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ON PLIOCENE MAMMAL REMAINS IN THE AREA OF EPANOMI (MACEDONIA, GREECE)

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Abstract: Neogene/Quaternary deposits along the east shoreline of Thermaikos Gulf (Thessaloniki, Greece) occasionally yielded several isolated fossil vertebrate remains. A proboscidean tusk and an equid astragalus have been recently unearthed from a new palaeontological spot near Epanomí. The finds are referred to *Mammuthus* cf. *meridionalis* and *Equus* sp. Based on biochronological data, the deposits are dated to the latest Pliocene.

Keywords: Elephantidae *Mammuthus* Equidae latest Pliocene Macedonia Greece

1. Introduction

The peninsula of Chalkidikí comprises several fossil mammal localities of Early Miocene – Middle Pleistocene age, including Petrálona (Sickenberg, 1964; Tsoukala, 1989), a famous cave locality that yielded a complete skull of *Homo heidelbergensis* (Kokkoros and Kanellis, 1960). The Miocene localities include Sáni (Koufos, 1977), Nikíti (Koufos et al., 1991b), Aghía Paraskeví (Tsoukala and Melentis, 1994), Antónios (Koufos and Syrides, 1997), Sílata (Vasileiadou et al., 2003) and Kryopigí (Tsoukala and Bartsiokas, 2008), while the Pliocene ones include Krímni (Sakellariou-Mané et al., 1979) and Megálo Émvolo (Arambourg and Piveteau, 1929; Koufos et. al., 1991a). The latter locality is located on the eastern shoreline of Thermaikós Gulf between Aggelochóri and Kallikráteia villages, an area that occasionally provides several isolated vertebrate fossils. The Pleistocene localities of Chalkidikí include, except for Petrálona, the site of Sithonía (Tsoukala, 1981).

In September 1999 a proboscidean tusk was found exposed due to marine erosion at the west coast of Chalkidikí Peninsula, N. Greece, at the area between the towns of Epanomí and Néa Herákleia (Prefecture of Thessaloniki, Fig. 1). The specimen was tracked down on the coastal cliff by local people, who delivered the information to the Ministry of Culture, 10th Ephorate of Byzantine Antiquities. The proximal part of the tusk was protruding out of the eroding calcareous-clayey matrix and was in part reburied by seashore sand and pebbles. The first author carried out an excavation at the end of October 1999, recovering most of the tusk (Fig. 2). Another excavation that followed in May 2000 yielded the distal end of the specimen, still remaining in the cliff, under thick vegetation cover. In spite of careful prospecting in the area, no other part of the proboscidean dentition or skeleton was found. The specimen was prepared in the laboratory of the Ephorate of Palaeoanthropology–Speleology (Hellenic Ministry of Culture, Athens) and is currently kept in the collection of the 10th Ephorate of Byzantine Antiquities (Polýgyros, Chalkidikí).

A brief survey at the site, carried out by the authors in 2005, yielded another single find, namely a horse astragalus.

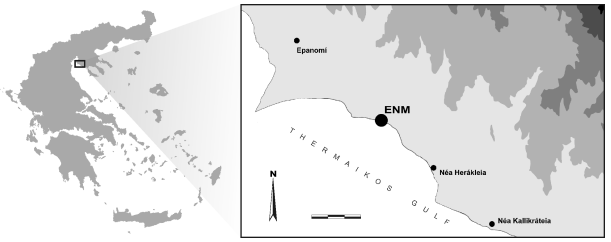

Fig. 1. Geographic location of the new site Epanomi (ENM).

2. Geology

Western Chalkidikí peninsula is covered by thick Neogene–Quaternary continental deposits that unconformably overly the Mesozoic basement that belongs to the zones of Paeonia and Circum Rho-

dope of the alpine orogen. The Neogene and Quaternary deposits of Western Chalkidikí peninsula have been studied in detail by Syrides (1990), who groups them in six formations (Antónios, Tríglia, Trílophos, Goniá, Moudaniá and Eleochória). The deposits are mainly of fluvial, fluvio-lacustrine or terrestrial origin and consist of clays, sands, sandstones, conglomerates and marly limestones. Their age spans from Early or Middle Miocene (Antónios Fm.) to later than Early Pleistocene (Moudaniá Fm.). The Eleochória Fm. comprises travertines of Pleistocene–Holocene age, deposited by thermal springs.

Fig. 2. The elephant tusk ENM-1 *in situ*, partly excavated.

