

# Protection and promotion of the palaeontological heritage: the virtuous case of Cessaniti (Vibo Valentia, Italy)

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**Abstract** – The site of Cessaniti (Vibo Valentia, Calabria, southern Italy) is here presented as a virtuous example of cooperation among researchers, palaeontology amateurs, and local administrations, under the supervision of the competent Superintendence of Archeological Heritage. The collaboration allowed the recovering, preservation, study, analysis and musealization of a huge palaeontological heritage, located in a popular touristic area. The site of Cessaniti and the surrounding area released an impressive abundance of fossil echinoids and other invertebrate, associated with marine and terrestrial mammals, late Miocene in age. In the last decade, the record of mammals with African and Pikermian affinities strongly contributed to enhance the knowledge of the paleogeographic evolution of the central Mediterranean at the end of Miocene.

## I. INTRODUCTION

The Paleontological site of Cessaniti (Vibo Valentia, Calabria, southern Italy) is known since the XIX century for the impressive abundance of fossils (Fig. 1). In particular, echinoids of the genus *Clypeaster* are remarkably preserved and abundant in the stratigraphic record. In addition, the site released abundant remains of marine mammals, mainly Sirenians and subordinately Cetaceans. Since 1995, an association of palaeontology amateurs (Gruppo Paleontologico Tropeano) collected and stored fossils from Cessaniti and the surrounding area, properly reporting the discoveries to the Calabria Superintendence.

In 2003, Ferretti et al. [1] reported the occurrence of land mammals at Cessaniti, testified by fossils of *Stegotrabelodon* cf. *syrticus*, a proboscidean of Afro-Arabian affinities.

A new impulse to studies on the mammal association

from Cessaniti started in 2008, under the permission of the Superintendence of Calabria and the scientific direction of one of the authors (A. C. Marra), regulated by an agreement protocol. The study also involved researchers from other Universities (Universities of Calabria, Firenze, Padova, Pisa, Barcelona, New York) as well as the “Gruppo Paleontologico Tropeano”.



Fig. 1. The geographic position of Cessaniti.

The field search and the studies also included fossils from correlatable sites from the Monte Poro area. Local administrations (Municipalities of Parghelia and Ricadi)

provided storage spaces in suitable public buildings. Some specimens have been stored at the University of Calabria.

At present, almost all the mammals have been determined, described, and related to a new stratigraphical framework. Moreover, the local administrations are setting up palaeontological sections in municipal museums: MuMe at Parghelia (“*Museo della Memoria*”, VV; with the scientific supervision of the University of Messina), MuRi at Ricadi (“*Museo di Ricadi*”, VV; with the scientific supervision of the University of Calabria), and MuMaT at Tropea (“*Museo del Mare*”, VV). The MuSNOB (“*Museo di Storia Naturale e Orto Botanico*”, University of Calabria, CS) houses a section dedicated to Cessaniti, as well as fossil collections sequestered by the “Arma dei Carabinieri - Nucleo Tutela Patrimonio Culturale” in Calabria.

A working group chaired by one of the authors (F. Sudano) coordinated the exhibition’s contents of MuMe, MuMaT, and MuRi, with the aim of creating a museum network.

## II. GEOLOGICAL SETTING

Cessaniti and the surrounding fossiliferous sites are located in the SW sector of the Calabria–Peloritani Arc, in the Capo Vaticano–Monte Poro sedimentary basin.

In the site of the Gentile’s Quarry at Cessaniti, the stratigraphic succession, overlying in unconformity the Paleozoic crystalline basement, is made up of four informal units that are, from base to top [2, 3, 4 with reference therein] (Fig. 2):

- “dark clayish sands with *Ostrea* and *Cerithium*”, alternating with coarse sandstones, attributed to lagoonal environment;
- “*Clypeaster* sandstones”, attributed to shallow marine environment;
- “*Heterostegina* yellow sandstones”, deposited in marine conditions;
- “*Orbulina* marls”, deposited in a hemipelagic environment.

In the stratigraphic succession at the Gentile’s quarry, reconstructed by Marra et al. [4], soils and fluvial deposits in the “*Clypeaster* sandstones” (FL1 to FL3) are recognised and attributed to temporary falls in sea level during the transgression, controlled by tectonics (Fig.2). Moreover, the Authors dated the succession (from LG to the top of SH4) between 8.1 and 7.2 Ma [4] (Fig.2).

