bones, fur and claw sheath of the finds were done to check the possible diet of the animal and specimens identity. The results compared with five more specimens of cave lion and some representatives of mammoth fauna from Chukchi and Yakut territories, namely mammoth, woolly rhinoceros, bison, horse, two species of deer, bighorn sheep and wolf (all samples from the Ice Age Museum, Moscow). The isotopic signature of the Anuy lion remains testifies that all of them nearly certainly came from the same individual, yet the mandible slightly differs from the rest. Stable isotope studies for this cave lion also define that the main prey included *Bison*, *Equus* and *Ovibos*. Notably, reindeer (*Rangifer tarandus*) was not among its most probable prey. The obtained stable isotope results for the found lion remains and its potential diet deviate from these for Western Europe, where reindeer remained the main food source (Bocherens et al., 2011). This deviation can be explained by relatively smaller reindeer population in the Asian North-East compared to the other available ungulate prey.

The tuft of fur found near the cave lion's remains has good differentiation: guard hair (I–IV categories) (GH) and woolly hair (I–II categories) (WH). GH colour varies from light-yellow to dark-brown, without a black tip. WH is light-yellow or whitish. GH type I are typical primary hairs, which, judging by their fragments of length up to 50 mm, are long, thick (up to 200 μm), strong and smooth. The shape of shaft at the base is cylindrical, but in the middle one side flattens a little. The medulla is well-developed, occupies up to 80% of the shaft diameter and runs through its middle. GH of other categories are thinner (45–90 μm) and have medulla less developed. WH are long, with 3–6 bends looking like elastic springs. In the bends the medulla is shifted in the direction of lesser radii. Unlike the modern lion's the found fur has very thick and dense woolly undercoat of numerous closely shut and compressed wavy woolly hairs with the medulla. The coloration of the hair is not fully similar to that of the modern lion. The microstructure and degree of development of the medulla and the cortex, and the ornament of the cuticle look similar between modern species and the found sample, but the cuticular scales of the find are larger. Because of the small size of the tuft and absence of other cave lion hair samples for comparison it is not possible to determine its origin topographically or relate to a season. Its attribution to a lion is still debatable.

Radiocarbon AMS dating was performed at ANSTO (Fink et al., 2004) for samples taken from a rib, claw sheath and fur tuft (lab codes OZQ290, OZQ291, OZQ292). Bone sample exhibited good collagen preservation, consistent with its origin from permafrost. Keratin was analysed for claw and fur. Both rib and claw gave 14C dates greater than 61 thousand years. Fur in contrast came out much younger (28690+130 14C years), which makes it impossible to come from the same specimen as the bones. However, its stable isotope signature fits that for the carnivore.

The remains from the Maly Anuy River represent the first associated skeleton of cave lion found in Russia and the most ancient for the region.

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The latest recorded bison of West Beringia

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A partial carcass of an ancient bison (*Bison priscus* Boj.) was found in 2012 at the mouth of the Rauchua River (Chukotka, Russia, 69° 30' N, 166° 40' E). The remains consist of the croup with both hind limbs and a big piece of skin (Fig. 1), the bones of fore limbs with soft tissues, vertebrae, broken ribs, the pelvis, fur and gastric contents. Some bones have signs of intense gnawing by a large predator, most probably by a wolf. Primary sex characteristics are not preserved. Based on Bedord's (1978) method of sexing metacarpalia the carcass most probably belongs to a female. The same result, but with less confidence, was obtained if the technique by Lewis et al. (2005) was applied. The metacarpal bone of the specimen from the Rauchua is characterized by unusual proportions with relatively narrow diaphysis (49.4 mm), small width of the distal end (80.0) but large total length (238.0) the latter exceeding known values of metacarpal length in both males and females of the late Pleistocene-Holocene Beringian bisons. The ^{14}C age determined based on a skin was 8030 ± 70 BP (SPb-743). AMS-dating based on a rib produced an age of 9497±92 (AA101271). This is the latest record of the ancient bison, at least for Chukotka.

The coat consists of several groups of hairs of different length, hardness, thickness and color. For the first time SEM-investigation of the primeval bison's hair has been conducted. Several types and categories of hairs have been distinguished: guard hairs, wavy zigzag hairs of three categories and wavy wooly hairs of two categories. The primeval bison had thicker guard and zigzag hairs but thinner wooly hairs compared with those of the recent aurochs (*Bison bonasus*) and bison (*B. bison*), i.e. it had a thicker hair coat, especially underfur, which ensured better heat insulating and damping properties of the coat. The structure of the coat suggests a warm period of the year, when the moult has been completed, and new winter hair has not yet formed.

Changes in the isotopic compositions of C and N along the floccus hairs length allow making cautious assumptions about the death season of the animal. Quite sharp increase in δ^{15}N and some decrease in δ^{13}C values near the base of hairs can indicate changes in the diet or seasonal stress. The isotopic composition of the body hairs correspond to that of the distal part of the floccus hairs. It suggests that the floccus hairs length increased by at least 10 cm since the last molting. Bisons have a single late-spring molting and the floccus hair growth rate of large herbivores amounts to about 1 mm per day. It follows that the death occurred at least 100 day after the last molt.

A gastric content has been studied by several paleobotanical methods. Plant macrofossils of grasses, sedge and motley herbs prevail; shrubs and mosses are present, too. *Polytrichum* sp. Betulaceae (*Duschekia*

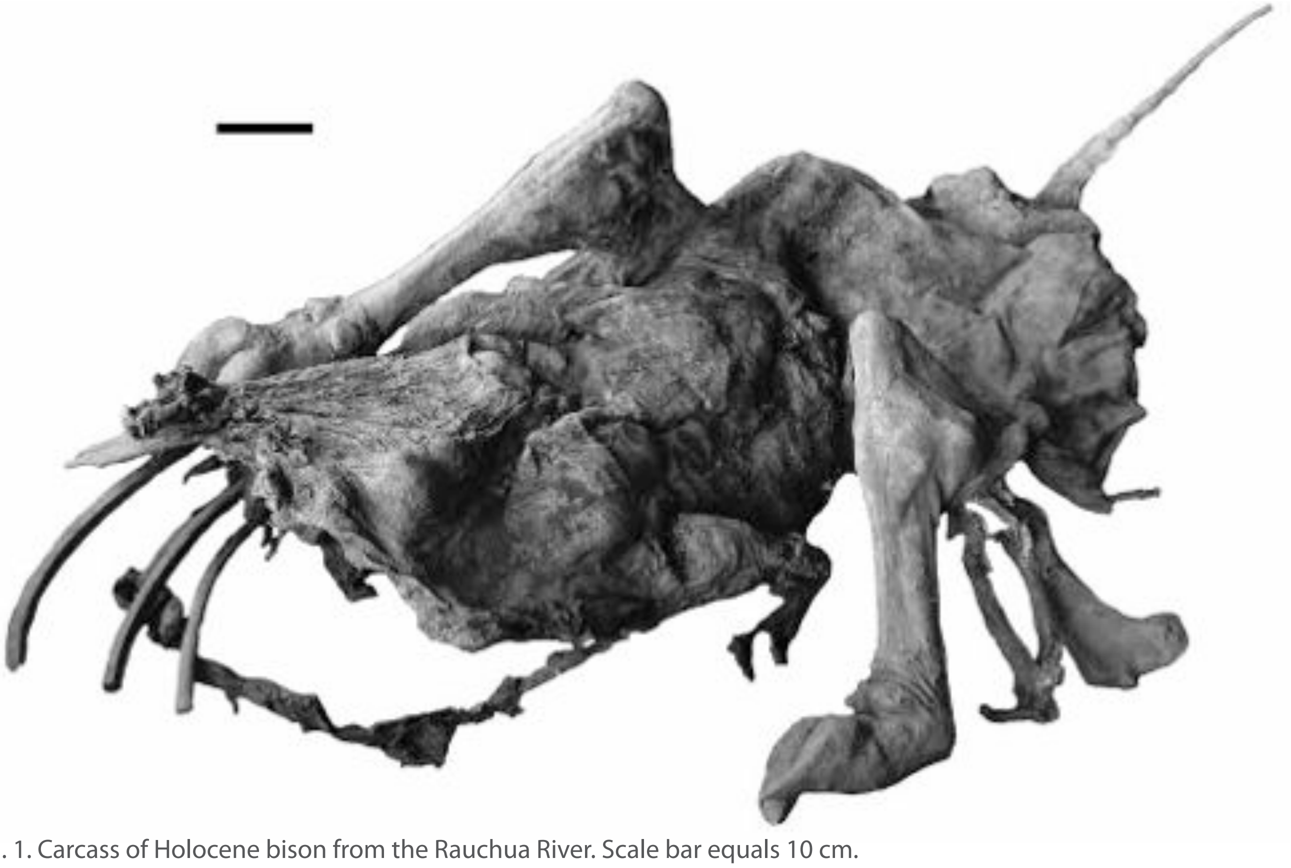

Fig. 1. Carcass of Holocene bison from the Rauchua River. Scale bar equals 10 cm.

fruticosa, *Betula* sect. Nana, Betulaceae), Salicaceae (*Salix* sp.), Cyperaceae (*Carex* sp.), Poaceae, Brassicaceae, Caryophyllaceae (*Moehringia* sp.), Ranunculaceae (*Ranunculus* cf. *hyperboreus*), Rosaceae (*Comarum palustre*, *Rubus arcticus*), Vacciniaceae (*Vaccinium vitis-idaea*), Menyanthaceae (*Menyanthes trifoliata*) have been identified.

According to the results of biomorphic analysis, the remains of mosses (*Polytrichum, Drepanocladus, Aulacomnium, Hylocomium*) and meadow grasses (*Poa* sp., *Bromus* sp.) dominate; a proportion of sedges and grasses is considerable. Some fragments of conductive fabrics and remnants of the herb epidermis were identified. *Sphagnum mosses*, wood forms, shrubs and forest grasses were not found. More than 20 morphotypes of phytoliths were defined. Most have a small size, rarely exceeding 50 microns, which implies low growth of plants.

Grasses (Poaceae) predominate in the pollen spectrum. Single pollen grains of sedges (Cyperaceae), wormwoods (*Artemisia*), composite family (Asteraceae), as well as birches (*Betula* sp. and *Betula* sect. Nana) and bush alder (*Duschekia fruticosa*) have been found. Single spores of Bryales and Sphagnum mosses have been identified. The pollen of conifers were not been found.

The co-occurrence of pollen of Poaceae and seeds of Cyperaceae can be explained by different blossoming and fruits ripening periods of these families' representatives. In the Arctic region the sedges blossoming is observed from the end of April till the beginning of July and seed ripening occurs within the period of blossoming of grasses from June till August. The combination of ripe seeds of sedges with a large amount of grasses pollen thus points to the second half of summer. The growth level of phytoliths confirms this suggestion. Consequently, in accordance with the paleobotanic data the last pasturage period and the death of the bison occurred in the second half of summer.

It is important to note the presence of a large amount of mosses remains in the stomach contents. Mosses were also found in the gastrointestinal tract of a Late-Pleistocene bison of the middle reach of the Indigirka River (Ukraintseva et al., 1978). The mosses which form the lowest storey of the vegetation cover are of low nutritive value for herbivores. They could be eaten together with herbal plants if bison bit the grass off near the soil surface and/or if the eaten plants were dwarfish (which is confirmed by small sizes of phytoliths).

The composition of plant remains prove that before its death the animal grazed generally on mesophytic meadows with a domination of sedges and grasses as well as on relatively drained lands with vegetation consisting of miscellaneous grasses and dwarf shrubs (*Rubus arcticus, Vaccinium vitis-idaea*) and in shrubberies of willows, dwarf birches and sedges. On the whole the nutrition spectrum of an ancient bison form the Rauchua River mouth concurs with the summer nutrition spectrum of the present wood bison (*Bison bison athabascae*) in Canada and Alaska.

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Taxonomic revision of the Japanese Middle Pleistocene *Mammuthus (M. protomammonteus)*, with a new observation method for fossil elephant molars using X-ray computed tomography

Hiromichi KITAGAWA ✉, Keiichi TAKAHASHI, and Rika BABA

Mammuthus trogontherii, the steppe mammoth, is the representative mammoth of the Middle Pleistocene, and was widely distributed in northern Eurasia. However, fossil molars that resemble those of *M. trogontherii* found in Japan, located on the eastern margin of Eurasia, have mainly been described as *M. protomammonteus*.

The first report of *M. protomammonteus* was by Matsumoto (1924), based on a right lower M3 from Chiba Prefecture, Japan. He described the specimen as a new species and erected a new genus, *Euelephas*, to accommodate it. Later, the genus *Euelephas* was considered to be a junior synonym of *Mammuthus* (Otsuka, 1978). However, because the molar characteristics of this species are similar to those of other species of *Mammuthus*, and also some species of *Palaeoloxodon*, three main opinions on the systematic assignment of this species have been presented: (1) *M. protomammonteus* is a valid species (Matsumoto, 1924; Otsuka, 1978; Takahashi and Namatsu, 2000). (2) *M. protomammonteus* is a *Palaeoloxodon* species, such as *P. naumanni* or *P. antiquus* (Dietrich, 1927). (3) *M. protomammonteus* is a junior synonym of the steppe mammoth, *M. trogontherii* (Taruno and Kawamura, 2007).

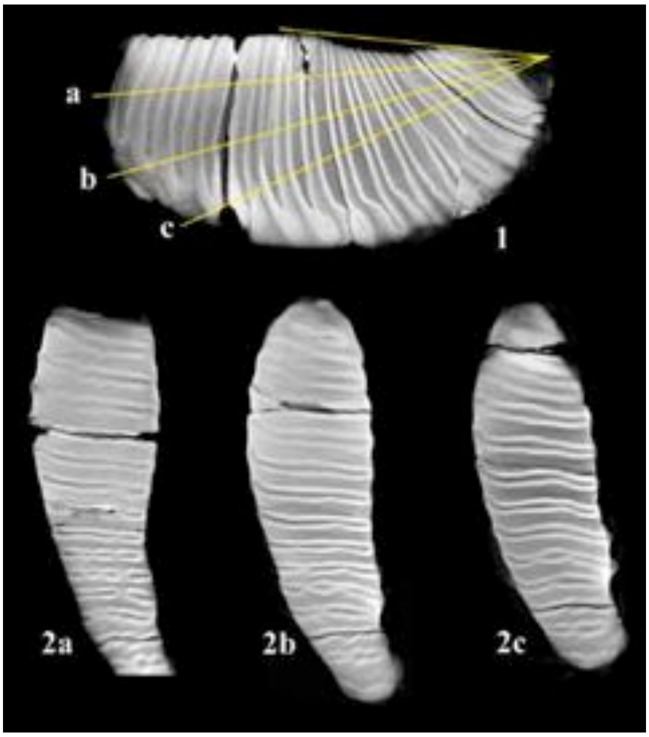

Fig. 1. Corn-beam CT cross section images of *Mammuthus protomammonteus*. **1**, Cutting-plane position; **2**, CT cross section images.

For this study, a comparative analysis was conducted between the holotype of *M. protomammonteus* from Japan and *M. trogontherii* specimens, including the lectotype, from Germany. For taxonomic studies based on morphological characteristics of molars, observations of the various attrition states are important, but such studies on *M. protomammonteus* are hindered by the small number of available specimens. To solve this problem, various attrition states of the holotype of *M. protomammonteus* were imaged with CT scanning, and these images and measurements of the molar were compared with data from other Eurasian specimens.

Results show that *M. protomammonteus* had a different enamel loop morphology and smaller molars compared with those of *M. trogontherii*. Additionally, morphological disparity in the mandibles of the two species was also recognized. We therefore conclude that *M. protomammonteus* is a valid species, endemic to the Japanese islands during the Early to Middle Pleistocene.

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Furrows on molars of woolly mammoths (*Mammuthus primigenius*)

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Woolly mammoth (*Mammuthus primigenius*) bone pathology is a sparsely investigated subject rarely mentioned in the literature. Pathological changes of mammoth teeth, on the other hand, are described more precisely (Guenther, 1955; Kubiak, 1965; van Essen, 2004; Kirillova, 2009). However, even in this subject there are still mysteries and one of them is the etiology of furrows in cement of mammoths' molars (Fig. 1). Such furrows have been reported from few different sites with woolly mammoth remains (Guenther, 1955; Kubiak, 1965; Kubiak and Zakrzewska, 1974; Niven and Wojtal 2002). Similar furrows on molars have been also noticed for some mammoth relatives like *M. columbi, M. trogontherii*, or *P. antiquus* (Kubiak, 1965; Niven and Wojtal, 2002). The etiology of those furrows is not known. So far hypoplasia and bacterial activity were proposed as the main possible explanations (Guenther, 1955; Kubiak, 1965; Niven and Wojtal, 2002). Scientists studying this subject pointed to the regularity and parallel arrangement of the furrows. A question of the different frequencies of such molars at different sites has been put forward.

Fig. 1. The *Mammuthus primigenius* left lower molar (M5) from Kraków Spadzista, Poland. A lingual view and a close up, deep single cement furrow visible. Scale bar equals 50 mm.

The present study was conducted on woolly mammoth molars from some of the biggest mammoth bone assemblages in Central Europe: Kraków Spadzista, Milovice I, and Dolní Věstonice I (Svoboda et al., 2005; Wojtal and Sobczyk, 2005; Brugère and Fontana, 2009). All of those sites provided mammoth molars with furrows. Due to such wide studies we postulate that they are not a result of hypoplasia or dental caries. They seem to be friction grooves – non-carious cervical lesions. Based on site comparisons we also think that various frequencies of such molars at different sites reflect different climate conditions.

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Functional diversity in the masticatory patterns of Proboscidea

Wighart von KOENIGSWALD ✉

The mastication of fossil proboscideans was reconstructed from wear facets and striations. The jaw movement is symbolized in the "mastication compass" distinguishing the direction and inclination of phases of the power stroke. Various functions can be distinguished as food is comminuted: compression, shear-cutting, and grinding. These are defined by the interaction of enamel exposed on occlusal surfaces (Koenigswald et al., 2013; Koenigswald, 2014).

The morphology of the occlusal surface, however, changes with wear. Therefore two different stages of wear are recognized: slightly worn teeth that show the optimal condition for a full range of functions, and intensively worn teeth in which grinding predominates. In early proboscideans the entire tooth row can be evaluated; in more modern proboscideans horizontal tooth displacement has to be considered.

The great diversity of Proboscidea is not discussed here in terms of systematics, but proboscideans are grouped according to their molar morphology. In the available material four functional **patterns of mastication (POM)** can be recognized that are indicated by typical genera (Fig.1):

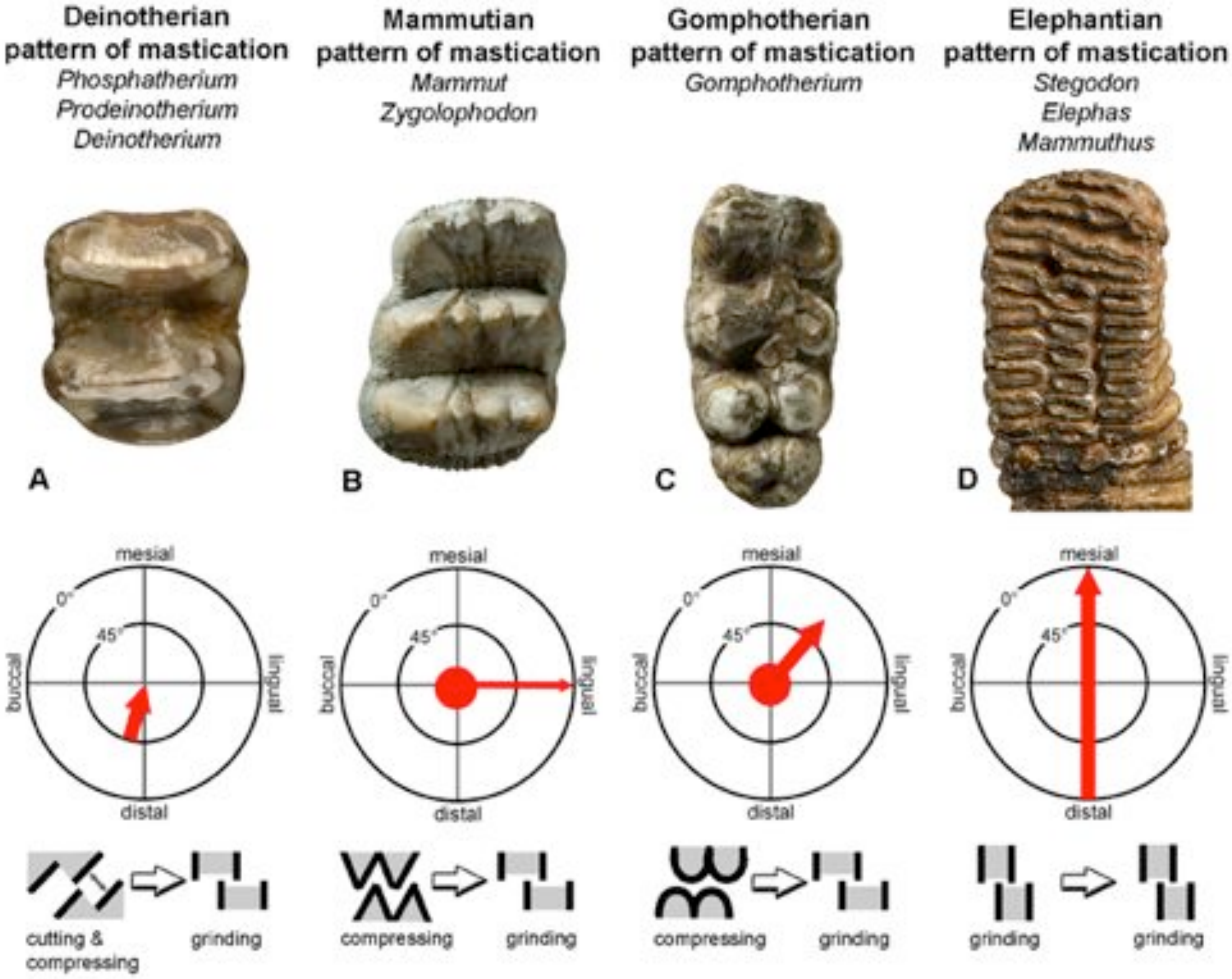

Fig. 1. Schematic characterization of the four functional patterns of mastication (POM) found in the proboscidean molar dentitions. Illustrations show typical molars of (**A**) *Deinotherium giganteum*, (**B**) *Mammut borsoni*, (**C**) *Gomphotherium angustidens*, (**D**) *Mammuthus primigenius*.

The mastication compass symbolises the movement of the left lower jaw. The direction of phase I and II of the power stroke are indicated by the compass rose, the inclination by the length of the arrow(s). Phase I ends in centric occlusion. An orthal movement of phase I is indicated by a dot in the center. When phase I and II cannot be discerned the arrow crosses the middle of the rose. - The symbols at the bottom indicate the changing functions from fresh to worn teeth. They demonstrate that fresh teeth of the four groups differ distinctly in their function, but become more similar as the teeth are worn down. Note that molars of the elephantian pattern are mostly hypsodont.

Deinotherium, *Mammut*, *Gomphotherium*, and *Elephas*.

The deinotherian POM shows a broad planar facet on the trailing side of the lophs. They are situated on the distal sides of lower lophs and mesial sides of upper lophs. The upper rim of these planar facet is formed by the sharp crest of enamel from the leading side of the loph. In most genera the unworn lophs are crenulated, which facilitates initiation of the facet in the most appropriate direction. Striations show movement of the lower jaw to have been mesio-lingual in direction, and steeply inclined. Movement representing phase I ends in centric occlusion.

Two different functions are fulfilled during phase I. When the sharp crests pass each other, their function is shear-cutting. Following this, the lophs interdigitate, and squeeze the bolus in a chamber of compression between the leading sides of antagonistic lophs. The lophs are strongly abraded from this compression and finally collapse, as in other bilophodont dentitions. In heavily worn teeth, the remaining enamel band surrounding the large dentine field functions as grinding tool. Besides of *Deinotherium* this POM was found e.g., in *Phosphatherium*, *Daouitherium*, *Numidotherium* and *Barytherium*. The deinotherian POM is found in several unrelated mammalian dentitions too, e.g., in *Lophiodon* and *Macropus*.

The mammutian POM has molars with sharp and multicuspid transverse lophs as in *Mammut*, but here lophs never bear attritional facets with a shear-cutting crest. Abrasional facets indicate an orthal jaw movement, by which the lophs interdigitate, with compression as the primary function. The jaw movement is not nearly as well controlled as in *Deinotherium*. In some fresh teeth of young individuals of *Mammut americanum* an additional movement is documented by horizontal striations, indicating the presence of a phase II, with movement in a lingual direction. With intensive wear the lophs collapse and the surrounding enamel band functions as a grinding tool until the tooth is shed. *Zygolophodon turicensis* shares the same functional pattern.

The gomphotherian POM is represented by the bunodont gomphotheres (sensu lato). The teeth do not show well defined facets, meaning that movement of the mandible is not as rigidly controlled. In fresh molars of *Gomphotherium angustidens* the mastication starts with an orthal interdigitation of the cusps (phase I). The blunt cusps break down a bolus of food mainly by compression. Following this, in phase II the lower jaw moves with low inclination in mesio-lingual direction. This movement causes the intensive wear on the pretrite side. If the dentine core is exposed, the surrounding enamel band forms a grinding surface. The movement during phase II is reflected in some teeth by striations. The pattern found in *Gomphotherium angustidens* is somewhat intermediate between that of the Oligocene *Phiomia* where compression is dominating and the more modern gomphotheres, e.g., *Cuvieronius* where horizontal grinding of phase II dominates.

The elephantian POM occurs in Stegodontidae and Elephantidae. They share polylophodont molars, with increasing hypsodonty. A flat occlusal surface indicates horizontal jaw movement, in which phases I and phase II are not discernable because there is no centric occlusion. Assuming that the elephantian POM derived from the gomphotherian pattern, a predominance of phase II can be postulated. The lophs on molars of stegodontids and the narrow lamellae on molars of elephantids are transversely oriented and suggest a mesial direction of jaw movement. Some molars show tooth wear striations directed mesial. The enamel bands that surround the lamellae then form a serial grinding tool. Since the spaces between the lamellae are filled with cementum, the occlusal surface of an entire tooth (or even two successive teeth) forms a continuous grinding surface.

The four functional patterns of mastication recognized within Proboscidea differ distinctly in the function of fresh or slightly worn teeth. Differences decrease with increasing wear, and all converge in a grinding function. Thus the grinding function that occurred in more primitive proboscideans only at a late stage of wear comes early in ontogeny in elephantids.

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The Somursun mammoth locality, Amga District, eastern Yakutia

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Somursun site is located on the "Tonus-Kyusa" lake (translated from Yakut as Tunguska), in the middle reaches of the Amga River (61°15'N, 132°40'E), about 5 km north of Mikhailovka settlement (Somorsunskiynasleg), Amginskiy Ulus, Yakutisa, Russia. The "Tonus-Kyusa" lake (approximately 700 x 400 m) is located 1.5 km far from the left bank of the Amga River. The remains of mammoths were found at the foot of a small hill (height 3-3.5 m) on the south-west shores of the lake. Each autumn the bank is flooded due to rains. By the time of our third expedition, the location was completely flooded.

About 40 skeletal remains (mammoth bones, fragments, and tusks) of a single species, *Mammuthus primigenius* (Blumenbach, 1799) were discovered in one concentration, occupying an area of approximately 4 x5 sq. m, excavated to 150 cm depth. The random arrangement of the bones indicates their random accumulation. In central Yakutia such bone concentrations are very rarely found. Postcranial skeleton bone measurements follow von den Driesch (1976) and Maschenko (2002).

At the time of the site discovery, the bones were found not deeper than 50-70 cm from the surface level; some slightly weathered bones were spotted on the surface. Skulls were not found, but few fragments a tusk were present. Possibly, due to bone's transportation (and re-deposition), the skulls were not preserved.

The tusk fragment comes from a young mammoth, based on its overall size and depth of the pulp cavity. Comparing the size of the tusk with those from other localities, we can estimate that the individual was about 16-17 years old.

The mammoth bones recovered from the site included 12 vertebra, 6 scapula and 4 femora. After comparative anatomical and morphological analyses we concluded that the vertebrae belong to at least three different individuals, because all the thoracic and one lumbar vertebrae were anatomically fitting together.

Continuing excavations yielded mammoth remains at a depth 50-150 cm in two separate soil layers. All the bones were laying within 3-4 m. Traces of human activity on the bones were not found. Bones collected from a depth of 1.5 m had black coloration, which turned into tan or light brown when drying.

Based on total amount of bones from the left and right sides and their sizes, along with comparisons with those from the other sites an estimation of 4-5 individuals belonging to 2.5-3, 7-10 and 25-40 years old mammoths is given.

We believe that there were two main causes of the mammoth bone accumulation at the site. The swamp or bog, which was formed during the warm Karginsky interstadial, became a trap for the mammoths, which were unable to get out. The predominant remains of young individuals found at the site confirm this hypothesis. The second factor is the vicinity of the river, which could contribute to the bone accumulations on the bank, as it was recorded at the Berelekh "cemetery", although the small concentration of the bones evidences the one-season event. The radiocarbon date is 38.770 ±320 (GIN 14740), i.e. the Karginsky interstadial.

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A modified technique for *in situ* micro-sampling of *Mammuthus* tooth enamel for stable isotope analyses

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Recent work on the timing of proboscidean tooth enamel formation has led to advances in the use of stable isotopes to understand the diet and behavior of these taxa (Dirks et. al. 2012, Metcalfe et al 2011). Although these techniques continue to yield excellent insights into the diet and behavior of mastodonts and mammoths (e.g., Metcalfe and Longstaffe 2012), sampling techniques typically require the removal of, sometimes large, sections of enamel ridge-plates. We have modified this technique to accommodate *in situ* micro-sampling of complete specimens (Fig. 1A). Precise movement of the specimen is controlled by a Newmark NSC-G, 3-axis motion controller. A 4-cm diameter ball joint is mounted to the 3-axis stage and is used to level the large metal plate (70 cm x 100 cm) that holds the specimen. The specimen is attached to the metal plate through the use of orthopedic thermoplastic. Thermoplastic softens above 70° C and, once heated, a cradle can be molded to conform to irregular specimen shapes. Machine screws are then punched through the thermoplastic and the specimen is firmly secured to the metal plate. A Proxxon 50/E drill, equipped with a 500 µm diameter burr bit, is affixed to the stationary arm above the 3-axis stage and is used to micro-sample the specimen.

Each specimen is sampled in multiple sets which each correspond to 1-cm of tooth growth. Each 1-cm set consists of ten samples and each sample consists of a series of vertical subsamples (Fig. 1B, 1C). Each 100 µm deep subsample is individually collected and processed through the entire thickness of the enamel. All enamel powder is collected in de-ionized water to; 1) maximize sample recovery, and 2) lubricate the bit. The sample nearest the enamel-dentin junction is analyzed for $\delta^{13}C$, $\delta^{18}O$ or $\delta^{87}Sr/^{86}Sr$ signatures. Although this technique is both time- and labor- intensive, it is minimally invasive and is capable of sampling enamel growth structures at high resolution.

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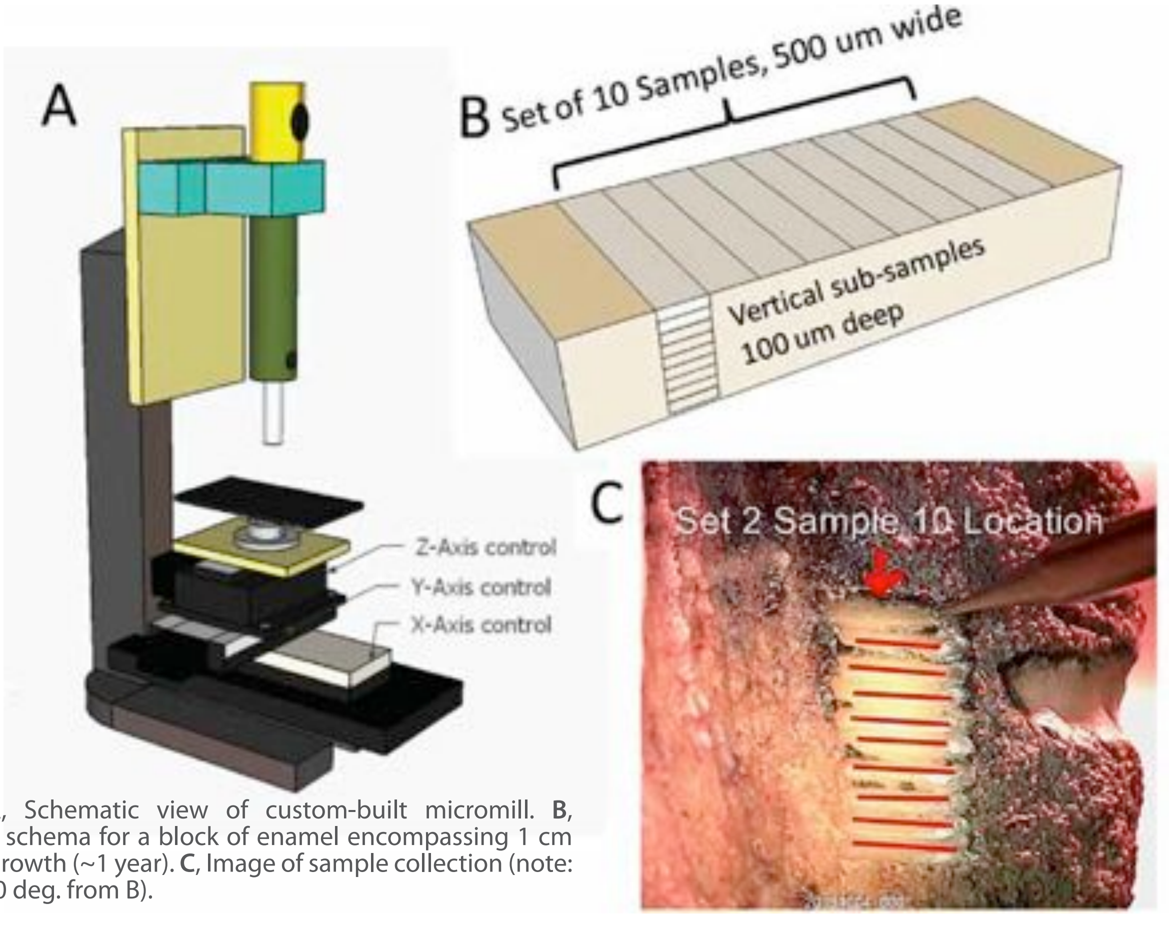

Fig. 1. **A**, Schematic view of custom-built micromill. **B**, Sampling schema for a block of enamel encompassing 1 cm of tooth growth (~1 year). **C**, Image of sample collection (note: rotated 90 deg. from B).

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Taxonomy, biostratigraphy and palaeoecology of the genus *Choerolophodon* (Proboscidea, Mammalia) during the Miocene of the peri-Mediterranean region

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Choerolophodons, represented by the single genus *Choerolophodon*, are bunodont, trilophodont elephantoids with unique craniodental features, such as the strong development of the facial region, the long and gutter-like mandibular symphysis without tusks, the upward-curved upper tusks that lack enamel and the choerolophodont cheek teeth, characterized by choerodonty, ptychodonty and chevroning (Fig. 1A-C). Choerolophodons existed from the early until the late Miocene and were widely distributed in Northern/Eastern Africa, Southwestern/Central Asia and Southeastern Europe, coexisting with deinotheres, mammutids and gomphotheres. During the late Miocene they flourished in the peri-Mediterranean region, where they were the dominant proboscidean group, known with abundant remains from various fossiliferous localities.

The last decades several excavation campaigns in Greece brought into light several new and important proboscidean specimens, studied recently by Konidaris (2013). Here, the choerolophodons from the peri-Mediterranean region are presented, based on the Greek fossil record, including the middle Miocene locality Thymiana (Chios Island, Aegean Sea) and the late Miocene localities of Axios Valley (Macedonia), Pikermi (Attica), Samos Island (Aegean Sea) and Nikiti (Chalkidiki) (Fig. 1D).

The study revealed that three choerolophodont species existed in Southeastern Europe-Southwestern Asia: the middle Miocene *Choerolophodon chioticus* and the late Miocene *Choerolophodon anatolicus* and *Choerolophodon pentelici*. *Choerolophodon chioticus* marks the first penetration of choerolophodons in Europe. The species is known from the locality Thymiana, dated to ~15.5 Ma (late Orleanian, MN 5). Cranial, mandibular and dental features indicate the primitive character of this species in regard to the late Miocene choerolophodons. In Thymiana *C. chioticus* coexisted with *Prodeinotherium bavaricum* and possibly with *Gomphotherium angustidens*.

Choerolophodon is known from several late Miocene localities of the Mediterranean region. In particular, the localities of Axios Valley, which cover the entire late Miocene and are tied to the absolute time, render their choerolopodont assemblage valuable for understanding the *Choerolophodon* evolution in the peri-Mediterranean region. Cranial, mandibular and dental features permit the recognition of two species and three evolutionary stages of *Choerolophodon* during the late Miocene of the peri-Mediterranean region (Konidaris and Koufos, 2013). The more primitive species *C. anatolicus* is traced in the early Vallesian (MN 9) and corresponds to the first evolutionary stage (Fig. 1E). Previously known only from Turkey (Yassiören, Sinap 12, Eşme Akçaköy, Akin, Kayadibi), this species is identified in Pentalophos (Axios Valley), recognized for the first time in Greece. The more evolved *C. pentelici* can be divided into two groups (Fig. 1E). The primitive group, dated from the late Vallesian (MN 10) until possibly early Turolian (MN 11), includes the material from Xirochori, Ravin de la Pluie, Ravin des Zouaves-1 (Axios Valley, Greece) and Kemiklitepe-D (Turkey). The more advanced group, dated to Turolian (MN 11- MN 13), is known from the Greek localities Ravin des Zouaves-5, Prochoma-1, Vathylakkos-2, Dytiko-2, 3 (Axios Valley), Pikermi (type locality), Samos and Nikiti-2, as well as from Turkey (e.g. Kemiklitepe-A, B, Akkaşdağı), Bulgaria (e.g. Hadjidimovo) and Iran (Maragheh).

The relationships among the several *Choerolophodon* species from the Miocene of the Old World are studied with cladistic analysis. Among the results is that *C. chioticus* occupies an intermediate position between the primitive early-middle Miocene *Choerolophodon kisumuensis* from Africa and the advanced late Miocene choerolophodont species, and that *C. anatolicus* consists sister group of (*Choerolophodon corrugatus, C. pentelici*).

Although the middle Miocene *C. chioticus* appears to have inhabited more closed ecosystems, late Miocene choerolophodons were adapted to open environments, as the dental microwear analysis suggests. The microwear study of choerolophodont teeth from the late Miocene of Northern Greece indicates that its dominant diet were graminoids. This type of vegetation is abundant in open environments, which were quite widespread in the region, especially along the Axios Valley. These results are concordant with the existing palaeoecological reconstructions of Greece for this period (Merceron et al., 2005; Koufos et al., 2009 and ref. cited). The abundance of *Choerolophodon* in the late Miocene localities of Greece is probably due to the fact that it was well adapted to these environmental conditions.

The absence of *Zygolophodon* and *Tetralophodon* from the Vallesian deposits of Axios Valley and the wider region is attributed to the different palaeoecological conditions between Central and Southeastern Europe. Respectively, *Choerolophodon*, although widespread in Southeastern Europe, did not succeed to migrate to Central Europe; rather it was constrained in the Greco-Iranian Province. During the Turolian *Choerolophodon* remained again restricted in the southeastern part of Europe. However, all other contemporary proboscideans of this region, *Deinotherium*, *"Mammut"* and the tetralophodont shovel-tusker *Konobelodon*, entered Central Europe (Konidaris et al., in press). Probably *Choerolophodon* was well adapted in the southeastern part of Europe, so that even minor ecological differences prohibited its north-western expansion. The coexistence of the various proboscidean species is attributed to the different ecological niches that they occupied. Although *Choerolophodon*

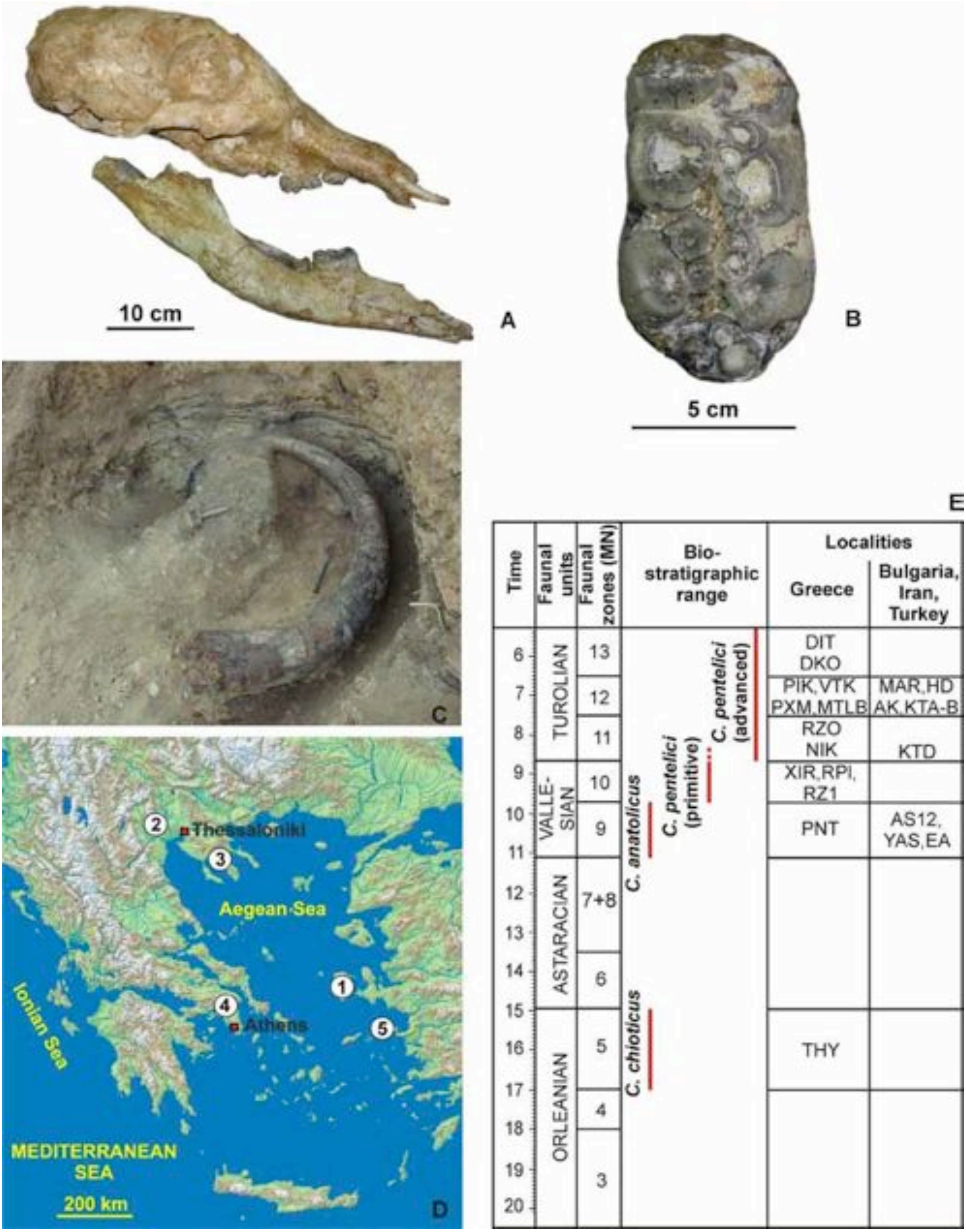

Fig. 1. **A**, juvenile skull and mandible, lateral view, *Choerolophodon pentelici*, RZO; **B**, right second molar, occlusal view, *Choerolophodon anatolicus*, PNT; **C**, right upper tusk in situ, *Choerolophodon pentelici*, NIK; **D**, map of Greece indicating the most important occurrences of *Choerolophodon*. The map was taken from www.shaded-relief.com. 1, Thymiana; 2, Axios Valley; 3, Nikiti; 4, Pikermi; 5, Samos Island; **E**, biostratigraphic distribution of *Choerolophodon* in the peri-Mediterranean region.

Abbreviations: AK, Akkaşdağı ; AS12, Ankara Sinap 12; DIT, Dytiko-2; DKO, Dytiko-3; EA, Eşme Akçaköy; HD, Hadjidimovo; KTA-B-D, Kemiklitepe-A-B-D; MAR, Maragheh; MTLB, Mytilinii-1B, Samos; NIK, Nikiti-2; PIK, Pikermi; PNT, Pentalophos; PXM, Prochoma-1; RPl, Ravin de la Pluie; RZ1, Ravin des Zouaves-1; RZO, Ravin des Zouaves-5; THY, Thymiana; VTK, Vathylakkos-2; XIR, Xirochori; YAS, Yassiören.

persisted in Greece during the late Turolian (MN 13), when a gradual transition towards more humid conditions took place, it could not survive during the Pliocene, when more forested environments were established.

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Early elephant remains from NW Greece

Dimitris S. KOSTOPOULOS ✉, and Ioanna KOULIDOU

Recent advances in elephant (subfamily Elephantinae) evolution and dispersion highlight the Balkans as an important reception area in the path of these legendary mammals from Africa to Eurasia. Nevertheless, the taxonomy of early Eurasian elephants and their relationships with their African forerunners remain rather obscure (Lister et al., 2005; Markov, 2012 and refs. cited). Fossil elephants are common elements of the Quaternary mammal faunas of both continental and insular Greece but findings, especially from the mainland, are usually isolated, fragmentary, and often lacking crucial stratigraphic information (e.g., Doukas and Athanassiou, 2003). A significant number of these findings come from NW Greece, in sites located along the post-molassic morpho-tectonic valleys of the upper Haliakmon river-system and the Florina-Ptolemais basin. Numerous straight-tusked elephant (genus *Elephas* (*Palaeoloxodon*)) and mammoth (genus *Mammuthus*) fossil remains are recorded from this area (e.g., Steensma, 1988; Doukas & Athanassiou, 2003; Tsoukala et al., 2011; Koulidou, 2013), though their study is not yet complete.

A partially preserved right maxilla with M2 and M3 and three isolated and partially preserved lower molars from NW Greece, housed in the Museum of Geology and Paleontology of the Aristotle University of Thessaloniki (LGPUT), are the subject of this study. Most specimens come from the Plio-Pleistocene fluvial deposits exposed SE of Tsotyli village, whereas a single specimen originates from the neighboring lignite-pits of Ptolemais sub-basin. In the absence of adequate stratigraphic information, all these specimens are indirectly and tentatively dated to the middle-late Pliocene (between 2.7-3.5 My), a time-frame that marks the invasion of elephants in Eurasia (Lister et al., 2005). Analysis of the morphometric characters of this molar sample reveals particularly primitive features such as a low number of plates (x8x for M3 and x4 for M2), low lamellar frequency (≤ 4.5) and high enamel thickness (with maximum values ≥5 mm in all specimens), features that are by far beyond the variation ranges of the predominant Plio-Pleistocene European species *M. meridionalis* and *E.*(*P.*) *antiquus*. Instead, this combination of characters closely matches that of early Eurasian elephants referred either to *Mammuthus* or to *Elephas* lineages, i.e., *Mammuthus rumanus* and *Elephas planifrons*, both of little known morphology and questionable relationships. The studied upper molars also appear to be more primitive than those of African *Mammuthus africanavus* and similar to those of *M. subplanifrons*. Comparison of the Greek sample with those from surrounding areas (Bulgaria, Romania) referred to *M. rumanus* (Markov, 2012), indicates strong similarities but allocation to a particular taxon necessitates in our opinion a critical overview the early Eurasian elephant record.

Fig. 1. Right maxilla LGPUT-MP04 showing M2 and M3 in fairly occlusal view. Scale bar equals 10 cm.

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An evaluation of direct seasonal mammoth mobility reconstruction from spatially-resolved Sr isotopic and trace elements ratios in molar enamel

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Strontium isotopic (^{87}Sr/^{86}Sr) and trace element ratios, especially in tooth enamel, are increasingly being used to reconstruct past mammalian mobility and/or relative palaeodiet. What is more, dental enamel represents – due to its incremental mineralization - an archive of time-resolved palaeoenvironmental conditions, which can be extracted using spatially-resolved analytical techniques such as laser-ablation MC-ICPMS, micromilling or SIMS.

In our pilot study we utilized a woolly mammoth (*Mammuthus primigenius* Blum.) molar excavated at the Gravettian (Upper Paleolithic) site Kraków Spadzista in Southern Poland, which is well known for its large accumulation of mammoth skeletal elements (Wilczyński et al. 2012). The main goals of this ongoing work are firstly to evaluate intra- and intertooth (isotope) geochemical variability and secondly to compare these time-resolved Sr isotopic signatures from molars with their decade(s)-long mineralization intervals to the biologically available Sr isotopic signatures of the studied area. The studied molar, probably an upper molar (M^3), was cut longitudinally and the exposed section of the dental plates was polished prior to analysis. Trace element and Sr isotopic ratios were measured in-situ by laser ablation (multi collector) inductively coupled plasma mass spectrometry (LA-(MC)-ICPMS) (Müller and Anczkiewicz, 2012; Müller et al., 2009) along continuous profiles along the innermost enamel layer near enamel dentine junction, which is a novel way to extract time-resolved mobility signals from continuously mineralizing enamel.

We measured X/Ca ratios of several elements (e.g. Mg, Sr, Ba and Zn) that naturally occur in dental enamel and others that are potentially incorporated during burial (U, REE) and thus serve as indicators of diagenetic alteration. Our data generally show very good preservation of the studied molar indicated by negligible U and REE uptake (some alteration was observed only in the basal area which also shows textural/colour changes). Dietary indicators (Sr/Ca and Ba/Ca) suggest uniform, plant-based diet.

The initial ^{87}Sr/^{86}Sr profile along a molar plate shows considerable regular variation with values ranging between 0.7108 – 0.7125. Such high ^{87}Sr/^{86}Sr values do not correlate with the local Kraków Spadzista Street site soil characterized by less radiogenic isotopic ratios obtained from teeth of small rodents. Along the profile, we observe fairly regular Sr isotope peaks spaced 5 mm (in the basal area) to 10 mm (in the centre of the plate) apart that correlate with subtly higher (up to 0.1 ppm) of U concentrations. At present it is not clear, whether this correlation is due to small alterations during burial or the fluctuations reflect seasonal changes. In order to verify the latter hypothesis we used mean mineralization times of *Mammuthus columbi* dental plates (Dirks et al. 2011) to estimate the time of growth of the studied molar. Preliminarily, the calculated duration between the observed ^{87}Sr/^{86}Sr peaks suggests that the observed variation is consistent with seasonal migration.

For the first time, this methodology represents a direct means to assess the palaeoecology of mammoth mobility, such as whether similar feeding areas were used each year or whether different animals have similar or contrasting isotopic mobility signals stored in their enamel; all corresponding data will be presented.

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Insect fauna and environment during the last interglacial in Western Beringia

Svetlana KUZMINA ✉

The Holocene warming played a significant role in mammoth extinction. Previous warm periods could provide important information that helps to understand mammoth population response for the environment changes. The last interglacial (Marine Isotope Stage 5e) is the best model. It was the period of earth history in which climate was comparable to or warmer than today. Last interglacial (LI) fossil insect assemblages have been studied from number of sites across Beringia. In Eastern Beringia the LI insect assemblages contain forest taxa, and an unusual presence of xerophilous insects such as the thermophilous steppe beetle *Connatichela artemisiae* (Kuzmina et al, 2009, 2014). Some species (*Kalissus nitidus* from Old Crow site in northern Yukon or *Cryptopleurum vagans* from Thistle Creek site in central Yukon) indicate warmer than recent climate.

In Western Beringia the LI insect assemblages are known only from a restricted number of sites, but the record provides indispensable information. Insect faunas were studied from two different regions: the Kolyma Lowland: Alazea, Molotkovsky Kamen' and the Laptev Strait area: Bolshoy Lyakhovsky, Oyagoss (Andreev et al, 2004, Kienast et al, 2011, Kuzmina, 1989). Similar to East Beringia, the LI insect assemblages from West Beringia contain some forest species in combination with xerophilous insects. The reconstructed environment is different, due to geographic position.

Insect assemblages from the Kolyma Lowland sites yield some thermophilous taxa (*Diacheila polita, Agonum quinquepunctatum, A. fuliginosum, Colymbetes dolabratus, Hydrobius fuscipes, Cyrtoplastus irregularis, Leiodes* sp., *Quedius* sp., *Corticaria* sp., *Phaedon concinnus, Phratora polaris, Luperus* sp., *Bromius obscurus, Notaris bimaculatus, Formica* sp.) which indicate forest-tundra environment, and also a couple of typical steppe-tundra species (*Morychus viridis, Troglocollops arcticus*). The steppe-tundra indicators decreased their number significantly in the LI time, but did not disappear completely. There is no evidence of warmer than present climate.

Another situation has been observed in the Laptev Strait region. The insect assemblages yield thermophilous taxa which indicate considerable warming (*Gyrinus opacus, Pelophila borealis, Carabus kolymensis, C. shilenkovi, Blethisa catenaria, Diacheila polita, Elaphrus lapponicus, E. riparius, Bembidion varium, Dicheirotrichus mannerheimi, Agonum impressum, Sericoda quadripunctata, Pterostichus magus, Amara interstitialis, Colymbetes dolabratus, Hydrobius fuscipes, Cyrtoplastus irregularis, Anisotoma* sp., *Colon* sp., *Eucnecosum tenue, Olophrum consimile, Gymnusa* sp., *Lathrobium longulum, Philonthus* sp., *Quedius* sp., *Caenocara bovistae, Aegalia kamtschatica, Corticaria* sp., *Hydrothassa glabra, Phaedon concinnus, Bromius obscurus, Gonioctena affinis, Notaris bimaculatus, Dorytomus imbecillus, Sciocoris microphthalmus, Leptothorax acervorum*). The role of the steppe-tundra indicators (*Morychus viridis, Harpalus vittatus kiselevi, Cymindis arctica, Troglocollops arcticus, Chrysolina brunnicornis bermani, Coniocleonus* sp., *Stephanocleonus eruditus, S. fossulatus*) was even higher here than in the pre LI and post LI periods. The environment was a mixture of shrub tundra and steppe-tundra.

A warming effect was much more significant in the North: LI climate was warmer than modern (shrub tundra in LI and arctic tundra nowadays), while the southern environment shows very little difference (forest tundra in LI and nowadays). The relatively warm northern treeless landscape became available for steppe-tundra biota during LI. The mosaic environment with grassy and shrub vegetation with little moss cover was favorable for mammoth fauna as well as for steppe-tundra insects. Refugia in the North probably helped grazing megafauna, including mammoth, to survive during LI. Another factor (more prominent in Eastern Beringia) was the presence of steppe-tundra areas inside the forest zone. These relict steppe areas in Beringia support the re-establishment of the steppe-tundra environment later in the Late Pleistocene.

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Eight thousand of horses' bones and none of woolly mammoth!

**Tatiana KUZNETSOVA ✉, Alexander N. BESSUDNOV, Natalia ZARETSKAYA,
Andrei PANIN, Alexander A. BESSUDNOV, and Natalia BUROVA**

Accumulation of horse's bones was found in 2004 at the right bank of Tikhaya Sosna River, a right tributary of the Don River (Voronezh Region, south part of European Russia), at 50.9649ºN, 39.3031ºE (Fig. 1A). Now this location is known as the Upper Paleolithic archaeological site Divnogorie-9, placed at the bottom of a deep Pleistocene gully (Bessudnov and Bessudnov, 2010). Bones lie within the Late Pleniglacial gully alluvium that was cut during the gully activity phase in the Late Glacial and now form the right side of the younger generation of the gully. The site has been excavated during the last six years. Investigated area is more than 180 m^2. The archaeological pit exposed the 18-m thick geological section composed of three major units (from base to top): gravelly-silty colluvium, stony alluvium, and gravelly-silty colluviums again. Seven levels of horse's bones were identified within the alluvial and the very base of the upper colluvial part of the section (Fig. 1B). Archaeozoological collection includes near 8000 bones of *Equus caballus* and two bones of wolverine and polar fox. Almost complete horse skeletons were found within two levels (level 5 and level 6) (Bessudnov and Bessudnov, 2012) (Fig. 1C). Four other levels include fragments of skeletons and isolated bone material. Horse's remains of different age are recognized: from 1-2 weeks old foals to old mares and stallions. Humane stone artifacts are not numerous (65 units).

Radiocarbon age of the location Divnogorie-9 falls into the period between ~14.5 to ~13 ka BP. Two options try to interpret this absolute chronology. The first is that during ca 1500 ^{14}C years horses periodically died at this area and their bones deposited very fast. Such a long duration of alluvial accumulation is not evident from the geological properties of the section, which lacks buried soils, thick layers of fines, or other evidences of interruption or slowing down of sedimentation, as well as any traces of considerable erosional removal of sedimentary archives. The alternative is that the wide dating range results from peculiarities in laboratory procedures of contaminant removal, crucial when dating bones greater than 2 to 3 half-lives of ^{14}C.

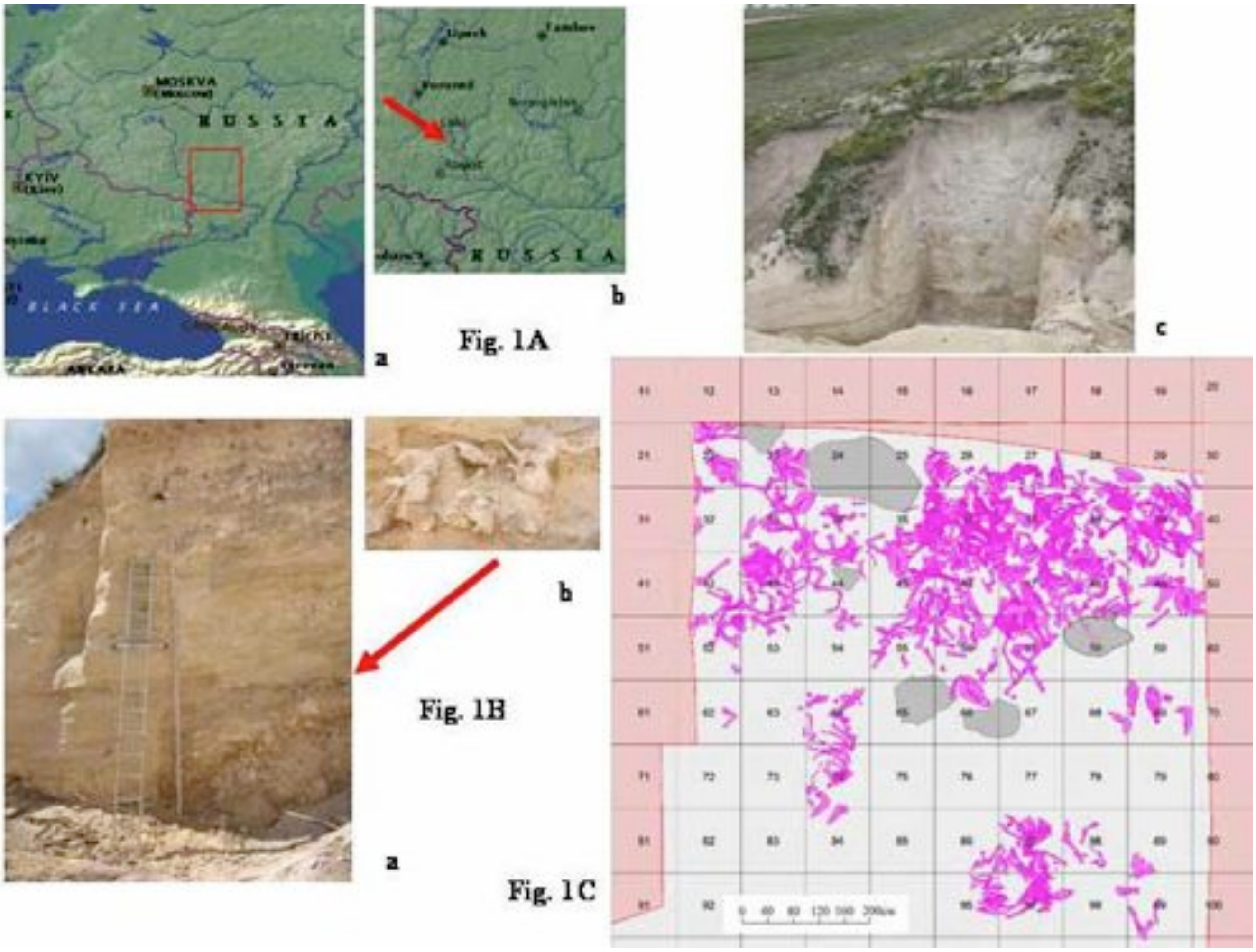

Fig. 1. **A**, Upper Paleolithic archaeological site Divnogorie-9: location maps (a, b); site area, viewed from the East (c). **B**, The alluvial and colluvial parts of the section (a); horse's bone level 6 (b). C, Summary plan of *Equus caballus* bones location. Divnogorie – 9, excavation 2009 – 2010 years, level 5 (Bessudnov, 2010).

There are several hypotheses of formation of the location that can be summarized in two main ideas. First, horses died without human intervention and accumulation of bone material was the result of geological processes only. In this case: (1) At this area there was water reservation with boggy lakesides, horses stuck in the mud, died and promptly buried. (2) Horses felt into mud flows and their remains were conserved in alluvial strata together with stones and mud. (3) During winter and spring periods horses died at upper reach of the ravine. Then spring snowmelt flows transported and collected their corpses and bones near the ravine mouth (Bessudnov et al., 2013). These hypotheses are supported by some geological characteristics of the deposits and some archaeozoological conclusions.

The second hypothesis states that horses died and accumulation of their remains has been produced by Paleolithic people, e.i. Divnogorie-9 is a kill site. Horse's bone levels are results of herding hunting. Little number of human artifacts within the levels can be interpreted, as people didn't take part in horses' death. We can't disclaim a role of people in the formation of bone levels of Divnogorie-9. Possibly different levels of bones were formed by different process.

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Choerolophodon pentelici (Gaudry & Lartet, 1856) from the Turolian locality of Kryopigi (Kassandra, Chalkidiki, Greece)

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Herein, we document proboscidean remains from the Kryopigi locality (Kassandra peninsula, Macedonia, Greece). The fossiliferous layer consists of fluvial sediments that include a rather rich fauna of about 25 vertebrate species (including aves and reptilian). These have been systematically excavated during last fifteen years. Proboscidean fossil material consists of mandible, dental and postcranial elements. Besides a unworn lower molar, all other teeth are deciduous. The morphology of the molar shows choerodonty, ptychodonty, cementodonty and chevroning that are typical characters for *Choerolophodon* (Schlesinger, 1917; Tobien, 1973; Sanders, 2003; Tassy, 1983; 2005). We have thus compared the Kryopigi deciduous dentition to that of three Late Miocene *Choereolophodon* species of Eurasia: *C. anatolicus, C. corrugatus and C. pentelici*.

Kryopigi deciduous dentition is antero-posterior longer than that of *C. anatolicus* and overlaps with that of *C. corrugatus*; the upper and lower third deciduous premolars are longer. The breadth distinguishes the material from *C. anatolicus* (Fig. 1). All dimensions are inside the observed range of *C. pentelici* and commonly close to the mean value for each tooth.

The morphology of the upper and lower third deciduous premolar differentiates the Kryopigi *Choerolophodon* from *C. anatolicus*: the upper teeth show well-developed second ectoflexus, the posttrite part of the postcingulum is well separated from the metacone and a complex pattern of postcingulum emerged from numerous conules and lower teeth due to well-developed postcingulum and second ectoflexus (Sanders, 2003). Moreover, another trait of *C. pentelicus* found in DP2 is the connection of paracone and hypocone with a crest-like alignment of central conules (Tassy, 2005). The overall size and morphology of the Kryopigi deciduous teeth varies from that of primitive Vallesian *C. pentelici* of Greece (Konidaris and Koufos, 2013).

Choerolophodon pentelici is the most common taxon found in the Late Miocene localities of the Greco-Iranian Province. It has been reported associated with other proboscideans such as *Deinotherium giganteum, Deinotherium gigantissimum, "Mammut"* sp. and *Konobelodon atticus* (Konidaris and Koufos, 2013). *Deinotherium giganteum* has been identified in Kassandra Peninsula (Tsoukala and Melentis, 1994).

The fossil collection of Kryopigi contains several thousands specimens, but no other proboscideans have been identified. This could be due to taphonomical, paleoenvironmental, or chronological reasons. The postcranial material, even though not articulated, is provisionally attributed to *Choerolophodon pentelici*.

Choerolophodon pentelici is known in Greece from Late Vallesian (MN10) localities with primitive forms: Ravin de la Pluie, Ravin des Zouaves-1 and Xirochori (Konidaris and Koufos, 2013) up to the Mio-Pliocene boundary (MN13/14) in Maramena locality (Schmidt-Kittler et al., 1995). The similarity of the Kryopigi *C. pentelici* with the typical Turolian representatives correlates to a proposed age for the locality of the latter half of the Turolian (Lazaridis and Tsoukala, 2014).

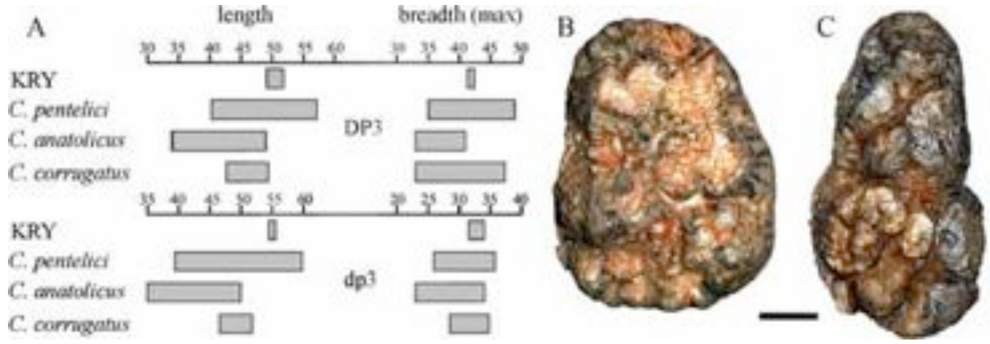

Fig. 1. **A**, Diagram comparing the observed range of length and breadth (maximum) of Kryopigi *Choerolophodon* with that of *C. pentelici, C. anatolicus* and *C. corrugatus* (Gaziry, 1976; Tassy, 1983; Tassy, 1994; Sanders, 2003; Konidaris and Koufos, 2013) from various localities; **B**, right DP3 KRY5077; C. left dp3 KRY125. Scale: 10 mm.

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Tetralophodon longirostris (Kaup, 1832) from Late Miocene of the Kassandra peninsula (Chalkidiki, Greece)

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Several proboscideans identified from the Late Miocene of Greece include: *Deinotherium giganteum, D. gigantissimum, Choerolophodon anatolicus, C. pentelici, Mammut* sp., *Konobelodon atticus* and *Anancus* sp. These fossils were located in several localities hosted by strata spanning the entire Vallesian and Turolian (MN9-13) (e.g. Konidaris and Koufos, 2013; Konidaris et al., in press). *C. pentelici* is the most common taxon, whereas attributions to *Tetralophodon* in earlier studies have been disputed.

