Mammuthus lamarmorae (Major, 1883) remains in the pre-Tyrrhenian deposits of San Giovanni in Sinis (Western Sardinia, Italy)

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SUMMARY: Scanty remains of endemic elephants have been recorded in the Late Pleistocene deposits of Sardinia. The stratigraphic position and paleoenvironmental setting of the molar from San Giovanni in Sinis is discussed in some detail, and a full description of the fossil is given, allowing discussion of some hypotheses about the mainland ancestor and the time of the colonisation of the island

1. Introduction

Fossil remains of endemic elephants have been collected from the Pleistocene deposits of several Mediterranean islands. They have been generally considered as paleoloxodontine, derived from the continental Middle and Late Pleistocene *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley. The only apparent exception is the middle-sized *Mammuthus lamarmorae* (Major) of Sardinia. Some tarsal, carpal and long bones, from Last Glacial aeolian deposits outcropping at Fontana Morimenta (Gonnesa), were first reported by Acconci (1881). Following this discovery, Major (1883) described the new species "*Elephas lamarmorae*", but did not illustrate it. During the second half of the 20th Century, two further molars were discovered: one in post-Tyrrhenian (post-OI stage 5) breccias at Tramariglio (Alghero) (Malatesta 1954), and the other in pre-Tyrrhenian (pre-OI stage 5) continental deposits at S. Giovanni in Sinis (Ambrosetti 1972). The latter is the only specimen for which stratigraphic control is available. We present here in some detail both the morphological characters and the local stratigraphic sequence.

2. Geological Setting

At the southern tip of the Sinis peninsula, on the western coast of Sardinia, marine and continental deposits of late Middle Pleistocene age outcrop near the village of San Giovanni (Fig. 1). Because of marine erosion, they are found over c. 1 km in a quickly retreating cliff. Roman tombs, cut into the consolidated deposits, can be spotted in huge collapsed blocks, washed by the sea. The stratigraphy is made complex by frequent lateral changes and several papers have been devoted to its interpretation (Maxia & Pecorini 1968; Ambrosetti 1972; Caloi *et al.* 1980; Ulzega *et al.* 1980; Ulzega & Ozer 1982; Ulzega & Hearty 1986; Carboni & Lecca 1985; Dudaud *et al*. 1991;

Kindler *et al.* 1997).

The deposits that we examined are located in the village itself, next to the Roman tombs. This is where the elephant tooth, studied by Maxia and Pecorini (1968), and by Ambrosetti (1972), was discovered at sea level. They include three different sequences.

2.1 San Giovanni in Sinis section (Fig. 2).

Sequence A, at the base of the outcrop, is characterised by calcrete in which the elephant molar was discovered. It is overlain by a pedogenised sandy deposit rich in remains of Helicidae and bioclastic fragments (benthic foraminifers, echinoids and red algae).

Sequence A, truncated by an erosional surface (S1) sloping towards the southeast, is overlapped by sequence B, comprising polygenic conglomerate, with fragments reworked from an eroded underlying level, and including basalt pebbles. This conglomerate is capped by beach sands showing low-angle cross-bedding, in the upper part of which is developed a palaeosol with rhyzoliths. This palaeosol is overlain by a calcarenite with tightly packed *Mytilus* and *Ostrea* shells, and then by lagoonal deposits with *Limnea* – with development of calcrete. An erosional surface (S2) marks the base of sequence C, which starts with a thin conglomerate including fragments from an eroded underlying level with *Mytilus*, followed by beach sand deposits, with low-angle cross-bedding, including some remains of *Megaceroides cazioti* (Dépéret) at the bottom. Sequence C ends with cross-bedded dune deposits. Ulzega and Hearty (1986) proposed an age of 90 ±15 ka (OI substage 5c) for the deposit with *Mytilus* in Sequence B, based on an A/l ratio on a *Glycymeris* shell of 0.32 . Accordingly, they dated sequence A deposits to OI substage 5e. Davaud *et al.* (1991) and Kindler *et al.* (1997) hypothesised that sequence A deposits could be earlier than OI substage 5e, i.e. actually pre-date the last interglacial period.