The stratigraphy at the Gentile’s Quarry is used as a reference to correlate the surrounding fossiliferous outcrops. The Capo Vaticano – Monte Poro sedimentary basin has a strategic role in deciphering the complex paleogeography of the central Mediterranean which underwent significant modifications during the late Miocene.

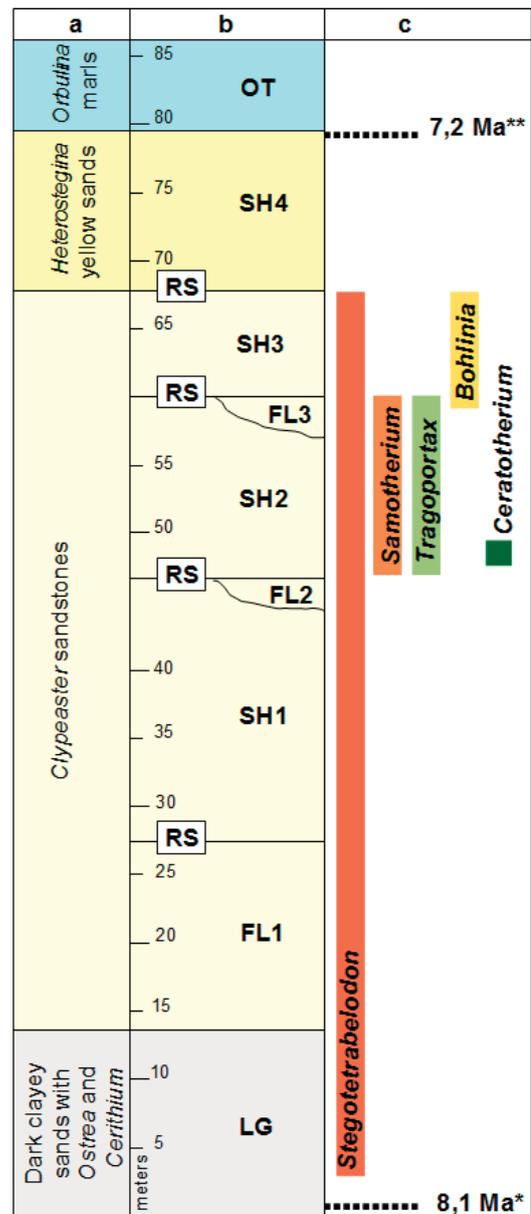


Fig. 2. Stratigraphy of the Gentile’s Quarry Succession (Cessaniti): a) informal stratigraphy; b) stratigraphy according to Marra et al. [4] (LG: Lagoonal deposits, FL: fluvial deposits, SH: shoreface deposits, OT offshore transition; RS, Ravinement Surface); c) occurrences of terrestrial mammal taxa. Legend: \* dating for the attribution of LG to the Chron C4n; \*\* dating for the attribution of OT to the nannoplankton zone CNM17.

## III. THE MAMMAL ASSEMBLAGE

The Sirenian *Metaxytherium serresii* is the most represented fossil mammal, being abundantly occurring in

the *Clypeaster* sandstones and in a good state of preservation [5]. The elevated number of specimens confirmed the reduction of the body size of *Metaxytherium serresii* with respect to the ancestor *M. medium* and demonstrated a broad intraspecific variability [6]. Cetaceans are represented by Physiteroidea indet. and few remains of other Odontocetes indet. [7]. Also, few remains of Mysticetes have been attributed to *Heterocetus* cf. *guiscardii* [7].

New findings of *Stegotrabelodon syrticus* confirmed the attribution to the Afro-Arabian species and extended the occurrence of the taxon also in the lagoonal deposits (LG), suggesting a long persistence in the area [8]. The primitive elephantoid *Stegotrabelodon* cf. *syrticus* occurs at Cessaniti both in deposits of lagoonal marls and sands (a single worn DP4 from LG unit) and in shoreface sands in the CG-SH1 to 3 units (one mandible, one incisor, one fragmentary molar, two fragmentary humeri, one right II metacarpal and one incomplete femur from the shoreface sands of SH1 to 3; Repository: MuMe). The species is well documented at As Sahabi, in Libya, a site dated about 6.7 Ma. It has also been found in sites of the Baynunah Formation (Abu Dhabi, United Arab Emirates), whose estimated time ranges from 8.2 to 5.3 Ma.

