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LITHOFACIAL, SEDIMENTOLOGICAL AND TECHNICAL CHARACTERISTICS OF THE NEOGENE BUILDING STONES EXTRACTED FROM SKOPI - SITIA (E. CRETE).

by

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Introduction

In Faneromeni coastal area of Sitia district, there exist old, abandoned, as well as active quarries of fossiliferous limestones, which according to GRADSTEIN (1973) belong to Faneromeni Formation, of Miocene age.

The extracted limestones were used since the Minoan period, not only as building stones for public and private buildings, but also as decorating stones and sculpture material for the lying furnaces and ovens in bakeries.

The scope of this study is to search for the mineralogical composition and the strength of these stones and to compare their petrological, textural and technical characteristics with the famous Malta stones.

Lithostratigraphy

The building stones which are studied, have been extracted from a locality near Skopi village of Sitia district, in Lasithi Province (Fig. 1). Lithologically they belong to Faneromeni Formation. This formation consists generally of biogenic and organo-clastic limestones, alternated by yellowish, non-laminated and laminated marls, rich in Foraminifera and sponge spicules and with occasional Pycnodonta (Fig. 2). Occasional small outcrops are found unconformably overlying preneogene rocks. Overlying deposits are rare, yet in some places the formations is succeeded by Quaternary sediments.

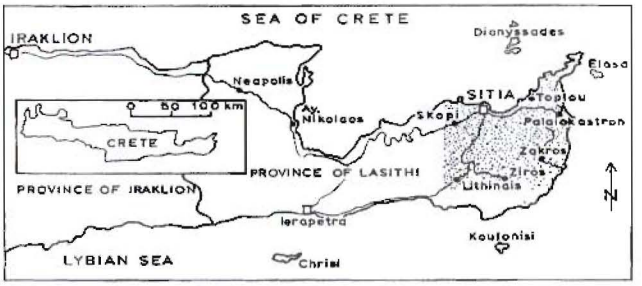

Fig. 1. Location of the Sitia district, Province of Lasithi, E. Crete.

In the Faneromeni section, about 35 m of marls are overlain by 65 m of bedded limestones. In addition, 1-2 m thick, non-laminated marly beds alternate regularly with thinner marls, which display a fine parallel lamination. The lowermost beds are sandy and contain *Pecten*. The uppermost marls include a 30 cm thick gypsum bed. A petrographic analysis revealed

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abundant volcanic glass. The marls above gypsum have been folded by slumping; the axial planes of the folds indicating movements directed towards the northeast (basinwards?).

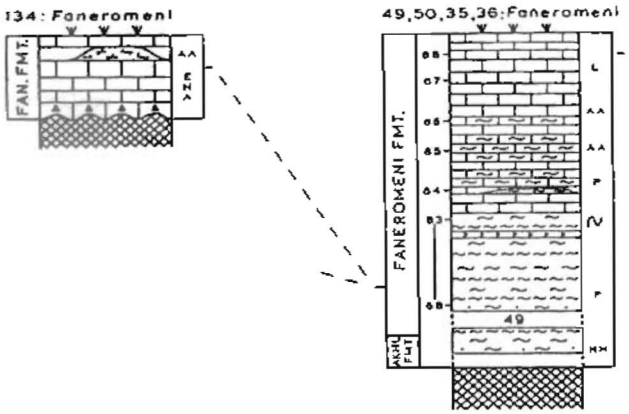

Fig. 2. Stratigraphic column of Faneromeni Formation (after GRADSTEIN, 1973).

The overlying limestones can be subdivided in a more marly lower part and a more calcareous, indurated, upper part. Quarries are situated at these stratigraphic levels, which are the uppermost part of the Faneromeni Formation.

In the lower part, 1-3 m thick, fine-grained, marly limestones contain *Pycnodonta*.The base of the limestones is often indurated; foraminifera and sponge spicules occur abundantly, while molluscs, algal encrustations and *Serpula* are common. Some beds show numerous horizontal grooves, which probably originated from solution of accumulated, flat algal thalli (*Halimeda*?). The upper limestones are up to 2 m thick, rather weathered and strongly indurated. They are mainly composed of small, often rounded remains of molluscs and echinids, with foraminifera and sponge spicules (GRADSTEIN, 1973).

