

The *Deinotherium* (Proboscidea, Mammalia): an abnormal tusk from Lisbon, the Miocene record in Portugal and the first appearance datum. Evidence from Lisbon, Portugal

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Résumé

Mots-clés: *Deinotherium*; 1ère arrivée; fin du Miocène inférieur; début du Miocène moyen; datation fine; Portugal.

Le contexte stratigraphique et chronologique particulièrement favorable du Miocène de Lisbonne permet de mettre en évidence qu'il y a deux data distincts et successifs quant aux premières immigrations de Proboscidiens, celle des Gomphothères et, plus tard, celle des Deinothères. L'étude d'une défense d'âge Langhien montre que *Deinotherium bavaricum* était encore présent alors. On a pu préciser la répartition chronologique de cette espèce. Après une discussion au sujet du genre *Deinotherium* et de son amplitude, on présente des considérations sur la présence et répartition des Deinothères au Portugal, ainsi que sur leur rôle écologique.

Abstract

Key-words: *Deinoiherium*; 1st arrival; end of Lower Miocene; lower Middle Miocene; accurate dating; Portugal.

An exceptionally favourable stratigraphic and chronologic context concerning the Miocene series in Lisbon allows us to stress that there are two successive data as far as the Proboscideans' immigration into western Europe is concerned: firstly, that of Gomphotheres, and later that of Deinotheres. The study of a Langhian (in age) tusk has shown that *Deinotherium bavaricum* was still present then. The time span of this species could be accurately recognized. A discussion on the genus *Deinotherium* is presented., as well as its occurrence in Portugal and on its ecologic meaning.

1. Introduction

The lower Tagus basin in the Lisbon area has especially good conditions for dating some very important biological events as the first Immigration of proboscideans into westernmost Europe. Alternating marine and continental levels, the much detailed stratigraphic knowledge and fine dating (foraminifera, K-Ar, ⁸⁷Sr-⁸⁶Sr) allow us to obtain an accurate chronology of these events (Antunes, 2000; Antunes *et al.*, 2000) (Fig. 1).

The presence of the first gomphotheres in Lisbon's IVb unit ("Areias da Quinta do Bacalhau", Burdigalian) had been shown (Zbyszewski, 1949).

On the other hand, data concerning *Deinotherium* were often confusing as they rely on unaccurately localised specimens (Zbyszewski, 1941, 1949). The occurrence of

Deinotherium at the IVb unit would mean (if true, and it is not) that the arrivals of gomphotheres and deinotheres would have been synchronous.

Some doubts about it were expressed (Antunes, 1960) Nearly all mammalian fossils from Quinta das Pedreiras (Lumiar) ascribed by Zbyszewski (1949) to the IVb unit had instead been collected in the overlying, Va2 pyrolusite-rich sands. The typical pyrolusite, black patina is clearly shown by the sole *Deinotherium* fossil (a right D4 germ, n° 7920, coll. Geologic Museum of the Instituto Geológico e Mineiro/ IGM) that was ascribed to the IVb unit (Zbyszewski, 1949, p.74). The IVb unit yielded there extremely rare gomphothere remnants, all devoid of pyrolusite. Deinotheres are always much rarer than gomphotheres. Their presence in the IVb had been claimed but on the referred tooth, which would have been collected

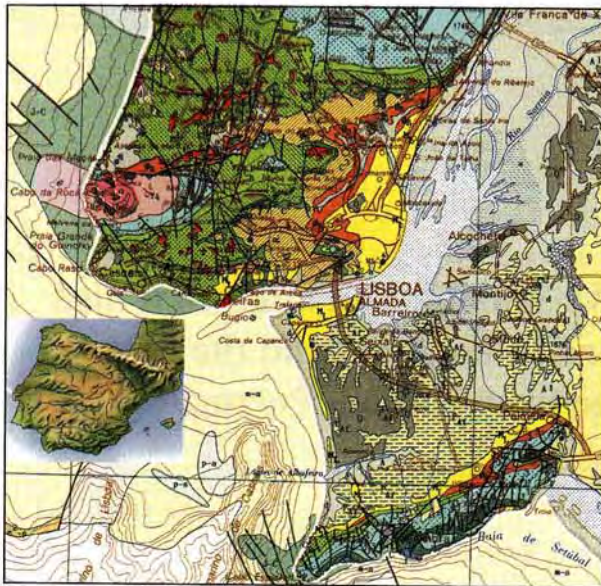


Fig. 1 - Lower Tagus basin (distal part), Lisbon and Setúbal Peninsula area (Antunes *et al.*, 2000).

during one of Zbyszewski's visits to the sandpits (not more than half an hour, nor more than once a month). This hypothesis is utterly unlikely.

The first appearance of *Deinotherium* in Lisbon must therefore be ascribed to the Va2 unit, although Zbyszewski (1973, p.101) did not acknowledge it.

Hence the first appearances of gomphotheres and deinotheres, by that order, are not synchronous but successive events (Ginsburg & Antunes, 1967; Antunes, 1990).

The presence of *Deinotherium* in Lisbon's next, Vb unit ("Areias do Vale de Chelas") is not so clear. This intensely exploited unit yielded hundreds of gomphothere teeth along with many other vertebrate fossils.

