Facies analysis and palaeoenvironmental interpretation of the Late Oligocene Attard Member (Lower Coralline Limestone Formation), Malta

Laura TOMASSETTI1, Marco BRANDANO1, Virgilio FREZZA1, Martyn H. PEDLEY2 & Ruggero MATTECCI2

Dipartimento di Scienze della Terra, Università di Roma "La Sapienza"
1Department of Geography, University of Hull, Cottingham Road, Hull, HU6 7RX, UK

The aim of this work is to present a detailed analysis of the Attard Member of the Lower Coralline Limestone Formation (late Oligocene) exposed along the Victoria Lines Fault of Central Malta by a high-resolution investigation of facies distribution in the field, followed by a detailed consideration of the internal and external factors controlling the depositional environments and the architecture of the late Oligocene ramp dominated by heterozoan and, subordinately by photozoan skeletal assemblages (Brandano et al. 2009a, b). The Attard Member is characterized by 4 members (fig. 1). Magniera, Attard, Xiendi and Il Mina (Pedley, 1978).

FACIES ASSOCIATION AND DEPOSITIONAL MODEL

The depositional profile of the Attard carbonate ramp is consistent with a homoclinal ramp (Fig. 2). The inner ramp is represented by cross-bedded, porcellaneous foraminiferal grainstones to packstones facies characterized by planar to trough cross bedding. These deposits pass down-dip into unsorted rhodolith floatstones to rudstone facies, crudely stratified and characterized by the abundance of small rhodoliths, scattered coral colonies, porcellaneous and encrusting foraminifera. Shallow-dated and unsorted rhodoliths suggest a depositional environment colonized by seagrass and interbedded with adjacent areas containing scattered corals often deposited on the non-cross-laminated, wackestones/floatstones facies. Middle ramp lithofacies consist of massive red algal coralline nannofossil packstones to wackestone facies composed by red rhodoliths, red algal branches and nodules, larger foraminifera, bryozoans, echinoids and molluscs.

METHODS

Good cliff exposures of the Attard Member along the southern side of the Victoria Line Fault offer the opportunity for detailed field mapping and lithostratigraphic analysis, including studies of bedding geometries and facies architecture of a 20 m thick portion of the carbonate ramp succession (Fig. 3).

Field observations were complemented by palynostratigraphic examination, including pollen counting of 126 thin sections for taxonomic characterization and identification of skeletal components. Pollen counts were analyzed statistically by a hierarchical cluster analysis after the Ward method with squared Euclidean distance using the SPSS 13.0 for Windows program. Facies associations, derived from the attard member study, were tested for robustness by hierarchical cluster analysis (Fig. 4). Before the cluster analysis was performed, a factor analysis of the main components was carried out.

For the palaeotemperature reconstruction (Fig. 5) we computed the palaeo-water temperatures of the Maltese Islands using palaeo-thermometric data from Schettino and Scottese (2005) assuming a negligible relative motion between the Malta-Malta Plateau block and the North-African plate over a 33 Ma time interval (Oligocene to Recent).

The diagenetic model of the Attard ramp shows many analogies with other Neogene ramps. Well-developed seagrass environments pass via scattered corals to a middle ramp dominated by red algae with subordinately larger barrolandic foraminifera (LBF) and coralline algae reef development characterized by porphyry development frameworks. The reduction of LBF that occurred during the late Oligocene allowed the red algae to expand into shallower environments.

The internal facies architecture of the Attard Member records an initial transgressive phase followed by a general regressive trend that provided the formation of the seagrass environments. The successions ends with a new transgressive phase represented by the final encrusting of the red algal barrolandic foraminifera seamounts into the inner ramp lithofacies. The correlation of the third-order eustatic cycles shows a good correspondence between the main regressive phase recorded by the Attard succession and the RuskO1 highstand sequence and following isotop of the CH22 sequence seen in the sea-level curves of Haq et al. (1987) and Hardenbol et al. (1986).

The biotic assemblages of the Attard Member and palaeotemperature reconstructions of the Maltese Islands during the Late Oligocene suggest that carbonate sedimentation took place in temperate waters and under oligostratic to slightly mesotrophic conditions. In modern carbonate platforms such water conditions and trophic regimes generally promote the development of a photozoan association, nevertheless our example is dominated by a heterozoan skeletal assemblage. The probable reason why an oligotrophic (phytozoan) carbonate factory did not develop is to be found in the paleoecology of Oligocene zoanthellate corals rather than in CO2 concentration and/or Mg/Ca ratios. Corals, until the late Miocene, lived in the middle to lower part of the photic zone (Pomer and Hallam, 2007). Consequently, the inability of Oligocene corals to thrive and form wave-resistant reef structures in shallow-water conditions must have been a significant factor in controlling facies distributions.