Beautiful patch reefs are present along the road between Skopi and Sitia (Fig. 3). The reefs occur in the middle part of the section and mainly consist of serpulids and algae. Algal dust may be an important costituent; molluscs and small striate brachiopods are common. Bedding is indistinct and the reef outline is irregular. The surrounding strata dip up to 10° away from the reef bodies. Talus deposits are not clearly present, which may indicate that quiet depositional conditions prevailed. Nearby the reefs, very pure, marly limestone beds are exploited for building stones. In these quarries, large and well-preserved fishes are found, which indicate a low energy depositional environment.

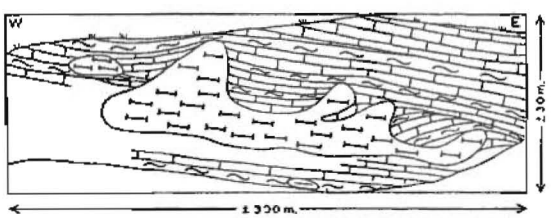

Fig. 3. Schematic cross-section of one of the patch reefs in the Faneromeni Formation (after GRADSTEIN, 1973).

In addition, the laminated and non-laminated marls should also have been deposited in a quiet environment. As it is known, when limestones pass laterally into marls, a transition from nearshore and offshore conditions, respectively, is possibly reflected.

Biostratigraphy

In the Faneromeni section, *Globorotalia scitula* var. *ventriosa* OGNIBEN is abundant. This species is common in the Tortonian stratotype.

In addition, at the base of the section, *Uvigerina selliana* was found together with *U. gaulensis* or *U. felixi*. These *Uvigerina* data point to an Early Tortonian age. In the highest part of the section *U. lucasi* is frequent. The range of this species coincides more or less with the deposits of the uppermost Miocene of so-called Messinian.

Finally, latest magnetostratigraphic analysis showed that the absolute age of Faneromeni section ranges from 7.8 to 6.4 Ma (HILGEN *et al.*, 1995, KRIJGSMAN *et al.*, 1995).

Sedimentological analysis of the building stones

The sedimentological analysis of the Faneromeni marly limestones revealed a calcified organic tissue, possibly algae or sponges. The calcification is considered to have been controlled by the decay of the soft organic parts (LANG, 1989)

The matrix is inhomogeneous and consists of a network of dark micritic biofilms which exhibit a characteristic fenestral like fabric (Fig. 4).

The micritic matrix represents a calcified organic tissue, whereas the fenestral cavities correspond either to primary organic cavities or to non-calcified tissue. Cavities have been filled by cloudy microgranular ferroan calcite cement. In places, the micritic matrix yields peloidal fabrics that tend to form clotted texture.

The above facies is included in a packstone with randomly dispersed bioclasts, such as sponge spicules, planktonic and benthic foraminifera and echinoids (Fig. 5).

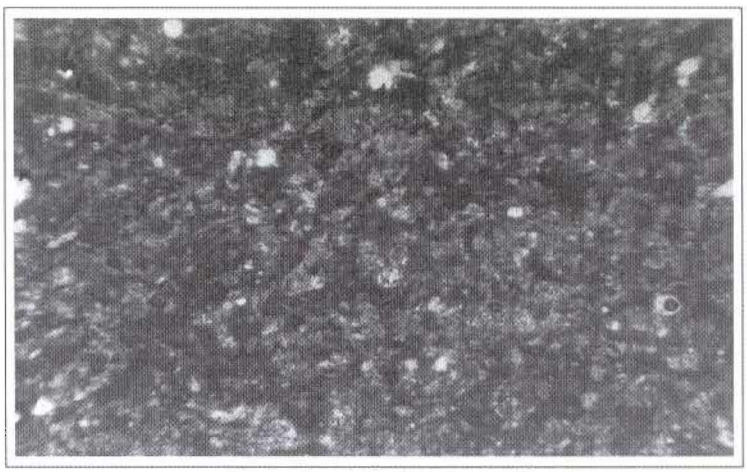

Fig. 4 Inhomogeneous matrix, consisting of a network of dark micritic biofilms, lumps and/or flakes (algae and/or sponges)

Fenestral fabrics include molds of sponge spicules of variable size. The original opal A of siliceous sponge spicules has been slowly dissolved, very early, under alkaline conditions, within the still soft sponge tissue and thus their original internal structure is not preserved. Slow silica dissolution combined eith rapid calcification of sponges, - synsedimentary calcification-, lead to the preservation of spicule molds (REITNER, 1993).

The necessary for carbonate precipitation alkaline conditions are provided by ammonification of the decaying organic matter and sulfate reduction, due to microbial activity (WARNKE, 1995).

