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Arid versus wet climatic evidence in the "middle Cretaceous" calcareous successions of the Southern Apennines (Italy)

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ABSTRACT

An upper Albian–lower Turonian shallow-water carbonate succession cropping out near the village of Monteforte Cilento (Campania Apennines, southern Italy) was analyzed in detail within the framework of studies showing contrasting climatic evidence from the "middle" Cretaceous peri-Mediterranean carbonate successions. The full succession covers a time span in which there was a major global transgression, superimposed by fluctuating sea levels, coupled with a significant increase in temperature. There is also evidence of repeated climatic shifts from humid to dry with seasonal contrasting conditions. Restricted peritidal facies dominate the section and demonstrate the general characteristics associated with restricted brackish/schizohaline up to hypersaline depositional settings in which mesotrophic to mildly eutrophic conditions largely prevail. However, an opening and/or deepening trend of the depositional areas is recorded upward in the succession by deeply bioturbated plankton-rich strata at the Cenomanian–Turonian transition. This trend stopped with the inception of new shallow-water depositional settings which radiolitid rudists repopulated or from which shallow-water skeletal remains were supplied. This transient drowning event was anticipated and then marked by the occurrence of sediments bearing low-oxygen tolerant planktonic assemblages adapted to mesotrophic conditions. This suggests ecological conditions that were unfavourable to the main carbonate-producing shallow-water assemblages at the Cenomanian/Turonian boundary. Conditions of stress in the reconstructed shallow-water settings correlate with the deterioration of the water mass that culminated in deep-water domains with the well-known OAE2 anoxic crisis. The uppermost Albian–lower Cenomanian interval is characterized by intertidal to supratidal, partially dolomitized limestone with abundant silica pseudomorphs after evaporites. The silicified evaporite nodules and layers are evidence of episodes of highly evaporitic conditions in very shallow subtidal to supratidal settings in which salty to hypersaline ponds and areas of sabkha occurred. The occurrence of xerophytic megafloral remains also suggests that an arid, evaporite-promoting climate obtained in the depositional areas of the Albian–Cenomanian succession studied. Within the framework of the climatic evolution of "middle" Cretaceous time, the evaporite cycles of the Monteforte Cilento section are of particular interest. The different peri-Mediterranean carbonate successions record widespread karst phenomena and bauxite, which are expressions of hot/humid climates. Accurate biostratigraphic analyses and published geochemical data constrain the evaporitic episodes recorded in the Monteforte Cilento section. The related arid/semiarid climatic conditions fall within a time interval in which different coeval Apennine successions show shallow-water deposits (from stromatolitic/loferitic peritidal cycles of restricted inner shelf areas to more open, subtidal deposits of an open shelf) sandwiched between two tectonically uplifted surfaces marked by humid climate-related mature soils (bauxite) and/or karst phenomena. This suggests that dry climatic episodes post-dated the hot/wet intervals in which the bauxite and karst systems developed but, in turn, predated more recent hot/wet climatic conditions that resulted in the karst systems which occur at the top of the upper Cenomanian limestone.

1. Introduction

Evidence of warm and humid climatic conditions in the peri-Tethyan region during Albian–Turonian times include karst features and bauxites that are widespread throughout the

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"middle" Cretaceous peri-Mediterranean shallow-water carbonate successions (D'Argenio and Mindszenty, 1991, 1995; Tisljar et al., 1998, among others). "Middle" Cretaceous limestones cropping out in several areas of the central-southern Apennines (Italy) are characterized by gaps variable in age and duration, mainly the product of exposure driven by tectonic uplift (Carannante et al., 1988, 2009; Mindszenty et al., 1995, and references therein). Discontinuous lenses of bauxite and karst networks mark the related exposure surfaces. Where a single gap occurs, this extends from the Aptian/base of the Albian to the upper Turonian. Where two gaps occur, the first is expressed by a discontinuous bauxite interval which covers an Aptian/base of the Albian karstified bedrock and is capped by lower/middle Cenomanian limestone (D'Argenio, 1963; Carannante et al., 2007), the second is expressed by thin and discontinuous reddish/yellowish marl levels resting on deeply karstified upper Cenomanian bedrock and capped by uppermost Turonian limestone.

Recent preliminary data have suggested that dry and warm climatic conditions also obtained during the "middle" Cretaceous in several areas of the peri-Tethyan region, including the southern Apennines, as well as the Tripolitza subzone of the External Hellenides (Bravi et al., 2008, 2009; Pomoni-Papaioannou and Zambetakis-Lekkas, 2008; Iannace et al., 2009). This is a time interval for which complex and conflicting climatic conditions have been hypothesized (Stoll and Schrag, 2000; Immenhauser, 2005; Steuber et al., 2005; Hay, 2008; Koch and Brenner, 2009 and references therein). In order to clarify the relationship between the above dry and warm climatic conditions and the hot and humid climatic conditions that caused the intensive karst and bauxite development in the "middle" Cretaceous peri-Tethyan carbonate platforms we need detailed stratigraphic and palaegeographic data. It was this relationship that was studied within the framework of studies in progress in circum-Mediterranean areas (Apennines, Dinarids, Greece), using the analysis of an Albian–Turonian carbonate succession cropping out in the Monte Chianello (Campanian Apennines, southern Italy; Fig. 1), near the village of Monteforte Cilento.

