

## On a *Deinotherium* (Proboscidea) finding in the Neogene of Crete

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**Abstract:** This paper reports the discovery of an incomplete proboscidean mandible near the village of Maroniá in eastern Crete. The fragment described here includes the first molar (m1) of a deinotherid, that because of its large size is identified as *Deinotherium giganteum*. The specimen was found in shallow-water marine sediments. The presence of *Deinotherium* on the island, together with other Miocene vertebrate faunas, suggests that during that epoch Crete was connected to the mainland by a wide land bridge.

**Key Words:** Greece; Crete; Late Miocene; Proboscidea; *Deinotherium*

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**Résumé :** *Découverte de Deinotherium (Proboscidea) dans le Néogène de Crète.*- Près du village Maroniá, en Crète orientale, une formation marine miocène a livré une mandibule incomplète de Proboscidién. Ce fragment comprend une première molaire (m1) de grande dimension attribuable à l'espèce *Deinotherium giganteum*. La présence d'un Déinothère dans la faune des mammifères miocènes de l'île de Crète montre qu'à cette époque il existait une liaison relativement large et durable avec le continent.

**Mots-Clefs :** Grèce ; Crète ; Miocène supérieur ; Proboscidea ; *Deinotherium*

### Introduction

Crete is well known for its faunas of large mammals in Quaternary times, mainly elephants, deer and hippos. These faunas are endemic and ecologically unbalanced due to the fact that Crete was already an island. To reach it from the mainland demanded the ability, possessed only by these larger mammals, to swim well (THEODOROU & DERMITZAKIS, 1991; DERMITZAKIS, 1994; LAX, 1996; SONDAAR *et alii*, 1996). However, Miocene larger mammal faunas reported from the island (recently revised by VAN DER MADE, 1996) have a clearly continental aspect, thus indicating that during the Miocene epoch Crete was not an island. These faunas comprise a gomphotheriid, cf. *Prohyrax hendeyi*, *Microstonyx* cf. *major*, cf. *Propotamochoerus palaeochoerus*, *Taucanamo* ? / *Yunnanochorus* ? sp., *Dorcatherium naui*, cf. *Dorcabone anthracotherioides*, cf. *Pliocervus pentelici*, Bovidae indet., *Hipparion* sp. and Carnivora indet. (BENDA *et alii*, 1970; DE BRUIJN *et alii*, 1971; DE BRUIJN & MEULENKAMP, 1972; BONNEAU & GINSBURG, 1974; KUSS, 1976; LEINDERS & MEULENKAMP, 1978; VAN DER MADE, 1996). Their age (often determined with the aid of micromammals) spans Middle to Late Miocene times (MN 6 to MN 11 – van der Made, 1996).

The new report of a large mammal in the Neogene of Crete is from a site situated south of the town of Seteía (Prefecture of Lasithi, Eastern Crete) in the vicinity of the village of Maroniá, WNW of the small settlement of Sfakiá (Fig. 1). The only fossil of a mammal found at the site, a *Deinotherium* dentary fragment, was collected about seven years ago by Mr. Ioannis DERMITZAKIS, a resident of Seteía. This is the

first deinotheriid found in Crete. In May 2004 the specimen was delivered to the Archaeological Museum of Seteía, where it will be on exhibit soon.

