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Neogene Lake Systems of Central Europe – diversity, gradients and faunistic interrelations

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The central European freshwater systems of the Neogene are all characterized by outstanding endemisms. Despite the enormous amount of systematic papers dealing with single faunas, the relations between these lake systems in space and time are still unexplored. These biogeographic entities are the Rzehakia Lake (18 ma, Bavaria, Austria and Moravia), the Dinarid Lake System (17-14 ma, Croatia, Bosnia, Serbia), Lake Steinheim and associated lentic systems (15-12 ma, Germany), the Sarmatian lakes (12 ma, Austria, Hungary, Romania), Lake Pannon (11.6-5 ma, Austria, Slovakia, Czech Rep., Hungary, Slovenia, Croatia, Serbia, Bosnia, Romania), the Dacian Lake (5-3 ma, Romania) and various short-lived systems with endemic molluscan fauna such as Lake Sostan (2.5 ma, Slovenia), Lake Oradea (0.5 ma, Romania), the Kosovo-Metohia lakes (Serbia, Pliocene?) and the Skopje lake (Macedonia, Pliocene?).

In total, 1176 gastropod species and subspecies from 119 localities have been described from these lake systems. This surprisingly high diversity is even comparable with marine biodiversity for the same geographic area during the Miocene (c. 1500 taxa). The diversities and faunistic compositions of these lake systems display interesting patterns. Generally, the lake faunas may be divided into dreissenid-thiarid-micromelaniid dominated lakes and unionid-viviparid dominated ones. Parallel evolution versus monophyletic lineages and the phenomenon of iterative morphologies reveal the analysis of ancient lake faunas tantalizing. Only few lineages can be traced throughout time in more than one lake system. A potential candidate is the strange endemic planorbid *Orygoceras* which has roots in the Early Miocene of the Dinarid Lake System and re-appears in the Late Miocene Lake Pannon. Iterative morphologies and examples of parallel evolution occur especially in the dreissenid-thiarid-micromelaniid dominated lakes. Spectacular ‘morpho-pairs’ are formed by *Clivunella*

and *Valenciennius*, which both emerge from freshwater dwelling ancestors. The DLS element *Clivunella* seems to be a planorbid, whilst the Lake Pannon element *Valenciennius* is a lymnaeid. Both soon adapt to deep water environments and form very similar depressed limpet-like shells, being the reason for a generic intermingling of these taxa in older literature.

The Hierarchical Cluster Analyses and non-metric Multidimensional Scaling have been conducted on the dataset in order to investigate the similarity and dissimilarity patterns between included localities. The number of taxa in single localities differed strongly ranging from one to maximally 97 recorded species. Prior to analysis the dataset was therefore filtered to records containing sufficient taxa for a reasonable comparison. The best results have been achieved from the species diversity of 24 upwards and using the Bray Curtis Similarity measure. The ordering of localities coincided apparently to their paleogeographical, stratigraphical and paleoecological patterns. Thus six paleobiogeographic units have been clearly filtered out: Dinaride Lake System, Sarmatian Lakes, Steinheim-Lake, Kosovo-Metohija Lake, early Pannonian Lake, the late Pannonian ("Pontian") Lake and the Pliocene "Paludina" Lake. The hierarchical ordering showed for the Central Paratethys a clear stratigraphic pattern with the oldest Sarmatian Lake in the base and the Pliocene "Paludina" Lake at the top of the line up. The peri-Paratethys lakes: Dinaride Lake System, Steinheim-Lake and Kosovo-Metohija Lake although principally followed the similar stratigraphical pattern ordered strictly aside from the Central Paratethys line-up underlining their autochthonous evolutionary and paleoecological status.

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