The proboscidean fossils of the Chalkidiki region studied comprise dispersed material including specimens from sand-pits of the Fourka area, the seabed in Kryopigi and the Chelona beach at Siviri in Kassandra. The specimens have been described, illustrated and compared with related taxa from other localities of Eurasia. From this work, we are able to make suggestions about the origin, chronology and paleoecological implications of these fossils. The material in this study (Fig. 1) belongs to a single taxon found at several localities: *Tetralophodon longirostris* (Kaup, 1832). Identification was made based on the size and morphology of each specimen separately. The most important morphological characteristics are these: the four lophs in M2, lack of cement, the 5½ lophids in m3 and 4½ (or five) in M3; the open interlophs (-ids), the feebly developed trefoil pattern (according to Osborn, 1924), pretrite main cusp distally displaced in m3 (according to Saegusa et al., 2005), concentric dentine and absence of a tubular in the lower tusk.

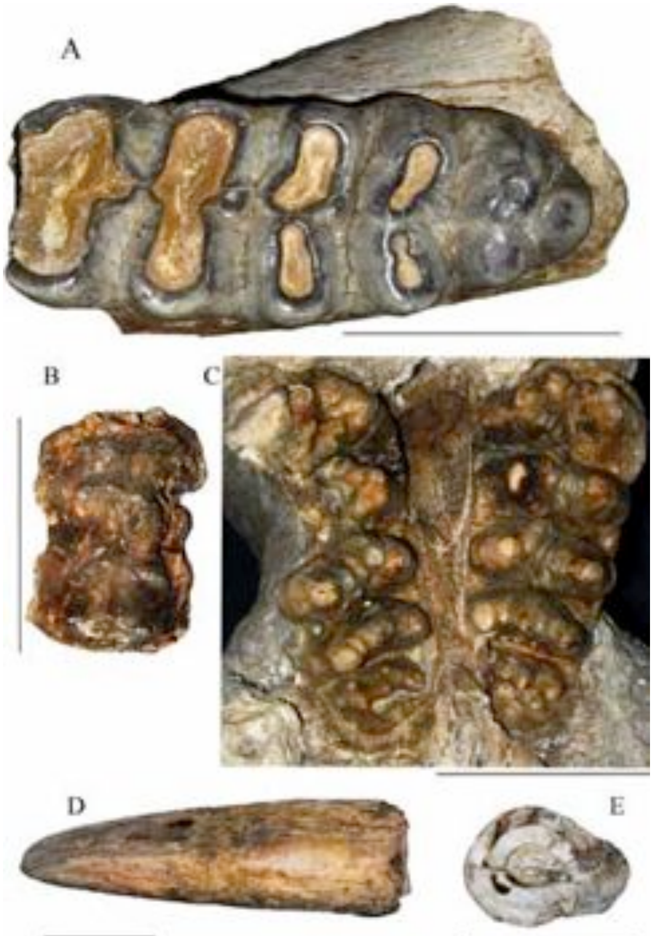

Fig. 1. *Tetralophodon longirostris* (Kaup, 1832) remains from Kassandra sand deposits. **A**, Right lower third molar FRK11 in mandible fragment; **B**, Internal imprint of broken left upper second molar of skull KSC1 showing four lophs; **C**, left and right upper third molars of skull KSC1, still not erupted; **D**, partial right lower tusk KKR1; E. cross-section of tusk KKR1. Scale equals to 10 cm.

The original stratigraphic provenance of these specimens is considered to be the Antonios Fm. (Syrides, 1990) based on their fossilization pattern and analyses of consolidated sediment on specimens. Previously recognized *Deinotherium giganteum* in Aghia Paraskevi (Tsoukala and Melentis, 1994) is consistent with the presence of *T. longirostris* in the same formation, since they commonly co-occur in Western and Central European localities. The dimensions of the former (see Göhlich and Huttunen, 2009) suggest an age of MN9-10 for the Aghia Paraskevi sands. However, in Greek localities this combination is so far unknown, and the closest geographical exception is that of Yulafli locality of MN10 (possibly around age 9.3-9.4Ma), in Turkish Thrace (Geraads et al., 2005). *Tetralophodon* has also been reported from nearby Bulgaria (in Varna; Markov and Vergiev 2012). A preliminary study of fauna in the Fourka localities shows the presence of *Hipparion*, which appeared in Early Vallesian of Europe. Based on this evidence, the age of the Fourka localities and sand deposits of Kassandra should be provisionally regarded as Vallesian.

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Strong evidence of Late Glacial mammoth osteodystrophy from the Berelyokh site, Northern Yakutia, Russia

Sergey LESHCHINSKIY ✉

Berelyokh (N 70o30/, E 144o02/) is the largest site of woolly mammoths in Siberian Arctic. It is located on the left bank of the Berelyokh River, in the Yano-Indigirka lowland. The site contained the remains of 156 mammoths found 1970–1980 during water jetting of the bone-bearing lens (Vereshchagin and Ukraintseva, 1985). The main part of the recovered materials, more than 7200 bones and teeth, is virtually unexplored, as it was buried back on the river banks. Except for a few dozen samples, the rest of the collection (~1600 specimens), is stored in the Zoological Institute of the RAS (St. Petersburg) in Collection 30957. *Mammuthus primigenius* Blum. samples represent nearly

Fig. 1. Evidence of the woolly mammoth osteodystrophy from the Berelyokh site, Northern Yakutia, Russia: **a**, development of osteoblastomae on the proximal tibia end (without number / sampling in 1971, scale bar equals 1 cm); **b**, osteoid-osteoma on a rib fracture (without number / sampling in 1980, scale bar equals 10 cm); **c**, the cavity at the base of the spinous processes of the thoracic vertebra (without number / sampling in 1971, scale bar equals 10 cm); **d**, large open pores in the body epiphysis of the cervical vertebra (№ 124, scale bar equals 1 cm); **e**, the ulcer on the articular surface of a cuboideum (№ 87, scale bar equals 1 cm); **f**, friction grooves on the articular surface of a humerus distal epiphysis (№ 11, scale bar equals 10 cm).

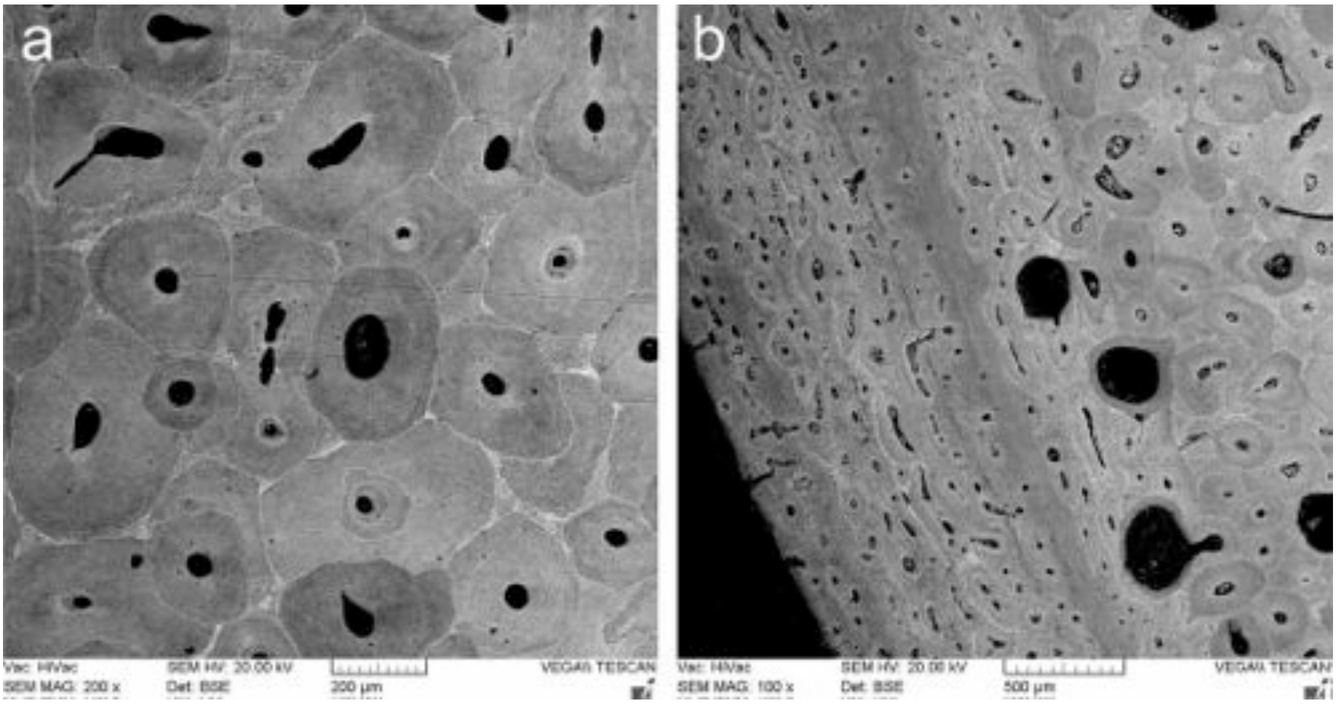

Fig. 2. Scanning electron microscope images of the cross-section of conditionally healthy (**a** – № 95) and osteoporotic (**b** – № 112) mammoth ribs from Berelyokh site, Northern Yakutia, Russ.

100% of the large mammals of this collection.

Radiocarbon dating indicates that the bone-bearing lens of the Berelyokh site was formed in the end of Sartan cryochron (~14000-10000 ^{14}C yr BP), which corresponds to the final period of mammoth extinction. The latest research has shown that the site also contains the remains of mammoths and other megafauna of the Karga thermochron that are older than 30000 ^{14}C yr BP (Nikolskiy et al., 2010; Pitulko, 2011). Most of the mammoth bones are dated 13000-12000 ^{14}C yr BP; however, paleoecological research is complicated by the fact that the exact proportion from the Karga remains unknown.

Permafrost conditions ensured excellent preservation of the Berelyokh samples. Visual examination with a magnifying glass (up to 10×) and selectively with a stereo-microscope (up to 200×) and a scanning electron microscope (up to 10,000×) revealed that more than 700 mammoth remains have signs of growth destructive changes of skeletal and connective tissue, which constitutes more than 40 % of the total. One of the main signs of osteodystrophy in the Berelyokh mammoths is osteofibrosis and similar bone changes. Particularly complex osteoid-osteomas of up to 5×2.5×1 cm and osteoblastomas of up to 10×5×5 cm are present in the vertebrae and long bones of the limbs (Fig. 1 a). Perhaps osteoid-osteomas also developed on rib fractures (Fig. 1 b), which led to false joint formation. Diagnosis and etiology of these pathologies is, however, ambiguous. Typical (stable) osteoid-osteoma has a well defined peripheral zone of osteosclerosis, whereas a typical osteoblastoma does not have such a zone. Diagnosis of the intermediate forms is difficult. Because these destructive changes have identical histological structure (Zatsepin, 2001) they are combined into one group of benign tumors. Malignant tumors are hard to identify in the paleontological material; however, they are unlikely to constitute a significant proportion of the findings. The same applies to abscesses, tuberculosis, and other similar disorders. Studies indicate that osteofibrosis may occur as a result of rickets – a disease that is largely associated with mineral starvation (Urazaev, 1978).

A special feature of the pathoanatomical spectrum of the Berelyokh population is strong spine damage. It is represented by osteofibrosis, osteoporosis, and other destructive changes. The spinous processes of vertebrae have holes and cavities of up to 3.8×1.7 cm that are possibly associated with osteoid-osteomas (Fig. 1c). A.Krzemińska (2008) considers the poor diet to be the possible cause of this disease. E.Maschenko (2002), on the other hand, suggests that it is a genetic abnormality.

It is also interesting to note that there are vertebrae with large open pores in the body epiphyses of up to 1.5×1 mm (Fig. 1d). Identical epiphyses belonging to subadult and adult mammoths were discovered in Krasnoyarskaya Kurya, Lugovskoye, Gari, and other Sartan sites of Western Siberia (Leshchinskiy, 2006). Even though studies indicate that the most likely cause of these changes is osteoporosis, paleoecological analysis has generally shown relatively low level of osteoporosis in Berelyokh mammoths. Scanning electron microscopy of compact bone of the ribs confirmed that in general the microstructure is healthy with more or less even osteons and Haversian canals less than 0.1 mm (Fig. 2a). Some of the osteoporotic samples demonstrate signs of Haversian canals dilatation to up to 0.6×0.7 mm and flattening osteons which leads to internal delamination of compact bone (Fig. 2 b). Such changes can not be explained by taphonomic processes. Chemical and microbial degradations of bone have different appearances, which is evident in the bones of mammoths from the subaerial site of Kraków Spadzista Street (Leshchinskiy, 2012). The Berelyokh bones were buried in permafrost conditions, where physical and chemical weathering were reduced and the activity of soil bacteria in the bones is not observed at all. In turn, this indirectly confirms the subaqueous genesis of the site.

Because of the rarity of paleontological samples containing preserved connective tissue and cartilage at a zero stage weathering of the articular surfaces, the diagnostics of joint disease is usually difficult. That is why the well-preserved bones of the Berelyokh collection have become reference point samples. Ulcers (Fig. 1e) and fissures, particularly on the bones of the manus and pes, constitute the most common type of lesions. These defects developed as a result of atrophy, necrosis and hyaline cartilage resorption, and osteolysis of subchondral bone. The articular surfaces of some of the long bones are entirely covered with grooves from friction (Fig. 1f), indicating complete absence of cartilage. Such lesions are typical of osteoarthrosis, which is a polyetiologic multifactorial disease; however, some scientists support the popular infections hypothesis (e.g., Rothschild and Laub, 2006). Abiotic relationships are rarely considered, even though modern foci of enzootic diseases are well known, the etiology of which is associated with adverse geochemical landscapes (Kovalskiy, 1974).

In addition to the evidence of osteodystrophy in Collection 30957, exostoses, ossification of ligaments, fractures and bony unions, and other pathologies have been found. Consecutive series, the high occurrence, and confinement of the destructive changes to certain elements of the skeleton identify the nutritional nature of these diseases. All of this does not support the view that the destructive changes in the remains of later mammoths of Northern Eurasia are rare.

Unfortunately, accurate paleoecological comparison of various mammoth populations is problematic because of the incompleteness of faunal collections. Nevertheless, a significant proportion of osteofibrosis and severe joint damage in connection with a relatively low level of osteoporosis connects the Berelyokh mammoths with their west-Siberian relatives of similar geological age from the Lugovskoye site. This significantly distinguishes them from mammoths that lived in Eurasia during the Last Glacial Maximum and somewhat earlier. For example, the proportion of osteoporosis in the Krasnoyarskaya Kurya and Kraków Spadzista Street populations could exceed 60-80%. Also, the Berelyokh and Lugovskoye mammoths were ~ 2 times smaller then those that lived ~ 24-17 ka BP. Apparently, the reduction of size was an adaptive mechanism to the deterioration of the geochemical environment due to abrupt landscape acidification. Thus, the 30957 collection demonstrates unique evidence of the geochemical stress mammoths experienced during the period of mass extinction also recorded in other sites of Northern Eurasia (Leshchinskiy, 2006, 2012).

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Last Glacial Maximum mammoth fauna of the Krasnoyarskaya Kurya site (southeastern part of the West Siberian Plain)

Sergey LESHCHINSKIY ✉, Elena BURKANOVA, Yulia POLUMOGINA, Sergei LAZAREV, and Vasily ZENIN

The Krasnoyarskaya Kurya site (N 57o13.5/; E 87o37.35/) is located in the Chulym River valley in the southeastern part of the West Siberian Plain. In 2003–2005 an area of more than 2000 m^2 at the site was destructed and looted by illegal diggers, who established dozens of dug holes and tunnels at the site unearthing more than 4000 bones and teeth from approximately 30 mammoths, including two embryos, together with horse, reindeer, wolf and rodent bones (Boiko et al., 2005; Maschenko, 2010). During these illegal excavations, hundreds of poorly preserved remains were destroyed and all associated information was lost. Such non-professionally collected and incomplete sample provided poor knowledge on the geological and taphonomic features of the site and partly incorrect basic data have resulted in some misleading conclusions in the aforementioned publications.

The complex investigation of the site was initiated by the Paleontological expedition of the Tomsk State University (TSU) in September 2005. The excavation of approximately 133 m^2 has shown three levels within the bone-bearing horizon (instead of two levels, as suggested previously). The bone-bearing horizon was detected at the depth of 1.5 – 3.3 m from the surface. The site has yielded more than 1400 fragments, intact bones and teeth of wooly mammoths, a horse tooth, several hare bones and 40 skeletal fragments of small rodents. Also, the lower bone-bearing level has yielded 14 chalcedony artifacts, at least 5 ivory and bone artifacts and dozens of burnt bone fragments. Furthermore, local citizens have passed two polar fox mandible fragments and two Paleolithic artifacts, which had been recovered from the site. These fossils and artifacts have formed the collection 201/KK presently stored in the TSU Paleontological Museum.

The large number of mammalian remains, including anatomical skeleton fragments and associated Paleolithic artifacts determine the uniqueness of the Krasnoyarskaya Kurya. In 2011 drilling works revealed the actual size of the burial area which is larger than 5000 m2, which makes this site one of the largest mammoth “cemeteries” of West Siberia, alongside with the sites of Volchia Griva, Shestakovo and Lugovskoye (Leshchinskiy, 2006). The field research and radiocarbon dates (~20 ka BP) suggest that the accumulation of bones at Krasnoyarskaya Kurya took place during the early part of the Last Glacial Maximum (LGM).

The subaquatic micro-topography and the associated processes determined the specific formation of the site.

Fig. 1. The lower level of the bone-bearing horizon of the Krasnoyarskaya Kurya site, West Siberian Plain, Russia (bones annotated with **m** belong to the middle level). Arrows point to the fastening elements of the looting tunnel made by illegal diggers, the dotted line marks the borders of the disturbed sediments.

The accumulation of the lower bone-bearing level (Fig. 1) took place on the bottom of an oxbow lake during the final stage of the development of this lake. Apparently, the lake was temporarily drained and mammoth remains were exposed and became available to ancient humans. The middle level was formed during the deposition of alluvial sand, which represented a floodplain scroll/natural levee or an islet. The taphonomic analysis suggests that many mammoth remains were reworked and redeposited from the underlayment. The higher stage of weathering on the bone surfaces and the frost cracks in the sediments suggest that draining and a stratigraphical hiatus occurred during the LGM (~20–18 ka BP). The upper level was formed with the partial destruction of the underlayers and the reworking of the skeletal remains, which is indicated by the comparatively few fragmented remains and a worse state of preservation of the bone surfaces.

The lower and middle levels contain rodent skeletal fragments in situ. These represent oval clods (up to 4×1.5×1 cm) containing a mixture of host sediments and skeletal parts, sometimes from several individuals. Undoubtedly, these clods represent pellets of predatory birds. The pellets are mostly concentrated around mammoth cranial fragments and tubular and flat bones. It seems that birds regurgitated the pellets sitting on exposed elevated surfaces. Rodent remains mostly demonstrate a good preservation, which could be explained by primary protection in fur and fast burial. Detailed study of 36 pellets have shown 35 skeletal fragments of *Dicrostonyx* Gloger and 5 fragments of *Microtus gregalis* Pallas. The ecology of the modern representatives of these taxa (Chernov, 1980) suggests that during the LGM, the territory was an open landscape of the so-called mammoth steppe with snow cover of not less than 50 cm thick in isolated places.

The pollen analysis has shown an extremely low content of spores and pollen in the bone-bearing horizon. However, the sediments are abundant in silicate micro-remains: sponge spicules, fragments of pennate diatoms and phytoliths. The few autochthonous spores and pollen grains have been classified into two categories: miospores with the thick, three-layer exines (Asteraceae and Cichoriaceae); and miospores of plants with high pollen and spore productivity (*Pinus* sp., *Betula* sp. and *Monoletes*). These data suggests unfavorable geochemical burial conditions. Allochtonous miospores from the lower bone-bearing level represent exclusively Jurassic taxa, while the upper level also contains Paleogene taxa, which suggests deep erosion of pre-Quaternary sediments during the uplifting of the mountain belt of Southern Siberia.

Cryoaridization of the climate during the LGM is recorded by the stratigraphical hiatus in the Krasnoyarskaya Kurya section. However, the lowering of the local erosion basis is related not only to the low global sea level, but also to the neotectonic uplifting of the land. These processes led to acidification of geochemical landscapes and subsequent mineral starvation of the large mammals. The results of the paleoecological analysis, X-ray and electron microscopy have shown a high percentage of osteoporosis lesions of ribs (more than 70 %), vertebrae and flat bones in mammoths of all age groups. Cases of osteomalacia, joint diseases and other pathologies have also been recorded. The numerous cases of destructive skeletal changes support the hypothesis of the geochemical stress that affected all the mammoth populations in Siberia during the Sartan cooling (Leshchinskiy, 2009). The location of Krasnoyarskaya Kurya 150 km north from the Shestakovo beast solonetz site suggests the seasonal meridional migration routes.

The petrographic compositions of artifacts have shown that the tools were made of imported raw material. The geological structure of the study area suggests that chalcedony sources might have been located in the Paleozoic rocks of the south of Western Siberia or in the Mesozoic piedmont sediments. This means that humans carried the stones from 100 km away. The artifacts mostly represent 10–15 mm wide blades with sub-parallel edges and unilateral flaking patterns on the dorsal surfaces. Some tools show modification of the edge using the so-called "episodic retouch" or traces of utilization retouch. No traces of flaking from the narrow face have been noted. The closest analogues have been recorded in the Shestakovo and Achinskaya site located 200 km southeast from Krasnoyarksya Kurya. These assemblages represent lithic industries based on small blades dating to the middle of the Late Paleolithic. Hence, the mentioned typological similarities in the lithic artifacts also suggest the north-south migrations of the prehistoric humans whose subsistence strategy depended on large mammals, primarily mammoth.

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Elephant food taboos: cross-cultural animal humanization?

Maayan LEV ✉, and Ran BARKAI

The Paleolithic archeological record depicts complex relationship between humans and elephants, as elephants were exploited for their meat, fat and bone over hundreds of thousands of years across the old world. Attention is focused on subsistence and the nutritional value of elephant carcasses. Another perspective is to view elephants as more than a food source, as a medium of taboos and restrictions that provide interplay between the practical and cosmological conception of elephants in human life today, and possibly in the past as well.

Food taboos are common in traditional societies. Meat, despite being a main food source, is also perceived ambivalently as potentially dangerous and an object of disgust. This is reflected in a dominance of animals in taboos.

Hunting and taboo are connected to ritual, world-views and values and as such, depend directly on social context. A hunter does not only hunt what is available, but operates according to norms including taboo that restrict access to certain animals, or even forbids access altogether.

Potential food sources are forbidden due to the perception of an animal as the owner of spiritual powers and\or due to its status in a cosmological hierarchy. The perception of those animals as totemic entities and their personification gives the animal attributes beyond what can be seen in the physical world. The magical concept, a common belief in traditional societies, can humanize certain animals and give them attributes that are parallel to humans, thus their consumption is linked to cannibalism or animalism (Fessler and Navarrete 2003).

In this study we explore the relationship between the humanization of elephants and elephant taboos. We suggest that the physical and social uniqueness of the elephant is what makes it appropriate for taboo. The role of taboo is sometimes as important as the nutritional values of elephant meat, and both have a central place in human-elephant relationship. Today's unique relationship between humans and elephants might reflect, to a degree, such possible relationship in the Past. We are strongly aware that modern hunter-gatherers cannot serve as a direct analogy to the past. However, we believe that since elephants and people have shared habitats for hundreds of thousands of years, there has probably always been an awareness of the special characteristics of these mighty mammals and their resemblance to humans, both in physical and social terms. The fact that in many cases elephant bones were shaped similarly to the characteristic stone handaxes might serve as a clue towards this long-lasting symbolic-cosmologic bond. We thus tend to believe that elephants were always conceived of as special creatures by humans.

Ethnographic studies see the humanization of elephants as the core of food restrictions and taboos. Among the Ikomain of Tanzania, the elephant is feared by the whole tribe for it is believed to be the reincarnation of the dead chiefs. The killing of an elephant requires a mourning period of seven days, the same as the mourning period for a member of the tribe. The members of this tribe have almost completely humanized the elephant (Kidghesho 2008).

The Nuer view elephant hunting in the same way as they view warfare between humans, hence there are certain restrictions that make the hunting process a complex action. The Nuer believes there is a mystical connection between man and elephant, observed in a popular myth that describes the common ancestor of both elephant and man (Howell 1945).

In a study conducted among local hunter-gatherers of Laikipia Kenya, of 33 people who claim they do not eat elephant meat, about half said they avoid it due to the resemblance between humans and elephants with regards to their social behavior, intelligence and external anatomy. This is also the case for Kikuyu, Maasai and Turkana groups (Gadd 2005).

The behavioral resemblance to humans can be seen in the 'family unit' of elephants which is composed of related adult females and their offspring. The family unit share daily activities such as bathing, eating and playing and it is a rare event when a member distances itself from the group. Elephants have a highly complex social structure, composed of multiple family relationships. The connection is reaffirmed daily by physical touch. Other behavioral similarities are the protection of young members and the treatment of the dead. Similar physical attributes such as a relatively late sexual maturity, few offspring and long birth intervals (Moss 2000) are also of note. Elephants are also considered to have the capacity for reasoning that is similar to humans (Brown and Alkemeyer 2013).

In addition to the physical and social attributes, humans recognize certain behavioral aspects that are considered to be 'human like' in elephants. Some traditional societies therefore enforce rules and restrictions on hunting and the consumption of elephant meat, even at times considering it equivalent to cannibalism. We claim that the very special connection between elephants and people in modern times is deeply embedded in what is considered as "being" human and "being" an elephant, and that the two share many similar characters that were observed not only today but also in the past when people and elephants interacted. Therefore we believe that the evidence presented in our study may well be of relevance to the human-elephant relationship in Paleolithic times as well.

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Global synthesis of mammoth evolution based on molar morphology

Adrian M. LISTER ✉

Molar morphology has played a key role in our understanding of proboscidean evolution generally, and that of the mammoth lineage (*Mammuthus* spp.) in particular. Molar morphometrics has its shortcomings in this regard, especially the occurrence of similar, plesiomorphic form in the early members of different lineages, and their subsequent tendency for homoplasy (parallel or convergent evolution). However, studies of cranial morphology, which would undoubtedly provide much evidence of evolutionary pattern, are hampered by a shortage of sufficiently complete, undistorted finds. Molar teeth are abundant and show striking evolutionary trends, provided full account is taken of practical problems such as the recognition of plate loss through wear, or the inverse relation of lamellar frequency to size (Lister & Joysey 1992). New and updated results will be presented from among the following current issues (cf. Lister et al. 2005):

— The earliest mammoths in Eurasia: *M. rumanus* from the Late Pliocene to earliest Pleistocene of Europe and China, and some enigmatic new finds from the Near East

— The question of a defined intermediate stage (‘*M. gromovi*’) between *M. rumanus* and *M. meridionalis*

— The Far-Eastern Early Pleistocene origin of *M. trogontherii*

— The interpretation of European assemblages around the Early to Middle Pleistocene boundary apparently showing co-existence of *M. meridionalis* and *M. trogontherii*, and implied cladogenetic speciation.

— Morphologically complex assemblages in Europe in the Late Middle Pleistocene transition from *M. trogontherii* to *M. primigenius*

— Claimed primitive (*meridionalis*-grade) mammoths in North America, and the Eurasian origin of the *M. columbi* lineage

— The spread of *M. primigenius* and the identity of *M. jeffersoni*

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Climate forcing of mammoth range shifts in the countdown to extinction

Adrian M. LISTER ✉, and Anthony STUART

Reviews of megafaunal range changes and extinction have sometimes been hampered by uncritical harvesting of published and unpublished radiocarbon determinations. Here, a global database of some 2400 published and new radiocarbon dates on woolly mammoth (*Mammuthus primigenius*) has been audited, using objective criteria, to around 1900 'good' dates for northern Eurasia and North America. Criteria for exclusion include dates obtained on apatite, burnt bone or an aggregate of more than one specimen; incorrect or uncertain species identification; ambiguous locality; reported laboratory problems (e.g. low collagen or suspected contamination); date superseded using more recent purification or analytical methods; date obtained before 1980; and all associated site dates not directly on mammoth fossils (Lister & Stuart 2013).

Time-sliced maps show changes in woolly mammoth distribution across northern Eurasia and North America from 40 ka to extinction, in comparison with known climate change. The number of good dates in North America (excluding Alaska/Yukon) is relatively low, partly because species identification of dated remains (*M. primigenius/ columbi/jeffersoni*) is not always clear.

The first possibly significant change in mammoth distribution within the range of radiocarbon dating is an apparent contraction in Siberia to the far north in the interval ca. 35-32 ka (all dates calibrated), which may explain an observed loss of genetic diversity around this time (Palkopoulou et al. 2013). Mammoth distribution then re-expands, but the species vacates western and central Europe entirely for the interval 21.5-19.5 ka, in the middle of GS-2 and corresponding to the maximum extent of the European ice sheet. The range expands again in late GS-2, but in the Bølling warming (14.6-13.9 ka) both the European and Siberian ranges become restricted and possibly disjunct. Re-dating of key specimens now suggests that with the afforestation of the Allerød (13.9-12.8 ka), Europe and western Siberia were completely vacated by mammoths; this corresponds closely in time with the global extinction of woolly rhino (*Coelodonta antiquitatis*) and cave lion (*Panthera spelaea*) (Stuart & Lister 2011, 2012). The Younger Dryas (GS-1, 12.8-11.7 ka) saw North American woolly mammoth extinct, and Eurasian populations restricted to northernmost Siberia with a short-lived re-invasion of north-east Europe. By 11 ka (within the earliest Holocene), mammoth was extinct in mainland Eurasia. Terminal island populations in the Beringian region expired on St Paul (Pribilof Islands) around 6.5 ka and Wrangel Island around 4ka.

The major shifts in mammoth range after 40 ka correspond to climatic and vegetational events, suggesting these as the main driving force. Although distributional gaps are hard to deduce from fossil data, the terminal distribution of *M. primigenius* is consistent with severe range reduction, and probably fragmentation. Human impact on these fragmented, climatically-stressed populations cannot be ruled out as a contributing factor to extinction, but direct evidence of mammoth hunting is limited, especially in the far northern 'refugial' areas, and the significance of celebrated mammoth-bone assemblages is unclear. Thus, Yana River (ca. 32ka) is anthropogenic but too early to be directly relevant to extinction; Berelekh (ca. 12 ka) is fluvially-accumulated and may largely precede local human reoccupation (Pitulko & Nikolskiy 2012). Thus far there is no clear evidence for human occupation of either St Paul or Wrangel Island until after the extinction of their respective mammoth populations.

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Microbial life on elephant fossil bones from La Polledrara di Cecanibbio. Is it a real threat for their conservation?

Federica MARANO, and Federico DI RITA

La Polledrara di Cecanibbio is one of the most important palaeontological sites of the Quaternary period in Italy. It was found near Rome in 1984 within a program of territorial surveys promoted by the "Soprintendenza per i Beni Archeologici di Roma". The palaeo-surface corresponds to a riverbed that incised the tuff sediments of the Sabatino Volcanos during the Middle Upper Pleistocene. Overlying it, an extraordinarily rich level of fossil remains was found. During more than twenty years of excavation, over 20,000 bone remains have been unearthed from the fossiliferous deposits (Anzidei et al., 2012). Thanks to the rarity of the finds and their excellent preservation, a musealization of the site was disposed by Soprintendenza per i Beni Archeologici and it is currently under way. To date a museum structure covers a palaeo-surface portion of about 900 m^2, where nearly 10,000 bones are exposed.

The exposed bones mostly belong to bovids (e.g. *Bos primigenius*) and elephants (e.g. *Palaeoloxodon antiquus*), while only few remains belong to other ungulates, such as deer, rhinoceros, horses and boar. The remains of herpethofauna, birds, small mammals, carnivores, and primates, are stored in the depository of Soprintedenza dei Beni Archeologici.

The elephant bones which have been left in situ deserve an outstanding mention, because they make La Polledrara di Cecanibbio the most important elephant site in Italy. Their scientific value requires careful conservation strategies that sometime are in contrast with the exhibition in situ. In fact, the exhibition in situ favors on the one hand the best safeguard of any taphonomic information, as well as a complete fruition of the palaeontological site in its depositional context and major tourist feedbacks; but, on the other hand, it may expose this cultural heritage to the threat of a series of potential pollutant agents, both atmospherical and biological.

Fig. 1. A rib (**A**), sediment (**B**), and a vertebra (**C**) of elephant exposed at La Polledrara di Cecanibbio site contamined by biofilm.

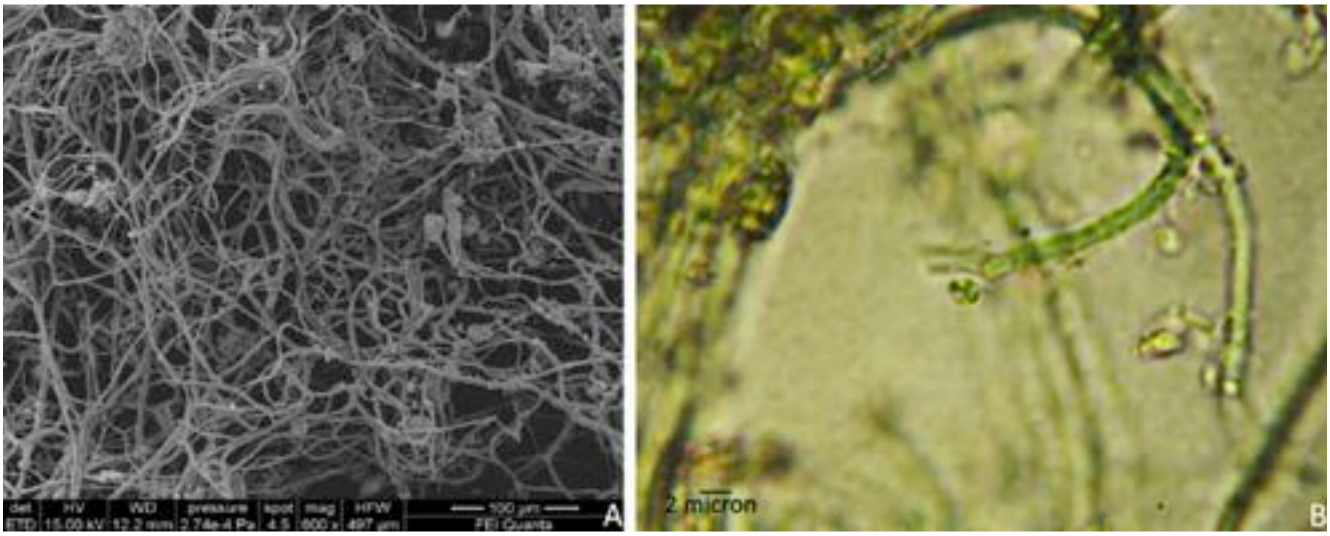

Fig. 2. Scanning Electron Microscope (SEM) image at 600 magnification (**A**) and Optical Microscope image (**B**) of cyanobacteria filaments (*Leptolyngbya* sp.)

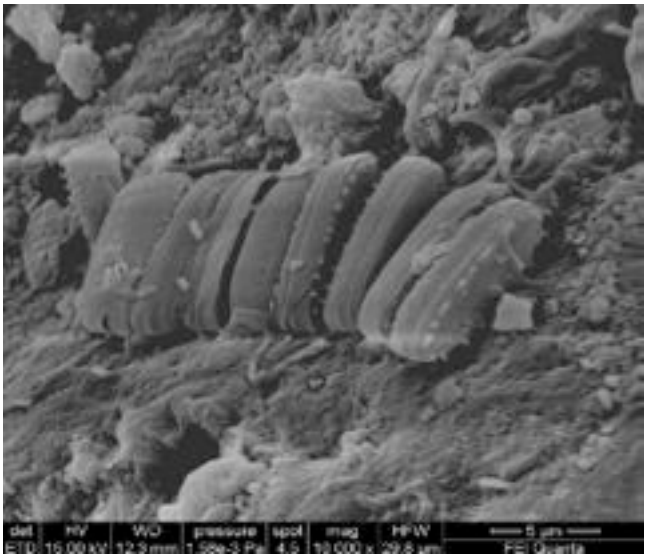

Fig.3. SEM image at 10.000 magnification of diatoms (*Diadesmis* sp.) in vital position observed on elephant tusk surface at the site of la Polledrara di Cecanibbio.

This mostly depends on the fact that at La Polledrara museum, the instability of the inside environmental conditions, mostly influenced by changes in relative humidity, seasonal temperature, sun irradiation, as well as by the presence of people working at the excavation. These factors have been determining the development of biofilms both on the palaeo-surface of the deposit and on fossil bones (Fig.1).

The colonization and the damages of artwork of wide cultural importance by microbial activity has been described by many scholars (Crispim & Gaylarde, 2003; Albertano & Urzì, 1999; Albertano, 2003, Sterflinger, 2010) but only few researches have been dedicated to fossil bones (Jans & Kars 2002; Schoeninger et al, 1989).

Here we present the first results of a study, mostly focused on the preservation of the elephant bones of this site, aimed to:

1. Assess the development of the biofilm covering both palaeo-surface and bones through a qualitative and quantitative study of its components;
2. Verify if the microbial activity may represent a real threat for the preservation of La Polledrara fossils in situ by analyzing the physical and chemical alterations on bone surfaces, using taphonomic and spectroscopic methodologies;
3. Find methods and develop strategies to reduce the proliferation of biomasses, which definitely affects the beauty of the site and limit the fruition of its cultural value.

The over one year monitoring of bones and sediment surface at la Polledrara di Cecanibbio, carried out by means of photographic documentary reports and maps, has provided the first assessment of the areas most extensively stricken by biofilm growth. A non-invasive sampling of organic material on elephant bones and the microscopic observations (optical microscope, Scanning Electron Microscope and Confocal Microscope) shows that the most extensive biofilm patina is composed of photosynthetic cyanobacteria and microalgae, often associated to fungi, mosses and diatoms which grow in the proximity of the windows and entrances (Fig. 2 and 3).

Ongoing research, the first thus far performed in Italy on fossil material exposed in situ, also intends to develop a pilot project to improve the preservation of the entirety of these types of paleontological sites, especially against biological attacks, so contributing to produce a correct balance between conservation and public fruition of these cultural heritages.

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Dimorphic traits in the dwarf elephant "*Palaeoloxodon falconeri*" from Spinagallo Cave (Siracusa, south-eastern Sicily)

Federica MARANO, and Maria Rita PALOMBO ✉

The Sicilian dwarf elephant belonging to the Middle Pleistocene deposits of Spinagallo Cave (Hyblean Plateau, south-eastern Sicily) (Fig. 1) is the smallest insular elephant known to have existed, and the most extreme example of insular dwarfism in large mammals (Ambrosetti, 1968; Palombo, 2003; 2007). The dwarf elephant, generally considered as con-specific with *Palaeoloxodon falconeri* from Malta, had a shoulder height of 0.9 - 1.20 m, and an average body mass of ca. 150 kg (Roth, 1990; Palombo and Giovinazzo, 2005). *P. 'falconeri'* was reduced by approximately 85% in height and 88% in mass with respect to its Italian mainland ancestor *Palaeoloxodon antiquus*, which had a body mass of ca. 10 tons and a shoulder height of 3.5-4 m in fully-adult males. In addition to its dramatically reduced size, *P. "falconeri"* from Spinagallo Cave is characterized by extremely high morphological and dimensional variation, as well as paedomorphic features and the absence of tusks in females (Fig. 2).

Deformed tusks, supernumerary tusklets, and the unilateral failure of tusk eruption, occasionally due to a trauma at an early stage of tusk development, are features, which are also common in both males and females of extant Asian and African elephants (e.g. Raubenheimer, 2000). Conversely, the bilateral tusklesseness - which is generally congenital and commonly evidenced in females of *Elephas maximus*, but also occasionally reported in females of *Loxodonta africana*- has been regarded by some researches as an inherited, non-dominant morphological trait with some dimorphic significance. In isolated populations, e.g. that of *Loxodonta africana* from Addo Elephant National Park (South Africa), the high percentage of bilateral tusklesseness has also been attributed to non-selective genetic drift resulting from a high frequency of inbreeding, or due to an augmented resource allocation to reproductive efforts (see e.g. Seydack et al., 2000; Whithouse, 2002 and Steenkamp et al., 2007 for discussion). The hypothesis that bilateral tusklessness in females from Spinagallo Cave (with poorly developed fan and ossified alveoli) might therefore relate to an increase in reproductive rate in order to reproduce more rapidly and decrease the likelihood of extinction cannot be rejected (Raia et al., 2003; Palombo, 2007). Whatever the actual significance of this morphological trait, it is undoubtedly the most evident dimorphic feature displayed in the dwarf elephant from Spinagallo Cave.

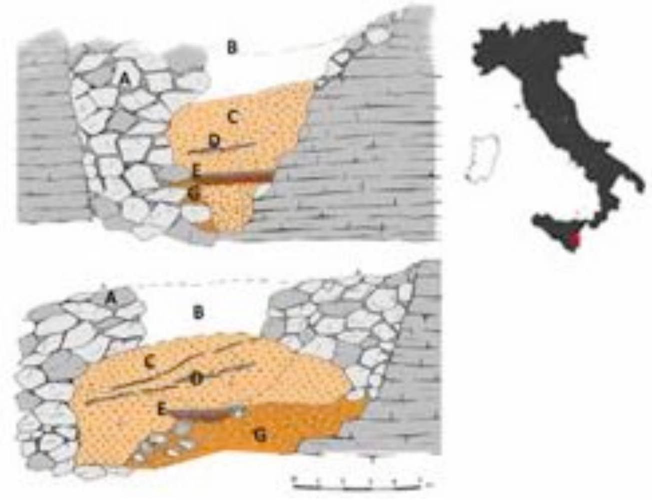

Fig. 1. Localization of Spinagallo Cave (Hyblean Plateau) east-southern Sicily. Trasversal (above) and longitudinal (belove) section of the cave.

A, collapsed and cemented block; B, Floor of the main cave; C, reddish heart containig fossil bones; D, Discontinuous flow stones; E, Black clayed level; G, marine fossiliferous calcarenite. Modified after Accordi and Colacicchi (1962).

Fig. 2. A complete skull of an adult female of *P. "falconeri"* from Spinagallo cave in lateral/frontal view.

Museum of Palaeontology, Sapienza University of Rome, Italy.

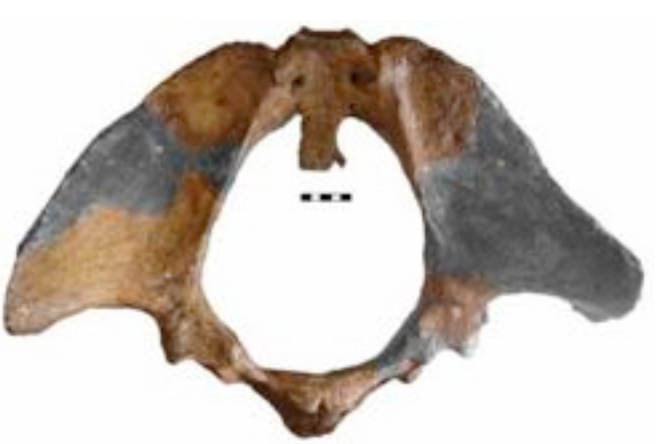

Fig. 3. A pelvis of *P. "falconeri"* from Spinagallo cave belonging to an adult individual.

Museum of Palaeontology, Sapienza University of Rome, Italy

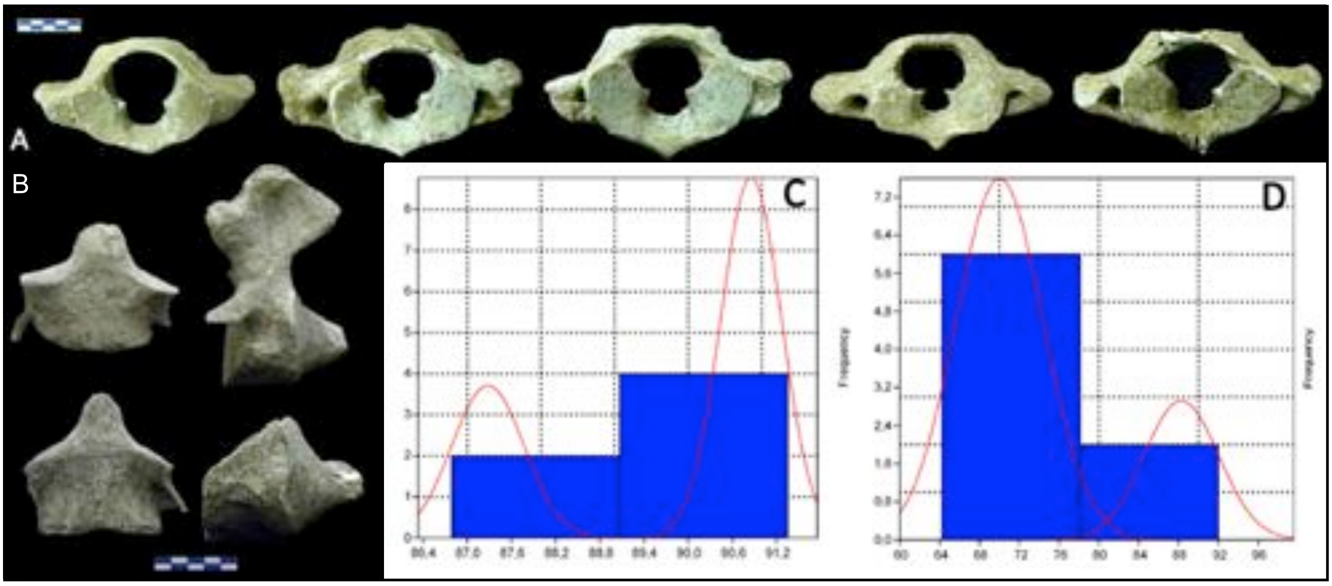

Fig. 4. **A**, Atlases of *P. "falconeri"* from Spinagallo cave belonging to individuals of the same age in cranial view. **B**, Epistropheus of *P. "falconeri"* from Spinagallo cave at the same ontogenetic stage in lateral (on the right) and ventral (on the left) view. Museum of Earth Sciences, University of Catania, Italy. The "best solution" obtained by mixture analysis of the maximum heigth of the atlas (**C**) and the maximum ventral width of the epistropheus (**D**) of *P. "falconeri"* from Spinagallo cave.

Pelvises are known to be particularly useful for determining the gender of elephants, but pelvises of *P. 'falconeri'* from Spinagallo are either incomplete or belong to young individuals. The shape of the pelvic aperture (commonly used to differentiate between males and females in fossil and extant Elephantini) and the ratio between the maximum diameter of the pelvic aperture and the minimum width of the shaft of the ilium in (PAMD/ISmW) (particularly useful with regard to *Mammuthus* and *Palaeoloxodon*, Lister 1996; Palombo and Villa, 2003; Marano and Palombo, 2013), can only be examined fully in two nearly complete pelvises belonging to adult individuals. In the specimen MPRV-P15 (Museum of Palaeontology, Sapienza University of Rome) the PAMD/ISmW value falls within the range of variation in males of European *Palaeoloxodon antiquus* (Fig. 3), in spite of its large pelvic aperture. In the specimen MCA-P17 (Museum of Earth Sciences, Catania University), which displays a more rounded pelvic aperture, the same ratio falls within the range of *P. antiquus* females.

Among the numerous specimens of atlas and epistropheus vertebrae found in Spinagallo Cave, most belong to very young and young individuals, while a few belong to young-adults and adults. Comparing specimens belonging to the same ontogenetic stage, two morphotypes may be detected in both atlas and epistropheus vertebrae, which may be attributed to females and males as is the case in some continental straight-tusked elephants (Marano and Palombo, 2013) (Fig. 4 A, B). In males the arcus dorsalis of the atlas is more robust and the odontoid process of the epistropheus stout and prominent, while in females the dorsal tubercle is less developed and the odontoid process protrudes less.

In conclusion, some dimorphic traits of *P. 'falconeri'* from Spinagallo Cave roughly match those displayed in its continental ancestor. Nonetheless, whether or not the peculiar large pelvic aperture which characterizes the pelvis of MPRV-P15 may relate to allometric growth of the iliac wing in male Spinagallo elephants or not requires further investigation.

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A reappraisal of the straight-tusked elephant from Grotte Santo Stefano (Viterbo, central Italy) kept in the Museum of Palaeontology of Sapienza University of Rome (Italy)

Federica MARANO ✉, and Maria Rita PALOMBO

A nearly complete skeleton of *Palaeoloxodon antiquus* was restored and mounted in the 70's at the Museum of Palaeontology of Rome (Sapienza University), where is still kept. The skeleton was found in the early 1950s in late Middle Pleistocene diatomaceous layers outcropping near the village of Grotte Santo Stefano (Viterbo, central Italy (Fig. 1). According to recent reconstructions and mapping of Quaternary volcanic terrains, the diatomaceous layers are interbedded within the pyroclastic succession of the Montefiascone volcanic complex (Vulsini Volcanic District) (226.6 ± 14.9 ka; see Palladino et al., 2010 and references therein). The fossiliferous deposit was the same outcropping at Campo del Gallo (or del Gatto), on the left side of the Fosso Fonte Campanile stream, where in the 40s nearly two completed skeletons, one of *Palaeoloxodon antiquus* (c.p. no. 1; C.E. no. 3544, Doria Museum of Natural History, Genova) preciously described by Trevisan (1948), the second of *Bos primigenius* (Museum of Palaeontology, Sapienza University of Rome), were found (Trevisan, 1948; Rozzi and Palombo, 2013). In the *Palaeoloxodon* skeleton exhibited in Rome (Fig. 2), the skull, dorso-ventrally deformed, was substituted by a model reconstructed on the basis of the biometry of the original one and the general shape of skulls of Italian adult straight-tusked elephants. The postcranial skeleton is nearly complete, thought a few carpal and tarsal bones are missing. The sexual dimorphic traits shown by both elephants found in the Grotte Santo Stefano area (biometry and morphology of skull, molariform teeth, tusks, atlas, epistroheus and pelvis) were already discussed by Palombo and Villa (2003). The skeleton kept in Rome was identified as a male, as confirmed by the ratio between the maximum diameter of the pelvic aperture and the minimum width of the shaft of the ilium, which has been proved to differentiate male from female in fossil specimens (Lister, 1996). The value (1.65) falls in the range of variation of *P. antiquus* males from Neumark Nord 1 (Germany) (Marano and Palombo, 2013).

Here we present and discuss further data giving information on the age and body size of this individual. We estimated the age on the basis of data in literature (Laws, 1966, Roth and Shoshani, 1988, Lee et al., 2012) and personal observations on eruption and degree of wear of lower and upper molariform teeth of several African and Indian elephants of different ages. In the specimen from Grotte Santo Stefano kept in the Museum of Paleontology of Rome, the penultimate upper and lower molariform teeth (M2) has 9 plates in wear , while the last (M3) only 3. Extant elephants about 30-37 years old show a similar wear-stage, though the large size of straight-tusked elephants might suggest a slightly older age for the Grotte Santo Stefano specimen. An ontogenetic age of about 35-40 year is consistent with the degree of ossification shown by scapula, pelvis and long bones.

We calculated the height at the shoulder by adding the functional length of each foreleg bone. The value obtained of about 3.50 m, is consistent with the value of about 3.65 m calculated by means of the Osborn's (1942) equation based on the length of the scapula. As for the body-mass, the peculiar dental anatomy and replacement pattern of elephantids makes it imperative to focus on either the shoulder height or long bones dimensions (Roth, 1990; Christiansen, 2004; Palombo and Giovinazzo, 2005). A body mass of about 10 tons was estimated for the skeleton mounted in Rome by using the equations with the lowest predictive errors among those based on dimensions measurable on the best preserved bones (e.g., height at the shoulder, pad circumference, maximum length of the humerus, radius, femur and tibia; circumference and antero-posterior diameter of femur and humerus), and then by averaging all the obtained body masses. However,

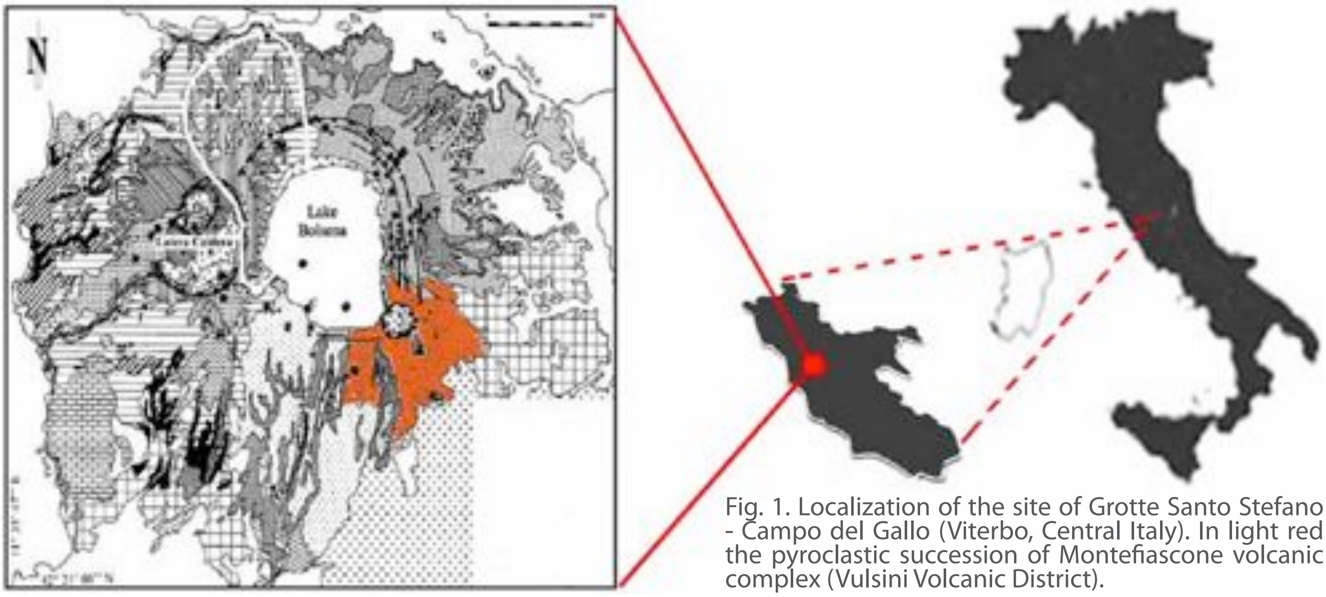

Fig. 1. Localization of the site of Grotte Santo Stefano - Campo del Gallo (Viterbo, Central Italy). In light red the pyroclastic succession of Montefiascone volcanic complex (Vulsini Volcanic District).

Fig. 2: The skeleton of *Palaeoloxodon antiquus* found in the early 50s in the diatomaceus deposits outcropping at Grotte Santo Stefano - Campo del Galo (courtesy of the Museum of Palaeontology, Sapienza University of Rome).

it is worth noting that the values obtained by means of the height at the shoulder (9.957 kg) and the maximum length of humerus (9.929 kg), radius (9.039 kg) and femur (8.724 kg) are consistent with each other, while those obtained by using the minimum circumference (16.725 kg) and transversal breadth (5.304 kg) of the ulna diaphysis respectively over- and under-estimate the actual body mass of the studied specimen.

All in all, and in spite of the not robust, only gently curved tusks, the body size of the straight-tusked elephant from Grotte Santo Stefano mounted in the Museum of Paleontology of Sapienza University of Rome falls in the range of variation of adult males of European straight-tusked elephants.

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A juvenile mandible of "*Mastodon*" *grandincisivus* Schlesinger, 1917 from Hadzhidimovo, SW Bulgaria

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Nearly a century after its description, "*Mastodon*" *grandincisivus* Schlesinger, 1917 remains poorly known. Referred to different elephantoid genera by different authors, it apparently represents an unnamed derived amebelodontid genus (Tassy, 1985, 1999). "*Mastodon*" *grandincisivus* finds are rare, and only two mandibles, belonging to adult individuals, have been published: one from Pestszentlörincz in Hungary (Schlesinger, 1922) and one from Oryahovo in Bulgaria (Bakalov & Nikolov, 1962). In both, the symphysis is missing: photo in Bakalov & Nikolov (1962) shows the specimen after a heavy restoration. A related taxon, if not synonymous, *Amebelodon cyrenaicus*, is described at Sahabi (Gaziry, 1987).

We describe a juvenile mandible from the Turolian locality Hadzhidimovo (SW Bulgaria). Excavated by one of the authors (DK), it is stored at the Assenovgrad branch of the National Museum of Natural History – BAS, coll. No. HD38029 (Fig. 1). The symphysis, despite some dorsal damage, is intact, bearing the two deciduous tusks. Growing permanent tusks are visible. Both dp3s are preserved, as well as the left dp2, with only a fragment of the right dp2. The dp3s have three lophids, confirming the full tetralophodont stage in "*M.*" *grandincisivus* – a character developed in parallel with tetralophodont gomphotheres. Morphology of the deciduous teeth of "*M.*" *grandincisivus* and "*Tetralophodon*" *atticus*, apparently co-occurring with the latter species in the Turolian localities of Central Europe to SW Asia, is thus comparable. Yet, the bunodont pattern of dp3 with enlarged central conules, seen at Hadzhidimovo, is more accentuated in "*M.*" *grandincisivus* than in "*Tetralophodon*" *atticus* from Pikermi. At Hadzhidimovo the preserved symphysis with flat lower tusks, however, favoured an allocation to the amebelodontid "*M.*" *grandincisivus*.

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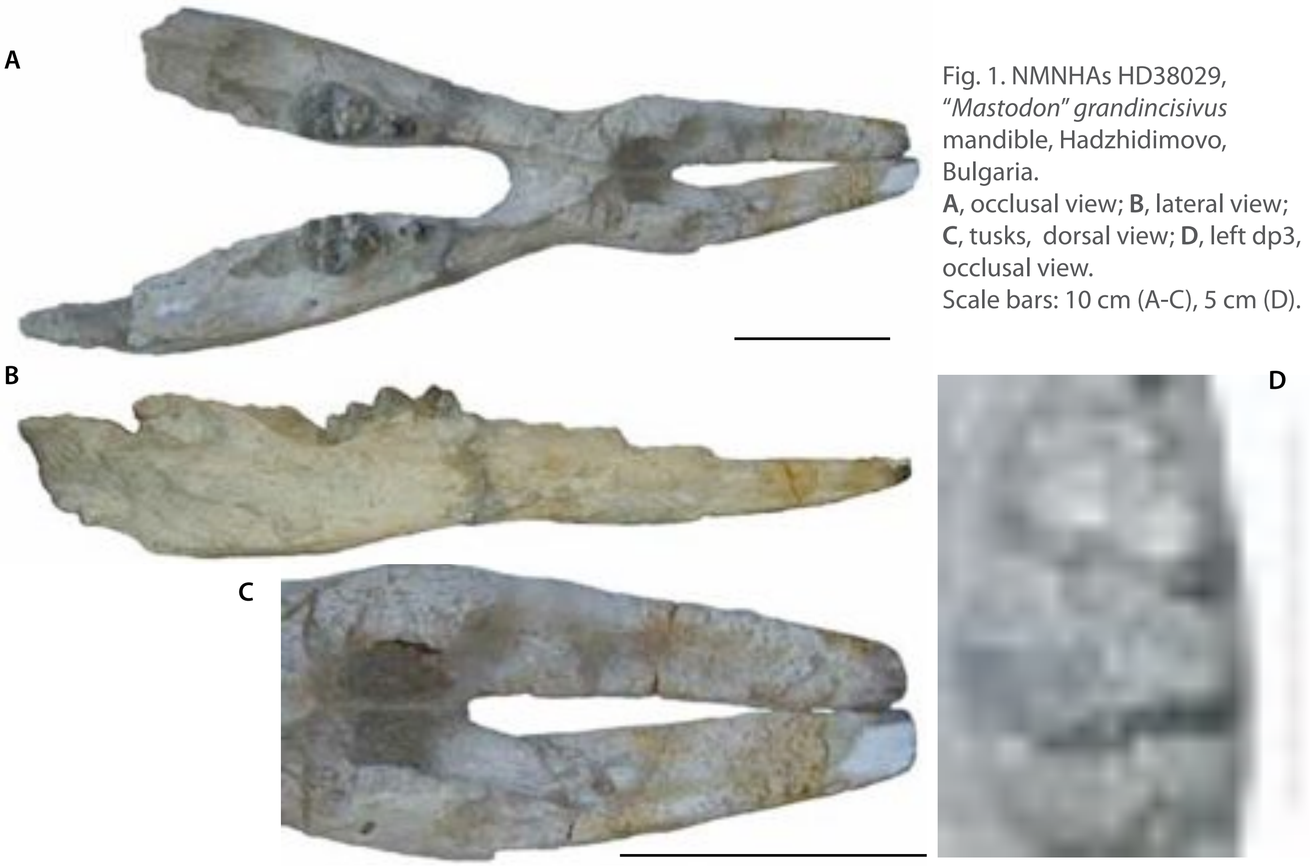

Fig. 1. NMNHAs HD38029, "*Mastodon*" *grandincisivus* mandible, Hadzhidimovo, Bulgaria.
A, occlusal view; **B**, lateral view; **C**, tusks, dorsal view; **D**, left dp3, occlusal view.
Scale bars: 10 cm (A-C), 5 cm (D).

Anancus from the Late Turolian locality Staniantsi, western Bulgaria

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Early stages of anancine evolution in Europe are still insufficiently known. Finds from various Turolian European localities seem to indicate the presence of one or more anancine species, distinct from Pliocene *Anancus arvernensis* (Tassy, 1986; Metz-Muller, 2000; Markov, 2008) but the available material is rare and consists mostly of isolated molars.

Recent excavations at the late Turolian (MN13) locality Staniantsi, western Bulgaria, yielded a rich vertebrate fauna (Böhme et al., 2013), including an anancine mandible with both third molars (Fig. 1).

While molar and mandibular morphology permit allocating the specimen to *Anancus*, it displays some primitive characters such as weak anancoidy. Molar lophids are visibly compressed antero-posteriorly, and cross-contacts are underdeveloped. The somewhat primitive morphology of the Staniantsi specimen seems to support the allocation of the European Turolian anancines to a species distinct from *A. arvernensis* (the proper name for which seems to be *A. lehmanni*, see Markov, 2008). Yet, morphology of the different finds varies, and the Turolian material in its entirety displays mixed primitive and derived characters: a situation closely resembling the observation made by Saegusa & Hlusko (2007) for late Miocene African anancines; thus, allocating all European Turolian anancines to *A. lehmanni* looks logical but can only be tentative. Mechanism of replacement of the Turolian form by *A. arvernensis* by the beginning of the Pliocene is also far from clear. Finds such as the one from Staniantsi – well preserved mandible of latest Turolian age – might prove valuable in both aspects.

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Fig. 1. *Anancus* sp., Staniantsi, Bulgaria. Scale bar equals 10 cm.

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The Eurasian mammoth distribution during the second half of the Late Pleistocene and the Holocene

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The PALEOFAUNA database developed by the authors contains information on more than 5500 Eurasian localities that yielded the Late Pleistocene and the Holocene mammalian fossils. The database is used to analyze the changes in the geographical distribution during the second half of the Late Pleistocene and the Holocene of the significant Pleistocene species – the mammoth *Mammuthus primigenius*. Based on the geographical information, combined with the last radiocarbon data, a correlation has been established between the observed shifts in mammoth range and the climatic changes that occurred during the past 50.000 years. During the Late Pleistocene *M. primigenius* inhabited a vast area in Eurasia (Fig. 1). Mammoth range changed their distribution repeatedly during the Middle and Late Valdai (Weichselian); the expansion of the range increased during stadial intervals and decreased during most of the interstadials. The mammoth was adapted to: a) a dry and cold climate controlled primarily by an anticyclonic circulation pattern, to b) a highly productive steppe environment, and to c) a thin snow cover during winter. The maximum expansion of mammoth range in Eurasia related to the Denekamp (=Bryansk) Interstadial. Later the range of mammoth reduced; this process was started before the end of the LGM in Europe (Fig. 2). The Pleistocene/Holocene transition marked by an increase in humidity, an increase of cloudiness and a related decrease of incoming solar radiation. The "mammoth steppe" began to degrade, along with the loss of productivity in open landscapes and reforestation. The newly formed climatic and environmental conditions resulted in the extinction of *M. primigenius*. Progressive warming from the end of the Pleistocene onwards resulted in dramatic changes in the environment that appeared to be critical for the distribution of this animal. Mammoth range disintegrated into isolated spots, and later it disappeared completely from Eurasia. Relict populations of small-sized mammoths persisted longer on isolated islands such as the New Siberian Islands, the St. Paul Island and the Wrangel Island. Late Paleolithic and Mesolithic hunters might also have additional affected the size of the mammoth population. Their impact was probably particularly higher when the species were close to extinction.

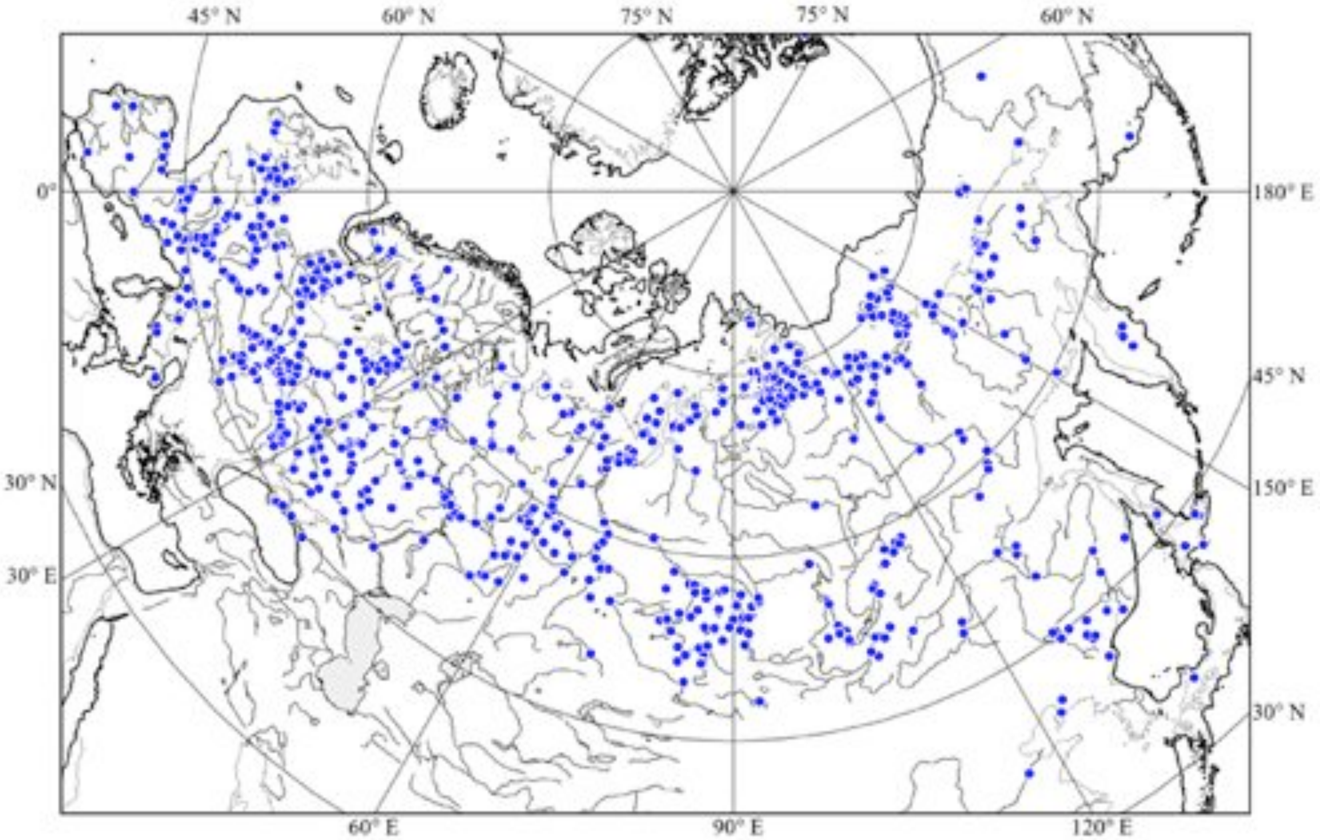

Fig. 1. Mammoth localities dated to the second part of the Late Pleistocene and the Holocene (PALEOFAUNA database: Markova et al., 1995; Markova et al., 2013).