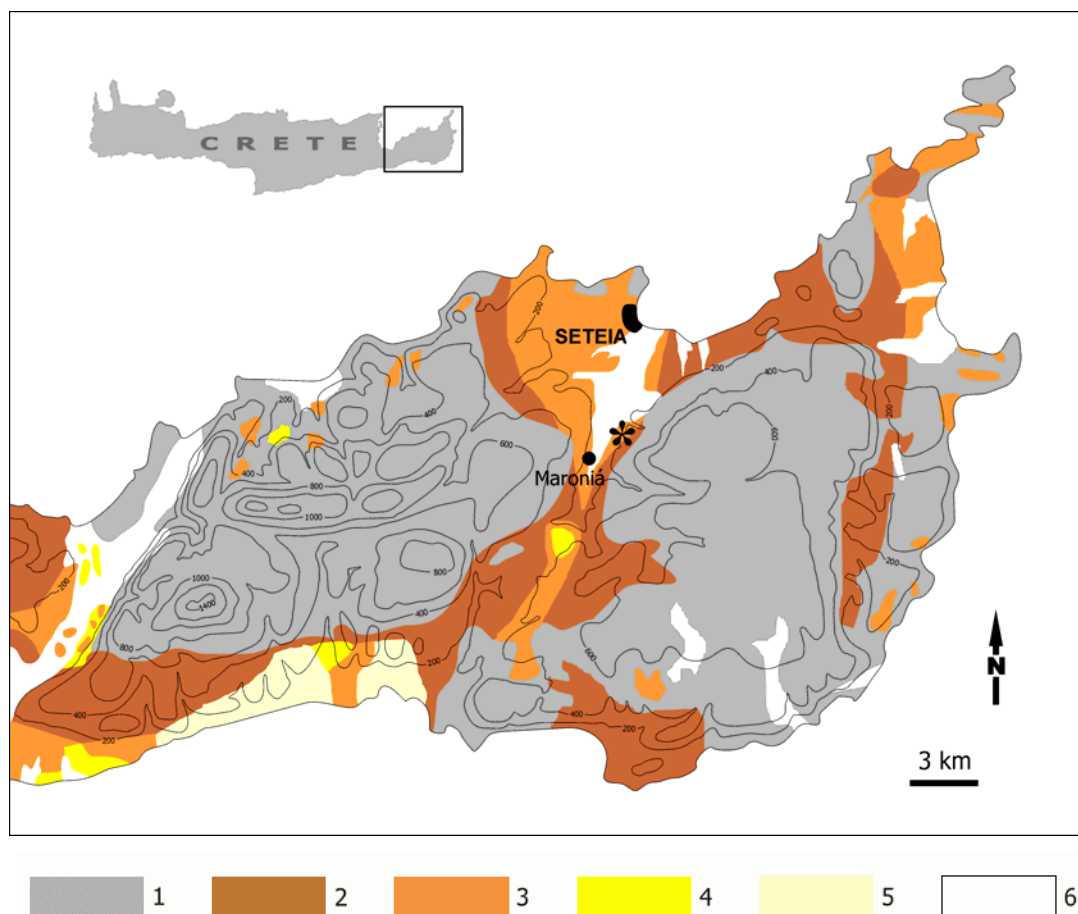
Fossil deinotheres have been reported from other localities in Greece (Fig. 2). Smaller and geologically older specimens, classified in *Prodeinotherium* ÉHIK, 1930 (HARRIS, 1973; GÖHLICH, 1999; HUTTUNEN, 2002a), have been found on the islands of Chíos, Psará and Lésbos in the eastern Aegean Sea (PARASKEVAIDIS, 1940; BESENECKER & SYMEONIDIS, 1975; KOUFOS *et alii*, 2003). Larger and younger specimens, classified in *Deinotherium* KAUP, 1829, are more common and more widely disseminated. They are represented in some of the classical "Pikermian"-type faunas (Pikérmi, Sámos, Halmyropótamos, Pýrgos Vassilíssis, Vathýlakkos – GAUDRY, 1862; MELENTIS, 1970; DERMITZAKIS *et alii*, 1982), as well as in other less well-known localities (a not tracked down locality in Central Macedonia and Haghía Paraskeví – SYMEONIDIS, 1970; TSOUKALA & MELENTIS, 1994). Another deinother site was discovered recently in Eastern Crete (POULAKAKIS *et alii*, in press). This locality too is near Seteía (Gela section), less than 10 km north of the Maroniá site, where the specimen described here was found. The Gela site yielded several dental and postcranial specimens, all from one large individual of *Deinotherium giganteum*.

### Geology

Geologically, eastern Crete consists of a predominantly Mesozoic Alpine succession that is expressed in a fairly high and steep relief, and of Neogene deposits that form hilly lowlands. The Maroniá area is in a graben of

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**Figure 1:** Geological map of the area of Seteia, based on CREUTZBURG *et alii* (1977). An asterisk indicates the Maroniá locality.

