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THE CLIFF BORDERING THE NORTHWESTERN MARGIN OF THE MESIMA BASIN (SOUTHERN CALABRIA) IS OF PLEISTOCENE AGE

ABSTRACT: IETTO F. & BERNASCONI M.PIA, *The cliff bordering the northwestern margin of the Mesima Basin (Southern Calabria) is of pleistocene age*. (IT ISSN 1724-4757, 2005).

In Calabria (near the town of Vibo Valentia) marine deposits at the toe of a cliff, made up of granulitic gneiss, indicate the beginning of a strong uplift of faulted slope. This event involves the tectonic opening and morphological widening of fractures and voids by carbonate sediments (early Pleistocene). The scenario suggests the geomorphic evolution of a high rocky coast that is experiencing strong seismo-tectonic activity. Landslides and megabreccias also characterize the deposit together with many large sediment veins, made up of fossils, which cross cut both the basement gneiss and cliff gneiss.

On the cliff front along ledges created by tectonic activity, there are occasional outcrops of small sandbanks or coarse fossil-rich carbonate banks.

KEY WORDS: Coastal Geomorphology, Doming Uplift, Sedimentary Veins, Calabrian Arc (Italy).

RIASSUNTO: IETTO F. & BERNASCONI M.PIA, *La scarpata che borda il margine nord-est del Bacino di Mesima (Calabria Meridionale) è di età pleistocenica*. (IT ISSN 1724-4757, 2005).

In Calabria, in prossimità del centro abitato di Vibo Valentia, depositi marini altamente fossiliferi riempiono filoni sedimentari aperti in un substrato gneissico che costituisce una scarpata alta circa 200 m. I filoni sedimentari, distribuiti a varie altezze, sono spesso associati a materiali grossolani (megabrecce) dovuti a fenomeni gravitativi di collasso lungo pendii sottomarini, fortemente acclivi e fratturati. I fossili presenti sono esclusivamente cenozoici, da forme mioceniche (*Clypeaster* sp. e *Porites* sp.) a forme medio pleistoceniche, nei quali la forma più abbondante è *Terebratula scillae*. La scarpata in gneiss è una scarpata di faglia e data un sollevamento esclusivamente quaternario, molto rapido, verosimilmente compreso tra il Pleistocene inferiore e il Siciliano, come confermano la presenza di *Gryphus minor* e *Terebratula scillae.*

TERMINI CHIAVE: Geomorfologia costiera, Sollevamento a duomo, Vene sedimentarie, Arco Calabro (Italia).

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INTRODUCTION

The Monte Poro plateau and the town of Vibo Valentia (Southern Italy) are bordered, on the S-E side, by a 200 m high slope with a mean steepness of 40°. Until now this escarpment, which extends for 20-25 km in a SW-NE direction, has been reported in the geological literature as being exclusively formed by outcrops of metamorphic rock (Cortese, 1895; Ghisetti, 1980; Nicotera, 1959; Tortorici, 2003). Furthermore, in the official cartography (Carta Geologica della Calabria 1:25000) the cliff is recorded as being exclusively made up of granulitic gneisses (bended gneiss), located at the NW limit of the Neogene sedimentary basin of the Mesima River.

During roadworks started in 2000 and still in progress, this slope was cut (then about 1.5 km) and several outcrops, up to 30 m high, were exposed. The outcropping gneisses appear to be extensively affected by tectonic activity and are crossed by a network of marine sediment veins, each with an estimated area ranging from 1-2 up to 80-100 m^2. The veins are filled with fossiliferous skeletons embedded in a carbonatic matrix: the fossils are generally fragmented and eroded but are on the whole recognizable. A first interpretation of this gneiss-carbonatic sediment system is that the perimetric escarpment of Vibo Valentia was a coastal cliff developed on a fault slope in Neogenic times. In particular, the occurrence within the fill of abundant *Porites* colonies, elsewhere in the Vibo Valentia district already referred to as Miocene in age (Barbera & *alii*, 1995), along with several fragments of *Clypeaster* sp., *Ostrea* sp., *Pecten* cf. *jacobeus*, venerids, scaphopods and other Neogene taxa, points to an Upper Miocene settlement of the cliff (Ietto & *alii*, 2003). This attribution was also supported by the comparison with similar facies recognized by Nicotera (1959) in the Miocene transgression on the M. Poro granites.

