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The first microbialite - coral mounds in the Cenozoic (Uppermost Paleocene) from the Northern Tethys (Slovenia): Environmentally-triggered phase shifts preceding the PETM?

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ABSTRACT

Upper Thanetian microbialite-coral mounds from the Adriatic Carbonate Platform (SW Slovenia) are described herein for the first time, representing an important case study of extensively microbially-cemented boundstones in the Early Paleogene. The mounds are constructed primarily by microbialites associated to small-sized coral colonies, forming metric bioconstructions in a mid-ramp setting.

Detailed macroscopic and microscopic studies show that microbes are the major framework builders, playing a prominent role in the stabilization and growth of the mounds, with corals being the second most important component. Microbial carbonates represent up to 70% of the mounds, forming centimetric-thick crusts alternating with coral colonies. The microbial nature of the crusts is demonstrated by their growth form and internal microfabrics, showing accretionary, binding, and encrusting growth fabrics, often with gravity-defying geometries. Thin sections and polished slabs reveal a broad range of mesofabrics, with dense, structureless micrite (leiolite), laminated crusts (stromatolites), and clotted micritic masses (thrombolites). A first layer of micro-encrusters, including leiolites and thrombolites, occurs in cryptic habitats, whereas discontinuous stromatolites encrust the upper surface of corals. A second encrustation, the major mound construction phase, follows and is dominated by thrombolites, encrusting corals and other micro-encrusters. This sequence represents the basic constructional unit horizontally and vertically interlocked, in an irregular pattern, to form the mounds. The processes, which favored the deposition of these microbial carbonates, were mainly related to *in situ* precipitation, with minor evidences for grain agglutination and trapping processes.

Scleractinian corals comprise moderately diversified community of small (centimetric) colonial, massive, platy encrusting, and branching forms. Coral colonies are distributed uniformly throughout the mounds without developing any ecological zonation. These features indicate that coral development remained at the pioneer stage throughout the mound growth.

The spatial relationships between corals and microbialites, as well as the characteristics of microbial crusts and coral colonies, indicate a strong ecological competition between corals and microbes. A model for the evolution of the trophic structures during the mound growth is proposed, with changes in the paleoecology of the main bioconstructors triggered by frequent environmental perturbations. Turbidity and nutrient pressure, interpreted here as related to frequent recurrences of wet phases during the warm, humid climate of the Uppermost Thanetian, might have promoted temporary dominance of microbes over corals, causing rapid environmentally-driven "phase shifts" in the dominant biota.

1. Introduction

Microbial carbonates have waxed and waned in the Earth History (Webb, 2001). Especially the Cenozoic was characterized by a drastic decline of microbialites. No microbial-dominated reefs were so far reported from the Early Paleogene (e.g., Perrin, 2002) and only few examples were described for the Neogene (Late Miocene, SE Spain; Riding et al., 1991; Braga et al., 1995). Thus, the study of the microbialite-coral mounds, object of this work, provides insights into the development of patch reef facies in the Late Thanetian, including previously unexpected microbially-cemented facies.

Starting from the 'mid' Danian, environmental conditions in (sub) tropical zones of the Tethys and Atlantic coasts were favorable for the expansion of coralgal communities to form buildups, for example in the Pyrenean basin (Baceta et al., 2005), in the Majella platform

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(Vecsei and Moussavian, 1997), and Egypt (Schuster, 1996). During the Thanetian smaller bioconstructions, mainly composed of calcareous algae associated with moderately diversified communities of small corals, were developed especially in mid-latitude settings both in the Tethys (Terry and Williams, 1969; Bebout and Pedexter, 1975; Vecsei and Moussavian, 1997) and in the Atlantic realm (Bryan, 1991; Baceta et al., 2005). Within these Paleocene bioconstructions, the occurrences of microbialites were until now neglected. However, a number of these studies reported the occurrence of micritic and peloids fabrics without attributing it specifically to a microbial origin (Bebout and Pedexter, 1975; Bryan, 1991; Vecsei and Moussavian, 1997). This holds true also for the Adriatic Carbonate Platform (AdCP, Vlahovič et al., 2005) where small Danian and Thanetian coral–algal buildups (SW Slovenia) were described, but no microbial-related structures were reported (Drobne et al., 1988; Turnšek and Drobne, 1998). Only reworked clasts, likely Thanetian in age and described as "mud-mound" type buildups, were found (Turnšek and Košir, 2004).