The Giraffid remains have been attributed to *Bohlinia attica* and *Samotherium boissieri* (Fig. 3), two species common in the Pikermian biome, a mammal association of savannah-like environment typical of the Greco-Iranian bioprovince [9].

*Samotherium boissieri* occurs at contrada Malopara (Zungri, VV), in sediments correlatable with SH1, where bones belonging to forelimbs of the same individual have been recovered (left forelimb: fragmentary humerus, proximal end of ulna, distal epiphysis of radius, capitatum, uncinatum, scaphoid, lunar, pyramidal, pisiform, metacarpal; right forelimb: distal end of radius, uncinatum, lunar, pyramidal, metacarpal, sesamoids and phalanges). From Cava Gentile, SH1-3 units comes: two metacarpals, two metatarsals and a distal tibia; Repository: MuSNOB and Muri).

An upper an upper tooththrow and postcranial elements (a distal radius, two astragalii, two cubo-naviculars and a distal tibia), all from Cava Gentile SH3 unit, are attributable to *Bohlinia* cf. *attica* (Repository: MuSNOB)

*Samotherium boissieri* is a species common in the Greco-Iranian bioprovince, in some cases associated with *Bohlinia*, between 8.0 and 7.4 Ma (early-middle Turolian). The first occurrence of *S. boissieri* was recorded at Gülpinar (Turkey) in the late Tortonian (Sen 2016). Although the species is not recorded in Africa, the genus *Samotherium* sp. is represented by scanty remains at As Sahabi in Libya, Bou Hanifia in Algeria and Nakali in Kenya.

*Bohlinia attica* is known from the Tortonian to the Messinian (Vallesian to late Turolian, according to European Land Mammal Ages) in the western regions of

the Greco-Iranian bioprovince, while its presence in the Late Miocene of Chad, in Africa, is under debate.



Fig. 3. *Samotherium boissieri*: left carpal bones anterior (A) and dorsal views (B, C); left metacarpal with phalanges (D); right metatarsal in anterior (E) and posterior (F) views; Repository: MuRi and MuSNOB.

The medium sized bovid remains have been identified as *Tragoptax* cf. *rugosifrons* (Fig. 4) [10]. Fossils come from Cava Gentile, units SH2–FL3: hemimandible, right humerus, left radius, anterior phalanx, left metatarsal, left patella, posterior phalanx, astragalus.

The genus *Tragoptax* was widespread in Eurasia and Africa during Late Miocene and its ecological niche is comparable to that of the extant *Hippotragus*: a forest-savannah alternating with open spaces.

The remains of another still undetermined bovid

(smaller in size) from the SH2 and SH3 units complete the bovid assemblage.



Fig. 4. *Tragoportax rugosifrons*: left hemimandible in occlusal (A), labial (B), and lingual (C) views; right humerus in anterior (D) and posterior (E) views; left radius in proximal (F), anterior (G) and posterior (H) views; left metatarsal bone in proximal (I), anterior (J) and posterior (K) views; right anterior phalanx in anterior (L) and posterior (M) views; right posterior phalanx in anterior (N) and posterior (O) views; stored at MuRi.

The morphological characters of Rhinocerotidae remains (a partial skull, a fragment of an upper tooth and few postcranial elements; Repository MuRi and MAUS, University of Salento, Lecce) allowed the proposal of a new species related to the African genera *Diceros* and *Ceratotherium*, and attributed to the new species '*Ceratotherium*' *advenientis* [11]. The skull recorded at Cava Gentile is characterized by peculiar features, in particular in the morphology and dimension of the neurocranial portion, and by having a nuchal crest wider than in the extant African rhinoceroses, *C. neumayri*, *C.*