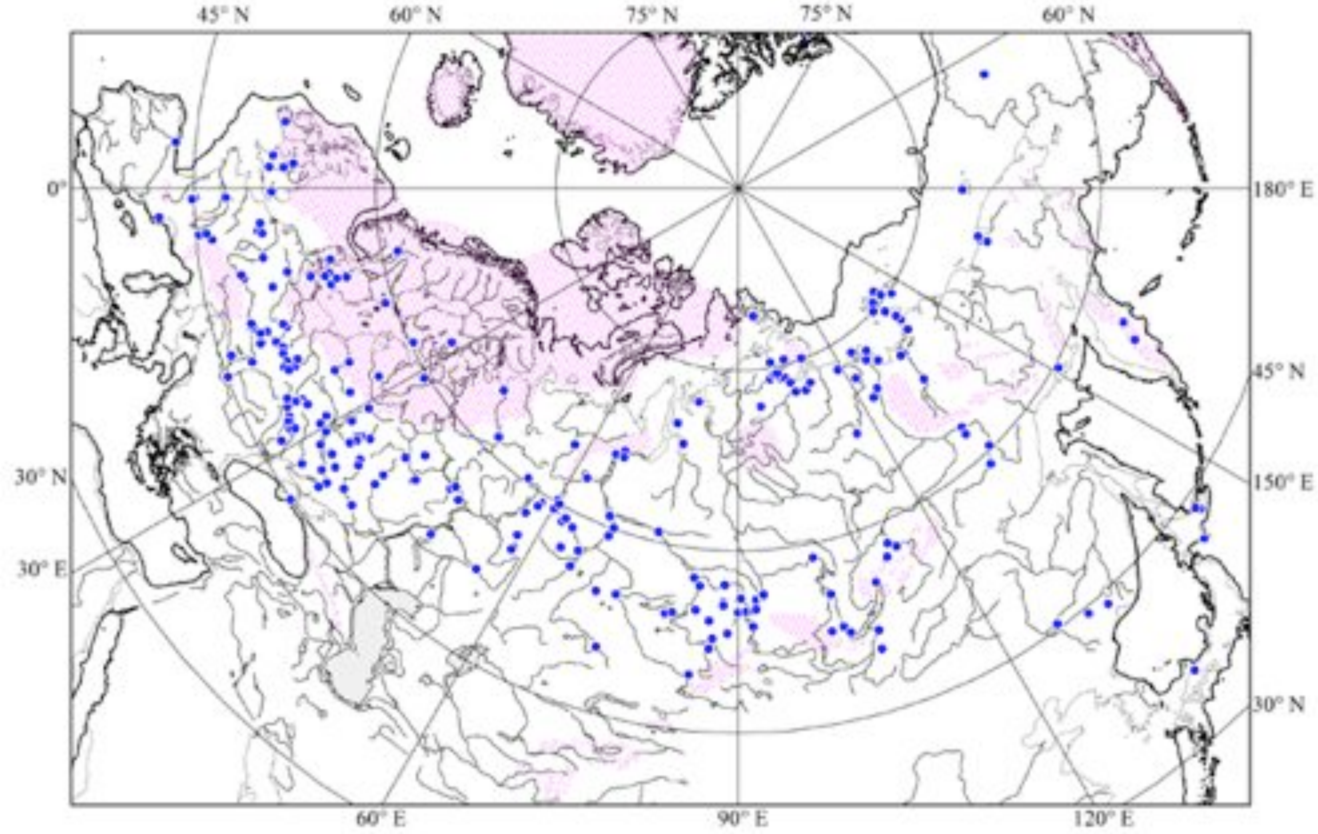

Fig. 2. LGM mammoth localities. The distribution of the LGM ice sheet is shown by pink color.

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The studies of the Yuka mammoth (*Mammuthus primigenius*) from northern Yakutia, Russia: the goals and overview of the first analyses and results

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A partially frozen and mummified carcass of woolly mammoth, *Mammuthus primigenius* was found on the continental coast of the Dmitry Laptev Strait, Yakutia, Russia, by the Yukagir community members in 2010. The site was discovered in the rich bone-bearing Pleistocene yedoma (permafrost) deposits of the Oyagossky Yar, approximately 30 km west from the mouth of Kondratieva River. The calibrated radiocarbon date of the rib is 39,440-38,850 calBP (1950) (GrA-53289) which corresponds to the Marine Isotope Stage 3 (MIS-3, or Karginski Interstadial) (Boeskorov et al., 2013).

The body of the mummy was discovered lying on its belly, with the right leg tucked under it, resting on the ice ledge in the upper part of thawing slope. It was established that the mummy was incomplete, missing most of its vertebral spine, ribs, both femora and left humerus, and all the muscles and inner organs of the torso. The hide with fur coloration varying from very light tan (lower legs) to light ochre – dark brown (upper legs and lower flanks) missed two large parts of the skin on the back and neck and bore rugged cuts that were not compatible with cut marks produced by Paleolithic or Mesolithic tool blades (Maschenko et al., 2012a).

The examination of exterior and interior morphology that we performed in 2012-2013 revealed that no bones (cranium, mandible, neck vertebra, few ribs, scapula, humerus, etc.) had any signs of pathologic or abnormal growths. The Yuka mammoth has, however, a combination of characters that could be unique in comparison to other known specimens, thus, significantly expanding our knowledge on the individual variation of woolly mammoth. These features include the brain anatomy, rates of the molariform teeth and tusks development, body size, number of the nail plates on the feet, trunk morphology, hide fur coloration and others.

Despite the revealed damage, the Yuka mammoth had intact trunk, lips, tail, and left ear, as well as breast nipples and a temporal gland on the left side of the head, available for the study. The trunk with long dorsal and ventral processes, which are characteristic for M. primigenius, appeared to be complete, thus allowing its comparison with a few other specimens.

The cranium and mandible CT scan performed in Yakutsk, Russia, confirmed the initial identification of the teeth as DP4/M1 in wear and presence of the un-erupted M2 in alveoli, which corresponds to 8-9.5 years old Asian elephants studied by Roth and Shoshani (1984). Taking into consideration the fact that mammoth DP2-DP4 replacement occurred at much younger age than in the African and Asian elephants (Maschenko, 2002), the Yuka mammoth age could be lowered down to approximately 6-8 years (Maschenko et al., 2012b). The immature state of the long bones, scapulae and pelvis, none of which have fused epiphysis (or apophysis) indicate that the animal was very young.

The small, permanent tusks protruding from the bony alveoli for just about 3 cm retained "two nested in cones" configuration, which was observed in very young mammoth individuals. Considering occurrences of bilateral tusklesness in female Asian elephant, this case of relatively "late" tusk development might be common in the woolly mammoth females, and can be attributed to the dimorphism within the species. This under-development of the tusks, along with presence of the genital opening in the Yuka mammoth hide and the morphology of the skin folds around it, supports the initial identification of the Yuka mammoth as a female.

The CT scans performed in Yakutsk and the National Research Centre "Kurchatov Institute" in Moscow, Russia, in 2012-2013 revealed a relatively good condition of the Yuka mammoth brain and at least one anatomical feature, ramification of the arteria basilaris, separating it from the African elephant (Kharlamova et al., 2013). A careful brain conservation procedure carried out by the research team in 2012 (Kurtova et al., 2012) allowed analysis of the brain gross morphology.

This analysis showed that the brain of the Yuka mammoth was similar to that of the modern elephants. It had slightly asymmetrical hemisphere volumes and weight and size corresponding to those of a 9-11 years old female African elephant. These findings indicate that the teeth development and replacement rates were accelerated in relation to the body growth, which was accompanied by a normal, similar to the African elephant growth of the brain.

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The partial carcass of the mammoth “Zhenya” (*Mammuthus primigenius*) from western Taymyr Peninsula, Russia: preliminary analysis and results

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The partial carcass of a male woolly mammoth, *Mammuthus primigenius* (Blumenbach, 1799) was found on August 28, 2012 by a young member of the Dolgan tribe, Evgeny Solinder, and named “**Zhenya**” after him. The site is located on the right bank of the Yenisei River Gulf, about 3 km north from the polar meteorological station "Sopochnaya Karga" on Sopochnaya Karga Cape (hence the second name, the “Sopkarga” mammoth), western Taimyr Peninsula, Western Siberia, Russia. In September 2012 the team headed by one of the authors (AT) excavated the specimen and transported it by helicopter to the town of Dudinka. From there, on April 17, 2013 the mammoth carcass was delivered by a special flight to St. Petersburg, and placed for storage and studies at the Zoological Institute, Russian Academy of Sciences.

The excavated mammoth carcass was discovered in a steep, 9 m high slope of the river bank composed by Pleistocene (~7.5 m) and overlaid by ~1.5 m-thick Holocene deposits. The cross-bedded sandy alluvial sediments contained the carcass ~4.5 m below the bank surface, immediately overlaid by ~1m-thick peat deposits, which completely filled the mammoth rib cage and abdomen area.

The site is located within the Quaternary coastal deposits of the lower Yenisei River, well known for established stratotypes of the Sanchugovskaya, Kazantsevsky, Zyrianian and Karginian (Karginsky) suites that are used for section references in entire Siberia. The age, genesis and position of the suites, including Karginsky stratotype located on Karginsky Cape and Malaya Kheta River, were recently questioned and their ages significantly reconsidered being supported by numerous OSL and AMS radiocarbon dates (Astakhov, et al. 2005; Astakhov, 2006, 2010). As a result, being inconsistent with its MIS 5e date, the Karginsky stratotype section was renamed into Kazantsevsky suit (Astakhov, 2009). Similar reconsideration was applied to the sediments correlated with the Karginsky “stratotype” and located between Shaitansky and Sopochnaya Karga Capes, revealing their Kazantsevsky age (Gusev et al., 2009; Streletskaya et al., 2009). However, the dates of the sites north from Sopochnaya Karga Cape, on Shaitanskii Cape (section E-0411: OSL 45,800+/-3,200, RLQG 1796-048; OSL 57,200+/-3,900 RLQG 1797-048), the site 800 m north from section E-0409 (^{14}C 40,100 ± 500 yr BP, GIN-3748) (Gusev et al., 2009; Streletskaya et al., 2009) and the new mammoth "Zhenya" dates, which is consistent with the

Samples	Material	^{14}C age, years BP	δ^{15}N (permil)	δ^{13}C (permil)
UGAMS- 12565	Bone collagen, left *ilium*	37,830 (+/- 160)	7.8	-22.6
UGAMS- 12566	Muscle tissue	43,350 (+/-240)	9.1	-22.5
UGAMS- 12567	Hair	41,100 (+/-190)	6.0	-22.8
GrA-57723	Bone collagen, *tibia*	44,750 (+950/-700)	6.84	-22.09

Table 1. 14C ages, Stable Isotope Ratio δ^{13}C and δ^{15}N analyses of the "Zhenya" mammoth.

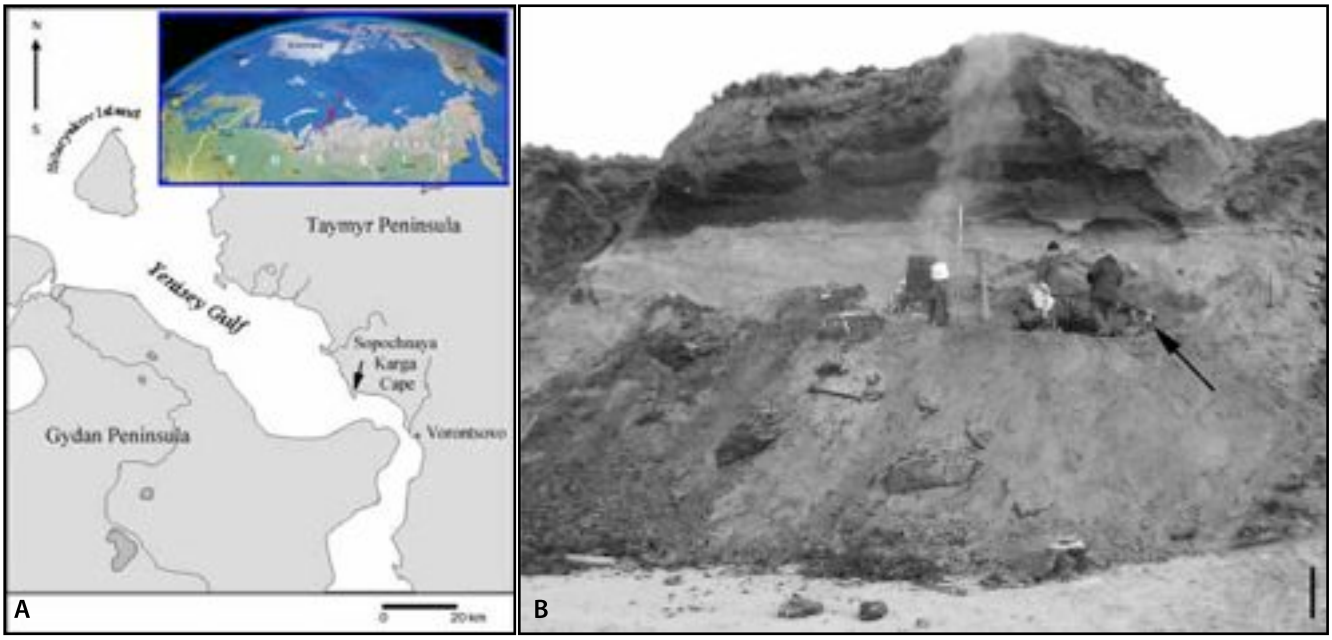

Fig. 1. Geographical location of the "Zhenya" mammoth. A - map of the site area, B - the Yenisei River bank slope with the excavated mammoth carcass in situ (arrow). Scale bar 1 m.

MIS 3. The collected samples provided the results of ^{14}C, and Stable Isotope Ratio $\delta^{13}C$ and $\delta^{15}N$ analyses, which are shown in Table 1.

The recovered in situ mammoth carcass was on its right side, oriented slightly across the bank edge, with most of the torso and hind legs exposed from the slope wall. When exposed after excavations, the frontal part of the body, and particularly, the skull appeared to be at higher (~ 0.3 m) elevation than the sacrum. The bones below femur were detached and scattered on the bank scree.

The carcass preserved a certain amount of soft tissues on the backbone (ligaments), and the unexposed right side of the body: ligaments and muscles of the right fore- and hind limbs, and the torso hide. Most of the hair was detached from the hide. Soft tissues of the head (skull and mandible), except a small skin patch in temporal area, were gone. The left side retained soft tissues only on distal parts of the limbs, down from the proximal carpal and tarsal articulations. Most of internal organs were gone, but fragments of the heart, liver and majority of the penis soft tissues were found in a relatively good state. The damages comprised the cleaved tusk tip and gnaw-marks on the femur caused by a medium-sized predator (possibly arctic fox).

The skull had only right permanent tusk with the outer curvature length of 1,600 mm and diameters at the alveoli are 86.5 (minimum) and 93.0 (maximum) mm. The left tusk alveolus was under-developed (slightly smaller than the right one) with a small opening remaining on its distal end. The analyses of the morphology and size of the left alveolus allowed concluding that the left permanent tusk was not developed at all.

The specimen had all erupted check teeth in place, which were (preliminary) identified as DP4/M1. The upper and lower DP4 on the left side retained the last 7 and 4 distal plates correspondingly. The upper and lower M1 contained 18 and 19 plates, with 11 and 14 proximal plates in wear. The un-erupted molars M2 appeared to be under-developed: only few, with reduced size plates in the jaw alveoli were present. Based on identified dentition (if correct), compared with the Asian elephant studied by the individual age of the specimen is around 13-16 years. The young age of the specimen is also supported by presence of all un-fused bone's apophyses and epiphyses preserved in the skeleton.

The mammoth Zhenya had almost complete set of skeletal elements. Only proximal epiphysis and diaphysis of the right fibula, distal epiphysis of left fibula, tail vertebra ##10-12 and second phalanges of the front and hind limbs were missing.

The body height in shoulders measured (along each limb section) before fleshing the right side of the body with front limb, with added estimated thickness of withers tissues and skin, was about 235 cm.

The cause of the mammoth death was not yet established. Neither the skeleton or preserved soft tissues have any visible lifetime injuries. Large amounts of fat discovered in the withers area of the animal rule out the death from starvation.

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Proboscideans without stratigraphic significance: the fate of specimens from the Institute's collection

Jadranka MAUCH LENARDIĆ ✉

In the paleontological collection, stored at the Institute for Quaternary paleontology and geology of the Croatian Academy of Sciences and Arts in Zagreb, there are different findings without any stratigraphic data, from which four interesting proboscidean specimens have been selected and presented. They are unique in the collection because of either their anatomical features (isolated teeth belonging to the same individuum, or juvenile mandible), or their taxonomical belonging (rare species in the collection such as *Anancus arvernensis* and *Palaeoloxodon antiquus*). For two isolated last permanent molars of *Anancus arvernensis* (M3 sin. /catalogue number ZPGK-151-PROB./ and M3 dext. /catalogue number ZPGK-152-PROB./) only approximate location is known, written on the old label, which the present author found together with these remains. On the same label is also written that the teeth were found in the Upper Pliocene sands beside the St. Martin's church in Dugo Selo, small town approximately 20 km eastern from Zagreb, while the year of discovery is unknown. The crowns of these two last lower molars are very well preserved, the roots are missing, and on the basis of the same morphometric characteristics it is concluded that they belonged to the same adult individuum (Fig. 1A; Tab. 1). No other skeletal parts have been found yet. The area around the St. Martin's church is nowadays inhabited, thus it can be presumed that no further excavations will be possible in the future.

The straight-tusked elephants (*Palaeoloxodon antiquus*) are very rare findings in Croatia. Therefore, another interesting specimen from the Institute's collection is one fragmented mandible of that species with the last left molar (M3 sin.; catalogue number ZPGK-160-PROB.; Fig. 1B; Tab. 1), dredged almost 30 years ago from the bottom of the Adriatic sea (depth cca. 50 m), somewhere near the island of Rab (northern Adriatic). The finding was provided through the courtesy of colleagues from the Institute of Oceanography and Fisheries in Split and the Natural History Museum in Zagreb in 2006. The molar and part of the horizontal ramus were cleaned from thick layer of

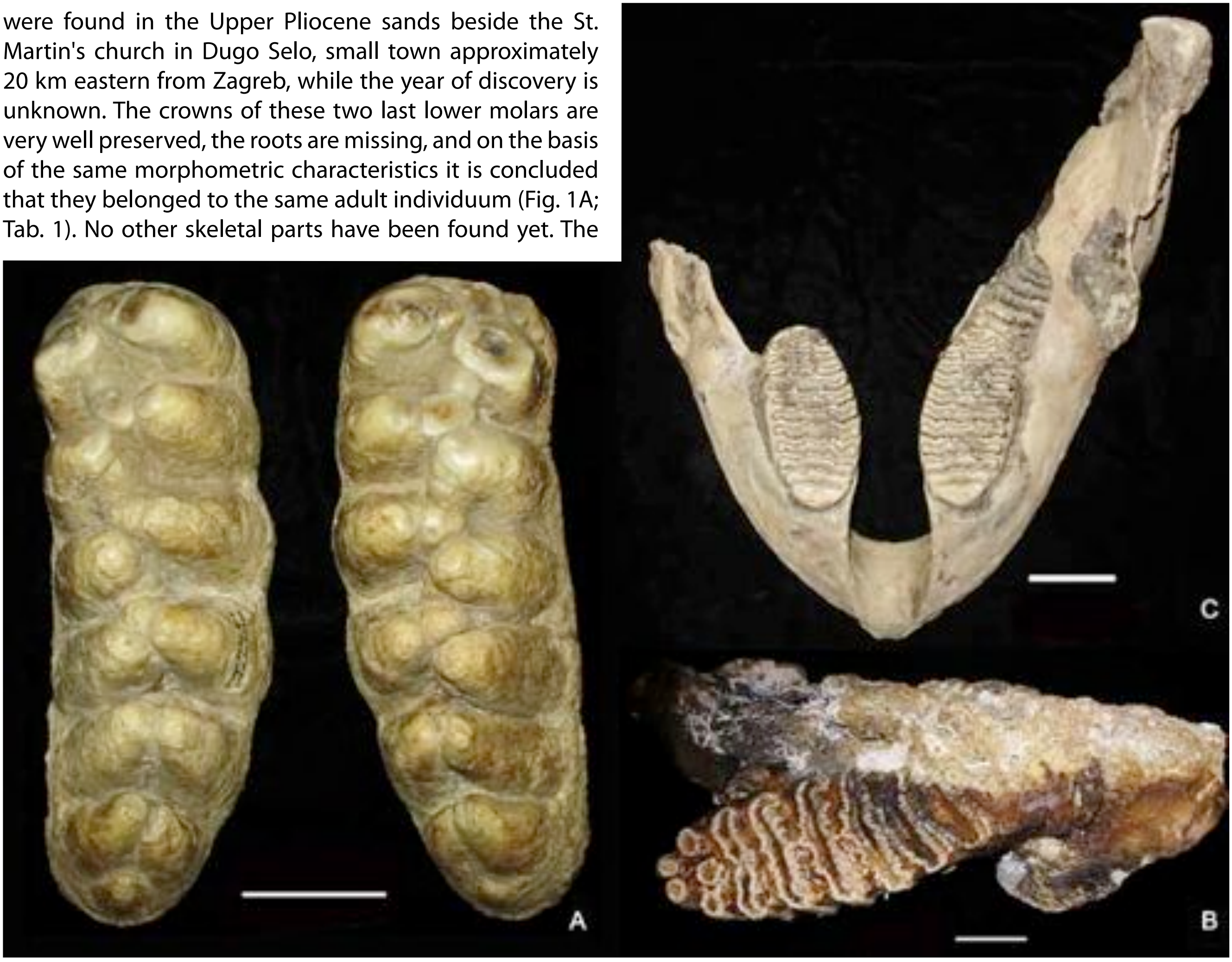

Fig. 1. Selected proboscidean specimens from the paleontological collection stored at the Institute for Quaternary paleontology and geology of the Croatian Academy of Sciences and Arts. **A**, *Anancus arvernensis*: M3 sin. and dext. (locality: Dugo Selo near Zagreb; catalogue numbers ZPGK-151-PROB. and 152-PROB.); **B**, *Palaeoloxodon antiquus*: part of mandible with M3 sin. (locality: bottom of the Adriatic sea near the island of Rab; catalogue number ZPGK-160-PROB.); **C**, *Mammuthus primigenius*: juvenile mandible with dp4 sin. and dext., and M1 sin. (unknown locality; catalogue number ZPGK-101-PROB.). All specimens in occlusal view. Scale bars equal 5 cm.

Table 1. Tooth measurements (L = length, W = width, ET = enamel thickness) of four proboscidean specimens stored at the Institute for Quaternary paleontology and geology of the Croatian Academy of Sciences and Arts.

Taxa	Tooth	L	W	ET
Anancus arvernensis	M_3 sin./M_3 dext.	213.5 / 214	80.5 / 81	-
Palaeoloxodon antiquus	M_3 sin.	250	~80*	2.0
Mammuthus primigenius	dp_4 sin./dp_4 dext.	107 / 105.5	52.5 / 51.5	0.9

**, approximate value, while the buccal side of the molar is in alveolus.*

marine organisms and sediments, which are still visible on the buccal side of the mandibular ramus and partly on the inner side of the damaged alveolus. The shape of lamellae on the occlusal surface is typical for the straight-tusked elephant (H. van Essen, personal communication), with small abnormality (additional enamel loop) on the buccal side of the III lamella on the posterior part of the crown. Few anterior lamellae had been completely worn off till the roots, and the unknown number is missing on the front part of the crown as well. On the basis of the molar wear pattern, the animal was the most probably in its 40s, or even a bit older.

One juvenile woolly mammoth (*Mammuthus primigenius*) mandible (catalogue number ZPGK-101-PROB.) with last deciduous molars (dp4 sin. and dext.) which were in function, and first left permanent molar (M1 sin.) still in alveolus, is the specimen without any location and/or stratigraphic data (Fig. 1C; Tab. 1). The mandible is unique in the Institute's collection. The deciduous teeth are very well preserved, with all 12 lamellae in wear. The crown length and width values are shown in Table 1. The permanent molar was not in function and unworned mammillae are 17 mm under the posterior edge of the occlusal surface of the dp4 sin., thus the tooth was just in the eruption phase. The age of the animal was approximately 5 to 6 years at the moment of death (according to Haynes, 1999). Although, there are no data about the site, it is presumed that the specimen originate from the alluvial sediments of some Croatian the biggest rivers, such as Sava, Drava or Dunav (Danube), or their tributary, while the majority of the woolly mammoth remains were discovered in that part of the continental Croatia (Mauch Lenardić, 2011).

Although the mentioned proboscidean specimens do not provide any valuable stratigraphic data, they are unique in the Institute's collection, and significant as the faunal members from the particular region(s), as the proof of the biodiversity during the different geological periods, and are good climate and environmental indicators, respectively.

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Review of the Late Neogene Proboscideans from Turkey

Serdar MAYDA ✉

Turkey is a unique country that extends on two continents - Europe and Asia and its position in the Neogene paleontology gains benefits from this geography. Thanks to extensive field works of geologist and paleontologist from MTA-Ankara and Ege Univ. Natural History Museum-Izmir for the last 50 years, over 400 fossil vertebrate localities were spotted in Turkey.

Within all these numerous localities and related studies, The publication of Calvert and Neumayr (1880) which originally recorded *Mastodon angustidens* and *Mastodon longirostris* from Çanakkale is the first paleontological study that described the fossil mammal content of the Miocene formations on both sides of Dardanelles. Almost 50 years later, Küçük Çekmece (Istanbul) mammal fauna, studied by Nafiz and Malik (1933), is the second locality where proboscideans were also recorded. The fauna comprises of well-preserved *Choerolophodon* and *Deinotherium* specimens which were briefly described and figured.

During the 1940s and the 1970s, the preliminary studies of proboscidean fossils mostly focused on Late Miocene (Turolian) faunas of Central and Western Anatolia (Ozansoy, 1955, 1957, 1961a, 1965; Senyürek, 1952; Tassy, 1994; Tassy et al., 1989); Late Miocene (Vallesian to Turolian) faunas of NW Anatolia-Thrace region (Viret, 1953; Viret and Yalçinlar, 1952; Yalçinlar, 1952) and few Early-Middle Miocene faunas from Western Anatolia (Ozansoy, 1961b).

During 1965–1969, a joint project called "Lignite Deposit Exploration in Turkey" and conducted by a group of German and Turkish geologists, led to the discovery of new fossil mammal localities throughout western and central Anatolia (Sickenberg et al., 1975). Gaziry (1976) compiled proboscidean collections that were found during this extensive field work. This publication is clearly the first comprehensive study on fossil proboscideans of Turkey.

Over the last two decades, renewed laboratory and fieldwork has added substantially to prior fossil collections made in Western and Central Anatolia, Especially, the monographs on the Hominoid sites (Sinap, Paşalar and Çandir) and sporadic publications have added new results to fossil Proboscideans and their evolutionary story (Geraads & Gülec, 2003; Geraads et al., 2005; Kaya et al., 2003; Kayseri et al., 2014; Sanders, 2003; Tobien, 1990).

The richest part of the fossil proboscidean specimens known from Turkey are of Middle-Late Miocene age. The present study provides (1) announcement of the first records of some Middle Miocene proboscidean taxa, such as *Gomphotherium subtapiroideum*; (2) new results of taxonomic analyses of the unstudied proboscidean collections, such as *G.angustidens, Zygolophodon turicensis, Tetralophodon longirostris, Choerolophodon ssp, Deinotherium giganteum* and *Prodeinotherium bavaricum*, that are mainly stored in Ege Univ. Natural History Museum, local Museums and private collections (F. Ozansoy); (3) partly revision of the aforementioned published collections; (4) new information on the temporal distribution and taxonomic diversity of the fossil proboscideans of Anatolia (Fig. 1).

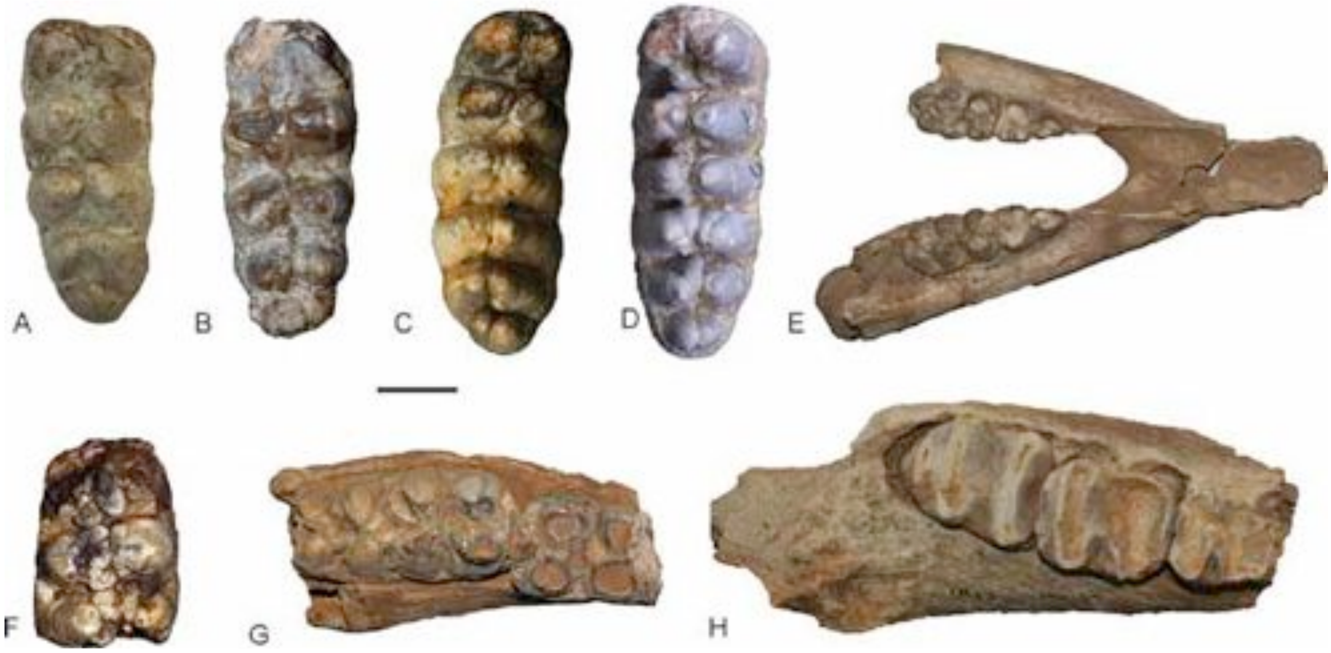

Fig. 1. New Miocene proboscidean collections in Ege Univ. Natural Hist. Museum, Izmir-Turkey. **A**, *Gomphotherium angustidens*, M3 dext. Kütahya; **B**, *G. subtapiroideum*, m3 sin. Imbros; **C**, *Tetralophodon longirostris*, m3 dext. , Tekirdağ-Yulafli; **D**, T.longirostris, m3 sin. Çanakkale-Bayraktepe; **E**, *Choerolophodon pentelici*, mandible, Uşak-Kemiklitepe A-B; **F**, *T.longirostris*, m3 sin. Çanakkale-Lapseki; **G**, *Choerolophodon* sp., m2-3 dext., Istanbul-Kilyos; **H**, *Deinotherium giganteum*, mandible, Tekirdağ-Yulafli. Scale bar equals 5 cm.

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Anancus in Turkey

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Although the remains of bunodont mastodons are typical for Miocene localities of Turkey, the data about late representatives of the aforementioned genus Anancus from the south Black Sea region are very scanty. Anancus ex gr. arvernensis were widespread in Pliocene and Early Pleistocene deposits at adjacent to territory of Turkey (Bulgaria, Rumania, Ukraine, Moldova, south of Russia, Greece) and other south European regions (Hungary, France, Italy) though the Turkish records are the least known. In this study, we present some unstudied *Anancus* fossils from Late Miocene - Early Pleistocene sites of Turkey.

Develi (EUNHM): This material was found by former Prof. Ozansoy during late 1970's in Develi (latest MN13) site and belongs to the Vertebrate Paleontology collections of EUNHM (Ege University Natural History Museum, Izmir). The material is composed of a pair of well-preserved upper M3 and an upper and a lower tetralophont intermediate molar. In the former studies, they were referred to as *Tetralophodon longirostris*. Upper M3 is distinguished from the following Anatolian Plio-Pleistocene *Anancus* records by the weak anancoidy, less developed central conules and its larger dimensions. Turolian anancines are known from many European localities in Spain, Germany, Hungary and Bulgaria. In the context of paleobiogeography, Bulgaria and Turkey, mostly share same proboscideans during Turolian and a common anancine during Mio-Pliocene boundary sounds plausible. Morphologically and metrically, Develi specimen is closest to Turolian form, *Anancus turoliensis*. Since the whole faunal study is in progress, we tentatively identified our material as *Anancus* cf. *turoliensis*.

Sabuncubağlari (Edirne Archaeology Museum): We came across this fragment of lower right jaw with m3 which was found 50 years ago by Prof. Kansu, in the exhibition of Archaeology Museum of Edirne. The specimen was labeled as "*Choerolophodon pentelicum*", a single record from a locality, which is an abandoned Pleistocene sand pit. The relatively large tooth is composed of 5 lophids, excluding well developed posterior talonid and with some intermediate conules in the valleys. The size and the morphology of the tooth is similar to the same of Pliocene *A. arvernensis* ex gr. *arvernensis-brevirostris* (MN 14-15).

Çobanisa (EUNHM): The material is represented by single isolated incomplete m3 composed of 5 lophids, excluding a small posterior talonid. There are few additional intermediate conules in valleys of lower and upper teeth. Size of teeth is intermediate between Early Pleistocene *A. arvernensis alexeevae* and Late Pliocene *A. arvernensis arvernensis*. Taking into consideration the morphological features, this form is closer to *A. arvernensis arvernensis*. According to accompanying fauna from the site we suppose the late Early Pliocene age (MN15).

Saruhanli (EUNHM): The material is rather numerous, represented by an upper M3, a lower jaw with m2-m3, and a fragment of right lower jaw with incomplete m3. Upper M3 is composed of 5 lophs and a small talon and characterized by thick coating of cementum in the transverse valleys and a rather simple crown with slightly undulated enamel. Lower jaw is composed of a typical tetralophodont intermediate molar and a m3 with 5 lophids (+ talonids) and expressed anancoidy. Since the additional intermediate conules around the valleys are not numerous, the crown morphology looks rather simple. The size is similar to Pliocene *A. arvernensis arvernensis*.

Yukarısögütönü (Eskisehir Archaeology Museum): During 2012-2013, one of us (SM) came across some new material from this locality which has been housed in the Archaeology Museum of Eskisehir town (NW Turkey). This new collection is comprised of mostly Proboscidean fossils, including 4 specimens of well-preserved Anancus remains as well as archaic mammoths. The *Anancus* collection is comprised of two upper M3's of different individuals and enamel-free upper tusk pairs of an adult male. Larger M3 consists of 6 transverse ridges (+talon) and the other M3 is composed of 5 with a weakly developed talon. Both upper M3 show incipient anancoidy which refers to alternate position of the pretrite and posttrite cusps pattern, though the larger molar has slightly better developed anancoidy and undulated enamel due to the wear degree. In both molars, transverse valleys partly filled with cement, additional central conules are numerous and basal cingulum is weakly developed. Tooth morphology and measurements of this small *Anancus* form are intermediate between those of *A. arvernensis alexeevae* (MNQ 17, south of Russia) and *A. arvernensis chilhiacensis* (MNQ 18, France) and surprisingly close to the new introduced Spanish form *A. arvernensis mencalensis* (MN 17, Spain; Garrido and Arribas, 2014). By the complex of the fauna, this Pleistocene locality was dated as beginning of Middle Villafranchian (mammal zone MN 17).

In the context of this new study, we can pick out three forms of *Anancus* from the territory of Turkey for the first time. The first one, latest Turolian (late MN13) *Anancus* cf. *turoliensis* (Develi), which is the oldest record of the genus and clearly referred plausible paleogeographical connections between Eastern Europe and Turkey. The second form is the Pliocene *A. arvernensis* cf. *arvernensis* (Saruhanli, Sabuncubağlari, Çobanisa) with rather large teeth; 5 transverse ridges at M3/m3 with weakly developed talon/talonids, and not numerous additional intermediate conules in the valleys. The clear progressive size reduction trend, starting from Miocene finalized by the third form – smaller Early Pleistocene *Anancus arvernensis* cf. *alexeevae* (Yukarısögütönü) with 6 lophs at M3 (or 5 lophs and developed posterior talon) and a rather complex crown pattern with numerous additional intermediate conules in valleys.

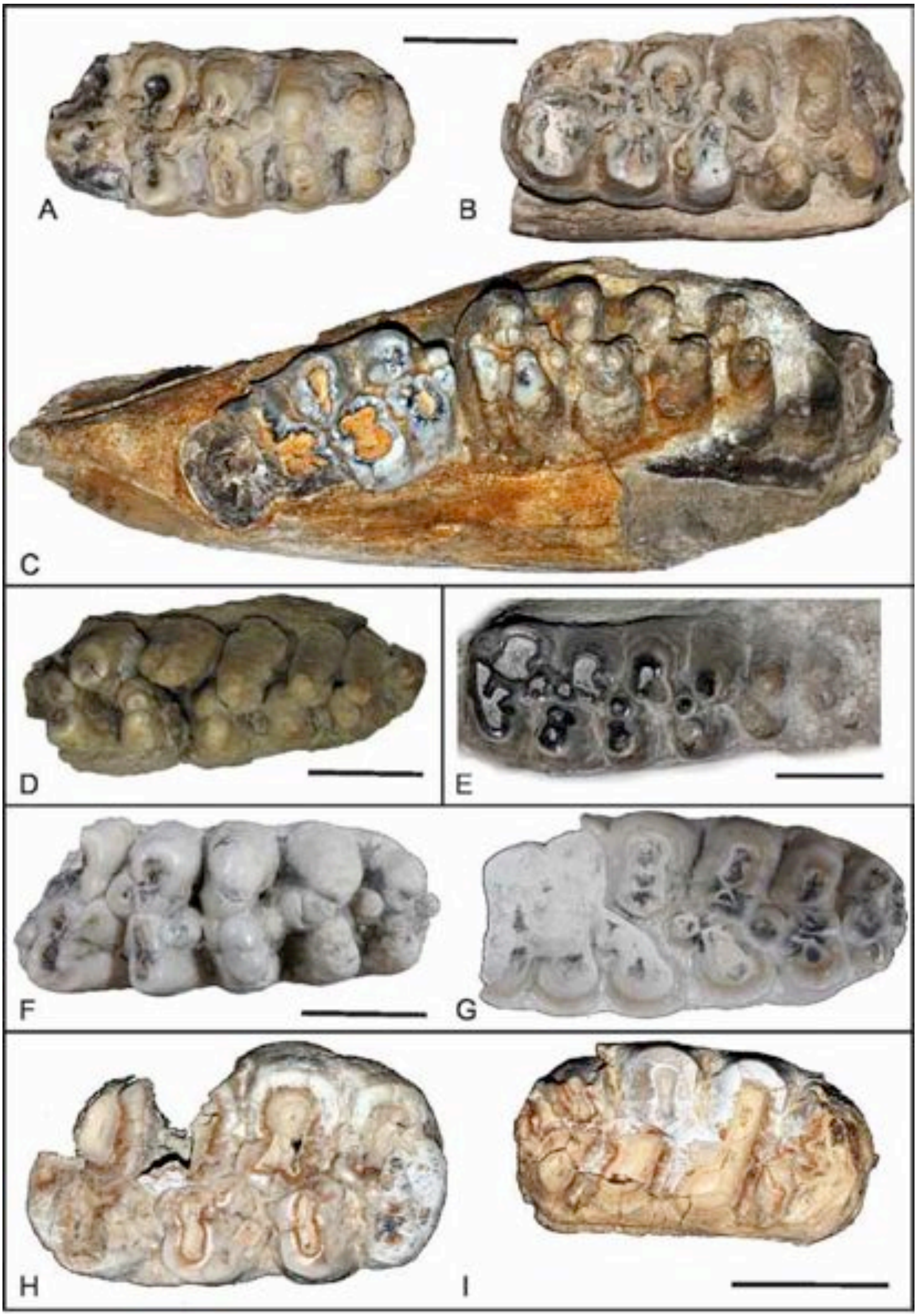

Fig. 1. Teeth of *Anancus* from territory of Turkey. *Anancus arvernensis* cf. *arvernensis*, Saruhanli: **A**, Upper right M3; **B**, lower left m3; **C**, lower m2-3. Çobanisa: **D**, lower right m3. Sabuncubağlari: **E**. lower right m3. *A. arvernensis* cf. *alexeevae*, Y.söğütönü: **F**, Upper right M3; **G**, Upper left M3. *Anancus* cf. *turoliensis*, Develi: **H**, Upper right M2; **I**, lower right m2. Scale bar equals 5 cm.

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The taphonomic study of Charkadio cave, Tilos Island. Evidence from elephant and avian remains

Dimitrios MICHAILIDIS ✉, Vasiliki MITSOPOULOU, Socrates ROUSSIAKIS, and Georgios THEODOROU

Several excavation periods at Charkadio cave, until 2012, resulted in the discovery of more than 17.000 *Elephas tiliensis* Theodorou et al., 2007 (*Palaeoloxodon tiliensis* according to other authors), skeletal elements and fragments, representing at least 75 individuals (Fig. 1). During the same time period, 375 avian skeletal elements were unearthed. The taxonomic analysis of the avian material led to the identification of twenty four different taxa. Fifteen of them were identified to species level, four to species confer, three to genus level, two to the family level, whereas some specimens were identified only to class (Michailidis, 2013). Research in Charkadio cave was funded by the Secretariat General of Aegean Sea and Island Policy (70/3/10323), the Special Account for Research Grants of the National and Kapodistrian University of Athens (70/4/3370, 70/4/11078) and by the THALES Research Program (MIS 380135).

The analytical excavation methods applied, led to the discovery of several *E. tiliensis* partial skeletons and avian remains in anatomical association. Charkadio cave is a rare example of a site with insular faunal elements, as it preserves a large number of articulated remains (Fig. 2). The above finds indicate minimal transfer of the material and point to the in situ deposition of part of the material. Additionally, the spatial distribution of the material inside the cave is analyzed according to data from photographs, excavation drawings and notes recorded during the latest excavation periods (1991-2012). The elephantid remains were examined for cut marks that would provide direct evidence of human influence on the assemblage. Quantitative units applicable to taphonomy such as MNI, NISP, MNE and MNU and ratios such as MNE/MNI, NIPS/MNE are used in this study (Bunn et al., 1991; Lyman, 1994). The data, until present, revealed that natural, non-biotic factors were the main cause in the accumulation of the specimens. Possible means of transfer of the material were studied, considering the interpretations expressed by previous researchers (Steinhauser et al., 2008). The taphonomic study of the avian remains focusing on the relative abundance of different skeletal elements, was based on Mourer-Chauviré's (1983) and Ericson's (1987) methods. The presence or absence of alterations of bone surfaces was also noted. The above analyses also do not support human involvement in the accumulation of the palaeoavifauna. The ultimate aim of the taphonomic study of Charkadio cave is the complete reconstruction of the mechanism of deposition and transfer of the fossil remains.

Fig. 1. Photograph of the interior of Charkadio cave, south aspect, excavation period 2012. Railings are used to remove sediment for wet sieving.

Fig. 2. Photograph of articulated left ulna, radius and carpal bones of *Elephas tiliensis*. Excavation grid, square P7, excavation period 2000.

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Applying allometric analogies of elephantid skeletal elements to Rapid Prototyping bones

**Vasiliki MITSOPOULOU ✉, Stelios ISIDOROU, Evangelos THEODOROU,
Stavros KOUSOULAKOS, and Minos TYLLIANAKIS**

Tilos Island, situated in the southeastern Mediterranean Sea is well known among vertebrate palaeontologists for its endemic elephant remains found in Charkadio cave. The fauna of the cave includes the endemic elephant *Elephas tiliensis* (*Palaeoloxodon tiliensis* according to other authors) and avian, deer and chelonian remains (Symeonidis, 1972; Bachmayer et al., 1976; Bachmayer et al., 1984; Theodorou et al., 2007). Research in Charkadio cave is been funded by the Research Funding Program THALES (MIS 380135). The elephant skeletal elements represent at least 75 individuals. The current study focuses on the biometry and ontogeny of selected long bones. Initially, the samples of each bone were divided into three age groups (infants, juveniles, and adults) according to their osteological characteristics. Highly correlated measurements of each separate bone were chosen in order to create mathematical equations describing allometric relationships. According to Huxley (1932) the equation of simple allometry (**$y=bx^a$**) describes the relationship of the studied measurements. Constants **a** and **b** were calculated following the methodology described in Jolicoeur (1963). Furthermore, the same constants were calculated by curve estimation through SPSS. In a previous study (Mitsopoulou et al., 2014) it was indicated that the mathematical equations, referring to highly correlated measurements, for example in the tibia of adult individuals, showed negative allometry. The current study presents how similar measurements are expressed in different age groups in terms of ontogeny. Specimens of infant and juvenile individuals appear to follow partly the adult pattern, due to the fact that various measurements such as the shaft length, proximal and distal transverse width at the epiphyseal line and the minimal transverse diameter of the shaft, display variations in allometry. It is also worth mentioning that the study of long bones gives a good insight in the allometric growth of a skeleton and can be used for practical purposes at Rapid Prototyping printing of 3D reconstructions. The measurements derived from the allometric equations generate data that proved to be a valuable tool for the restoration of missing skeletal parts and the measurement estimation of fragmented material.

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Thales. Investing in knowledge society through the European Social Fund.

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Special Volume 102 131-132 Thessaloniki, 2014

A cranium of a mammoth calf [*Mammuthus primigenius* (BLUMENBACH, 1799)] from the Eurogully, North Sea

Dick MOL ✉, Klaas POST, and Hans VAN DER PLICHT

During a special fishing expedition in search of Pleistocene mammal remains, a fragmented skull of a woolly mammoth calf was dredged up. The trip took place April 22, 2011 on the fishing vessel OD 7 in the Eurogully (Fig. 1A), the North Sea, The Netherlands (coordinates 52° 00' 51.40'' latitude; 3° 55' 19.50" longitude') (van der Plicht et al., 2012). Research has shown that the skull belonged to a calf which was only one and a half years old at the time of death. The matching skeleton elements suggest that the mammoth remains were not transported very far from the discovery site.

The maxilla and the right frontal were collected during the fifth trawl of this fishing trip (van der Plicht et al., 2011, Mol and Post, 2010), while the next trawl produced the right tusk and the left frontal as well as the mandible, broken in two parts, amongst other remains. Both trawls yielded a total of 14 skull parts and fragments, while no fragments at all were found in the previous and subsequent trawls at the same location. After cleaning and preservation, ten fragments could be assembled into a coherent reconstruction (Fig. 1B). Unfortunately, because of missing pieces, four fragments of the braincase could not be placed in the reconstruction. The reconstructed skull is stored in the collection of Klaas Post in Urk, The Netherlands and catalogued as NO 4513.

The right premaxilla is completely intact. Only part of the left premaxilla was found. This fragment includes the depression that accommodates the muscle attachments of the trunk. Both depressions together form the facial part of the skull. A large flat surface at the back of the premaxilla towards the top spans the entire width. This enables a seamless articulate connection to the frontal. The largest width of the premaxilla is 94 mm, and the maximum length is 203 mm. The perfectly intact tusk is located in the right premaxilla. It has a maximum length of 213 mm, measured along the outer tusk curvature. The oval cross-section has a maximum diameter of 34 mm at the base. Given the discoloration and abrasion of the tip, at most 15-25 mm of the tusk would have been visible, protruding from the alveolus.

The maxilla is complete and perfectly intact. The relatively robust infraorbital foramen is visible to the left and right. The greatest diameter on the left side is 41 mm. Both lateral protrusions of the maxilla are well preserved up to the articulation surface of the cheekbone. Both dP3 premolars consist of seven lamellae, which all show chewing abrasion. The occlusal surface measures up to 61 x 36 mm, and both surfaces are strikingly alike (the difference between the left and right molar is less than 1 mm). Unfortunately, the dP4 premolars are not preserved, but the robust cavities of the front molar roots can be clearly observed in both left and right alveoli. Furthermore, three lamellae depressions are visible on the right inner side of the alveolus and two on the left side.

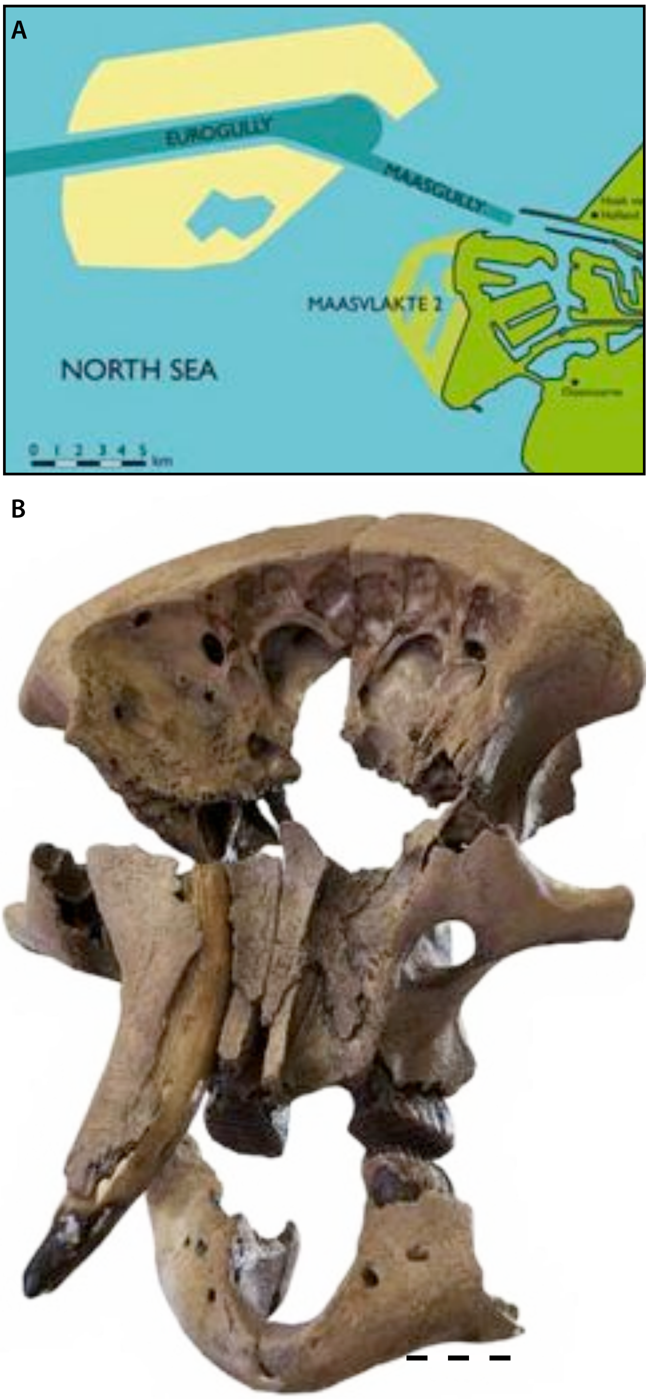

Fig. 1. **A**, The Eurogully, off the coast of The Netherlands; **B**, Damaged cranium of a mammoth calf, Eurogully, North Sea (antero-lateral view). Collection Klaas Post, Urk, NO 4513. Scale bar equals 5 cm.

Both maxillae are not completely fused together, and a clear zigzag structure is visible over the entire length of the palate, the width varying between 1-3 mm. The greatest width of the maxilla, including both zygomatic arches, is 296 mm, the maximum width measured along the outer edge of both premolars is 112 mm, and the largest length preserved is 168 mm.

The left and right frontals are completely intact and they articulate in the central surface of the cranium over a length of 57 mm. The length of the right frontal is 209 mm, whereas the left frontal is 202 mm. The height of the highest point of the articulation surface between the two frontals and the highest point of the premaxilla is 176 mm. The eye sockets have a maximum diameter of 61 mm. The upper part of the frontals show a weak imprint of the non-fused nasals which were not recovered.

Much more striking are the aforementioned clearly visible large S - shaped curved articulation surfaces of the premaxilla. This also applies to the large triangular articulation surfaces of the rear parietals that are prominently displayed adjacent to the inside pattern of the brain cavity. The bone of the forehead is 102 mm thick at this place, but it still gives a lightweight impression as a result of the typical cavity structures (sinuses) which are so characteristic for the mammoth cranium.

The mandible was broken in two halves in the nets during trawling, but both halves were originally seamlessly fused. The right mandible misses the condyle and both premolars; the alveolus of dp3 is prominent and deep and clearly separated in two parts; the alveolus of dp4 exhibits no lamellae impressions at the interior side. At the front and on the outside of the alveoli of the dp3 are three major foramina; a smaller foramen and three tiny foramina can be seen lingually. The largest measurable length of this mandible is 214 mm. The left ramus remains extend to just behind the dp3; the part behind it is missing. Two major foramina are present on the front and outside, and two smaller foramina and three very small foramina are present on the lingual side. The mandible shows remains of the dp2 alveoli directly in front of the dp3. The dp3 of the left mandible shows eight lamellae, all in use, the grinding surface measuring 54 x 27 mm.

Maschenko (2002) provided numerous measurements of mammoth calves from Russia on which the following analysis is based. It shows that the permanent tusk starts to protrude from the premaxilla at an age of about 12 months. Furthermore, both the rate of abrasion and the length of the tip of the right tusk would limit the age of this mammoth calf to a maximum of two and a half years at time of death. The two upper dP3 are fully in use without substantial reduction of the premolars and it seems likely that the dP4 was hardly in use at all. This would indicate an age of the calf of at least one and a half up to two years. The dp3 in the mandible is completely worn as well, but that stage should likely have been reached just before the death of the calf.

A similar mandible collected from the North Sea (Van der Plicht et al., 2012) shows a similar or slightly increased use of the dp3. Yet it also contains a pristine dp4 and still shows the remainder of an alveolus of a shedded dp2 premolar. This particular combination indicates an age of 11-16 months. If we compare the mandible and the stage of wear of the premolars of this mammoth calf with the known individual ages of African elephants (*Loxodonta africana*) as published by Laws (1966), then we reach the same individual age, expressed in African Equivalent Years (AEY). The stage of wear of the dp3 of NO 4513 indicates that it falls into age groups Laws III (1 AEY) and IV (2 AEY), which corresponds well with the data provided by Maschenko, 2002.

Summarizing, we conclude that the mammoth calf was 16 to 18 months old at time of death in the Eurogully area. In addition, we conclude that the skeleton elements belonging together must all have been covered by sediments soon afterwards, facilitating preservation. The skull could not have been transported over a large distance.

All hitherto known ^{14}C dates of mammoth fossils from the Eurogully Area and the adjacent North Sea area are between 33,800 + / - 1200 and > 45 ka BP (n = 15); (Mol et al , 2008). Given its condition, it seems likely that this skull must be dated within these limits.

Like this cranium, many other fossils from the Eurogully are very well preserved, like craniums of mammoths, bison, rhinoceroses and other megafaunal elements. There are many reports from fishermen about assemblages of perfectly articulated bones coming up in the nets. Articulated skeletons and the pristine undamaged state of thousands of mammoth bones indicate that these fossils were located *in situ* before they were dredged up. It suggests that there are numerous articulated skeletons (or parts thereof) in the layers below the sea floor in the Eurogully. This makes the Eurogully one of the most important and richest deposits of mammoth fossils in the world.

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Once upon a time, the Gomphotheriidae (Proboscidea, Mammalia) ruled South America

Dimila MOTHÉ ✉, Leonardo AVILLA, and Alexander KELLNER

The South American Gomphotheriidae (SAG) is one of the most common megafaunal fossils. However, its taxonomy, phylogeny and biogeography are still unsolved – unclear species diagnosis, misidentified records, doubtful biogeographic and stratigraphic distributions and lack of absolute datings (Mothé et al., 2012; Lucas, 2013). Thus, the classic knowledge of SAG is, currently, outdated and a revision of the "dogmatic concepts" is needed.

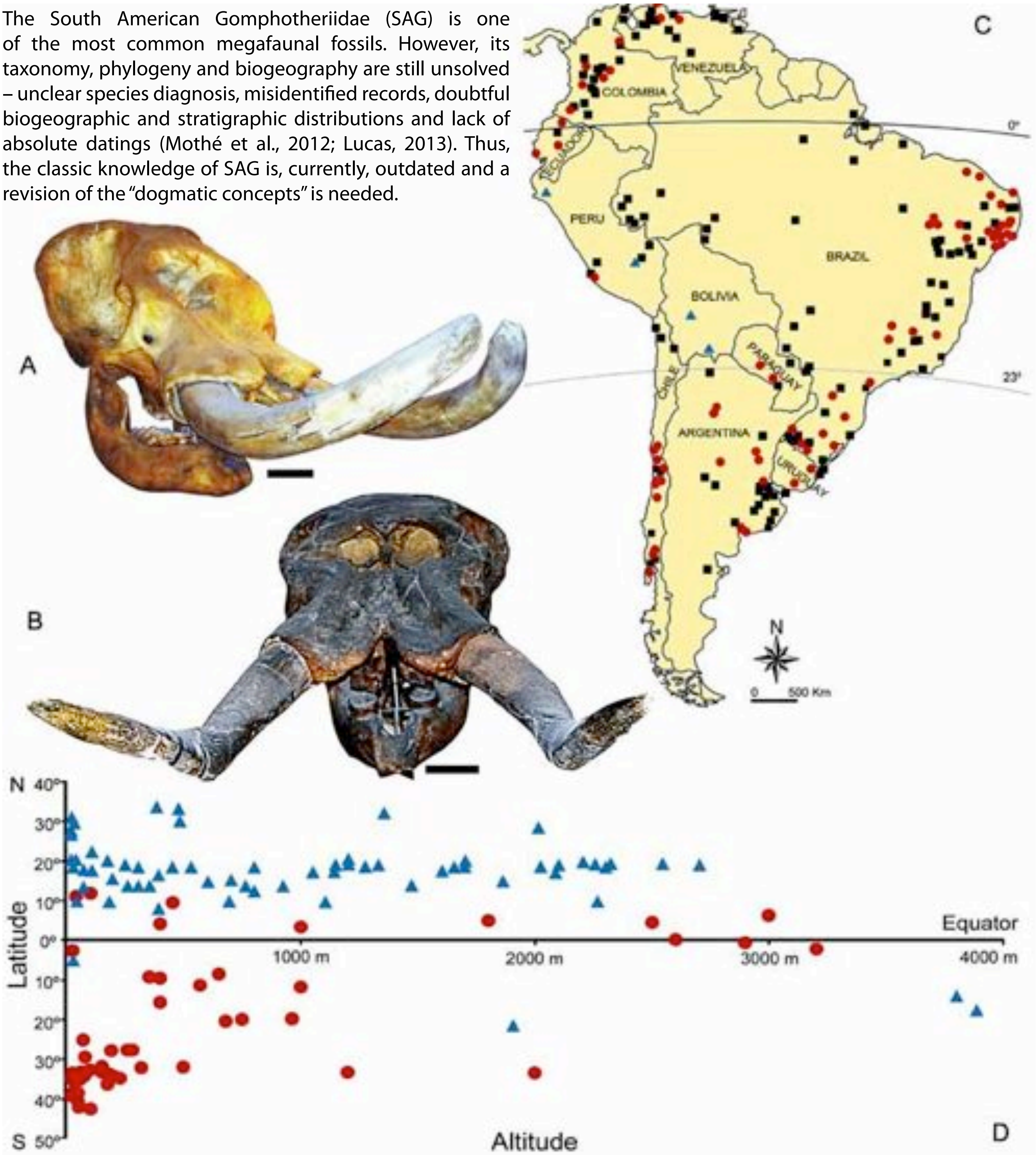

Fig. 1. General aspect and biogeographic distribution of the South American Gomphotheriidae. **A**, Skull of *Notiomastodon platensis* from Minas Gerais, Brazil (no collection number, paleontological collection of Museo de Ciências Naturais da PUCMinas, Minas Gerais, Brazil); **B**, skull of *Cuvieronius hyodon* from Tarija, Bolivia (MACN 1891, paleontological collection of Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina); **C**, geographical distribution of South American gomphotheres; **D**, latitudinal and altitudinal distribution of *C. hyodon* and *N. platensis* in Central and South Americas. Both taxa occur from sea level up to 3000 m height in a latitudinal range of 12ºN to 21ºS. Records of *C. hyodon* in Northern hemisphere refer to Central America, and *N. platensis* records refer to South America. Scale bar equals 15 cm.

▲= *Cuvieronius hyodon;* ●= *Notiomastodon platensis;* ■= non-diagnostic records of Gomphotheriidae

We analyzed a large sample of Gomphotheriidae (over 4.000 specimens) from North (Plio-Pleistocene) and South (Pleistocene) Americas. The morphological comparative analysis was based on the observation of diagnostic characters of *Cuvieronius*, *Notiomastodon*, *Stegomastodon*, *Rhynchotherium* and *Gomphotherium*. The reviewed records resulted in an updated distribution map for SAG recognized taxa and the proposition of a biogeographic hypothesis for their arrival in South America.

Many SAG specimens could not be taxonomically identified due to their fragmentary nature, deformations caused by taphonomic processes and/or lack of diagnostic features – those are restricted to upper tusks and/or complete skull. A taxonomic revision based on well preserved diagnostic material allowed the recognition of two species for SAG: *Notiomastodon platensis* and *Cuvieronius hyodon*. Although, traditionally, two species were attributed to *Stegomastodon* (*S. waringi* and *S. platensis*) in South America and, after our revision, both were reviewed and synonymized with *N. platensis* (which also includes *Haplomastodon chimborazi*). Also, the genera *Stegomastodon*, *Rhynchotherium* and *Gomphotherium* were not recognized to South America. *Notiomastodon platensis* is characterized by having a brachycephalic skull (high parieto-occipital region), a pair of non twisted upper tusks which vary from robust to thin and straight to upcurved, with enamel present or absence (Fig. 1A). *Cuvieronius hyodon* is characterized by the presence of a pair of twisted upper tusks with a longitudinal enamel band, a brachycephalic skull with a flattened frontal region and large upper incisor fossa (Fig. 1B). The molar morphology and post-crania elements of SAG still remain indistinguishable.

The geographic distribution revision of SAG records indicates that *C. hyodon* is restricted to Bolivia and Peru, while *N. platensis* is widely recorded (Brazil, Uruguay, Argentina, Chile, Paraguay, Peru, Colombia, Ecuador and Venezuela; (Fig. 1C) and endemic to South America. Also, SAG occurred from sea level to highland areas (over 3000 AMSL) and in the latitudinal range from 21° of the south latitude to 12° of the north latitude (including the Central America occurrence of *C. hyodon*; (Fig. 1D), sympatric only in Peru. Therefore, the SAG biogeographical pattern recognized here does not support the "traditional" dispersal routes proposed in previous studies – an Andean route to *C. hyodon* and eastern route to *N. platensis*, since they are recorded in a lowland locality (La Huaca, Peru) and in Andean region from Ecuador, Venezuela, Colombia and Chile, respectively. Thus, *N. platensis* also has an Andean distribution and the records of *C. hyodon* are insufficient to establish an ensured migratory route.

Moreover, the understanding of SAG biogeography is directly related to *Amahuacatherium peruvium* validity, which encompasses several disagreements. M.T. Alberdi et al. (2004) and Ferretti (2008) argue that *A. peruvium* is undistinguishable to other SAG from Peru, and we observed that all its exclusive features are in the morphological variability range of *C. hyodon* and/or *N. platensis*. Also, the structure proposed by K.E. Campbell et al. (2010) as the *A. peruvium* lower tusk "root" is, in fact, a molar root fragment. The stratigraphic and type locality of *A. peruvium* is considered controversial and questionable (Lucas, 2013) and we agree with several authors that it is invalid and possibly represents a Pleistocene gomphotere remain (Alberdi et al., 2004; Ferretti, 2008; Carlotto, et al., 2008; Lucas, 2013).

Regarding the arrival of Gomphotheriidae in South America, considering the genus *Stegomastodon restricted* to North America, *A. peruvium* invalidity and the most recent phylogenetic proposition to South American gomphotheres (Mothé et al., 2013), in which *C. hyodon* or *N. platensis* form a monophyletic clade, we suggest a single immigration pulse of Gomphotheriidae to South America, after the closure of the Isthmus of Panamá, throughout the dispersion of *C. hyodon* from Central America, at least at 2.5 Mya (oldest record of Gomphotheriidae in South America). As previously proposed by Mothé et al. (2013), the ancestor of SAG gave rise to *C. hyodon* and the South American endemic *N. platensis*, during the Pliocene in Central or North America. However, the few diagnostic records and the lack of absolute dating information directly impact the knowledge about evolutionary history of Gomphotheriidae in South America.

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Anatomy of a *Notiomastodon platensis* (Gomphotheriidae, Proboscidea) calf skull using CT-scan and 3D reconstruction

Dimila MOTHÉ ✉, Shirlley RODRIGUES, Sérgio Alex K. AZEVEDO, and Leonardo AVILLA

Computed tomography (CT) is one of the best techniques to analyze internal structures of fossils due to its non-destructive nature. CT scans can be studied individually or used for three dimensional reconstructions (Sutton, 2008). There are few studies using non-invasive techniques describing cranial structures of young fossil proboscideans (Mashchenko et al., 2005; Aguilar, 2011). In this study, we recognized and described the cranial (internal and external) structures of a *Notiomastodon platensis* calf using CT scans and 3D reconstitution.