1, pre-Neogene basement; 2, continental Miocene (fluvio-lacustrine sediments); 3, shallow-water marine Miocene–Lower Pliocene; 4, shallow-water marine Pliocene; 5, continental Pleistocene; 6, alluvium. Contour interval: 200 m.

neotectonic origin, filled by Neogene, shallow-water marine sediments that overlie a pre-Neogene series. The Neogene deposits of the Seteia District consist primarily of marls, clays, marly limestones and sandstones. They are rich in invertebrate fossils (Foraminifera, Bivalvia, Gastropoda, Echinodermata, etc.) that indicate a Middle Miocene to Pliocene age (SYMEONIDIS, 1966; GRADSTEIN, 1973; MARKOPOULOU-DIACANTONI *et alii*, 1993). Cranial and postcranial remains of a Miocene sirenian, *Metaxytherium cuvieri*, were found at the village of Achládiá, WNW of Maroniá (MARKOPOULOU-DIACANTONI & LOGOS, 2004). GRADSTEIN (1973) recognises seven Neogene lithostratigraphic formations in the Seteia region, two of which are present around Maroniá: an underlying Skopí Formation, mainly conglomerates, sands, silts and clays with *Crassostrea*, *Ostrea* and plant remains, and the Faneroméni Formation, consisting mainly of limestones and marls with foraminiferans, sponges, algae and molluscs. The fossil content of these Neogene deposits indicates a low energy littoral shallow-water milieu (GRADSTEIN, 1973; MARKOPOULOU-DIACANTONI & LOGOS, 2004). The *Deinotherium* specimen was found in the Faneroméni Formation (*sensu* GRADSTEIN, 1973), in a pebble bed intercalated in white

marls, which include several *Ostrea* banks. Based on biostratigraphic data GRADSTEIN (1973, p. 569) reports a Late Miocene age for the Faneroméni Formation.

### Systematics

Order: Proboscidea ILLIGER, 1811

Suborder: Deinotherioidea OSBORN, 1921

Family: Deinotheriidae BONAPARTE, 1845

Genus: *Deinotherium* KAUP, 1829

*Deinotherium giganteum* KAUP, 1829

**Material:** right dentary fragment with the first molar (m1), MAP-1 (Fig. 3).

**Locality:** Maroniá, Prefecture of Lasíthi, E Crete.

**Stratigraphic level:** Upper Miocene, Faneroméni Formation.

**Description:** The dentary fragment MAP-1 is too incomplete to provide clues about the morphology of the mandible. The first molar is preserved in good condition, except for a part of the enamel on the lingual side, which was detached post-mortem. As is the case in all

deinotheriid first molars, the molar of MAP-1 is trilophodont (it consists of three transverse lophids) and is elongated. The lophids are curved, the concave side facing anteriorly. The tooth is almost pristine, presenting only slight attrition (wear facets are hardly visible at the posterior side of the lophids). The cutting edges of the lophids retain traces of crenulations, which are very clear on the unworn distal lophid. The enamel is thick, ranging in thickness from 1 mm at the sides of the crown, to 4 mm on the occlusal surface. The mesial (first) lophid (protolophid) is the most prominent, while the distal one is the least. Lophids are separated by deep and wide valleys, which are open at both sides and deeper labially. The anterior valley is a little wider than the posterior one. There is a mesial crenulated cingulid, which is well developed, especially on the labial half of the mesial side. The talonid, which is also crenulated, is weak. The dimensions of MAP-1 are given in Table 1.

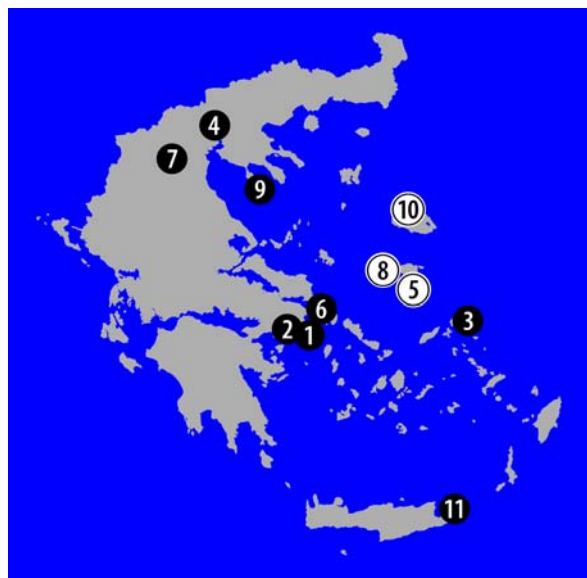
	L	W1	W2	W3	H
<b>MAP-1</b>	105.3	70.5	70.5	64.9	51.5

**Table 1:** Dental dimensions in mm of the specimen MAP-1. L: maximal length; W1,2,3: maximal widths of the first, second and third lophid respectively; H: maximal crown height (at the metaconid).