The morphoevolutionary and sedimentary context of the slope appearing from the outcrop is that of a rapid uplift of the cliff, made of high grade metamorphites: the well known «dioritico-kinzingitic formation» Autoch. (Cortese, 1985). These are gneisses with a banded structure and evident phenomena of anatexis (banded gneiss). The cliff is very probably situated in an active fault zone (fig. 1). This is suggested by outcrop evidence such as:

- Sediment veins along open lesions in the kinzingites, which follow in sequence up to more than 20 m in height and which have openings of up to 1-1.5 m (fig. 1).
- Debris avalanches (megabreccias) with blocks up to 2.5-3 m in diameter, made up exclusively of gray or blackish metamorphites (fig. 1).
- Paleo-landslides of thicknesses up to 10-15 m and front widths of up to 70-80 m (fig. 1).

The marine sedimentary component is represented exclusively by carbonates: tawny-colored waxy calcareous shelly rocks; zoned gray micritic calcareous deposits, only in the veins; breccias and megabreccias with carbonatic matrix and cement; calci-rudites and calcarenites with varied cementing. At first assessment, the thickness of this basal sedimentary interval outcropping in a disjointed way on the cliff front can be estimated at around 70-80 m.

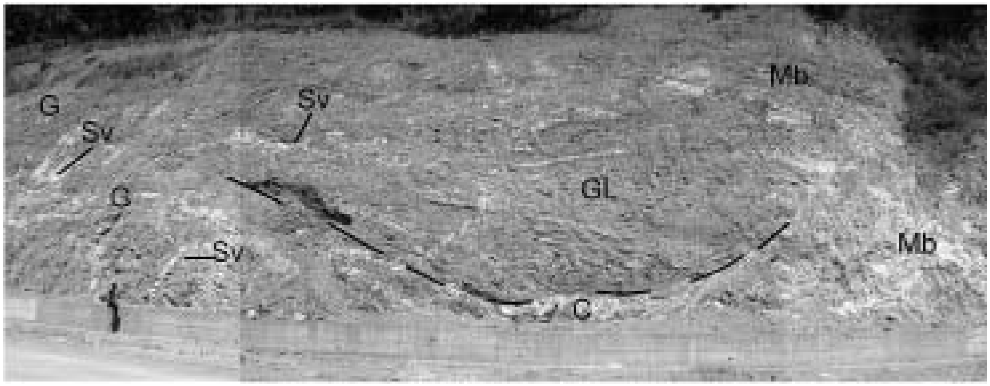


FIG. 1 - C: Levels of carbonatic slabs along the internal cut planes or shear plane of the landslide; GL: Massive landslid gneisses; G: Basement gneiss; Sv: Sediment veins; Mb: Megabreccias welded by fossiliferous carbonates; Settling surface of the landslide on Mb and other sediments.

Above, and sometimes laterally, the rock falls from the cliff and landslips are gradually substituted by monogenic calci-rudites (gneiss) with a carbonate matrix and by poorly stratified coarse calcarenites, which include lenticular coquinas (fig. 2). A carbonate matrix, often micrite, is frequently rich in pelagic phoraminifera.

Near the village of Stefanaconi the unfaulted coarse calcarenites, which include coquinas, extend from the cliff toe to the top of the neogenic sedimentary sequence (upper Miocene-Pleistocene) of the Mesima River.

The latest roadworks extension over a further 6 km (along the main fault - fig. 2) has revealed about 20 new large sedimentary veins, all of them fossiliferous. The paleontological sampling carried out in 2004 provided well preserved fossils that indicate an Early Pleistocene age for the cliff.

In the following, the age of the cliff is redefined on the basis of the new paleontological records. In addition, some geomorphological and neotectonic elements, which indirectly support the new stratigraphic attribution, are also presented. As regards the sedimentological and more detailed geomorphological remarks, reference is made to Ietto & *alii* (2003).