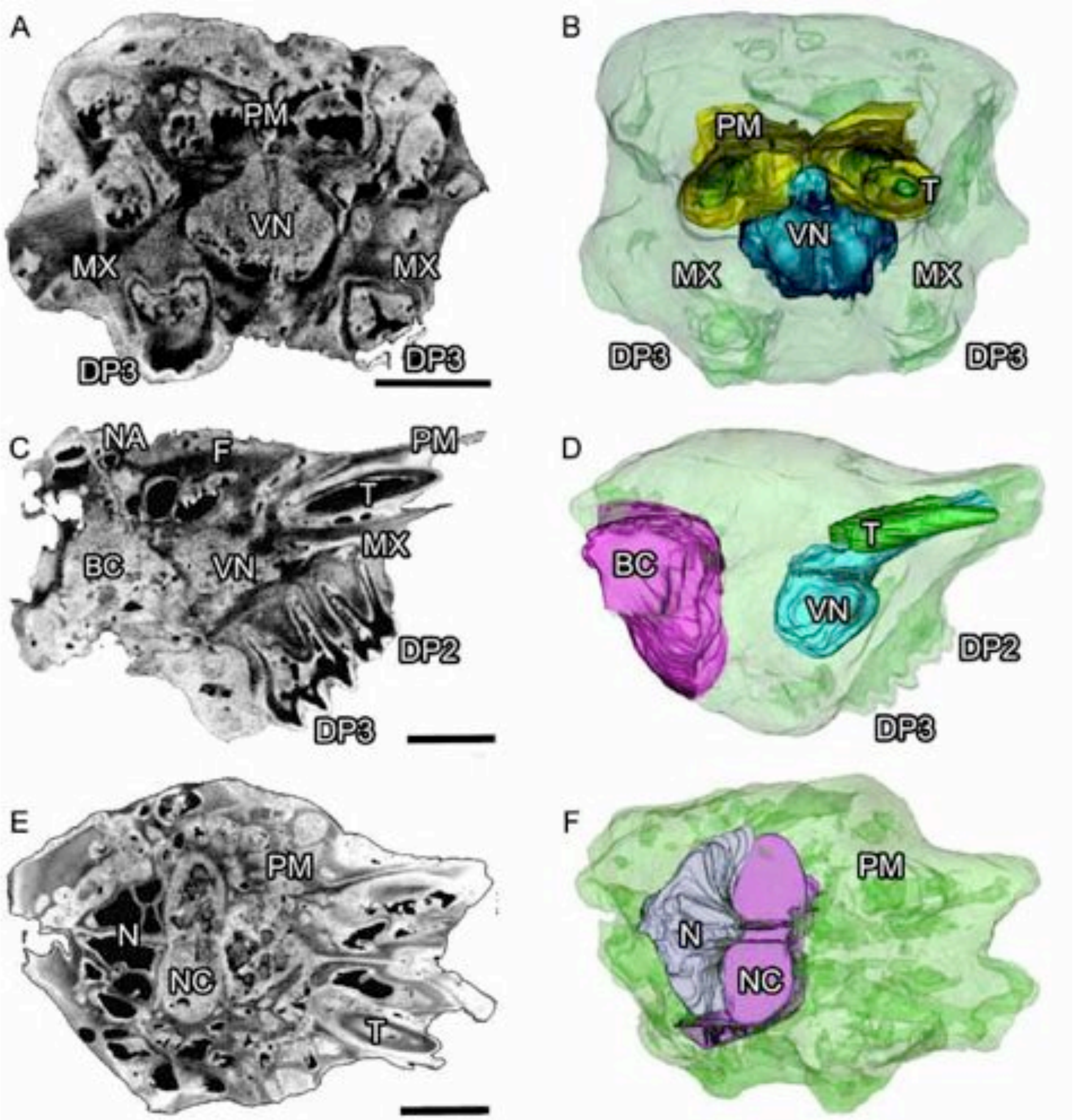

Fig. 1. Computed tomography images (A, C and E) and 3D reconstruction of skull structures of the *Notiomastodon platensis* calf MHN-33 (B, D and F). **A**, Frontal section showing the erupted molars, maxillary (MX) and premaxillary (PM) bones and vomeronasal apparatus VN); **B**, Frontal view of the 3D reconstruction showing premaxillary bones (yellow), tushes (T) inside de alveolar pocket (green) and vomeronasal organ (blue); **C**, Lateral left section showing the nasal (N), frontal (F), premaxillary and maxillary bones, vomeronasal apparatus, frontal lobes of the brain cavity (BC), nasal aperture (NA) and teeth (deciduous left tusk, DP2 and DP3); **D**, 3D reconstruction on lateral view showing vomeronasal apparatus (blue), deciduous tusks (green) and frontal lobes of the brain cavity (fuchsia); **E**, Dorsal section showing the right deciduous tusk, nasal and premaxillary bones and nasal cavity (NC); **F**, 3D reconstruction on dorsal view showing nasal bones (gray) and nasal cavity (purple). Scale bar equals 5 cm.

The analyzed specimen (MHN-33) is a fragmented skull from Lapa do Caetano, Minas Gerais State, Brazil, and it was part of the paleontological collection of the Universidade Federal de Minas Gerais, Brazil. Unfortunately, in 2012 the specimen was stolen and has not been located yet. However, a 3D model and CT scans of the specimen were fortunately made prior to its loss, allowing the execution of this study. The CT scans were performed at the Hospital Universitário Pedro Ernesto (Rio de Janeiro, Brazil) and the 3D reconstruction was produced using the software Mimics CT slices of frontal, lateral/sagittal and ventral views were analyzed and both internal and external structures were compared with extant young specimens of elephants (Gregory, 1903; Van der Merwe et al., 1995; Shoshani et al., 2006) and *Mammuthus primigenius* (Mashchenko et al., 2005).

We observed that MHN-33 is slightly deformed, fragmented on its ventraldorsal portion and lacks the parieto-occipital region, including the occipital condyles and the acoustic meatuses (Fig. 1). The skull is encrusted by sediment on the rostral region, which covers the proximal part of premaxillary bones, the nasal aperture, the right incisor alveolus, and the nasal and frontal bones.

On frontal view, the premaxillary bones are horizontally wide and dorsoventrally narrow at the medial region (Fig.1A, 1B). Between the tush alveoli and the nasal cavity, ca. 60 mm of the premaxillary bone is pneumatized. The upper deciduous tusks (tushes) are visible inside the alveoli and have open roots. Both tushes are small (the left one measures 77 mm in length and the right one 73 mm in length). The left tush is partially erupted and the right tush and its alveolus are totally covered with sediment and fragmented medially (Fig.1B).

The vomeronasal apparatus is anteroventrally displaced, positioned between the proximal part of the maxillary and premaxillary bones (Fig.1C, 1D). On its rostral portion there is an elongated duct placed between the incisor process of the maxillary and premaxillary bones, identified as the vomeronasal cartilage by comparisonwith *Loxodonta africana* (Göbbel et al., 2004). On coronal view, the vomeronasal organ is well-developed and bilobated, reaching the nasal cavity distally (Fig. 1C). This degree of development may be related to high chemoreception sensitivity (Johnson & Rasmussen, 2002). On sagittal view, the nasal cavity is distinctive, extending from the nasal aperture to the fragmented ventrodistal portion of the skull, behind the palatine bone (Fig. 1E, 1F). The entire nasal cavity is filled with sediment. On dorsal view, the nasal aperture is oval shaped and narrow at the medial portion (Fig. 1F).

The place where the frontal lobes are positioned is the only preserved portion of the brain cavity. This portion is located posterior to the nasal cavity and ventral to the nasal and frontal bones (Fig. 1D). On sagittal view, the *N. platensis* frontal lobes are similar to those of *L. africana* (Shoshani et al., 2006).

The nasal, maxillary and anterior parts of the frontal bones are poorly pneumatized when compared to older individuals of *N. platensis* (Alberdi et al., 2002). Two erupted molars in each hemi-arcade are in use and the maxillary bones have well developed sinus which reach the distal part of the tush alveoli. The DP2 are bilophodont, and the DP3 and DP4 are trilophodonts with the posterior loph always larger than the anterior one. Both left and right DP2 are worn with adjacent enamel figures on all cusps. DP3 are worn only at the protoloph. Both DP4 are still forming inside the alveolar pocket (Fig. 1C). The observed degree of tooth wear, based on Laws (1966), suggests that this was a very young individual of approximately six months old.

The use of CT scans and 3D reconstructions for paleontological studies are increasing, but some aspects need to be improved, such as taphonomic processes. Our next steps in this study are: 1) to conduct a taphonomic analysis on this specimen through the CT scans; and 2) to compare the identified anatomy of this calf with adult specimens of *N. platensis*.

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The exploitation of mammoth in the Swabian Jura (SW-Germany) during the Aurignacian and Gravettian Periods

Susanne C. MÜNZEL ✉, Sibylle WOLF, Dorothée G. DRUCKER, and Nicholas J. CONARD

In this presentation, we aim to give an overview on the exploitation of mammoth in the Ach and Lone valleys in the Swabian Jura (SW-Germany). Both valleys are former tributaries of the Danube River. Almost all the caves have revealed mammoth remains in different quantities, but there is a striking difference between the Aurignacian (42-34 ka cal BP) and the Gravettian period (34-30 ka cal BP) concerning the exploitation of mammoth for diet and raw materials, which we would like to discuss, along with some aspects of their ecology.

A continuous stratigraphic transition from Aurignacian to Gravettian is well documented in the caves of the Ach Valley, especially at Geißenklösterle and Hohle Fels. In the Lone Valley, where the Aurignacian assemblages are well represented, hardly any archaeological remains were assigned to the Gravettian. A very small Gravettian assemblage is known from Bockstein-Törle.

For the Ach Valley we focus on the caves of Hohle Fels, Geißenklösterle and Brillenhöhle. Here the first excavations started in Hohle Fels by Oscar Fraas 1870/71. Later in the 1960s the University of Tübingen conducted excavations in the Brillenhöhle, and during the 1970s Joachim Hahn excavated in Geißenklösterle and Hohle Fels. Since 1997 Nicholas Conard conducted yearly excavations in Hohle Fels. For the Lone Valley we focus on the caves of Vogelherd, Hohlenstein-Stadel and Bockstein-Törle. In the Lone Valley the research history also started by Oscar Fraas in 1862. In the 1930s the Vogelherd cave was excavated by Gustav Riek and the Hohlenstein-Stadel by Robert Wetzel. Between 2005 and 2012 as well as 2009 and 2013 recent excavations took place in the backdirt of the Vogelherd and inside the Hohlenstein-Stadel.

Hunted Game and Diet: The faunal composition during Aurignacian and Gravettian is quite constant (Münzel and Conard, 2004a, b; Conard et al., 2013). The caves of the Swabian Jura revealed species characteristic for the

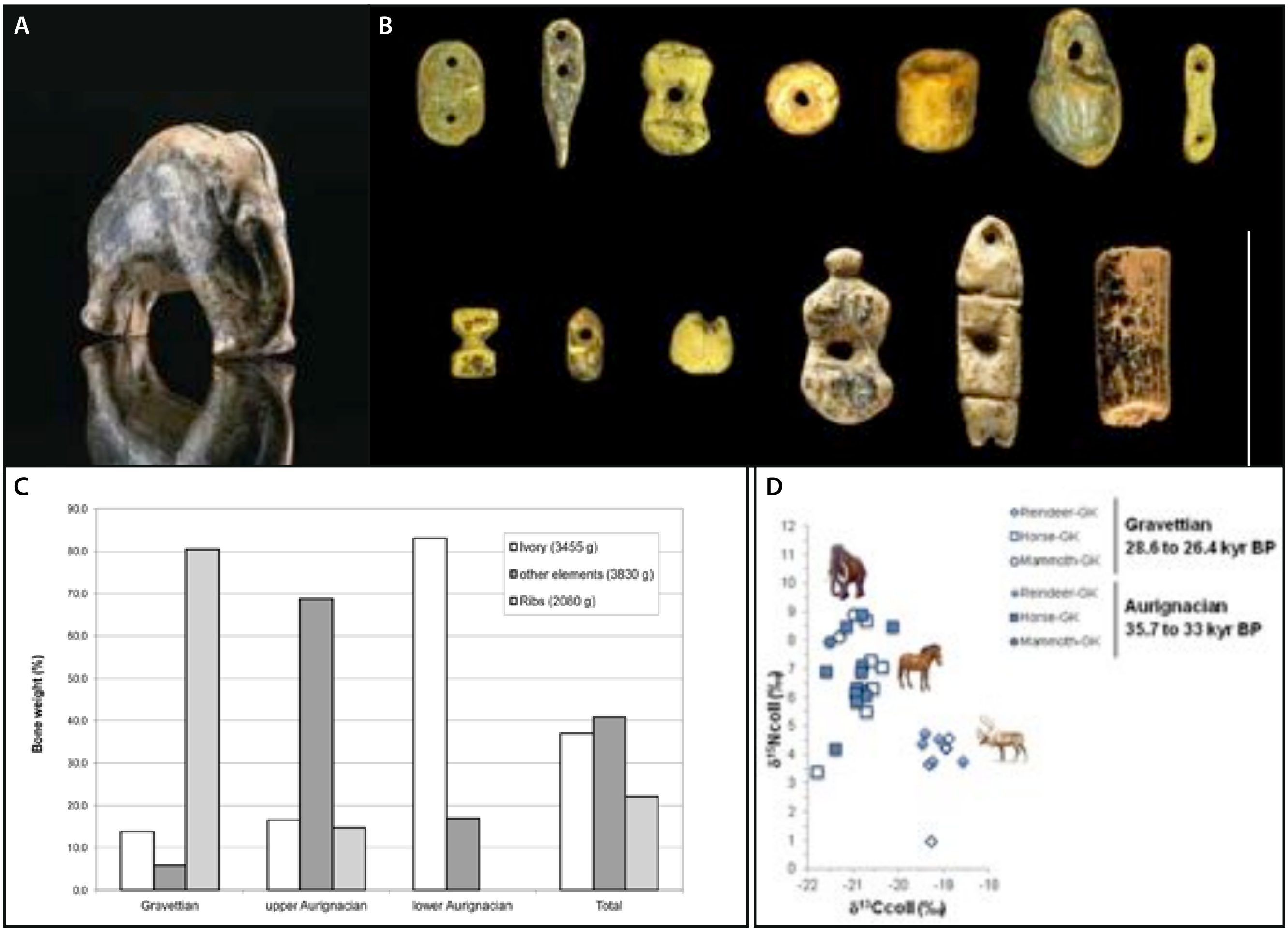

Fig. 1. A, Aurignacian ivory figurine of a mammoth from Vogelherd cave (lenght: 3,7 cm). Foto: J. Lipták, copyright University of Tübingen; B, Aurignacian jewelry from Hohle Fels (scale bar equals 3 cm). Fotos: S. Wolf, H. Jensen, copyright University of Tübingen; C, Skeletal element composition of mammoth in Geißenklösterle cave, Ach Valley; D, Carbon-13 and nitrogen-15 abundances of mammoth, horse and reindeer. The overlapping between mammoth and horse reflect the occupation of the expected mammoth habitat by horse.

mammoth-steppe environment, such as woolly mammoth, woolly rhinoceros, wild horses and reindeer. There is, however, a difference in the number of cervid species between the two periods. During the Aurignacian, four different cervids were present in the Ach Valley, namely giant deer, red deer, roe deer and reindeer. Each of these cervids has different nutritional needs and represents a different ecological niche. During the Gravettian, however, only reindeer and red deer remained. This indicates a climatic deterioration from the Aurignacian to the Gravettian and toward the upcoming Last Glacial Maximum.

Mammoth remains are present in all the cave sites, and butchering marks indicate a careful processing of the game. However the skeletal element representation is biased towards ivory and ribs (Münzel, 2005) and Aurignacian and Gravettian people had clear preferences in the use of raw materials (Fig. 1C): While ivory was an important raw material during the Aurignacian for all kinds of everyday tools, such as chisels, retouchers, and projectile points, as well as for personal ornaments (Fig. 1B), figurative art (Fig. 1A), and flutes, the Gravettian people rarely used any ivory that was mainly chosen for the production of personal ornaments. However, the ivory beads in the Gravettian are accompanied by an increased number of pendants made from teeth, which are rare in the Aurignacian assemblages. Furthermore during the Gravettian, projectile points and other tools have been exclusively made from bone, most often mammoth ribs.

Raw material ivory: Differences also occur between the caves of Ach and Lone valleys concerning the procurement of ivory. During the Aurignacian, people treated and used ivory differently at each of the sites. While already prepared smashed parts of the tusk were brought into Hohle Fels and people worked with fresh ivory there, in other caves, such as Vogelherd and Hohlenstein-Stadel, whole tusks were stored (Wolf, in press).

Ecology of mammoth: The question of the density of mammoth population over time in the Swabian Jura needs also to be considered. The specificity of the ecological niche occupied by the woolly mammoth is clearly reflected by their distinct stable isotope signature in collagen (Fig. 1D). The abundances of carbon-13 in mammoth collagen are comparable to those of other grazers like horse, while the nitrogen-15 abundances are significantly higher (about 3‰) than the other herbivores. This enrichment, comparable to the one expected for a carnivore, is attributed to the consumption of mature grasses from disturbed areas (Bocherens, 2003). In Geißenklösterle, the mammoths delivered the expected stable isotope signature, but the nitrogen-15 of horses showed an unexpected overlap with those of the mammoth. A change in the habitat of mammoth would affect the pattern in another way, with nitrogen-15 abundances of mammoth collagen as low as those of horse (Drucker et al., in press). Thus, we hypothesize that during Gravettian the ecological niche of mammoth was intact but not occupied intensively by mammoth due to a decline in their population. This decline could be tentatively explained by human pressure through hunting. In this scenario, the interspecific competition between horse and mammoth would be replaced by an intra-specific one among horse individuals, some of them occupying the niche vacated by mammoth.

After the LGM, the exploitation of mammoth plays a minor role. Mammoth populations seemed to have already decreased during the Gravettian based on the stable isotope results, which show that mammoths might have been slowly replaced by horse already prior to the LGM.

This raises the question: what caused the change in mammoth exploitation? Mammoth infant remains are present in both periods (Münzel, 2005), indicating that adult mammoth cows persisted in the region providing both ivory and bones. Thus, we suggest a cultural break in raw material use and a change in technology from the Aurignacian to the Gravettian against a mammoth population already numerically reduced by human exploitation well before the LGM.

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Mammoth microfloras preserved in Yakutian permafrost

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Vital processes in the biosphere as the formation of atmospheric gas, soil fertility, the formation of groundwater and minerals, the mechanisms of food cycle and self-cleaning of the planet and many others are managed without the participation of microorganisms.

In the proposed research we present alive bacteria of Pleistocene age identified from microfloral elements related with mammoth fauna (e.g., Neustroev, 2007, 2010; Tarabukina et al., 2010). Microbiological studies of paleomicroflora extracted from Mokhsunuokhsk and Yukagir mammoths, Oimyakon and Khroma young mammoths and Kolyma woolly rhinoceros, the young mammoth of Yuka, the Yukagir horse and the Yukagir bison all preserved in permafrost, allow identification of a unique bacteria of the genus *Bacillus*, which not only survived (for 18-30 thousands of years), but retained the ability to produce biologically active substances. The results are as amazing as the preserved remains of fossil animals themselves.

Microbiological studies of fossil animals preserved in permafrost started in 2003, and in November 2004 the first results appeared, indicating the allocation of strains of bacteria of the genus *Bacillus* from tissues of Pleistocene mammoth that show biologically active properties. Later on, the allocation of *Bacillus* from microflora of mammoth fauna is confirmed by studies of the State Research Center of Biotechnology "Vector" (Novosibirsk, 2005), and the center of sanitary-epidemiological service of the Republic of Sakha (Yakutia) (Yakutsk, 2007), both specialized laboratories of the Anti-Plague Institute of Siberia and the Far East (Irkutsk, 2010).

The microbiological studies on soft tissues of Mokhsunuokhsk and Yukagir mammoths, Oimyakon and Khroma young mammoths, Kolyma woolly rhino, young mammoth of Yuka, and Yukagir horses and bison allow isolating 43 strains of microorganisms, including 26 strains of bacteria assigned to the genus *Bacillus*. According to biochemical, and physiological properties they are attributed to the species: *Bac. megatherium, Bac. subtilis, Bac. alvei, Bac. pumilis, Bac. brevis, Bac. popilae, Bac. steurothermophilus*,and *Bac. circulans*.

We studied the physiological and biochemical, antagonistic, antibiotic-resistant, and oil-oxidizing, properties including emulsifying and herbal stimulant ones. We investigated the electron microscopic morphological characteristics, by obtain scans of strains of *Bacillus*, isolated from representatives of the mammoth fauna (e.g., Tarabukina, 2005, 2007).

According to the results of our research, we can conclude a high antagonistic activity of strains of the isolated bacteria of the genus Bacillus in relation to opportunistic and pathogenic microorganisms, including toxigenic fungi. It should be noted that in the Pleistocene paleomicroflora there is no putrefactive microorganisms. The obtained results of microbiological research and observations suggest that strains of antagonist-bacteria of *Bacillus* dominating in paleomicroflora contribute to the preservation of soft tissues of mammoth fauna representatives, preserved in permafrost.

The study allowed for the first time to certify and deposit strains of bacteria *Bacillus subtilis* «Kolyma-7/2K» and *Bacillus subtilis* «Oimyakon-6/1», extracted from the Kolyma woolly rhinos and the Oimyakon young mammoth in the collection of microorganisms of the Russian Research of Agricultural Microbiology (St. Petersburg, 2010) for further modern biotechnological studies.

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Convincing evidence of mammoth hunting in the Siberian Arctic between 29,000 and 27,000 ^{14}C years BP (new data from Yana Palaeolithic site)

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Although mammoth hunting by Paleolithic humans has become an iconic reconstruction, definite evidence of mammoth kills by humans remains surprisingly scarce. Here we show convincing evidence of mammoth hunting in the Siberian Arctic between 29,000 and 27,000 ^{14}C years BP or 32,000-34,000 calendar years BP.

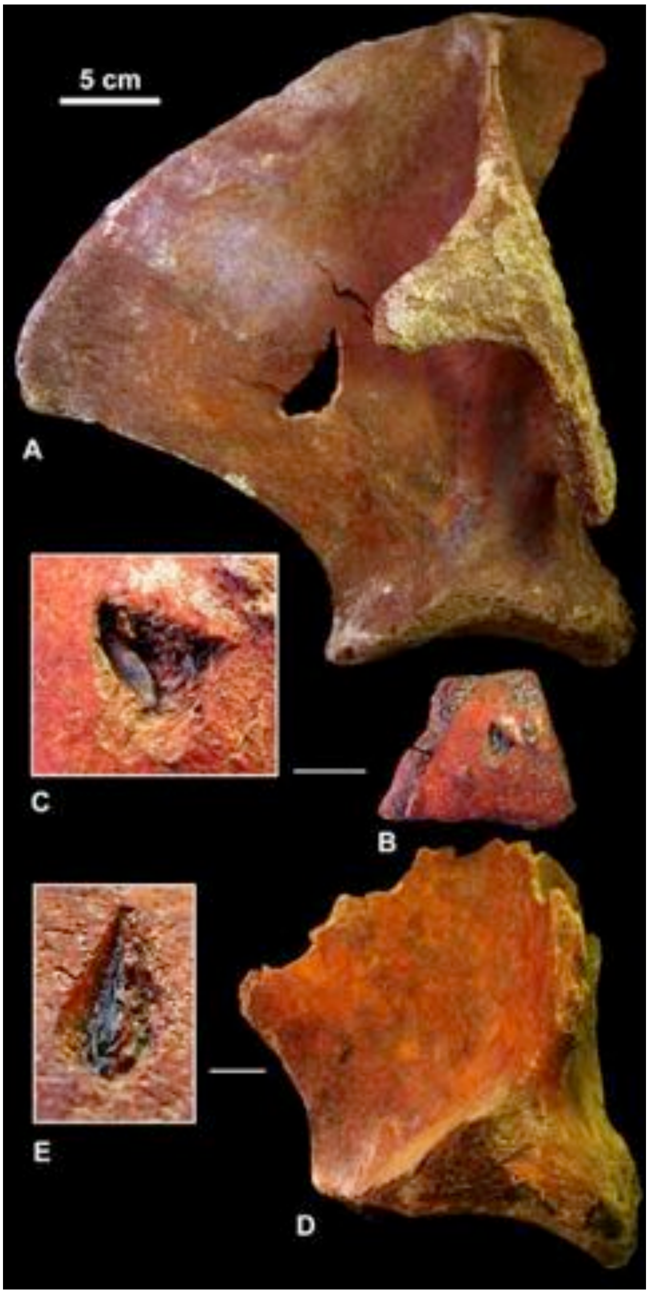

Fig. 1. Open hole left by hunting weapon on the right scapula of a juvenile mammoth (**A**); stone tools embedded in bones (**B-E**): two lithics and an osseous fragment embedded in a fragment of right scapula from a mid-size mammoth (**B-C**), and a tip of a narrow flat-convex siltstone point embedded in another right scapula of a young mammoth (**D-E**). Yana Palaeolithic site, Arctic Siberia, 29000-27000 ^{14}C BP or 32000-34000 calendar YBP (see Nikolskiy, Pitulko, 2013 for details).

In 2008, a mass accumulation of woolly mammoth bones (YMAM) was found near Siberia's northernmost Upper Palaeolithic site (Yana RHS) (Pitulko et al., 2004), on the lower Yana River at 70°43′25″ N, 135°24′47″ E (Basilyan et al., 2011). The accumulation constitutes a portion of the spatial structure of the Yana site. At least 31 mammoth individuals have been recovered from YMAM. The timing of the YMAM exactly corresponds to that of the cultural layer of the Yana RHS. This, along with the unnatural spatial distribution and the orientation of the bones in the deposits, the peculiarities of preservation, and the composition of skeletal elements in the sample, indicate the anthropogenic nature of the YMAM (Basilyan et al., 2011). At last, during 2009-2013 field seasons convincing proofs of mammoth hunting were obtained from the Yana site (Nikolskiy, Pitulko, 2013) that include fragments of lithic points and ivory shaft embedded in two mammoth scapulae (Fig. 1); two identical holes made by projectiles in a mammoth scapula (Fig. 1) and a pelvic bone; mammoth tongue bones found in the cultural layer far away from the main mammoth bone accumulation, indicating the consumption of fresh mammoth meat; and a narrow mammoth bone size distribution, implying hunting selection based on animal size. The data suggest that humans hunted mammoths sporadically, presumably when ivory was needed for making tools. Such hunting pressure would not be fatal to a sustainable mammoth population (Nikolskiy et al., 2010, 2011; Pitulko, Nikolskiy, 2012), but after the Last Glacial Maximum, when mammoth habitat shrank due to climate changes , such an impact could have become the "last straw" that led to the final extinction of the mammoth.

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Preliminary data from the study of the intact 50 000 YBP frozen mummy of the Anyuy steppe bison (Anyuy River, Arctic Far East)

Pavel NIKOLSKIY ✉, and Fedor SHIDLOVSKY

Ice Age Museum, Moscow, starts a multidisciplinary ANBIS project aiming to study the intact frozen carcass of Late Pleistocene bison that have recently been recovered from the Anyuy locality. Here we report the preliminary data from the study of this unique specimen (the Anyuy bison hereafter).

The complete mummy of Late Pleistocene steppe bison (*Bison priscus* Bojanus) was discovered in late September 2009 under the steep frozen left bank of the Anyuy River near Anyuysk settlement at 68°16'31.96"N;161°42'35.69"E (Chukotka, Arctic Far East, Russia). Local resident Vatagin have had found the mummy, while floating down a river, immediately after the carcass fell out of the frozen bluff, thereby the bison remained completely frozen (the temperature was allready below zero). The frozen body was soon re-entombed into the specially constructed ice chamber next to the place of discovery, and in 2011 it was safely transported to the ice house in Anyuysk settlement. In spring 2012 the mummy was at last delivered to Moscow where it now resides in a freezer at a temperature similar to the bluff in which it was entombed. So the bison has never thawed since the discovery.

The state of preservation of the Anyuy bison mummy is unique even comparing to the mummyes of other Pleistocene mammals that are sometimes found in northern Siberia and Northern North America – not even minor signs of decay have been revealed. The carcass is about intact; the only damage is a large laceration at the right underbelly. Horn covering and hoofs are intact. The fur has mostly detached, but was collected in abundance around the place of bison discovery. At some body parts the fur remains. Skin is brownish-gray-blue in color, small aggregates of vivianite scattered through the body surface.

Pilot abdominal autopsy showed the complete integrity of the internal organs, although they had some postmortem cryo deformations.

The mummy pose - lying down, with its legs pulled up, head slightly lowered and rotated to the right, the rear part of the body is rotated counterclockwise relative to the front, tail upturned.

The mummy has been found at the river beach just at the bottom of the 27 m bluff along which frozen fluvial, taberal (thawed and refrozen), and lacustrine deposits outcrop. The sequence here in general consists of two units – a horizontal thinly laminated floodplain sands up to 18 m thick (bed 1) with large ice wedge pseudomorphs (ice wedge casts) that are cut into the Bed 1 from above, and are overlaid by laminated lacustrine deposits and peat layers (Bed 2) altogether up to 15 m thick.

Although the carcass was found not in situ, its initial position was traced by wisps of fur that stretched down the slope from the lower portion of one of the pseudomorphs (base of the Bed 2). Plant organic (wood and peat) from middle and lower portions of this pseudomorph was radiocarbon dated at 31300 – 38100 ^{14}C YBP. The direct dating of collagen from the mummy tissues (bone and skin) yields ^{14}C ages > 48000 and > 41000 YBP. There are only a few meters of sediments between the lowest piece of the wood, dated to 38100 ± 500 YBP, and the level, close to the base of the pseudomorph, that yielded the mummy. Taking into account low sedimentation rate here, we suggest that the age of the bison is somewhat between 48000 and 50000 ^{14}C YBP.

Fig. 1. Microbiologists are collecting the sterile samples from the Anyuy bison mummy inside a specially designed microbiologically clean plastic capsule. The temperature is - 21° C.

As was proposed, the mummy occurred from mud deposits inside of an ice wedge pseudomorph (ice wedge cast) that was formed by infilling of a wedge cavity while ice thawing under the shallow lake. Taking into account that the abdominal cavity of the bison is filled with blood and there is a large laceration at the underbelly, it is possible that the animal was attacked by a predator (most probably a wolf), was than escaped and tried to save himself sitting in the lake water (such a defense strategy is common among modern bison). Soon after the bison died from a blood loss the mud buried it, and there it remained, its body becoming permafrost.

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Early Biharian *Archidiskodon meridionalis* (Nesti, 1825) from Sarkel (Lower Don area, southern European Russia) and associated small mammals

Pavel NIKOLSKIY ✉, Vadim TITOV, Alexey TESAKOV, Irina FORONOVA, and Vera BAYGUSHEVA

Evolutionary concepts and biostratigraphic interpretations of "southern elephants" (genus *Archidiskodon*) are strongly influenced by the accuracy of relative and/or absolute age determination. Unfortunately, many records lack reliable information on stratigraphic position and age. Even the age of the name-bearing types of *Archidiskodon*, such as the lectotype of *A. meridionalis* (Nesti, 1825) from Upper Valdarno, and the holotype of *A. meridionalis tamanensis* Dubrovo, 1964 from Sinyaya Balka are not precisely defined. This is why all finds of fossil elephants with clear stratigraphic and/or biostratigraphic context are very important. *Archidiskodon meridionalis* cf. *tamanensis* recovered from the site of Sarkel (47°42'N, 42°12'E, lower Don River, southern European Russia) is exactly such a case (Nikolskiy, Tesakov, 2003; Dodonov et al., 2007; Tesakov, 2008; Baygusheva, Titov, 2012). Sarkel locality was found in 2001. In this site, fossiliferous fluvial crossbedded grey sands up to 4 m thick (Sarkel beds), outcrop along the steep northern bank of the Tsymla Reservoir near Sarkel settlement. The Sarkel beds unconformably overlay the blue Eocene clays and are overlaid by Early Pleistocene greenish brown sandy-clays crowned by paleosoil, altogether up to 6 m thick, followed by Middle-Late Pleistocene loams and loesses, up to 2-5 m thick (Nikolskiy, Tesakov, 2003; Dodonov et al., 2007). The Sarkel beds have been shown to be reversely magnetized and referred to the late Matuyama Chron (Dodonov et al., 2007).

The Sarkel beds yielded a rich and diverse Early Pleistocene mammalian fauna. The large mammals represented by detached postcranial fragments and teeth, small mammals, mostly by isolated teeth, and occasionally by mandibles and postcranial elements.

The faunal list currently includes: *Archidiskodon meridionalis* cf. *tamanensis*, *Equus* sp., *Stephanorhinus* sp., *Elasmotherium* sp., *Cervalces* (*Libralces*) sp., Cervidae indet., *Pontoceros* sp., Bovidae indet., *Bison* sp., *Martes* sp., *Sorex* ex gr. *araneus*, *Sorex* cf. *minutissimus*, ?*Drepanosorex* sp., *Beremendia fissidens*, Erinaceidae gen., *Talpa* cf. *minor*, *Desmana* sp., *Lepus* sp., *Ochotona* sp., *Ochotona* ex gr. *pusilla*, *Trogontherium* sp., *Sicista* sp., *Pygeretmus* cf. *brachydens*, *Allactaga* sp.1, *Allactaga* sp. 2, *Plioscirtopoda stepanovi, Apodemus* sp., *Spermophilus* sp., *Spalax minor, Cricetus nanus, Allocricetus ehiki, Cricetulus* sp., *Eolagurus argyropuloi adventus, Prolagurus pannonicus, Lagurodon arankae, Allophaiomys pliocaenicus, Mimomys pusillus, Mimomys intermedius, Clethrionomys hintonianus, Ellobius (Bramus) tarchancutensis, Ellobius (Ellobius)* sp.

The Sarkel small fauna is dominated by advanced *Allophaiomys pliocaenicus*, *Lagurodon arankae*, and *Prolagurus pannonicus*, and it is correlated to the Calabrian stage of the Early Pleistocene, or to early Biharian. The fauna belongs to the local Tamanian faunal assemblage, and the regional zone MQR8 (Pevzner et al, 2001). The age of the fauna is therefore estimated between 1.2 and 0.9 Ma.

The following remains of *Archidiskodon meridionalis* cf. *tamanensis* have been recovered from Sarkel locality (Fig. 1): 1M3, 7m3, 1M2, 5m2, fragmented tusks – 2, limb bones – 8, ribs and vertebrae – 7. The lamellar frequency of the studied *Archidiskodon* teeth varies from 4.5 to 5.5, and the enamel thickness – from 2.5 to 3.2, corresponding to respective parameters of the type series of *Archidiskodon meridionalis tamanensis* from Sinyaya Balka, and somewhat overlaping values of *Archidiskodon meridionalis meridionalis* from Upper Valdarno.

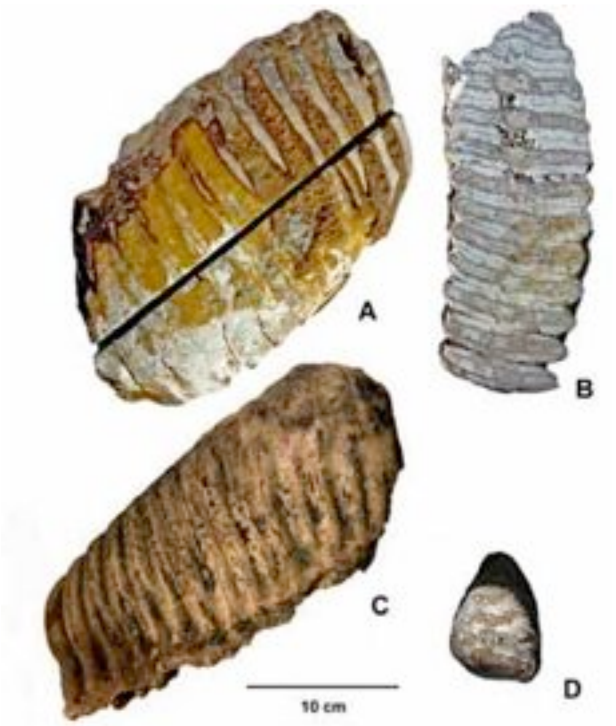

Fig. 1. *Archidiskodon meridionalis* cf. *tamanensis* from Sarkel locality, lower Don River, southern European Russia, late Early Pleistocene. **A-B**, M3 in A, buccal view and B, crosscut; **C-D**, m3 in C, buccal view and D, occlusal surface.

Latest Villafranchian/Early Biharian fauna of Sarkel, that includes "meridionaloid" elephants as well as diverse and stratigraphically significant small mammals, becomes a very important biostratigraphic reference level for southern Eastern Europe.

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Preliminary data on the *Mammut borsoni* (Hays, 1834) from Otman Hill (Colibaşi, Republic of Moldova)

Theodor OBADĂ

At the beginning of November 2011, Vasile Grigoriţa, history professor of the „Vasile Alecsandri" theoretical high school from Colibaşi village, Cahul District, was announced by the villagers that some very large teeth were found in the sand quarry from Otman Hill (45.73° N, 28.20° E), located north-east of the above-mentioned locality, and, in his turn, brought the discovery to the author's attention.

As a result of subsequent excavations (November 9-13, 2011), other remains belonging to the so-called Borson's mastodont, *Mammut borsoni* (Hays, 1834), were unearthed, among which the most important are those of the skull. The braincase was found in situ, in the easternmost wall of the quarry, and was lying on a west-east direction, 50 cm deep (Fig. 1. A). Other remains were collected from the slopes near the braincase.

The specimens were collected from horizontally stratified

Table 1. Features of the upper molars (M1-M2-M3 dex and sin) belonging to the *M. borsoni* specimen from Otman Hill, Colibaşi village.

	M1 dex	M1 sin	M2 dex	M2 sin	M3 dex	M3 sin
No. of crests	III	III	III	III	IV+t	IV+t
Length (cm)	92	94.6	112.1	113.1	160.02	160
Width (cm)	82.7 (III)	83.5 (II)	92.0 (III)	96.5 (III)	105.4 (II)	108.7 (II)
Height (cm)	>50.04 (III)	>51.5 (III)	61 (III)	62.5 (III)	64.5 (II)	69 (II)
Enamel thickness (cm)	-	-	-	3.9	-	-
Width index (3:2)	89.89	88.26	54.41	64.76	40.31	43.12

Fig. 1. Fossil remains of the *M. borsoni* individual from Otman Hill quarry. **A**, skull as it was found in situ. View from south to north (November 10, 2001). Arrow points to the occipital bones; **B**, during preparation at the „Vasile Alecsandri" High School, Colibaşi village (November 13, 2011). Braincase is 720 mm wide.

coarse alluvial sands, of yellow-gray and light brown colour, with local occurences of iron and manganese oxides, boulders of clay, and sandstones. Such deposits occur in the southern part of the Republic of Moldova, and are typical for the faunal sites of the Moldovian Faunal Unit of Eastern Europe, the MN 15 biozone (Vangengeim et al., 2005).

The material consists in: fragments of I2; left and right premaxillary fragments bearing fragments of I2 in the alveoli; the almost complete braincase; two maxillo-palatine fragments bearing the left and right M1-M2s; left and right M3s; a crest of m3; rib fragments, and other bone fragments (Fig. 1. B and Table 1, 2 for measurements). Specimens belonging to other vertebrates were also found: 10 turtle shell fragments; the second phalanx of a (probably tragocerid) bovid; micromammals; coprolites; a beaver bone.

Prior to this discovery, skull fragments from a senile *Mammut borsoni* individual, of which only the maxillo-palatines bearing the left and right M3s were preserved, were found at the Budăi site, about 23 km north-east from the Otman Hill quarry (Obadă, 2001).

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Table 2. Skull dimensions (after von den Driech, 1981; Tassy, 1997; Maschenko, 2002) of *M. borsoni* from Otman Hill, Colibaşi village.

Measured parameter	Size in mm
Greatest length starting from the occipital margin	>350
Occipital width	720
Greatest supraorbital width	420
Greatest width across the frontals	410
Basal length	422
Sagital occipital height	>450
Gratest length of occipital condyle	218
Greatest height of occipital condyle	119.9
Greatest width of foramen magnum	154
Length of M1-M2 sin and dex dental rows	M1-M2 sin: 209 M1-M2 dex: 209
Greatest diameter of dex I2, at the alveolus	width: 59 height: 66
Greatest diameter of sin I2 sin, at the alveolus	width: 63.4 height: 64

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Evidence of contact between *Mammuthus intermedius* (Jourdan, 1861) and ancient humans from Duruitoarea Veche, Republic of Moldova: preliminary data

Theodor OBADĂ ✉

In 2004, in the village of Duruitoarea Veche (Râscani district, northwestern Republic of Moldova), Eugen Tomuz (worker at the local stone quarry), found mammoth ivory and a mandible, in a landslide of the old country road near the northwestern part of the limestone cliffs of a Badenian reef (27°15' eastern longitude; 47° 52' northern latitude).

The animal's remains were found on the slope of a landslide, about 20-30 m northwest from the reef mentioned above, where the archaeological monument from the Duruitoarea Veche Cave (the "Starye Duruitory" Cave – in the old Soviet literature) is found. The cave contains four layers with evidence of different human industries, of which three are Paleolithic: two Lower Paleolithic layers (IV and III) with Acheulean industry, and one (II) with Upper Palaeolithic industry (Chetraru, 1973; Chetraru, 1995). The recovery of the specimens took place under the author's supervision, with support from Professor Dragoş Panţâru (mayor of the Costeşti commune) and from Professor L. A. Radcenco („Silvian Lucaci" Theoretical Highscool, Costeşti commune), with help from local volunteers in 2004 (5-8 August) and 2009 (7-8 September).

A surface of 23 m^2 was exposed in 2004. Some of the remains were lying at an angle of 30°, at a depth ranging from 0.5 m (in the west) to 1 m (in the east). The bone remains were found quite separated from a few centimeters to a few decimeters from one another. It is worth mentioning that only two metapodials were found underneath the ivory, near its base, and the lateral-medial surface of the ivory was flattened (Fig. 1A), probably as a result of hits intentionally made by ancient humans, as on an anvil. This allows only for the assumption that ancient humans were present at this site.

In 2009, the excavation was extended 9 m^2 eastward, and the remains were found 1.2-1.5 m deep, at the eastern margin of the excavation. The total surface exposed during the excavations carried out in 2004 and 2009 therefore reached 32 m^2.

In the sector investigated in 2009, the bone remains were randomly positioned. Some limestone fragments had sharp edges and were found right next to fractured bones. This allows for the idea that these limestone fragments were used by ancient people as tools to crack or crush some of the animal bones.

Fig. 1. Mammoth fossil remains and elements of human industry from Duruitoarea Veche. **A**, Part of the 2004 excavation. Crescent-shaped mammoth ivory: length along the circumference – 2750 mm; thickness at the base – 200 mm. Two metapodials were found near the base of the ivory which was latero-medially flattened, allowing for the assumption that this surface was used as an anvil. **B**, View of the 2009 excavation. The arrow points to the location of the flint tool, beneath the mammoth rib fragment. Rounded limestone boulders several decimeters in diameter (result of ancient deluvial processes or possible result of human activities) were found on the slope in the back, at the eastern end of the excavation; **C**, Flint tool found in the eastern part of the 2009 excavation, underneath a rib fragment (scale bar equals 1 cm).

In the eastern part of the 2009 excavation, under a rib fragment (Fig. 1B) was found a black flint tool (crude ridge flake, Fig. 1C). The tool presents secondary, pretty rough, but clearly visible working. The material used for the tool is locally available (the so-called Prut flint) as pebbles and rubble. A sector covered in gray crust, 3-6.5 mm thick, is present on the distal end of the tool. The maximum dimensions of the flake are: length – 47.1 mm, width – 25.7 mm, thickness – 12.4 mm.

Black flint tools are predominant in the industry layers IV and III from Duruitoarea Veche Cave, both assigned to the Acheulean teyac variety, based on their typology (Chetraru, 1973; Chirica and Borziac, 2005). The following information is given by David and Chetraru (1978) on the mammoth remains from this multi-layered station: "*The fact that bones and teeth are found near the station, more so at the base of the stone crest, allows the assumption that the mammoths were hunted in groups, being directed towards gorges and ravines*".

The fossil remains recovered so far is represented by: ivory (I2); skull fragment bearing M3 sin. and dex.; mandibulae bearing m3 sin. and dex.; distal humerus epiphysis; ulna; radius (proximal end); fibula sin. and dex.; rib fragments; complete and fragmentary vertebrae; pelvis fragment. Feet bones are represented by: metacarpale I dex., metacarpale III sin., metacarpale IV sin. and dex., metacarpale V sin., metatarsale II dex., cuboideum sin. and dex., lunar bone sin. and dex., magnum dex., naviculare sin., trapezoid sin. and dex., trapezium dex., lateral cuneiform. The age of the *Mammuthus intermedius* (previously assigned to *M.* cf. *chosaricus* Dubrovo, 1966) individual (following the method proposed by Laws, 1966) is estimated to 36-39 years (Obadă and David, 2008).

Evidence of *M. intermedius* bones being crushed, the presence of the latero-medially flattened ivory, the probably intended positioning of two metapodials under the ivory (probably to maintain the latter in a sub-horizontal position during the hitting that would be made on its lateral surface), and the tool found right under one of the *M. intermedius* ribs, allow at least for the hypothesis that the mammoth skeleton was chopped by the ancient people, which probably inhabited the nearby Duruitoarea Veche Cave, where layers with Acheulean industry were found. The possible hunt of the mammoth by ancient humans is also admitted.

Mammuthus intermedius appears as the peculiar species of the MNQ 23-26 zone, correlatable with the Singilian and Chosarian large mammal assemblages of Eastern Europe. These zones correspond to a rather wide time span (MOIS 6-12). The absolute age of this time interval is comprised between 470 and 130 ka BP (Markova, 2007). The rehabilitation and acknowledgement of the species *M. intermedius* was made by several authors (e.g. Labe & Guérin, 2005). The age of the mammoth was confirmed by the diagnostic measurements of the molars (lamellar frequency, enamel thickness, the length of a plate, etc.) presented in the paper published by Obadă & David (2008). The age was also confirmed by the typology of the flint tool collected from between the ribs of this mammoth.

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On the problems about the systematic position of the Taribana elephant, *Archidiskodon meridionalis taribanensis* Gabunia et Vekua, 1963

Theodor OBADĂ ✉

The spatio-temporal distribution and evolutionary history of the Subfamily Elephantinae Gray, 1821 in Eurasia are of great biostratigraphical significance. However, many researchers (e.g. Tesakov, 2004) have drawn the attention on the problematic polifacial geological structure of the Plio-Pleistocene continental deposits, which are often represented by several generations of deposition, overlapping or interdigitating with each other. Estimating the geological age of deposits containing large mammal remains becomes, therefore, a complicated task. A remarkable series of papers on this topic is the example of the formidable sites from the Upper Valdarno Basin (e. g. Fidolini et al., 2013).

Some researchers consider the species *Archidiskodon "gromovi"* (having as holotype the incomplete skull from Liventsovka quarry, from the so-called "Khapry sands" – Alexeeva and Garrut, 1965). Gabunia and Vekua (1966) mention that *"There were probably some deficiencies in the systematic assignment of the Liventsovka Archidiskodon, even by the authors of this species, who preferred to keep silent on its relation to the Taribana elephant"*. The discussion regarding the validity of this species went on for more decades (e.g. Gabunia, Dubrovo, 1990). However, according to V. Gromov (1948), the Liventsovka site yielded remains of elephants from different evolutionary stages: "*Elephas* cf. *planifrons*" (more basal) and "*E. meridionalis*" (more derived). Gromov (1948) also noted that: "the fossil remains are not only found at the base of the Khaprovian sands, but also inside them". Some researchers considered that the "Khapry sands" belong to various ages (e.g. Tesakov, 2004).

The name *Archidiskodon* Pohlig, 1888 (type species *Elephas meridionalis* Nesti, 1825) is taxonomically valid and may be used at the generic or subgeneric level, although other authors refer these species to *Mammuthus*. Maschenko (2010) re-examined the *A. "gromovi"* holotype. He reached the conclusion that the main evolutionary parameters of this holotype are identical to those of the *A. meridionalis meridionalis* holotype. Maschenko (2010) erects a new elephant species to replace *A. "gromovi"*. However, the definition of this new species – *A. "garutti"* – was declared by Baygusheva et al. (2011) a non-available species name. Subsequently, the holotype specimen was assigned to *A.* cf. "*rumanus*" and *A. "meridionalis rumanus"* (e.g. Baygusheva et al., 2011; Baygusheva and Titov, 2012). Baygusheva and Titov (2012) support the validity of "*A. meridionalis gromovi*".

The subspecies *Archidiskodon meridionalis taribanensis* Gabunia et Vekua, 1963 was described from the Taribana fossiliferous site (Georgia). Its age was initially estimated as late Akchiagylian-early Apşeronian (end of MNQ 17 biozone – beginning of MNQ 18 biozone). Additional field research allowed a better estimation of the elephant skeleton's age as Late Akchiagylian, MNQ 17 biozone (e.g. Vekua et al., 2010), corresponding to an age of approximately 1,8 Ma. Professor Vekua (personal communication, 2011) considered that the deposits which contained Taribana elephant are 2 Ma old. The author believes that the same evolutionary degree is seen in the elephants from Ioannina, north-western Greece (Melentis, 1960).

In September 2011, the author of this abstract visited the Georgian National Museum (Tbilisi, Georgia), to study once more the Taribana elephant skeleton. Molar measurements of the Taribana elephant holotype, revealed an evolutionary degree more basal than in the case of the *A. "gromovi"* holotype (data given by Maschenko, 2010). However, it was shown that *A. m. taribanensis* has nomenclatural priority (Obadă, 2012). Therefore, in the author's opinion, the Taribana elephant, *A. m. taribanensis* – the index *Archidiskodon* species for biozone MNQ 17 in Europe, can be considered as descendent of Ştefănescu's elephant, *A. stefanescui* (Obadă, 2010) – the index *Archidiskodon* species for biozone MN16 in Europe. The rehabilitation of the Romanian elephant – *Elephas rumanus* – the index *Elephas* species for biozone MN16 in Europe, was presented by Obadă (2010). This species is reported by other authors to the *Archidiskodon-Mammuthus* phylogenetic line (e.g. Lister et al., 2005; Baygusheva and Titov, 2012).

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Note on the Eastern European occurrences of *Stegotetrabelodon* Petrocchi, 1941

Theodor OBADĂ

Specimens assigned to *Stegotetrabelodon* Petrocchi, 1941 are so far reported from the following fossiliferous sites of Eastern Europe: Kerch, Ukraine (Pavlow, 1903), Khersonian, MN 10 biozone; Sklearovka (Novoalexandrovski District, Stavropol Territory), Russia (Alekseeva, 1959), Khersonian-Meotian, MN 10-MN 11 biozone; Tanacu (Vaslui District), Romania (Macarovci and Zaharia, 1967), Khersonian, MN 10 biozone; Novoukrainka, (Razdelnyansky District, Odessa Territory), Ukraine (Korotkevichi, 1979; Krakhmalnaya, 2008), Khersonian, MN 10 biozone; Cherevychne (Belyaev District, Odessa Territory), Ukraine (Korotkevichi, 1979), latest Meotian, MN 13a biozone; Ţareuca (Rezina District), Republic of Moldova (e.g. Obadă, 2007), Khersonian, MN 10 biozone.

The revision of some collections from the Republic of Moldova and Romania led to the taxonomical assignment of some fossil proboscidean remains. Some of these specimens were assigned to the genus *Stegotetrabelodon*: 1. The basal ivory fragment from Ungheni, previously assigned to *Amebelodon* sp. (e.g. Obadă, 2005) or to *Protanancus* sp. (Markov and Verghiev, 2010) allowed for the identification of Schreger lines in the outer layer, in transverse section, a typical feature of the genus *Stegotetrabelodon* (Ferretti et al., 2003); 2. A distal ivory fragment from Teleneşti District, Republic of Moldova (precise locality unknown), was identified in the collection of the State University of Tiraspol (with the headquarters in Chişinău), presenting a ivory pattern similar to the specimen form Ungheni. Its probable age is (?) - Khersonian, MN 10 biozone; 3. The following specimens, assigned to *Stegotetrabelodon* are housed in the collection of the National Museum of Ethnography and Natural History of Moldova, Chişinău: Pd4–M1 sin. and M1 dex., from the same specimen. They were collected during the excavations made for the foundations of the "Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection, from Schinoasa slum (Ialoveni street, Chişinău) at the absolute altitude of 222-226 m (in gray-greenish sands, possibly deposited in an oxbow lake), Khersonian, MN 10 biozone. Three Zygolophodon turicensis (Schinz, 1824) isolated molars (m2 and m3 sin. and dex.) were collected alongside the specimens mentioned above; 4. The Museum of Original Paleontological Collections from the „Alexandru Ioan Cuza" University, Iaşi, Romania, houses a fragment of the mandible, including the symphyseal portion and the base of the vertical branch, also bearing the m3 dex., found at Vutcani, Vaslui District. This specimen is also reported here as belonging to the genus *Stegotetrabelodon*.

E.L. Korotkevichi (1979) identified two „forms" of stegoterabelodons in Ukraine: a basal one, from Upper Sarmatian deposits (Novoukrainca, Ukraine; she also assigns to this "form" the specimens from Mannersdorf, Austria, and Oreahovo), and a derived one, from Meotian deposits (Cerevichnyi, Ukraine). Tobien (1978) estimates that stegotetrabelodontids are not primitive elephants, but evolved bunodont mastodons. Geraads et al. (2005) assign (even if provisionally) the specimens determined by different authors as *„Mastodon" grandincisivus* and the *„T. longirostris* grandincisivoid form" of this group to the genus *Amebelodon* Barbour, 1927. The same authors mention that more complete skull and mandibles are necessary for choosing one option and the other. It is worth mentioning now that the only *Stegotetrabelodon* skull known from Eastern Europe (and possibly the only one in Europe) was collected from Cerevichnyi fossil site, Ukraine (Meotian, MN 13 biozone) (Korotkevichi, 1979), but it was destroyed during transportation to the "V. Topachvsky" Palaeontological Museum (National Museum of Natural History at the National Academy of Sciences of Ukraine, Kiev) and requires extensive restoration. Given that the African deposits that yielded *Stegotetrabelodon* orbus are around 7.5 My old (Lothagam, Kenya; Sanders et al, 2010), and the ones in Eastern Europe are about 10.2 My age (Pevzner et al., 1987; Pevzner and Vangengeim, 1993; Krakhmalnaya, 2008) we can presume that this genus appeared in Eastern Europe, and subsequently migrated to the African continent.

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Holarctic genetic structure and range dynamics in the woolly mammoth

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The woolly mammoth is not only the most iconic Ice Age species but also one of the best candidates for genetic and genomic studies given the abundance of permafrost fossil material. Being widespread and abundant during the late Pleistocene, it disappeared from most of its geographical range at ca. 11,000 years before present (BP; Lister and Stuart, 2008) and finally became extinct at ca. 3,500 years BP on Wrangel Island (Vartanyan et al., 1993).

Using mitochondrial DNA (mtDNA) variation from the species' holarctic distribution over the last 200,000 years, we revealed a complex history of demographic changes, range expansions and genetic turnovers (Palkopoulou et al., 2013). In particular, we found that Europe was inhabited by a previously undocumented major mtDNA lineage up to ca. 34,000 years BP when it was replaced by another major mtDNA lineage. Moreover, we recovered genetic signals of population expansions at ca. 121,000 years BP, close to the time when the previous interglacial period, the Eemian, came to an end. Our data further support a following demographic expansion at ca. 66,000 years BP that led to the colonization of Eurasia by the North American mtDNA lineage. This event appears to coincide with the first time that the Bering Land Bridge became exposed since the penultimate glacial period (Hu et al., 2010). Levels of genetic variation through time depict a dramatic drop in effective population size towards the end of the last Ice Age. These findings suggest that climate induced environmental changes, such as warm periods and sea-level changes could have been instrumental in shaping the demographic history of the woolly mammoth. The role of climate on the woolly mammoth's final extinction still remains under debate (Lorenzen et al., 2011; MacDonald et al., 2012); however, our results indicate that climatic changes could have contributed to the disappearance of the species from most of its distribution. Genomic data from the last surviving population are anticipated to help us resolve the mystery of the woolly mammoth's final extinction.

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On the dwarf elephant stylohyoid bones from Spinagallo Cave (Hyblean Plateau, south-eastern Sicily)

Maria Rita PALOMBO

The peculiar hyoid apparatus of proboscideans, which likely evolved by the end of the Oligocene, is considered to be a key element in their evolution, as well as being a structure which helps to elucidate certain aspects of the physiology and herd behaviour of extinct proboscideans (Shoshani et al., 2007; Shoshani and Marchant, 2008 and references therein). The hyoid apparatus, which consists of only five bones (a pair of stylohyoidea, a pair of thyrohyoidea, and an unpaired basihyoideum) is situated deep within the throat. It connects to the cranium and the


a'-a'', left stylohyoideum MPVR-Sp1 **b'-b''**, left stylohyoideum MPVR-Sp2 **c'-c''**, right stylohyoideum MPVR-Sp3

Fig. 1. Stylohyoidea from Spinagallo Cave (Hyblean Plateau, south-eastern Sicily) in medial (above) and lateral (below) view.

base of the tongue, supporting the end of the trachea and larynx, and plays a role in the function of the pharyngeal pouch. This pouch is a structure which is unique to elephants, connected by means of the deep-gular musculature (digastricus, stylopharingeus, styloglossus and stylogastricus muscles) to the hyoid bones (Marchant and Shoshani, 2007; Shoshani and Marchant, 2008).

Although remains of the hyoid fragile apparatus are rare in the fossil record, in recent decades studies on stylohyoid bones have steadily increased in number, particularly with regard to the genera *Mammut*, *Mammuthus* and *Palaeoloxodon*. However, the stylohyoidea of dwarf elephants remain little-known, and thus far only a single dwarf elephant stylohyoid has been reported from Benghisa Gap (south-east Malta), described and figured as "*Elephas melitensis*" by Adams (Adams, 1874, page 45, plate15, fig. 10)

This study aims to provide new insights into dwarf elephant stylohyoidea by describing three stylohyoid bones (MPVR-Sp1, MPVR-Sp2 and MPVR-Sp3, Fig. 1) from the rich assemblage of dwarf elephant bones recovered in 1958/1960 from the Middle Pleistocene deposits infilling the lower chamber of Spinagallo Cave (Siracuse, Hyblean Plateau, Sicily) (Accordi and Colacicchi, 1962; Ambrosetti, 1968).The three stylohyoidea from Spinagallo display several morphological and dimensional differences amongst each other, the significance of which is difficult to ascertain. This uncertainty is in part due to the variation in shape and proportions displayed in the stylohyoidea of continental straight-tusked elephants (Palombo, 2012), and the limited number of specimens from Spinagallo.

The specimen MPVR-Sp1 (Fig. 1, a'-a''), the largest and best preserved from Spinagallo, is characterised by a robust superior ramus (SR), displaying conspicuous ribs and scars at the tip. The SR is flat on the lateral side and slightly expanded on the medial, where a groove first runs parallel to the SR posterior border and then extends along the origin of the posterior ramus (PR). The PR, which serves as the insertion of the digastricus muscle, is broken close to its origin, where it is sub-triangular in section, and its superior-lateral face is flattened. The inferior ramus (IR), broken at about two-thirds of its length, diverges from the PR with an angle of about 60°. The preserved portion of the IR, seen in anterior view, bends towards the lateral side, suggesting that the axis of the IR is somehow deflected from that of the PR. On the medial side, where the IR and PR meet and the stylopharyngeus muscle originates, both ribs and scars for the muscle attachment are evident.

In the specimen MPVR-Sp2 (Fig. 1, b'-b''), the IR is broken off, the SR is slender and has a deep and pronounced groove on its medial side, running from the posterior tip of the SR to the anterior-medial origin of the PR. The latter is definitely longer than the SR, flat and slightly rotated towards the medial side at its origin.

Specimen MPVR-Sp3 (Fig. 1, c'-c'') the smallest from Spinagallo Cave, has a somewhat slender SR, and a slender IR broken not far from its origin, with the preserved proximal portion strongly curved towards the lateral side. This specimen is characterized by a pronounced, deep groove running along the SR medial-posterior side, which extends into the proximal part of the PR. As a result, the PR appears folded medially on itself, with a superior-lateral face that appears to nearly extend to the top of the SR. This feature is much more pronounced than in the Maltese specimen, which, based on its dimensions, could be tentatively referred to *P. falconeri*.

Although the actual significance of the morphological and dimensional differences observed in stylohyoidea from Spinagallo Cave remain difficult to ascertain, it appears that all specimens were capable of supporting robust muscles, possibly affording increased support to the pharyngeal pouch. This structure, located at the base of the tongue stores water for drinking or dousing the body in time of stress, and facilitates the production and also resonance of low frequency sounds (e.g. Garstang, 2010). Accordingly, we may speculate that members of *P. falconeri* herds were capable of communicating among each other via infrasonic calls, over a distance of a few kilometers. However, whether or not the differences evidenced in styloihyoidea from Spinagallo Cave are merely related to intra-specific variation or also have dimorphic or taxonomic significance is a question which remains unanswered.

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Elephantids from the Pleistocene of Poland: state of knowledge

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The presence of three elephant species (*Mammuthus trogontherii*, *Elephas (Palaeoloxodon) antiquus*, and *Mammuthus primigenius*) among fossil mammal assemblages from the Pleistocene has been established in Poland (Table 1). The most abundant species in these finds is *Mammuthus primigenius*; however, there are also known records of *Mammuthus trogontherii* (Fig. 1) and *Elephas (Palaeoloxodon) antiquus*. Most fossil elephant remains have been provided by research from the 19th and 20th centuries, though there are more recent results from new localities. This paper is intended to present the current state of knowledge concerning sites in Poland at which these species have been found. The aim here is to examine the diversity of elephants in Poland in the Pleistocene. The geographical and temporal variability of elephantid remains will be also considered.

Fig. 1. Right upper M3 of the Bełchatów mammoth (*Mammuthus trogontherii*; 51022’N, 19022’E; Mazovian (MIS-11, Holsteinian) or Zbójnian (MIS-9, Reinsdorf) Interglacial).

Table 1. Selected sites with elephantid remains in Poland.

Localities	Chronology	Material	Source
Mammuthus primigenius: over 280 localities, including:			
Jarosław-Garbarze	MIS 3-2	Radiocarbon dating of ulna	Nadachowski et al., 2011
Dzierżysław	-	Radiocarbon dating of tooth	Nadachowski et al., 2011
Obłazowa Cave	-	Artifact	Nadachowski et al., 2011
Kraków, Spadzista	-	Archeological site	Nadachowski et al., 2011 (with further references)
Góra Winnica	-	Fragment of cranium, tusks, mandible with molar, molars, scapula, humeri, radius, ulnae, femurs, tibiae	this paper
Pińczów-Kolosy	-	Radius, mandible	this paper
Żyrardów-Stężyca	-	Pelvis, tibia	this paper
Outer Carpathians	-	Tusk, mandible with molar, scapula, humeri, ulna, pelvis, femurs, astragalus	this paper
Krosinko	-	Fragment of cranium, tusks, molars, mandibles, atlas, ribs, scapulae, humerus, carpals, pelves, femurs, tibia	this paper
Konarzyce	-	Molar	this paper
Zaniemyśl	-	Ulna	this paper
Pyzdry	-	Tusk, vertebra, radius	this paper
Bydgoszcz-Bielawy	-	Molar	this paper
Klempicz	-	Molar	this paper
Siedliszowice	-	Scapula, humerus	this paper
Radłów	-	Tusk, scapula	this paper
Parkosz	-	Humerus	this paper
Ostrów	-	Molar	this paper
Tarnów	-	Molar	this paper
Karsy-Borusowa	-	Humerus	this paper
Bielinek	-	Tusk, molars, humerus, femur, scapula	this paper
Elephas (Palaeoloxodon) antiquus			
Witków	-	Mandible with molars	Kowalski, 1959 (with further references)
Oborniki	-	Molars	Kowalski, 1959 (with further references)
Przemyśl, River San	-	Molar	Kowalski, 1959 (with further references)
Radymno-Jarosław, River San	-	Molars	Kubiak, 1965
Warsaw	-	Skeleton	Kubiak, 2001 (with further references)
Jóźwin/Konin	Eemian Interglacial	Skeleton	Kubiak, 2001 (with further references)
Ciechanów	-	Skeleton	Kubiak, 2001 (with further references)
Sokółka/Białystok	-	Molars	Kubiak, 2001 (with further references)
Tatra Mts.	-	Part of molar	Kubiak, 2001 (with further references)
Mammuthus trogontherii			
Gliwice, Piotrowice	-	Mandible with molars	Kowalski, 1959 (with further references)
Radymno	-	Molar	Kubiak, 1965
Stare Stawy	-	Molar	Kubiak, 1965
Łańcut	-	Molars	Kubiak, 1965, 2001
Przemyśl	-	Molars	Kubiak, 1965, 2001
Rzochów	-	Skeleton	Kubiak, 2001 (with further references)
Bełchatów	MIS 11-9	Molars	Pawłowska et al., in press (with further references)

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Studies on Pleistocene and Holocene mammals from Poland: the legacy of Edward Feliks Lubicz-Niezabitowski (1875–1946)

Kamilla PAWŁOWSKA ✉

Edward Feliks Lubicz-Niezabitowski (1875–1946) was a Polish scientist, biologist, zoologist, and physician. In the years 1928–1929, he served as Rector (Chancellor) of the University of Poznań.

His scientific achievements include about 150 works in medical and natural sciences, and in topics as diverse as entomology, botany, zooarcheology, and the study of modern vertebrates and Pleistocene mammals. At the same time, he also dealt with issues of natural protection.

The purpose of this paper is to present the legacy of Edward Feliks Lubicz-Niezabitowski in the form of published results of his studies of Pleistocene-Holocene mammalian remains found at various sites in Poland. A significant number of specimens comes from sites in Wielkopolska in Poland, and some of the fossil remains originate from contemporary Ukraine. The collected results of his analyses show the taxonomic diversity of mammals. Among others, he identified remains of woolly mammoth (*Mammuthus primigenius*), straight-tusked elephant *(Elephas (Palaeoloxodon) antiquus)*, woolly rhinoceros (*Coelodonta antiquitatis*), giant deer (*Megaloceros giganteus*), Eurasian elk (*Alces alces*), European bison (*Bison bonasus*), steppe wisent (*Bison priscus*), reindeer (*Rangifer tarandus*), horse (*Equus* sp.), Eurasian cave lion (*Panthera leo spelaea*), and cave bear (*Ursus spelaeus*) (Lubicz-Niezabitowski, 1912, 1925, 1926, 1929, 1948).

He wrote and published not only in Polish, but also in French and German, which was uncommon at that time. His work provided knowledge of morphological and morphometric issues and zoogeography, along with environmental aspects of animals. As his research belongs to the period of the World Wars, it is difficult to quantitatively and qualitatively assess the surviving state of his specimens. In this context, his published works (most of which have good illustrations of the specimens), constitute an invaluable source of information from the first half of the century. All of his published and accessible analyses of fossil material were used to prepare a faunal list specified for each taxon, reconsidering the names of sites which have in some cases been renamed, due to geographical updates. The collected data can be used for synthetic works concerning diversity and occurrence of Pleistocene mammals in Europe, with reference to Poland.