Deinotherium was identified for the first time by Zbyszewski (1941) on a fragment of left maxillary with the last molars (M2 and M3); the specimen is vaguely said to have been found at Charneca, near Lisbon (Vb) (*ibid.*). Our late Colleague Zbyszewski explained that it was not purchased at the sandpit, as usual; somebody had noticed that a vertebrate fossil was kept by another person and persuaded the owner to offer it to the IGM museum. The specimen shows the typical pyrolusite patina from Quinta das Pedreiras, near Lumiar (Va2). As the toponym Charneca is an abridged version of Charneca do Lumiar, a village north-east of Lumiar, confusion is almost certain. Hence the specimen does not prove the presence of *Deinotherium* in the Vb (even if it has been included in a list given by Bergounioux *et al.*, 1953, p. 16).

Zbyszewski (1973, p.101) recorded *Deinotherium* from two Vb sites, (a) Azinhaga do Pinhal and (b) Quinta da Farinheira:

(a) Azinhaga do Pinhal - there is no reference on this site, not even in Zbyszewski's synthesis in Bergounioux *et al.* (1953, p. 15, fig. B). A fragment of left maxillary with M2-M3 (n° 5528, IGM museum) was collected (according to its label) at Quinta da Casinha - Azinhaga do Pinhal. It also shows the typical pyrolusite patina from

Quinta das Pedreiras. This doubtfully-localized specimen is worthless as a proof of the *Deinotherium* presence in the Vb unit.

(b) Quinta da Farinheira - this was one of the richest Vb sites. It yielded a lot of specimens that represent the "Hispanotherium fauna". Gomphothere teeth are plentiful. Bones and teeth from Quinta da Farinheira show an iron-rich (goethite and other) crust patina that includes sand grains. One of us (M.T.A.) could verify this after his field researches and through the cleaning of specimens collected there. Or, the only *Deinotherium* tooth in the IGM museum labelled as from Quinta da Farinheira (a right m3, n° 5530), does not show such a patina nor the usual rust-colour. It is light-coloured, the dentine being white and unstained. It certainly was not collected at Quinta da Farinheira. Owing to the very closely similar aspect, the concerned tooth could well come also from Quinta da Barbacena (Va2) as the left P4 n° 5529, IGM museum. The same m3 does not prove either the presence of *Deinotherium* in the Vb unit.

2. A discussion on the genus

The taxonomic status of the first european deinotheres has been discussed. A revision of the problem is under way (Ginsburg, *in press*). We accept the following points: - the distinction between *Deinotherium* and *Prodeinotherium* is not justified; - the sole early european species is *Deinotherium bavaricum* H. von Meyer, 1834.

Gohlich (1999), after Hanis (1973), report the european Deinotheriidae to the genera *Deinotherium* (type species *D. giganteum* Kaup, 1829) and *Prodinotherium* (type species *P. hungaricum* Éhik, 1930).

P. hungaricum is represented but by the type specimen (one mandible and some remains from the fore limb from Kotyhaza), besides a P3 from Kirald, Hungary. This deinotheres is the same size as *D. cuvieri*. Éhik ascribed these specimens to a new species on the following reasons:

- 1) p3 - the hypoconid is not linked to the entoconid, as it is in *D. hobleiy*;
- 2) mandible - the posterior foramen mentale is located under the middle part of the p4, whereas in *D. hobleiy* it is located under the diastheme between p3 and p4;
- 3) mandible - the anterior foramen mentale is under the middle part of p3 whilst in *D. hobleiy* it is under the anterior border of the same tooth.

Éhik segregates a new genus because of MclV (the sole available metapodial) proportions are different from those of the *D. giganteum* MclV from Pikermi (cf. Gaudry, 1862, pl. XXV, fig.3; Dietrich, 1916). The MclV from Pikermi is short and stout, the same bone from Hungary being distinctly more slender.

As far as *P. hungaricum* specific characters are concerned, the p3 structure cannot be upheld because the metaconid-hypoconid connection widely varies from one specimen to another. On four *Deinotherium* p3 from Pontlevoy (Muséum de Pans collections), three show this

connection as a small transverse crest, but it entirely lacks on the fourth specimen. Furthermore, the right p3 from the *Deinotherium giganteum* type specimen shows this connecting crest that is entirely absent in the left p3.

The positions of the mentale foramina in the two species under comparison are too close for them to have a meaningful taxonomic value.

As far as the different McIV proportions (that justified the segregation of two genera) are concerned, Tobien (1962) described a *Deinotherium giganteum* hand from Höwenegg (near Eppelsheim) whose McIV proportions are the same as in the hungarian deinother. We may conclude that the genus and species proposed by Éhik cannot be accepted on this author's criteria.

Harris (1973) restored the genus, however naming it as *Prodeinotherium* instead of *Prodinotherium*. He included in it the species *hobleyi* (ascribed to *Deinotherium* by Éhik). Harris presented a table to stress the differences between the two genera. As for dentition, he presents 3 characters (table 1).

Table 1

<i>Prodeinotherium</i>	<i>Deinotherium</i>
P _{3,4} usually lack mesostyles	P _{3,4} often possess mesostyles
M _{2,3} with well developed postmetaloph ornamentation	M _{2,3} with reduced postmetaloph ornamentation
Tusks nearly vertical	Tusks longer and Maybe recurved beneath symphysis

The P3-4 mesostyle may be present or not in the two genera.

The postmetaloph ornamentation exists in both genera, although it may be more or less important. It may be added that *Deinotherium* material (Muséum de Paris collections) from Pontlevoy and "Faluns de l'Anjou" (MN5, *D. bavaricum*), from Samatan (later age, *D. giganteum*) as well as that from Montredon described by Tobien (1988) show exactly the reverse situation: the always weak mesostyle is clearly more distinct in the MN5 specimens than in *D. giganteum*. This is also the case as far as the postmetaloph ornamentation is concerned. These two characters do not seem stable nor convincing enough to separate two genera.

