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Palaeoclimatic record based on the irregular echinoid tests

Zapisi o paleoklimi u čahurama nepravilnih ježinaca

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Irregular echinoids emerged in the Lower Jurassic, but their significant evolution occurred during the Paleogene period, especially during the Eocene epoch, when the environmental conditions were most favourable. At the end of the Eocene epoch, as result of the global tectonic movements, a cooler climatic period started. Most species of Irregularia were retreating to the warmer, tropical seas. At the end of the Badenian and during the Sarmatian, Paratethys completely separated from Tethys Sea. Due to the fresh water conditions Irregularia disappeared from the Paratethys Sea.

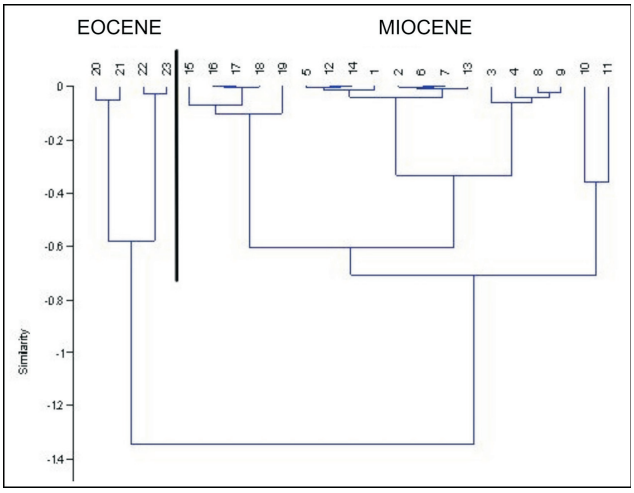

Figure 1. The cladogram showing Eocene and Miocene Irregularia specimen groups. The diagrams show two biggest clusters marking the Badenian and Eocene samples. In the Eocene cluster, marked by the enhanced magnesium content, separation for *Echinolampas* (20 i 21) and for *Conoclypeus* (22 i 23) genus can be noticed. Samples 15, 16, 17, 18 and 19 are indicative for Late Badenian showing higher Mg content in concern to the other Badenian samples. Samples 10 and 11 mark the *Echinolampas (Heteroclypeus) hungaricus* with the highest Mg content.

Slika 1. U kladogramu su prikazana grupiranja eocenskih i miocenskih vrsta nepravilnih ježinaca. Dva najveća grupiranja razdvajaju badenske i eocenske primjerke. Eocenska grupa, koja ima povišen udio magnezija, razdvaja se na dva roda *Echinolampas* (20 i 21) i *Conoclypeus* (22 i 23). Uzorci 15, 16, 17, 18 i 19, iz gornjeg badena, pokazuju povišen udio Mg u odnosu na druge primjerke iz badena. Brojevi 10 i 11 pripadaju vrsti *Echinolampas (Heteroclypeus) hungaricus* i pokazuju najveći sadržaj magnezija.

In Croatia, Eocene irregular echinoids can be found in flysch sediments, marls and conglomerates, and rarely in laminated marly limestones, in Istria (Raša valley, Pazin region), on the islands of Rab, Brač and Hvar, in the vicinity of Bribirske mostine area and in the Benkovac area (MITROVIĆ-PETROVIĆ, 1970). The Miocene Irregularia can be found in the Badenian deposits of the Medvednica Mt., Samoborska, Petrova and Zrinska Gora, in the Dilj and Psunj Mts., and in the other localities containing Lithothamnium Limestone ("Litavac") and grey marly clays (POLJAK, 1938).

To analyse the Irregularia tests composition, the calcite crystal fragments were prepared by fracturing and carbon coating. Samples were analysed by Energy Dispersive Spectrometer (EDS) coupled with Scanning Electron Microscope (SEM) Tescan VEGA to obtain chemical composition, especially magnesium content in Mg-calcite tests. The aim of this research is to determine whether the weight percent of magnesium in the tests can be used as the indicator of the sea water temperature. The enhanced magnesium content should correspond to higher, and decreased to the lower sea temperatures (PILKEY & HOWER, 1960). Stable isotope analyses ($^{18}O/^{16}O$) are planned in order to verify these preliminary conclusions.

The Eocene Irregularia tests have shown relatively uniform magnesium content (Fig. 1). The magnesium weight percent varies from 0.49% in *Conoclypeus conoideus* ZITTEL, to 0.68% in *Echinolampas*, averaging 0.6% for the Eocene samples. The *Echinolampas* genus shows increased magnesium weight percent for both Eocene (0.63–0.68%) and Miocene samples (0.36–0.98%).

The Miocene samples have shown a wider range of magnesium weight percent in the tests (Fig. 1). The *Clypeaster* specimens display values from 0.05 to 0.84%, while *Echinolampas* (*Heteroclypeus*) *hungaricus* VADÁSZ shows range from 0.36–0.98%. The average value of the magnesium content for the Miocene specimens is 0.35%.

These results can be compared with the average Earth temperature curve during Eocene epoch when the average temperature was above 20°C (Fig. 2). The environmental

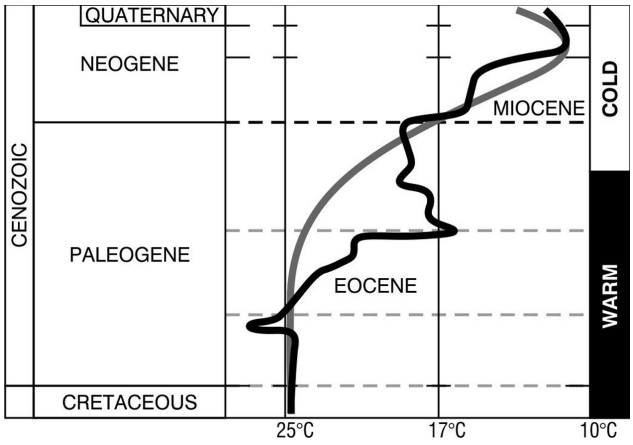

Figure 2. Average temperature on Earth during Cenozoic era (modified after www.scotese.com).
Slika 2. Prosječna temperatura na Zemlji tijekom kenozoika (preuzeto i modificirano prema www.scotese.com).

conditions in shallow-water realms of the Tethys Sea were similar to recent tropical sea conditions and therefore suitable for the Irregularia. This is consistent with relatively uniform and high magnesium content found in the Eocene Irregularia tests. The climate changes at the end of the Eocene and during the Oligocene and Miocene coincide with the reduction of living area for Irregularia, especially in the Paratethys Sea, which becomes physically separated from the Tethys Sea.

The average Earth temperature in Miocene was around 15°C (Fig. 2). The average annual temperature fall in Miocene can also be seen from the magnesium weight percent in tests of Miocene Irregular Echinoids. The biggest number of samples contains less than 0.30% of magnesium. The Miocene *Echinolampas* specimens living in the colder Paratethys Sea show lower and more variable magnesium content in relation to their Eocene relatives. The increased magnesium weight percent determined within some of the *Clypeaster* specimens may be related to some local environmental factor such as low salinity (PILKEY & HOWER, 1960).

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