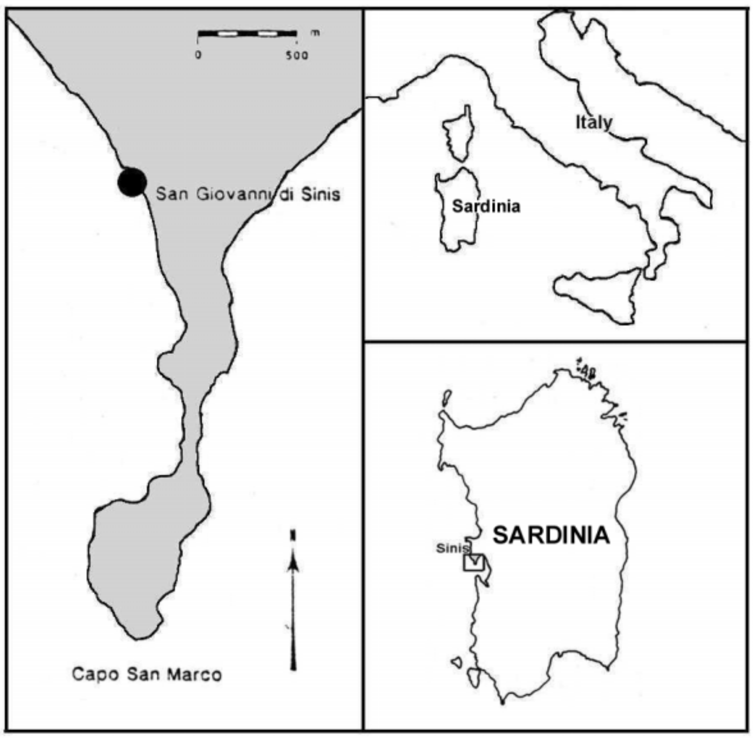

Fig.1 - Location of the S. Giovanni section.

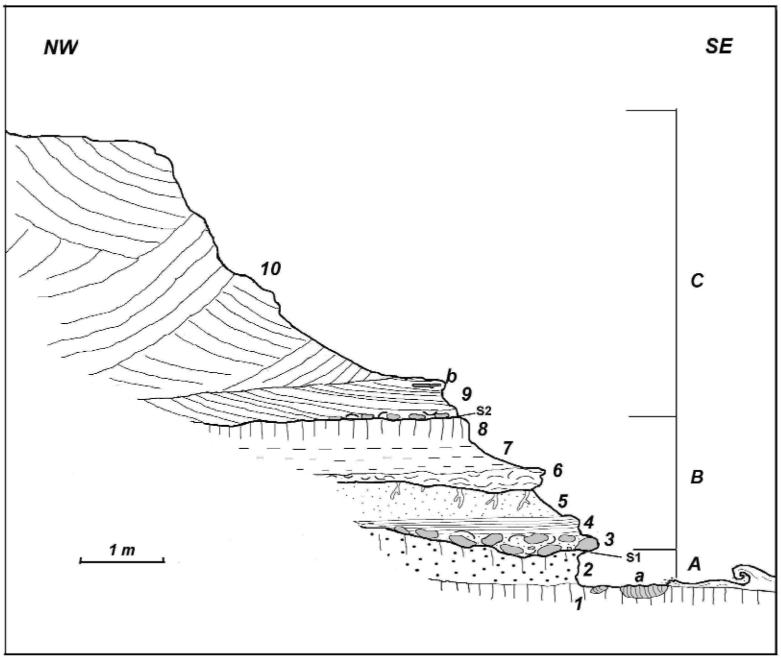

Fig.2 - San Giovanni section. 1: calcrete; 2: palaeosol developed on beach sediments rich in Helicodae remains; 3 conglomerate containing pebbles from the erosion of the underlying level as well as basalt pebbles; 4: beach sediments; 5: palaesols with rhizoliths; 6: marine deposits rich in *Mytilus* and *Ostrea* shells (OI substage 5e); 7: lagoonal deposits with *Limnea*; 8: calcrete; 9: beach deposits, overlying a conglomerate with remains of *Ostrea* shells; 10: dunes; a: Elephant molar; b: cervid remains; S1 and S2 erosional surfaces. A, B, C: sequences.

