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Palaeoecological changes through the Sarmatian based on calcareous nannnofossils of North Croatia, Central Paratethys

Paleoekološke spremembe v sarmatiju, temelječe na apnenčastih nanofosilih severne Hrvaške, centralna Paratetida

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Abstract

Seven representative geological sections have been investigated on calcareous nannofossil assemblages at Medvednica Mt. The sections mostly consist of marly sediments. This SW part of the Central Paratethys belongs to the marginal Sarmatian Sea which was connected to the Eastern Paratethys, and linked through the Mediterranean to the Atlantic and towards the Indopacific during the Middle Sarmatian. Biozone succession of the deposits ranges from the upper part of NN6 to NN8 calcareous nannoplankton Zone. Throughout the Sarmatian, the climate was becoming more temperate, with seasonal changes.

Key words: Sarmatian, calcareous nannofossils, biozonation, paleoecology, Medvednica Mt., Central Paratethys

Izvleček

Na gori Medvednici pri Zagrebu je bilo na združbe apnenčastih nanofosilov preiskano sedem reprezentativnih geoloških profilov. Le-te po večini sestavljajo lapornati sedimenti. Ta jugozahodni del centralne Paratetide je v sarmatiju označevalo robno morje, ki je bilo povezano z vzhodno Paratetido in hkrati preko Mediterana z Atlantikom ter med srednjim sarmatijem tudi z Indopacifikom. Zaporedje biocon v sedimentih kaže razpon med zgornjim delom NN6 in NN8 apnenčastega nanoplanktona. V celotnem sarmatiju je klima postajala zmerna s sezonskimi nihanji.

Ključne besede: sarmatij, apnenčasti nanofosili, bioconacija, paleoekologija, gora Medvednica, centralna Paratetida

Investigated area

The investigated area was the SW, S and NE parts of Medvednica Mt. where the following geological sections were systematically sampled: Podsusedsko Dolje (Dol-I), Kostanjek (Kst-I), Markuševac (Mar-I) and Laz Stubički (LSt-I). Additionally three isolated outcrops (Susedgrad – Jarek (Dol-II), Glavnica (Glv) and Donje Orešje (Dor)) have been sampled as well (Figure 1).

Geological setting

First geological information regarding the geological structure and paleontological contents of the Neogene deposits on Medvednica Mt. come from the second half of the 19th century (Brusina – 1884, 1892, 1893; Foetterle –1861/62; Gorjanović-Kramberger –1889, 1898; Pilar – 1883; Vukotinović – 1855, 1870, 1874 and others). More detailed biostratigraphic and paleontological research was done in the second half of the 20th century, presented in the works of Kochansky-Devidé (1957, 1973), Šikić (1966, 1967, 1968, 1975), Sokač (1965, 1967, 1972, 1985), Kochansky-Devidé & Bajraktarević (1981), Bajraktarević (1976, 1986), Basch (1990a, b), Šikić (1995) Vrsaljko (1999), Galović (2001) and Galović & Bajraktarević (2006).

In a regional sense, Medvednica Mt. belongs to the Supradinaricum geotectonic unit (Herak, 1986) and represents the northern part of the Inner Dinaride marginal zone (Šikić, 1995). During the Lower Badenian, the transgression spread over the NE part of Medvednica Mt. and in the Upper Badenian it further progressed over the SW parts. At the end of the Badenian, the Paratethys started to become more isolated, and characterised by some uplift of blocks (Avanić et al., 2003). During the Sarmatian, marine sedimentation still existed but toward the end of the Sarmatian it became less saline due to the reduced connection with the world sea (Galović & Bajraktarević, 2006). During the Pannonian, the central Paratethys became isolated with more fresh-water character.

Paleoecology and Biostratigraphy

The Sarmatian was characterised by strong endemism with numerous endemic taxa (genera and species) including phytoplankton (Jurilj, 1957; Jerković, 1963, 1965; Bajraktarević, 1983a, b; Galović & Young, 2012). The biostratigraphy of the calcareous nannoplankton was investigated in more detail by Jerković (1969), Bajraktarević (1983, 1984), Galović et al. (2000), Galović (2002), Avanić et al. (2003) and Bajraktarević & Galović (2004), Galović & Young (2012).

The beginning of the Sarmatian defined the uppermost part of the NN6 - lower part of the NN7 Zone (Perch-Nielsen, 1985), which was indentified on the NE slope of Medvednica Mt. (LSt-I). The boundary of the NN6/NN7 Zone was defined on the NE part of Medvednica Mt. (DOr). It is marked by the last occurrence or absence of *Cyclicargolithus floridanus,*

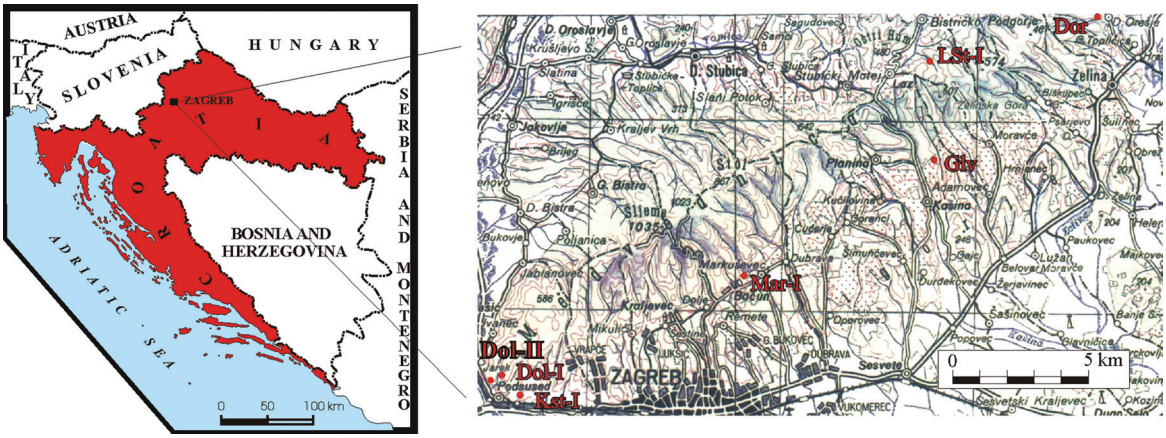

Figure 1: *Topographic map of Medvednica Mt. with localities of the investigated area.*