As for the third character (tusks), in our opinion it seems deceptive on the two skulls where tusks remain in situ:

- the *D. giganteum* type skull from Eppelsheim, and
- the *P. bavaricum* from Langenau depicted by Heizmann *et al.* (1996, fig.8).

The tusk's size difference is quite weak, and in both cases each tusk is arched until the rear part of the symphysis (against Harris' viewpoint).

Furthermore, one of us (L.G.) collected at Chevilly - the type locality of *Deinotherium cuvieri* - a 50 cm long tusk (CHE 99) arched in a way more closely similar to that of the *D. giganteum* type than to the deinother from Langenau.

Heimiann (1992) gives *Deinotherium* as genus name for the Langenau deinother and Ginsburg (2000) called

Deinotherium bavaricum the small deinother from the "faluns" of the Anjou. This means that the genus *Prodinotherium* cannot be accepted on the basis of the dental criteria proposed by Harris. The skull and postskull characters put forward by Harris are not valid because he (maybe a priori) has included in the same genus both the species *bavaricum* (from Europe) and *hobleyi* (from Africa), the latter being the only species he compares to *D. giganteum*. Hence his conclusions about the segregation of the european forms in two genera are worthless.

Can these two genera be distinguished after skeletal elements? It would be needed to compare the *Deinotherium gigantissimum* from Romania to that of *Deinotherium bavaricum* from Langenau (discovered in 1976 and mounted at the Stuttgart Museum). However this has not yet been done.

A similar case is known as far as Carnivora are concerned. It is the case of *Pseudaelurus* (Heinzmann, 1973; Ginsburg, 1983). This genus includes a single early (MN3) species, *Pseudaelurus turnauensis*, from which a somewhat larger form, *P. lorteti*, derived later (MN4); from the latter derived (still later in MN4 or MN4b) *P. romieviensis*, and from that a fourth, still larger species, *P. quadridentatus*. As it also occurred with the deinotheres, each new species did not eliminate the species from which it derived: it persisted. As an example, the same level yielded at La Grive-Saint-Alban *Pseudaelurus turnauensis*, *P. lorteti* and *P. quadridentatus*. Nobody ever felt the need to ascribe these different species to different genera. At most, Viret (1951) proposed subgenus names for each species.

This is further corroborated by the coexistence of *P. turnauensis*, *P. lorteti* and *P. romieviensis* in Lisbon's Vb unit (Antunes, 2000, table 1, p. 292).

At last, Tobien (1988) studied the Montredon *Deinotherium* and named the small european species as *Deinotherium bavaricum*...

3. An abnormal *Deinotherium* tusk from the early middle Miocene of Lisbon

A previously unreported specimen from Lisbon (Vb unit) is described and classified.

Systematics

Class MAMMALIA Linnaeus, 1758
 Order PROBOSCIDEA Illiger, 1811
 Family Deinotheriidae Bonaparte, 1845
 Genus *Deinotherium* Kaup, 1829
 (Type-species: *Deinotherium giganteum* Kaup, 1829)

Deinotherium bavaricum H. v. Meyer 1831
 (Text-fig. 2; Pl. 1, figs 1-3)

Site: Quinta Grande, near Charneca do Lumiar (North of Lisbon).

Stratigraphy and age: Vb unit ("Areias do Vale de Chelas") from Lisbon's Miocene series. MN5 Mammal-unit. Db Iberian Mammal-unit. Ca. 15.9-16.1 Ma. Stage: Langhian.

Material & dimensions (mm): a left tusk. Total length, 300. Proximal transverse & anterior-posterior diameters (A, fig.1), 59 x 71.5. Proximal section at the level where the tooth gets out of its alveolus (B, fig.1), transverse & anterior-posterior diameters, 55.5 x 68. Distal-most measurable section (C, fig.1), transverse & anterior-posterior diameters, 42 x 53.

Description: this tooth is simple and long. Section is subelliptic. The proximal (root's) extremity shows: (a) the beginnings of an axial hole (shaped as an upside-down cone) that corresponds to the root; (b) the section of the tooth, much larger than the section near its tip; (c) a bone fragment adhering on the tooth surface (this fragment's extremity indicates the line where tooth gets out of the mandibular bone). On the medial side, the tooth is flatter than on lateral side. It shows a large number of growing striae that are fine, parallel and slightly sinuous (especially on the lateral surface); there are also longitudinal, parallel striae (spaced from 2 to 6 mm). Three remnants of enamel strips are preserved between longitudinal striae at the proximal part of the antero-lateral surface. These enamel strip remnants measurements (mm) are as follows: Length x proximal width x distal width = 28 x 4.5 x 5.5; 24 x 6 x 5; 22.5 x 8 x 8.5. Total (reconstructed) length would be ca. 400.

Relationships and differences: The tusk under study cannot be confused with a gomphothere's one. The mandibular tusks of the gomphotheres are straight or nearly so, and show a distinctly different section - the lower tusks are ventrally plate, slightly convex dorsally, and laterally thinner. The gomphothere's upper tusks are nearly elliptic proximally, but very different distally - entirely flat at the ventral side and dorsally arched; a broad enamel band is present on the ventral surface near the distal extremity (observing the tusk in proximal direction, that band turns progressively to the external side); when the band is vertical (and proximal) it can become reduced and dissociated into fine strips that remind the small enamel strips on the Quinta Grande tusk. However the tooth under study is elliptic in section over its whole length and shows a general arched shape that is not known in gomphothere's tusks. This shape is indeed identical to that from deinotheres' tusks whenever found in situ on the mandible (Eppelsheim, Langenau, Omo).