Fig. 5 Packstone with randomly dispersed sponge spicules, planktonic and benthic foraminifera and echinoids.

The above sedimentological analysis suggests that the Faneromeni limestones have been deposited in a shallow-marine environment, possibly with patch reefs/bioherms (WARNKE & MEISCHNER, 1995).

The X-ray diffraction analysis revealed only calcite and minor amounts of aragonite and quartz.

Concerning the strength of the material, the following technical properties have been found:

-Uniaxial Compressive Strength Mpa: 94,3 kgr/cm^2 (medium strength: 50-100 kgr/cm^2 after DEERE & MILLER, 1966, In LAMA & VUTUKURI, 1978).
-Dry Unit Weight: 1,87 gr/cm^3
-Hardness (MOSH): 2
-% of insoluble residue: 4%.

Comparison with other Neogene building stones

In Rethymnon Province, there are also quarries for the extraction of Neogene limestones that have been used as building and decorative stones, many years ago. There exist about seven quarries in the area near the village Alfa.

There are evidences that these rocks were intensely quarried by the Venetian Colonies and Cretans during the Middle Age, before the Turkish invasion in the island of Crete.

The Alfa Formation consists of neritic limestones, which microscopically arrear as well-sorted, fine to medium grained packstones rich in benthic and planktonic foraminifera, molluscs, echinoids, ostracodes, bryozoans, corals and algae (Fig. 6, VIDAKIS *et al.*, 1988.).

Some samples are characterized as boundstones, being composed of calcareous algae.

In western Keffallinia island, in the area between the villages Skineas and Aghia Thekla, there exist active quarries that have been periodically worked many years ago. The extracted material is a porous to massive fossiliferous limestone of upper Tortonian age, which according to PARTSCH (1890) looks like to Malta stone.

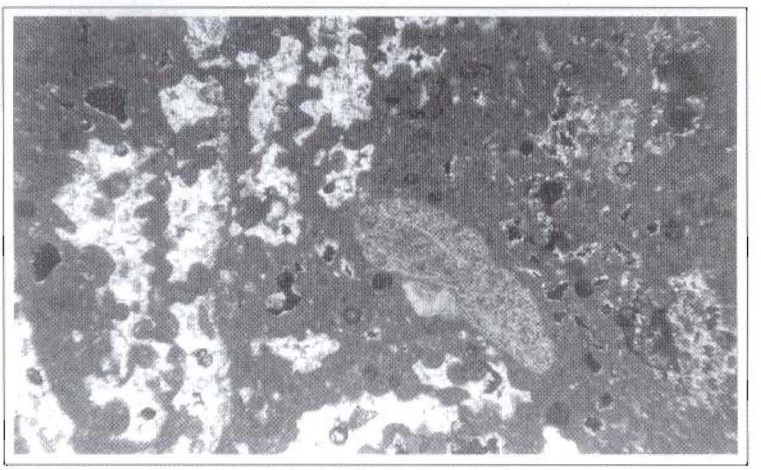

Fig. 6. Well-sorted, fine to medium packstone rich in foraminifera and algae, from Alfa Formation.

This limestone represents a pelagic calcium carbonate formation with grain-supported texture, rich in planktonic foraminifera. The fauna is composed of microbioclasts of echinoderms, bivalves, bryozoans and benthic foraminifera (Fig. 7). In places, phosphate peloids and fish remains of apatite composition are also observed (POMONI-PAPAIOANNOU, 1994).

The foraminifera included have undergone a pronounced dissolution developing a system of intra-porosity. Inter-porosity has been developed as well, cavities being cemented by coarse-grained poekilotopic calcite (POMONI-PAPAIOANNOU *et al.*, in press).

Conclusions

The studied building stones represent biogenic limestones derived by calcification of an organic tissue (algae and/or sponges). They are characterized by fenestral-like fabrics which include molds of sponge spicules, preserved due to slow silica dissolution combined with rapid calcification of sponges. The surrounding matrix corresponds to a packstone with sponge spicules, planktonic and benthic foraminifera and echinoids.

Fig. 7. Well-sorted, fine-grained packstone rich in planktonic foraminifera from Kefallinia island.

The above facies have been deposited in a shallow-marine environment, possibly with local patch reefs/bioherms.

The above characters support deposition of sediments in submarine highs, such as seamounts (SCHOLLE *et al.*, 1983).

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