*douariense*, and European latest Miocene species. This new species displays morphological characters close to Rhinocerotina, in particular to dicerotines, and can be distinguished from the late Miocene elasmotheres, teleoceratines and aceratheres recorded in Eurasia and Africa. The new taxon clearly differs from the European latest Miocene species of the genus *Dihoplus* and from *Ceratotherium neumayri*, and from the African species belonging to the genus *Ceratotherium*, as well as from the Chinese dicerotine *Diceros gansuensis* and from the extant African species. A cladistic analysis places '*Ceratotherium*' *advenientis* in a polytomy with the extant *Diceros bicornis*, *C. neumayri* and a small clade composed by *C. simum* e *C. antiquitatis*. The African affinities of the new taxon support the Calabrian-Peloritan arc as a northern extension of the African continental shelf during the late Miocene.

Isolated limb bones seem attributable to an Antracotherid and are still under study.

The land mammals from Cessaniti, including North African and Greco-Iranian species, define a peculiar bioprovince, probably resulting from a stable land connection between Calabria and Africa when the Pikermian biome expanded its geographical range reaching the northern part of the continent [4, 9, 12]. A more precise palaeogeographical reconstruction is still under study and could be useful for the reconstruction of the complex geological evolution of the central Mediterranean.

#### IV. ANALYSIS ON MICROSTRUCTURE AND PRESERVATION STATE OF THE FOSSIL BONES

Mammal bones are well preserved at Cessaniti and samples of *Metaxytherium* sp. bones have been subjected to optical microscopy, SEM observations, EDS, and FT-IR analyses [5], with the supervision of one of the Authors (A. Guido) (Figs. 5 and 6). The bones have the pachyosteosclerotic structure typical of Dugongidae; ribs, in particular, are compact and missing the medullar cavities. The external layer of ribs is usually not preserved in the Cessaniti samples and alteration traces are observed. A relatively rapid sedimentation rate is suggested by the lack of epibiontic activity and borings. The bone canals and the microfractures are usually empty, rarely filled by thin siliciclastic sediments. The bright epifluorescence under UV-excitation reveals organic matter remains preserved inside the paleohistological structure (Fig. 6).

The mineralogy of the fossil bones resulting from SEM-EDS analyses detected well-preserved crystals of francolite (carbonate fluorapatite) (Fig. 5c). The FTIR spectra revealed a F content of ca. 1.42 wt% and a strong 1,092  $\text{cm}^{-1}$  band, consistent with low carbonate fluorapatite minerals. The external layer, when preserved, is thinned and deeply micritized, while the paleohistologic structures of the rest of the bone are easily observable.

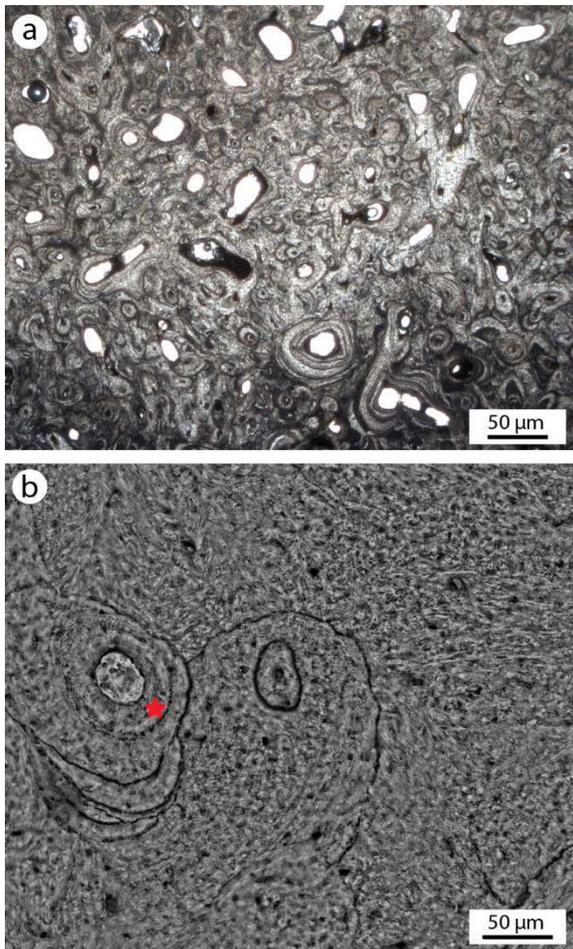


Fig. 5. Micromorphological and compositional characteristics of a sirenian rib. a) Thin-section in transmitted light. b) Backscattered SEM microphotograph showing the well-preserved paleohistological structure. c) EDS spectra performed on an Haversian channel tissue (red star). Note the well preserved composition of the bone tissue consisting of carbonate fluorapatite [ $Ca_5(PO_4CO_3)_3F$ ]. After Guido et al. [5].