3. *Mammuthus lamarmorae* (Major, 1883)

In the Sixties, as mentioned above, scanty dental remains of a small-sized elephant were discovered by Prof. Giuseppe Pecorini in sediments outcropping at San Giovanni in Sinis. The most important of these remains is a well preserved upper molar, with only the roots missing, now at the Dipartimento di Scienze della Terra of the University of Cagliari. The molar was described by Ambrosetti (1972), who considered it an M^3. Indeed, there is no clear evidence of pressure by a posterior tooth, so it could be a last molar even if the gradually reducing height, typical of an elephantid M^3, is not evident. The tooth is almost completely in wear: of the 11 laminae, 9 are in use, and the anterior half of the first lamina, worn down to the root, is lost. The short, wide shape of the tooth suggests the loss by wear of some other laminae at the front. However, the three very worn anterior plates are nearly fused to each other, and apparently belong to the same root. Consequently the hypothesis that the molar could be complete cannot be ruled out. With the exception of the almost unworn 9th, all the laminae of the occlusal surface show a complete, undulating enamel loop. Additional lingual and buccal conules, very reduced, are present at the posterior side of the 4th and 5th lamina. The laminae are quite well packed even near the top of the crown, and the enamel is rather thick; the enamel loops are regularly plicated; and the folds, extending to the lateral and medial faces of the laminae, are more tightly packed near the root.

The morphological and biometrical characters of the molar, with a more-or-less oval shaped occlusal surface, undulated enamel plates, and regularly folded enamel loops, as well as the enamel thickness and average lamellar frequency, all suggest an attribution to the genus *Mammuthus*.

Tab.1 - Measurements of *M. lamarmorae* M^3 from San Giovanni in Sinis.

Measurements of *M. lamarmorae* M^3 from San Giovanni in Sinis
Plate formula = ?10 _ + posterior talon; number of functional laminae = 8 _; greatest mesio-distal length =130 mm, functional (occlusal) length = 116 mm, greatest bucco-lingual breadth = 69 mm; functional (occlusal) breadth = 55 mm; height = 90+ mm; average lamellar frequency = 8; enamel thickness = 1,8; hypsodonty index = 1,55 (minimal value); functional lamellar index (functional laminae/functional length X 100) = 7,33

According to current evidence, the molars of endemic elephants are characterised by less advanced features when compared to their mainland ancestors, especially so when taking into account the size reduction, which would produce, among other things, an increased lamellar frequency (Lister & Joysey 1992).

All things considered, according to enamel thickness, lamellar frequency and enamel loop morphology it seem more probable that the ancestor of *M. lamarmorae* from San Giovanni in Sinis was *Mammuthus trogontheri* (Pohlig) rather than *Mammuthus meridionalis* (Nesti). Nevertheless, due to the scarcity of remains, this hypothesis still has to be fully substantiated.

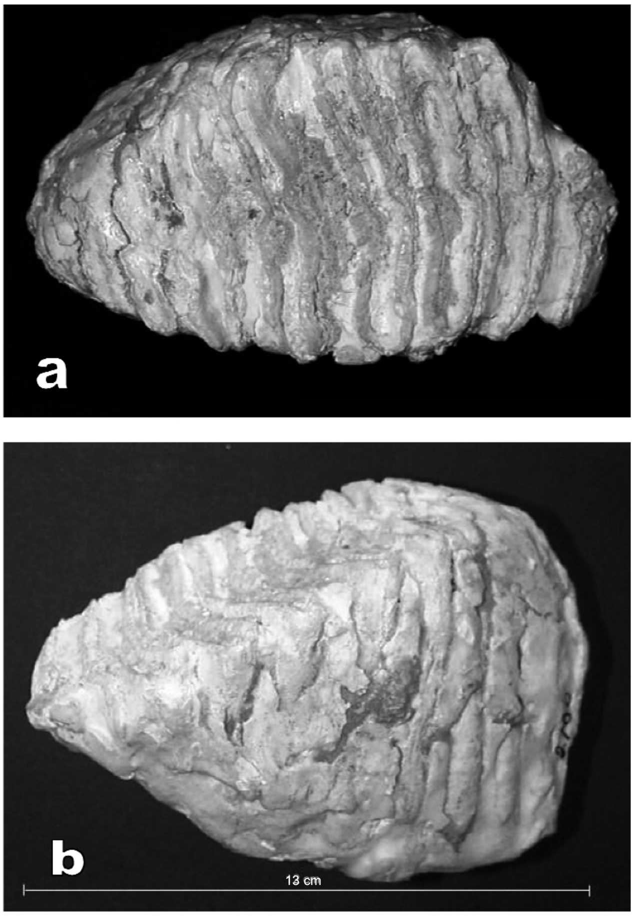

Fig.3 - *Mammuthus lamarmorae* (Major, 1883) from San Giovanni in Sinis: M^3 in occlusal view, approximately x0.7 of natural size.