## Discussion

The family Deinotheriidae is an extinct proboscidean group that originated in Africa, where it was already present in the Late Oligocene and survived until the Early Pleistocene. Deinotheres soon dispersed in Europe and southwest Asia during the Early Miocene, where they survived until the Pliocene (BERGOUNIOUX & CROUZEL, 1962; HUTTUNEN, 2002a). They are characterised by typical proboscidean cranial and postcranial morphology, including large size, short body on long columnar limbs with short distal elements, pneumatized cranial bones, retracted nasals, the inferred presence of a proboscis, and the presence of elongate incisors that form tusks. They retain some ancestral characters - a low skull and bunodont dentition with deciduous and permanent tooth generations that erupt vertically. However, deinotheres show a unique derived character: the lack of upper tusks and the presence of downturned, vertically developed tusks in the mandible (BERGOUNIOUX & CROUZEL, 1962; TOBIEN, 1988; SHOSHANI *et alii*, 1996; HUTTUNEN, 2002a).

Their distinctive morphology led to the classification of the family in a separate suborder, Deinotherioidea. However, several opinions have been expressed about taxonomy at the genus and species level (OSBORN, 1936; GRÄF, 1957; BERGOUNIOUX & CROUZEL, 1962;



**Figure 2:** Map of Greece, indicating the Deinotheriidae bearing localities: white circles indicate the presence of *Prodeinotherium bavaricum*; black circles indicate the presence of *Deinotherium giganteum*.

1: Pikérmí (GAUDRY, 1862), 2: Pýrgos Vassilíssis, 3: Sámos, 4: Vathýlakkos (DERMITZAKIS *et alii*, 1982), 5: Thymianá (PARASKEVAIDIS, 1940), 6: Halmyropótamos (MELENTIS, 1970), 7: Central Macedonia (exact locality unknown) (SYMEONIDIS, 1970), 8: Psará Island (BESENECKER & SYMEONIDIS, 1975), 9: Haghía Paraskeví (TSOUKALA & MELENTIS, 1994), 10: Gavathás (KOUFOS *et alii*, 2003), 11: Maroniá, present study, and Gela section (POULAKAKIS *et alii*, in press).

HARRIS, 1973, HUTTUNEN, 2002a; among others). Deinotheres were originally referred to a single genus, *Deinotherium* KAUP, 1829. Nevertheless, important anatomical (cranial and postcranial) differences between the earlier, smaller forms and the later larger forms supported the grouping of the former ones in another genus, *Prodeinotherium* ÉRIK, 1930. The division of the family into two genera is generally accepted and is adopted in recent taxonomical works (HARRIS, 1973; SHOSHANI *et alii*, 1996; GÖHLICH, 1999; HUTTUNEN, 2002a). The distinction between *Prodeinotherium* and *Deinotherium* is based mainly on size, the morphology of the p3, snout and cranial roof shape, inclination of the occiput, relative position of the occipital condyles, development of the scapular spine and disposition of the carpals and tarsals. *Deinotherium* has also a more cursorially adapted skeleton than *Prodeinotherium*. The dental morphology does not offer any diagnostic character (except for p3), and the distinction of genus from dental material is based primarily on size. More recently, a third deinotherine genus, *Chilgatherium*, was erected to accommodate dentally primitive, very diminutive specimens from the Late Oligocene site of Chilga, Ethiopia (SANDERS *et alii*, 2004). The Deinotheriidae present a constant trend towards larger size, which culminated in the gigantic size of late representatives of *Deinotherium*.