The microbialite-coral mounds described here represent the first *in situ*, microbially-cemented bioconstructions described from the AdCP, and hitherto from the Tethyan realm. Located on the southern part of the Kras region, some road-cuts near to Divača village (SW Slovenia) reveal the existence of meter-size microbialite-coral mounds, latest Paleocene (Latest Thanetian) in age. These well-exposed bioconstructions are characterized by an exceptional development and preservation of microbial crusts, associated with a diverse coral community. Objectives of this work are: (1) describe for the first time these Upper Paleocene microbialite-coral mounds and their variety of fabrics, through field observations and petrographic analysis; (2) propose a model for the development of these microbial-coral mounds, interpreting the factors which determined the settlement, morphology, growth, and ecological relationships of microbial and coral communities.

2. Stratigraphical and geological settings

The carbonate succession investigated in this study crops out in the southern part of the Kras Plateau in SW Slovenia (Fig. 1). This area during the latest Cretaceous to Early Paleogene was characterized by

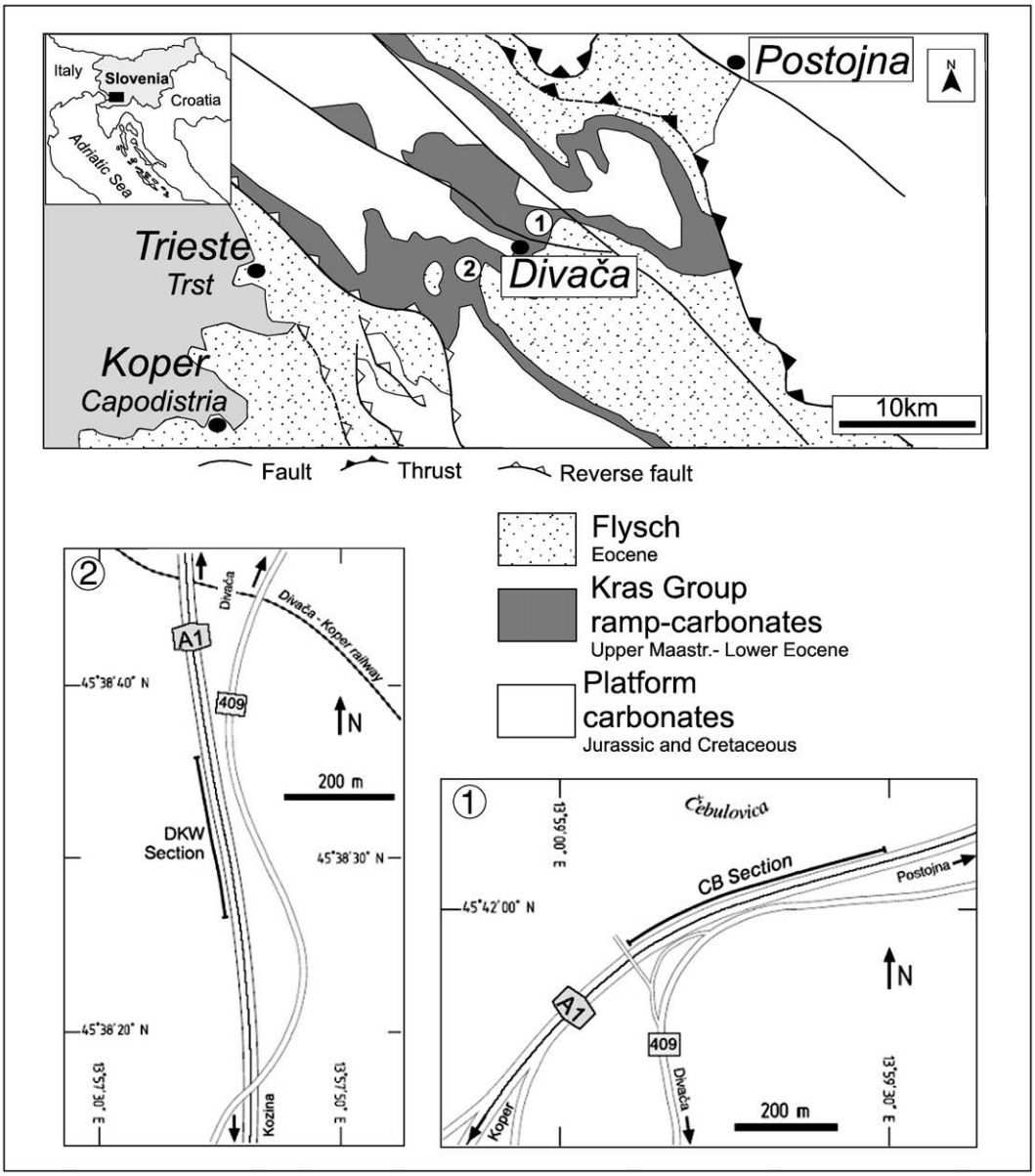

Fig. 1. Simplified geological map of the Kras region (SW Slovenia) modified from Košir (2003), with location of the studied sections: (1) Divača; (2) Čebulovica.