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Unusual *Braarudosphaera bigelowii* and *Micrantholithus vesper* enrichment in the Early Miocene sediments from the Slovenian Corridor, a seaway linking the Central Paratethys and the Mediterranean

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ABSTRACT

During a stratigraphic survey of an Early Miocene sedimentary sequence outcropping in SE Slovenia an unusual enrichment of the calcareous nannoplankton assemblage with pentaliths – pentagonal nannoliths consisting of five crystal units and showing radial symmetry – was detected. Pentaliths were only abundant in a short interval, which was sampled in detail. The lithological composition of this interval was indistinguishable from that of the underlying and the overlying strata. The composition of nannoplankton assemblages and distribution patterns of different taxa were studied. Mineral composition, total calcite content and $\delta^{13}C$ values of chosen sediment samples were analysed as well. The pentalith-enriched strata were deposited in the lower Early Miocene, corresponding to the Egerian stage of the Central Paratethys and the Aquitanian of the Mediterranean, in the Slovenian Corridor — a seaway linking the Central Paratethys and the Mediterranean. The presence of rare specimens of *Discoaster druggii* and *Helicosphaera carteri* allows stratigraphic correlation with the transition of NN1 — *Triquetrorhabdulus carinatus* Zone and NN2 — *Discoaster druggii* Zone of Martini [Martini, E., 1971. Standard Tertiary and Quarternary calcareous nannoplankton zonation. In: Farinacci, A. (Ed.), Proceedings of the II Planctonic Conference, Roma, 1970, Ed. Technoscienza, pp. 739–785]. Pentaliths belong to two species: *Braarudosphaera bigelowii* and *Micrantholithus vesper.* Both species display a wide range of morphological variation and most likely represent a group of sibling species. The pattern of distribution of both species displays obvious similarities throughout most of the studied interval. In the upper part of the studied interval *B. bigelowii* reaches maximum abundance, while *M. vesper* disappears. Since the ability of *B. bigelowii* to thrive in hyposaline water is well known, it appears that *M. vesper* tolerates reduced water salinity as well, but to a lesser extent than *B. bigelowii*. No significant paleoclimatic and paleogeographical changes are known in this particular region during the Early Miocene, however, the onset of far reaching extensional tectonic processes took place during this time. The enrichment of nannoplankton assemblage with pentaliths may represent a reflection of a short-lived episode of hyposaline conditions. Enhanced influx of freshwater and terrigenous material is indicated by a drop in ^{13}C values, a rise in nannoplankton productivity and the presence of sand in some samples from the pentalith-enriched strata. The most likely causes of this episode are regional tectonic changes, associated with the onset of intensive tectonic activity in the western part of the Central Paratethys.

1. Introduction

During a stratigraphic survey of an Early Miocene sedimentary sequence outcropping in SE Slovenia, an unusual enrichment of the calcareous nannoplankton assemblage with pentaliths was observed. Pentaliths are pentagonal nannoliths belonging to the calcareous nannoplankton family Braarudosphaeraceae, showing radial symmetry and consisting of five segments which appear to be single crystal units. A short report about this enrichment was given in Pavšič and Aničić (2000), yet the entire collection of samples had never been thoroughly studied.

The succession of exposed strata is several hundred meters thick and was deposited in the Slovenian Corridor, a seaway linking the Central Paratethys and the Mediterranean (Fig. 1A). Lithology of the outcropping strata is rather monotonous, so sediment samples were

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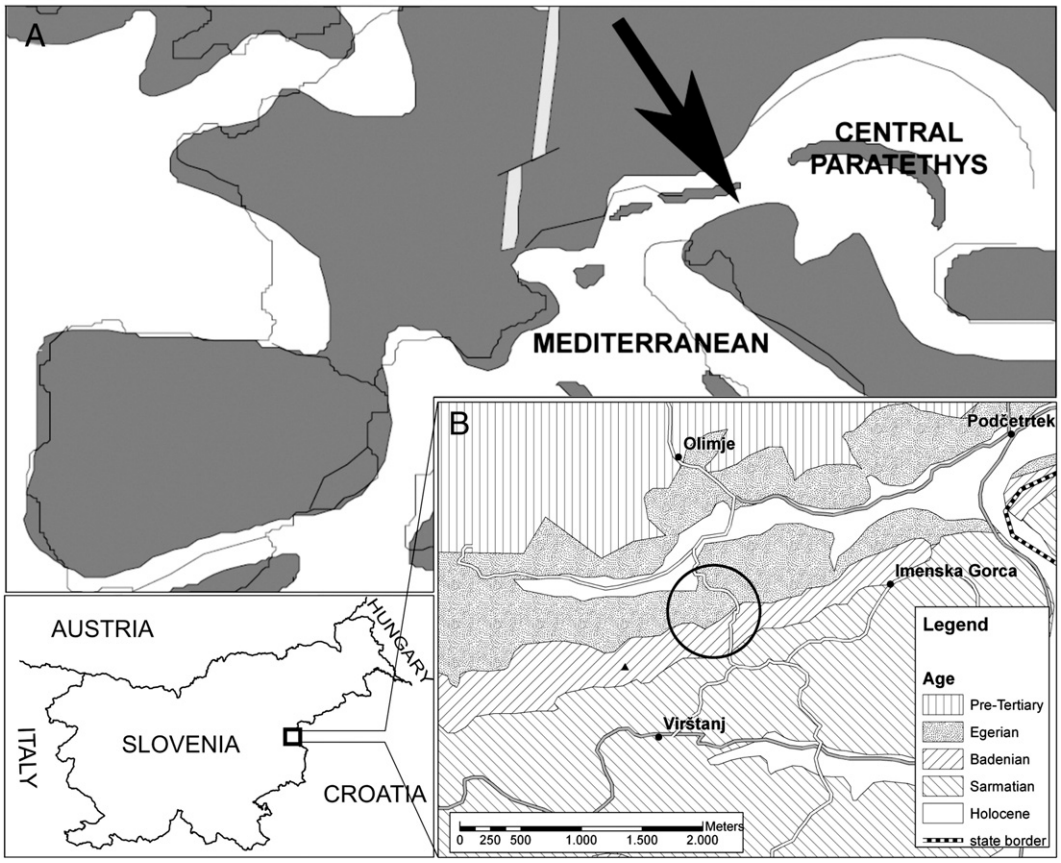