The sediments exposed at the sea cliff at the area of the new Epanomí site are alternations of silty sands, gritstones to sandstones, clays and thin rather massive marls of fluvio-lacustrine-marshy origin, whereas some residual intercalations of redbeds are shown on the upper part of the section. The lithological characters of these deposits recall those of the upper horizons of the Goniá Fm, namely the Kallikráteia Member (Syrides, 1990). The proboscidean tusk was laid within a marly horizon at the very bottom of the cliff whereas the equid astragalus was found in a block of overlaying sandstones.

3. Systematics

Order: Proboscidea ILLIGER, 1811
Family: Elephantidae GRAY, 1821
Genus: *Mammuthus* BURNETT, 1830
Mammuthus cf. *meridionalis* (NESTI, 1825)
Material: ENM-1: left tusk (I^2).
Description: The tusk is preserved virtually in its entire length. A small part of the tip (probably less than 10 cm) is missing. Its length is 280 cm, measured along its convex ventral side, and 255 cm in a straight line from the proximal to distal end, exhibiting moderate curvature, as well as rather weak but clear torsion. In cross section it is sub-circular in shape. Distally, near the base of the tusk, the maximum and the minimum diameters are 145 and 130 mm respectively. The specimen is preserved in rather bad condition, particularly distally, as well as along its ventral side, where the dentine is fractured in small pieces that are scattered in the sedimentary matrix. This makes the distal end of the tusk rather ill defined.

The tusk was also originally fractured in seven pieces, following the fissures of the surrounding rock. This permitted the examination of natural cross sections before the final restoration of the specimen. When examined macroscopically most sections exhibit the Schreger pattern, a unique characteristic of the proboscidean ivory (Owen, 1840–1845; Palombo and Villa, 2001; Trapani and Fisher, 2003). The Schreger pattern consists of two intersecting sets of spiral lines that radiate clockwise and counterclockwise from the tusk longitudinal axis. This pattern, visible in cross sections, particularly near the periphery of the tusk, is the visual effect of the undulating arrangement of the dentine tubules along the longitudinal axis of the tusk (Miles and Boyde, 1961; Fisher et al., 1998; Palombo and Villa, 2001; Trapani and Fisher, 2003).

Schreger angle measurements (that is the angle between the two sets of spiral lines) were carried out on photographs taken perpendicular to the natural sections of the studied specimen (Fig. 3). The measurements were taken in the section areas where the pattern was clearly visible, that is in a rather small area of each section, given the bad preservation state of the specimen. The measured Schreger angles exhibit considerable consistency along the longitudinal axis of the tusk, as well as from the

axis to its periphery: They are almost always obtuse (only two angles measure slightly above 90°) and usually at the range of about 80–85°. The outer Schreger lines are, though, not well observable, due to the bad preservation of the specimen surface. The dentine/cement junction is also not visible. The variation of Schreger angles is given in Table 1.

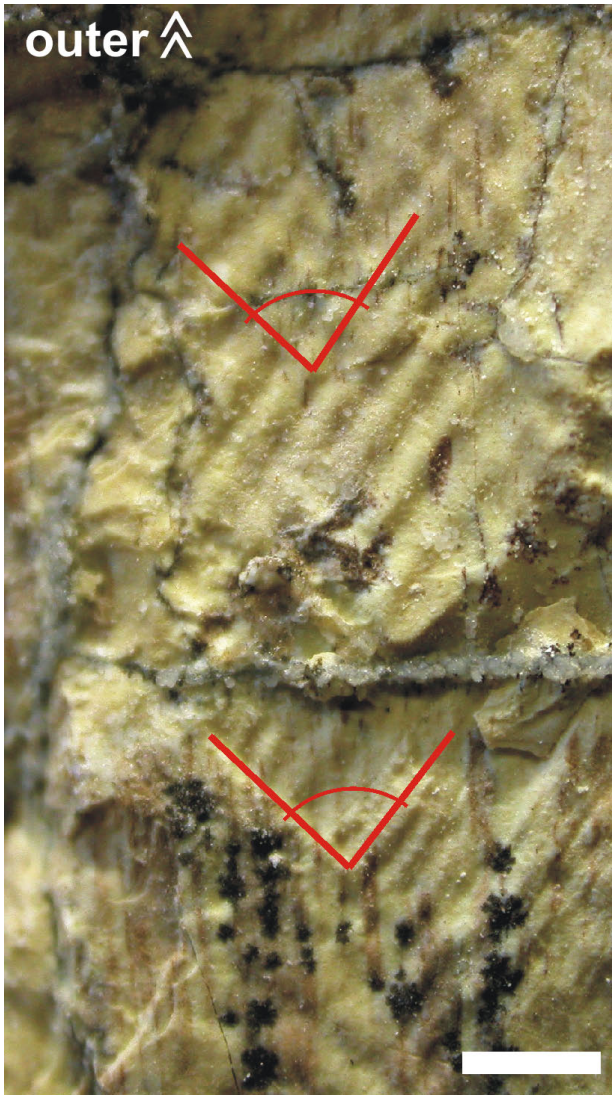

Fig. 3. Cross section of the elephant tusk ENM-1, situated about 92 cm from its tip, exhibiting the Schreger pattern. Two Schreger angles are shown. Graphical scale: 20 mm.