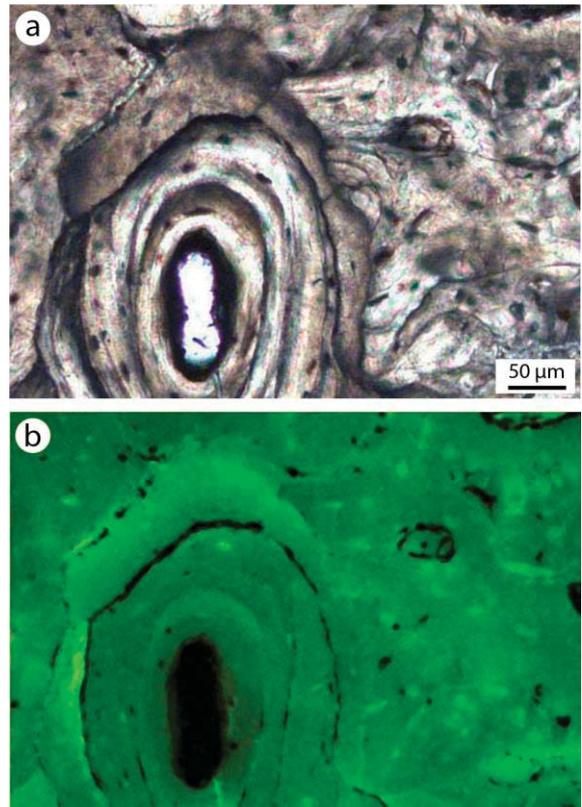


Fig. 6. Lamellar osteonic tissue under transmitted light (a) and b UV epifluorescence (b): bright color enhances the organic matter remains; after Guido et al. [5].

The ribs underwent very slight diagenetic processes, as suggested by absent or little relevant processes of dissolution/recrystallization, organic molecules present in the bone tissue and strong band assigned to  $\nu_2 CO_3^{2-}$  functional groups.

## V. EXHIBITION PLAN

The huge fossil record from the Palaeontological site of Cessaniti and the surrounding area (Fig. 7) is going to be displayed in a museum network in the province of Vibo Valentia. The projects for the exhibitions are approved by the Superintendence and will be completed after the final permissions by the Ministry of Culture.

In the palaeontological section housed at the MuRi museum, a general presentation of Cessaniti, including stratigraphy and paleoenvironmental reconstructions, will be provided, and the main part of the museum itinerary will show terrestrial mammals. The paleontological section of the MuMaT will be devoted to marine mammals and invertebrates, enhancing the contribution of the Sirenian fossils to the phylogenesis of the genus *Metaxytherium*. The exhibition at MuMe will preserve its original

educational vocation and will be restaged as a didactic space addressed to schoolchildren and tourists.

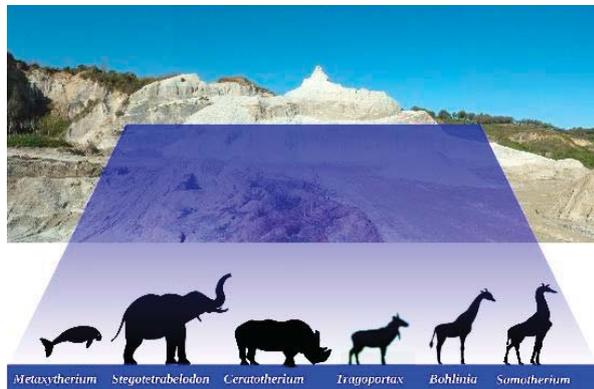


Fig. 7. The mammal assemblage of Cessaniti at the Cava Gentile's Quarry (graphic for musealization by A.C. Marra).

The section of Cessaniti at the MuSNOB, geographically farthest, is included in the museum itinerary dedicated to the most relevant palaeontological sites of Calabria.