which is replaced by abundant appearance of *Reticulofenestra pseudoumbilicus*. It is characterised by the monofloral development of the nannoplankton: *Reticulofenestra pseudoumbilicus* and ascidian spicules (as *Perforocalcinella fusiformis)*. Young & Bown (1991) suggested that the monospecific cocolithophore represent blooming in a high-nutrient media. The 'blooms' of species *P. fusiformis* are characteristic for the Sarmatian (Bajraktarević, 1984), but it is also known from Pannonian sediments of Hungary where they have their development in a less saline (2.5–3.8 ‰) environment (Bona & Gal, 1985). It could be explained that the marine environment was under direct influence of river input, what caused a drop of salinity in the upper layers. Furthermore, the beginning or slight changes in climate and/or circulation was recognized on the basis of rare abundance of colder water species *Reticulofenestra pseudoumbilicus gelida* and larger *Calcidiscus leptoporus (*Backman, 1980; Ziveri et al., 2004; Galović & Young, 2012).

The Discoaster kugleri – NN7 Zone was identified for the first time in the N, SW and S part of Medvednica Mt. on the following localities/locations: Podsusedsko Dolje, Susedgrad – Jarek, Markuševac, and Laz Stubički. The nannoplankton assemblages of this Zone are characterised by: *Calcidiscus leptoporus, C. macintyrei, Coccolithus miopelagicus, Co. pelagicus, Discoaster exilis, D. kugleri, D. variabilis, Reticulofenestra pseudoumbilicus, Umbilicosphaera rotula,* and *U. jafari.* The laminated marly sediments of the varve type (dark/pale microlamination in succession) were deposited in the deeper marine part of the semi-enclosed basin where the coccospheres were also preserved (Galović & Bajraktarević, 2006). The near-shore area of the marginal marine zone, where the upwelling occurs (*Co. pelagicus, Helicosphaera carteri*), was under the influence of seasonal changes in a more temperate climate. The increased eutrophication caused nannoplankton blooms (Puškarić et al., 1990; Lees et al., 2004). The connections with other marine areas (Eastern Paratethys-*Braarudosphaera bigelowi*, *Reticulofenestra pseudoumbilica*, Mediterranean-*Calcidiscus macintyrei*, *Coccolithus miopelagicus,* and Indopacific-*Discoaster kugleri, D. exilis, D. variabilis*) during the Middle Sarmatian are still present but oscillating.

The boundary of the NN7/NN8 Zone has been established in the SW, S, SE and N part of Medvednica Mt. at the following locations: Dolje, Kostanjek, Markuševac and Glavnica. The last occurrence or absence of *Coccolithus miopelagicus* and *Discoaster kugleri* (Martini, 1971; Perch-Nielsen, 1985; Iaccarino et al., 2001; Marunteanu, 1999), the lack of most species representative for the NN7 Zone and the monospecific development of *H. carteri* characterise the nannoplankton boundary. Based on coccolith association with *Braarudosphaera bigelowii* and ascidian spicules the environment appears to have a more near-shore character with the drop of salinity.

In the upper part of the sections (Dol-I, Kst-I, Mar-I) a calcareous nannofossil assemblage belongs to the Catinaster coalitus – NN8 Zone on the SW and S part of Medvednica Mt. The first occurrences of *Catinaster coalitus* and *Ca. calyculus* characterise this zone. It consists of *Catinaster coalitus, Coronocyclus nitescens, Discoaster broweri, D. challengeri, Reticulofenestra minutula, Scyphosphaera apsteinii, Sphenolithus abies, Sph. neoabies, Syracosphaera clathrata.* The environment belongs to the basinal part of the hemipelagial development (*Syracolithus schilleri, Sphenolithus).* The sedimentation was generated from suspension in a low energy environment (bentonite clay), and many species from Eocene, lower Miocene and Badenian are found in it. A drastic decrease of both individuals and species diversity at the end of the Sarmatian is probably the result of a lower salinity, more near shore influence, and, possibly, a change in the water chemistry that occurred in the marginal seas or locally in enclosed bays. Because of specific conditions (seasonality, high carbonate content and depth lower than 100 m) this could be the reason of relatively good preservation of *Catinaster coalitus* species.

Conclusion

The lower Sarmatian part (upper part of the NN6 - lower part of the NN7 Zone), is identified on the NE slope of Medvednica Mt., characterising shalow and more endemic developments because of possible river influence. During the Sarmatian (NN7 - NN8 Zone), in the area of Medvednica Mt., the climate becomes more temperate, with seasonal changes (varve type of sediments) and with a more transgressive than regressive trend (oscillations of the sea-level). For the first time the NN8 Zone with *Catinaster coalitus* has been detected in this part of the investigated area, which belongs to the marginal Paratethian Sea. At the end of the Sarmatian the connections with other oceans became weaker, salinity decreased, and the more near shore development became predominant. The connections with Eastern Paratethys which was linked with the Mediterranean Sea oscillated and existed until their ends.

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