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Mammoth bone assemblage from Changis-sur-Marne (Paris Basin, France): preliminary results

Stéphane PÉAN ✉, Grégory BAYLE, Laëtitia DEMAY, Frédéric BLASER, and Patrice WUSCHER

In 2012, an accumulation of mammoth bones was discovered in a sand and gravel quarry, located at Changis-sur-Marne (Seine-et-Marne, France), 75 km east of Paris (Bayle et al., 2013). During fieldworks at the Gallo-Roman site at this quarry, first bones were found in a geological test pit. Rescue excavation was conducted during six weeks in order to perform a geological survey, to unearth the bones and record their spatial position, and collect sediment samples. A cast of the surface of the excavated bones was taken.

Bones were found in Pleistocene sandy sediments (late Saalian or Weichselian), within an area of 28 m^2, most of them were concentrated in 5 m^2 range. The accumulation occurred in a fluvial environment, on a former bank of the Marne River.


(© G. Bayle, Inrap)

Fig. 1. Central view of the excavated Mammoth bone assemblage, Changis-sur-Marne, France.

Attributed to *Mammuthus primigenius*, the bone assemblage is composed of major skeletal parts: the rostral part of a skull with two molars, the left tusk, the disassiocated right tusk and a mandible; vertebrae and ribs; two scapulae; one left hip bone, seven long bones from the fore and rear limbs; and small bones (notably sesamoids) from the distal limbs.

They mainly belong to an adult individual. At least three bones come from another adult.

The thorax and the upper right forelimb were partly found in anatomic position (Fig. 1).

The bone surface is mostly well preserved. Nevertheless, the material was very fragmented by post-depositional taphonomic processes.

In addition, three Palaeolithic flint flakes were found around the mammoth bone assemblage, one of them found very close to the skull remain.

Sediment and bone dating (OSL, ESR and Ur/Th), palaeo-environmental analyses (malacology, palynology, sedimentology, biogeochemistry) and bone conservation are in process.

Current zooarchaeological studies address two issues: the woolly mammoth population in the Marne valley, in regards to the evolution of *Mammuthus primigenius* in Western Europe, and the taphonomic history of the mammoth bone accumulation in a fluvial context with possible human action.

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Mammoth «Graveyards» of the Northern Yana-Indighirka Lowland, Arctic Siberia

Vladimir PITULKO ✉, Elena PAVLOVA, and Aleksandr BASILYAN

Since the discovery of the Berelekh archaeological site next to the Berelekh mass accumulation of mammoths (Vereschagin, Mochanov, 1972), this geoarchaeological complex remained unique in Arctic Siberia. Since 2000, systematic survey aimed at Pleistocene cultural remains began north of the Yana-Indighirka lowland as part of the Zhokhov-2000 research project. During the explorations in the Yana-Indighirka interfluve, discovery of pre-LGM Yana RHS site (Pitulko et al., 2004) was followed by finding the Yana mass accumulation of mammoths, or YMAM (Basilyan et al., 2011), and by the reevaluation of Achchaghyi-Allaikha (Nikolskiy et al., 2010) and Berelekh accumulations of mammoths (Pitulko et al. 2014). Additionally, several new mammoth sites were discovered in 2011-2013. It has to be stressed that all of them became known after the perennially frozen deposits were destroyed by local residents' power-washing efforts during illegal ivory mining.

Nikita site (NKL, N 71° 34', E 141° 37'), located on the right bank of Maksunuokha River, represents a secondary context formed by a low-energy stream. Mammoth bones are associated with those of other herbivore (bison, horse, reindeer) and carnivore species (wolf, wolverine, brown bear). There are at least 11 mammoth individuals, mostly adults and a few juveniles. Several mammoth ribs display unequivocal butchering marks and some have clear hunting lesions (embedded lithic tool fragments). Radiocarbon dating allowed estimated the assemblage age at 12,000 BP (12,050 ± 50 BP, Beta-309157 and 11,960 ± 140 BP, LE-9493). Artifacts are very few but characteristic: they include ivory debitage and spear point preforms and formal lithic artifacts - tear-drop bifaces identical to the Berelekh specimens (Pitulko et al., 2014) known in NW North America as Chindadn points. NKL site fully replicates the Berelekh complex in geology, age, and bone/artifact association as well.

Another locality found in the Maksunuokha River, MKR/UR-22, sits slightly north of NKL site (N 71° 42', E 141° 12'). Bones and artifacts are found within the deluvial-proluvial deposits backfilling the erosion channel made by a small stream. The site yielded ivory debitage, a spear point blank, and several stone flakes that indicate rejuvenation of lithic tools and possibly microblade core maintenance, but no tool production. Regular knapping is presented by true microblades while core technology is not recognizable. Bone remains collected at the site suggest that at least 12 mammoth individuals, both juveniles and adults, were killed (?) here around 12,370 ± 50 BP (Beta-362950).

Ilin-Syalakh River in the Yana-Indighirka interfluve produced two more sites. This first, Ilin-Syalakh «mammoth graveyard», or the ISYLAKH site, is located at N 70° 47' and E 140° 45'. The bone bed, belonging to the base part of the river terrace, yielded a set of almost exclusively mammoth bones (presumably about ten mid-sized animals are represented, indicating prey selection by size). Other species (woolly rhinoceros, reindeer, horse, bison, hare, and birds) are also present. According to 14C dating of mammoth bones (12,260 ± 220 BP, LE-9507 and 12,300 ± 85 BP, LE-9494), the bone material of the bone bed was accumulating from before 12,000 BP. The accumulation mechanism is similar to that of the Berelekh (Pitulko et al. 2014). Past human activity is indicated by a distinctive ivory artifact - a 27 cm long three-edged preform for a thrusting spear, typical for many Siberian sites.

The other small concentration of bones, called ISYLAKH-034 site, was found 3 km downstream from the «graveyard» on the right river bank. Although there were about 15 specimens found in the narrow spot (7-8 m wide), Pleistocene fauna is represented widely at this site: the concentration includes mammoth, bison, horse, reindeer and elk bones. There are rib and vertebra fragments, and limb bones. Bone-bearing horizon produced a mammoth mandible (22,700 ± 300 BP, LE 9506), mammoth ribs with clear human impact (hunting lesions or butchering marks?), and elk antler fragments. This site perhaps starts closing the «LGM gap» in the human habitation record in NE Asia.

There are no lithics associated with these finds; however, the lack of lithics may be explained by the shortage of high quality lithic raw material in this region. Thus, human exploitation of bone beds does not necessarily leave supplementary evidence, even when human involvement in the bone bed formation and human use of mammoth bones is indisputable.

Interestingly, many of mammoth bone beds found in northern Yana-Indighirka lowland (Achchaghyi-Allaikha, Berelekh, Ilin-Syalakh, Nikita, and MKR/UR22) are roughly simultaneous, forming between 12,600 – 11,900 BP, contemporary to Bølling and then to Allerod warming (Nikolskiy et al., 2010; Pitulko et al. 2014). Bone remains in all of them are almost 100% mammoth, and often represent a small group (family group?). In general, the last peak of mammoth population in Arctic Siberia corresponds to this time, predating the animal's final decline, in which humans have certainly played a role (Nikolskiy et al., 2010) since they had inhabited the area widely. Finally, we have to mention that there are strong indications for presence of Late Pleistocene human populations further north, including New Siberia, Zhokhov, and, possibly, Kotelny island.

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Human-inflicted lesion on a 45,000-year-old Pleistocene wolf humerus from the Yana river, Arctic Siberia

Vladimir PITULKO ✉, Aleksei TIKHONOV, Konstantin KUPER, and Roman POLOZOV

In 1884, the Russian Academy of Science dispatched an expedition to explore the Arctic Ocean shoreline in East Siberia around the Lena and Yana Rivers (Bunge and Toll, 1887). It was led by Aleksander Bunge, a medical doctor, and Eduard von Toll, a geologist. In 1885, Toll described a Pleistocene bison skull concentration near a small unnamed creek entering the Yana River at N 68° 55´ 05.2˝, E 134° 28´ 46.2˝ (Fig. 1A). An assemblage of Pleistocene faunal remains containing mammoth, wooly rhinoceros, bison, and a few bones from other species (Fig. 1B) was collected from this locality (hereafter, the Bunge-Toll site) in 2012. The fauna comes from the upper part of the

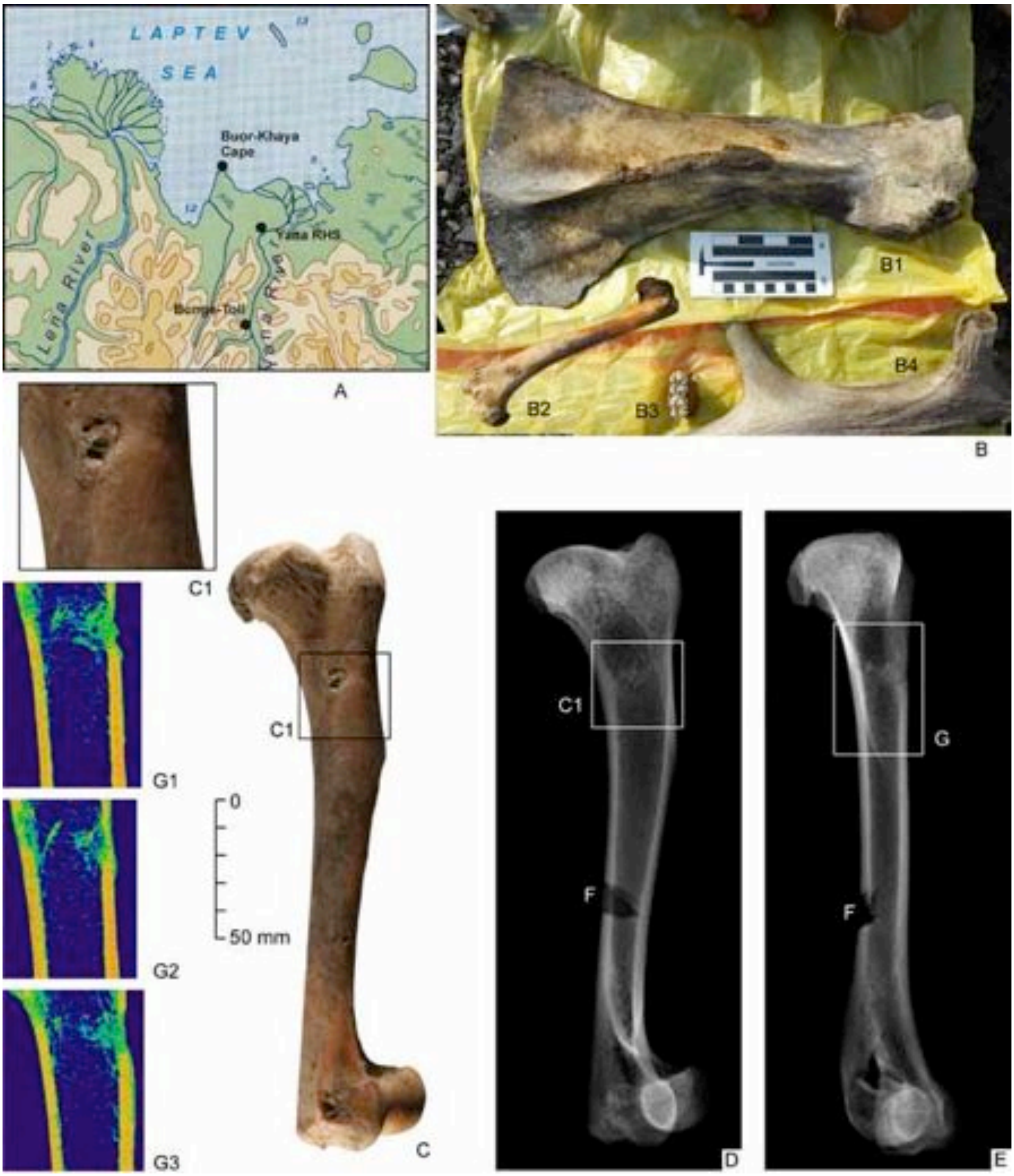

Fig. 1. Bunge-Toll 1885 site. **A**, site location. **B**, human-modified (?) bones and red deer antler. **B1**, woolly rhinoceros scapula. **B2**, Pleistocene wolf humerus (left). **B3**, reindeer mandible fragment. **B4**, red deer antler. **C**, wolf humerus with pathological changes. **C1**, close up of studied zone. **D**, X-ray photograph of the wolf humerus, same side as view (C). **E**, X-ray photograph of the wolf humerus, profile of the hunting lesion. **F**, AMS 14C sample cut out. G, X-ray computer tomography zone. **G1, G2, G3** – slices on different depth. Note: scale bar for C, D, E is 50 mm.

Table 1. Radiocarbon dates from Bunge-Toll 1885 site (Note: GrA 57022 is AMS ^{14}C).

N	Sample	Dated material	^{14}C age, uncalibrated years before present
	LE 9888	Bison, humerus	36,300 ± 640
	LE 9889	Woolly rhinoceros, costa	40,500 ± 1600
	GrA 57022	Wolf, humerus	44, 650 +950 /-700
	LE 9887	Woolly mammoth, pelvic bone	47,600 +2600/-2000

permafrost deposits, which fill the depressions in bedrock around 50m above the river level. Radiocarbon dating (Table 1) indicates that water-washing by local residents looking for mammoth ivory likely exposed the upper portions of the Yana River's third (?) terrace sediments. Most of the dates (obtained from bone collagen) are over 40 kya and in two cases the measurement resulted in a skewed distribution.

Archaeological study of the collection revealed that some bones, such as a rhino scapula, display likely evidence of human modification (Fig. 1, B1). In addition, a diagnostic fragment of a smashed reindeer mandible (the tooth row) was found. Zooarchaeological research indicates that such damage is very typical for reindeer bones from archaeological sites, but never caused by natural processes. Individual ^{14}C ages of these bones are unknown.

Archaeologically, the most interesting find is a left humerus of a mid-sized adult Pleistocene wolf (Fig. 1, B2, C). Its individual ^{14}C age was obtained from a diaphysis fragment drilled out for the analysis (Table 1, Fig. 1, F). Even in the field photos, some bone pathology on the upper third of the proximal end's lateral surface is visible (Fig. 1, B2, C, C1).

To clarify the character and nature of the injury, two x-ray methods were used: (1) regular X-ray at the Saint Petersburg State Pediatric University Clinic (Fig. 1, D, E) and (2) X-ray computed tomography (XCT) at Budker Institute of Nuclear Physics RAS SB, Novosibirsk. The latter was applied to the bone sample with the use of synchrotron radiation (SR) from the VEPP-3 storage ring (Novosibirsk, Russia) at the X-Ray microscopy and tomography beamline station (Fig. 1, G1, G2, G3). Each scan consisted of 360 back projections with an angular step of 0.5° (from 0 to 180°).

The methods described above show that the proximal third of the humerus (the metadiaphysis zone) contains a round break in the cortical plate with a porous structure, 12 x 8 mm in size. There is no bone deformation or bone tissue excess, which is common when a displaced bone fracture heals. Hence, this injury probably represents a fracture of a limited area of the bone.

X-ray images of two projections show slight changes in the cortical plate structure of a limited area in the metadiaphysis zone of the proximal third of the humerus. A sclerosis zone, with approximately triangular borders, covers the entire width of the bone. XCT images (Fig. 1, G1, G2, G3) show signs of cortical plate lesions; some of the cortical plates appear pushed inward (Fig. 1, G2). Inside the bone, the bone tissue is altered. A limited, irregularly-shaped area is characterized by uneven thickening of bone tissue (sclerosis), spread to the opposite cortical plate, which does not show these modifications as clearly. We can conclude that this evidence points to efficient natural regeneration of the animal's bone tissue in the location where an atypical fracture occurred. The puncture-cut damage was probably caused by a sharp wounding object, which was used with impressive force and punctured the bone 10mm deep, stopping before the bone was penetrated all the way through. The shape of the object, based on the 3D reconstruction from the XCT data, can be described as very pointed and thinned. Post-trauma alterations in modern animal bones, similar to the ones seen on the Bunge-Toll 1885 site humerus, occur approximately 6 months or more after the trauma.

This puncture-cut wound on the wolf's left humerus, caused by a sharp object with great force, could only have been inflicted by a human. The weapon shape reconstruction indicates it was a rather sharp implement, most likely a projectile point made of mammoth bone or ivory. Hence, the Bunge-Toll 1885 site find represents indirect evidence of human presence in Northern Siberia around 45 kya, long before the Yana site was occupied. It is not clear to what extent the other bones from the Bunge-Toll 1885 site are associated with human activity; however, the entire complex dates to no younger than 36 kya. Interestingly, the closest radiocarbon date to the age of the wolf humerus (44, 650 +950 /-700) in the Bunge-Toll 1885 collection comes from mammoth remains (47,600 +2600/-2000). Clearly, wolves were not a prey category, but it is easy to imagine some kind of a conflict between this animal and humans.

Such an early human presence has not previously been observed in Arctic Siberia, the Yana site (Pitulko et al., 2013) and the Buor-Khaya mammoth "graveyard" (Pitulko et al., 2014) being slightly younger than 30 kya. Sites chronologically comparable to the Bunge-Toll 1885 site (dating to 40-45 kya) are very rare in Siberia in general. However, their list could be expanded significantly by including indirect evidence, such as paleontological remains of Pleistocene animals, which are encountered much more often than Paleolithic sites. Some of this fauna could have still been hunted by humans, and the Bunge-Toll 1885 site provides a good example for Arctic Western Beringia.

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A MIS 3 kill-butchery mammoth site on Buor-Khaya Peninsula, Eastern Laptev Sea, Russian Arctic

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Lutz SCHIRRMEISTER, Tatiana KUZNETSOVA, Pavel NIKOLSKIY, and Elena PAVLOVA

An assemblage of late Pleistocene faunal remains was collected during the Eastern Laptev Sea - Buor Khaya Peninsula expedition (Strauss et al., 2011) near the Orto-Stan River, in Buor-Khaya Peninsula (Fig. 1, A). The bones were sampled from a concentration located next to the edge of a thermokast lake (N 71° 36,120' E 132° 15,597'; Fig. 1, B, C).

Direct dates on two mammoth bones with human impact and a horse bone (Fig. 1, D, E) estimate the age of the site at 27,000 – 27,600 BP, which corresponds to the end of the

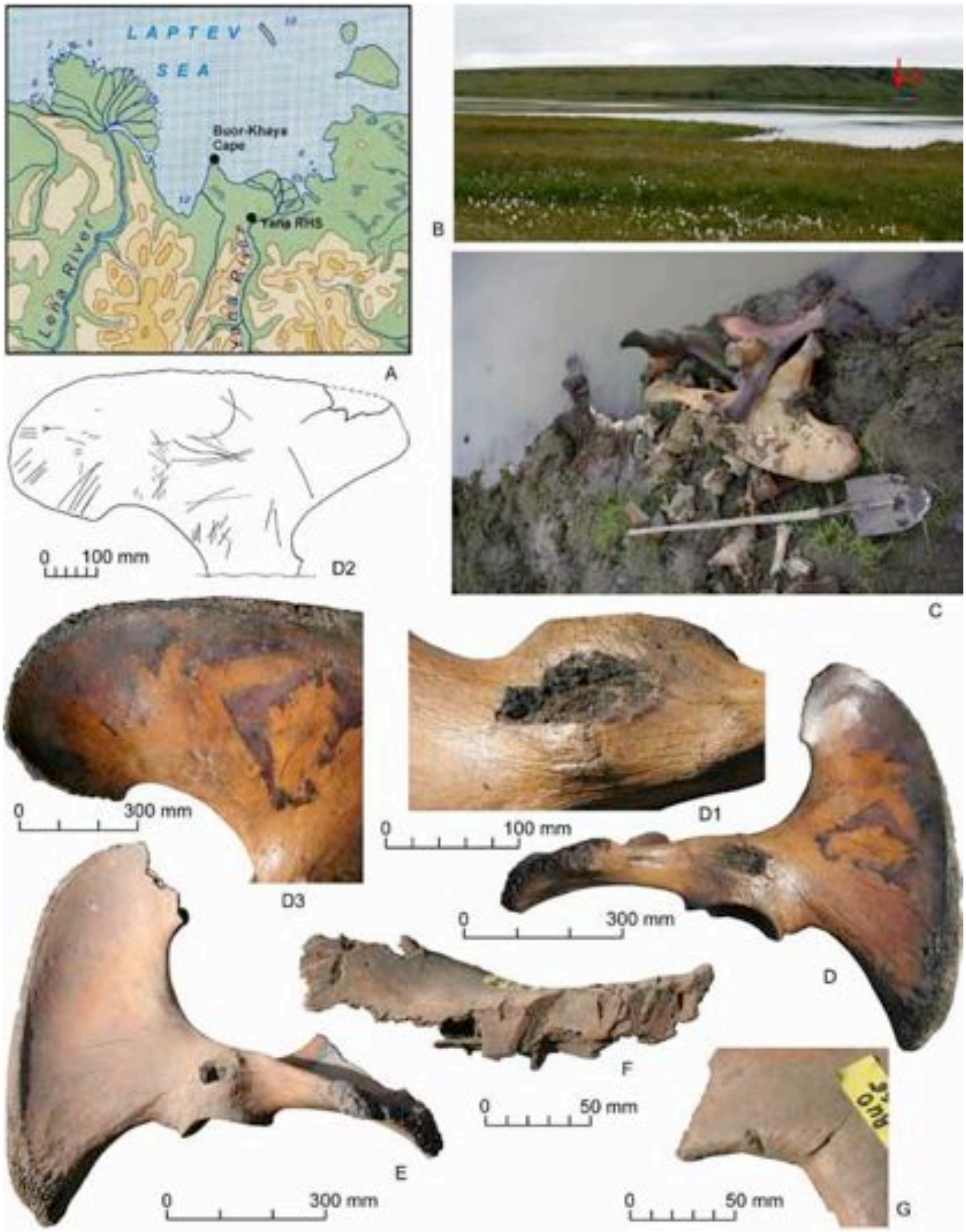

Fig. 1. The Buor-Khaya/Orto-Stan mammoth kill-butchery site. **A**, site location. **B**, site area, viewed from the South. **C**, location of wash outs made by mammoth ivory miners. **D**, mammoth pelvic bone (right) with human impact (blind hole and engravings on caudal surface). **D1**, close up for the blind hole. D2, engravings sketch by Alla Mashezerskaya. **D3**, caudal surface with engravings. **E**, mammoth pelvic bone (left) with human impact (blind hole) near the joint. **F**, mammoth skull fragment with cut mark. **G**, mammoth skull fragment with cut mark.

Table 1. AMS ^{14}C dates for Buor-Khaya/Orto-Stan mammoth kill-butchery site

Sample	Skeleton element	Species	^{14}C age, uncalibrated years before present [yrs BP]
Beta-362946	Pelvic bone with a hole, right	mammoth	27,080 ± 140 yrs BP
Beta-362947	Pelvic bone with a hole, left	mammoth	27,430 ± 150 yrs BP
Beta-362948	Mt III, right	Pleistocene horse	28,790 ± 160 yrs BP

Marine Isotope Stage (MIS) 3 (Table 1), or slightly older if the horse bone belongs to the same depositional horizon. The rate of accumulation of mammoth bones remains uncertain. The accumulation event could have been relatively short (taking approx. 60 years) or longer, taking up to 640 years, as seen from the mammoth bone ages (ignoring the horse bone date).

Mammoth remains represent two thirds of the collected material (Table 2), and include at least five mammoth individuals, both adults and juveniles. Two pelvic bones (Fig. 1, D, E) have identical blind holes near the coxofemoral articulation (Fig. 1, D1) on the bones' caudal sides. Evidently, bone cracks, resulting from the impact of some heavy chopping tool, loosened the joint and facilitated removing the head of the femur from the hip socket.

Multiple lines (1.2-2 mm wide and ~0.7 mm deep) engraved by sharp lithic tools are visible on the caudal surface of a right innominate (Fig. 1, D, D2, D3, G). In addition to the butchering marks, the Buor-Khaya/Orto-Stan mammoth site provides evidence that humans killed these animals. Finds from Yana RHS site (Nikolskiy and Pitulko, 2013) suggest that people applied a «spear-fall» hunting strategy, similar to that practiced by modern African hunter-gatherers. For example, Kulik (1971) describes a specific coup de grâce method practiced by Pygmies: a spear thrust into the elephant's trunk cuts important arteries and causes mortal bleeding. The position of the cut-marks on the edge of the nasal opening of the mammoth skull fragments at the Buor-Khaya/Orto-Stan, i.e. near the trunk, (Fig. 1, F, G), suggests that they were caused by the same action. This evidence is sufficient to accept the Buor-Khaya/Orto-Stan site as a kill-butchery mammoth site, and currently the northernmost Paleolithic site in the world, which sheds light on human dispersal through the Arctic at the end of MIS 3.

Table 2. Bone assemblage from Orto-Stan River (based on Strauss et al., 2011).

Taxon	NISP
Mammoth (*M. primigenius*)	67
Large herbivore animal	3
Pleistocene horse (*Equus* sp.)	2
Reindeer (*R. tarandus*)	2
Unidentifiable fragments (Mammalia)	7
Total	**94**

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Overview and preliminary analysis of the new finds of Late Pleistocene mammoth fauna in the Yana-Indigirka Lowland, Yakutia, Russia

Valerii PLOTNIKOV ✉, Albert PROTOPOPOV, Stanislav KOLESOV, and Aisen KLIMOVSKII

Our analyses incorporate three localities with numerous (Selliach, MusKhaya, Bulguniakch lakes) and two with single (Chondon and Buor Yuriakh) woolly mammoths remains in the Yano-Indigirka lowland.

The first site (70°45'N, 140°45'E) is located on the right bank of the Selliach River, 57 km upstream to the east from a settlement "Tumat" (Fig. 1). The discovered bones come from a single horizon at 5-6 m depth. The bone concentration occupied approximately 10-12 square meters area. About 99% of all fossil remains belong to *Mammuthus primigenius* (Blumenbach, 1799). The amount of the right and left limb bones, tusks, as well as fragments of skulls corresponds to about 20 mammoth individuals. The group consisted mainly of mature animals of 20/30 to 45 years old (62%), supplemented by young individuals from 1/6 to13/16 years old (38%) (Fig. 2A). Probably, the small group of mammoths died by accident (flood, trapped in bog).

The Mus-Khaya site is located 30 km downstream from the settlement "North", 70°43 'N 135°24'E (Fig. 1). The site rests on the bank at a 30-40 m height above the water surface, and represents 1300-1400m long ice core outcrops, which are constantly thawing. Studies of numerous bone remains of *M. primigenius* revealed the following mammoth age groups: from 1/2 to 13 years old - 55% , from 13/35 to 50/60 years old - 41%, and 50/60 years old- 4% (Fig. 2B). In total, remains of 13 mammoths (with at least one male and three females) were aged between 2 to 70 years old individuals.

The Bulguniakh lake (70°45'N, 138°17'E; Fig. 1) is a thermokarst lake formed as a result of a thawing 40-meters deep ice composing its bottom and banks. The Bulguniakh fauna included the following taxa, typical for the Late Pleistocene mammoth fauna of northeastern Eurasia: Proboscidea (*M. primigenius*), Perissodactyla (*Equus lenensis, Coelodonta antiquitatis*), Artiodactyla (*Bison* sp., *Ovibos* sp., *Rangifer tarandus*) and carnivorous mammals. The largest number of bones found at the site belongs to the woolly mammoth. Among those, remains of mature and old individuals (males and females), as well as young mammoths (3 calves from 1 to 3- 4 years old) are identified. Total number of mammoths suggests 10 individuals at least: three of them are represented by sexually matured males (two old and one young, with unfused epiphyses on long bones), four sexually matured females (three females with fused long bone's epiphyses and one female with unfused epiphyses), 3 calves (1 about a year old and two calves from 2 to 3/4 years old) (Fig. 2C).

According to E.N. Mashchenko (2002), the structure of mammoth and modern elephant herds are similar. The groups were mainly formed by females and their calves. Under adverse conditions or some common threats, groups could form a "clan" containing up to 70 individuals headed by a senior female. Males that reached sexual

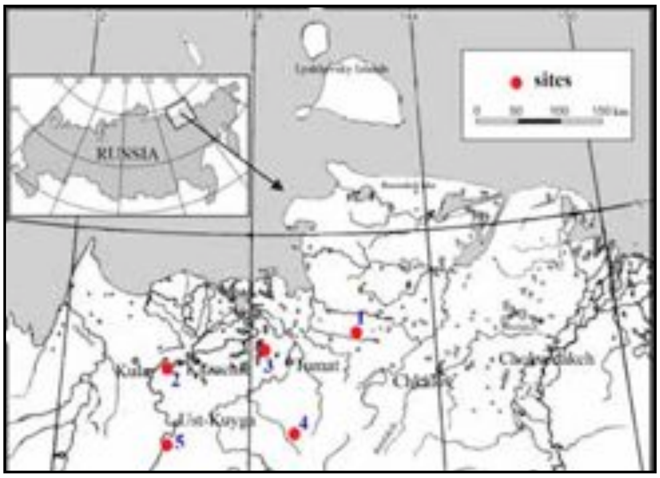

Fig. 1. The studied sites in the Yana-Indigirka lowland: **1**, Selliach River; **2**, Mus-Khaya; **3**, Lake Bulguniakhtakh; **4**, Chondon River; **5**, Buor-Uriakh River.

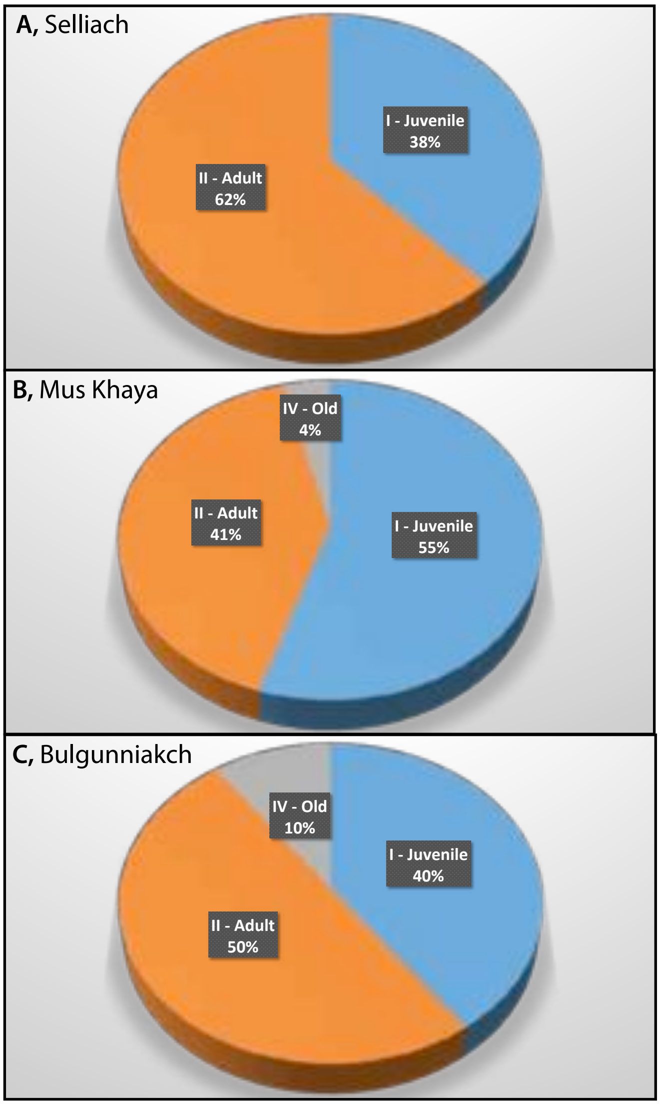

Fig. 2. The persentage of age groups in the studied sites.

maturity would leave, being expelled from the herd and form a small group of young males. Forming groups was one of their ways of adapting to environment. Collective behavior includes the joint care of the offspring and protection from predators. By analogy to modern elephants, mammoth groups might have formed a large herd, which is confirmed by findings of individuals of different ages together in many localities. Groups were formed to protect the youngs, as well as for long-term migrations, which determined their survival.

The site (70° 17'N, 138° 00'E) of the Chondonskiy mammoth (*M. primigenius*) is located on the bank of the right unnamed tributary of the Chondon River, at the foot of the Poluosniy Ridge, in the region of "Ygyannya", 66 km south-west from the settlement Tumat, Ust-Yana Ulus (Fig. 1). The site occupies the approximately 250-300 m long and 20-30 m high outcrop exposure formed as a result of thawing sediments of the right bank of the river. The remains discovered at the site belonged to a single woolly mammoth, *M. primigenius*, about 47-50 years old with estimated withers height 290-300 cm.

The site (69°33'N; 134°43' E) on the Buor-Yuriakh River is located 66 km southwest from the settlement Ust-Kuiga, Ust-Yana Ulus, Osokhtokh Region (Fig. 1). The area is a typical taiga with numerous bogs and lakes. The discovered bones of *M. primigenius* comprise 15% of the skeleton. The dense localization of bone elements and proportions of limb bones (scapula, ulna, femura and tibia) indicate that the bones belong to a single individual. Based on the compact tissue morphology in diaphyses of long bones and vertebrae, and complete obliteration of the epiphyseal fusions on long bones, vertebral centrums, as well as the presence of the last (sixth) molar (M3), the age of the individual was over 50 years old. The estimated height of the Buor-Yuryakh mammoth at withers, calculated from long limb bones, is about 318 cm.

Apparently, the mammoth fauna lived in open and semi-open landscapes (arctic steppe, shrubs) in Yana-Indigirka lowland during the Late Pleistocene. In this period, several major changes occurred in the landscape and climatic conditions (the phase of late postglacial warming from about 12,800 to 12,300 years ago) (Nikolskiy et al., 2010). During this period, specific disastrous conditions were formed for the largest representatives of the mammoth fauna - woolly mammoths, in the Yana-Indigirka lowland. This happened due to the specifics of the relief (prevalence of the lowland habitats) and the presence of major river basins (Omoloy, Yana, Indigirka Rivers). Seasonal river floods could have destroyed not only the individuals, but entire herds of mammoths.

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Influence of cryogenic processes on the Late Pleistocene vegetation reconstruction

Albert PROTOPOPOV ✉, and Victoria PROTOPOPOVA

Although the study of the Late Pleistocene landscapes that were capable to maintain the megafauna in cold climates has a long history, paleontologists still do not have a consensus on the dominant vegetation type of that period.

Adopted at the end of the 60s of the 20th century the definition of the Late Pleistocene landscape as a "tundra-steppe" was based on analysis of the floristic component of pollen spectra, where pollen relating to either steppe or tundra associations occurred at the same horizon.

The plant community reconstructions based strictly on paleo-entomological studies of highly stenobiontic beetle, *Morychus viridis* yielded unexpected result: there were vast plains with extremely low amounts of grasses in the Pleistocene contradicting the presence of the flourishing mammoth fauna (Berman, Alfimov, 2010). The paradox results reflected the beetle habitat preference rather than revealing natural mosaic distribution of different flora biotopes. The thermophylic steppe phytocenoces were occupying southern slopes, cryosteppe groups with the *Morychus viridis* inhabited drained areas, while mesophytic meadows (with tundra plants) were spread in flooded lowlands serving as pastures for mammoths and other grazers.

In this paper, we would like to point out one important environmental factor that has not been taken into account by many paleobotanists while reconstructing paleolandscapes of the Late Pleistocene. This factor is the presence of a cryolithozone. Formed and developed in the north of Eurasia in the Early Pleistocene, permafrost still has an enormous impact on modern vegetation.

In contrast to the past, the cryolithozone's influence on the modern vegetation is well studied. It has not only a direct effect of low temperatures on the plant root systems, but also on accumulation of moisture in the soil, supporting the survival of modern taiga vegetation in the central regions of Yakutia. If it were not permafrost, there would be widespread desert or arid steppes.

Another important feature of the permafrost in respect of vegetation is distribution of moisture. Influence of cryogenic processes leads to the formation of negative landforms due to subsidence - frost cracks, alases, landfills and others, which develop bog vegetation and, at low latitudes, tundra-marsh vegetation. Due to cryogenic processes, soil heave occurs, resulting in the formation of rollers, hydrolaccolith (pingo) and migration mounds. Alases, thermokarst subsidence of oval form with diameters from hundreds of meters to several kilometers, occur during thermochrons. Wedge ice develops and engrosses during cryochrons, when the most typical form of landscape, the roller polygonal and heaving mounds are formed at the same time.

Processes associated with the formation of heaving hillocks, including hydrolaccolith (pingo or bulgunnyakhi) and polygons, are actively taking place in modern time. Alases, common in the central part of Yakutia, which are often located in modern hydrolaccolith mainly formed in the Early Holocene. The current process of alases formation also takes place, though not at a pace as was recorded for the Holocene optimum.

Similar processes associated with the dynamics of the cryolithozone occurred in the Late Pleistocene, when alases and heaving mounds formed (Kaplina, 2011). At the same time, various forms of permafrost terrain of different times of origin coexist with each other for thousands of years.

The golden age of the mammoth fauna is associated with chryochron, when heaving mounds and polygons with rollers and hollows occupied alases that were formed during preceding thermochrons. Cold and dry climate of the Late Pleistocene contributed to the fact that xerophytic plants typical to steppe phytocenosises, predominantly grew on the swelling hills. At the same time, studies have shown that vegetation of hydrolaccolith in Central Yakutia and vegetation on the top knolls where soil surface is strongly eroded are represented by sagebrush associations of *Artemisia jakutica, A. commutata, A. sieversiana*, as well as xerophytes plants, *Carex duriuscula* and *Festuca ovina*.

During cryochron periods, hollows in poligons, alas lake coasts were overgrown mostly by hygrophilic vegetation such as *Calamagrostia langsdorfii, Beckmannia syzigachne, Carex rhynchophysa, C. aquatilis*, and *C. wiluica*. Analysis of pollen spectra gives xerophilic-hygrophilous script. All of them grow on a few hundred square meters area. The reason for this is the permafrost origin of landforms.

Thickness of loess deposits in the Arctic, filled through with ice cores, serve as evidence that the late Pleistocene cryogenic process was more extensive than in modern times, directly affecting landforms, which in turn more directly affected the distribution of vegetation according to moisture gradients.

Thus, the Pleistocene vegetation reconstructions must consider that permafrost has been one of the key factors affecting the flora composition for hundreds of thousands of years. It is possible that the Late Pleistocene tundra-steppe scenario is directly linked to cryogenic processes of that time.

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The "Mammoth Portal" database as a new global accounting system for the mammoth fauna

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Integration of informational resources into a single, widely shared and free informational database is one of prioritized tasks in biological science in general and paleontology in particular. Unlike general databases developed world-wide in the last three decades that includes the whole content of accumulated collections by single institution (i.e. institutions linked by "Paleontological Portal"), or aimed at single taxa (i.e. Mammal Species of the World (MSW3)), the "Mammoth Portal" offers centralization and unification of the relevant data, and invites institutions and organizations possessing collections of the mammoth fauna, to join the project.

In order to facilitate studies and perform accurate analyses of the Pleistocene mammoth fauna discovered on the territory of Yakutia (Sakha) Republic with further extension to the other countries, the Yakutian Academy of Sciences (Yakutsk, Russia) sponsored development and long-range term maintenance of the multi-level digital database the "Mammoth Portal" (http://mammothportal.com), for registration and inventory of the paleontological objects from the Pliocene and Pleistocene epochs. In its initial design, the "Mammoth Portal" database includes information on sites location and species composition, supplemented with geographical positions and ArcGIS maps, to be gradually expanded into more categories of entry. Sites yielded continental and insular mammoth species alone or together with other faunal elements (including invertebrates) in public domain and/ or associated (accessioned and catalogued) with the public, not-for-profit or state museum or organization, will be of primary interest. The fields of entry are planned to be expanded with available information on geology, stratigraphy and pedology of the sites, isotope data, 2D and 3D images, containing both published and un-published material, contact information of the organizations/ operators and references of relevant publications.

One of the database objectives is to provide free access to and organize the data into standard fields and friendly designed interfaces. Incorporating the HTML, CSS, JavaScript and NodeJS scripts, the system allows implementation of the noSQL and MongoDB programs, and the data optimizations in MapReduce. The architecture application provides functionality that can be extended by writing new modules.

The development of the "Mammoth Portal" database is specifically aiming at unification of mammoth fauna collections data coming from different countries, allowing easy administrative and operator's accesses for entry and updates by participating institutions. The system will have three major users, administrator, operator and guest. Administrator (centered in Yakutsk, Russia) is identified as a user controlling the entry order, storage, data processing and maintenance of the Portal. Operators (participating institutions) are users allowed to edit their accounts, perform data entry and updates, and decision making on the entry fields. Guests are public users with free access and information downloads, but without rights to modify the database entries.

The Mammoth Portal is designed as a not-for-profit and free for participating institutions/organizations project, with appropriate reference to the "Mammoth Portal" in publications. Through free exchange of the information it will create more opportunities for scientists and significantly facilitate collaborative studies of the mammoth fauna and its environment.

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Preliminary results of dietary and environmental reconstructions of Early to Middle Pleistocene Stegodons from the So'a Basin of Flores, Indonesia, based on enamel stable isotope records

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Considered as an oceanic island that was never connected to the Asian continent, Flores has yielded a remarkable Pleistocene insular fossil record of *Stegodon*. Two successive *Stegodon* species extending back to the Early and Middle Pleistocene periods and a subspecies known from Late Pleistocene deposits of Liang Bua cave have been recorded on Flores (van den Bergh et al, 2008). The oldest and smallest is *Stegodon sondaari*, which stood around 0.9 m in height at the shoulders and was found in the oldest fossil-bearing site in So'a Basin in west central Flores, Tangi Talo (>1 Ma). The intermediate-sized *Stegodon florensis* (estimated shoulder height c. 1.9 m) occurs at a number of younger basin localities, including Dozu Dhalu, Mata Menge, Boa Leza and Kobatuwa, among others, which all range in age between 0.88-0.7 Ma (Brumm et al, 2006). *S. florensis* is thought to represent a distinct lineage marking a faunal turn-over on the island around the late Early Pleistocene. The remains of *Stegodon florensis insularis* (estimated shoulder height c. 1.3 m), a younger and smaller subspecies from the *S. florensis* lineage, have been recovered at Liang Bua in association with skeletal and cultural materials attributed to the endemic hominin *Homo floresiensis*.

The aim of our research was to test the hypothesis that adaptation to insular conditions in the generally drier islands of East Indonesia was accompanied by a shift in dietary preferences from C3 to C4 plants. We conducted stable carbon and oxygen isotope composition analysis on tooth enamel samples from Flores and compared them with *S. trigonocephalus* from Java, a continental island that forms part of the Asian mainland and has yielded *Stegodon* fossils from numerous localities ranging in age from late Early to late Middle Pleistocene. The $\delta^{13}C$ of carbonate from fossil enamel reflects the $\delta^{13}C$ of the dominant type of food consumed when the enamel was formed, and is thought not to change after its formation (e.g. Lister 2013). The $\delta^{13}C$ on tooth enamel is thus commonly used to assess whether herbivores had a diet dominated by grass (C4 plants, including most tropical grasses: grazers) or dominated by leafy browse (C3 plant: browsers), or a mixed diet of both types of plants (mixed feeders).

Our analytical sample includes *Stegodon* fossils from two different species and different localities of slightly different ages: *Stegodon sondaari* from Tangi Talo Trenches F and G, and *S. florensis* from excavated contexts at Mata Menge, Boa

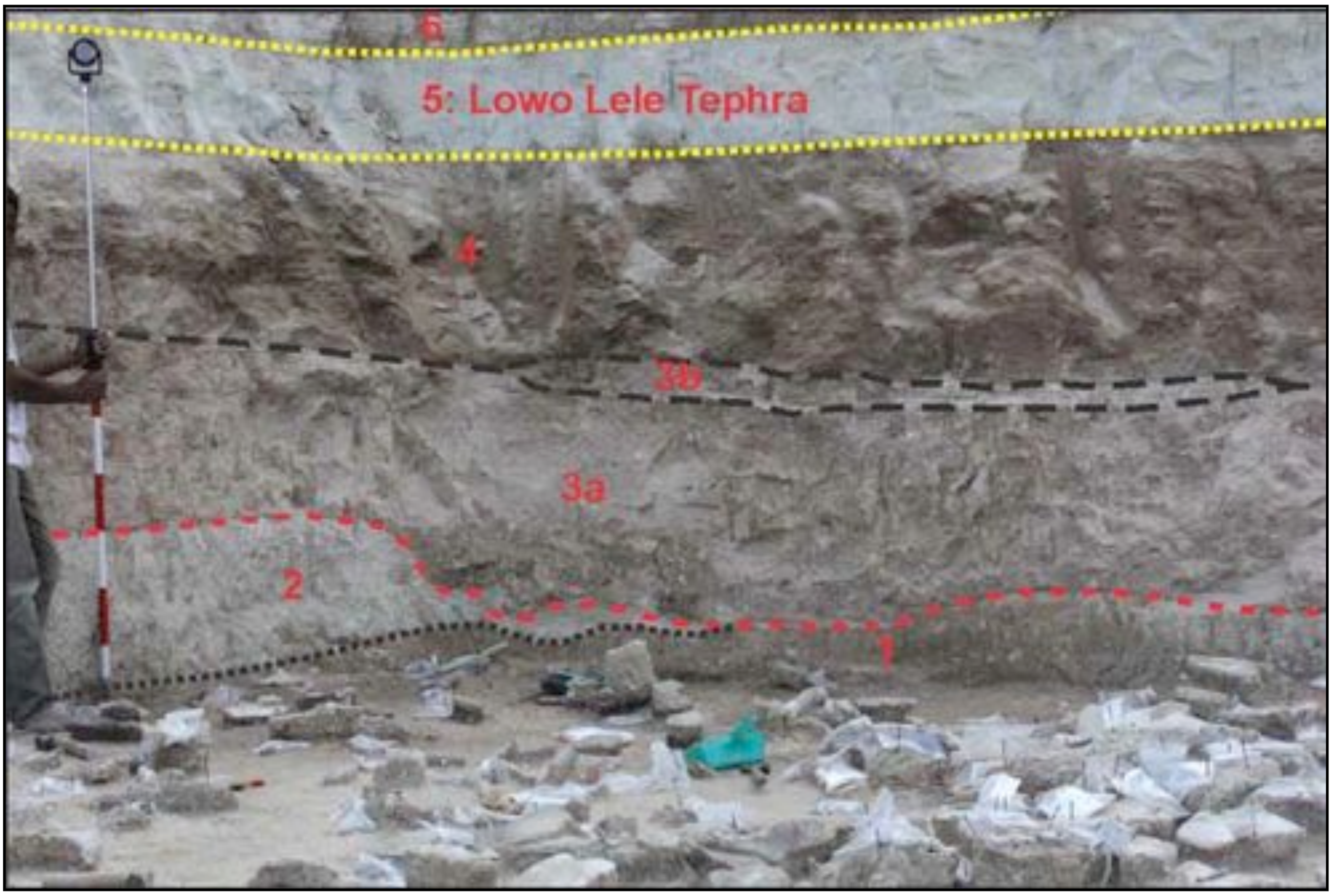

Fig. 1. The 2012 excavation at Tangi Talo (Trench G), showing the main fossil-bearing layer (1) that yielded fossils of giant tortoise, *Stegodon sondaari*, *Varanus komodoensis* and crocodile. The fossil deposit represents a volcanic mudflow or lahar (1), and most fossils have been damaged during or prior to transport. The overlying layers (2-4, 6) are also mudflows, except layer 5, which is a volcanic ash layer.

Leza, Kobatuwa and Dozo Dhalu. For comparison, molar samples of Middle Pleistocene *Stegodon trigonocephalus* from Java (reflecting partly insular, partly continental conditions), were analyzed.

Our preliminary results suggest a significant difference in diet between the successive Flores species: *S. sondaari* was a mixed feeder whereas *S. florensis* had a predominantly C4 diet, with no overlap in $\delta^{13}C$ values between the two. In comparison, the $\delta^{13}C$ values *S. trigonocephalus* from Java overlap with those of *S. florensis*, but have some outliers in the mixed feeder isotope signature, indicating a predominantly C4 plant intake. Considering that the Javanese sample spans a wider time-range, the results suggest that there was no environmental difference between Flores and Java during the Middle Pleistocene, both being dominated by open grasslands, as is confirmed by palynological evidence. The results correspond with increasing aridity during the Southeast Asian Pleistocene as revealed by climatic records from across the region (Birds et al, 2005). A study of a geographically wider area, including Sulawesi, Timor, Sumba, Java and the SE Asia continent, and including both *Stegodon* and *Elephas*, is currently underway.

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"Nativity" in the bone-bearing beds of Bethlehem - taxonomy and taphonomy of the elephant remains

Rivka RABINOVICH ✉, and Adrian LISTER

The bone-bearing beds of Bethlehem (Judean Mountains, Palestine) were excavated by Gardner and Bate in the late 1930s. The history of the excavations reflects political events as well as personal circumstances that impeded the final publication of the site. However, the locality is an important Plio-Pleistocene assemblage of varied faunal components (Bate, 1934; Bate, 1941; Gardner and Bate, 1937). Hooijer (1958) revised the fauna and reported the existence of the following species: *Nyctereutes megamastoides, Homotherium* (?) sp., *Hipparion* sp., *Dicerorhinus etruscus, Sus* cf. *strozzii*, *Giraffa* cf. *camelopardalis*, *Leptobos* sp. nov., *Gazellospira torticornis*. The elephant remains include tusk, mandibles, teeth and some post-cranial elements, identified by Hooijer as *Archidiskodon* cf. *planifrons* (i.e. *Elephas* cf. *planifrons*).

A taxonomic revision of the fauna is in progress, together with an assessment of site taphonomy. Through unpublished archive sources (see Shindler, 2005) we are attempting to reconstruct the nature of the sediments, the history of deposition and the taphonomic history of the faunal components leading to the creation of the "bone-bearing beds". While revising the fauna (at NHM, London) un-described elements and species have been found. Some of the faunal specimens suffered post depositional destruction and are slightly deformed. Thus X-Ray, 3D scanning and isotopic analysis are being used to enhance the description of the elements. The elephant material has been examined in detail and compared morphometrically with both Siwalik *Elephas planifrons* and European *Mammuthus rumanus*.

The age of the locality is a further focus of research, based on both faunal biostratigraphy and the position of the site within regional geology.

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A matter of taste: the probable role of elephant meat in Paleolithic diet preferences

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Taste is essential in human life and has a major impact on food preferences (Drewnowski, 1997). The development of individual flavor perception is linked to human life history and influenced by internal and external preferences (Birch, 1999). Based on the recent discovery of taste-related-genes in a Neanderthal (Lalueza-Fox, et al. 2009) and the assumption that taste preferences are likely to have existed in earlier Paleolithic times also, we believe that this is a potentially useful line of inquiry. Since taste preferences are embedded within social and cultural imprinting, we decided to explore the very long nutritional, cultural and perceptional connection between humans and elephants in the Paleolithic in order to examine the probable role of taste in decision-making regarding elephant procurement and consumption.

Though we are fully aware that modern hunter-gatherers, and modern sport-hunters, cannot serve as a direct analogy to the past; as a starting point we compiled ethnohistorical accounts of elephant consumption from Africa. The aim of this study was to explore the extent to which taste preference could be detected in relation to elephant consumption. We then investigated Paleolithic faunal assemblages that contained elephant remains in an attempt to detect preferences that might have influenced food selection in the deep past.

Palaeolithic nutrition was based on animal meat and fat in addition to plant-based foods. Many Paleolithic sites have extensive evidence for large mammal consumption and big game hunting was a principal procurement strategy. As elephants are present at Paleolithic sites over several hundred thousand years, we have focused on the question of whether elephants were targeted only for the extraordinary amount of meat and fat they supplied (e.g. Ben-Dor, et al. 2011) or whether taste might have also played a role.

Within this context we highlight two examples that hint of a probable role of taste in the selection of elephants for hunting in the Paleolithic: 1. In the case of Ma'anshan site in China, the authors argue that:"*Juveniles were preferred, possibly because adults were too dangerous to hunt. One ethnoarchaeological study reports that the Liangula hunters of east Kenya who hunted elephants for meat, preferred to prey upon juveniles because their meat tasted better. However, adult elephant meat is consumed by a variety of African groups today, so "taste" is not sufficient to explain the difference in prey age selection*" (Zhang, et al. 2010, p. 2076). 2. A research at Middle Paleolithic Spy cave in Belgium suggested that the presence of newborn mammoths indicate selective hunting of young individuals by hominins (Germonpré, et al. 2012). Examples such as these serve as a starting point for our discussion of the probable role of taste in elephant procurement.

Some ethnographic groups such as the aborigines (Australia) do have a taste preference and hunt accordingly, while other groups do not have the liberty of choosing and hunt any available game (O'Dea, et al. 1991; Koster, et al. 2010).

Although elephant hunting today is prohibited, historical texts describe the taste of elephant meat. Christy (1922) explains that elephant meat tastes quite good and yet when cooked over a fire on a stick, it can be very tough; and while elephant is palatable for Africans, outsiders would find the flesh coarse. Other evidence of elephant taste is reported by Selous (1881, p. 50) "*… I tasted elephant's heart, roasted on a forked stick over the ashes, which I thought then, and still consider, to be one of the greatest delicacies that an African hunter is likely to enjoy…*".

As the presence of elephant remains on Paleolithic sites, including elephant bones bearing cut marks and elephant bones broken for marrow extraction, reveals that there is little doubt that Paleolithic diet was at least partially based on calories extracted from megafauna. We used the taste preferences identified in texts related to recent elephant consumption to reconstruct taste-preferred categories (preferred body parts, internal organs, age dependant preferences etc.). We then examined the evidence from Paleolithic sites that contained elephant remains, to explore whether we could identify evidence for any potentially similar pattern. We hope that our attempt will shed light on the significant relationship between humans and elephants in the Paleolithic.

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Dietary traits and resource partitioning in mammoth (*Mammuthus rumanus* and *Mammuthus meridionalis*) and mastodon (*Anancus arvernensis*) in the Early Pleistocene of Europe

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Ungulate tooth mesowear and microwear studies provide valuable proxies for demonstrating the existence of geographical and/or temporal variability in diet and vegetation structure (Rivals et al., 2012; Semprebon et al., 2004a; Semprebon and Rivals, 2010), but also in niche segregation and resource partitioning (Rivals et al., 2010; Rivals et al., 2008).

The objective of this study is (1) to infer the dietary traits of three proboscidean species: *Mammuthus rumanus*, *Mammuthus meridionalis*, and *Anancus arvernensis*, and (2) to investigate any resource partitioning existing between *Mammuthus* and *Anancus* when they co-occur at a locality. We collected and analyzed samples from four European localities where the two genera were present (Figure 1): Red Crag (UK, ca. 2.5 Ma), Norwich Crag (UK, ca. 2.2 Ma), Chilhac (France, ca. 2 Ma) and Oosterschelde (Netherlands, ca. 1.7 Ma).

We used dental microwear analysis to study dietary traits

Fig. 1. Geographic position of the localities sampled: (1) Red Crag, (2) Norwich Crag, (3) Chilhac, and (4) Oosterschelde.

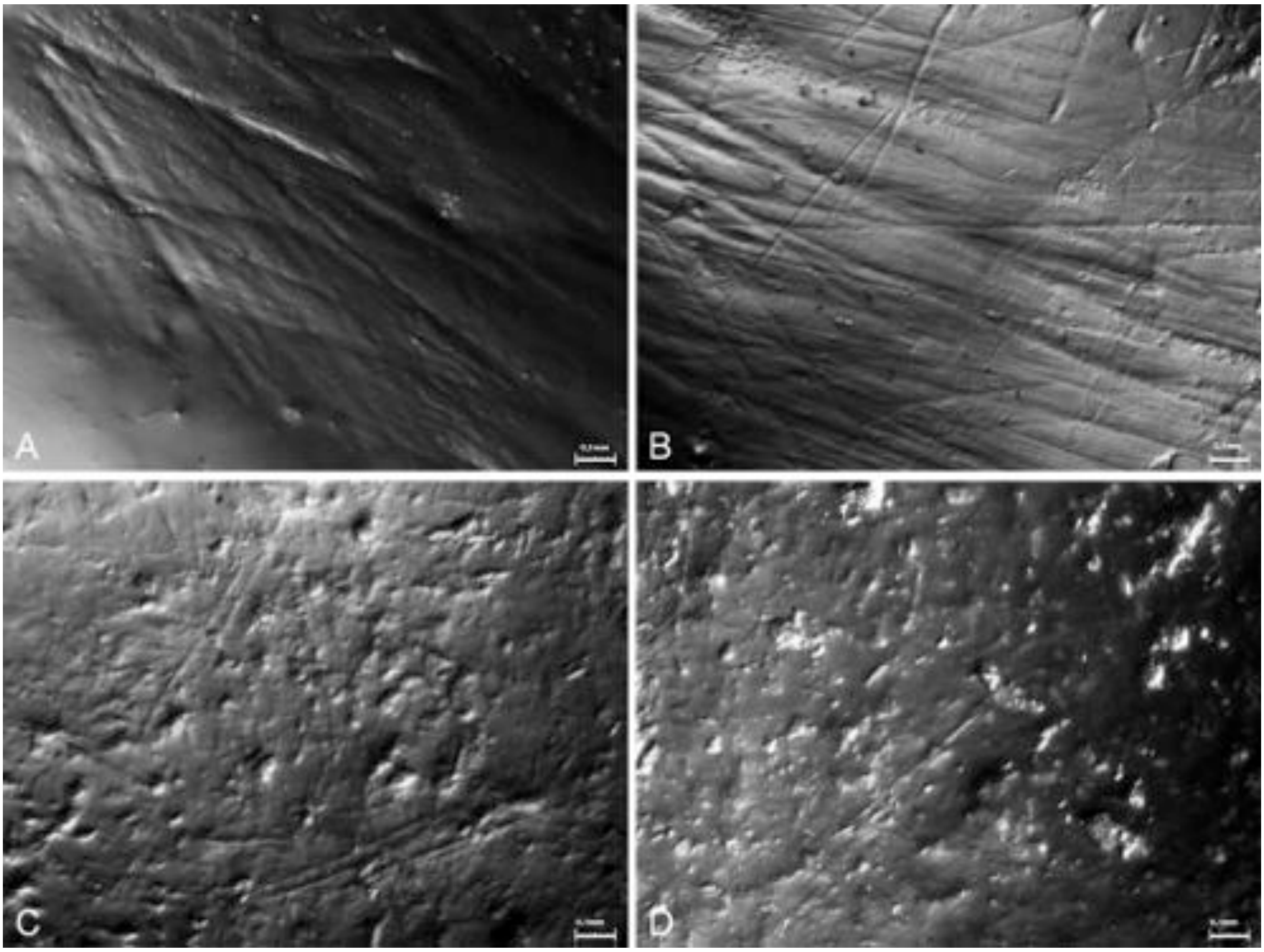

Fig. 2. Microphotographs of selected fossil proboscideans tooth enamel surfaces at 35 times magnification from Chilhac (**A** and **B**) and Red Crag (**C** and **D**). **A**, *Anancus arvernensis* from Chilhac (2011-4-65); **B**, *Mammuthus meridionalis* from Chilhac (2011-4-60); **C**, *Anancus arvernensis* from Red Crag (NHM M9141); **D**, *Mammuthus rumanus* from Red Crag (IPSMG R955-12-11). Scale bar equals 100 µm.

of *Mammuthus* and *Anancus*. Dental microwear patterns mirror the physical properties of food preferences from the last few days or weeks (Teaford and Oyen, 1989; Walker et al., 1978). The microwear analysis was performed following methods described by Solounias and Semprebon (2002) and Semprebon et al. (2004b). Tooth surfaces were cleaned and moulded using dental silicone and used to produce high resolution tooth casts. These casts were used to identify and quantify the microwear features (pits and scratches) at 35× magnification using a stereomicroscope. For the three fossil species, the analysis was made on the central enamel areas of the occlusal surface. The data were compared to a database made of extant wild ungulates, including modern elephants (Solounias and Semprebon, 2002).

The data collected on the samples from Red Crag, Norwich Crag, Chilhac, and Oosterschelde indicate that the diet of the two taxa is highly variable. For both genera, *Mammuthus* and *Anancus*, they range from pure browsing, as at Chilhac, to grass-dominated mixed feeding, as at Norwich Crag. Looking at the traditional microwear variables, such as the numbers of pits and scratches, the two genera display the same microwear pattern at each locality, indicating the use of similar vegetal resources. However, when looking at other microwear variables, such as the presence of large pits or puncture pits, or the scratch width, some differences between species can be detected. Our data suggest that some populations, such as *Anancus arvernensis* from Chilhac or *Mammuthus rumanus* from the Red Crag, also included large proportions of seeds, fruits, or bark in their diet. Consequently even if the broad dietary category for *Anancus* and *Mammuthus* at a given locality is the same, the microwear pattern suggests niche partitioning to avoid direct competition for food resources, as previously observed in some Miocene proboscideans (Calandra et al., 2008).

This study also confirms the importance of taking into account all microwear variables for dietary assessments because the raw numbers of pits and scratches seem to be dominated more by local environment rather than niche-partitioning.

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Age profile of terminal Pleistocene Columbian mammoths (*Mammuthus columbi*) from the Tule Springs fossils beds of Nevada, U.S.A.

Stephen M. ROWLAND ✉

The Tule Springs Fossil Beds are highly fossiliferous, Late Pleistocene deposits adjacent to Las Vegas, in southern Nevada (Wormington and Ellis, 1967). Fossil remains of Columbian mammoths (*Mammuthus columbi*) are especially abundant. One site, on private property owned by Bill Gilcrease, has produced more than one hundred mammoth teeth and fragments of molars and premolars. The abundance of mammoth cheek teeth at the Gilcrease cauldron spring site provides an opportunity to construct an age profile of the local mammoth population.

I selected 46 teeth that are complete enough for the age of the animal to be determined, using the methodology described by Roth and Shoshani (1988) and Haynes (1991). Twenty-six are maxillary teeth, and twenty are mandibular teeth. A minimum of twenty individual animals are represented by these 46 teeth. Radiocarbon dates of a subset of these teeth indicate an age range of at least five thousand years, from approximately 18 ka to approximately 13 ka (Vetter, 2007).

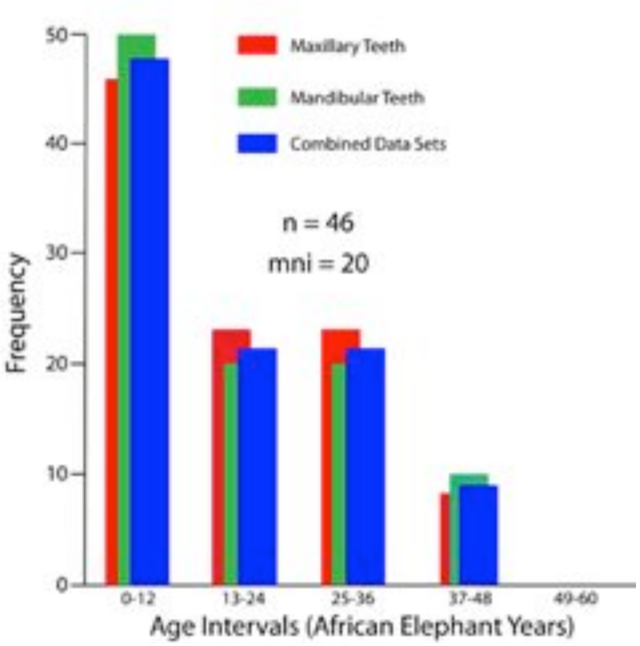

Fig. 1. *Mammuthus columbi* age distribution histogram based on 48 cheek teeth from the Gilcrease cauldron spring site, Tule Springs Fossil Beds of southern Nevada.

As shown in Fig. 1, 48% of the teeth came from juveniles (age 0-12), 22% represent young adults (age 13-24), another 22% represent mature adults (age 25-36), and 9% represent older adults (age 37-48). Age data from maxillary teeth are in close accordance with age data from mandibular teeth. The resulting age profile closely matches Haynes's (1991) 'type A' profile, which is typical of stable or expanding populations in which deaths are time-averaged and non-selective.

These results suggest that between the Last Glacial Maximum and 13 ka the *M. columbi* population in southern Nevada was stable.

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Remarks on new proboscidean remains from the classical Late Miocene locality of Pikermi and their associated fauna

Socrates ROUSSIAKIS ✉, Athanassios ATHANASSIOU, Dimitrios MICHAILIDIS, Vasiliki MITSOPOULOU, Christos SOLOMOS, and George THEODOROU

The fossiliferous locality of Pikermi (Attica, Greece), discovered in 1836, constitutes a reference locality for the Eurasian continental Upper Miocene and specifically for the western part of the Greco-Iranian province. The Pikermi fauna is the product of several excavations carried out mainly during the 19th and early in the 20th century. The most important excavations were those conducted by Albert Gaudry (1855-56 and 1860), Arthur Smith Woodward and Theodor Skoufos (1901) and Othenio Abel (1912), and yielded an abundance of fossils dispersed in several museums all over the world. Following Abel's excavation and for almost 100 years there had been no research activity in the classical Pikermi site.

The fauna of Pikermi is generally correlated to the middle Turolian (MN12). However, as already noticed by early authors, the fossils in Pikermi occur along the ravine of Megalo Rema stream (locally known as Valanaris), on at least two stratigraphic levels. Gaudry (1855; 1862-1867) recorded the presence of two fossiliferous horizons: one at the water level and one slightly higher. Subsequently, Woodward (1901) referred to two or locally three fossiliferous horizons. This is well documented in a photograph by Th. Skoufos published by Abel (1922, fig. 132). However, the exact stratigraphic provenance of the Pikermi fossils is not specified in the relevant museum collections or publications. Consequently, the faunal content of each fossiliferous level is unknown and the famous Pikermi fauna may not represent a homogenous palaeocommunity (Theodorou et al., 2010; 2013).

In 2008 the National and Kapodistrian University of Athens started new research in Pikermi in order to locate new fossiliferous sites. Geological prospecting resulted in the discovery of the new site "Pikermi Valley-1" (PV1). Since 2008 three more fossiliferous sites have been discovered, dubbed PV2–PV4, and systematic excavations are conducted on a yearly basis. The more recent excavation was carried out in September 2013. Until present, the most comprehensively excavated sites are PV1 and PV3 that have yielded a large number of specimens, including some proboscidean remains.

In PV1, where only one fossiliferous horizon has been detected, two isolated proboscidean teeth, a d3 and a d4 (Fig. 1A), have been unearthed. They exhibit zygodont characters and following Konidaris (2013) can be attributed to "*Mammut*" sp. Other taxa preliminarily identified in PV1 are: *Mesopithecus pentelicus, Adcrocuta eximia, Amphimachairodus giganteus*, a medium-sized felid (size of *Metailurus major*), *Promeles palaeatticus, Cremohipparion mediterraneum, Hippotherium brachypus*, Rhinocerotidae indet., *Tragoportax amalthea, Palaeoreas lindermayeri, Protragelaphus skouzesi, Palaeoryx pallasi, Gazella capricornis, Bohlinia attica, Palaeotragus rouenii, Microstonyx major erymanthius, Hystrix primigenia, Testudo* sp. and *Phasianus archiaci*.