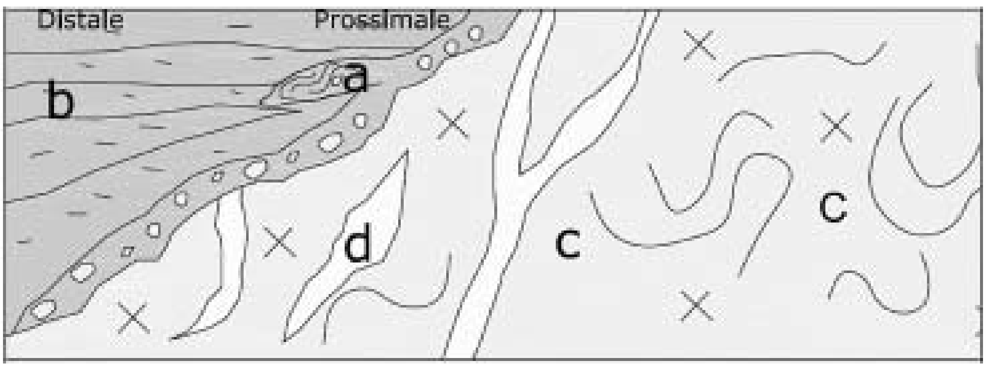


FIG. 2 - Relationship between sediments-metamorphic basement - a: Breccias, debris avalanches and submarine landslides; c: Metamorphic basement (banded gneiss); d: Sedimentary veins often with karstification.

GEOMORPHOLOGY, FOSSILS AND UPLIFT OF THE ESCARPMENT

The escarpment bordering the southeastern side of Vibo Valentia represents the margin of the large Mt. Poro marine terrace, which extends from 420 to 711 m in altitude (Westawey 1993; Tortorici & *alii*, 2003). It progressively becomes lower northeasternwards to 100 m, close to the village of S. Onofrio.

At the base of the slope, above the other marine terrace, between 360 and 370 m of altitude there are the villages of Piscopio, Stefanaconi and S. Onofrio.

Several authors refer the Stefanaconi terrace to a specific order of terraces: Miyauchi, 1994 (IV-VI order); Westaway, 1993 (III and IV order). In addition, our opinion is that the terrace at nearly 370 m of altitude is a regressive marine terrace, extensive and always remaining at the top of the entire Neogene sedimentary succession of the Mesima basin. Nevertheless, the M. Poro-Vibo terrace is more complex from a topographic and stratigraphic point of view: it includes terraces on granites and on Miocene and Pliocene sediments, all belonging to the same event.

Accordingly, the edge whose margin southeastward of the Monte Poro terrace forms an escarpment, rose exclusively in the early Pleistocene. During the uplift out of the sea, faults (more or less open and crossed), landslides, debris-avalanches and widespread erosion created ideal conditions for sediment veins and fossil deposits.

The fossil assemblages are dominated by brachiopods followed by molluscs, arthropods, briozoa, corals and others. So far the abundant fossils identified in the sediment veins and coastal coarse sediments are the following:

Molluscs:

Amussium sp.
Chlamys (*Chlamys*) *multistriata* (Poli, 1795)
Chlamys (Flexopecten) flexuosa (Poli, 1795)
Gibbula sp.
Glicimeris sp.
Lima lima (Linnaeus)
Modiola mytiloides (Bronn)
Ostrea sp.
Pecten (Pecten) jacobeus (Linné, 1758)
Pseudammussium sp.
Venus (Ventricoloidea) casina (Linnaeus, 1758)
Raphitoma (Raphitoma) echinata (Brocchi, 1814)
Superfamiglia *Patelloidea* (Rafinesque, 1815)
Trochus sp.
Dentalium (Fissidentalium) rectum (Gmelin)

Brachiopods:

Crania anomala (Müller)
Gryphus minor (Philippi)
Gryphus vitreus (Born)
Megerlia truncata (Linnaeus)
Megathiris detruncata (Gmelin)
Terebratula scillae (Seguenza)
Terebratula retusa (Linnaeus)

Arthropods:

Cancer sismondai (Meyer 1843)
Balanus sp
Ostracoda sp.