Furthermore, this deinotheres tusk somewhat recalls the distal part of an upper morse's tusk as far as size is concerned, but it is otherwise distinctly different in shape, in its section, and in geologic age. Indeed the Odobeninae appeared much later, only in Pleistocene times, according to Mitchell (1968). They descend from the Otariidae Imagotariinae (Barnes, 1979); these only appear in Middle Miocene, that is to say, distinctly later than the deposition of Lisbon's lower Middle Miocene Vb unit.

On the other hand, the distal part of *Deinotherium* tusks usually presents an axis that is straight and a round section, whereas the specimen under study shows an arched axis, a median surface that is somewhat flatter than the lateral surface, as well as a distinctly elliptical section (whose great axis is more or less antero-posterior). The Quinta Grande tusk is obviously a pathologic tooth, both very small (its corresponding Chevilly tusk is one and a half times larger), with an abnormal axis and an abnormal section, and presenting utterly uncommon growth striae and enamel stnps.

3. The *Deinotherium* record in Portugal

As it has been shown (Introduction), a discussion on the occurrence of *Deinotherium* in Portugal (and especially on the time span of *Deinotherium bavaricum* in the Lisbon area) is interesting (Table 2).

Deinotherium bavaricum is mainly represented in the Lisbon area by 13 specimens from the Miocene Va2 unit. If account is taken of a fragment (MTA coll.) from Quinta do Pombeiro near Chelas (Va2), the total amount is 14.

The same species have been recognized in the Vb unit (Langhian, early middle Miocene) after the tusk described here. It still occurs a little later in Langhian at Quintanelas (a small basin NW from Lisbon) (Zbyszewski, 1952).

Afterwards, the important Serravallian (middle Miocene) transgression is related to moister conditions, although less warm than before (text-fig. 3). That allowed the same genus to reappear in the inner part of the lower Tagus basin at Formiga, Azambuja (later part of middle Miocene) (Antunes *et al.*, 1971): it is represented there by *Deinotherium giganteum*.

D. giganteum still persisted at Azambujeira (middle level), in Upper Vallesian (Antunes, 1984).

Both occurrences are related to less-warm but rather moist environments.

4. Comparisons with other european areas

In France, the first *Deinotherium* occur in the "Sables de l'Orléanais" (dated MN4b) at Chevilly (Loiret). Cuvier (1822, chapter: Animaux fossiles voisins des Tapirs) has shown 3 teeth (1822, t. II, pl. IV, corresponding to the text page 222):

- fig. 1: ml (Muséum de Paris' collection number: CHE 19);
- fig. 2: M3 (CHE 22);
- fig. 3: dp4 (CHE 20).

Kaup (1832) established the species *Deinotherium cuvieri* on these remnants. However, the same species falls in synonymy (as L.G. verified) on (or maybe better said, after) *Deinotherium bavaricum* (H. von Meyer, 1831). The last species was described after some remnants from Georgensmund that have been destroyed, with the sole exception of a p3 kept at the Vienna (Austria) Museum. Georgensmund has been reported to MN6 by Abusch-