The site PV3 has not yet been excavated as extensively as PV1. All collected fossils come from the same fossiliferous horizon. Concerning the proboscideans, we note the presence of *Deinotherium* sp. as indicated by a large-sized second metacarpal with a triangular shaped cross-section at mid-length and a transversely concave distal articular surface. A large-sized scapula with maximal length of about 93 cm (parallel to the spine) could also be attributed to *Deinotherium* sp. as well (Fig. 1B). This specimen is still under preparation and it seems that the scapular spine lacks an acromion and a metacromion, as in *Deinotherium* (Harris, 1978). We also note the discovery of an almost complete still unidentified proboscidean femur. The preliminary faunal list of PV3 includes *Amphimachairodus*

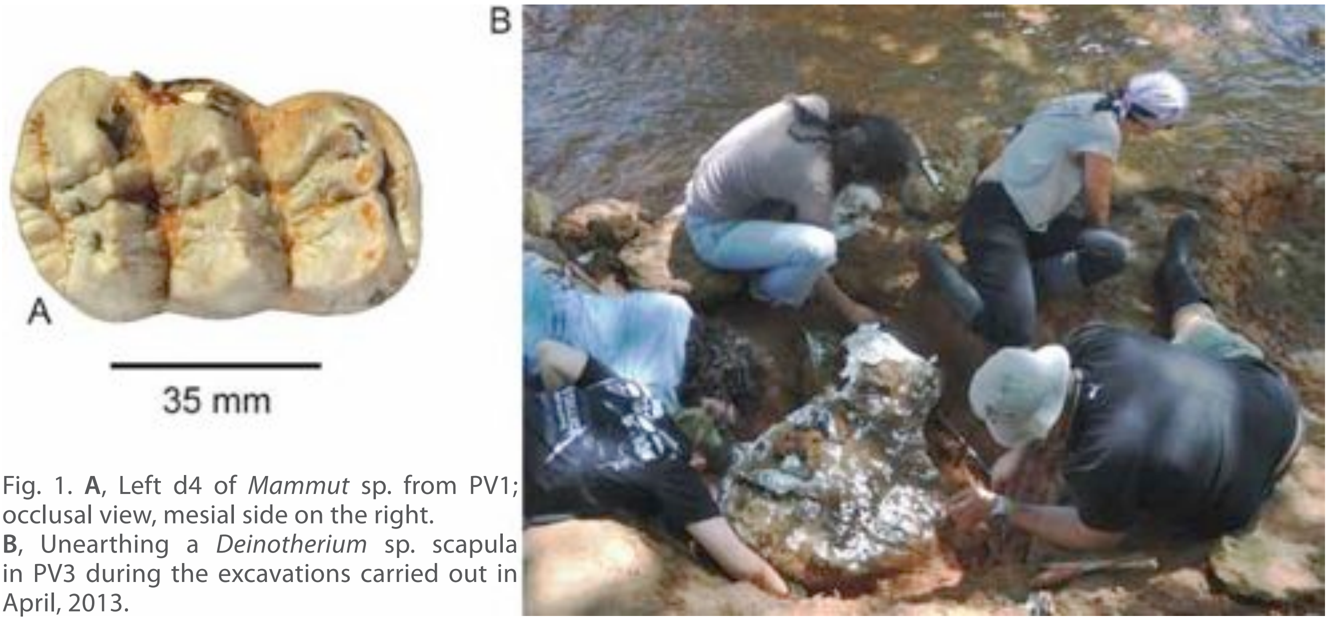

Fig. 1. **A**, Left d4 of *Mammut* sp. from PV1; occlusal view, mesial side on the right.
B, Unearthing a *Deinotherium* sp. scapula in PV3 during the excavations carried out in April, 2013.

giganteus, Cremohipparion mediterraneum, Hippotherium brachypus, Dihoplus pikermiensis, Ancylotherium pentelicum, Tragoportax amalthea, Miotragocerus valenciennesi, Palaeoreas lindermayeri, Gazella capricornis, Helladotherium duvernoyi, Bohlinia attica, Microstonyx major erymanthius, and ?*Gyps* sp.

The geographical position of PV3 matches the alleged location excavated by Albert Gaudry. The newly collected fossils come from a single fossiliferous horizon situated in the stream bed and/or the right bank of the Megalo Rema stream. This level corresponds to the lower fossiliferous horizon mentioned by Gaudry (1855; 1862-67). The presence of an upper horizon was confirmed during the excavation carried out in September 2013, when fossils were spotted about 2 m above the current water level of the stream. PV1 site is about 500 m east-southeast of PV3. The fossils collected also come from a single fossiliferous horizon, at or slightly above the water level, which quite probably corresponds to the lower level of PV1. However, a direct stratigraphic correlation with PV3 is not possible at the moment as the intervening sections along the Megalo Rema ravine are interrupted by agricultural activities.

The new research carried out in Pikermi has revealed a significant faunal assemblage. The collection of taphonomical data concerning the stratigraphic provenance of the specimens can provide new information that would help clarify the local stratigraphy and improve the correlation between Pikermi and other similar faunas (e.g. Kerassia, Samos, Axios Valley).

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Landscapes of the 'Yuka' Mammoth habitat: a paleobotanical approach

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Valery PLOTNIKOV, and Snezhana ZHILICH**

In August 2010, a well-preserved woolly mammoth carcass was found along the Oyogos Yar coast (Fig. 1A,D) in the region of the Laptev Sea. The juvenile female mummy was nicknamed 'Yuka' after the name of the village of Yukagir, whose local people discovered it. The mammoth carcass was found hanging over a melting ledge in the upper third of a north-facing slope composed of loess sediments from the rich Late Pleistocene fossil-bearing Yedoma. By analysing the teeth and tusks, Yuka was determined to be approximately 6–8 years old when it died (Maschenko et al., 2012). The mammoth had most likely been attacked by lions or other predators. However, there were no indications that the predators had killed the mammoth. A 40-cm incision was found in the lumbar region and appears to have been made by a sharp implement. Most of the internal organs were missing. The skull, pelvis, ribs and several other bones had also been removed and were placed alongside the carcass. A fragment of Yuka's rib was AMS-dated to 34,300+260/-240 14C (GrA-53289), which corresponds to the termination of the MIS3. The onset, duration, and termination of the MIS3 Interstadial optimum based on paleoproxies vary in the Eastern Siberian Arctic in different records (see review in Wetterich et al., 2014), however, its limits can be identified as 44–32 kyr BP.

Two frozen sediment samples from the area of the skull condyles were collected for pollen and plant macrofossil analyses. This was the only place to obtain the samples, since the Yukagirs washed all the mammoth remains, including the gut, with water from a pump. Pollen sample was thawed, dried, and sieved through a 250-

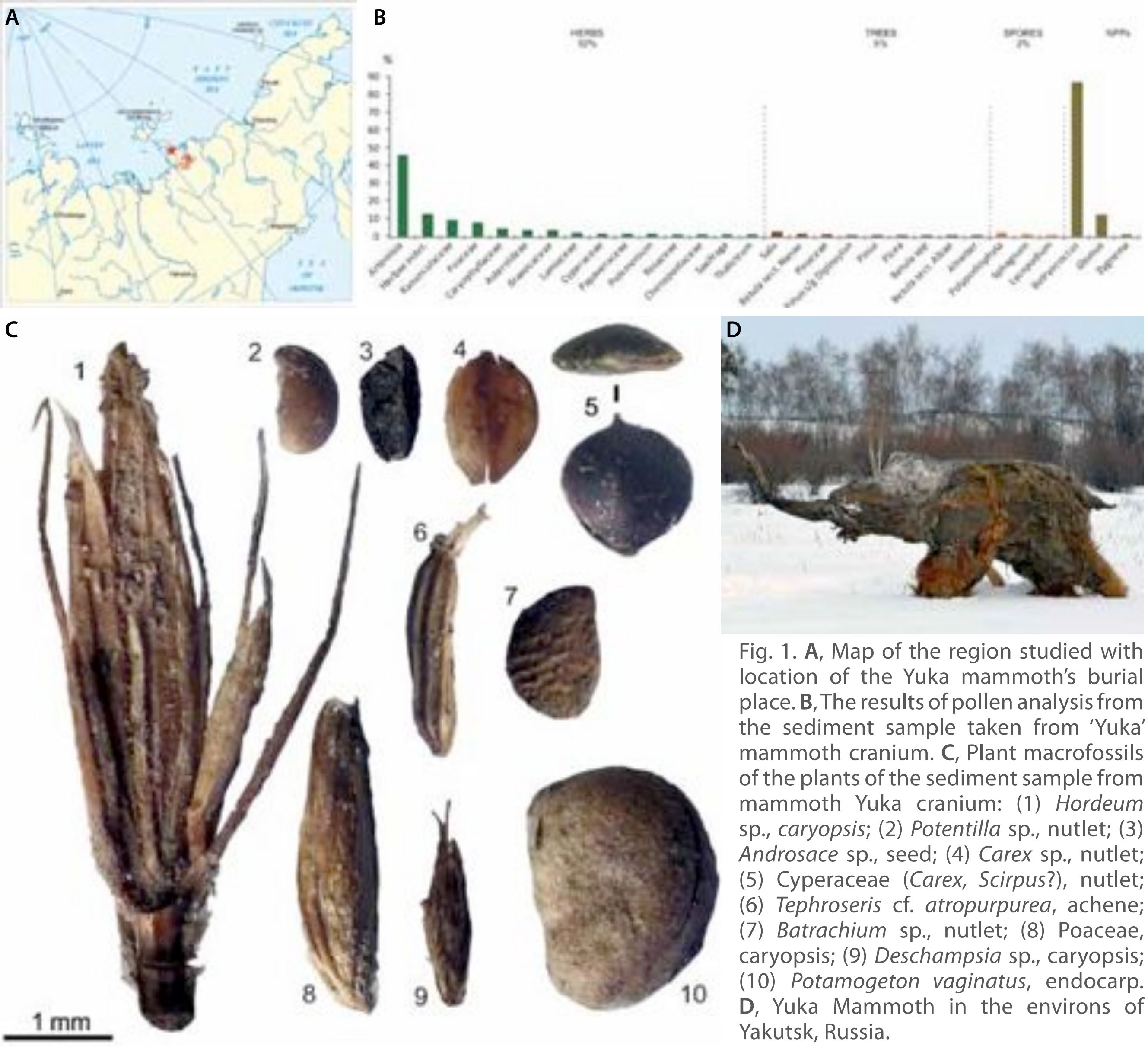

Fig. 1. **A**, Map of the region studied with location of the Yuka mammoth's burial place. **B**, The results of pollen analysis from the sediment sample taken from 'Yuka' mammoth cranium. **C**, Plant macrofossils of the plants of the sediment sample from mammoth Yuka cranium: (1) *Hordeum* sp., *caryopsis*; (2) *Potentilla* sp., nutlet; (3) *Androsace* sp., seed; (4) *Carex* sp., nutlet; (5) Cyperaceae (*Carex, Scirpus*?), nutlet; (6) *Tephroseris* cf. *atropurpurea*, achene; (7) *Batrachium* sp., nutlet; (8) Poaceae, caryopsis; (9) *Deschampsia* sp., caryopsis; (10) *Potamogeton vaginatus*, endocarp. **D**, Yuka Mammoth in the environs of Yakutsk, Russia.

µm mesh to remove coarse organic matter, which was later used for plant macrofossil analysis. The sample was treated using standard procedure (Faegri and Iversen, 1989). A total of 329 pollen grains and spores, which were taken as 100% for determining percentages of pollen taxa, were counted in the sample. The total number of palynomorphs, including the NPPs was 481. The total number of NPPs was taken as 100% when calculating the percentages of individual NPPs. The plant macrofossil sample was washed through a 250-µm mesh sieve and then air-dried. A total of 40 ml dry matter was examined and subjected to analysis using a Carl Zeiss Stemi 2000-C stereomicroscope.

In total, 25 taxa of pollen and spores were identified in the sample. Herbaceous taxa (92%) dominated the pollen spectrum with 6% of the pollen originating from trees (Fig. 1B). Among herbs, *Artemisia* pollen dominated (46%), together with indeterminable forb pollen (12.5%), and pollen from the Ranunculaceae, Poaceae, Caryophyllaceae, Asteraceae, and Brassicaceae. Plant macrofossils included 12 taxa (Fig. 1C). Seeds belonged to *Potamogeton vaginatus* (one endocarp); *Deschampsia* sp. (one caryopsis), *Hordeum* sp. (one caryopsis), Poaceae sp. (one caryopsis); *Carex* spp. (seven fragments of nutlets), Cyperaceae (*Carex, Scirpus*?) (one nutlet), *Potentilla* sp. (three nutlets); *Ranunculus* sp. (one fragment of nutlet), *Batrachium* sp. (one nutlet); *Androsace* sp. (one seed); Caryophyllaceae (one seed); *Tephroseris* cf. *atropurpurea* (one achene).

The vegetation of the MIS3 optimum became mosaic and the earlier-prevailing tundra-steppe was combined with willow shrubs or relatively mesophytic communities that were spread throughout protected and wet places (Andreev et al, 2011). Paleobotanical data obtained in this study represent two sets of taxa (macro- and microfossils); whereas macrofossils more reflect the local vegetation in the burial place of the Yuka mammoth, the pollen spectrum mainly reflects the regional vegetation. In general, macrofossil plant remains are characteristic of the herbaceous taxa that are widespread on the modern Yakutian tundra. However, seeds of *Potamogeton vaginatus* and *Batrachium* sp. as well as remnants of ostracod shells and ephippia of *Daphnia* reflect the existence of small freshwater ponds with stagnant or slowly moving water exactly at the site where the mammoth carcass was found. Except for aquatic and wet-site plants, the macrofossil spectrum includes steppe elements such as Caryophyllaceae and *Potentilla* sp. The type of vegetation, including these macrofossils, resembles the plant community that is relic today, and persisted in various parts of Metaberingia (Yurtzev, 2001). It is so called 'mesic-xeric meadows enriched with steppe elements' which are sometimes zoogenic and have a sparse canopy of shrubs. This conclusion is confirmed by pollen data. Despite the dominance in the pollen spectrum of *Artemisia*, the Ranunculaceae and Poaceae are highly abundant; the percentages of *Salix* and *Betula* sect. *Nanae* are also significant and are the most common arboreal taxa.

The pollen spectrum from the sample studied is generally typical of pollen spectra from the late Kargin records of the Eastern Siberian Arctic. Six leading taxa in the spectra are Artemisia, the Ranunculaceae, Poaceae, Caryophyllaceae, Asteraceae, and Brassicaceae. Five taxa (excluding Ranunculaceae) might characterise steppe-like vegetation and we suggest that it is a regional (zonal) feature. However, the percentage of *Artemisia* (46%) is significantly higher than in contemporary pollen records from North Yakutia (e.g., in Bol'shoy Lyakhovsky Island it is up to 4% (Wetterich et al., 2014) and Kurungnakh Island and Bykovsky Peninsula it is up to 10% (Andreev et al., 2011). The over-represention of *Artemisia* might be explained by the existence of disturbed soils close to the studied site, where wormwoods grew as weeds.

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Earliest elephantid remains from the Late Miocene locality, Nakali, Kenya

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The family Elephantidae, which includes three genera *Loxodonta*, *Elephas* and *Mammuthus*, has been considered to be of African origin. However, the materials directly relating to the African origin of the elephantids have been represented only by three materials, a cranial fragment of a fairly derived tetralophodont from the late Miocene Namurungule Formation (ca. 9.3-9.6Ma) from Kenya (Nakaya et al., 1984) and two elephantid remains, a M3 of from the late Miocene Karara Formation of Uganda (Tassy, 1994) and a m3 from the Chorora Formation of Ethiopia (Geraads et al., 2002).

Recently, the Nakali Formation (ca. 9.7-9.9 Ma) of Kenya has yielded four pieces of the cheek teeth of an earliest elephant (dp2, p4, m1or 2, M3). They exhibit primitive characters comparable to those of the tetralophodont gomphotheres but at the same time share several derived features with later elephantids. In dp2, the second lophid is plate-like with hypo-, and entoconid connected to each other by mesoconelets. The p4 is similar to that of Tetralophodon longirostris but differs from the latter in the absence of cprp1, thinner enamel layer and stronger development of the distal cingulum. The anterior fragment of M3 is similar to the corresponding part of a M3 (KI 64' 92) from Karara Formation, which has been described as "Elephantidae, forme primitive, gen. et sp. incertae sedis" by Tassy (1994), though the former differs from the latter in greater anteroposterior width of the ridges. A fragment of a m2 or m1 is composed only of distal two ridges and distal cingulum, but it exhibits two derived elephantid features: the pret- and posttrite worn almost equally and ridges relatively thin.

The m3 of an earliest elephant from the Chorora Formation is smaller than those of the Nakali elephant and appears not conspecific with the latter. A tetralophodont from the late Miocene Namurungule Formation exhibits a fairly steep eruption angle of the cheek teeth and its close relation to the elephants has been argued (e.g., Tassy, 1999). However, geologically older Nakali elephantid lacks the secondary trefoil and shares more derived characters with later elephantids than the geologically younger tetralophodont from the Namurungule Formation. Tassy (1996) suggested the similarity between the earliest elephants and *Tetralophodon atticus* from the Pikermi of Greece, but the latter exhibits the secondary trefoil which does not developed in geologically older Nakali elephantids. Derived features seen in those derived tetralophodonts could be convergent characters rather than synapomorphy .

The same holds true for the stegodonts that share many derived characters with the elephants. The loph(id) structure of the cheek teeth of the earliest elephants from Nakali, Karara and Chorora is similar to those of *Tetralophodon longirostris* rather than *Stegolophodon*, suggesting that the elephantids have been derived from the advanced tetralophonts in Africa. If this is the case, the derived dentognathic features shared by the stegodonts and the elephants are convergent or parallel characters rather than synapomorphy.

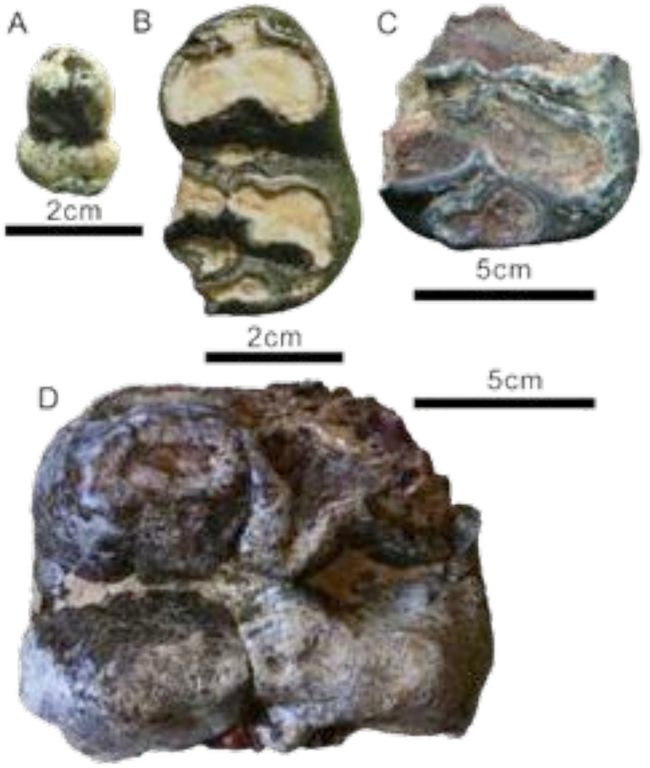

Fig. 1. Occlusal views of cheek teeth of Nakali elephantid. **A**, left dp2; **B**, right p4; **C**, distal fragment of right m1 or m2; **D**, mesial fragment of right M3.

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Proboscidean fossil fauna from the Siwalik Hills of Pakistan

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Proboscidean remains belonging to four species of the family Elephantidae, *Elephas namadicus, Elephas planifrons, Stegodon bombifrons* and *Stegolophodon cautleyi* from Siwalik Hills of Pakistan (Barry et al., 1982; Dennell et al., 2006) are described and discussed here. The material comes from the Siwalik localities of Sardhok (Gujrat District, Punjab, Pakistan), Jari Kas, Mirpur, AJK and Khural sharif, Near Dina (District Jhelum, Punjab, Pakistan), and Padri outcrops of the Dhok Pathan Formation (Middle Siwaliks) and comprises upper and lower teeth, a fragmentary cranium with right and left maxillary molars, a mandible having a right M3 and a completely eroded left molar. The main aim of this study is to provide credentials, comparison and morphometric analysis of collected Proboscidean remains from the Siwalik Hills of Pakistan.

Elephas planifrons, regarded as the most primitive species of its genus, is present in all zones of upper Siwalik and it is a characterisitic proboscidean of the Pinjor, Tatrot (Lewis, 1937; Hooijer, 1955) and Boulder Conglomerate Formations (Shah, 1980). The first occurrence of *Elephas planifrons* is dated at 5.9 Ma (Barry et al., 2002). An upper left third molar of *Elephas planifrons*, (PUPC 2010/12; Fig.1A, B) recovered from Pinjor formation of Sardhok, Gujrat distict, Pakistan is finely preserved with moderately broad ridge plates. The central part of the tooth is the widest with gentle anterior and posterior tapering. The ridge plates are widely spaced. Which assume that the worn away portion probably consisted of two ridge plates. The enamel loop is complete in the last four preserved ridge plates but slightly incomplete in the third and fourth preserved ridge plates. The enamel layer is quite simple. The penultimate ridge plate shows five conelets all of which are still maintaining their identity. As the tooth is much worn, its precise height cannot be given however, it appears to be subhypsodont.

Elephas namadicus is present in the Eurasia from Middle to Late Pleistocene (Maglio 1973). An, upper left second molar (PUPC 2010/10; Fig. 1 C, D) of this species is recovered from Pinjor formation of Sardhok, Gujrat distict, Pakistan. PUPC 2010/10 is half worn, finely preserved, subhypsodont and extremely broad. A clear retroflection in 3rd to 6th ridge can be observed on both sides while other plates are more regular and oval in shape. The enamel is thin and finely crenulated with many folds, especially in the middle where the folds on both sides are very marked. There is no indication for the presence of pre or post sinus in any ridge plate. The ridge plates are much compressed anteroposteriorly. Cement is abundantly developed. All ridges distinctly bent backward and anterior enamel walls of posterior ridges is more broadly exposed than posterior enamel walls.

The family Stegodontidae has its origin in the Early Miocene of Asia known by two genera, *Stegodon* and *Stegolophodon* (Saegusa, 2001). The earliest chronological record of the

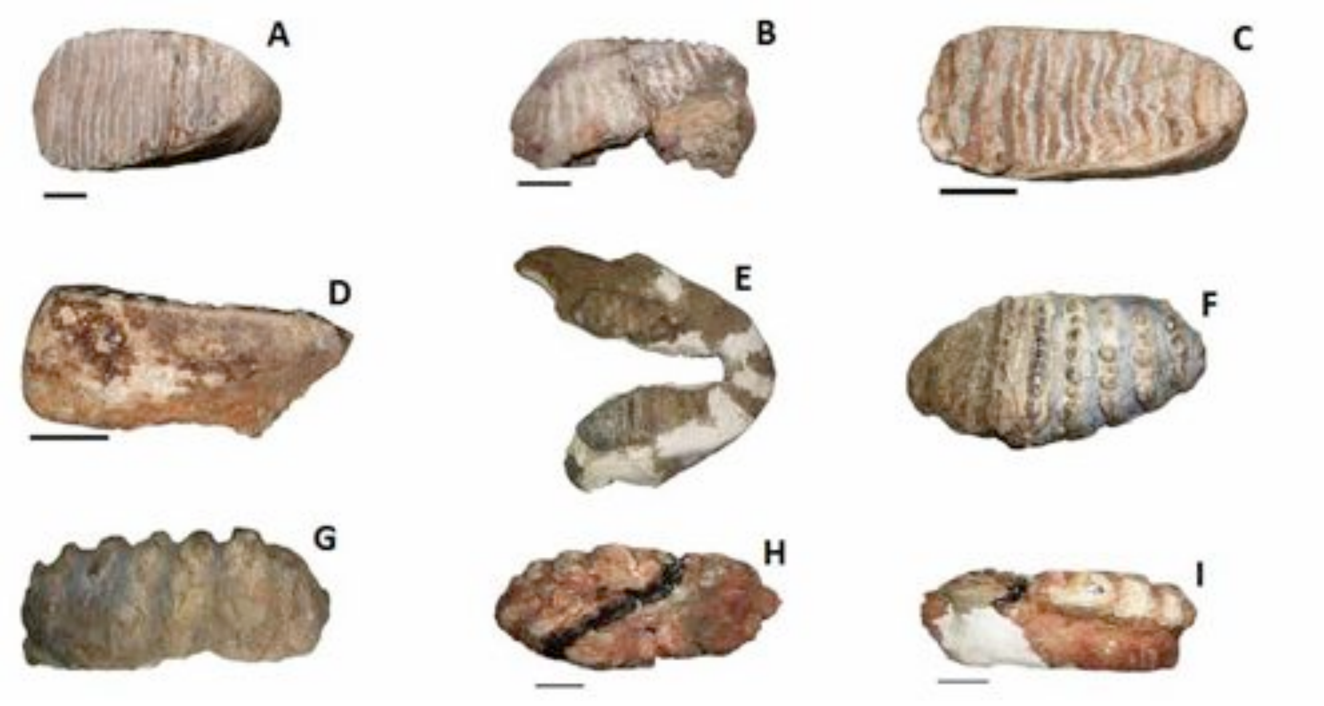

Fig. 1. *Elephas planifrons*: PUPC 2010/12, upper left third molar, **A**, Crown view, **B**, Lateral view. *Elephas namadicus*: PUPC 2010/10, upper left second molar, **C**, Crown view, **D**, Lateral view (scale bar is 50 mm). *Stegodon bombifrons*: PUPC 2010/18, **E**, Occlusal view of the mandible of studied specimen, **F**, Occlusal view of the right M_3, **G**, Lateral view of the right M_3. *Stegolophodon cautley*: PUPC 09/13, a preserved upper third molar, **H**, Occlusal view, **I**, Lateral view (Scale bar 20 mm).

genus *Stegodon* is from the lower Pliocene of Pakistan. A mandible of *Stegodon bombifrons*, (PUPC 2010/18; Fig. 1 E, F & G) is quite robust and gigantic. The ascending ramus is much wider anteroposteriorly in the coronoidal region. The maximum preserved anteroposterior length of right mandible is 402 mm left mandible is 505 mm and maximum preserved transverse width of right mandible is 172 mm while left mandible is 160 mm. The brachydont third molar in early wear stage has thick enamel, broad crown and ten ridge-plates which are widely spaced at their summits.

A preserved upper third molar (PUPC 09/13; Figure 1 H, I), from Padri (Dhok Pathan Formation), district Jhelum, belongs to *Stegolophodon cautleyi*. The tooth is poorly preserved and narrow crowned, brachyodont with only two preserved ridge-plates. The ridge-plates are closely spaced with inconspicuous intermediate valleys. Only trace amount of cement is present. The enamel is thick, smooth and simple. The roots are also nicely preserved.

The biochronologic and geographic expansion of each species will be discussed in detail.

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Palaeoloxodon exploitation in the late Middle Pleistocene site of Polledrara di Cecanibbio (Rome, Italy)

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The site of Polledrara di Cecanibbio, located on the slopes of the Sabatino volcanic complex NW of Rome, is included within the fluvio-palustrine sediments of the depositional sequence of Ponte Galeria (PG6) and is correlated to MIS 9 (Anzidei et al., 2004, 2012). The site underwent extensive excavations since 1985 (Anzidei et al., 1989); nowadays takes part of a protected area and is accessible to the public.

Two main phases in the formation of the site have been recognized: the older one is represented by a fluvial episode characterized by an irregular ancient riverbed, with alternating raised and depressed areas. At the bottom there are bones that have been transported and deposited according to the strength of the flow; such bones belong mainly to *Palaeoloxodon antiquus* (Palombo et al., 2003) and *Bos primigenius*. In the later phase the river became progressively more marshy leading to the formation of swampy areas with muddy pools where some elephants were trapped as documented by the presence of two individuals whose zeugopodia and autopodia are still in living position.

In the sector that is presently being excavated an almost complete articulated skeleton of *Palaeoloxodon* was discovered; its carcass had been exploited by humans. More recently, in the same area and close to the paleosurface, seven cervical vertebras and some long bones belonging to a second adult individual have been recovered. Taphonomic analysis on these bones exclude any fluvial transport.

In the articulated skeleton, the outstanding specimen is the skull, surrounded by lithic implements, with the penultimate and ultimate molariform teeth in wear. The skull has been found in anatomical connection with the mandible, while the left stylohyoideum is slightly displaced but close to it. Most of the postcranial bones of this individual are present, thought those of axial skeleton only consist of four cervical vertebrae and a thoracic vertebra, scattered few meters far from the skull. Bones of the appendicular skeleton are well preserved and mostly found in anatomical connection. In the fore limbs the right humerus is missing as well as both scapulae. As regards the hind limbs, both right and left distal part of femurs, a right broken caput femoris, patellae, tibias, fibulae, and tarsal bones were found. Both feet are complete, being the sesamoid bones also preserved. The elephant carcass belongs to an adult individual, about 40 years old as indicated by the wear stage of the molars and by the degree of long bone ossification. It lies with the posterior limbs slightly folded towards the bottom.

This context, exceptionally well-preserved due also to the features of the sediment, allows reconstructing the position of the animal at its death as well as hypothesizing the dynamics of how it became mired. The presence of more than five hundred lithic implements (cores, tools, flakes, working debris), documents also human activity related to the exploitation of the carcass by scavenging; such evidence is proved mainly by the wear traces detected on some tools used on soft animal tissues. The lithic industry, on small flint pebbles, was produced at the site as evidenced by the refitting and by the presence of working debris indicating very simple reduction chains. It is also worth mentioning the presence of some blocks of effusive rocks (leucitite) transported there by humans; they may be related to the fragmentation of the bones of the carcass. In fact, there are numerous bone fragments and flakes with an extremely fresh appearance that in some cases have been refitted together; it has been recently assumed that some of these may have been occasionally used as tools.

Ongoing research include, among others, isotopic study of the volcanoclastic sediments, K-Ar and ESR - U/Th datings, as well as some chemical analyses devoted to a better understanding of fossilization processes and to recognize the causal factors producing surface alterations on exposed bones, in order to indicate methodologies suitable for an optimal in situ preservation of vertebrate specimens.

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Locomotory adaptations in the astralagus-calcaneus of Siculo-Maltese dwarf elephants

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Insular endemic proboscideans, due to the range in body mass changes and diverse insular environments which they became adapted to, represent a unique taxon for investigating the evolutionary processes and mechanisms which large mammals undergo in response to the biotic/abiotic characteristics of island ecosystems. Of particular interest are the Pleistocene insular elephants from the Siculo-Maltese (palaeo)archipelago which evolved highly derived morphologies with respect to their putative mainland ancestor *Palaeoloxodon antiquus* (Palombo, 1996; 2007; van der Geer et al., 2010; Herridge, 2010), and also display a very diverse range in body mass.

Here we examine locomotory adaptations in Siculo-Maltese dwarf elephants, with a particular emphasis on the smallest elephant *Palaeoloxodon 'falconeri'*, from Spinagallo Cave (Hyblean Plateau, southeastern Sicily) (Ambrosetti, 1968) as inferred from the morphology of the astralagus and calcaneus (51 and 52 specimens respectively, representing all ontogenetic stages). We investigate the relative significance of the different factors which likely contributed (whether directly or indirectly) to the evolution of the hind-foot's locomotor function, including steeper topography in a more confined and resource-limited area, a reduction in body mass and rockier substrate, and the combined effects of the absence of both predators and competitors (ecological release, see Palombo, 2007; Lomolino et al. 2012).

Of particular interest in *P. 'falconeri'* is the presence of a large, continuous articular facet for the tibia-fibula on the calcaneus, which likely evolved in concert with the synostosis of the tibia and fibula, present in nearly all specimens including young individuals. The functional significance of the articular facet for the tibia-fibula likely included i) an increased range of plantar/dorsiflexion of the hind-foot, possibly beneficial for climbing steep gradients by providing more upslope leverage, ii) a more secure braking mechanism for walking downslope, iii) a shift in body mass towards the lateral side of the hind-foot, iv) a shift in body mass posteriorly, and v) synostosis between the tibia and fibula, resulting in a combined articular facet for both.

Furthermore, if the suggestion that *P. 'falconeri'* is more cursorial than its putative ancestor is correct (see Palombo, 2003), it would be consistent with the medio-laterally constrained and more sagitally-oriented locomotion observed in *P. 'falconeri'*, which is typical for cursorial quadrupeds (Biewener, 2003); as well as the observation that quadrupeds with a mass of ~300 kg or more are required to sacrifice much of their cursorial performance to the demands of support (Biewener, 1989; 1990). Since *P. 'falconeri'* from Spinagallo Cave did not exceed 150 kg in adult males (Palombo and Giovinazzo, 2005), a reduction in body mass was likely a significant factor in the evolution of its locomotion. All considered, morphological evidence from the astragalus-calcaneus suggest several highly derived adaptations to the hilly landscape of Sicily. Ongoing research into the appendicular anatomy of Siculo-Maltese dwarf elephants will also help to address the question as to what extent differences observed in foot bones might support a new taxonomic assessment (Scarborough, in prep.).

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The rhinoceroses of the genus *Elasmotherium* in the biochronology of Eastern Europe

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The associations of large mammals, combined by V. I. Gromov (1948) in the faunistic complexes, are used for the stratigraphy of Pleistocene continental sediments of Eastern Europe. In their characterization Gromov and his followers pay special attention to the chronospecies / subspecies of the elephants of mammoth line. Along with other animals the representatives of genus *Elasmotherium* are also important elements for the paleontological characterization of the faunistic complexes. Modern level of knowledge allows us to offer the representatives of genus *Elasmotherium* as the guiding forms in mammalian biochronology of Eastern Europe, because all species have a clear diagnostic features, they lived in a very short time, as well every species of elasmoteriums corresponds only with one biozone of the elephants of mammoth line.

The interval of existence of genus *Elasmotherium* in Eastern Europe contains approximately 2.5 million years. They appear in the early Pleistocene and disappear in the Middle Pleistocene in the epoch of the development of maximum Dnieper glaciation. The evolution of elasmoteriums was directed towards improving the dental system and organs of locomotion in the direction of adaptation to the rapid running in the open landscapes and to the nutrition of tough plant food. The development of dental system is reflected in the reduction of incisors, canines, in the reduction the amount premolars, in increase of the length of the series of molars, in complication of the folds of the enamel, in the development absolute hypsodontia. Improving of the locomotion ensured of the overall limb lengthening, especially their distal departments. Four stages of speciation can be clearly seen in the evolution of elasmotheriums.

The earliest representative of the elasmoteriums *Elasmotherium chaprovicum* Shvyreva is fixed in the composition of the haprovsky faunistic assemblage in the whereabouts in the North Caucasus and Moldova. The elasmoteriums of that time are characterized by the relative massiveness, they have a low talus with a narrow trochlea of talus and with a wide distal portion, massive metapodiums. Their teeth have the thick rough enamel with irregular folding. The haprovsky faunistic complex corresponds to the biochron of the archaic elephant *Archidiskodon meridionalis gromovi*. Constancy finds of *Elasmotherium chaprovicum* Shvyreva with *Archidiskodon meridionalis gromovi* in the whereabouts of the haprovsky faunistic assemblage give reason to think *Elasmotherium chaprovicum* as the chronospecies of this complex. The taxonomic composition of the haprovsky fauna has a resemblance with faunas of the middle Villafranchian of Italy. (Vangengeim & Zazhigin, 1982). The interval of existence of the haprovsky complex of mammals can limit 2.6 - 2.2 million years ago.

The psekupsky faunistic complex is known from many whereabouts of the Northern Black Sea, Moldova, Northern Caucasus. This complex corresponds to the biozone *Archidiskodon meridionalis meridionalis*. In whereabouts of the psekupsky faunistic complex *Elasmotherium peii* Chow is found in combination with the southern elephant, close to the typical form of the Upper Valdarno in Italy. Its teeth have early closure of the roots, the prolonged existence open of posterior hollow (postfossette), the presence of the collar on the back wall of the tooth, a strong deflexion back of transversal protolof and metalof, a clear differentiation of the crown and roots. The interval of development of the psekupsky complex is 2,2 - 1,1 million years ago. Fauna of this type corresponds to the stages of development of faunas Tasso and Olivola of Upper Villafranchian from Italy (Azzaroli, 1977; Vangengeim etc, 1990).

According to faunal data the age limit of the Taman fauna is limited by biozone of progressive southern elephant *Archidiskodon meridionalis tamanensis*. The characteristic form of this complex is *Elasmotherium caucasicum* Boriss. Compared with the more ancient forms the teeth of *Elasmotherium caucasicum* lose a collar, have more pronounced prismatic shape, as well later closure of the pulp and of posterior hollow (postfossette), disorderly growth and greater tortuosity of enamel. Judging by the size of the teeth and astragalus, *Elasmotherium caucasicum* inherited the large size of his ancestors.

However, among researchers there is still no consensus on the exact geological age of the Taman faunistic complex. According to E.A. Vangengeim etc (1991), the time interval of its development is 1.1 - 0.8 million years. The probable analogues of the Taman fauna are Western transitional faunas between Villafranchian and Galerian by scheme of A. Azzaroli (Azzaroli, 1983).

Several researchers (Titov etc, 2012) offer to lower the lower boundary of the Taman faunistic complex by the composition of rodents and determine its age limits 1.55 - 0.85 million years. It corresponds to the second half of the Late Villafranchian and most part of Biharian (with *Allophaiomys pliocaenicus*).

Stratotype of the Tiraspol faunistic complex is located in the outskirts of the town of Tiraspol (Kolkotova Balka). The chronospecies of this complex is the elephant *Mammuthus trogontherii* (= *Elephas wüsti*). In whereabouts of the Tiraspol fauna in Eastern Europe, coeval with typal, it is usual the large form *Elasmotherium sibiricum* Fischer. This elasmoterium detects a reduction dental formula by reducing the amount of premolars Its molars despite the great wear have the open roots. The enamel of the upper and the lower teeth gets thinner and acquire strong folding. For this type it is typical of the early closure and disappearance of posterior hollow (postfossette). All teeth have a slightly curved shape of the prism, differentiation of the crown and the root can not be traced. Time of the

Tiraspol complex is estimated interval 0.8 - 0.4 million years. Approximate analogy of Tiraspol fauna is considered faunas of the Galerian Italy.

The singilsky faunistic complex is included in the stratigraphic scale of the Eastern Paratethys in the 60-ies of the 20th century. It was highlighted between layers of Baku and of the Lower Khazars on based findings of the fauna in deposits of kosozhsky and singilsky formations. Its development is limited to the time of Likhvin interglacial. During the propagation of singilsky fauna *Palaeoloxodon antiquus* is the chronospecies. In addition, it includes the numerous finds of small form *Elasmotherium sibiricum*. Its teeth are characterized by more thin enamel and still more depth and randomness of its folds, especially on the lower teeth. The length of the complex is estimated 0.4 - 0.3 million years.

In the Volga-Ural region very often finds elasmoteriums meet with representatives of the Khazar faunistic assemblage: *Camelus knoblochi*, *Bison priscus longicornis*, *Megaloceros giganteus*, *Saiga borealis*, early mammoth *Mammuthus chosaricus* etc. All of them were find not in situ. But the constancy of such faunal combination suggests that *Elasmotherium sibiricum* was the representative of the Khazar faunistic complex. During the development of the maximum Dnieper glaciation it has already not found. Time of the Khazar complex covers 0.3-0.2 million years.

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The effect of insular dwarfism on dietary niche occupation in mammoths: what were the pygmy mammoths from Santa Rosa Island of California eating?

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Tooth wear studies have been used extensively to elucidate paleodietary and environmental trends at both local and global levels. Proxies such as microwear studies have been shown to be particularly adept at demonstrating dietary behavioral differences in taxa with similar or even virtually identical gross tooth morphologies (Semprebon et al. 2004a; Semprebon & Rivals 2007; Rivals et al. 2007). Despite the recent flurry of studies aimed at reconstructing ungulate diets using microwear, relatively few studies have focused on proboscidean microwear.

We used dental microwear analysis to study a large sample of pygmy mammoths (*Mammuthus exilis*) from Santa Rosa Island of California and compared our results to those of extant ungulates, proboscideans, and mainland fossil mammoths and mastodons from North America and Europe. Microwear features such as pits and scratches were identified and quantified using a stereomicroscope in a square area of 0.16 mm^2 and an ocular reticle at 35 times magnification, and large pits, gouges, and scratch textures were assessed via differential light refraction

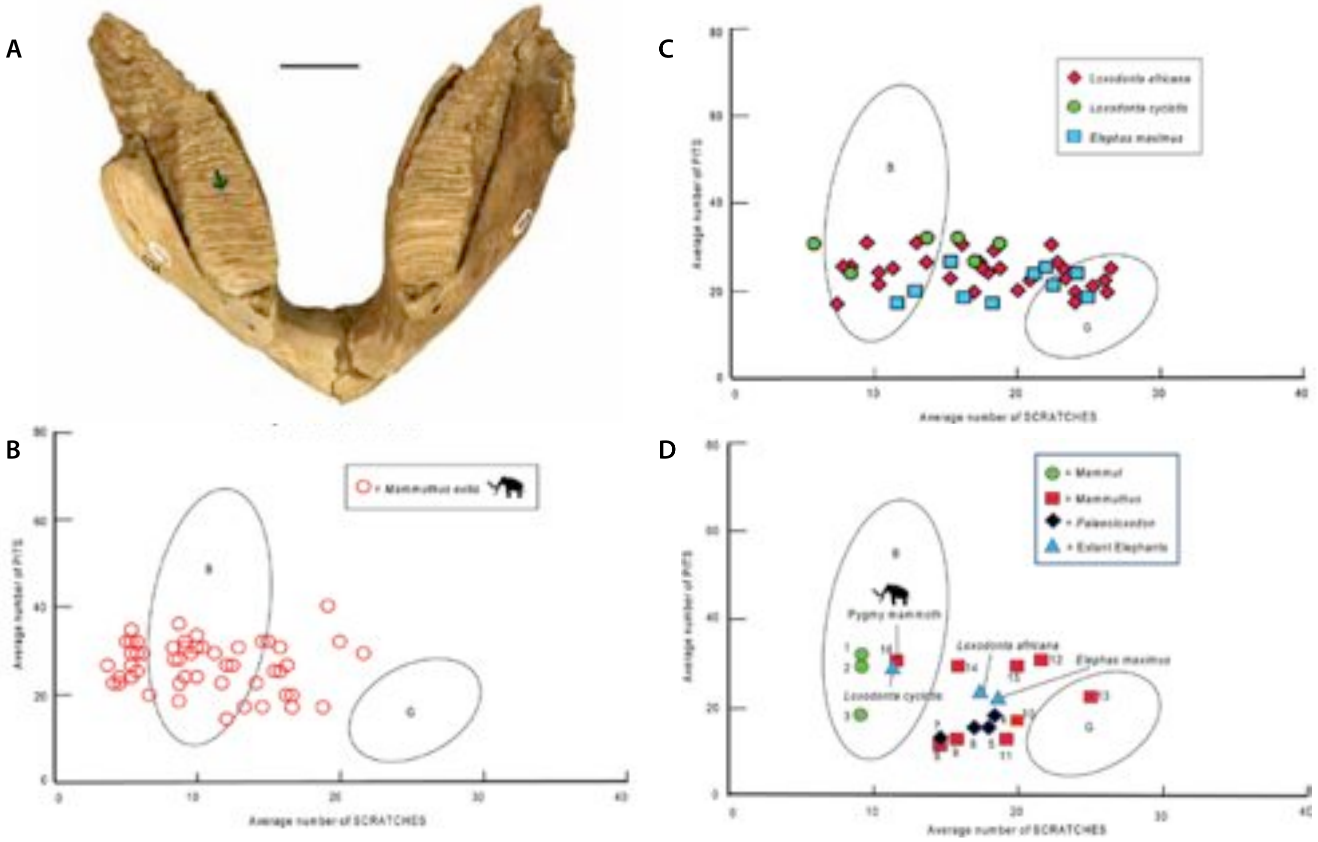

Fig. 1. **A**, Mandible of *Mammuthus exilis* from Santa Rosa Island, California. Specimen from Santa Barbara Museum of Natural History (catalogue number SBMNH-VP1078). Black arrow depicts sampling area for microwear analysis. Scale bar = 5 cm. **B-C**, Bivariate plots of the number of pits versus the number of scratches for the extant proboscideans analyzed and for *Mammuthus exilis* from Santa Rosa Island. Gaussian confidence ellipses (p=0.95) on the centroid are indicated for the extant browsers (B) and grazers (G) (convex hulls) adjusted by sample size (extant ungulate data from Solounias and Semprebon, 2002). **B**, Raw scratch/pit results for extant proboscideans. **C**, Raw scratch/pit results for *M. exilis*. **D**, Bivariate plot of the average number of pits versus the average number of scratches for extant elephants and fossil proboscideans plotted in reference to Gaussian confidence ellipses (p=0.95) on the centroid for the extant browsers (B) and grazers (G) adjusted by sample size. Comparative extant data from Solounias and Semprebon, 2002; comparative fossil proboscidean data from Green et al., 2005 and Rivals et al., 2012).

Taxon Key (centroids of samples are shown): **1** = *Mammut americanum* from Phosphate Beds, SC, USA, **2** = *Mammut americanum* from Ingleside, San Patricio Co., TX, USA, **3** = *Mammut americanum* from Gainesville, FL, USA, **4** = *Paleoloxodon antiquus* from Grays Thurrock, UK, **5** = *Paleoloxodon antiquus* from Aveley & Ilford, UK, **6** = *Paleoloxodon antiquus* from Crayford & Slade Green, UK, **7** = *Paleoloxodon antiquus* from Taubach, Germany, **8** = *Mammuthus meridionalis* from Wissenkerke, Netherlands, **9** = *Mammuthus* cf. *trogontherii* from Ilford, UK, **10** = *Mammuthus trogontherii -M. primigenius* from Crayford - Erith - Slade Green, UK, **11** = *Mammuthus primigenius* from Brown Bank, North Sea, **12** = *Mammuthus columbi* from Quarry G, Sheridan Co., NE, USA, **13** = *Mammuthus columbi* from Grayson, Sheridan Co., NE, **14** = *Mammuthus columbi* from Phosphate Beds, SC, USA, **15** = *Mammuthus columbi* from Ingleside, San Patricio Co., TX, USA, **16** = *Mammuthus exilis* from Santa Rosa Island, California.

as detailed in Solounias and Semprebon (2002) and Semprebon et al. (2004b). The analysis was made from the central portion of the central enamel bands of the occlusal surface (Fig. 1A).

Results are presented in Figures 1B-D. Fig. 1B depicts raw scratch versus pit results for extant elephants compared to average scratch versus pit results for extant ungulate taxa of known dietary behavior whereas Figure 1C shows raw scratch versus pit results obtained on *M. exilis*. The raw scratch distribution of *M. exilis* is skewed more toward the low scratch browsing range much like that of *Loxodonta cyclotis*, indicating a more homogenous dietary regime than that found in *L. africana* and *E. maximus* which have broader scratch distributions more typical of modern mixed feeders. Fig. 1D shows average scratch versus pit results of *M. exilis* compared to extant ungulates (convex hulls) and living and fossil proboscidean average values. Fig. 1D clearly shows that *M. exilis* has average scratch and pit results nearly identical to the forest elephant (*Loxodonta cyclotis*) and distinctive from more mixed feeding forms (*L. africana* and *Elephas maximus*). Also, these results are more similar to those found in prior studies for the mastodon *Mammut americanum* than those found in extant elephants or extinct mammoths, the latter taxa displaying values more intermediate between the browsing and grazing extant morphospaces (Green et al., 2005, Rivals et al., 2012). Other microwear variable results in *M. exilis* such as large pitting, gouging, and scratch textures are similar to those of *Loxodonta* and *Elephas*, (very wide scratches) suggesting that bark was an important dietary item.

Prior work (Rivals et al., 2012) has shown that *Mammuthus* species often show dietary plasticity with browsing, grazing, and mixed feeding patterns observed. Results here clearly show a shift in mammoth dietary niche occupation as mainland mammoths colonized the Channel Islands. Our results suggest that *M. exilis* narrowed its dietary breadth from that of its mainland ancestor (*M. columbi*) and became more specialized on browsing on leaves and twigs rather than the more typical mammoth pattern of switching between browse and grass. These results are consistent with the Pleistocene vegetation history of Santa Rosa Island whereby extensive coastal conifer forests were available during the last glacial as well as *Pinus* stands, and sage scrub as the climate warmed (Anderson et al., 2010).

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Small mammals from the Paleolithic site Strashnaya cave (Russia, Altai)

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The Strashnaya Cave, a multilayered Paleolithic site, is located in the Charysh River basin of Northwest Altai, just below the Inya and Tigirek Rivers. At this point, the Strashnoy stream meets the Inya river at its left bank. The name of the stream gives the name to the cave. The Strashnaya Cave is located on a steep slope of the south-eastern exposure of the left side of the Inya River valley at the height of 40 m above the river's edge. This cave is characterized by a simple horizontal structure and a length of about 20 m. The average width of the passage is approximately 2-3 m. The width and the ceiling height of the cave increase from the entrance inwards.

The archaeological materials of Strashnaya cave belong to the Upper Paleolithic and Mousterian complexes (Krivoshapkin and all, 2013). The remains of large and small mammals were found along with stone tools. Taphocenosis of large mammals is generally formed by the activity of predators, especially cave hyenas and wolf. Fragments of skeletons of typical representatives of the mammoth fauna were found: *Bison priscus* (Bojanus, 1827), *Equus ferus caballus* (Linnaeus, 1758), *Coelodonta antiquitatis* (Blumenbach, 1799), *Saiga tatarica* (Linnaeus, 1758), *Ovis ammon* (Linnaeus, 1758), *Bos (Poëphagus) baicalensis* (Vereshchagin, 1954), *Capreolus capreolus* (Linnaeus, 1758), *Gazella gutturosa* (Pallas, 1777), *Capra sibirica* (Pallas, 1776), *Crocuta spelaea* (Goldfuss, 1823), *Panthera spelaea* (Goldfuss, 1810) and *Panthera uncia* (Schreber, 1775) (Vasiliev, Zenin, 2009).

Accumulation of finds of small mammals was possible through the activity of predator birds, which could have nest near or directly into the cave. The small mammals have been used for paleoecological reconstructions of ancient man.

The bone material of small mammals was obtained as a result of the fieldwork in 2006-2009.

13 layers were described from Strashnaya cave. Lays № 11, 12 and 13 are sterile, without archaeological or paleontological finds. Part of the remains of middle-sized rodents and lagomorphs, which did not fall into small sieves, are viewed as large mammal fauna.

Altogether more 34 thousand small bone elements were found and ascribed to various groups of small vertebrates: Pisces, Amphibia (Anura), Reptilia, Mammalia (Insectivora, Chiroptera, Lagomorpha, Rodentia). The material is from light yellow to brown color. Most of remains are scattered teeth, mandibles, and long bones of limbs.

The total list of the small mammals includes 43 species. The quantities of each species were determined by counting all isolated teeth. The calculation results were included in

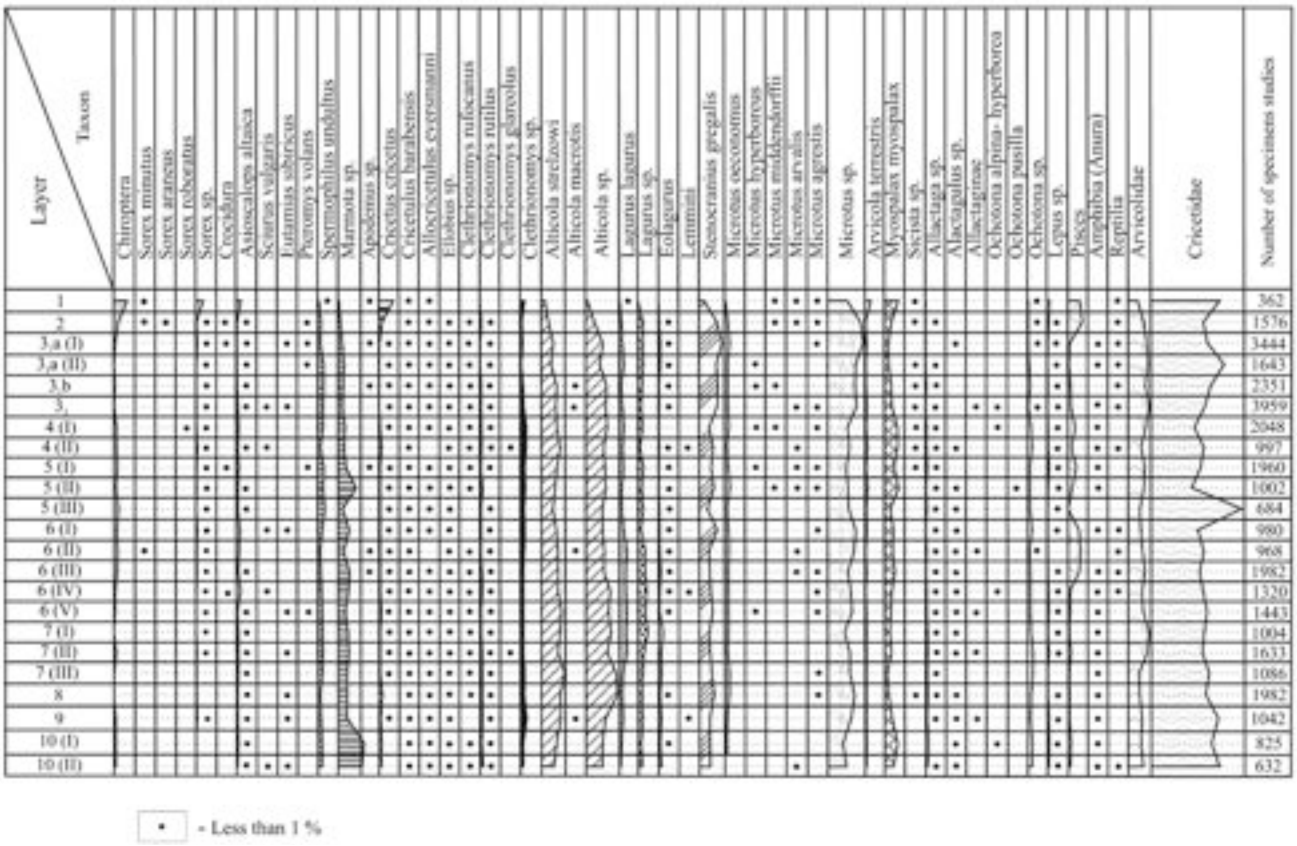

Fig. 1. General composition of small mammals in Strashnaya cave.

the prepared tables. The percentage of each species was calculated layer-by layer. Based on this table a graph was drawn, which reflects the dynamics of the small mammals composition (Fig. 1).

The dominant groups during the whole sediment accumulation in the Strashnaya cave were: rock voles *Alticola strelzovi* (Kastschenko, 1899), narrow-skulled voles *Stenocranius gregalis* (Pallas, 1779), grey voles *Microtus*, and Altai zokor *Myospalax myospalax* (Laxmann, 1773). Co-dominant groups are Altai mole *Asioscalops altaica* (Nikolsky, 1883), marmot *Marmota* sp., long-tailed Siberian ground squirrel *Spermophilus undulates* (Pallas 1778), red-backed vole *Clethrionomys*, steppe lemming *Lagurus lagurus* (Pallas, 1773), pika *Ochotona*. Smaller percentages characterize common shrew *Sorex*, black-bellied hamster *Cricetus cricetus*, Baraba hamster *Cricetulus barabensis* (Pallas, 1773), Eversmann hamster *Allocricetus eversmanni*, (Brandt, 1859) mole-voles *Ellobius* sp., yellow steppe lemming *Eolagurus luteus* (Eversmann, 1840), water vole *Arvicola terrestris* (Linnaeus, 1758), birch mice *Sicista* sp. and five-toed jerboas *Allactaga* sp. Bats, which are typical for the cave faunas, are also few in numbers.

The conducted study has indicated that:

1. The general composition of the small mammal association of the Strashnaya Cave points to a Late Pleistocene-Holocene age.
2. The dominating landscapes during the whole deposit accumulation were mountain steppes, semi-deserts (except for the sand semi-deserts), open rubbly and stone scatterings, stone accumulations with numerous niches and hollows.
3. The times of Late Pleistocene are characterized by highly mosaic landscapes.
4. The Pleistocene climate was much milder and more humid than at present.

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The relict steppe soils in the northeast Eurasia – refugium sites of the Pleistocene mammoth steppes

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The cold steppes, representing a nearly uniform zone, were widespread during the Pleistocene in North Eurasia and North America. During cold periods of the Pleistocene these steppes were stretching as a continuous strip from the Baikal region and Mongolia to the high latitudes of the Arctic. They were the basis on which the Mammoth fauna established. Today in the tundra and taiga zones of the vast territory of Yakutia there are areas of intrazonal relict steppes. These steppes occupy large areas in Central Yakutia, and sporadic ones to the north, in the basins of the Yana, Indigirka and Kolyma rivers (Yurtsev, 1981; Zakharova, 2009). These steppes are remains of the vast steppe zone of Pleistocene cold steppes. Results of palynological and carpological research show the significant similarity of the Late Pleistocene and Holocene plant association complexes and the identity of the modern Yakutia steppe associations to the vegetation of the Pleistocene cold steppes of Western Beringia (Ukraintseva, 1996; Maksimovich et al., 2005; Boeskorov et al., 2011).

Comprehensive study of the relict steppes biocenoses, including soil microbial ones allow better characterizing the unique structure of Mammoth steppe that supplied many herbivore species of the Late Pleistocene.

In the lower reaches of the Kolyma River (near Chersky settlement) we studied the microflora of steppefied soils, developed under petrophytic steppes on gravelly eluvium bedrock and under thermophytic steppes (Fig. 1) on the silty loam. The second type of steppes often appears after the fire impacts. Among the dominant pre-tundra woodlands these little spots of relict steppes are found only on the steep southern slopes. Steppefied soils are characterized by extreme dryness, increased supply of heat and longer (10-20 days) growing season compared to cryozems - zonal soils of the northern taiga. Steppe soils have sharply decreasing accumulative type of distribution of organic matter, close to neutral reaction of the soil medium, saturated at 80-99 % base soil absorbing complex. In the soil humus-accumulative horizon under petrophytic steppes the composition of humus is fulvic-humate, and under thermophytic steppes it is humate-fulvic. One of the main features of steppefied soils is the forming of water-stable structure with aggregate sizes ranging within 1,00-

Fig. 1. The plot of thermophytic steppe near settlement Chersky.

0,05 mm, which is not observed in any other soils of Lower Kolyma Region (Davydov et al., 2009).

The peculiar conditions of soil formation of relict steppe soils are reflected in the feature of their microbial cenoses. The relict steppe soils are distinguished from the forest soils of northern taiga by the large saturation of microorganisms of the soil profile. Our studies show that the number of major ecological trophic groups of microorganisms in the upper humus horizons of steppefied soils is of 10^6-10^7 cells/g, and in organic horizons of cryozems it reaches 10^5-10^7 cells/g. Distribution of microorganisms in the soil profile is of accumulative nature. In the steppefied soil profiles the number of microorganisms decreases with depth less sharply than in cryozems. Differentiation coefficient between the humus horizon and mineral horizon is 3-5 in steppefied soils, but 7-10 between the organic horizon and mineral horizon in cryozems. The number of bacteria in the middle part of the soil profile (at a depth of 40-50 cm) under the petrophytic steppe may reach 10^4-10^6 cells/g, and in cryozems it is 10^3-10^4 cells/g at the same depth.

Steppefied soils show higher stock of microorganisms compared with zonal northern-taiga soils. According to this model, they form a decreasing series: soil under thermophytic> soil under petrophytic steppe> cryozems. Moreover, 26-55% of the total stock of microorganisms is concentrated in the upper layer (0-10 cm) of the steppefied soil profile, and 70-80% of the stock is accumulated in the upper layer of the cryozems. Unlike to northern-taiga cryozems, the actinomycetes are actively developing in steppefied soils. Their number reaches 1.5 million colonies/g. They totally predominate among microorganisms utilizing mineral nitrogen, and reach 85% of their number. Actinomycetes are found to a depth of 50-80 cm in the soil profile. The widespread of actinomycetes in steppe soils depends of their dryness. This group of bacteria is adapted to arid conditions and prevails in all steppe soils series. The number of actinomycetes is significantly smaller (up to 0.5 million colonies/g) in cryozems, and they are found only in the upper 10cm layer of soil. The activity of actinomycetes is also binding more profound transformation of organic matter. In this regard it should be noted that the steppefied soils are characterized by higher stocks of dehydrogenase and polyphenol oxidase compared to cryozems. These enzymes are involved in the biogenesis of humus. Dehydrogenase and polyphenol oxidase activity in humus horizons is higher in soils under petrophytic steppe, than in soils under thermophytic steppe. In the same direction the processes of humification in soils is strengthened. The composition of humus is fulvate-humatic in the soil under petrophytic steppe, and humate-fulvatic in soil under thermophytic steppe.

Thus, the relict steppe soils of the Lower Kolyma Region have an arid “spectra” of the microbial cenosis and are higher biogenic compared to zonal soils of the northern taiga. Metabolic activity of the microflora in the steppefied soils is constrained by a shortage of moisture, and in cryozems it is constrained by a lack of heat. It was shown that the cellulose destruction processes proceed very slowly in the soils. During 2 years in the upper 20 cm layer of steppefied soils up to 58 % cellulose is destroyed, and in the cryozems it is of only 35%.

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Abnormal mammoth remnants in the Ice Age Museum Collection

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The Ice Age Museum stores mammoth remains found in the North East of Russia. The museum includes the most scientifically valuable specimens, especially those with pronounced deviations from normal morphology. Some remains belonged to one and the same individual, others are just single.

The skeleton of an adult female mammoth F-2466 from Kastykhtakh river (Taimyr) has some peculiarities: fractures of ribs caused during lifetime that led to the false joint formation of them, fissures in the atlas' neural arch and a sigmoid contact of m2 and m3 teeth (Kirillova et al., 2012). These characteristics may have been caused genetically or by metabolic disorder during pregnancy and lactation, which is peculiar for females.

A few specimens of pathologically changed vertebras represent a different kind of spinal diseases. There is a case of an ankylosing hyperostosis (Fig. 1) caused by the tissue ageing. The fusion of four vertebrae was caused by ligaments and muscles ossification. The surface of the proliferative tissue is firm and shiny. Between vertebrae there are empty spaces that were occupied by intervertebral discs during the lifetime. Another case is pathology of the atlas (F-910) and epistropheus (F-769) of one individual. Surface accrementition is porous, dim; on the corpus vertebrae there is a large abnormal cavity. There are specimens with marked osteochondrosis, arthrosis and osteoporosis.

Deviations in buccal teeth structure in the Ice Age museum's collection are represented by different types: root formation pathology, odontoma, occlusion pathology of the last teeth (M3), cavities in the occlusal surface during lifetime, etc. Several M3 are so extremely twisted that their front and rear parts are almost touch each other. In early stages of development of some m3 the rear plates of the teeth are separated and later they are re-united with the same tooth in the form of excess appendage (Kirillova, 2009).

About 1500 mammoth tusks were examined. The most interesting ones were selected for the scientific collection according to a number of criteria. Specimens selected for taphonomical reasons include tusks of different conditions, from almost completely destroyed to excellent; a tusk that was broken up by a frost crack; tusks of different colors, from the "modern" ivory color to brown and black. Specimens selected by individual age include a range of tusks from juvenile to old, obliterated to the root.

Specific traces, both ancient and modern, are of different origin. Among them there are both lifetime peculiarities of a tusk (variations of working occlusion surface; hatchwork

Fig. 1. Sample F-313. Pathology of thoracic vertebrae, side view. Scale bar equals 10 cm.

that inscribed the directions of tusk's movement on the ground when unearthing it from snow) and postmortem ones. The latter include traces of a caterpillar's "fang", or other signs of human influence. There are specimens with numerous natural surface caverns of different size.

Tusks with marked individual peculiarities and pathologies usually belong adults and old individuals. Normally an elephant's tusk grows by means of adding one dentin cone a year throughout all life. Each subsequent cone of a growing animal is larger than the previous one. After animal's passing the physical matureness peak, the size of cones gradually decreases. Usually annual growths are distinguished by their colour but sometimes we can see a transverse ringed deepening. It is a sign of a sharp slowdown (until a complete stop) of process. Sometimes these features are expressed significantly (F-626). It is most likely that the reason of the formation of these narrowings is sharp climate (or food supply) changes. The feature is expressed sharply in about 3% of the tusks.

Odontoblasts in the pulp of adult and old animal tusks can come off (individually or in groups), then attach and grow elsewhere. These accretions have a specific texture that can be seen in their cross-cuts (F-197). Sometimes they form specific crests on cone surfaces (F-581). Very often the last cone on the tusk of old animals is formed on the side of the tusk but not at the end of it. A selection of such variations is collected. At that the last cone is frequently filled with dentin but the character of this process may be different. Usually this happens when the tusk is extremely worn out. There is only one instance of a mature female's tusk, which is slightly worn out and whose proximal part at the same time is completely filled with dentin (F-2921).

The example F-196 represents a unique case. 4 roundish clots of dentin were formed in alveole-like holes in the alveolar walls of large male's tusk. One of them sprang through a bone. Others are located on the internal part of the alveolar wall. All the formations are mobile in their hollows. In the cut of the largest of them it's possible to see the same cross-grained structure that accretions of old mammoths' tusks have.

It is not always possible to determine whether a deviation is pathology or not. The idea of norm is very well developed in serial materials for human but almost does not exist for proboscidean. Lifetime injuries were discovered on the mammoth remains of different individual age. But only adult and old specimens were registered with significant deviations, as pathology development is a feature of this age. In many locations such remains prevail. Mammoths had a chance to live long lives despite all the diseases. They were undoubtedly susceptible to illnesses related to the supporting-motor system (Krzeminska, 2009; Leshchinskiy, 2012). However analysis of similar diseases of modern elephants would probably give a very bright picture, too. Pathologies of buccal teeth and tusks of mammoths and of modern elephants are very similar.

The collection of aberrant remains provides new important knowledge of the mammoth biology.

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Neanderthal-mammoth interactions: re-evaluating evidence for repeated "Mammoth Drives" at La Cotte de St Brelade (Jersey)

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In Europe, Middle Palaeolithic sites with Neanderthal stone tools associated with mammoth remains mainly date to after the MIS-6 glacial (ca. 190,000-130,000 years ago). The recurrent, widespread, though generally sporadic, presence of mammoth remains at Neanderthal sites (e.g. Mont Dol (France), Spy (Belgium) and Lynford (UK)) has been interpreted as evidence for their systematic exploitation (Louguet-Lefebvre, 2005; Schreve, 2006; Germonpré et al., 2012). Isotope evidence further suggests that Neanderthal diets consisted of large quantities of terrestrial meat (Bocherens et al., 2005), which could be satisfied by the exploitation of mammoth and other megafauna. Zooarchaeological evidence for mammoth exploitation (age/ body part profiles, bone surface modifications) is, however, limited (Smith, 2012). This paper provides a zooarchaeological re-evaluation and wider contextualisation of the mammoth, and other mammal, remains from La Cotte de St Brelade (Jersey), a site which remains key for understanding and investigating Neanderthal-mammoth interactions during the early Middle Palaeolithic.