Coelenterates:

Dendrophyllia sp.
Oculina sp
Desmophyllum cristagalli (Milne-Edwards & Haime, 1848)

Among the identified brachiopod taxa, the association of the *Terebratula scillae* (Seguenza) (Pliocene-Sicilian) (fig. 3) and *Gryphus minor* (Philippi) (Pleistocene-Recent) (fig. 3) indicates that the cliff settled during the Pleistocene (1.8 Ma) not later than the Sicilian [0.95 Ma; or 0.75 Ma; respectively Shackleton & *alii*, 1990 and ICS (International Commission on Stratigraphy 2004) (tab. 1).

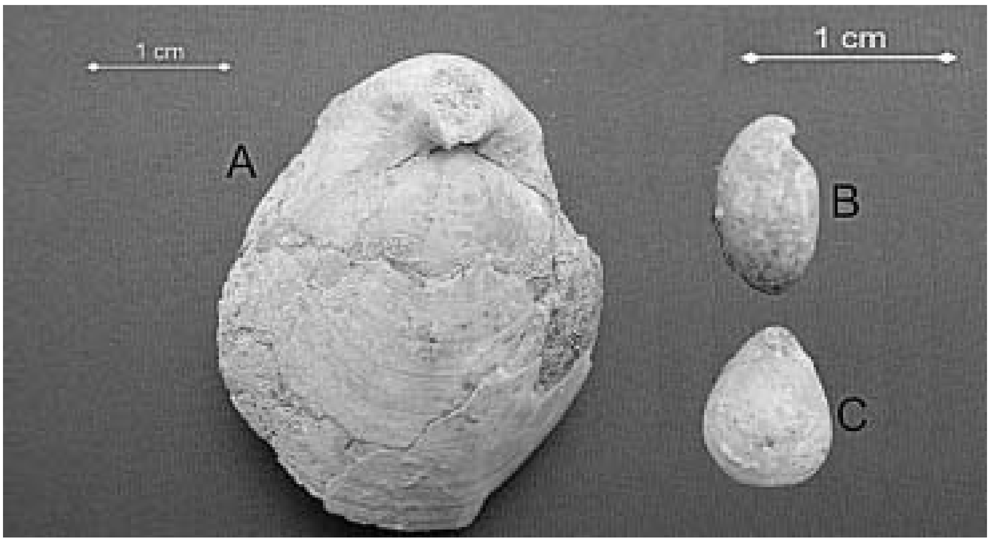


FIG. 3 - A. *Terebratula scillae*, view of the brachial valve; B. *Gryphus minor*, lateral commissure; C. *Gryphus minor*, view of the brachial valve.

	Mioc.	Plioc.	Pleist. (Low. Mid. Upp.)	Rec.
Crania anomala (Müller)		- - - - -	- - - - -	- - - - -
Gryphus minor (Philippi)			- - - - -	- - - - -
Gryphus vitreus (Born)		- - - - -	- - - - -	- - - - -
Megerlia truncata (Linnaeus)	- - - - -	- - - - -	- - - - -	- - - - -
Megathiris detruncata (Gmelin)	- - - - -	- - - - -	- - - - -	- - - - -
Terebratula scillae (Seguenza)		- - - - -	- - (Low.)	
Terebratulina retusa (Linnaeus)	- - - - -	- - - - -	- - - - -	- - - - -

TABLE 1 - Stratigraphic distribution of most important fossils Interval of morphostructural evolution of the cliff: Early Pleistocene.

This chronological attribution is in agreement with the geomorphological analysis carried out by Miyauchi & *alii* (1994). The authors have distinguished XII orders of terraces in Calabria, referring that of Mt. Poro to the I and II orders, between the peaks 25 and 35 of the oxygen isotopic curve, falling in turn between 1000 and 1200 Ka (Shackleton & *alii*, 1990).

The development of the cliff in the early Pleistocene is thus compatible. On the contrary, the age suggested for the same terrace by Tortorici & *alii* (2003) does not seem to be reliable: according to these authors the settlement of the Mt. Poro terrace should fall between 330 and 240 Ka, corresponding to the VII terrace order of Miyauchi & *alii* (1994) and in the isotopic interval 7.5-9 of Shackleton & *alii* (1990).