Discussion: The weak curvature and torsion exhibited in the studied tusk preclude its attribution to late gomphotheres (*Anancus*), late *Mammuthus* species and *Elephas (Palaeoloxodon) antiquus*: *Anancus* has practically straight tusks; *Mammuthus trogontherii* and —particularly— *M. primigenius* tusks are characterised by strong bent and torsion; *E. antiquus* tusks exhibit no torsion. The observed morphology of ENM-1 is, however, comparable to that of the early forms of *Mammuthus*, collectively referred to *M. meridionalis*, the tusks of which are much less bent and tortuous than the Middle–Late Pleistocene species of this genus.

The study of the Schreger pattern as an optical expression of the ivory internal structure has been often used for the identification of the proboscidean tusks. The angle between the two sets of lines near the tusk periphery (near the dentine/cement junction), as well as the variation of this angle from the axis towards the periphery of the tusk, have been used in proboscidean taxonomy to the genus level (Palombo and Villa, 2001; Agiadi, 2001; Theodorou and Agiadi, 2001; Trapani and Fisher, 2003; Agiadi and Theodorou, 2005; Ábelová, 2008). The acute angles formed by the Schreger lines in the studied tusk cross sections suggest an attribution to *Mammuthus*, since *Elephas* exhibits clearly obtuse outer Schreger angles (Espinoza and Mann, 1993; Palombo and Villa, 2001; Trapani and Fisher, 2003). However, in elephant ivory the Schreger angles tend to get larger from the tusk axis to the dentine/cement junction, which seems not to be the case in ENM-1. According to Palombo and Villa (2001) only *Anancus* shows acute (<82°) and relatively constant angles throughout the tusk cross section. Nevertheless, an attribution to this genus is not plausible due to the general shape of the tusk (see above). Mammutid and gomphotheriid genera of Early Pliocene or earlier age were not considered in comparison, as —to our knowledge— there are not any published descriptions of their Schreger pattern, and because ENM-1 is stratigraphically associated with an *Equus* specimen (ENM-2), indicating later age.

Table 1. Schreger angles in various distances from the tusk tip. The parentheses indicate inaccurate measurement.

distance from the tip (cm)	**71**	**92**			**119**			**183**		
		x	**range**	***n***	**x**	**range**	***n***	**x**	**range**	***n***
outer	(71)	83	70–89	19	83	74–92	18	76	71–79	5
inner	—	80	74–89	20	82	71–89	20	—	—	—

The discrepancy between our own observations and published data regarding the angle constancy throughout the tusk sections is attributed to bad preservation. Alternatively it might be due to individual variation, since the published statistical samples are always small.

Considering the discussed morphological data, the proboscidean tusk ENM-1 is tentatively referred to *Mammuthus meridionalis.*

Order: Perissodactyla OWEN, 1848
Family: Equidae GRAY, 1821
Genus: *Equus* LINNAEUS, 1758
Equus sp. (stenonid type)
Material: ENM-2: right astragalus (Fig. 4).
Description–Discussion: The specimen belongs to a medium-sized horse of the genus *Equus*. Its dimensions are given in the table 2. ENM-2 is wider than high (measurements 4 and 1 respectively; table 2). Figure 5 exhibits clearly its relatively wide proportions. This is considered by Gromova (1949) as a distinctive character of *Equus ferus*, but a later study has shown that this criterion is not valid (De Giuli, 1972). Prat (1964) mentioned that the wider trochlea of the astragalus might better distinguish the caballoid horses than the maximal width. As seen in figure 5, the corresponding measurement 3 of ENM-2 is low when compared to both stenonid and caballoid samples. Anyway, ENM-2 is certainly small for a caballoid horse, at least the Middle Pleistocene ones (Fig. 5). The distal articular facets for the navicular and the cuboid are sharply divided, a condition more frequently observed in stenonid horses (De Giuli, 1972). Conclusively, the available data indicate that ENM-2 belongs probably to a stenonid horse. When compared to other stenonid horses (Fig. 6), ENM-2 is smaller than the robust *Equus stenonis* from Saint-Vallier, placed among the larger specimens from Senèze, and among the smaller specimens from Sésklo.

