

Nutrient “cooling” effect on carbonates: evidence from a Miocene limestone

G. Coletti¹, D. Basso², A. Frixia³

^{1,2} University of Milano-Bicocca, Piazza della Scienza 4, 20126 Milan, Italy

³ Eni E&P Division, Via Emilia 1, 20097 San Donato Milanese (MI), Italy.

Email: g.coletti@campus.unimib.it

Carbonates factories grain association is related to environmental temperature. Tropical platforms are dominated by hermatipic corals and calcareous green algae as main sediment producers, while at higher latitudes bryozoans, mollusks and benthic foraminifers dominate. Calcareous red algae may occur or even be locally dominant on the shelf across all latitudes. Temperature and light control carbonate production from the chemical and biological point of view acting on both equilibrium of calcium carbonate minerals and metabolic rate of organisms.

A third parameter controlling the biogenic carbonate production is nutrients availability. Growth of photosynthesizing organisms depends on nutrient concentration in water. Increase in plankton biomass, boosted by phosphorus, nitrogen and iron abundance, enhances the particulate organic carbon (POC) which in turn reduces water transparency and light availability to the benthic community (Hallock and Schlager, 1986). For example, in the present-day Gulf of California, where eutrophic condition prevails, cool-water carbonate assemblages are present on the shelf, while, according to temperature, a warm-water association would be expected (Halfar et al., 2006). In recent sediments this kind of situation is easily detected since low percentages of warm-water carbonate bioclasts (like hermatipic corals) are mixed up with cool water ones. On the contrary, preferential dissolution of aragonite and high-Mg calcite skeletal particles during fossil diagenesis affect the grain association with the consequent loss of ecological information.

The bioclastic limestone of the Pietra da Cantoni Group (Monferrato, Piedmont Tertiary Basin) developed during the lower Miocene in a warm climate. The carbonate assemblage is largely dominated by calcareous red algae and large benthic foraminifera, however, prominent variations locally occur. In Castello di Uviglie and Villa San Bartolomeo quarries, levels of rhodolithic rudstone, are composed of barnacle plates (40%), calcareous red algae thalli (35%), bryozoan colonies (5%) and by lesser amount of mollusks, benthic foraminifers, serpulid worms and echinoids. Melobesioids dominate (>80%) the algal assemblage of rhodoliths, as frequently observed in cool water or in deep warm-water associations (Adey, 1979).

The tropical origin of the limestone has been assessed by a detailed paleontological analysis of both fossil flora and fauna. In the algal assemblage few thalli of the warm-water genera *Sporolithon* and *Lithoporella* have been identified, along with the foraminifers of the genus *Amphistegina* and the species *Operculina complanata* and *Stomatorbina torrei*.

Barnacles plate accumulation is the most outstanding feature of these rocks. In the fossil record extensive deposits of barnacle plates are known and widespread in the Pliocene limestone of New Zealand, and have been interpreted as formed in a current-swept temperate to cool benthic environment (Kamp et al., 1988). In the present-day ocean, similar sediments accumulate on isolated and current-dominated banks in the Barents Sea (Henrich and Freiwald, 1995). However, the barnacles of Pietra da Cantoni Group. belong to the *Balanus trigonus* “group” which is composed by sub-tidal warm-waters species.

Amongst bryozoans, *Bifissurinella lindenbergi*, belonging to the problematic Bicorniferidae family, is the most abundant element. This uncommon fossil species is exclusive of Neogene warm-water associations, and in the Pietra da Cantoni limestone its distribution seems to be tied to the barnacle abundance.

Such a peculiar carbonate assemblage, mainly composed of warm-water suspension-feeders, with the noteworthy absence of symbiont-bearing organisms, probably formed in POC-rich and high-energy tropical waters. The organic carbon provided plenty of food to suspension feeders, like barnacles and bryozoans, and reduced light availability at the seafloor, thus explaining the red algal assemblage. Currents possibly delivered food to the suspension feeders and at the same time prevented fine sediment settling, also contributing to the increase of primary production by mixing up the water column. The interplay of these environmental factors resulted in high primary porosity, which is preserved in the studied limestone (Fig1). The barnacle-dominated facies of the Miocene Pietra da Cantoni Fm. represents a fossil example of prevailing non-oligotrophic conditions which largely exclude hermatypic corals and allow the deposition of cool-water assemblages in warm water. This effect could solely be identified through a paleontological analysis taking into account the complete array of biotic components along with chemistry and mineralogy of the limestone.

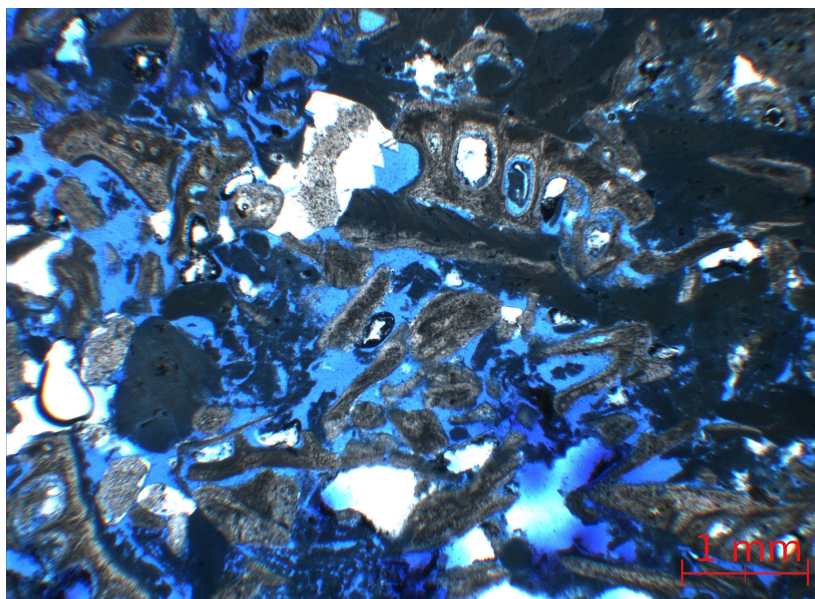


Fig 1 – Thin section of Castello di Uviglie limestone. Effective porosity is marked by methylen blue

Adey W.H. (1979) Crustose coralline algae as microenvironmental indicators for the Tertiary. In: Gray J., Boucot A.J. (Eds), *Historical biogeography, plate tectonics and the changing environment*, Oregon State Univ. Press: 459-464.

Halfar J., Strasser M., Riegl B., Godinez-Orta L. (2006) Oceanography, sedimentology and acoustic mapping of a bryomol carbonate factory in the northern Gulf of California, Mexico. In: Pedley H. M., Carannante G. (Eds) *Cool-Water Carbonates: Depositional Systems and Paleoenvironmental Controls*. Geological Society, London, special publication 255:197-215.

Hallock P., Schlager W. (1986) Nutrient Excess and the Demise of Coral Reefs and Carbonate Platforms. *Palaios*, 1 (4):389-398.

Henrich R., Freiwald A. (1995) Controls on Modern Carbonate Sedimentation on Warm-temperate to Arctic Coasts, Shelves and Seamounts in the Northern Hemisphere: Implications for Fossil Counterparts. *Facies*, 32 (1):71-108.

Kamp P.J.J., Harmsen F.J., Nelson C.S., Boyle S.F. (1988) Barnacle-dominated limestone with giant cross-beds in a non tropical, tide swept, Pliocene forearc seaway, Hawke's Bay, New Zealand. *Sedimentary Geology*, 60, (1-4):173-195.