La Cotte de St Brelade (CSB) is one of the most prolific Middle Palaeolithic localities in Western Europe (ca. 96,000 lithic and 1,500 faunal remains). Based on the analyses of two distinct "bone heap" levels (Layers 3 and 6), composed almost entirely of megafaunal remains, it has been suggested Neanderthals were repeatedly and systematically driving herds of mammoths over the CSB cliff face. Since publication of the CSB monograph (Callow and Cornford, 1986), the interpretation of the site as a mammoth drive locality (Scott, 1980; 1986) has remained a unique, if untested, hypothesis regarding Neanderthal subsistence strategies and landscape use. Presently, such structured and repetitive subsistence behaviour has been suggested, but never concisely argued, for any other European Middle Palaeolithic site, calling for a re-evaluation of the CSB fauna.

This paper presents results of new, detailed analyses of the fauna recovered during the McBurney excavations (1961-78). 1,494 faunal remains were recorded from all horizons, placing the two "bone heaps" within context. Zooarchaeological techniques, such as species and body part identification, were allied with a range of attributes (weathering, abrasion and root-etching) to fully understand the site formation processes. Furthermore, an oblique light source and hand lens (20xmagnification) allowed for a detailed assessment of bone surface modifications.

Results confirm the dominance of mammoth and woolly rhino with smaller quantities of other species. Overall, per layer, mammoth Minimum Number of Individuals (MNI) are very low, usually 1 or 2. Only within the "bone heaps" do mammoths dominate with MNIs of 7 and 11, respectively. Further data, however, indicates complex site formation and preservation. Bone weathering throughout all horizons, including the bone heaps, suggests more prolonged exposure, repeated input of faunal material and differential preservation, potentially related to shelter from the granite walls.

Neanderthal presence was identified within all deposits through either burnt bone or butchery modifications. Additional cut marks identified on mammoth suggest the exploitation of these individuals, throughout all contexts. Newly identified carnivore modifications were only recorded on faunal material from the "bone heap" horizons. Detailed analysis of the quantity and distribution of these modifications suggests a more complex Neanderthal subsistence pattern than previously acknowledged, questioning the interpretation of CSB as game drive locality. These new bone surface modifications suggests more prolonged Neanderthal occupation in the deposits that underlie the "bone heaps", to the exclusion of other large carnivores. Contrastingly, in Layers 3 and 6 the almost equal quantity and distribution of hominin and carnivore modifications, suggests more discontinuous Neanderthal and carnivore occupation events at CSB.

Contextualising this new research at the broader European scale of Neanderthal-mammoth interactions permits a further, more detailed discussion about the importance of these species in the Middle Palaeolithic diet. Whilst regular exploitation of megafauna by Neanderthals has been suggested, there is no evidence for the systematic hunting of these species and hence their dietary contribution appears limited. Whilst CSB remains exceptional, being unique in the recurrent presence of mammoth remains and Neanderthal stone tools, a more intricate scenario for human-mammoth interactions presents itself. Rather than Neanderthal occupation, punctuated by large-scale game drives, the site is similar to other cave faunas from Europe, with an accumulative role for both hominins and carnivores. At CSB Neanderthals regularly utilised the surrounding landscape, exploiting various species, including mammoth. The CSB ravine system could have provided the perfect location to track and hunt animals, whilst the enclosed site structure provided protection and shelter for butchery and processing. Similarly, this locality would have proved an attractive locale for carnivores, making the fauna accumulated at the site a composite mix of Neanderthal hunts, carnivore kills and natural deaths, and not merely the results of mammoth drives.

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Elephants, Acheulian tools, and large game processing: a use-wear and experimental perspective from Lower Palaeolithic Revadim, Israel

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The nature of interaction between early humans and elephants during the Palaeolithic period is still under discussion. While some scholars strongly advocate the significant role of elephants in early human subsistence and culture (e.g. Ben-Dor et al., 2011; Nikolsky and Pitulko, 2013), others have questioned the nature of such interactions (e.g. Boschian and Sacca, 2010; Smith, 2013). Elephant remains are found in many European, Asian and African Palaeolithic sites. In the Levant there are several Lower Palaeolithic Acheulian contexts characterised by the association of megafaunal remains and human made tools enabling a glimpse into the interactions between humans and elephants (Goren-Inbar, 1994; Chazan and Kolska-Horwitz, 2006; Rabinovich et al., 2012).

Our work is focused on testing the efficiency of Acheulian stone tools found in association with elephant remains in processing large game. This is achieved by means of an experimental program testing the efficiency of replicas of the archaeological items to process portions of a large animal body parts. Taking into consideration some of the typical implements present in the Acheulian toolkit (handaxes, notches, scrapers and retouched flakes) we set up an experimental framework in order to test their efficiency in butchering a large animal carcass. We investigate both the edge damage and the micro use wear generated by this activity using both the low and high power approaches (Keeley and Newcomer, 1977; Tringham et al., 1974). The experimental use wear signs are compared to the wear patterns found on the archaeological finds from Revadim.

Our study includes the analysis of the stone tools found at a specific context from the Late Acheulian site Revadim Quarry (Israel), dated to a minimum age of 300-500 thousand years (Marder et al., 1999; 2011; Rabinovich et al., 2012). Locality 21 is part of a rich and well-defined archaeological layer B2 showing specific activity areas characterized by a high density of artifacts.

Locality 21 is defined as a well-preserved fast palimpsest with a discrete activity area and it exhibits elephant remains in association with flint tools. Especially interesting is an elephant rib, bearing cut marks, that was found alongside a number of flint items, one of which is a handaxe (Fig. 1). In the publication of the faunal material from the site, including the rib from Locality 21, it was stated that "The cut marks on the scapula and ribs are particularly notable because they indicate filleting of meat. Coping with large quantities

Fig. 1. Locality 21, Layer B2, Area B.

of meat may require a combination of immediate- and delayed-return strategies such as consumption on site, and drying meat for later consumption at Revadim" (Rabinovich et al., 2012).

Using low and high power magnification approach, we analysed handaxes, scrapers, notches and retouched flakes from Locality 21 looking at both edge damage and/or the microwear (polishes, abrasions and striations) present on these tools. From our analyses it is possible to highlight the average state of preservation of the materials from Locality 21 of Revadim, despite the age of the site, which allowed proposing several hypothesis about the tools' use. Throughout our microscopic analysis we have identified evidence suggesting the possible use of several lithic implements for processing medium hard materials.

The wear generated on the experimental tools and the pattern identified on the archaeological sample from Locality 21 are compared in order to suggest the probable use of the Acheulian artefacts. Our research provides a rare opportunity to study the function of Lower Paleolithic artefacts directly associated with elephant remains and discuss the possibility that these tools were actually used in processing large game. Indeed, the presence of either edge damage or polishes allows speculating about the actual use of the tools recovered at Revadim Locality 21, and provides strong and direct evidence related both to the behaviour of Acheulian human groups and the exploitation of elephants.

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"Black" elephant bones in a cave: the case of Charkadio cave on Tilos Island, Greece

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The objective of this paper is to study the origin of the black colour of skeletal remains recovered from the fossiliferous site in Charkadio Cave on Tilos Island (Dodekanese, Greece). This site has given thousands of fossils of the endemic elephant of Tilos *Elephas tiliensis*, which were found in the cave deposits at a depth of 0-4 meters from zero point, in sediment rich in volcanic tuff that was redeposited in the cave. These dwarf elephants lived on the island during the Upper Pleistocene and part of the Holocene (+/- 45.000 - 3.500 years BP) (Theodorou et al, 2007). The associated fauna includes long bones of *Testudo marginata* and various bird remains. Material of sub endemic deers (*Dama dama*) is also present at Charkadio but about 90.000 years earlier than the elephants (Bachmayer et al. 1976; Symeonidis 1972; Theodorou et al, 2007). Up to this moment it has not been possible to document the coexistence of the Tilos elephants and Neolithic man.

During the processing and preparation of skeletal material coming from the excavation periods of 2001 and 2012 (work realized for THALES -MIS380135), numerous dark coloured (brown-dark brown-black) skeletal remains were discovered. These findings are of great interest, as black bones have also been observed and studied in numerous sites all over the world (Chadefaux et al, 2009; Reiche, 2010; Simmons et al, 1999; Stathopoulou et al, 2004; 2013), and have often been connected to the presence of fire due to humans. The possibility of burnt bones in the cave would allow us to imply for the first time, the coexistence of man and elephants on the island.

Black colouring of skeletal material at archaeological and palaeontological sites can be attributed to burning, oxide staining or a combination of both procedures. (Reiche, 2010; Shashack-Gross, 1997). The identification of burnt bone through the study of features such as colour has been one of the most common methods in zooarchaeological research, though increasingly the need for analytical techniques has become obvious (Nicholson, 1993). As a result, various such techniques and methods have been applied on "dark coloured" bones in the past and many attempts towards a straightforward analytical protocol concerning the presence of burning in osteological material have been made (Goncalves, 2012; Hanson & Cain, 2007; Lebon et al, 2008; Piga et al, 2009; Stathopoulou, 2008; Stathopoulou et al, 2004; 2013).

During our study, a combination of modern analytical techniques are applied on a selection of "black" bones as well as samples of the surrounding sediment from the Charkadio cave, in order to explore the origin of their colouration. Specifically Optical microscopy, Scanning Electron Microscopy (SEM) combined with X-ray Microanalysis (EDXA), X-ray Diffraction (XRD) and Infrared Spectroscopy techniques are applied.

The preliminary results on the histology, mineralogical and chemical composition, crystallinity and structural parameters, due to diagenesis but also due to possible burning, will be presented and their correlation to the palaeontological context discussed.

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How many Asian elephants are killed illegally for ivory and in conflicts?

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The poaching of African elephants (*Loxodonta africana* and *L. cyclotis*) for ivory has attracted worldwide attention from conservationists but, in contrast, little is known of this problem among Asian elephants (E*lephas maximus*). In Asian elephants only males may possess full-grown tusks and are usually selectively targeted for ivory, resulting in artificially skewed sex ratios. Highly skewed sex-ratio may affect the viability of a population therefore a serious conservation concern. Both male and female Asian elephants are however killed in the process of conflicts with agriculture. The extent of such illegal killing of Asian elephants is only partly known because of incomplete detection and under reporting of carcasses in dense forested habitat. A population modeling approach is therefore necessary for estimating unknown harvest rates.

We have described a method to infer unknown harvest rates from crude current age and sex ratios of an elephant population (Chelliah, Bukka and Sukumar 2013). The ratios are adult (>15 years) female to male ratio, male old-adult to young-adult ratio, and proportion of adult males in the population, henceforth referred to as population signature ratios. We modeled an elephant population as Jensen's (2000) 2-sex, density-dependent Leslie matrix model. We simulated various combinations of male and female harvest regimes operating for 200 time steps (1 time step = 5 years) on a population assumed to be at a stable state (w.r.t. to age structure and size) initially. At each time step we compared the signature ratios of the simulated population with observed ratios from field data of a population and logged the male and female rates along with the time step at which the simulated and observed ratios matched closely. This brute force search algorithm would typically yield multiple harvest regimes that could possibly produce the current observed signature ratios in a population. The solution set, however, is of tractable size and some knowledge about the history of harvest in the population under scrutiny will help in identifying the most likely harvest regime.

We applied the above method of reverse engineering harvest rates to several Asian elephant populations in India with adult sex ratios varying from about 1:2.5 to 1:60. Mortality rates in adult male elephants were enhanced by only 17% due to illegal killing in populations such as Kaziranga in northeastern India, not much affected by ivory poaching because >50% of bulls are tuskless. In contrast, southern Indian elephant populations where tusked bulls constitute >90% of male phenotype showed enhanced adult male mortality by over 300% at places such as Periyar. When results from the six sampled sites are extrapolated across the country, our model indicates that about 125 adult male elephants have been killed annually on average for ivory and in conflicts since the 1980s. Ivory poaching has declined noticeably in the past decade.

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Megalopolis - 112 years after the first excavation by National and Kapodistrian University of Athens (NKUA) - and the Post Lignite era

Georgios THEODOROU ✉

Megalopolis, has been known since antiquity (Pausanias um 160 v. Cr. in Melentis, 1961 p. 171) for its wealth in fossil mammals. Fossil bones found in antiquity have been attributed to mythical giants. In our times Megalopolis lignite Basin is mainly known as a place with strong environmental problems due to the use of lignite, to acquire electric power since the 70s.

At the beginning of the 20th century (summer of 1902) excavations at Isioma Karyon near Megalopolis, carried out by Prof. Th. Skoufos, brought to light numerous significant palaeontological findings, now stored at the Museum of Palaeontology and Geology of NKUA. The rich vertebrate fauna has been attributed to elephants, deer and other mammals. Detailed presentation, and stratigraphical information for the excavations of this period is almost entirely missing. Scarce photos have been published by J. Melentis (1961 TAFEL, XXII) and the same author published during the following years a lot of significant papers regarding the Megalopolis fossil fauna. The existing photos by Th. Skoufos show findings in situ, excavated at Isioma Karyon, at the ravine called now by locals "Grana tou Skoufou" to honor the first excavator.

During World War II University Museum rooms have been used for military purposes by Germans, (Symeonides N., pers. communication), and since that period a lot of material and showcases have been moved to other buildings (personal observations in the old Museum collections and rooms in the period 1970 - 1980). The result was loss of data and minor partial mixing of some collections. The same is true for museum archives that have been disorganized during the First and Second World War and a lot of information, no doubt, has been lost forever. Since the 80s as the University Museum moved to the new University Campus, and a systematic effort started in order to reorganize the old collections with the precious help of pre and post graduate students and some funding from different projects. This effort is still going on due to the fact that numerous collections still need a lot of preparation and cataloging work.

During the 90s we started an ambitious project to create a data base with the chemical fingerprints or each Greek fossiliferous locality of vertebrates and to understand the diagenetic processes at each site. This work demands new excavations at most localities and it will take many more

Fig. 1. Students and late Professors (I. Melentis, N. Symeonidis, K. Anapliotis) of the Department of Natural History and Geography – Current Department of Geology and Geoenvironment of Athens University- at Isioma Karyon, Megalopolis Greece at the ravine known today as Grana tou Skoufou. This historical photograph at Aghios Ioannis, at the exit of the Grana tou Skoufou taken in 1966. (Photo Archive: J. Asimakopoulos).

Fig. 2. Excavating a tusk of *P. antiquus* at Grana tou Skoufou (September 2012). From left to right: V. Mitsopoulou, S. Rousiakis and G. Theodorou. (2012-09-17). The tusk is undercut and slowly supported before transportation with a wooden frame constructed step by step in situ. (Photo by N. Tsoukalas).

years to be finished, due to very low funding or ignorance of the exact excavation sites or due to the lack of GPS technology at earlier periods.

More than half century after the excavations by Th. Skoufos in 1902, Prof. J. Melentis, excavated again at Isioma Karyon (Fig. 1). The new material has been thoroughly studied and has been published. At these publications Melentis has incorporated the collections of Th. Skoufos excavations. During 60s Megalopolis findings were presented to public at the rooms of the old Museum at Central Athens (Akademias and Sina street). Recently some authors questioned if some specimens attributed to Skoufos collection had a different origin. The result of these studies is highly unreliable, since there is no database with the chemical fingertips of all Megalopolis fossiliferous localities. Clearly the reasons for possible minor mixing of collections has been misunderstood and misinterpreted by younger scientists, a fact that makes every relative publication very questionable. It is clear that science has to wait for the new excavations data.

Again, almost half century later than the excavations by J. Melentis, I have been invited by "Syllogos Isiomataion Karyon" to promote the idea of a local Palaeontological Museum and to organize palaeontological excavations at the area. Municipality of Megalopolis and its Major Panagiotis Mpouras, were already working hard for the Museum idea. It was the council of Megalopolis Municipality that decided to finance the first excavations of the 21st century at Megalopolis Basin, despite the deep economic crisis. It has become clear that citizens of Megalopolis had to think about the Post Lignite Era and the promotion of Cultural Heritage. The first trial excavation by our team was carried out at the KYT (Kentron Yperipslis Tasis) area (Sept. 2011) and one year later a new excavation followed at "Grana tou Skoufou". The main survey and excavation period was carried out during August and September 2012. At KYT area findings included bones from elephants and deer as well as a lithic, that has been send to Ministry of Culture according to Greek laws. Due to the heavy machinery that was working at the area, the lithic was found disturbed, significantly higher than the bed where the elephant fossils were lying. Lithic of Megalopolis and human findings in the wider area have been documented by Sickenberg, (1975). It is now impossible to correlate the collected lithic finding with the elephant fossils. The elephant bones are now stored at a building that belongs to "Syllogos Isiomataion Karyon" and has been given to our team as a supporting base for the excavations. During summer of 2013 the building was transformed by NKUA to an "INFORMATION STATION OF NKUA PALEONTOLOGICAL TEAM" (Opening day, July 28, 2013). During 2012 - 2013 it became possible to locate at least 6 more promising excavation sites, including sites in the lignite basin that were sampled (2013, Sept 10) and gave us scarce fossil bird remains. Systematic excavation carried out at "Grana tou Skoufou" during September 2012, though repeatedly disturbed by extremely heavy rains, brought to light a complete tusk and isolated molars of P. antiquus and some deer and hippo bone fragments.

At the end of 2014 a new nonprofit organization (ΠΠΠΚ – Παράσσιο Πάρκο Πολιτιστικής Κληρονομιάς – Parassian Park of Cultural Heritage) was founded with the scope to create a geopark to embrace the extremely rich Cultural Heritage of the area and of course the Palaeontological sites. This private organization aims to create the necessary man power to cope with the Post Lignite Era.

Our next significant step, will be the new excavation, again funded by Municipality of Megalopolis (NKUA Research Account 70/3/ 11474) planned for Spring-Summer 2014.

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From the Charkadio cave excavation, to a full 3D reconstruction of an extinct elephant

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Without doubt Greece has a unique natural and cultural heritage. Over the years paleontological excavations have contributed to this rich heritage. Charkadio cave, on the Island of Tilos, is one of the richest fossiliferous sites with remains of the last European elephant, *Elephas tiliensis*. These dwarf elephants were the last to inhabit a Mediterranean Island. A highly innovating project was set up under the Research Funding Program THALES (MIS380135) with the unique goal to fully reconstruct an anatomically complete *E. tiliensis* skeleton that will be presented to the wider public, taking advantage of the breakthroughs in mechanical engineering and then utilizing them in a paleontological process.

An extensive *E. tiliensis* fossil collection is deposited at the Museum of Palaeontology and Geology of the National and Kapodistrian University of Athens. The identified skeletal elements were prepared by highly skilled laboratory personnel, and a large number of specimens, selected according to a series of biometric criteria, were sorted in order to be digitized and represented in a virtual prototyping environment.

The specimens were scanned with a computed tomographic scanner. The sample was carefully packed into cardboard boxes, separated with the use of appropriate supporting material that would not interfere or produced noise to Computed Tomographies. In addition, different skeletal elements were sorted out to be digitized using a state-of-the-art Laser Scanning Measuring Arm. The combination of these two methodologies resulted in an extensive number of raw digital data (DICOM files, Point Clouds). Each data set was then inserted into several commercial 3D manipulation software programs (Mimics, Geomagic, Solidworks). Each bone structure is then broken down to its primary data construct and the main dimensions are measured in the 3D model, based on the body related coordinated system. Using Solidworks and Geomagic, the aforementioned data are then implemented into parts of each bone. Based on these 3D files, the measured dimensions, ontogenic observations, allometry and taphonomy the paleontologists are able to locate areas of interest and create the necessary alternations on the virtual parts. Furthermore statistical analyses of selected measurements are combined in order to formulate mathematical equations that will estimate missing values of measurements in the sample. The completion of the above methodology will lead to the construction of an accurate *E. tiliensis* skeleton printed three-dimensionally. The initial goal is the creation of a virtual model for each bone, in order to be tested and assembled as a representation of the skeletal structure of an extinct dwarf elephant. The next step in this process would be for the bone structure to be ”printed”/manufactured with the use of state-of-the-art Rapid Prototyping technics, in order to pass from the virtual prototyping phase to the actual prototype phase.

Currently, all stages of the project are ongoing, and partial results are promising, especially those focusing on the mathematical aspect that will provide a skeletal element resizing guide. The first digitized specimens through the use of Rapid Prototyping Technologies are printed by both Laminated Object Manufacturing (LOM) and Fused Deposition Modeling (FDM) procedures that will be used to construct the complete skeletal reconstruction.

The research teams involved are conducting an interdisciplinary study in the field of vertebrate paleontology in Greece with partial results revealing significant findings for the biometry of *E. tiliensis*. The three dimensional reconstruction of the anatomical correct skeleton will be housed in a Museum situated next to the excavation site of Charkadio cave.

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Thales. Investing in knowledge society through the European Social Fund.

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Preliminary data on the remains of woolly mammoth *Mammuthus primigenius* (Blum.) with soft tissues from the Anabar river basin, North-Eastern Siberia

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In the period from July 31 to August 5, 2013, an expedition to the lower reaches of the Anabar river was undertaken with the aim of excavating skeletal remains of a male woolly mammoth (*Mammuthus primigenius* Blum.) with partially preserved soft tissues, found by local residents in September, 2012. This is the westernmost finding of a woolly mammoth carcass within the territory of Yakutia.

The skeleton was found in deposits of the first terrace above the floodplain, on the right bank of Morgogor creek in the Anabar river basin, approximately 78 km northeast of Saskylakh settlement, which is the administrative center of the Anabarsky district (Yakutia). The locality has a northward- facing exposure.

The material was collected from two separate loci divided by a recent slump with its principal displacement in a westward direction. The main elements of the skeleton were revealed in the central part of the excavated portion of the site, in a detached sediment block. Three vertebrae were found in articulation, in vertical position; complete pelvic bones and separate ribs were found in a horizontal position.

While clearing the site near the western edge of the excavation, in order to collect hair and wool, two fragments of the sole of the animal's foot and a portion of the gastrointestinal tract were revealed under a covering layer of hair. This suggests that the animal's corpse was eroded, and parts of the body were displaced by flowing water from their initial burial location.

Pieces not found: vertebrae thoracicae - nr. 3-19; vertebrae lumbales; vertebrae caudales; sternum; humerus (sin.), radius (sin.), scapula (sin.), some foot bones.

Collected material: cranium with M3 sin. and dext.; mandible with m3 (sin. and dext.); atlas; axis; 5 vertebrae cervicales; first 2 vertebrae thoracicae; 22 costae: 10 sin. (nr. 1, 2, 3, 6 et al.), 12 dext. (nr. 1, 2, et al.) and other fragments of costae; humerus (dext.); radius and ulna (dext.); scapula (dext.); pelvis; femur (sin. and dext.); tibia (sin. and dext.); fibula (sin. and dext.); metacarpale (II, III, IV, V. dext.); external cuneiforme (sin.); trapezium (sin.); scaphoideum (dext.); lunare (dext.); magnum (dext.); trapezoideum (dext.); cuneiforme (dext.); unciforme (dext.); phalanges (3 ex.).

Several dozen skull fragments were collected from the excavation site. During preparation, under laboratory conditions, the overwhelming majority of fragments were successfully joined and bonded. However, due to extreme deformation of some skull parts (cracks and compressed areas) its three main assembled blocks cannot be securely joined, although it is possible that they could be mounted using a supporting framework. 21 fragments of the external skull surface remain non-conjoined. The age of the individual was determined by comparison with living elephants (stages of dental wear and replacement in modern African elephants; Laws, 1966) and was inferred to be approximately 43 years.

Fig. 1. **A**, Soft tissues of the right knee. **B**, Foot sole with two corneous nails.

Soft tissues (fragments of skin, tendons, muscle and fat) were found on the ribs, the right femur, tibia and fibula (Fig. 1A) and on some foot bones, and the nearly complete sole of the foot with two nails (Fig. 1B). Some fat accumulations were discovered while rinsing hair and wool.

Osteological investigation of this material revealed signs of trauma and illnesses of the individual during his life: a non-united rib fracture and a fistula trace on the forehead. The latter is caused either by Nematoda (parasitic worms) or by larvae of the gadfly (Vereschagin, 1981). Most of the epiphyses of longbones (radius, ulna, femur, tibia) and flat bones (scapula, pelvis), the rib epiphyses and separate skull bones were non-fused.

The size of the bones suggests that this individual mammoth was unusually large. Using I.A. Dubrovo's methodology (1982) based on the length of longbones (we took into account the measurements of the fibula (sin) – 677 mm and humerus (dext.) – 1000,5 mm), the shoulder height of the skeleton was calculated as 310-315 cm.

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Data on elephants from Middle – Upper Pleistocene sediments of Astrakhan Volga area (Astrakhan Region, Russia)

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In river bank cliffs of the lower Volga Valley the Middle and Upper Pleistocene deposits are exposed. They contain remains of freshwater and brackish-water mollusk shells, as well as the remains of large and small vertebrates. Based on materials from the Lower Volga Region the Middle Pleistocene Singil and Khazar faunal complexes of mammals were substantiated (Gromov, 1935, 1948; Gromov et al., 1965). Here there are the typical localities of these complexes (Raygorod – for Singil and Cherniy Yar – for Khazar ones). Over the recent 100 years the representative collection of the Pleistocene elephant remains from this territory has been gathered in collections of the Astrakhan Museum-Reserve (teeth of different wear stages, jaws and bones of the postcranial skeleton). Unfortunately, the most part of the finds has no precise stratigraphic data. They come from consolidated sand and gravel, brought from local sand pits and obtained by dredging in the river. However, some ancient elephant specimens were found directly in the Middle Pleistocene layers. For example, several diagnostic teeth and almost complete skeleton of mammoth were found in the Khazar and Singil deposits at the Cherniy Yar site. Mammuthus trogontherii chosaricus Dubrovo, 1966 from this locality was described previously.

The revision of the Astrakhan Museum-Reserve collections identified four elephant taxa: *Mammuthus trogontherii*, *M. chosaricus*, *M. primigenius* ssp. (small form) and *Elephas* (*Palaeoloxodon*) sp. At this stage of investigation only the last generation teeth were analyzed.

Mammuthus trogontherii. Lower teeth m3 of this large elephant form (n=5) are characterized by a long crown of 356-372 mm, rather broad crown (IW, ratio of width to length of crown, n=2) of 29 and 31.7 %, lamellar frequency (LF, min-M-max) – 6.25-(7.12)-8.25, the length of single plate (LSP) – 17.3-(18.99)-21,55, relatively thick enamel (ET) – 1.8-(2.02)-2.18 mm. The plate number is 19-20 in m3 (without talonids), 21-22 with talonids. The incipient lamellar wear figures are of mixed type - from meridionaloid –•–, and intermediate – – – to antiquoid •–•. The remains of this elephant probably come from the so-called "Singil" Middle Pleistocene clays deposited in marsh-lake, estuary or oxbow lake environments, which are exposed at the base of coastal cliffs in the region.

M. chosaricus. The length of M3/m3 crowns of this elephant form exceeds 310-320 mm and the plate number is 22-23 / 20-26 (without talons/talonids) and 24-25 / 22-28 with talons. Index width of crown IW is (n = 8/7) – 36 % / 29.4-33.6 %. LF is 7.25-(7.73)-8.25 / 7.25-(7.59)-8.25, LSP is 13.2-(11.55)-14.3 / 13.5-(12.44)-14.15 mm, ET is 1.7-(1.88)-2.2 / 1.8-(1.96)-2.1 mm. Hypsodonty index (HI) – 1.3-(1.81)-2.3 / 1.3-(1.73)-2.4. The incipient lamellar wear figures are of mixed type – it consists of three roughly equal ovals – – – or, sometimes similar to antiquoid one •–•. The bone findings of this elephant form come from the Khazar fluvial deposits.

M. primigenius ssp. (small form). There are no complete teeth of this form of elephant in collections, what makes it difficult to restore the exact number of enamel plates in the crown. LF at M3 (n=3) is 8.5-(9.56)-11, LSP is 10-(11.02)-12.3 mm, ET is 1.8 mm (average). The incipient lamellar wear figures are of mixed type, it consists of three roughly equal ovals – – – or, sometimes it is similar to antiquoid one •–•. The teeth of that form have a relatively high crown, HI is 1.6-(1.99)-2.2. The remains of these mammoths may come from the lower Upper Pleistocene sediments, so-called Atel deluvial loess loam and sandy loam, and from the synchronized alluvial deposits which are typical for the region.

Elephas (Palaeoloxodon)* cf. *antiquus. The upper M3 of this elephant (n=1) is characterized by a high crown (HI – 2.4), strongly plicate enamel and weakly marked median sinus. The incipient wear figures are of implicit antiquoid type •–•. LF is 7.5, LSP is 13.3 mm, ET is 2.57 mm. The lower m3 of this elephant form (n=4) are narrow and long (the ratio of width to length of crown is 26.3 %) with weak medial sinus and explicit incipient antiquoid type of plate's wear figure •–•. LF is 6.25-(7.12)-8.25, LSP is 12.3-(14.36)-16.1 mm, ET is 1.7-(1.87)-2 mm. The forest elephant probably coexisted with the Trogontherian and Chasarian elephants in the Middle Pleistocene during warm periods, when the deciduous forest landscapes expanded in south of Eastern Europe.

The study of this elephant collection from the Lower Volga Region will contribute to test the validity of *M. chosaricus*, and concepts about the "early" woolly mammoths.

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Biodiversity and stratigraphic distribution of Gomphotheriidae in Eurasia (Kazakhstan)

Piruza TLEUBERDINA ✉

Kazakhstan represents a unique scientific ground for the study of animal world diversity of past epochs. This is related with the geographic position of Kazakhstan in the center of Eurasia. Kazakhstan is a key geographic area for the interpretation of Palearctic evolution of mammals. Until now, finds of Gomphotheres in Asia and Kazakhstan, in particular, are known from the Early Miocene to Early Pleistocene are present a wide geographic range. In Early Miocene of Kazakhstan, Gomphoteriidae were well represented by the "*angustidens*" group. They are known from Kushuk deposits of Tersek suite in precipices of Ulu-Zhilanchik River (right bank), near winter stay Kushuk of Turgai bending flexure. The Kushuk layers have provided a fossil fauna as well as a fossil flora. The fauna is composed by remains of the so called "*Gomphotherium* fauna" with *Serridentinus inopinatus* Boriss., *G. atavus Boriss., Aceratherium depereti* Boriss., *Diaceratherium* (=*Brachipotherium*) *aurelianense gailiti* Boriss., *Testudo turgaica* Rjab. According to Borissiak, this fauna is characteristic of the Early Miocene (Borissiak, Beliajeva, 1928). In Zhilanchic fauna two forms are presented: forms, representing *Trilophodon angustidens* in its primitive stage and very large forms with rather complex teeth. Gomphotheres with trilophodont intermediate teeth were widely distributed form in Burdigalian. They are known from many localities of Europe and Asia, at the beginning of Miocene. It must be noted, that the appearance of first *Gomphotherium*, *Aceratherium* and *Brachypotherium* in Europe, Asia and North America is connected with MN 3-4, what is corresponded to the second half of Early Miocene or Burdigalian. From the bone-bearing lens of Kushuk a xerophitic ancient Mediterranean flora is known, consisted mainly by deciduous forms (about 50 species). On the basis of these finds, the age of Kushuk layers is Burdigalian and corresponds well with the age of the *Gomphotherium* fauna from the same layers. On the South-East of Kazakhstan, *Gomphotherium* is known from deposits of the upper Aktau suite in Aktau Mountain (foothills of Northern Tien-Shan). Jointly with *Gomphotherium* remains the following mammals are found: *Gomphotherium angustidens* (Cuvier), *Brachypotherium aurelianense* (Nouel), *Stephanocemas aralensis* Beliajeva, *Procervulus gracilis* Visl., *Lagomeryx triacuminatus* Colbert, *Prepalaeotragus aktauensis* Godina, Vislobokova, & Abdrakhmanova (Tleuberdina, Abdrakhmanova, Baishashov, 1993).

The presence of *Gomphotherium* and *Diaceratherium (Brachypotherium)* in the Aktau fauna reveals its similarity with the Kushuk one. However, the Aktau fauna is more similar in its artiodactyls composition to Mongolian faunas, what is indicated to close paleozoogeographical relations of the South-Eastern Kazakhstan territory with that of Mongolia during the Miocene. The prevalence in the Aktau fauna of some archaic elements, such as *Gomphotherium angustidens, Brachypotherium aralense, Stephanocemas aralensis* and *Prepaleotragus actauensis* correlates this fauna to the second half of the Early Miocene, corresponding to MN 3-4 zones (Tleuberdina, Abdrakhmanova, Baishashov, 1993). Lenses of aleurite clays have preserved the imprints of a deciduous flora, consisting of 56 species. Gomphotheres are also found in deposits of Bestobe suite, in Ustyurt chinks (small plateau) in Bestobe locality (Western Priaralie). Bestobe represents the easternmost occurrence of the Neogene deposits of Eastern Paratethys. The Bestobe vertebrates fauna is included *Migalea* sp., Talpidae, *Heteroxerus*, Crocodilidae gen.?, *Buteo* sp., Mustelidae gen., Ursidae gen., *Gomphotherium* sp., *Serridentinus inopinatus*, Rhinocerotidae gen.?, *Stephanocemas aralensis, Amphitragulus* sp., *Lagomeryx* sp., *Atlantoxerus* sp. All this complex of vertebrates was found in the layer of micaceous grey sandstones, corresponding to the middle part of the section, jointly with accumulation of *Rzhehakia nuclei*. On Ustyurt plateau, the same thickness of deposits is overlapped by green montmorillonite clays of Kyzylbulak suite (layers with *Grossostrea griptoides*). The Bestobe mammalian fauna, which is deposited in Kotsachurian onkoforic layers (i.e. in marine deposits of upper Lower Miocene of Eastern Paratethys), was very important for the stratigraphy of the Neogene deposits, since it gave the real chance of direct correlation of Ustyurt Bestobe suite with the Neogene Scale of Central and Western Paratethys (Kotsachurian-=Ottnangian=Late Burdigalian). Thus, the stratigraphic distribution of Kazakhstan "*angustidens*" group is regarded within the interval of MN 3-6 (Tleuberdina, Bendukidze, 2005). In Asia, this group has appeared earlier than in Europe and was characterized by considerable diversity. Remains of *G. angustidens* are common in Lower and Middle Miocene deposits of Western and Central Europe. Appeared there first in Burdigalian, roughly at Arthene level (MN 4), Gomphotheres have existed in composition of Miocene complexes mammals up to Tortonian. In Asia, they appeared apparently earlier than in Europe and were represented by various species: *G. atavus, G. inopinatus, G. cooperi, G. palaeoindicus, G. connexus, G. chijiensis, G. annectens, G. spectabilis* and others. Borissiak (1936), on the basis of *Gomphotherium angustidens* from the Lower Miocene of Kazakhstan, has suggested that Asia was a secondary centre of mastodons evolution. Although, the validity of many Asiatic forms needs further investigation, it is possible that all of them belongs to a particular Asiatic branch, not excepting that many of them were actually attributed to 'serridentoid' Gomphotheres. *Gomphotherium* penetrated into America relatively later: according to Osborn (1936) not earlier than in Middle Miocene and according to Tobien (1973), only in Mio –Pliocene times. In Late Cenozoic of Kazakhstan, wide distribution are received the representatives of subfam. Anancinae. The most archaic species out of them is *Anancus kazakhstanensis* Aubek., 1974 (Aubekerova, 1972; Tleuberdina,1982). Its skeleton remains are known from the deposits of Esekartkan and Adyrgan mountains of Tekess depression (Northern Tien-Shan). It differs from earlier and later representatives of *Anancus arvernensis* by the narrow tooth crown, the absence of cement in teeth, the more deep valleys, the location and ratio of main, intermediate and additional tubercles. On the basis of paleomagnetic researches, the bone-bearing horizon in Esekartkan section is situated below the boundary of Gilbert-Gauss epoch, i.e. 3,4 Ma. In the zonal scale of Western Europe, Esekartkan complex corresponds to the uppermost part of MN 15 (Tleuberdina, 2005). According to the late data of International Stratigraphic Scale, the Esekartkan fauna is correlated to Piacenzian level and Adyrgan fauna may be regarded as Gelassian. Later, in Kazakhstan has received distribution *Anancus arvernensis*. The areal of this species has occupied Western and Eastern Europe, Transcaucasian and Kazakhstan. The stratigraphic distribution of Kazakhstan '*arvernensis*' group is considered within the interval of MN 16-17. In Kazakhstan, its remains are known form the deposits of Late Pliocene (Akchagyl-Apsheron) age: at the foot of Northern Tien-Shan hills, in Ili depression, in the southern hills of Dzhungar mountain system, on the bank of Caspian Sea, near Shevchenko town, in Central Kazakhstan, in the basin of Tasty R. (Torgai depression). Thus, Gomphotheriidae in Kazakhstan were distributed from west to east covered the epoch of early Miocene (MN 3-5); representatives of Anancinae flourished in the second half of Pliocene and during the beginning of the Early Pleistocene (MN 15-17).

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Possible cause of death of a juvenile mammoth, called the Yuka mammoth

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Permafrost sediments of northern latitudes have a unique property to preserve skeletal remains of Pleistocene animals, as well as their frozen bodies. The arctic part of Yakutia, where glacial deposits of Yedoma are widespread, belongs to such regions. So far, 15 frozen carcasses are found here, amongst others are mammoths, rhinos, horses, bison etc. (Vereshchagin, 1979; Lazarev, 2008; Boeskorov, et al., 2011). Study of mummified bodies of Pleistocene mammals, preserved in the permafrost, provides a lot of new information, inaccessible during study of ordinary skeletal remains. At the same time, the question on reason of the animal's death, and in general, disappearance of particular population of species, often remains unclear.

In 2010-2011, 3 new frozen carcasses of mammals, including so called "Yuka" mammoth (Fig. 1), were found at the southern coast of the Dmitry Laptev's Strait (Boeskorov et al., 2013). It's the first record of a juvenile *Mammuthus primigenius* of adolescent (puberty) age, 6-11 years old. Radiocarbon age of the Yuka mammoth (about 34.300 BP) corresponds to relatively warm Marine Isotope Stage 3 (MIS-3, Karginian interstadial). Remains of the mammoth are represented by the hide, head with trunk, ears and lips and lower part of carcass almost completely preserved in anatomical position with the remains of internal organs. Deep scratches, likely produced by the cave lion (*Panthera spelaea*) claws, are found on the hide near the occiput, throat, belly and hind legs of the mammoth. But these wounds were not fatal, and the mammoth was not a lion's prey. Otherwise, trunk, lips and internal organs would have been eaten first of all. Young mammoth, being rather large animal (its height at withers reached 165 cm, and living weight estimated about 350-400 kg), apparently could fend off a predator and escape. If large predator's, whether a lion or tiger, first attempt failed to capture a prey, it usually doesn't pursue it (Heptner and Sludsky, 1972; Schaller, 1972). Further it can be assumed that, frightened wounded running away mammoth, lost orientation, fell into pitfall trap, made by Upper Paleolithic Man, or into one of crevices, or permafrost crack, which are often formed in bank outcrops as the result of solifluction. The animal fell down on its head, that probably causing its death, and particularly, preservation of the trunk. Dead animal was found by Upper Paleolithic Man. Probably, they could not get it out of the pit, due to great weight. That is why they cut the hide on carcass and took available upper part of the meat with bones and internal organs of the mammoth. It can be assumed that the animal died in the spring, as evidenced by the absence of subcutaneous fat layer. The remains of animal were naturally buried by silting deposits during spring flooding. And after all, it favored mammoth preservation from predators and subsequent defrost.

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Fig. 1. The Yuka mammoth carcass (partly restored).

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More calf fossils of steppe mammoth (*Mammuthus trogontherii*) unearthed recently from Nihewan (Nihowan) Basin, North China

Hao-wen TONG ✉, and Xi CHEN

The Shanshenmiaozui Site is an Early Pleistocene locality rich in mammalian fossils that was excavated during the past years. The site is located on the south bank of the Sangganhe River (40˚13′ 08"N; 114˚ 39′ 54"E) and is nearby Xiaochangliang, a well-known Paleolithic site. The preliminary study shows that the fossils from the new locality belong to the following taxa: *Lepus* sp., *Ochotona* sp., *Canis chihliensis*, Felidae gen. et sp. indet., *Pachycrocuta* sp., *Mammuthus trogontherii*, *Coelodonta nihowanensis*, *Elasmotherium* sp., *Proboscidipparion* sp., *Equus sanmeniensis*, *Sus* sp., *Eucladoceros* sp., *Spirocerus* sp., *Gazella sinensis*, *Bison palaeosinensis* etc. (Tong et al.,

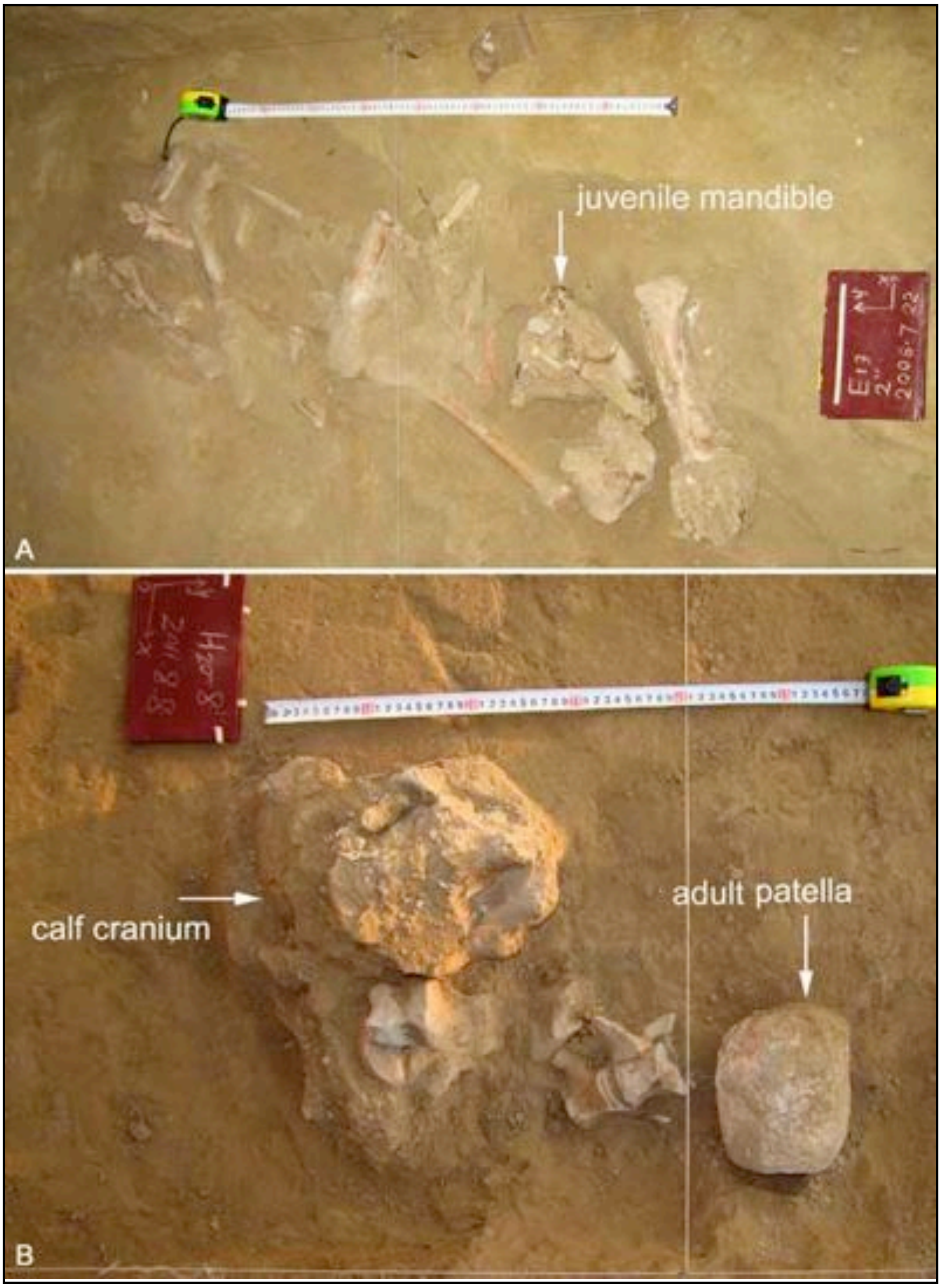

Fig. 1. A, Juvenile mandible of *Mammuthus trogontherii* was exposed at the Shanshenmiaozui Site in Nihewan Basin in 2006; B, Cranium of calf *Mammuthus trogontherii* was exposed in situ in 2011.

2011), all of which represent the principal elements of the Nihewan Fauna (sensu stricto) (Teilhard de Chardin and Piveteau, 1930). Preservation conditions and taxa diversity suggest this new locality is the best site ever excavated in the Nihewan Basin during the past half-century.

The recent stratigraphic survey indicates that the Shanshenmiaozui Site can be correlated with the palaeolithic layer of the Xiaochangliang Site, and has a geologic age of ca. 1.3 Ma B.P. according to magnetostratigraphic results (Zhu et al., 2001). In a wider however scale, the Nihewan Fauna (sensu stricto) is comparable to the Olivola Fauna of Europe (Qiu, 2004).

Although numerous juvenile specimens, including skulls and deciduous teeth, of the true woolly mammoth (*Mammuthus primigenius*) have been reported before (Maschenko, 2002), few of such kind of fossils have ever been discovered for the early mammoth species, including *Mammuthus meridionalis* and *Mammuthus trogontherii*. Fossil records of adult *Mammuthus trogontherii* are already well-known (Guenther, 1969; Lister and Stuart, 2010; Athanassiou, 2012), but the DP2 and DP3 of this species were completely unknown (Mol and Lacombat, 2009) since the discovery of the Shanshenmiaozui Site in the Nihewan Basin. Since the report of the juvenile mandibles and the associated lower deciduous teeth of *Mammuthus trogontherii* (Tong, 2012), some more specimens, including an almost complete calf skull with the DP2 and DP3 of both sides preserved in situ, have been recovered from the Shanshenmiaozui site. This specimen represents therefore a first discovery for the species *Mammuthus trogontherii*. Though previous scholars proposed that the Nihewan Basin would be the origin center for *Mammuthus trogontherii* (Wei et al., 2003), the so far studied fossil material was rather insufficient. For that reason, the newly discovered skull specimens at Shanshenmiaozui Site are of great importance in the study of the origin of steppe mammoth, as well as in the reconstruction of the phylogenetic relationships within the mammoth lineage. In addition, the juvenile dominated proboscidean fauna is also important for taphonomic studies.

During the Quaternary Period, the proboscidean taxa were quite diversified in the Nihewan Basin (Tong, 2010a, 2010b), which is very helpful for the evolutionary and biostratigraphic studies in the Nihewan Basin.

Because of the rareness of deciduous teeth for the early mammoth species, the comparative studies have been limited to *Mammuthus primigenius* and the two living elephant species. The study shows that both the upper and lower DP2s of *Mammuthus trogontherii* are more elongated than that of *Mammuthus primigenius*, whereas the DP3 has less lamella (or plate), and is less hypsodont than that of *Mammuthus primigenius*. The comparative study of skull and dental morphology also show that the newborn calves of the elephantids, including different extinct mammoth species as well as the extant *Elephas* and *Loxodonta*, are very close to each other; but in adult stage, they are distinctly different.

The Shanshenmiaozui site is extraordinarily rich in juvenile large mammals, including juvenile horses, woolly rhinos, steppe mammoths and large bovids. On the contrary, the only dominant carnivore taxon, *Canis chihliensis*, is exclusively composed of adult individuals (Tong et al., 2012). It's still open to discussion whether the Shanshenmiaozui Fauna is a human-hunted assemblage or a wolf-collected assemblage.

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Megafaunal split ends: microscopical characterisation of hair structure and function in extinct woolly mammoth and woolly rhino

Silvana TRIDICO ✉, Paul RIGBY, K. Paul KIRKBRIDE, James HAILE, and Michael BUNCE

The large extinct megafaunal species of the Late Pleistocene, *Mammuthus primigenius* (woolly mammoth) and *Coelodonta antiquitatis* (woolly rhino) are renowned for their pelage. Despite this, very little research has been conducted on the form and function of hair from these iconic species. Using permafrost preserved hair samples from seven extinct megafaunal remains, this study presents an in-depth microscopical characterisation of preservation, taphonomy, microbial damage, pigmentation and morphological features of more than 420 hairs (Tridico et al. 2014). The presence of unique structural features in hairs, from two extinct megafauna species, such as multiple medullae and unparalleled stiffness suggests evolution of traits that may have been critical for their survival in the harsh arctic environment. Lastly, despite popular depictions of red-haired and/or uniformly coloured mammoths, a closer examination of pigmentation reveals that mammoth coats may have exhibited a mottled/variegated appearance and that their 'true' colours were not the vivid red/orange colour often depicted in reconstructions. Insights gained from microscopical examination of hundreds of extinct megafauna hairs demonstrate the value of extracting as much morphological data as possible from ancient hairs prior to destructive sampling for molecular analyses.

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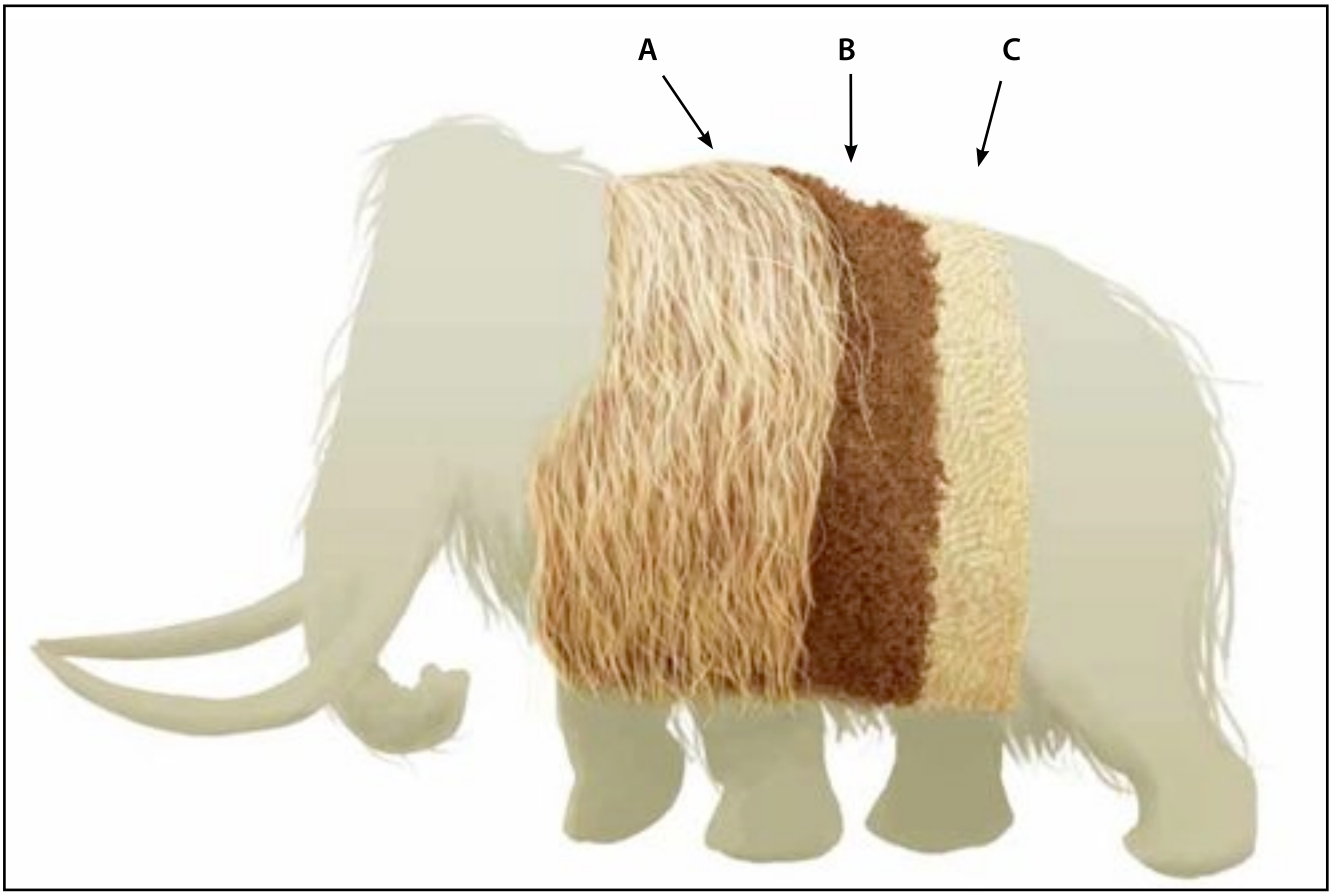

Fig. 1. Illustration showing a 'deconvoluted' view of extinct megafauna coats, based on the hairs examined in the present study. (**A**) The outermost hairs were colorless and devoid of pigmentation , these were very light (flyaway) and felt like fishing line, (**B**) shows the next layer of hairs which would be exposed (if the outermost hairs were pulled aside). These hairs showed a range of colors ranging from light, medium and dark brown; in addition to the uniformly colored hairs, some were variegated along the shaft (not shown). (**C**) shows the final, insulating, layer of hairs which which were essentially colorless and very wavy and formed the bulk of the coat.

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Taphonomy of *Stegodon florensis* remains from the early Middle Pleistocene archaeological site Mata Menge, Flores, Indonesia

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Mata Menge is an open-air fossil and stone artefact locality dating to the early Middle Pleistocene of Flores, Indonesia. It is situated on the western margins of the So'a Basin, a ~200 km2 depression in the central part of the island. The site forms part of an up to 100 m thick sequence of primary and secondary volcaniclastic and lacustrine deposits dated to between 1.8 and 0.65 Ma (Sondaar et al. 1994; O'Sullivan et al. 2001; Brumm et al. 2010). Current best age estimates for the Mata Menge fossil deposits were obtained using the fission-track method and fall between 0.88 and 0.8 Ma (O'Sullivan et al. 2001). Recent research suggests that hominin occupation of the basin extends back to at least 1 Ma (Brumm et al. 2010) and there is proxy evidence for hominins (stone artefacts) until ~700 Ka (O'Sullivan et al. 2001). In fact, the So'a Basin hominins are the most likely ancestral candidates for *Homo floresiensis*, the diminutive hominin from the Late Pleistocene of western Flores.

More than a decade of large-scale excavations at Mata Menge have yielded an insular vertebrate fauna consisting of the intermediate-sized *Stegodon florensis*, a giant rat (*Hooijeromys nusatenggara*), Komodo Dragon (*Varanus komodoensis*), crocodile, birds and frogs. To date, ~10,000 fossil elements have been excavated from the site. In addition, over 3000 stone artefacts were recovered in direct association with the fossils (Brumm et al. 2006; Aziz & Morwood 2009; van den Bergh et al. 2009). These artefacts provide clear evidence for hominin activity at Mata Menge. Despite this, it remains uncertain whether hominins played a significant role (or any role) in the accumulation of fossil fauna at the site, in particular *Stegodon*. The current research is aimed at addressing this problem.

The *Stegodon* bones are mainly concentrated in three successive sedimentary units: a homogeneous sandstone, fine-grained tuffaceous silts, and a cross-bedded fluviatile deposit. The majority of the *Stegodon* remains are highly fragmentary and none of the *Stegodon* bones were found articulated in the above-mentioned contexts. Previous studies have shown that fluvial transport has been responsible for selective loss of the smaller and easily transportable bones such as carpals (van den Bergh et al. 2009). No clear cut-marks have been found, and most of the bone breakage appears to have occurred postmortem on dry bone, although helicoidal fractures are also present. Bone preservation is highly variable, including well-preserved fresh bone appearances, but also rounding due to fluvial transport, presence of various stages of cortical bone weathering, rooting by plant roots and dissolution features.

Due to the large amount of fossil material, we conducted a preliminary taphonomic study on a sub-sample of the fossil assemblage, consisting only of the *Stegodon* dental

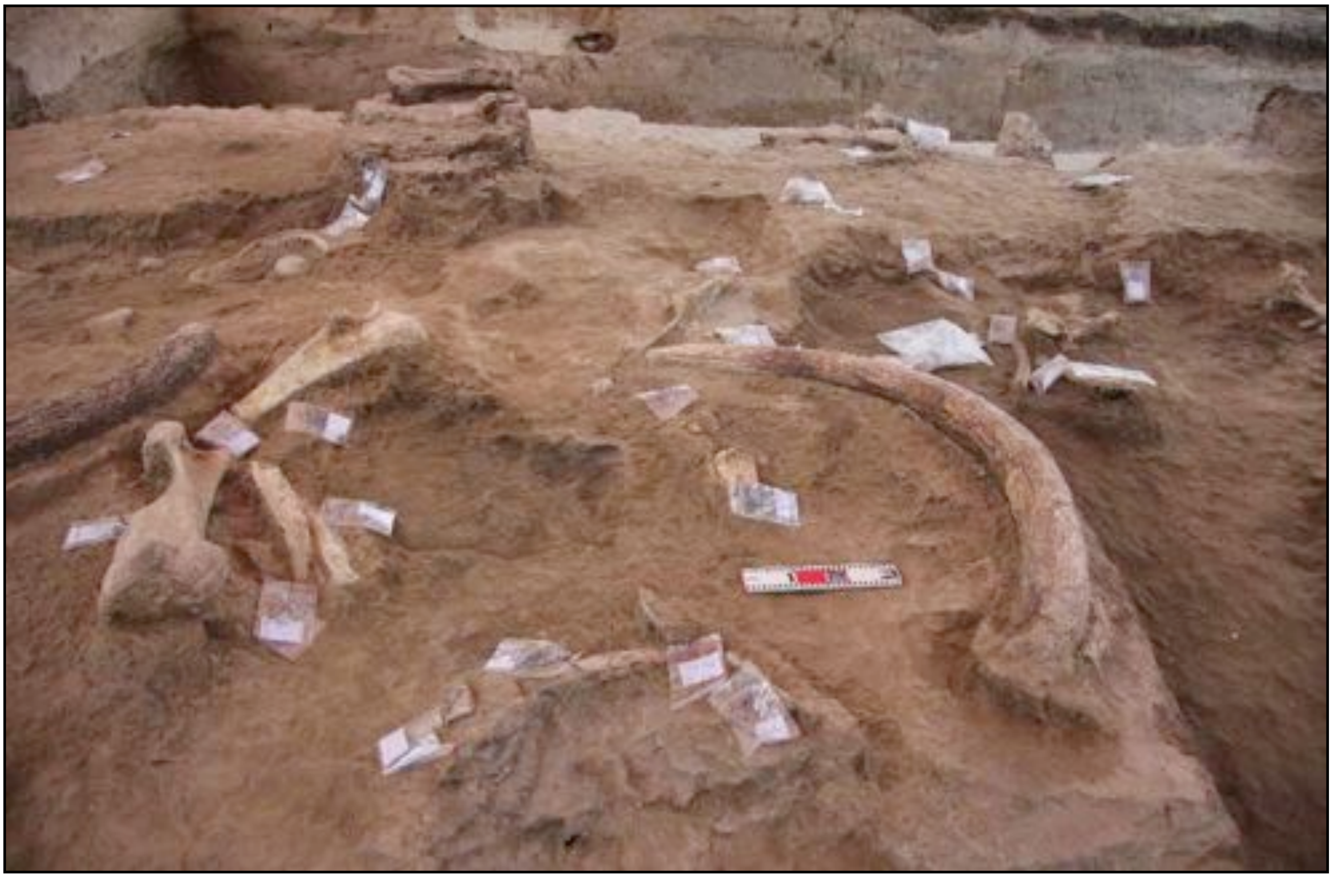

Fig. 1. *Stegodon florensis* bone accumulation at Mata Menge.

material from Mata Menge (excluding tusks and numerous smaller tusk fragments), as well as all mandible and maxilla material. Earlier work at Mata Menge indicated that the dental remains provide the best estimate of the Minimum Number of Individuals (MNI) (van den Bergh et al. 2009) as the dental enamel is more resistant to post-mortem alteration.

Analysis of the dental remains indicates an MNI of at least 120 individuals of all ages. The larger males could be distinguished from the more abundant female adult individuals based on the size differences of mandibles. The age profile of the death assemblage (based on molar wear stages) corresponds with that of a living population, indicative of non-selective mortality affecting individuals of all size classes. This usually points to a catastrophic event that killed-off an entire population. Although some evidence for this is provided by the volcanic origin of the surrounding deposits, Mata Menge lacks primary volcanic units that could have caused mass-death events, such as pyroclastic flows or air-fall tephra deposits.

Our results suggest that *Stegodon* carcasses at the site were probably not entirely covered over with volcanic tuff, but seem to have been exposed on the surface for extended periods and later transported by flowing water prior to their final burial. *Stegodon* carcasses lying about on the surface may have attracted hominins and the top reptilian predators in the basin (Komodos and crocodiles), but so far there is no clear evidence that hominins butchered *Stegodon* remains. Importantly, the stone artefacts, of which ~35% are slightly abraded and 13% heavily abraded (Brumm et al. 2006), have largely been transported by the same agents as the bones, although the occurrence of larger stone tools in fine-grained tuffaceous silt deposits would be harder to reconcile with fluvial transport.

In sum, we cannot rule out the possibility that hominins played a role in the accumulation of fossil remains at Mata Menge, but our findings suggest – somewhat counter-intuitively – that this was unlikely. It may be the case that the spatial juxtaposition of stone artefacts and *Stegodon* remains at the site was largely accidental. Further research is needed to explore the link between *Stegodon* fossils and hominin activities at Mata Menge.

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Why are there no giants at the dwarf's feet? Insular micromammals in the eastern Mediterranean

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Dwarfed proboscideans are probably the most spectacular example of island evolution, with the 120 cm tall *Palaeoloxodon falconeri* from Sicily as prime example. Also the islands of the Aegean housed elephant species with a much reduced body mass, such as *Mammuthus cretensis* and *Palaeoloxodon creutzbergi* (Crete), *Palaeoloxodon tiliensis* (Tilos), *Palaeoloxodon cypriotes* (Cyprus) and a new species of *Palaeoloxodon* from Naxos (Van der Geer et al., submitted). Not all size changes in proboscideans are equally spectacular. *Palaeoloxodon creutzbergi* from Crete was about 50% the size of its presumed mainland ancestor, whereas the other Aegean species dwarfed to less than 10% of the ancestral size (Lomolino et al., 2013).

Insular micromammals also show adaptations in their body size (Foster, 1964). They tend to grow larger on islands and here, too, the size changes can be quite spectacular. In contrast to the proboscideans, some of these insular forms still survive today, such as *Papagomys* on Flores (Locatelli et al., 2012) and *Phloemys* on the Philippines. Examples of insular giants in the Mediterranean are only known from the fossil record, but they are many and varied. Giant glirids include *Hypnomys* (Baleares), *Stertomys* (Gargano), and *Maltamys* and *Leithia* (Sicily, Malta). Giant murids comprise *Anthracomys* (Tuscany), *Mikrotia* (Gargano) and *Kritimys* (Crete). Giant lagomorphs are the giant rabbit *Nuralagus* and the giant pikas *Gymnesicolagus* (Balearics) and *Prolagus imperialis* (Gargano). Other families have fewer examples of spectacular gigantism: the giant hedgehog *Deinogalerix* and giant hamster *Hattomys* (Gargano) and the giant shrew *Nesiotites* (Balearics). Some of these genera (*Mikrotia, Stertomys*) show an adaptive radiation, in which lineages of different body size live together. This phenomenon is also known from Flores; the different endemic murids of the island presumably belong to a single clade (Locatelli et al., 2012).

Whereas gigantism, often accompanied with adaptive radiation, is a common feature in insular micromammals, it is conspicuously absent in the eastern Mediterranean. Admittedly, *Kritimys* must be considered a giant rat, well larger than the Brown Rat and likely about four times the mass of its ancestor (Lomolino et al., 2013). As Mayhew (1977) determined, there is no indication of a radiation within the genus. In contrast, the geologically younger *Mus minotaurus* was only about 20% larger than the house mouse *M. musculus* (Mayhew, 1977). Moreover, the mouse from Cyprus, *Mus cypriacus*, wasn't even recognised as an endemic until DNA-analyses proved it to be a separate species (Cucchi et al., 2006). The mouse that co-occurs with the new dwarf proboscidean from Naxos turned even out to be a mainland species, *Mus mystacinus* (Van der Geer et al., submitted). Apart from the near lack of extreme gigantism, it is remarkable that murids did not show any speciation on Crete, whereas the island was large enough to support an entire adaptive radiation of deer.

The clues behind the absence of gigantism in the eastern Mediterranean are:

1) Spectacular gigantism in Late Pleistocene rodents in the Mediterranean is only found in dormice (*Hypnomys, Maltamys, Leithia*). The family never successfully colonised the Aegean islands.

2) The only clearly enlarged murid in the area, *Kritimys*, belongs to the early Middle Pleistocene.

3) Giant murids that show an adaptive radiation with different sizes are restricted to the Late Miocene of the Mediterranean (Gargano) or the Tropics (Flores, Philippines).

Mayhew (1977) already indicated that climate was a major factor in the size changes of the insular rodents from Crete. We concur, but the process is just the opposite of what he proposed. Climatic conditions favoured the smaller, r- select species. Dormice, because of their capability to hibernate or go into torpor during unfavourable circumstances, are better equipped to deal with harsh winter conditions than murids. The latter still needed to invest in high reproduction rates in order to survive, rather than go into a K-select mode with larger bodies. Size differentiation is the main driver behind adaptive radiation, and hence the lack of possibilities for attaining large body sizes also blocked the opportunity for adaptive radiations.

We learn to understand rules by their exceptions. In this regard, the absence of insular giants on the Aegean Islands provides a valuable insight into the process of insular evolution.

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Radiocarbon and fossil bones: what's in a date

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The Radiocarbon method was developed around 1950 by W.F. Libby, who received the Nobel Price in chemistry for this important discovery in 1960. The method became the main chronological dating tool for many disciplines. Organic matter such as fossil bones can be directly dated by a physical measurement, rather than by cultural, stratigraphic or other inferences. The method is obviously also of crucial importance for dating mammoth bones. But this is often hampered by the dating range which is limited to roughly 50.000 years ago. The method is also admittedly sensitive to contamination of foreign material. For paleontology, dealing mostly with pre-Holocene bones, both age range and contamination can easily result in problematic dates; methodological problems amplify for dates closer to the dating limit, as well as for degraded sample materials. The result is that the validity of the ^{14}C method for Late Pleistocene samples is often questioned, in cases when the outcome is not what is expected. But whether this is justified is not always clear.

In terms of sample integrity, there are good bones and bad bones; likewise, there are good dates and bad dates. Unfortunately, there is no simple one-to-one correlation between these. The aim of this contribution is to shed some light on the matter, discuss methodological aspects and pitfalls. The datable fraction for bones is the organic collagen. The inorganic bioapatite usually produces only good dates for samples which do not exchange carbon with the environment. In practice this is (not degraded) tooth and tusks. For bone collagen, quality parameters are the content of Carbon and Nitrogen, their C/N ratio, and the stable isotope ratios for ^{13}C and ^{15}N. The parameter values are derived from fresh and pristine bone.

