Cyclostratigraphy as a powerful evolutionist tool: case study from the Miocene of the Dinaride Ancient Lake System

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Ancient lakes are laboratories of evolution. They are long-living isolated ecosystems characterized by highly diversified endemic faunas, often displaying spectacular radiations starting from few pioneer taxa. The descendants of these opportunistic pioneers often developed exceptional strategies to conquer ecological niches that are far out beyond the reach of their ancestors. Impressive examples are found especially in the deep-water assemblages of such lake systems. The time resolution based on a modern, integrated stratigraphic approach provides a unique opportunity for a critical proof of the evolutionary parameters.

The Miocene Dinaride Ancient Lake System, was a large scaled endemic lacustrine environment positioned on an about 200 km wide and at least 500 km long land mass. That NW-SE striking basinal system had its major depositional centers in Croatia and Bosnia and Herzegovina. Its origin was bounded to the continental collision between the African and European plates. The northward movement of the African plate triggered strong geodynamic modifications in the western Tethys at the terminal Eocene. The rising Dinaride land represented a part of the geographic barrier separating the new marine realm the Paratethys Sea in the NE from the relic Tethys Ocean in the SW.

The often very thick lacustrine sediments filling the basins (e.g. >4km in Sarajevo-Zenica Basin, BIH) provide an exceptional record associated with a manifold depositional environments (coals, volcanic ashes, siliciclastics, tuffaceous carbonates). These sediments show in part highly diversified fossil record comprising only for the mollusks more than 130 mainly endemic species level taxa. Many of those taxa can be traced in a time series as links of autochthonous phylogenetic lines. Such a spectacular but in fact poorly known Miocene mollusk radiation of the Dinaride Lake System apparently preceded the famous Lake Pannon (Late Miocene, Pannonian Basin System) endemic event by about 5 to 10 my.

The taxonomic inventory of the Sinj basin (SE Croatia) represents one of the best known for the whole Dinaride Lake System. The detailed paleontological studies of its fauna were funded already in the 19th century. Hence for the section at Sutina brook near Lučane several gastropod evolutionary lines became known. The section itself is about 140 m thick and comprises an in part intensive alternation of lignite layers with limestones and marls.

It has been investigated in detail by means of detailed sedimentological measurements and geophysical gamma-ray logging. Thereby the alternation could be recognized for being clearly astronomically forced, following examples from similar southern European Neogene lacustrine basins. That promised an excellent opportunity for the cyclostratigraphic determination of evolutionary rates in its fossil record. The preliminary results showed two main transgressive-regressive cycles ending with massive lignite horizons, fitting at best to 400 kyr. eccentricity periods. The spectral analysis of gamma-log data proved indeed the significance of 17 m thick sedimentary cycle interpreted as being forced by the 100 kyr. eccentricity period. Hence the succession was tentatively interpreted as representing the sedimentation period of about 0.8 myr. with mean sedimentation rate of about 0.2 mm/yr.
The represented gastropod phylogenetic lines show around two lignite horizons smooth morphologies and low morphologic disparity / taxonomic diversity. The radiation pulse started above the top of the first transgressive-regressive cycle. The diversification enriched the fossil record from 5 to 14 subspecies-level taxa, characterized by prominent sculptural elements. The massive extinction event around the lignite top of the second cycle diminished the species richness to the starting position, although with complete renewed taxonomic content. The observed evolutionary cycle correspond then exactly to one transgressive-regressive cycle and therefore most probably to one single 400 kyr. eccentricity period.
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