Fig. 1. (A) Paleogeographical sketch of the studied area in Late Egerian; Slovenian Corridor is marked with an arrow (after Rögl, 1999). (B) Topographic location of the sampling site and general age the rocks and sediments in the studied area (Aničić, 1999). The section is located along a road marked with a circle.

collected at large (5 m) intervals. In most samples pentaliths were rare or absent. Only in a single sample from the marl beds in the bottom part of the section, an abundance of pentaliths, belonging to the genera *Braarudosphaera* and *Micrantholithus*, was detected. No change in lithology was observed at or near the point from which this sample was collected. A closer look was taken at this part of the sedimentary sequence to determine the exact thickness of the interval enriched with pentaliths, identify all pentalith taxa and analyze their morphology and distribution patterns. We assumed that the enrichment with pentaliths was caused by some short-lived paleoecological event, which strongly affected the composition of nannoplankton assemblage, yet caused no visible change in lithology.

2. Paleogeographical setting and lithology

2.1. Paleogeographical setting

The interval, enriched with pentaliths was deposited in the Slovenian Corridor (Fig. 1). During the Early Miocene distribution of land and sea in the wider surrounding area of the studied site was complex (Pleničar and Nosan, 1958) and subjected to several episodes of drastic changes.

During the Oligocene/Miocene transition, corresponding to the Egerian (27.25–21.4 Ma) stage of the Central Paratethys and the Chattian (the Late Oligocene, 28.45–23.03 Ma) and the Aquitanian (Early Miocene, 23.03–20.43 Ma) stages of the Mediterranean (absolute ages after Piller et al., 2007), the Paratethys communicated with the neighbouring seas. Seaways to the Indian Ocean (Royden and Baldi, 1988) and the Mediterranean, were open (Steininger et al., 1976; Rögl, 1998, 1999; Popov et al., 2004a). The Slovenian Corridor, a link between the Central Paratethys and the Mediterranean, was situated south of the Eastern Alps and north of the Dinarides (Pleničar et al., 1991). Active open ocean connections are confirmed by the presence of tide-influenced Egerian deposits in the North Hungarian Bay (Sztanó, 1995). By the end of the Egerian (Late Aquitanian) the Slovenian Corridor had closed, yet a connection of the Central Paratethys with the Mediterranean through the Alpine Foredeep re-opened (Steininger et al., 1976; Sztano, 1995; Popov et al., 2004b; Harzhauser and Piller, 2007). After re-opening at least once the Slovenian Corridor had permanently closed by the end of the Badenian (corresponding to middle Serravallian of the Mediterranean).

South of the Slovenian Corridor, a system of shallow freshwater lacustrine, fluvial and wetland environments had evolved by the end of the Oligocene (Tari and Pamić, 1998) and persisted throughout the Early Miocene (Popov et al., 2004b). Near the southern shore of the Slovenian Corridor a transition zone between the freshwater lakes and marshes and the shallow shelf sea existed (Popov et al., 2004a). North of the Slovenian Corridor – in the Peri-Alpine Foredeep – sediments are characterized by open marine flora and fauna and terrigenous sedimentation, associated with the beginning uplift and northward movement of the Alpine orogen (Molasse basin) (Steininger and Wessely, 1999).

In the Early Miocene the entire western part of Central Paratethys was subjected to intensive rifting and extensional tectonics (Tari and Pamić, 1998). The onset of extensional tectonics, responsible for the structural development of the southwestern part of the Pannonian Basin, occurred in the Egerian, while main extensional processes took place during much of the Early and the Middle Miocene (Prelogović et al., 1998).