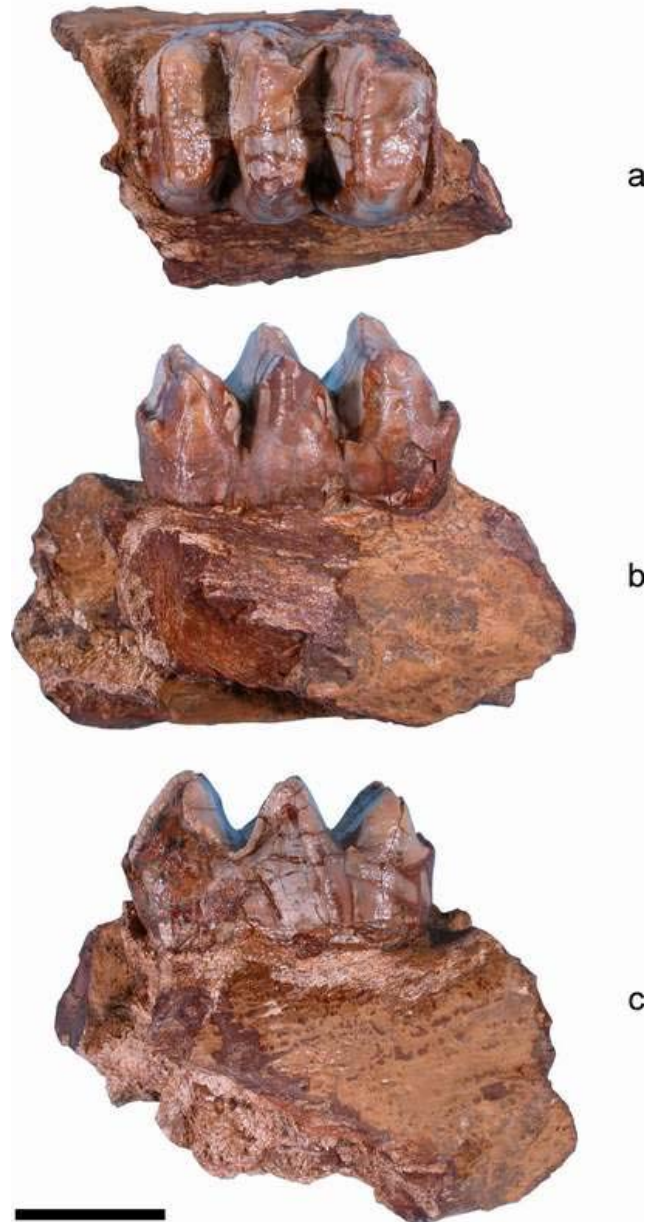
The history of specific classification in the Deinotheriidae is more complicated: apart from the recently described *Chilgatherium harrisi* SANDERS *et alii*, 2004, 31 species have been erected (for the most part during the 19<sup>th</sup> century), based primarily on morphological and metrical diversity in the dental elements of specimens from African, European and Asian localities (HUTTUNEN, 2002a). However, more recent studies (BERGOUNIOUX & CROUZEL, 1962; HARRIS, 1973; HUTTUNEN, 2002a) have shown that most of these differences (often in minor dental features) are due to intra- and not interspecific variation. Today, only six of these species are considered valid (HARRIS, 1973, 1978; HUTTUNEN, 2002a), of which two are confined to Europe: *Prodeinotherium bavaricum* VON MEYER, 1831 of Early to Middle Miocene age, and *Deinotherium giganteum* of Middle Miocene to Pliocene age. Some authors (e.g. GÖHLICH, 1999) also accept another, not as well known Late Miocene – Pliocene species, *Deinotherium gigantissimum* STEFĂNESCU, 1892, which is of gigantic size and palaeobiogeographically confined to Europe. Most authors, however, consider it to be a large-sized variety of *Deinotherium giganteum* (BERGOUNIOUX & CROUZEL, 1962; HARRIS, 1978; HUTTUNEN, 2002a).

The specimen reported here is characterised by its large size. Compared to published m1 measurements, MAP-1 appears to be much larger than any known specimen of *Prodeinotherium bavaricum*, and is even larger than certain *Deinotherium giganteum* from German, French, Hungarian and Austrian localities (Fig. 4). However, there are two specimens, referred by KAUP (1832) and OSBORN (1936, p. 109) to *Deinotherium giganteum*, which are comparable in size to MAP-1. The former (plotted in Fig. 4), slightly longer and narrower than MAP-1, has dimensions close to those of *Deinotherium gigantissimum* (a species erected many years after KAUP's publication); the latter has a length of 104 mm (not plotted in Fig. 4, as OSBORN does not give any width measurement). Actually, the dimensions of MAP-1 seem to be slightly smaller, but very near those of first lower molars attributed to *Deinotherium gigantissimum*. A metrical comparison with the other Cretan deinotherid find is not possible, as this material does not include a lower first molar (POULAKAKIS *et alii*, in press).

The morphology of MAP-1 does not differ from that typical of deinotheriids, for the molars of all members of the family show great morphological homogeneity.

If we accept *Deinotherium gigantissimum* as a valid species, then the size of MAP-1 places it among the largest *D. giganteum* and the smallest *D. gigantissimum*. So a specific attribution is difficult, given that there is no discontinuity in the range of sizes between

these species (BERGOUNIOUX & CROUZEL, 1962). If we accept the synonymy of *D. gigantissimum* and *D. giganteum* (the most common contemporary trend), MAP-1 is a large specimen of *Deinotherium giganteum*, but is considerably smaller than the largest reported measurements for the species (length: 112 mm, width: 90 mm, according to BERGOUNIOUX & CROUZEL, 1962). As the synonymy of the two species has been generally accepted, the specimen MAP-1 is referred to the species *Deinotherium giganteum*.