~ Deinotherium bavaricum ~

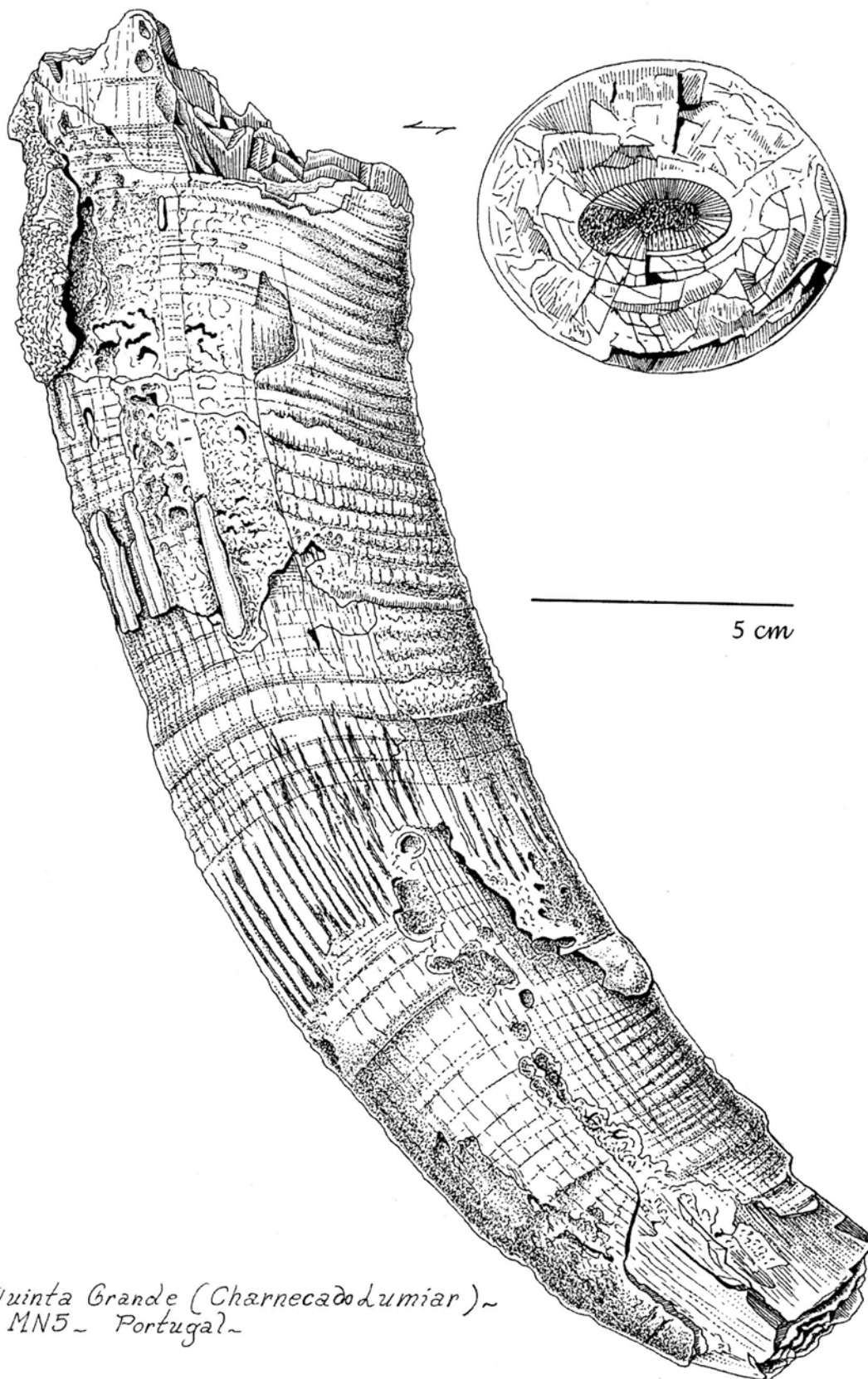


Fig. 2 - Lateral view and proximal section; exceptionally, the surface presents remnants of longitudinal enamel strips as well as some fragments of mandibular bone.

Table 2

Miocene *Deinotherium* teeth from Portugal and measurements (mm).
(Collections: IGM, Instituto Geológico e Mineiro; IST, Instituto Superior Técnico, Lisbon; MTA, M. T. Antunes).

Species Specimen / Collection	Locality	Age/ unit/ MN/ Dating (Ma)	Max. Length	Max. width
<i>Deinotherium bavaricum</i> Right D ⁴ germ / IGM n° 7920	Quinta das Pedreiras (reported by error to the earlier IVb unit)	Uppermost Burdigalian/ Va2/ MN 4/ 17.8 - 16.4 Ma	not measured	not measured
Left P ⁴ / IGM n° 5529	Quinta da Barbacena	id.	not measured	not measured
Right M ¹ / MTA	Quinta das Pedreiras	id.	61.8	49.0
Left M ¹ / IGM n° 5658	id.	id.	not measured	not measured
Left maxillary / IGM n° 5528 (Zby.1941)	Quinta das Pedreiras (ascribed by error to Quinta da Casinha- Azinhaga do Pinhal, Vb unit)	id. (also Va2)		
M ² M ³			63 63	62 59
Left maxillary / IGM n° 5659 with M ² -M ³	Quinta das Pedreiras	id.	not measured	not measured
Left M ² / MTA	id.	id.	64.3	64.6
Right M ² / MTA	id.	id.	61.3	60.7
Left hemimand./ MTA M ₂ M ₃	Quinta das Pedreiras		(60) 73.2	>53 55.6
Mandible / IGM (Zby., 1973) left right P ₃ P ₄ M ₁ M ₂ M ₃	id.	id.		
			41 41 49 49 60 60 63 63 74 74	31 31 41 41 45 44 55 55 57 55
Complete, left tusk / MTA	id.	id.	ca. 505 (total) x - 91.9 (proximal)	- 59.8 (proximal)
Left P ₃ germ/ MTA	id.	id.	38.3	24.0
Right M ₃ / IGM n° 5530	According to the label, from Quinta da Farinheira (Vb); but certainly from elsewhere, maybe Quinta da Barbacena	id., most probably Va2	not measured	not measured
Nearly complete left tusk	Quinta Grande (Charneca do Lumiar)	Langhian/ Vb/ early MN 5/ 16.4 - 15.3 Ma	300 or - 400 as reconstructed x 71.5 (prox.)	- 59 (proximal)
Mandible / IGM (Zby.1952, p.77) Uncomplete right M ₃ (other teeth lost)	Quintanelas	lower Middle Mioc/ MN 5	- >54	- >52
<i>Deinotherium giganteum</i> / IGM (Antunes <i>et al.</i> , 1971) Left P ³ Right M ²	Casais da Formiga, near Azambuja	upper Middle Mioc/ MN 7 - 8	>63 82	>65 83
IST (Alberdi <i>et al.</i> , 1978; Antunes, 1984) uncomplete m1	Azambujeira, middle level	lower Upper Miocene / MN10	not measured	not measured

Siewert (1983) and by De Bruijn *et al.*, (1992); however, it is most clearly MN5 (Ginsburg, 1999).

In Germany, the oldest *Deinotherium* is the complete skeleton from Langenau, MN4 (Stuttgart Museum).

Let us add that Blainville (1845) has depicted (*Deinotherium*, pl. III) a hemimandible (certainly a left one, but reversed in the figure) from Chevilly; that figure was presented again in 1958 by Vaufrey (Traité de Paléontologie J. Piveteau, t.VI (2), p. 249, fig. 61). We regret that the species *bavaricum* (named by von Meyer without any figure in a letter that was published soon after) has the priority over *cuvieri*, created by Kaup and established on published (and perfectly well drawn) specimens.

As far as we can ascertain, the first appearance of *Deinotherium* in Germany and France closely agrees with available data from Portugal.