Additional information on the slope concerns the extensive tectonic activity observed, characterized by high angle faults with prevalent directions parallel to the escarpment: N30-35°E. Other vertical faults with a transcurrent motion (N100-120; pitch 10-15° W) are also present: they transversely cut the small ridge, as well as the included sedimentary veins and cut the main faults (NE-SW).

The SW-NE oriented faults are currently on all the outcropping gneisses, whereas they are hidden by the Neogene and Recent sedimentary cover to the S and SW of Vibo Valentia and to the N and NE of S. Onofrio. None of the NE-SW faults cut the terrace of Stefanaconi at the foot of the slope: this should suggest that the fault slope, between the two orders of terraces (Mt. Poro and Stefanaconi), was active throughout the Pleistocene, producing the uplift of the rim of the Mt. Poro upper terrace.

Therefore the Vibo Valentia cliff, which rose nearly 7-800 Ka ago, represents a peak of regional doming uplift (Miyauchi & *alii*, 1994), here influencing the Mt. Poro block, bordered by gravitational faults: Valle Mesima (eastward), Nicotera-Gioiosa (southward), S. Eufemia streat (northward) and Tyrrhenian offshore (westward).

CONSIDERATIONS AND CONCLUSIONS

For Southern Calabria, the following phenomena combine and contribute towards a dramatic tectonic phase, occurring between 7 and 8 Ka, where:

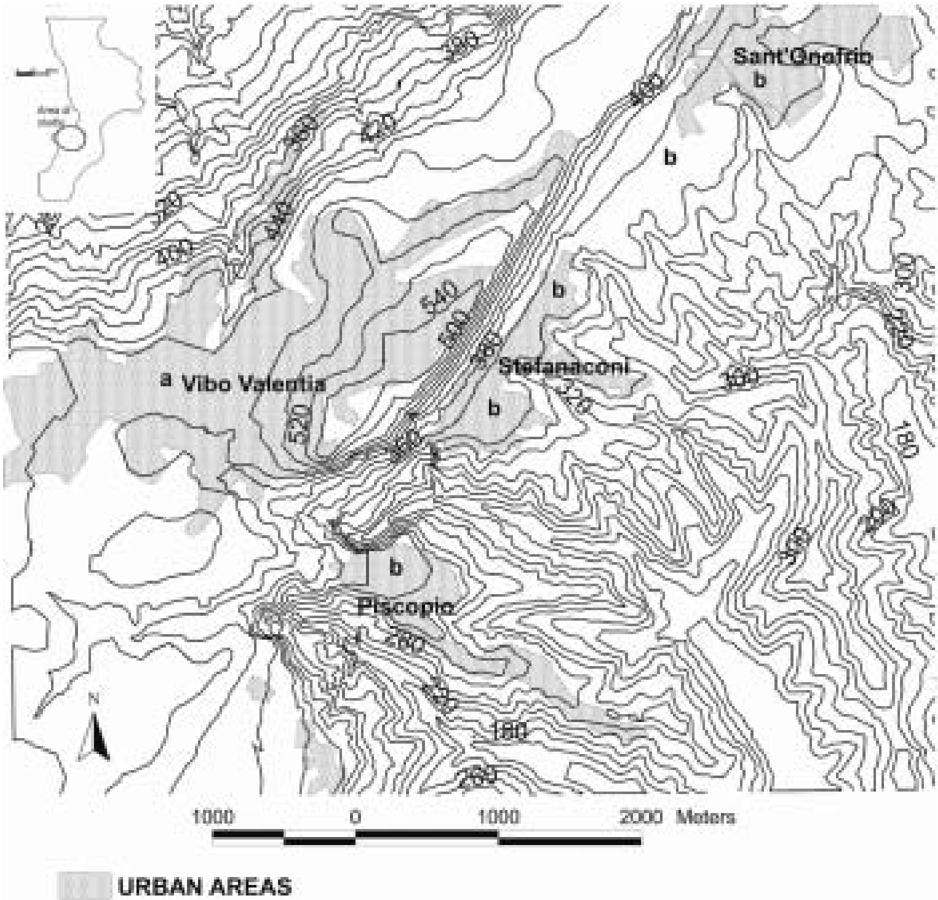
A. Cliff uplift (rising at a rate of close to 3.8 m/Ka - Miyauchi & *alii*, 1994) along the NE-SW fault from Pizzo to Nicotera. This great tensive structure, until now never clearly recognized in the literature, seems to control the morphostructure of entire peninsula of Monte Poro (figg. 4-5);

