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Correlating Mediterranean shallow water deposits with global Oligocene–Miocene stratigraphy and oceanic events

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ABSTRACT

Shallow-marine sediment records have the strong potential to display sensitive environmental changes in sedimentary geometries and skeletal content. However, the time resolution of most neritic carbonate records is not high enough to be compared with climatic events as recorded in the deep-sea sediment archives. In order to resolve the paleoceanographic and paleoclimatic changes during the Oligocene–Miocene transition in the Mediterranean shallow water carbonate systems with the best possible time resolution, we re-evaluated the Decontra section on the Maiella Platform (central Apennines, Italy), which acts as a reference for the correlation of Oligocene–Miocene shallow water deposits in the Mediterranean region. The 120-m-thick late Oligocene–late Miocene carbonate succession is composed of larger foraminiferal, bryozoan and corallinacean limestones interlayered with distinct planktonic foraminiferal carbonates representing a mostly outer neritic setting. Integrated multi-proxy and facies analyses indicate that $CaCO_3$ and total organic carbon contents as well as gamma-ray display only local to regional processes on the carbonate platform and are not suited for stratigraphic correlation on a wider scale. In contrast, new biostratigraphic data correlate the Decontra stable carbon isotope record to the global deep-sea carbon isotope record. This links relative sea level fluctuations, which are reflected by facies and magnetic susceptibility changes, to third-order eustatic cycles. The new integrated bio-, chemo-, and sequence stratigraphic framework enables a more precise timing of environmental changes within the studied time interval and identifies Decontra as an important locality for correlating not only shallow and deep water sediments of the Mediterranean region but also on a global scale.

1. Introduction

For stratigraphy of the Cenozoic Era, the Mediterranean is of peculiar meaning because nearly all stages are defined with their GSSPs in this region. These GSSPs were established in deep water successions, many of them in Italy, which have a complete record and planktonic fossils afford the necessary biostratigraphic resolution (Hilgen et al., 2012; Vandenberghe et al., 2012). More recently, this time resolution was distinctly enhanced by astrochronology, which allows to resolve at a scale of thousands of years (e.g., Shackleton et al., 2000; Hilgen et al., 2003; Iaccarino et al., 2004, 2011; Hilgen, 2008; Turco et al., 2011a). Due to this high time resolution and more stable environmental conditions paleoceanographic and paleoclimatic interpretations for the Cenozoic mainly rest on isotope studies of deep water deposits (e.g., Miller et al., 1991; Zachos et al., 2001; Billups and Schrag, 2003; Holbourn et al., 2007). In contrast to deep water successions, there is an intrinsic limitation regarding achievable age resolution of shallow water deposits (Mutti et al., 2010). Hence, Cenozoic shallow-marine sedimentary successions in the Mediterranean region are predominantly lithostratigraphically classified. Accurate chronostratigraphic correlations are generally impeded by the stratigraphically incomplete record and the less precise biostratigraphic resolution in shallow and marginal marine settings (Mutti et al., 2010). Accordingly, the stratigraphic distribution of specific heterozoan and chlorozoan carbonate facies associations in the central Mediterranean and their relationship to the Neogene climate trends and particular paleoceanographic conditions in the Mediterranean Sea mainly rely on $\delta^{13}C$ records (Jacobs et al., 1996; Mutti et al., 1997, 1999, 2006; John et al., 2003; Kocsis et al., 2008; Brandano et al., 2010). However, a comparison between sections evidences specific regional offsets and, generally, an offset with the global carbon isotope record (Mutti et al., 1997, 1999; Brandano et al., 2010). Two main factors may explain these discrepancies between the Mediterranean shallow-marine and the global deep-sea isotope curves: (1) an inadequate or low resolution stratigraphy; or (2) the specific

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paleogeographic and paleoceanographic changes, which occur in this region during the Oligocene–Miocene (Pedley, 1987; Brandano and Corda, 2002; Bosellini and Perrin, 2008; Brandano et al., 2009a,b, 2010).

The Maiella (Abruzzi, central Apennines, Italy) represents a tectonically relative stable carbonate platform in the central Mediterranean Sea (Vecsei and Sanders, 1997). Due to its isolated position (Mutti et al., 1999; Brandano et al., 2012) and long-term stratigraphic record of shallow water sediments (Vecsei and Sanders, 1997) this carbonate platform is well suited to identify local processes possibly overprinting regional or global signals in neritic carbonates. The Oligocene–Miocene Decontra section, at the northwestern platform margin, is a reference section for the correlation of Mediterranean shallow water deposits (Mutti et al., 1997, 1999, 2006; Brandano et al., 2010). To assess the influence of local vs. global factors in the Oligocene–Miocene central Mediterranean Sea, we re-evaluate the biostratigraphy as well as oxygen and carbon stable isotope trends from the Decontra section and complement the multi-proxy data set with $CaCO_3$, total organic carbon, magnetic susceptibility and gamma-ray data.