There is no contradicting ecologic evidence from the concerned european areas.

5. Ecology

It is not just by chance that Georges Cuvier, in 1822, ascribed isolated molars of the later-named *Deinotherium* to a “tapir de taille gigantesque”. Such molars are typically lophodont and brachyodont, with distinct crests; under these viewpoints there are real likelinesses towards the tapirs. Hence, ecologic comparisons with the extant tapirs (that are typically tropical, humid forest dwellers) are logical.

Other data seem to support these interpretation. Indeed the evidence from Lisbon is highly meaningful because there are many palaeontologic and geologic data that allow quite accurate environment reconstitutions. Temperature and moisture control is possible for marine and non marine levels as well (pollen & spores, foraminifera, molluscs, fishes, reptiles, clay mineralogy, O and C isotopes) [see Antunes (2000, table 3, according to J. Pais)] (Fig. 3).

On the other hand, clear environment differences between Va2 and Vb stratigraphic units have long been recognized. Successive and more and more accurate reconstitutions were produced (Antunes, 1965, 1969, 1984; Antunes & Pais, 1983). There are some basic facts:

a) in Va2 times - warm, tropical to subtropical, moist conditions prevailed. The presence (among others) of the pelecypod genus *Placuna* as well as the prevalence of stenotherm, warm water sharks (a nurse-shark, *Ginglymostoma*; lemon shark, *Negaprion*; *Hemipristis*; tiger shark, *Galeocerdo*) and large barracudas (*Sphyræna olisiponensis*) leave no doubt as to environmental conditions rather similar to Senegal's today - as far as sea waters are concerned.

As for fresh- or estuarine waters, common *Lates* and catfishes are at least subtropical and point out to sizable freshwater contributions. Reptilian fauna points out the same way: an association of common, typically tropical crocodylians (large *Tomistoma* and *Gavialis*) with a monitor lizard (*Iberoveranus*) and an especially

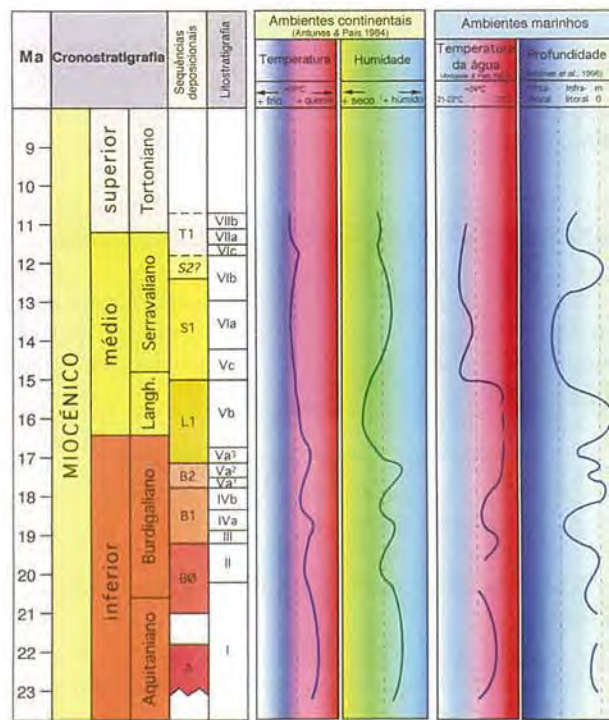


Fig. 3 - Temperature and moisture evolution during Miocene (data from lower Tagus basin), modified from Pais, 1999).

interesting assemblage of (highly characteristic for the Lower-Middle Miocene transition) thermophilous snakes that comprise a large boa (*Bavarioboa* sp.) and large “oriental vipers” (*Vipera* sp.) (Szyndlar, 2000).

Gomphotheres prevail among proboscideans and may indicate the occurrence of open spaces, but *Deinotherium bavaricum* is not rare and suggests a nearby forest development (the whole environment conditions would be excellent for this) (Pl. 4).

b) in Vb times - palaeobotanical and other evidence clearly shows that climate became much drier, even if still subtropical. Open, savannah areas prevailed and were the habitat of prevailing cursorial, rather hypsodont-teethed rhinoceros as another immigrant from Asia: *Hispanotherium*.

Primary forest to bush dwellers as Glinds among rodents (that prevailed before) became scarce and were (for the first time) largely superseded by Cricetids. *Deinotherium bavaricum* became exceedingly rare. On the contrary, gomphotheres were plentiful.

6. Conclusions

Summing up as far as the occurrence of *Deinotherium bavaricum* is concerned in Portugal - taking into account the chronologic data (Antunes, 2000, p. 294, tab. 2) as well as the concerned Mammal-units MN and the corresponding Iberian biochronology units (Mein, 2000), this study leads to the following conclusions.

1. Discussion of all evidence from the lower Tagus Basin concerning the Lisbon area does not confirm the presence of *Deinotherium* in the TVb local stratigraphic unit, the first one where there is evidence of the arrival of gomphotheres in Portugal (datum) at 18-18.2 Ma.

2. *Deinotherium bavaricum* is rather common in the Va2 unit, the main locality being Quinta das Pedreiras.

3. There are indeed two successive, diachronic data for Proboscideans' immigration in Europe: that of gomphotheres and later that of deinotheres. The first appearances are:

- that of gomphotheres in the IVb unit, ca. 18 -18.2 Ma, MN3-MN4 limit, A/B Iberian unit;
- that of *Deinotherium* in the Va2 unit at ca. 17 - 17.2 Ma, MN4; C Iber. unit.