4. Final Remarks

The study of the stratigraphic section of San Giovanni confirms that, as already suggested by previous studies, the layer in which the elephant molar was found occurs in sequence A (Fig. 2). According to Davaud *et al.* (1991) and Kindler *et al.* (1997) the deposits of sequence A could be assigned to the pre-Tyrrhenian age (pre-OI stage 5).

The deposition of the remains probably occurred within sandy beach sediments, subsequently affected by pedogenesis while the sea level was falling. A calcrete then developed during an arid climatic phase with low rainfall. An erosive phase followed, related to increased rainfall, and this eventually truncated the soil overlying the calcrete. A marine transgression and deposition of Tyrrhenian (OI stage 5) sediments followed this erosive phase.

Since elephant remains have not been recorded from earlier deposits in Sardinia, and even if other hypotheses cannot be ruled out, it seems likely that the ancestors colonised the island during the late Middle Pleistocene.

5. Acknowledgements

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6. References

Acconci, L. 1881. Sopra alcune ossa fossili di Elefante rinvenute nel Quaternario della zona di Marimenta in Sardegna. *Proc. Verb. Atti Soc. Tosc. Sc. Nat.* 2: 266-267

Ambrosetti, P. 1972. L'elefante fossile della Sardegna. *Bol. Soc. Geol. Ital.* 91: 127-13.

Caloi, L., Katsakis, T., Palombo, M.R., Petronio, C. 1980. Il giacimento a vertebrati del Pleistocene superiore di San Giovanni in Sinis (Sardegna occidentale). *Rend. Sci. Fis. Mat. Nat. Lincei* 69: 185-197.

Carboni, S. & Lecca, L. 1985. Osservazioni sul Pleistocene medio-superiore della penisola del Sinis Sardegna Occidentale. *Bol. Soc. Geol. Ital.* 104: 459-477.

Duvaud, E., Kindler, P., Martini, R., Strasser, A. 1991. Enregistrement des variations eustatiques dans des littoraux du Pleistocène superieur San Giovanni di Sinis (Sardegna occidentale). *Bull. Soc. Géol. Fr.* 162: 523-533.

Kindler, P., Duvaud, E., Strasser, A. 1997. Tyrrhenian coastal deposits from Sardinia (Italy): a petrographic record of high sea levels and shifting climate belts during the last interglacial (isotopic substage 5e). *Palaeogeography, Palaeoclimatology, Palaeoecology* 133: 1-25.

Lister, A.M. & Joysey, K.A. 1992. Scaling effects in elephant dental evolution - the example of Eurasian *Mammuthus*. In Smith P. & Tchernov E. (eds.), *Structure, function and evolution of teeth*: 185-213. London & Tel Aviv: Freund Publishing House Ltd.

Malatesta, A. 1954. Primo dente di elefante fossile rinvenuto in Sardegna. *Quaternaria* I: 97-105.

Maxia, C. & Pecorini, G. 1968. *Il Quaternario della Sardegna. Atti X° Congresso Int. Studi Sardi*: 247-266.

Ulzega, A. & Hearty, P.J. 1986. Geomorphology, stratigraphy and geochronology of Late Quaternary marine deposits in Sardinia. *Z. Geomorphol. N.F., Suppl. Bd.* 62: 119-129.

Ulzega, A., Oser, A., Lecca, L., Leone, F., Pecorini, G., Spano, C., Cordy, J.M. 1980. *Excursion – Table ronde Tyrrhénien de Sardaigne. Guidebook*: 88 pp. INQUA, Univ. Cagliari.

Ulzega, A., Oser, A. 1982. *Comptes-rendus de l'Excursion- Table ronde Tyrrhénien de Sardaigne*: 110 p. INQUA, Univ. Cagliari, April 1980.