The Monteforte Cilento succession shows recurrent episodes of evaporite deposition, evidenced by silicified layers and nodules that suggest evaporite precursors (Bravi et al., 2008) and paralic deposits in which the remains of xerophytic megaflora occur (see Bravi et al., 2004; Bartiromo et al., 2009). The succession was analyzed in detail to understand better the depositional settings and their precise timing so as to contribute to studies of the above climatic events.

The replacement of anhydrite nodules by quartz and carbonates has been recognized in sedimentary rocks as old as the Precambrian (Siedlecka, 1972; Ulmer-Scholle and Scholle, 1994; Alonso-Zarza et al., 2002; Henchiri and Slim-S'Himi, 2006, among others). These nodules have often been termed "cauliflower nodules" because of their shape and colour. They are common in settings interpreted to be sabkhas (Chowns and Elkins, 1974) as well as in intertidal/shallow subtidal settings (Geeslin and Chafetz, 1982). They are also known from deeper subtidal deposits overlain by evaporitic supratidal sediments (Elorza and Rodriguez-Lazaro, 1984; la Maliva, 1987). In terrestrial settings, these nodules have only been reported in playa-lake deposits (Tucker, 2001). Evaporite nodules may serve as indicators of ancient shorelines, emersion surfaces and palaeoclimate, and also as evidence of hypersaline pore-waters during early diagenesis. Deciphering of the sequence of sedimentary and diagenetic processes responsible for the formation of the silicified nodules and layers in the succession may provide useful information on palaeoclimate and composition and levels of ancient groundwater in the study area in the Albian–Turonian time interval.

2. Geological setting

The Monte Chianello ridge (1314 m) provides the major relief to a sector of the Campanian Apennines, extending WNW–ESE from the village of Capaccio Vecchia to the village of Magliano Nuovo, in the Cilento area (southern Italy; Fig. 1). It constitutes a single ridge from Magliano Nuovo to the Monte Vesole (1210 m) and westwards of the latter, two parallel ridges: the higher and wider one culminating in the Monte Soprano (1083 m), the lower in the Monte Sottano (632 m). The carbonate topography here is expressed as steep slopes separated by the Calore and Alento river valleys to the north and south of the ridge respectively, in which terrigenous successions characterized by gentle morphologies crop out. This terrain represents a deformed portion of a Meso-Cenozoic carbonate platform domain ("piattaforma campano-lucana" sensu D'Argenio et al., 1973; "piattaforma appenninica" sensu Mostardini and Merlini, 1986) whose succession, up to 4 km thick, is constituted by (1) a lower dolomitic portion, late Triassic in age; (2) limestone and dolomitic limestone, Jurassic–Cretaceous in age; (3) mudstone, calcareous breccias and marls, Paleocene–middle Eocene in age; (4) bioclastic and glauconitic grainstones, Aquitanian–Burdigalian in age; and (5) clays, marls and quartz-lithic sandstones, Langhian in age.

The Meso-Cenozoic carbonate platform units are tectonically over-ridden, at a regional level, by units of basinal character ("Internal Units"), made up of the terrigenous deposits that crop out in the Calore and Alento river valleys. From a stratigraphic perspective, the oldest terrains cropping out along the ridge are the Lower Cretaceous carbonates. These are well exposed on the southern slopes of the Monte Soprano (east of the village of Capaccio) and the Monte Chianello (between the villages of Monteforte Cilento and Magliano Vetere). The upstanding Upper Cretaceous carbonates cover a wider area, forming most of the ridge of the mountain. The Paleocene–Eocene and Miocene terrains are preserved mainly along the northern slopes of the ridge. The best exposed outcrop of the succession corresponds to the south-east slope of the ridge (Fig. 1B), in the part between the villages of Monteforte Cilento and Magliano Vetere. Here, a relatively undisturbed, NE-dipping Meso-Cenozoic carbonate homocline is overlain by strata belonging to the "internal" basinal successions. The homocline is dislocated to the south by an important SW-dipping fault. In the body of the ridge the higher part of the Lower Cretaceous and all of the Upper Cretaceous strata crop out. A structural study of the area (Torrente et al., 2000) shows the presence of a complex pattern of meso-faults dislocating the succession, in which N–S, N70–90 W, NW–SE and NE–SW oriented-systems are recognizable.

3. Methods

The uppermost Albian–lower Turonian interval of the Monteforte Cilento succession (Fig. 1C), which is more than 300 m thick, was densely sampled (sample numbers in Fig. 2). More than 500 thin sections were prepared and studied to determine the sedimentology and micropalaeontology of the succession. In addition, the cherty intervals, which are a few metres thick and interpreted herein as replacing evaporite precursors, were sampled bed by bed. X-ray diffraction analyses were performed on selected specimens to determine their mineralogy. The marly layers were also subjected to detailed sampling. These samples were treated with hydrogen peroxide and then sieved to separate the fractions >250 μm and those between 250 and 124 μm. Micropalaeontological, geochemical and mineralogical analyses were carried out on the residue. Detailed field observations and an in-depth study of the lithologies and related palaeontological and taphonomic characteristics, enabled us to define the Monteforte Cilento succession