**Figure 3:** *Deinotherium giganteum*, right mandibular part with m1; a, occlusal view; b, labial view; c, lingual view. Scale: 50 mm.

### Biochronology-Palaeobiogeography-Paleoecology

In Eurasia, *Deinotherium giganteum* has a broad stratigraphical distribution: from the Middle Miocene (MN 6) to the Pliocene, although the upper limit is not known precisely. MEIN

(1990) places the last occurrence of the species in Central and Western Europe in MN 13, while VISLOBKOVÁ (in press) reports the presence of *Deinotherium* in Russia until the end of the Ruscinian (MN 15). Given the deinotheriid trend towards larger size during the Miocene (GRÄF, 1957; HARRIS, 1978; GÖHLICH, 1999; HUTTUNEN, 2002a) and the large size of the new deinotheriid specimen, a Late Miocene or even later age can be assumed. Published marine biostratigraphical data for the Maroniá area place its Neogene sediments in the Upper Miocene (GRADSTEIN, 1973), thus limiting the age of the find. Moreover, a Pliocene age for MAP-1 is not plausible, as an extensive marine transgression during that epoch broke Crete up into small islands (SONDAAR *et alii*, 1996). This resulted in the submergence of large tracts of land, leaving areas insufficient to sustain a population of large mammals. The continental Middle to Late Miocene mammalian faunas found in Crete, together with the new *Deinotherium* find, show that the island was connected to the mainland by a land bridge at that time. The discovery of *Deinotherium* at another site in the Seteia region (POULAKAKIS *et alii*, in press) suggests that deinotheres were probably not visitors by happenstance but were established residents on the island.

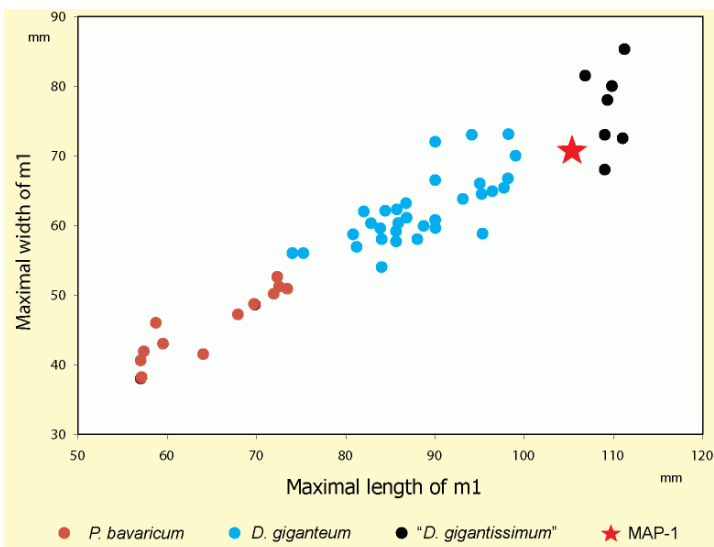
*Prodeinotherium*, exhibits cursorial adaptations, such as the relative elongation of the distal limb elements. This feature, together with the very large size of the animal and that deinotheres may have had to travel widely to find adequate forage, suggests a landscape more open than that of a forest. Thus, the presence of the *Deinotherium giganteum* tooth in the Maroniá area makes plausible the inference that an open forest or woodland landscape prevailed in Eastern Crete during the Late Miocene.

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**Figure 4:** First lower molar dimensions diagram of MAP-1, compared to European Deinotheriidae samples. Data according to KAUP (1832), GRÄF (1957), BERGOUNIOUX & CROUZEL (1962), TOBIEN (1988), GASPARIK (1993), HUTTUNEN (2002b) and KOUFOS *et alii* (2003).

The morphology of the deinotheriid cheek teeth, which are lophodont, brachyodont and simple in shape, indicate that the deinotheres were primarily folivores, consumers of soft, non-abrasive vegetation. This feeding adaptation commonly implies a forested environment. Another feature that points to a closed habitat is the increased mobility of the head as compared to that of the Elephantoids (HARRIS, 1973, 1978). Conversely, the skeleton of *Deinotherium*, in contrast to that of

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