Bone chemistry and contamination are a main issue. Collagen preparation follows similar procedures in the ^{14}C laboratories. Recently, additional purification (the so-called ultrafiltration) was introduced, with the purpose of removing contaminants not removed by the standard chemical protocols. Not all laboratories use this method, because their effectiveness can be questioned. This is hotly debated, in particular concerning Palaeolithic human bones (modern humans and Neanderthals). Problematic young dates became older after applying filters, making archaeologists happy, justified or not. On the other hand, inter-laboratory tests (with and without filters) show that good quality bones usually yield similar dates, within error. Backgrounds is another key issue. The "blanks" of the laboratory are usually determined by measuring samples of infinite age. Traditionally this is anthracite, which is of geological age and thus infinite for the ^{14}C method. Nevertheless ^{14}C counts will be registered; they are there because the sample treatment can not be made completely 100% ^{14}C-free. These "noise registrations" determine the blank or background and correspond to ^{14}C ages of about 50.000 BP. Anthracite works fine for the majority of samples in the practice of ^{14}C dating: botanical samples. But also for old bone? Infinitely old charcoal is not the same as infinitely old bone, the latter being the ideal blank. For the Groningen laboratory, bones known to be much older than the ^{14}C range measure 45.000 BP which then is the background for bones, whereas the background for charcoal is 50.000 BP. The consequence: a bone can yield a date of 47.000 BP when charcoal is taken as the blank, while in reality it is older than 45.000 BP (thus can also be, for example, 100.000). Why not take infinitely old bone as background? This does not help, because this requires good quality old bones (for example from the permafrost). And this is not a good blank for bones preserved under completely different conditions, like on the bottom of the North Sea.

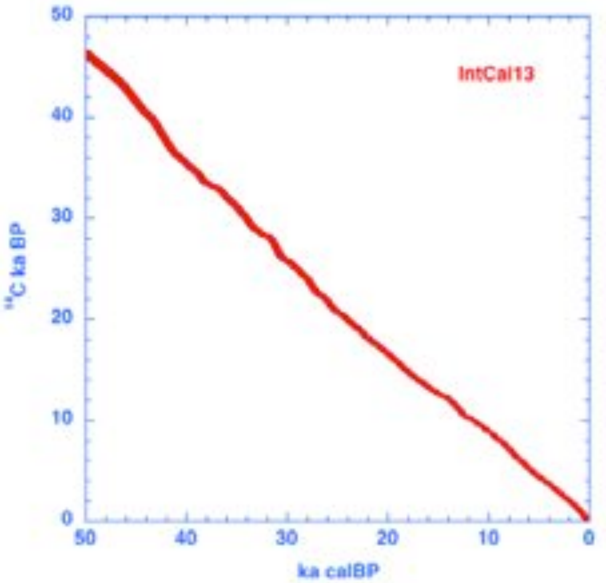

Fig. 1. The Radiocarbon calibration curve Intcal13.

A similar issue is known for fossil shells, creating complications and confusion on dating issues from the marine environment. This is the case for the North Sea, obviously a marine environment today, but a dry area during the last ice age. It was part of the mammoth steppe at the time, so that many faunal remains (predominantly mammoth and rhinoceros) are recovered today. Carbon exchange easily causes ^{14}C dates of 35.000 BP for infinitely old shells, depending on the shell species. Therefore, comparing ^{14}C dates for shells and fauna is a classic case of comparing apples and oranges for the oldest part of the ^{14}C dating range.

At present, all ^{14}C laboratories participate in a cross-check program known as SIRI (Sixth International Radiocarbon Intercomparison). This is expected to shed light on some of the issues raised above. A final chronological issue for dates towards the end of the ^{14}C range is calibration. The natural ^{14}C content is varying through time, which causes the ^{14}C timescale to be different from the real calendar. Beyond the Holocene, this difference can be several millennia. We know this because of calibration: the comparison of ^{14}C dates with independent dates for the same sample. The classic method for this is tree-ring analysis: wood dated by both dendrochronology and ^{14}C. But this stops beyond the Glacial/Holocene boundary.

During recent years, however, remarkable progress has been made, resulting in a newly developed calibration curve for the complete 50.000 years. It is based on mainly laminated sediments containing ^{14}C datable samples. The curve is called IntCal13, and is approved by the ^{14}C community for general use (Reimer et al., 2013). The calibration curve is shown in the figure above. The vertical axis shows the ^{14}C ages (in thousands of BP), the horizontal axis the calendar ages (in thousands of years calBP, i.e. relative to 1950 AD).

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Cause and timing of late Early – early Middle Pleistocene European mammoth turnover with special emphasis on Hungary

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During the period between 1.0-0.7 Ma, the climate became drier and colder, consequently the forested areas were rolled back and the steppe vegetation was expanded in Europe. The process begun in the Eastern margin of the continent (e.g. at Taman Peninsula or at the lower Don River area; Tesakov, 2008 and Shchelinsky et al., 2010), and coincided with the first immigration of the steppe mammoth (*Mammuthus trogontherii*), which progressively replaced the indigenous *Mammuthus meridionalis* (often associated with closed habitats). The transition between the two species in Europe was achieved by input from Eastern Asia, either in the form of migrating herds or by gene flow without the long distance movement of individual animals (Lister et al., 2005).

Micromammal assamblages from Russia (Sarkel and Sinyaya Balka) indicate mosaic environment combining closely spaced steppe-like (*Spermophilus, Spalax, Allocricetus, Cricetulus, Cricetus*), wooded (*Sorex, Apodemus, Clethrionomys*), meadow (*Desmana*), and desert (*Plioscirtopoda*) biotopes under conditions of relatively warm climate. At the Taman Peninsula, both *M. meridionalis* and *M. trogontherii* are documented (third molars with low tooth crown and 14-15 plates and third molars with 16-19 plates and higher crown). Van Essen (2011) mentioned some individuals, which show mosaic characteristics (low crown and high plate number) due to the hybridization of the overlapping *M. meridionalis* and *M. trogontherii* populations in such a mosaic environment. At the same time, *M. trogontherii* was absent from the central and western part of Europe (e.g. Saint-Prest, France, where the large mammalian community indicates an open forest landscape under a temperate wet climate; Guerin et al., 2003).

The older layers of the rich 900 ka micromammal fauna from the Somssich Hill 2 locality (South Hungary) are characterized by the dominance of *Lagurus* and cricetids (mainly *Cricetus runtonensis*), which are indicators of probably the oldest known open steppe vegetation of Hungary. In contrast, mice (*Apodemus*), dormice (*Glis, Muscardinus, Dryomimus*) and the dominance of voles like *Pitymys*, *Myodes* and *Pliomys* in younger parts of the section are indicative of warmer, more humid climate and more closed (shrubby or forested) habitats (Pazonyi et al., 2013). *M. trogontherii* remains has not been found so far from this period in Hungary.

The 800 ka micromammal fauna of Villány 8 (South Hungary) indicates mosaic environment with the co-occurrence of both steppe (e.g. *Spermophilus, Spalax, Cricetus, Allocricetus, Prolagurus*) and forest elements (e.g. *Sorex, Apodemus, Myodes*) (Jánossy, 1986).

About 800-700 ka, the opening of the vegetation reached Western Europe. The first *M. trogontherii* remains in the central and western part of the continent can be dated to the beginning of this period, nevertheless, contemporaneously *M. meridionalis* populations were also

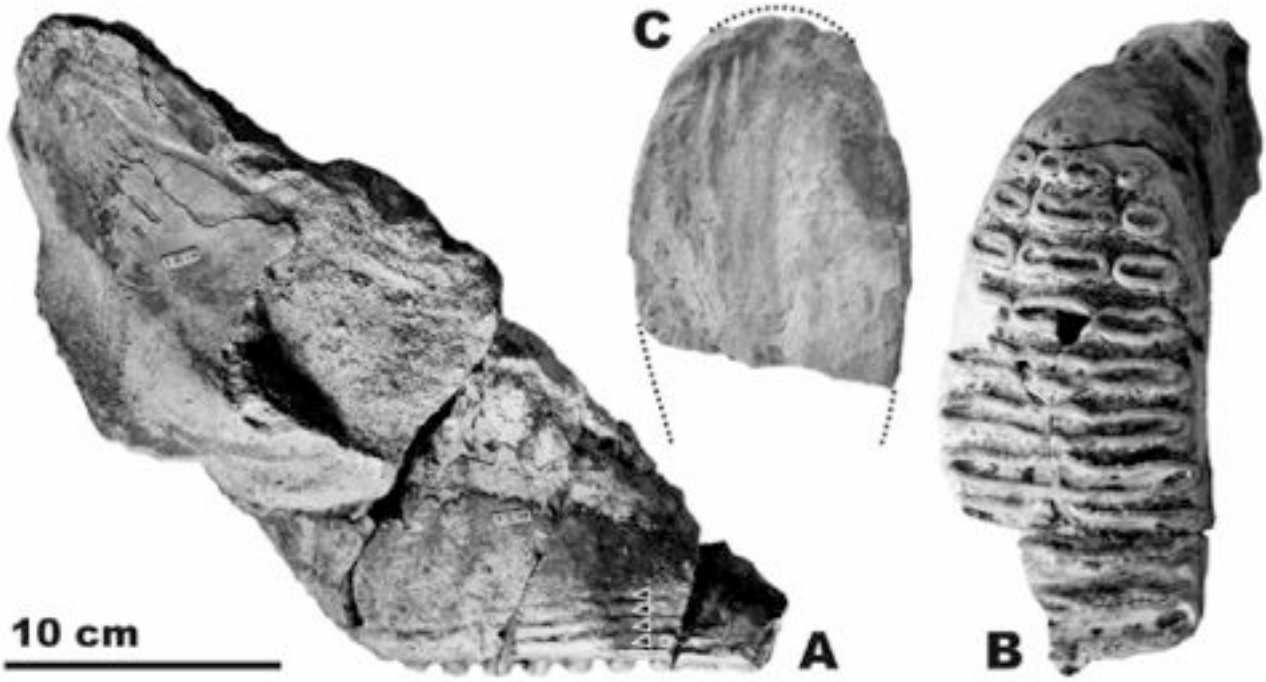

Fig. 1. *Mammuthus trogontherii* upper left third molar (Hungarian Natural History Museum, V.72.116) from Üröm Hill (North-Hungary) from lingual (**A**) and occlusal (**B**) view. **C**, posterior view of a plate in midcrown area. The arrows on A indicate well-developed cement furrows.

documented in the region (e.g. from Győrújfalu in Hungary or from the Ponte Galeria Formation in Italy, and from Dorn-Dürkheim 3 in Germany; Palombo & Ferretti, 2005 and van Essen, 2011). Despite the slight recovery of closed vegetation, *M. meridionalis* almost entirely disappeared from Europe by the end of this period. Only the remains of hybrid individuals support, that the last representatives of the species had to be present in some refugia at that time. Such mosaic specimen (an upper third molar with a reconstructed plate number of 17 or even 18 and relatively high crown but with plesiomorph enamel, thicker than 3.0 mm, see Fig. 1. and Virág, 2009 for details) was found at the 800-700 ka locality, called Üröm Hill (North Hungary). Similar specimens turned out from Campo del Conte in Italy (although Palombo et al., 2003 identified the molar as *M. meridionalis*) or from Voigtstedt and Edersleben in Germany (van Essen, 2011).

The fauna of Üröm Hill mainly contain hygrophilous taxa (like *Desmana thermalis*, *Mimomys savini* or *Hippopotamus antiquus*) and the micromammal fauna of the contemporaneous Kövesvárad locality (North Hungary) unequivocally indicate warm, humid climate and closed, forested vegetation with the dominance of dormice (*Glis, Muscardinus*) and forest voles (*Myodes*) (Jánossy, 1986). Similar warm-temperate conditions with mainly forest elements and scanty open landscape indicators (such as *Spermophilus*) are typical for Voigtstedt (Maul & Parfitt, 2010).

By 600 ka, only *M. trogontherii* occurred in Europe, as at Süssenborn (Germany), the type locality of the species (Lister et al., 2005). The extinction of the *M. meridionalis* populations was most plausibly triggered not solely by the immigration of the steppe-adapted, grazer *M. trogontherii* from Eastern Asia, but the arrival of the browser or mixed-feeder *Elephas antiquus* from Africa through the Levant, which happened broadly 900-800 ka (Albayrak & Lister, 2012). The earliest occurrence of the latter species in Hungary is most plausibly Győrújfalu. Following this period, *E. antiquus* has unfortunately very scanty record in Hungary.

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Taxonomic identification of mammoth molars based on enamel microstructure

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Enamel matrix is secreted by a closely linked sheet of cells (ameloblasts) that differentiate from the internal enamel epithelium of the tooth (Dean, 2006). Enamel maturation involves removing the protein and water content of the original matrix, and increasing the size of the crystallite nuclei deposited during matrix production. As a consequence of the latter processes, mature enamel becomes heavily mineralised, and so, normally the best preserved of hard tissues (Hillson, 2005 and Ungar, 2010).

The enamel crystallites are usually organised into approximately 4-12 µm wide bundles, which are called prisms. These prisms almost never run straight through the enamel which is achieved by a coordinated movement of ameloblasts within the internal enamel epithelium. According to Hillson (2005), this complex arrangement makes the enamel stronger and gives the worn surface particular characteristics that enable it to function in grinding or cutting.

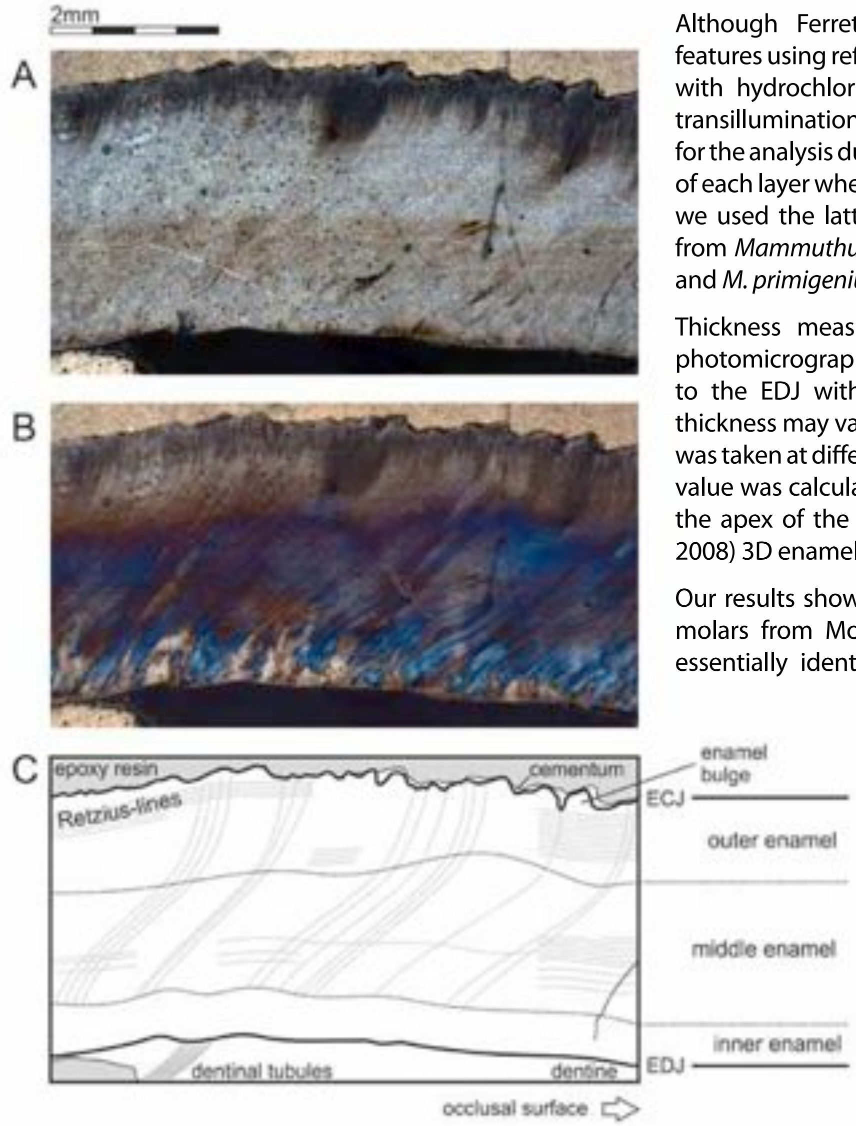

Fig. 1. Sagittal thin section of the enamel of a *M. rumanus* right upper third molar from Cernăteşti (Romania). The photographs were made using transillumination without (**A**) and with (**B**) crossed Nicol prisms. **C**, schematic representation of the section. The brown striae of Retzius are marking out the former successive positions of the matrix-forming front.

Abbreviations: **ECJ**, enamel cementum junction, **EDJ**, enamel dentine junction. Scale bar equals 2 mm.

Based on the shapes, orientations and packing patterns of the adjacent prismatic bundles, the enamel of the elephantids can be separated into four different layers (Ferretti, 2003). Adjacent to the enamel dentine junction (EDJ), there is a part in which the orientation of the prisms makes an irregular impression. This part is often called inner or 3D enamel. In the next layer, the prisms are rising concordantly towards the outer surface of the enamel. The boundary between this middle and the third layer is marked by a sudden decrease of the inclination of the prisms, which become parallel to the occlusal plane. Right before the enamel cementum junction (ECJ), there is a thin, fourth layer which lacks prismatic organization. Since this prismless part is often hardly distinguishable from the previous layer under relatively low magnification, it was treated here together with the latter (as outer layer) during the measurements discussed below. The ECJ is heavily wrinkled, and the enamel can often be seen to bulge along the boundary plane.

Although Ferretti (2003) examined the same enamel features using reflected light microscopy on sections etched with hydrochloric acid, Vasile et al. (2012) showed that transillumination of sagittal thin sections is also applicable for the analysis due to the difference in the optical properties of each layer when viewed under crossed Nicol prisms. Here, we used the latter method on enamel samples detached from *Mammuthus rumanus, M. meridionalis, M. trogontherii,* and *M. primigenius* molars found in Hungary and Romania.

Thickness measurements of the layers were taken on photomicrographs of the sections along a line perpendicular to the EDJ with the usage of ImageJ software. As the thickness may vary locally, a minimum of 10 measurements was taken at different sites on each section, and then a mean value was calculated for each specimen. The enamel cap at the apex of the tooth cones where (according to Ferretti, 2008) 3D enamel is absent were avoided during sampling.

Our results showed that the enamel microstructure of the molars from Montopoli (see Ferretti, 2003 for details) is essentially identical to the type material of *M. rumanus* from Tuluceşti and Cernăteşti (Romania) and a *M. rumanus* specimen from Ócsa (Hungary). The inner layer makes up 15-16%, the middle makes up 50-55% and the outer makes up 30-35% of the total enamel thickness. Based on molars from e.g. Aszód, Szomód, or Dunaalmás in Hungary, an approximately 4-5% relative thickening of the middle layer at the expense of the outer one is characteristic for mammoths from the beginning of the Early Pleistocene (former MN17 Biozone). Typical *M. meridionalis* remains (such as the type material from Upper Valdarno, see Ferretti, 2003 for details) show additional 5% relative thickening of the middle layer which was compensated by the further thinning of the outer layer. The type material from Süssenborn (Ferretti, 2003) and the specimens from several contemporaneous or younger Hungarian localities (e.g. Visonta, Ercsi, Kiskunlacháza and Kecskemét) prove that the enamel evolution continued in the case of the *M. trogontherii*. According to our data, the middle layer of the latter species makes up 2-3% more of the full enamel thickness than in the case of the latest *M. meridionalis* populations, whereas the inner layer is proportionately thinner. The middle layer of *M. primigenius* samples (from e.g. Tiszalök and Fegyvernek in Hungary) makes up even 70-80% of the full enamel thickness which means additional 5-10% thickening related to the *M. trogontherii*. This was compensated by the approximately 5% thinning of both the inner and the outer layer separately. The inner layer makes up roughly 5%, whereas the outer makes up 10-20% of the total enamel thickness in the case of *M. primigenius* samples.

During the more than 2.5 million years of evolution of the Eurasian mammoth lineage, the molar morphology underwent several important changes, such as the multiplication of the plates forming the tooth, the heightening of the crown, and the thinning of the enamel. All of these processes are usually considered as a probable adaptation to a progressively predominant grass diet (see Maglio, 1973 or Virág et al., 2014). According to Ferretti (2008), decussating prisms (e.g. in the inner layer) enhances resistance to crack propagation in the enamel of teeth subjected to high occlusal stresses, whereas occlusally rising prisms (e.g. in the middle layer) are more resistant to abrasive wear. Therefore the above discussed evolution of the inner structure of the enamel (i.e. the proportional thickening of the middle layer, in which the prisms are angled to the occlusal surface, at the expense of the less resistant parts) can be interpreted as an adaptation which kept the rate of wear to a minimum as the whole enamel had become thinner and the diet had become more abrasive. As consequence of this process, the relative thicknesses of the enamel layers slightly differ in the case of each successive species, therefore the analysis of the inner enamel structure could contribute to intrageneric systematics by allowing the rapid, although coarse categorization of mammoths from even a small fragment of a molar.

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Palaeodietary reconstruction of fossil proboscideans from Hungary and Romania

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According to Maglio (1973) the emergence of elephantids from Miocene gomphotheres reflects an adaptive shift in their method of chewing, which helped to process a newly available food source, grass. Since the latter is more abrasive than leaves, it provided a selective force on the evolution of tooth crown height. Although this assumption is widely accepted, it is not yet properly confirmed and only few studies dealt with the alimentary habits of the successive species so far (e.g. Rivals et al., 2012).

The oxygen isotopic composition of phosphate in enamel of homoeothermic obligate drinkers is directly related to the $\delta^{18}O$ of body water, which is related to the $\delta^{18}O$ of ingested water. The latter can be linked to the isotopic composition of the local meteoric water, which shows significant correlation with mean annual temperature (MAT). The carbon isotopic composition of molars of herbivorous mammals reflects the photosynthetic pathway of the consumed plants (with a 14.1‰ offset according to Cerling et al. 1999), hence indirectly the paleoflora. As a consequence, the isotopic composition of molar enamel can be interpreted as an archive of dietary and climatic information. In addition, since the phosphate and carbonate are cogenetic oxygen-bearing phases in isotopic equilibrium with the same reservoir (body water) at the same temperature (37°C for mammals), a linear correlation exists between the $\delta^{18}OPO_4$ and $\delta^{18}OCO_3$ values. Due to this fact, coupled measurements can be used for obtaining information about post-mortem alteration effects (Iacumin et al., 1996). As an independent proxy, the microwear pattern of enamel was examined, which is attributed to the interaction during mastication between tooth and abrasives. The microwear tracks are represented in browsers by more circular wear features (pits) and fewer elongated ones (scratches), whereas the opposite is true for grazers.

The present study is based on samples taken from molar teeth of *Mammuthus meridionalis*, *M. trogontherii*, *M. primigenius*, and *Elephas antiquus* from Hungary and *Mammuthus rumanus* (including the holotype) from Romania. Samples from *Deinotherium*, *Mammut*, *Anancus*, and *Gomphotherium* were analysed for comparative purposes.

Microwear analysis was carried out using Microware 4.0 software on SEM micrographs made from the surface of high-resolution epoxy casts. Although the magnification used here (300×) differs from the 35× magnification used in

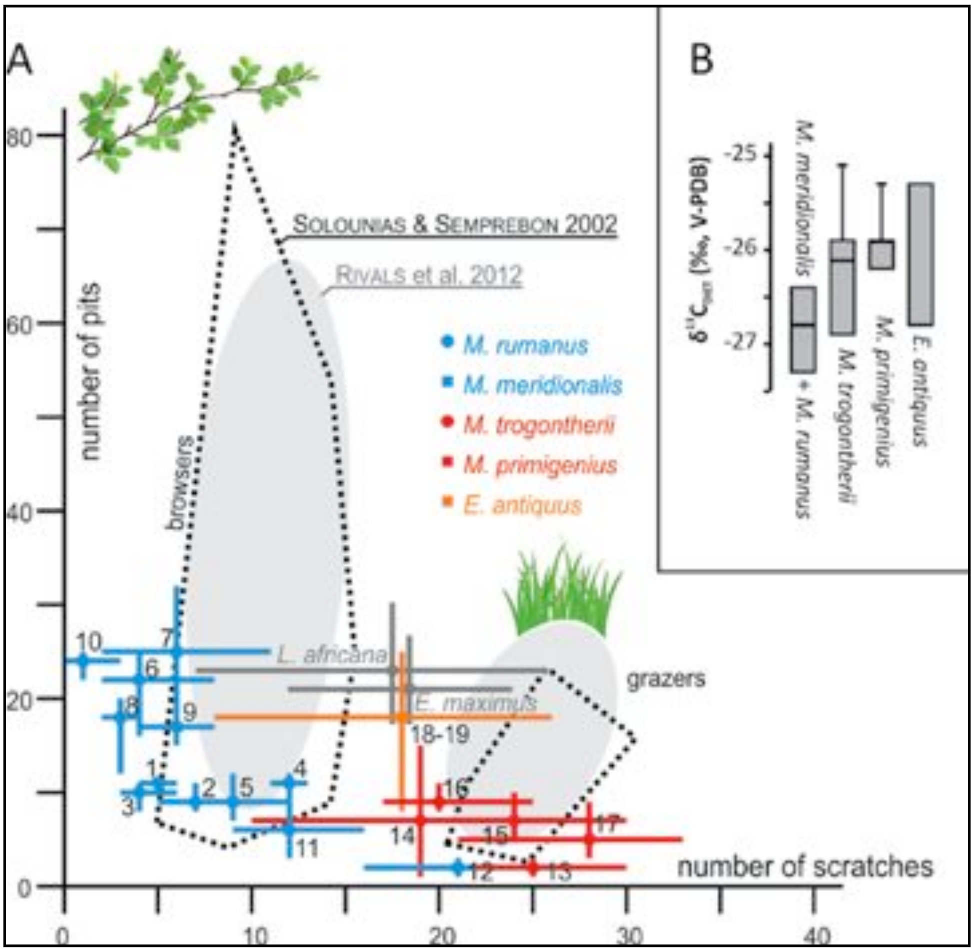

Fig. 1. Microwear features (**A**) and stable carbon isotopic data (**B**) of enamel samples from Hungarian and Romanian elephantids.

Abbreviations:
1, Tuluceşti;
2, Cernăteşti;
3, Ócsa;
4, Aszód, HNHM V.82.6.;
5, Aszód, HNHM V.69.1120.;
6, Szomód, HNHM. V.75.35.1.;
7, Süttő, HNHM V.72.113.;
8, Nyergesújfalu, HNHM V.79.9.;
9, Almásfüzitő, HNHM V.79.13.;
10, Budapest, HNHM V72.7.;
11, Visonta, HNHM V.90.14.;
12, Visonta, HNHM V.82.61.;
13, Visonta, HNHM V.82.60.;
14, Visonta, 644/3.;
15, Üröm-hegy, HNHM V.72.116.;
16, Ercsi, HNHM V.75.138.;
17, Kiskunlacháza, HNHM V.80.119.;
18-19, Győrszabadhegy.

HNHM,Hungarian Natural History Museum.

regular light-microscopic studies, the field of view (0.4×0.3 mm) and the total number of observed scars (usually 20-40 on each image) was approximately the same, therefore we used the light microscopic data of Solounias & Semprebon (2002) and Rivals et al. (2012) for comparison. Palombo et al. (2005) or Todd et al. (2007) reached similar conclusions regarding the comparability of these methods.

According to our microwear data (Fig. 1A), *M. rumanus* and *M. meridionalis* were browsers, whereas *M. trogontherii* and *M. primigenius* were mixed feeders or more likely grazers. Preliminary results show that the studied non-elephantid proboscideans were mainly browsers with extensive bark consumption. Variation of wear features within a single molar is less than 30% (or usually less than 10% in the case of grazers).

Each isotopic sample here is a bulk of three or more subsamples over the whole height of a single plate, therefore represents the whole period of tooth formation. The oxygen isotopic composition of the carbonate and phosphate from enamel show strong linear correlation ($r^2=0.75$) and plot close and parallel to the expected equilibrium line derived from modern mammals, however with an average of 2‰ higher intercept.

The overall $\delta^{18}OPO_4$ range is 10.4‰-15.4‰ (V-SMOW) for elephantids. These data were converted to the isotopic composition of the meteoric waters in the time of the deposition of enamel based on Ayliffe et al. (1992). A linear regression was fitted to the data of four GNIP meteorological stations (Zagreb, Vienna, Bratislava, Debrecen) and the resulting equation ($T=1.84\times\delta^{18}OH_2O+26.4$) was used for calculating MAT estimates. Early Pleistocene samples reflect a MAT range of 8-10°C, similar to present value (11°C), whereas our results suggest that the MAT was approximately 5°C lower during the cold periods of the Middle Pleistocene and up to 9-10°C lower during the Late Pleistocene glaciations. Preliminary calculations for the non-elephantid samples resulted in MAT estimates up to 13°C. The data are in good agreement with other climatic proxies from the same period (e.g. Kovács et al., 2013).

The $\delta^{13}C$ values range from 13.2‰ to 7.4‰ (V-PDB), which suggest a C3 diet. The average and minimum values of the successive species were increasing with 1‰ during the Pleistocene (Fig. 1B) which is explicable by drier climate and more open vegetation.

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Diversification of fossil proboscideans from the Neogene of the Linxia Basin, northern China

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ShanQin CHEN, and Jaroon DUANGKRAYOM

Recent studies reveal extraordinary diversity of fossil proboscideans from the Neogene of the Linxia Basin. The record of fossil proboscideans spans about 6 Myr from the early to late Miocene but may extend into the early Pleistocene based on one unidentified tusk segment (Deng et al., 2013; Fig. 1).This tusk indicates that proboscideans persisted in the Lixian Basin at least into the early Pleistocene in spite of middle Miocene tectonic reorganizations including basin isolation and potentially local and regional surface uplift (Craddock et al., 2011). We have identified at least 11 species belonging to seven genera of three families of Miocene proboscideans, which include examples from all Miocene proboscidean subfamilies.

Prodeinotherium sinense is the only member Deinotheriidae known in China. The discovered lower mandible is characterized by its relatively small p3 with separated protoconid and metaconid, and with very rudimentary ectolophid. Its symphysis is anteroventraly oblique. The material is from the earliest late Miocene. Thus *P. sinense* is a terminal, isolated representative of *Prodeinotherium* (Qiu et al., 2007).

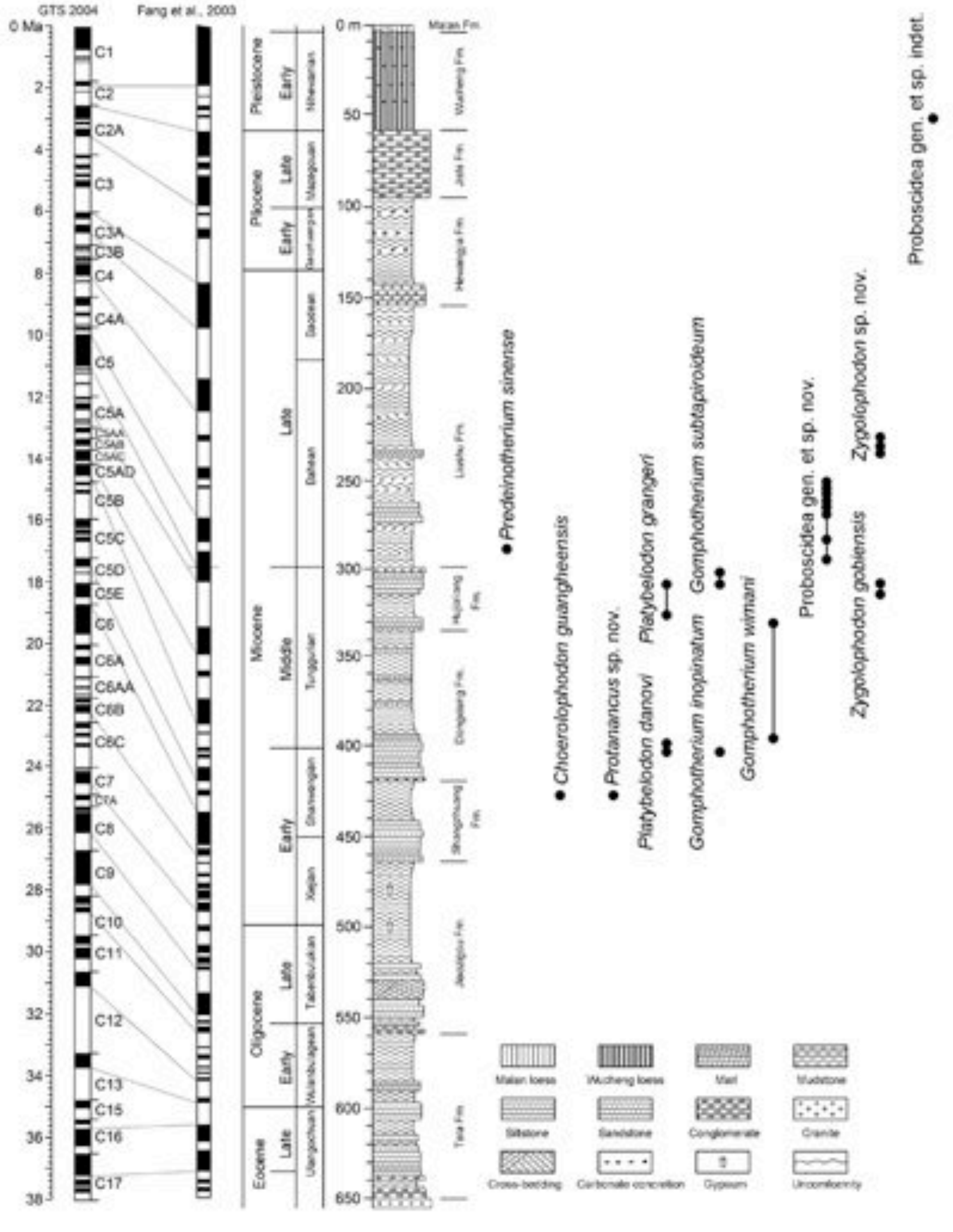

Fig. 1. Stratigraphic section of the Linxia Basin, showing proboscideans' distribution.

The only representative genus of Mammutidae is *Zygolophodon*. As with other Eurasian specimens, they belong to the "*Z. turicensis* group". Tobien et al. (1988) attributed all the Chinese zygolophodont specimens to *Z. gobiensis*. This is also in case for the zygolophodont specimens from the middle Miocene of the Linxia Basin. The zygolophodonty of these teeth is rudimentary. From the late Miocene, *Zygolophodon* sp. nov. was also discovered including a complete cranium. Well developed thin crests on the cheek teeth resemble those of *Mammut*, and are different from the middle Miocene *Z. gobiensis*. The cranium also shares a flattened neurocranium but erected basicranium with the terminal taxon, *M. americanus*. However, the ventrally bent upper tusks take precedence, indicating a close relationship to *Zygolophodon*.

Another family of fossil proboscideans is Gomphotheriidae. *Choerolophodon guangheensis*, the only example of the subfamily Choerolophodontinae, was discovered from the early Miocene and is represented by a completed cranium. As is typical of choerolophodontine, this species is characterized by dorsally bent upper tusks which lack enamel and by its choerolophodonty (although relatively incipient). However, its orbit is anteriorly positioned and P4 is retained, showing plesiomorphies of the subfamily. This specimen is the most primitive extant cranium of Choerolophodontinae, and may be related with *C. palaeoindicus*.

Specimens of another subfamily, Amebelodontinae, are very abundant. A complete cranium with associated mandible of *Protanancus* sp. nov. has been discovered from the early Miocene. This skull features very rudimentary secondary trefoils and pseudo-anancoidy suggesting that it is the most primitive extant *Protanancus*. However, it shares a relatively short and broad mandibular symphysis with *Pr. tobieni* from middle Miocene strata of eastern Asian suggesting that the two species may be related. Another genus is *Platybelodon*. It is represented by the ancestral *Pl. danovi* (from the early middle Miocene) and *Pl. grangeri* (from the late middle Miocene). The latter has features distinguishing it from the former, including more prominent secondary trefoils, pseudo-anancoidy, and cementodonty, as well as broader symphysis. *Pl. grangeri* represents the most abundant mastodont assemblage all over the world. Almost 60 relatively complete crania plus mandibles have been excavated from the Linxia Basin.

For the basal group, Gomphotheriinae, at least three species of *Gomphotherium* have been recognized. *G. inopinatum* is the most conservative species and is represented by an incomplete lower hemimandible from the early Miocene. The interlophids of the cheek teeth are moderately open, but it lacks subdivision of the pretrite central conules and subdivision of the posttrite half lophids. This contrasts with *G. subtapiroideum* from the late middle Miocene which is characterized by further opening of the interloph(id)s, subdivision of pretrite central conules, and subdivision of posttrite half loph(id)s. An additional complete cranium of *G. subtapiroideum* represents the first known cranium of this species. The upper tusks are relatively divergent and twisted. *G. subtapiroideum* is possibly the direct descendant of *G. inopinatum*, and both of them belongs to the "*G. angustidens* group" (Tassy, 1985). Another species, *G. wimani*, lasted from the early to middle Miocene and may be the ancestor of the Pliocene–Pleistocene *Sinomastodon*. It is characterized by narrowed interloph(id)s, subdivided pretrite central conules, and subdivided posttrite half loph(id)s. It is an endemic species, and possibly grouped with *G. steinheimense*.

A tetralophodont gomphothere was also discovered in the late Miocene and represented by crania, mandibles, isolated teeth, and postcranial bones. This taxon exhibits flattened lower tusks, elongated mandibular symphysis, and tetralophodonty. This feature combination resembles "*Mastodon*" *grandincisivus* and North American *Amebelodon*. However, It differs from *Amebelodon* by its divergent lower tusks that are longer than the symphysis and also differs from "*M.*" *grandincisivus* by its rudimentary tubular structure in lower tusks thus representing a new species. The latter also indicates derivation of a tusk tubular structure that is independent from *Platybelodon* and *Amebelodon*. The limb bones of the new taxon are also thicker than any known mastodonts or extant elephants.

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First discovery of Middle Pleistocene steppe mammoth (*Mammuthus trogontherii*) remains from northern China

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Mammuthus is one of the most prominent proboscidean taxa during the late Cenozoic through Eurasia (Lister et al., 2005). During the last several years, some achievements have been gained on the research of Chinese mammoth remains, and a Plio-Pleistocene biostratigraphic framework based on mammoth fossils of northern China has been established (Wei et al., 2010).

The earliest globally steppe mammoth (*Mammuthus trogontherii*) remains were recovered from Majuangou, Nihewan basin, China, with palaeomagnetic dating of 1.66 Ma (Wei et al., 2003; Wei and Lister, 2005). The mammoth remains recently found from Gaoling (Shaanxi Province) and Zalainuoer (Inner Mongolia) indicate that *Mammuthus trogontherii* survived in northern China into the late Pleistocene (Wei et al., 2010). So North China is considered as the area of origin and extinction of *M. trogontherii*. However, no Middle Pleistocene steppe mammoth has been reported from northern China.

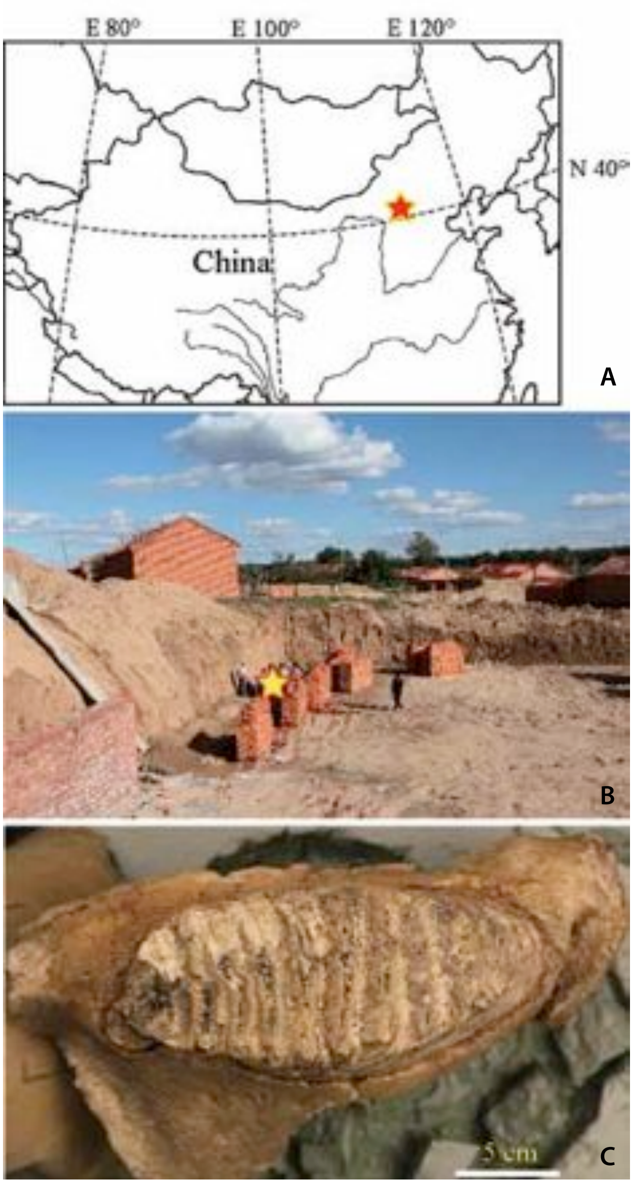

Fig. 1. Maps showing geographical location (**A**) and geomorphological landscape (**B**) of fossil site, as well as one complete M3 (**C**) of *Mammuthus trogontherii* from Shangyi, Hebei Province, northern China.

The present study deals with the new elephantid fossil remains, including one complete M3, a fragmentary incisor and some postcranial bones, which was recovered from the sandy deposits of an ancient channel from Shangyi, Hebei Province, northern China (Figure 1A and B). The occlusal surface of the new M3 (Figure 1C) bears typical morphological characters of *Mammuthus*. The enamel layers of the mesial and distal plate sides are parallel to each other in medium or advanced wear. In slightly worn lamellae the labio-lingual width of the central enamel loop is nearly equal to those of the two lateral enamel loops. A prominent and obtuse mesial and/or distal median sinus is developed in the central part. The M3 should be assigned to *Mammuthus trogontherii* while all the measurements of this molar, such as plate number (P), lamellar frequency (LF), enamel thickness (E), and width (W) and height (H) of crown, fall within the ranges of steppe mammoth.

The fine-grained and coarse quartz single-aliquot regenerative-dose (SAR) optically stimulated luminescence (OSL) results for six samples from Shangyi deposits indicate that the age of the steppe mammoth should be beyond the last interglacial (~130 ka). Furthermore, the ESR/U-series study (US-ESR model) based on a fossil tooth provides a more precise age of the mammoth remains, 410±30 ka.

The first discovery of *Mammuthus trogontherii* from the Middle Pleistocene in northern China has significant implications for discussing the evolution, dispersal and paleoecological variation of *Mammuthus* lineage in Eurasia.

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Disorders affecting hard tissues in elephants

Gerald WEISSENGRUBER ✉, and Gerhard FORSTENPOINTNER

Disorders of the locomotor system and teeth are well known, yet often poorly documented pathologic alterations in elephants. In the literature from European countries and British colonies, so-called feet disorders have been described as early as in the middle of the 19th century. Elephants suffering from disorders of the musculoskeletal system may exhibit lameness, changes in movement or limb use or even complete immobility. Some alterations lead to the death of the animal. Although the reported prevalence in captive elephants is obviously higher, disorders such as fractures, (sub)luxations, distortions, pododermatitis, thermal burns, wounds and various infections are documented in rare cases also in free-ranging elephants. Infections of the skin, abscess formation and fistulas sometimes affect deeper structures such as bones or joints, which can lead to a lysis of bone or joint tissues (Ruthe, 1961). Besides these local infections, systemic infectious diseases such as chlamydiosis, mycoplasmosis, tuberculosis or salmonellosis could play a role in cases of osteomyelitis or arthritis (West, 2006). One of the most common musculoskeletal diseases in captive elephants is degenerative joint disease (osteoarthritis, osteoarthrosis). Hereditary, developmental, metabolic causes and mechanic insults may contribute to the development of this disease which is characterized by an initial loss of cartilage and subsequent alterations of the subchondral bone tissue and development of osteophytes. Fibrous osteodystrophies, deformities of bones and osteochondrosis are discussed to be caused by nutritional deficits or congenital defects. Although the majority of bone and joint diseases is described to occur within the limbs, we found signs of osteoarthritis also on vertebrae and, furthermore, conditions similar to the kissing spines disease of horses.

Traumatic injury of tusks is common in both captive and free-ranging elephants. The healing ability of the tusk pulp is very good and the production rate of reparative dentin is remarkably high which leads in the majority of cases to the recovery of the animal (Weissengruber et al., 2005). Periodontitis around the molars is often caused by foreign bodies and can lead to chronic stomatitis and failure of dental abrasion. Other disorders affecting molars are malformed, fused or retained teeth, failure of fragmentation, impaired forward progression and malocclusions. These conditions may cause severe digestive problems and weight loss.

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Proboscidean biogeography in midwestern North America, with a comment on the extinction of *Mammut americanum*

Chris WIDGA ✉, Stacey LENGYEL, Jeff SAUNDERS, Greg HODGINS, and J. Douglas WALKER

The North American Midwest has one of the highest densities of terminal Pleistocene proboscideans on the continent (Osborn 1936:177; 1942:1133). Although regionally dominated by the American Mastodont (*Mammut americanum*), two species of mammoths (*Mammuthus primigenius* and *M. jeffersonii*) are also sympatric (Saunders et al. 2010). A recent census of Proboscidea in regional museum collections produced a dataset of >1600 specimens, vouchering 576 different localities. Although single-animal localities are by far the most common, multi-animal (e.g., Boney Spring, MO, Saunders 1977) and multi-taxic (e.g., Minooka, IL--Riggs 1936; Jones Spring, MO--Saunders 1988) assemblages are also present. During the Last-Glacial-Maximum (LGM), *Mammuthus* is the dominant proboscidean across the midwestern landscape. *Mammut* is rare or absent from the region during this time. During the subsequent post-LGM period, *Mammut* becomes the dominant taxon in forested and parkland habitats east of the Mississippi River and throughout the Ozark uplift. At this time, *Mammuthus* are more common in grassland habitats in the western part of the study area, although they maintain small local populations in forested and parkland areas until their local extirpation at 13,470 cal BP (~11630 ^{14}C BP).

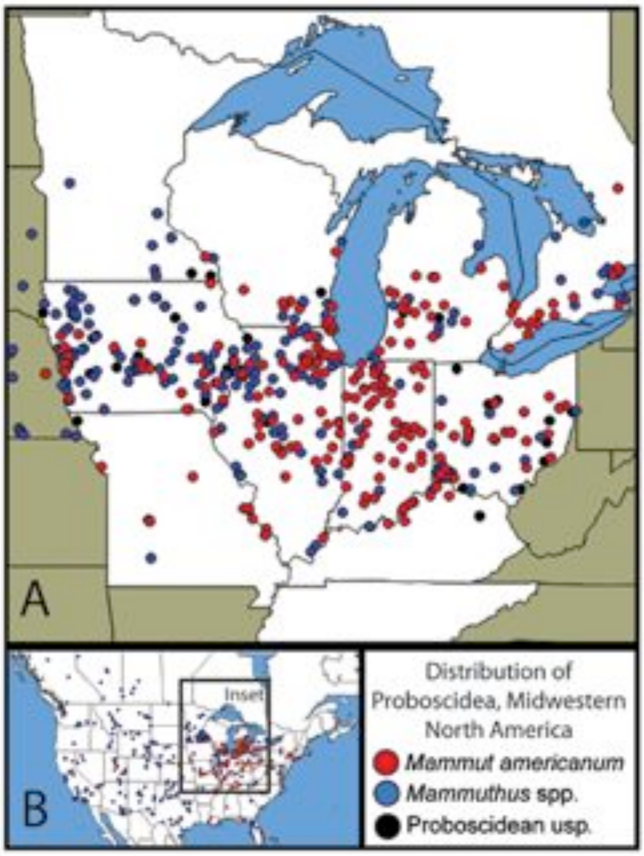

Fig. 1. **A**, Distribution of Proboscidea vouchered in Midwestern museum collections (N=576). *Mammuthus* spp.=271 localities; *Mammut americanum*=248 localities. **B**, North American distribution of Proboscidea south of the Laurentide Ice sheet (primary data source, Neotoma Paleoecology Database, http://www.neotomadb.org; 2013).

Mammut populations decrease in situ until ultimate extinction ~12,700 cal BP (~10,800 ^{14}C BP). Regional populations of terminal Pleistocene *Mammut* are morphologically diverse suggesting distinct local populations with limited gene flow. All multi-animal death assemblages in the study region occur within 500 years of the terminal extinction date.

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Jaksice II - new site of the mammoth hunters from southern Poland

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In the years 2010-2013, almost a hundred years after the discovery of Palaeolithic site at Jaksice made by L. Kozłowski and W. Kuźniar, the new fieldwork's were carried out (Kozłowski and Kuźniar, 1914; Wilczyński and Wojtal, 2011). The site is located on a left bank of a Vistula River opposite the mouth of the Raba River (Fig. 1), about 40 km from Kraków Spadzista site (Kozłowski et al., 1974). The technology and typology of the lithic assemblage as well as radiometric data indicate that this inventory could be interpreted as a remnant of the camp site inhabited by groups of Gravettian hunters in the period 24-20 kyr BP.

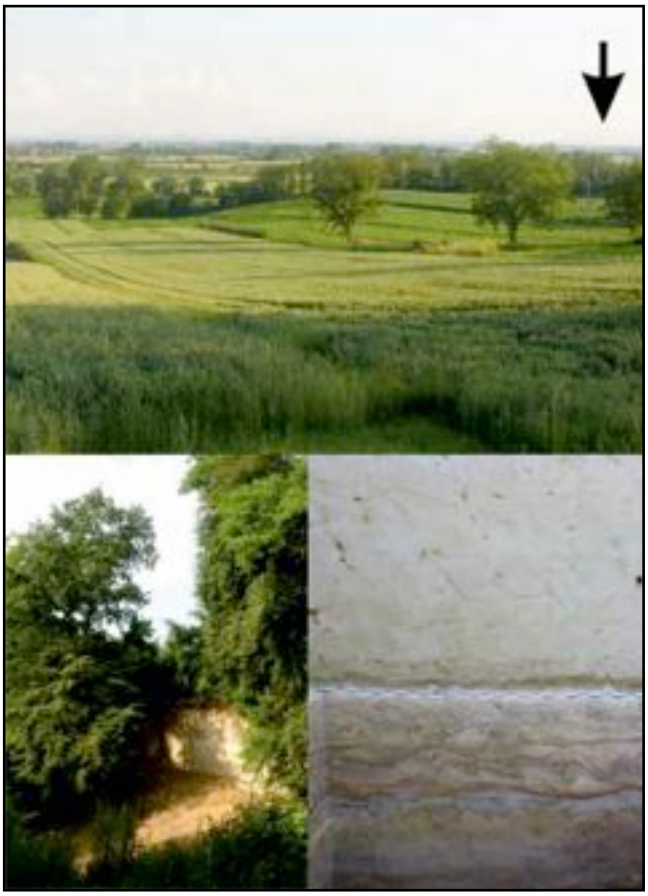

Fig. 1. General view and western profile of the Jaksice II site.

During excavations abundant archaeological and palaeontological assemblages were discovered. Among archaeological assemblage we could mention ivory artefact and fragments associated with its manufacture, mollusc shell pendants, hematite fragments and numerous retouched tools - especially backed artefacts. Woolly mammoth and reindeer remains vastly outnumber other mammal species remains. These species were the main source of meat and raw material for the Gravettian hunter-gatherers from this site. The mammoth is represented mostly by ribs, vertebrae fragments and phalanges. It should be noted that no long bones, except for a just a few small fragments (10 cm long), were discovered. Given the impressive quantity of burnt bone discovered at the site it is likely that it was burnt in the hearth as fuel. They formed a concentration in the northern and southern area of the trench – interpreted as the place of a hearth. All this information persuade us to interpret the site as a base camp, where closeness of large river facilitated the hunting of big game animals.

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Mammoth hunter settlement of Dolni Vestonice I - preliminary results of taphonomic studies

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Dolni Vestonice I is possibly one of the most significant Mid Upper Palaeolithic sites. The research carried out at this location led to the discovery of extremely rich Gravettian deposits containing numerous lithic artefacts, bone products, human remains and - last but not least - art objects, most notably the famous clay figurine known as Venus of Dolní Věstonice. Dolni Vestonice I was excavated for the first time in 1924, by K. Absolon, and later, by B. Klima (Absolon 1945; Klíma 1963). Different areas of the site were investigated and a vast assemblage of animal bone was recovered. A significant part of mammoth bones filled a natural depression (Czech *skladka kosti*) with, to the north of it, five dwelling structures. These were surrounded by single mammoth bones and originally were a sort of an enclosure within which were carried out diverse activities including stone processing (Klíma 1963). Unfortunately despite the extraordinary importance of this material it was never analysed comprehensively and published in a satisfactory manner. With main focus of earlier studies placed on the archaeological record much less time and energy were spent on the analysis of the animal remain (Musil 1959). In this situation it is imperative to re-examine the results of earlier taxonomic studies. This is the main purpose of our project – to make a taxonomic, zooarchaeological and taphonomic study of animal bone remains from the domestic structures at Dolni Vestonice linked with Gravettian settlement.

In the area of dwelling structures remains of different mammals species were found. Bones and teeth of woolly mammoth, wolf, reindeer, fox and horse are most numerous. Traces of human activity (e.g. cut marks) are visible on many of them - especially at carnivore bones. It should be noted that at the dumping area woolly mammoth bones vastly outnumbering remains other mammals.

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Hunters of the giants. Woolly mammoth-hunting during the Gravettian in Central Europe (Poland and Czech Republic)

Piotr WOJTAL ✉, and Jarosław WILCZYŃSKI

Between 30,000 and 20,000 years ago, rapid climatic changes occurred as the Scandinavian ice sheet expanded. Not only did palaeoenvironments change, but human societies also transformed themselves. A considerable cultural unification occurred in Europe, which resulted in the origin of the Gravettian technocomplex. Throughout the next millennia, Gravettian hunters occupied a huge part of Europe, in an area covering several million square kilometers, stretching from the Atlantic Ocean to the Russian plains, from the Pyrenees to the Ural mountains. The most distinctive features of the Gravettian are characteristic stone tools (backed bladelets and shouldered points) and female figurines ("Paleolithic Venuses"), the most famous being the so-called "Venus of Willendorf".

The Gravettian technocomplex had several stages, including, among others, the early (Pavlovian) and the later (Willendorf-Kostienkian) stages. The most famous sites in Central Europe related to the early stage are located in the roots of the Pavlovské (Palava) Hills (Czech Republic). They are Pavlov I, Dolní Věstonice I, and Dolní Věstonice II. During successive millennia hunter-gatherers moved into new places of residence, such as the Vah river valley (Slovakia) and south Poland (Kraków region). The Willendorf-Kostienkian stage is represented at: Willendorf II (Austria), Petřkovice (Czech Republic), Moravany (Slovakia), and Kraków Spadzista Street (Poland) (Musil 2003).

Zooarchaeological studies allow us to reconstruct and compare animal food resources from various sites and different periods of the Gravettian. The oldest Gravettian sites, Pavlov I and Dolní Věstonice II in the Czech Republic, were inhabited over many seasons and did not show clear hunting specialization (Wojtal et al. 2012). The sites have yielded a large number of remains, sometimes thousands of bones belonging to dozens of individuals of different birds and mammals. At the younger Gravettian sites from the Czech Republic, Poland, and Slovakia huge accumulations of mammal bones have also been discovered. However the younger assemblages are dominated by bones of single species, while remains of the other mammalian taxa are found in much smaller amounts. At Kraków Spadzista Street and Milovice I, a very large number of woolly mammoth remains was found. But at Moravany Lopata II (Slovakia), the dominating species in osteological material is reindeer. We suggest that at these sites specializations in hunting mammoths and reindeer can be observed (Svoboda et al. 2005; Wojtal and Sobczyk 2005).

Mammoth remains were found at early and late Gravettian sites. On the basis of our studies it is possible to conclude that mammoths played a very important role in the life of Gravettian hunters. The animals provided both meat and raw materials for the production of bone tools, weapons, and ornaments.

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A Pleistocene mammal bone site near Garwolin (Mazovian Lowland, Poland)

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The remains of mammoth, woolly rhinoceros, bison, reindeer and horse were found in 2006 in a gravel pit in the Wilga River Valley near Garwolin (Central Poland), fig. 1 (Żarski et al., 2014). The most numerous remains represent mammoth bones: skull fragments, teeth, and a pelvis with predator tooth marks. Garwolin is located on the Mazovian Lowland about 60 km south of Warsaw (Fig. 1A). The area around is covered with tills and glacifluvial sands and gravels of the Middle Polish Glaciation (MIS 8-6). This area is situated outside the range of the last glaciation of the Vistulian Glaciation (MIS 2-5d; 11,700- 115,000 BP) (Fig. 1A). The ice sheet margin was about 160-200 km north of the Garwolin area. The bones were found in the fluvial sands and gravels at a depth of 5-6 m below the ground surface. Geological studies suggest that the deposits originate from the period of the Vistulian Glaciations. A 2-m-thick Holocene peat layer is located above of fluvial sands and gravels. The mammoth bones were dated twice using the 14C method between 38 and 46 ka, which is correlated with the Grudziadz Interstadial (MIS3). The climate in Poland during this interstadial was slightly warmer and the average July temperature reached 10°C. The bones of Pleistocene mammals were found in a secondary

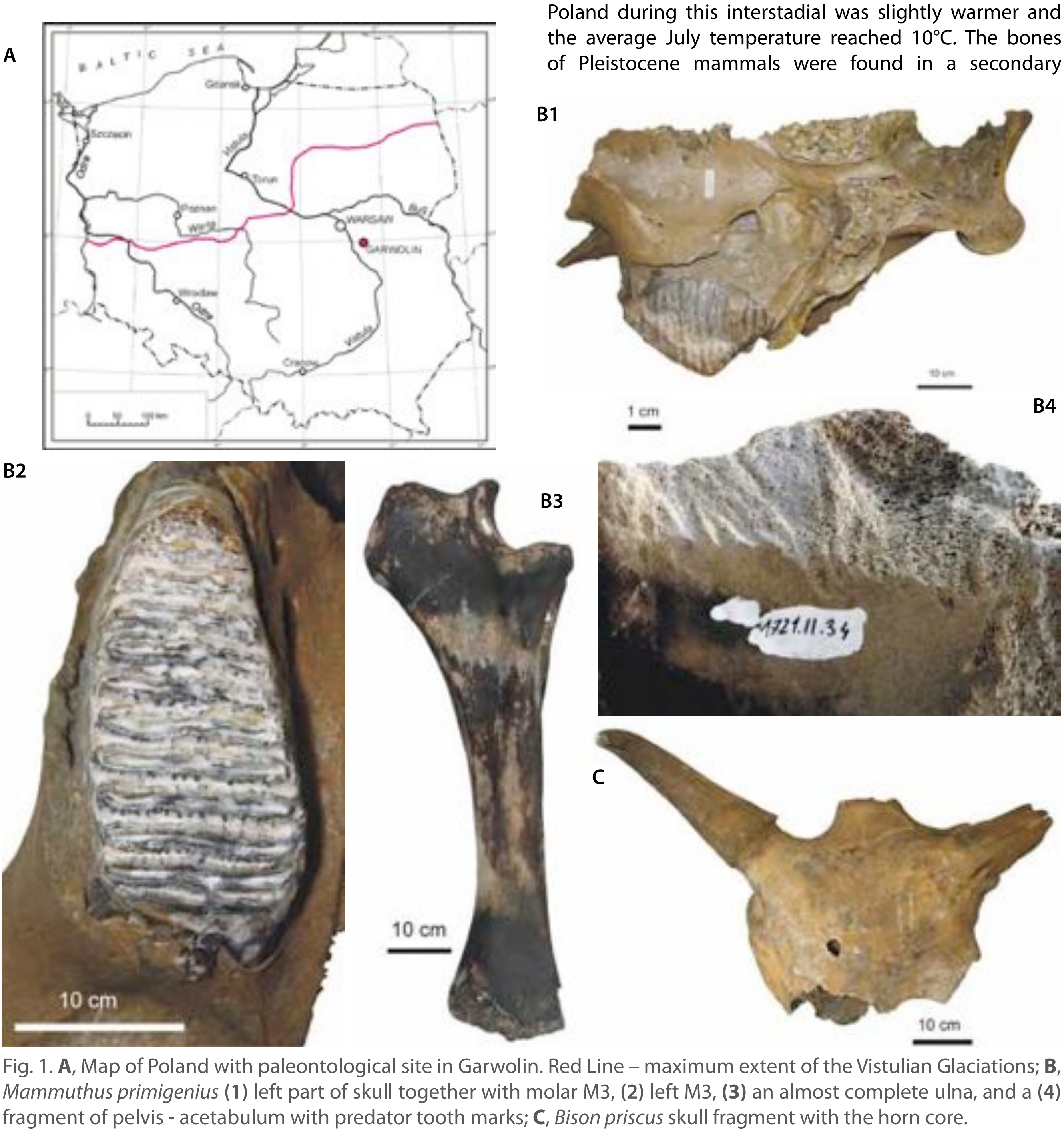

Fig. 1. **A**, Map of Poland with paleontological site in Garwolin. Red Line – maximum extent of the Vistulian Glaciations; **B**, *Mammuthus primigenius* **(1)** left part of skull together with molar M3, **(2)** left M3, **(3)** an almost complete ulna, and a **(4)** fragment of pelvis - acetabulum with predator tooth marks; **C**, *Bison priscus* skull fragment with the horn core.

deposit. Two flint artifacts were among the collection. The accumulation of bones in the fluvial sediments could have been caused by the drowning of the animals during a violent flood or by the river washing out a Neanderthal archaeological site.

The mammoth [*Mammuthus primigenius* (Blumenbach, 1799)] is represented by: an incompletely preserved fragment of the left part of a skull bearing the M3 (Fig. 1.B1), a few fragments of the skull bones, completely preserved upper third molars (Fig. 1.B2), and half of M3, a distal part of humerus and an almost completely preserved ulna (Fig. 1.B3), 6 fragments of pelvis, one of them with predator tooth marks (Fig. 1.B4), a head of a femur, 3 shafts of the femur, and shaft of the tibia, one vertebral spinosus process and a rib shaft.

The woolly rhinoceros [*Coelodonta antiquitatis* (Blumenbach, 1807)] is represented by a cervical vertebra, a scapula, a humerus shaft and an uncompletely preserved pelvis together with fragments of ilium, pubis and ischium.

The steppe bison [*Bison priscus* (Bojanus, 1827)] is represented by an incompletely preserved skull, a skull fragment with the left horn core (Fig. 1C), a skull fragment with the occipital condyles, and a femur.

The reindeer (*Rangifer tarandus* (Linnaeus, 1758) is represented by two fragments of antlers and a rib shaft.

The horse (*Equus ferus* Boddaert, 1785) is represented by a tibia.

Bone finds of Pleistocene mammals from the area of the Mazovian Lowland in Poland are quite common. The first descriptions are from the end of the nineteenth century. The bones were found during construction works and in the Vistula river. One of the most interesting paleontological finds in Warsaw took place in 1962 during earthworks in Leszno Street, where at almost 5 m depth a nearly complete skeleton of the forest elephant *Palaeoloxodon antiquus* (Falconer and Cautley, 1847) was found (Jakubowski et al., 1968). An almost complete skull of a forest rhino *Dicerorhinus kirchbergensis* (Jäger, 1839) discovered in the Vistula River valley in 1971 is also very important. It is worth noting that this is the first skull of this species unearthed in Poland and the best preserved of the four so far found and described in the world (Jakubowski, 1971; Borsuk-Białynicka and Jakubowski, 1972). The last known discovery of Pleistocene mammal bones, namely two incomplete mammoth skeletons, was during the construction of the underpass under Jerozolimskie Avenue, in Warsaw at the end of 1971 (Jakubowski, 1973).

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The use of elephant bones for making Acheulian handaxes

Katia ZUTOVSKI, and Ran BARKAI

The archaeological record reveals that Lower Paleolithic (LP) early humans exploited elephants by hunting or by collecting carcasses apparently for meat consumption and possibly for utilizing bone marrow over the three continents of the old world and for hundreds of thousands of years (e.g. Ben-Dor et al., 2011; Anzidei et al., 2012; Rabinovich et al., 2012; Saccà, 2012). In some cases elephant bones were exploited for the manufacture of artifacts that closely resemble Acheulian stone handaxes (Rabinovich et al., 2012; Saccà, 2012; Beyene et al., 2013).

This study examines Lower Paleolithic archaeological assemblages from Africa, Europe and the Levant, containing tools made of elephant bones. Special attention will be given to bone bifacial tools (handaxes) that resemble the characteristic Acheulian stone bifaces (Fig. 1).

The aims of this study are to update and summarize the available evidence of elephant bone tool manufacturing in the Acheulian, analyze the patterns of the elephant bone industry compared to the stone tools industry and to bone industries based on other taxa at the sites, and finally to address the question whether LP elephant bone handaxes were manufactured solely for functional purposes or whether cultural and/or symbolic properties could be reflected by the production of handaxes from elephant bones. We focus on the association of stone and bone bifaces at particular Acheulian sites, and suggest a new perspective regarding the exclusive correlation between handaxes made of the two raw materials at these sites. LP sites with elephant remains in association with lithic tools but without the use of elephant bones in tool manufacturing present another interesting aspect of this phenomenon.

Stone LP bifacial tools have been a focal issue of research during the last century. The purpose of manufacturing handaxes has long been debated, as well as its probable cultural and social significance. Some researchers claim that handaxes are efficient in animal butchering practices and wood working (e.g. Dominguez-Rodrigo et al., 2001; Machin et al., 2007), while others wonder why early humans invested in symmetry of those items and their peripheral flaking if it is possible to cut and disarticulate animals with chopping tools and flakes. An over-investment in the aesthetic aspect would be very conspicuous and several theories of symbolic and social meaning of these tools have been raised (e.g. Kohn and Mithen, 1999). It is our working hypothesis that the significance of the Acheulian stone bifaces might be relevant for a better understanding of the bone bifaces as well, and thus we would like to discuss the bone bifaces in light of the plethora of data and interpretation related to the Acheulian stone bifaces.

Fig. 1. A biface made on an elephant bone from the Middle Pleistocene site of Fontana Ranuccio, Italy. Modified after Mussi, 2005.

Ethnographic studies reveal that contemporary human-elephant relationships were not established solely on hunting/scavenging activities, meat consumption and tool manufacturing, and there are numerous examples of the deeply symbolic and cosmologic meaning of elephants to people (e.g. James, 1988, pp 50; Kuriyan, 2002).Taking the ethnographic evidence with caution, we will present a combination of the different data sets presented above in order to suggest a new understanding of the use of elephant bones in Acheulian tool production and discuss its implications on reconstruction of human-elephant relationships in the Lower Paleolithic.

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