4. Biochronology–Palaeoecology

Based mainly on lithostratigraphic indications of volcanoclastic origin, Syrides (1990) suggested a Pliocene age for the Goniá Fm. that is fully supported by biochronological evidences. Analysis of the micromammalian assemblage revealed from the locality of Sílata, placed at the base of the formation indicates a latest Turolian / earliest Ruscinian age (Vasileiadou et al., 2003). A Late Ruscinian / Early Villafranchian age is suggested for the Goniá Fm. deposits exposed in the area of Megálo Émvolo (localities MEV and MEM; Koufos et al., 1991a) in agreement with the age indication provided by the remains of the giant tortoise *Cheirogaster* cf. *perpignana*, discovered to the south of Néa Michanióna village (Vlachos, 2007).

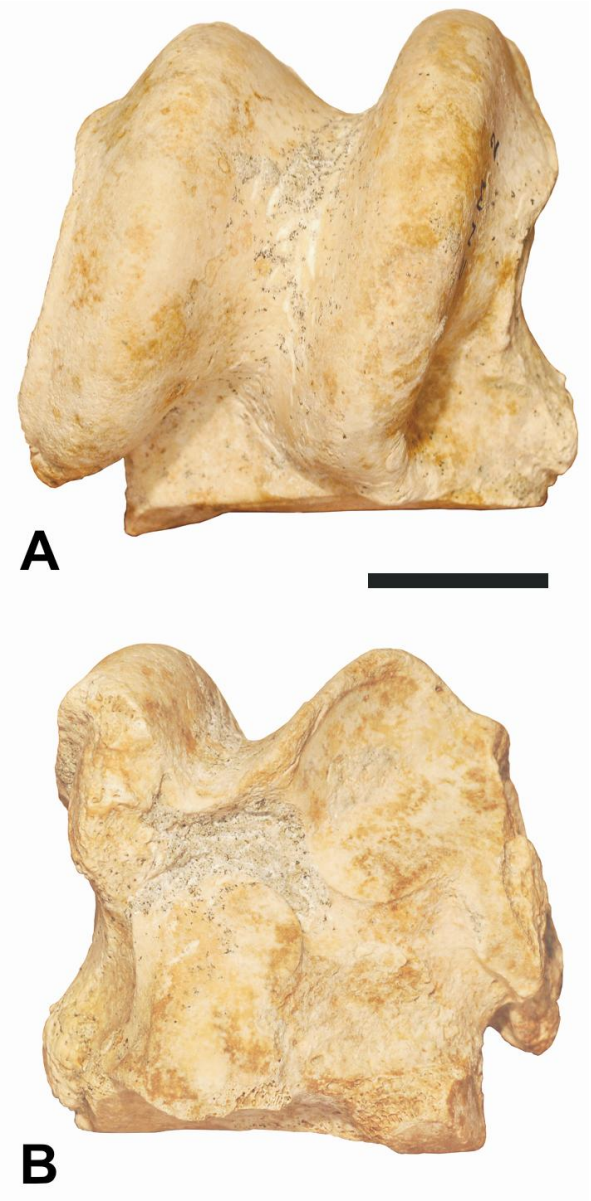

Fig. 4. The horse astragalus ENM-2: A, dorsal view; B, pedal view. Graphical scale: 20 mm.

Table 2. Measurements of the astrgalus ENM-2 taken according to Eisenmann et al. (1988): 1, maximal height; 2, maximal diameter of the medial condyle; 3, width of the trochlea (at the apex of each condyle); 4, maximal width; 5, distal articular width; 6, distal articular depth; 7, maximal medial depth.

	1	**2**	**3**	**4**	**5**	**6**	**7**
ENM-2	60.5	60.7	27.8	63.0	49.7	36.8	53.3

Although the few new mammal remains from Epanomí are not sufficient for adequate biochronological conclusions, the combination of the two identified mammal species is rather indicative of a latest Pliocene age: *Mammuthus meridionalis* lived during a long time interval that spans from Late Pliocene (upper MN16) to the end of Early Pleistocene (Maglio, 1973; Mein, 1990), whereas the biostratigraphic span of stenonid horses is similar (Forstén 1998), though some late stenonid horses possibly survive into the Middle Pleistocene. Following both the lithostratigraphy and the geometry of the bedding, the deposits exposed south of Epanomí village should correspond to the upper horizons of Goniá Fm., which are therefore dated to the end of Pliocene.