## VI. DISCUSSION AND CONCLUSIONS

At Cessaniti, the cooperation among researchers, palaeontology amateurs, and local administrations, under the supervision of the competent Superintendence, allowed considerable scientific results and remarkable museum projects. Scientific results were immediately acquired for planning exhibitions and transferring knowledge to a wide public.

It is important to note that the Capo Vaticano - Monte Poro area includes popular touristic locations of the so-called "Coast of the Gods", such as Tropea, Parghelia, and Ricadi, of incomparable beauty.

Moreover, the educational role provided by museum initiatives is particularly important in supporting the development of the social tissue [13].

## REFERENCES

- [1] Ferretti M.P., Rook L. & Torre D. (2003). *Stegotetrabelodon* (Proboscidea, Elephantidae) from the Late Miocene of Southern Italy. *Journal of Vertebrate Paleontology*, 23: 659-666.
- [2] Nicotera P. (1959) - Rilevamento geologico del versante settentrionale del Monte Poro (Calabria). *Mem. Note Ist. Geol. Appl. Napoli*, 7: 1-92.
- [3] Gramigna P., Guido A., Mastandrea A & Russo F. (2008). The paleontological site of Cessaniti: a

window on a coastal marine environment of seven million years ago (Southern Calabria, Italy). *Geologica Romana*, 41, 25-34

- [4] Marra A.C., Carone G., Agnini C., Ghinassi M., Oms O. & Rook L. (2017). Stratigraphic and chronologic framework of the Upper Miocene Cessaniti succession (Vibo Valentia, Calabria, Italy). *Rivista Italiana di Paleontologia e Stratigrafia*, 123 (3): 379–393.
- [5] Guido A., Marra A.C., Mastandrea A., Tosti F. & Russo F. (2011). Micromorphological, geochemical, and diagenetic characterization of sirenian ribs preserved in the Late Miocene paleontological site of Cessaniti (southern Calabria, Italy). *Facies*, 58: 179-190.
- [6] Carone G., Domning D.P. & Marra A.C. (2013). New finds of *Metaxytherium serresii* (Gervais, 1847) (Mammalia: Sirenia) from the Upper Miocene of Monte Poro (Calabria, Italy). *Bollettino della Società Paleontologica Italiana*, 52: 187-196.
- [7] Marra, A.C., Carone, G. & Bianucci, G. (2016). Sperm whale teeth from the late Miocene of Cessaniti (Southern Italy). *Bollettino della Società Paleontologica Italiana*, 55(3): 223–225.
- [8] Ferretti M.P., Rook L., Carone G. & Marra A.C. (2017) - New findings of *Stegotetrabelodon syrticus* from the Late Miocene of Cessaniti, Southern Italy. *Boll. Soc. Paleontol. It.*, 56: 89- 92.
- [9] Marra A.C., Solounias N., Carone G. & Rook L. (2011). Palaeogeographic significance of the giraffid remains (Mammalia, Arctiodactyla) from Cessaniti (Late Miocene, Southern Italy). *Géobios*, 44: 189-197.
- [10] Marra A. C. (2018). *Tragoportax cf. rugosifrons* (Schlosser, 1904) from the late Miocene of Cessaniti (Southern Italy). *Comptes Rendus Palévol*, 17: 378–387.
- [11] Pandolfi L., Marra A. C., Carone G., Maiorino L., Rook L. (2019) A new rhinocerotid (Mammalia, Rhinocerotidae) from the latest Miocene of Southern Italy. *Historical Biology*, <https://doi.org/10.1080/08912963.2019.1602615>.
- [12] Marra A. C. (2019) Contribution of the Late Miocene Mammals from Calabria and Sicily to the Palaeogeography of Central Mediterranean. *AAPP*, Vol. 97, No. S2, A29 (2019), DOI: 10.1478/AAPP.97S2A29.
- [13] Somma, R. (2022). The Inventory and Quantitative Assessment of Geodiversity as Strategic Tools for Promoting Sustainable Geoconservation and Geo-Education in the Peloritani Mountains (Italy). *Educ. Sci.*, 12, 580. <https://doi.org/10.3390/educsci12090580>.