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# Mollusc-based stable isotope record of a Miocene Central European Inland Sea

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The Central Paratethys Sea came into existence during the latest Eocene and Early Oligocene due to the rising Alpine island chains, which acted as geographic barriers. It existed throughout the Early and Middle Miocene. Already during the latest Middle Miocene, marine connections to adjacent seas were strongly narrowed. Finally, at 11.6 Ma the western part of that sea became isolated within the Pannonian basins system and Lake Pannon formed. In this fragile system, severe changes in the composition of the Paratethyan nearshore faunas are triggered by climatic and geodynamic developments. The latter are indicated by repeated isolation-events with highly endemic faunas.

To reveal theses changes within the stable isotope record, 859 $\delta^{13}$C and $\delta^{18}$O data-pairs have been collected for this study, being derived from 9 Miocene time slices. The stable isotopes have been measured in gastropod and bivalves shells from littoral to shallow marine environments of the Paratethys Sea and Lake Pannon. Fluvial and lacustrine taxa (e.g. *Melanopsis, Lymnaea, Unio, Margaritifera*) provide data for the freshwater endmembers and are used to discriminate between marine to brackish and purely freshwater values. Geographically, the samples have been collected at various localities in the Austrian part of the North Alpine Foreland Basin and the Austrian part of the Pannonian Basin System (Vienna Basin, Korneuburg Basin, Styrian Basin). Additional, literature-based data are derived from the Hungarian and Rumanian part of the Pannonian Basins system (Kisaföld Basin, Transylvanian Basin).

The $\delta^{18}$O data display a steady increase from the Early Miocene to the Middle

Miocene with an early Sarmatian maximum of 1.74 ‰ at ~12.5 Ma. After a strong incision during the late Sarmatian (~12 Ma) with a rather depleted value of -1.2 ‰ a slight increase is evident again during the early Pannonian (~11.5-10.5 Ma) coinciding with the formation of Lake Pannon. Afterwards, during the middle and late Pannonian a continuous decrease sets in corresponding to the brackish-water composition of Lake Pannon as documented in earlier studies. A generally similar trend is reflected by $\delta^{13}$C average values. A focus on the maximum $\delta^{13}$C values, however, reveals an outstanding excursion at ~12 Ma, indicated as Sarmatian Anomaly. This positive peak of 6.8 ‰ is opposed by Early to Middle Miocene carbon maxima between 3 and 4 ‰. The resulting distribution of the $\delta^{18}$O values in frequency-diagrams shows a generally negative skewness throughout the Miocene. The only exception is the Sarmatian with a positive skewness of 1.1. A fully parallel trend is documented for the $\delta^{13}$C values with an erratic Sarmatian positive peak of 0.94. Kurtosis for $\delta^{18}$O distribution patterns is also roughly parallel to the skewness data reflecting a positive peak for the Sarmatian. The Sarmatian is also an outsider concerning the $\delta^{18}$O/$\delta^{13}$C covariance. Throughout the Miocene the carbon-oxygen-coupling is poor. Usually, the correlation coefficient ($r^2$) ranges between 0.05 and 0.25. Two exceptions are represented by the Badenian and the Sarmatian data-sets. The Badenian is characterised by a comparatively tight coupling ($r^2$=0.65) whilst the Sarmatian lacks any correlation between both stable isotopes ($r^2$=0.0008).

Hence, average values suggest three principle isotope-regimes acting in large, semi- to fully enclosed, initially marine waterbodies. The driving force in these settings is geodynamics superimposed by climatic modulation or amplification. Water-exchange with the world-oceans during the Early and large parts of the Middle Miocene coincides with Paratethyan oxygen patterns reminiscent of global trends. Severe isolation due to the disconnection of seaways during the late Middle Miocene is reflected by a complete decoupling from global trends. Isotope composition in this phase is controlled by regional climate resulting in strong amplification of expected values. A further separation of an even smaller waterbody from the nearly completely disconnected sea in the Pannonian Basin system caused the breakdown of marine isotope signatures. Instead, the observed isotope trends suggest a comparably simple system of a brackish lake with steadily declining salinity.

The “ocean-derived” Paratethys Sea may thus act as key for understanding nearshore isotope trends in past epicontinental seas.