2. Geological setting and Oligocene–Miocene stratigraphy

The Maiella Platform is a long-lived carbonate platform (Jurassic–Miocene) at the northern edge of the isolated Apulia Platform. The last phase of carbonate deposition is represented by the up to 200-m-thick Bolognano Formation (Oligocene–Miocene), which was deposited on a low inclined ramp at the northwestern platform margin (Vecsei et al., 1997; Mutti et al., 1999). The Bolognano Formation is subdivided into various informal members (Crescenti et al., 1969; Mutti et al., 1999; Vecsei and Sanders, 1999; Carnevale et al., 2011; Fig. 1). According to Mutti et al. (1997, 1999) three depositional sequences, including shallow water to deeper water sediments, were differentiated in the northwestern Maiella. The first depositional sequence is unconformably overlying Eocene limestones (Vecsei and Sanders, 1999). It starts with cross-bedded, bioclastic grainstones and rudstones of the Lower Bryozoan Limestone. Due to the dominance of lepidocyclinids this informal lithostratigraphic unit is also named *Lepidocyclina* Limestone by several authors (Merola, 2007; Carnevale et al., 2011; Brandano et al., 2012). It is overlain by siliceous hemipelagic marls and marly limestones (*Orbulina* Marls sensu Mutti et al., 1997, 1999; Cerratina cherty Limestone of Carnevale et al., 2011). The second depositional sequence begins with a monotonous succession of cross-bedded grainstones dominated by planktonic foraminifers, bryozoans, and echinoderms (Upper Bryozoan Limestone of Mutti et al., 1997, 1999) and ends with *Orbulina*-rich marls (*Orbulina* Marls sensu Mutti et al., 1997, 1999; *Orbulina* Limestone of Carnevale et al., 2011). The hemipelagic deposits in the upper part of the first and second depositional sequences (*Orbulina* Marls/Cerratina cherty Limestone, *Orbulina* Limestone) are wedge-shaped in cross-section and disappear toward the platform in the SE (Mutti et al., 1999). Due to its lesser SE-extent, the second hemipelagic interval does not occur in the section studied by Mutti et al. (1997, 1999; Decontra section) (Fig. 1). The second depositional sequence is unconformably overlain by the *Lithothamnium* Limestone, which is composed of coralline red algae, benthic foraminifers and molluscs followed by hemipelagic marls (*Orbulina* Marls according to Mutti et al., 1997, 1999; *Turborotalia multiloba* Marl of Carnevale et al., 2011). These informal lithostratigraphic units form the third depositional sequence of Mutti et al. (1997, 1999). The uppermost interval *Orbulina* Marls/*T. multiloba* Marl is not exposed in the Decontra section (Mutti et al., 1997, 1999; this study; Fig. 1) but laterally present.

In terms of sequence stratigraphy, the Bolognano Formation is interpreted as a (2nd-order) supersequence that is subdivided into four 3rd-order sequences (S 6.1–S 6.4; Bernoulli et al., 1992; Vecsei et al., 1997; Vecsei and Sanders, 1999; Fig. 1). Each 3rd-order sequence is composed of bryozoan and corallinacean dominated skeletal limestones in its lower part, representing the TST, and planktonic foraminifera-rich marly limestones in its upper part, representing the HST (Vecsei and Sanders, 1999). The age constraints of these 3rd-order sequences are, however, insufficient for correlation with the global sea level curve (Vecsei and Sanders, 1999).

To overcome the poor biostratigraphic resolution of the Bolognano Formation, Mutti et al. (1997, 1999) established a strontium isotope chronology for the Decontra section. Following this, the Lower Bryozoan Limestone/*Lepidocyclina* Limestone started immediately before 26.5 Ma and lasted to 26.2 Ma (Chattian; Fig. 1). It also indicates a late Aquitanian to middle Langhian age for the second depositional sequence of Mutti et al. (1997, 1999; Fig. 1). Conflictingly with this interpretation, Mutti et al. (1997, 1999) document *Orbulina* Marls at the top of the first depositional sequence (Fig. 1). The first occurrence of the foraminiferal genus

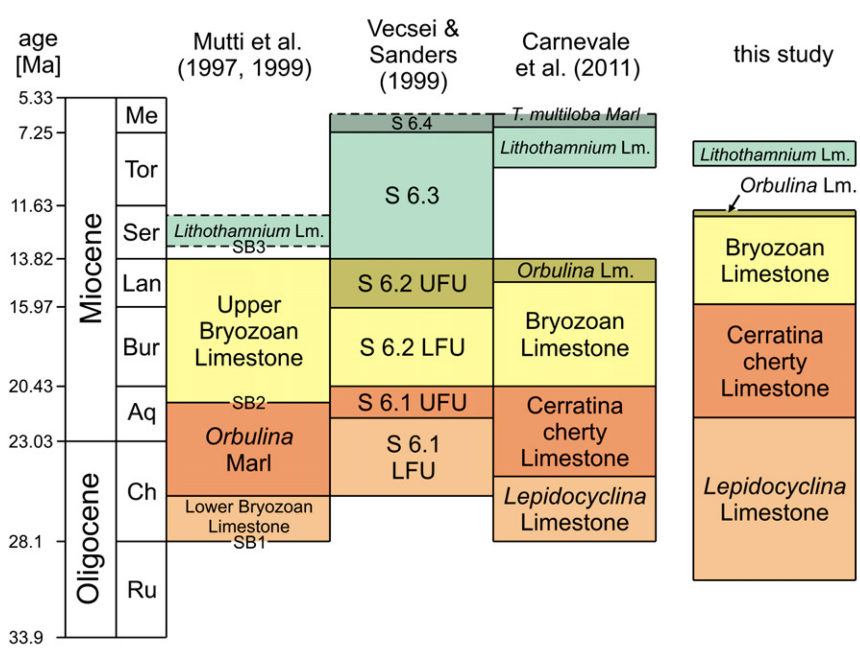

Fig. 1. Comparison of the various informal lithostratigraphic units and present age models for the Oligocene–Miocene Bolognano Formation on the Maiella carbonate platform; chronostratigraphy according to Gradstein et al. (2012), SB = boundaries of depositional sequences (Mutti et al., 1999).