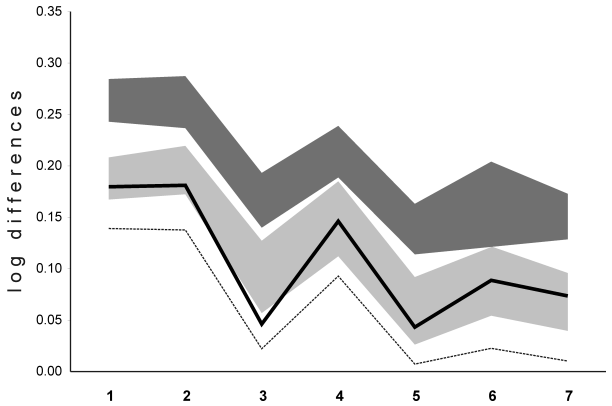

Fig. 5. Ratio diagram comparing the horse astragalus measurements of various samples: solid line: ENM-1; dashed line: *Equus stenonis mygdoniensis* from Gerakaroú (Koufos, 1992); dark gray area: range of variation of *Equus mosbachensis* (Eisenmann, pers. com.); light gray area: range of variation of *Equus stenonis* from Sésklo (Athanassiou 2001). Measurement methodology according to (Eisenmann et al., 1988). A description of measurements is also given in the caption of table 2.

Palaeoecologically, the presence of a horse certainly points to an open environment, while *Mammuthus meridionalis* is a woodland form. This probably suggests an open woodland environment, or an open environment with forested patches, for the Epanomí area during the latest Pliocene.

5. Conclusions

The new locality of Epanomí yielded scanty mammal remains (an elephant tusk and a horse astragalus), which are referred to *Mammuthus* cf. *meridionalis* and *Equus* sp. (stenonid type). The currently available material is not sufficient for an adequate biochronological study, as both taxa have wide stratigraphic distributions. Nevertheless, previous palaeontological and stratigraphic work carried out in western Chalkidikí Peninsula permits the correlation of the new site with the upper horizon of Goniá Fm., limiting its age to the latest Pliocene. Epanomí adds another site to the mammal-bearing localities of western Chalkidikí.

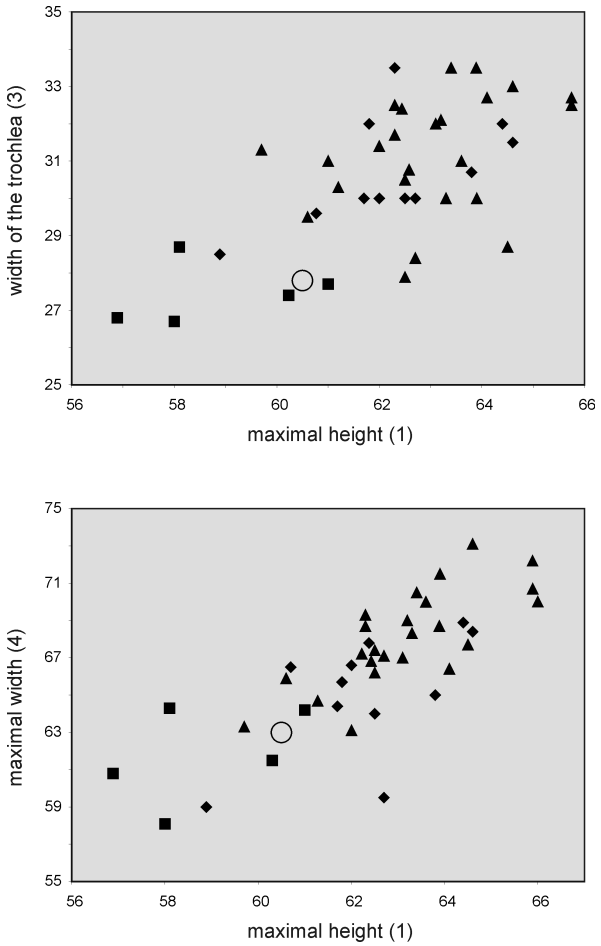

Fig. 6. Scatter plots comparing the horse astragalus measurement 1 with 3 and 4: open circle: ENM-1; triangles: *Equus stenonis vireti* from Saint-Vallier, France (Naturhistorisches Museum Basel); squares: *Equus stenonis senezensis* from Senèze (Naturhistorisches Museum Basel); diamonds: *Equus stenonis* from Sésklo (Athanassiou, 2001). Measurements in mm.

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