This situation seems general for western Europe at least.

4. The *Deinotherium bavaricum* occurrence in the Vb unit (ca. 15.9 - 16.1 Ma; MN5; Db Iber. unit), among the "Hispanotherium fauna" cannot be demonstrated on previous data. We can ascertain on the evidence of the abnormal tusk described here that *Deinotherium bavaricum* indeed occurs in the Vb unit but is exceedingly rare.

5. The *Deinotherium bavaricum* recorded time span in Portugal from its first appearance is from ca. 17 Ma (late Burdigalian) to ca. 15.5 Ma (Langhian), or from the end of MN3 to MN5.

8. *Deinotherium bavaricum* was collected in the small Quintanelas basin in association with elements of the Hispanotherium fauna, thus confirming the Vb evidence.

9. Ranty in the Vb unit is related to environmental changes from a climate optimal event (tropical to subtropical, humid prevailing conditions) that corresponds to the Va2 unit to much drier conditions that correspond to the Vb (accompanied by forest recession and savannah development).

10. It is obvious that deinotheres and gomphotheres had very different environmental requirements. Deinotheres certainly needed developed, rich forest areas whose development required a high degree of humidity. Lisbon' evidence distinctly corroborates this interpretation.

11. The genus is represented much later by *Deinotherium giganteum* in the inner part of the lower Tagus basin at Formiga (later part of Middle Miocene); and at Azambujeira, middle level (Upper Vallesian). Both occurrences are related to less-warm but rather moist environments.

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Plate 1

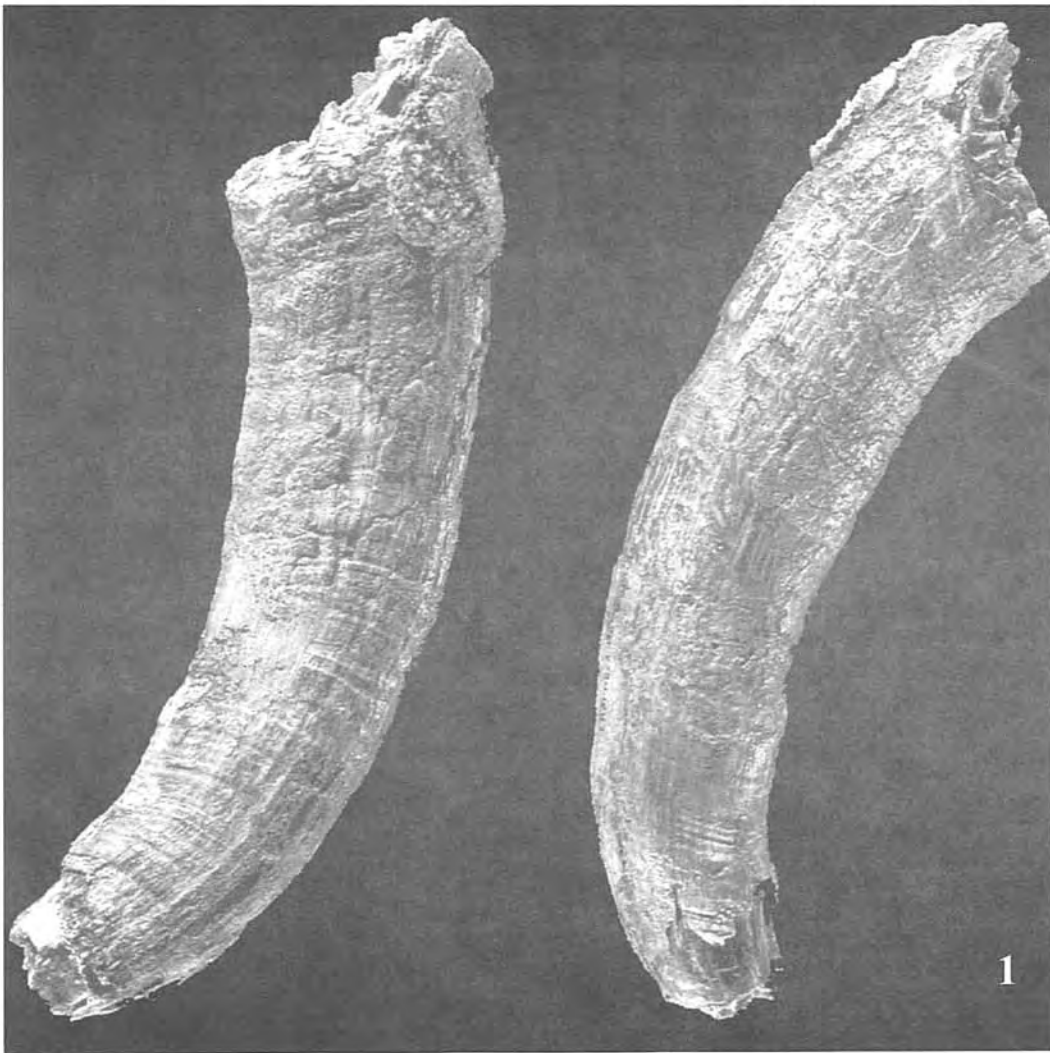
Deinotherium bavaricum from Quinta Grande, left incisor

Fig. 1 – (a) Median view; at the proximal part there are some remnants of the mandibular bone; (b) lateral view, showing remains of enamel strips in its proximal part (detail fig. 2). x 1/2. Scale, 10 cm.