B. Southwestward extension of the Tyrrhenian sea (Gvirtzman & Nur, 2001). At this time the Ionian slab detachment and consequentially the gap between the Ionian lithosphere and Tyrrhenian plate is filled with viscous astenospheric material (Argnani, 2000);

C. Rollback motion of the slab, and suction of astenosphere from the underside of the African plate (Gvirtzman & Nur, 2001). This event, made possible when the uplift of the slab occurred in an astenosphere of lower viscosity (spoken communication Prof. Ignazio Guerra, UNICAL), seems to be well confirmed by the geology and outcropping structures throughout southern Calabria (Ietto & *alii*, 2002) (figg. 4-5);

D. The asthenospheric flow under the overriding plate (Calabrian crust) triggers its doming uplift and consequently produces the rise of the Vibo Valentia cliff.

FIG. 4 - Location and topographic reference of the escarpment of the study area - a) Marine terrace of Vibo-Monte Poro 5-700 m/slm); b) Marine terrace of higher order (3-400 m/slm) on which the villages of Piscopio, Stefanaconi and S. Onofrio are located.



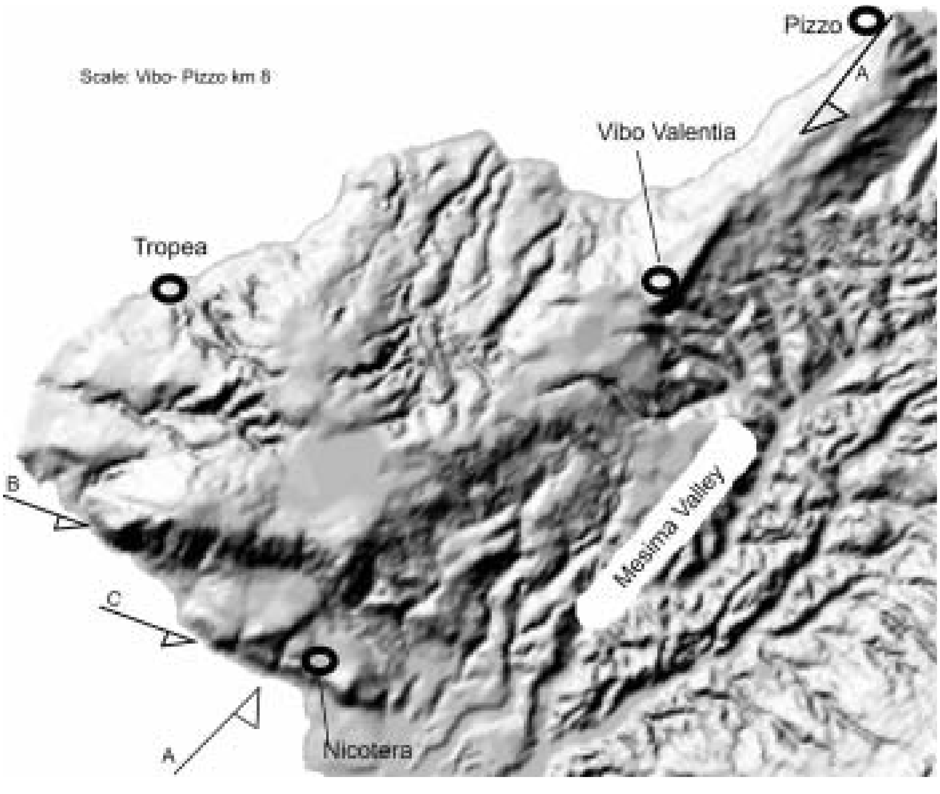


FIG. 5 - Trend of the regional fault (Nicotera-Pizzo Fault) activated in the Upper Pleistocene (perhaps along previous tectonic lineaments); A) Nicotera Pizzo fault and study area near Vibo valentia; B)-C) Faults known in the literature (Ghisetti 1980, Meullekamp 1993; Tortorici 2000); Coccorino Fault (B); Nicotera-Gioiosa Fault (C).

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