Fig. 2 – Lateral view, detail to show remains of enamel strips. Natural size. Scale, 5 cm

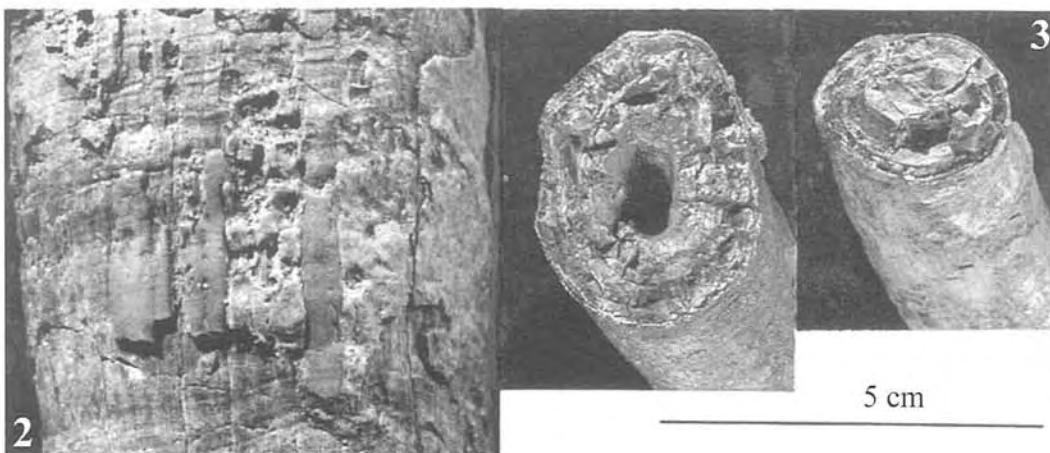
Fig. 3 – (a) Proximal view to show the beginnings of the axial hole (shaped as an upside-down cone); (b) distal extremity. Natural size.

PLATE 1



10 cm

5 cm



5 cm

Plate 2

Deinotherium bavaricum from Quinta das Pedreiras (Va2 unit, MN4), fossils with the typical black, pyrolusite gangue - M.T.A. collection

Fig. 1-3 – Complete left tusk median (1), anterior (2) and lateral (3) views. Scale, 10 cm.

PLATE 2



Plate 3

Deinotherium bavaricum from Quinta das Pedreiras (Va2 unit, MN4), fossils with the typical black, pyrolusite gangue - M.T.A. collection

Fig. 1-2 - Incomplete left hemimandible with M2 (part) and M3, lateral (4) and occlusal (5) views. Scale, 10 cm.

PLATE 3

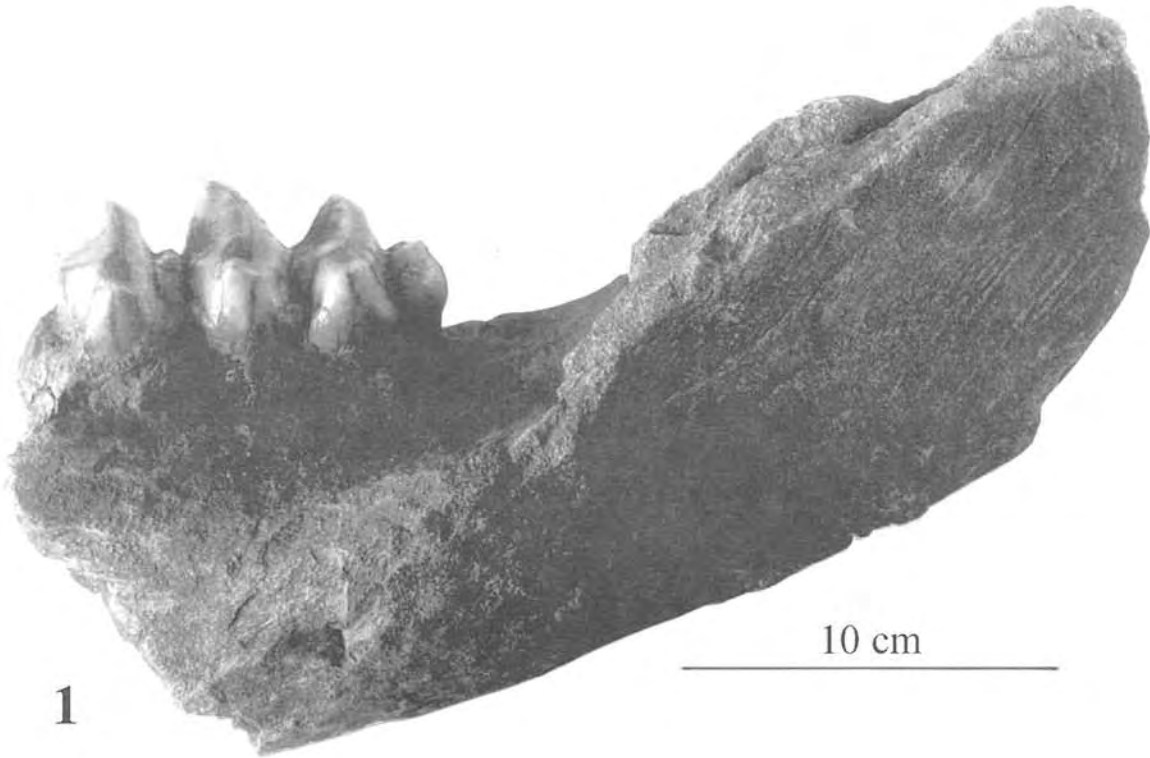


Plate 4

Deinotherium bavaricum, a reconstitution. Coloured after a sketch by M.T. Antunes.

PLATE 4

