Episodic carbonate cementation in Eger Graben claystone: insights into metal cycling and biogeochemical dynamics in Early Miocene lake systems

Petrash, Daniel A.[1]*; Jačková, Ivana[1]; Knésl, Ilja[1]; Čejková, Bohuslava[1]; Laufek, František[1], Staudigel, Philip[2]

[1]*Czech Geological Survey, Prague, Czech Republic,*
[2]*Goethe-Universität, Frankfurt am Main, Germany*

**daniel.petras@geology.cz*

The lacustrine sedimentary records of the Eger Graben in the Czech Republic serve as a window into the Miocene Climatic Optimum (MCO, 16.9-14.7 Ma)—a period that bears concerning similarities to our future projections of pCO_2 levels and climate. In that geological framework, we investigated the intricacies of metal respiration, biogeochemical cycles, and microbial lake paleoecosystem dynamics. These aspects are elucidated by studying stratigraphic abundances of primary ferroan dolomite. This mineral punctuates the Early Miocene sedimentary infill of the Eger Graben. Lacustrine carbonates are widely recognized as reliable carriers of paleoenvironmental and paleoclimate signals. In this context, we analyzed bulk-rock elemental concentrations, stable isotopes (C, O, N), and carbonate clumped isotope paleothermometry, complemented by detailed mineralogical data of the dolomite-bearing intervals. Our findings shed light on how fluctuations in pCO_2 during the MCO influenced aqueous dolomite equilibrium in brackish alkaline paleolakes. The interplay between redox and salinity fluctuations served as an additional driver for lacustrine dolomite precipitation, highlighting the impact of climate change on runoff rates and delivery of solutes and nutrients. Microbial activity left a distinct isotopic imprint on the sediments, with $\delta^{15}N$ values averaging +9.8±0.7‰ (N=18), indicative of substantial N_2 losses. The mean $\delta^{13}C$ values of dolomite, +5.3±0.3‰ (N=13), on the other hand, captured a mix of dissolved inorganic carbon sources, including methanogenesis and a prevalent mantle-derived flux with $\delta^{13}C$ of about −4.0‰. Our data show that periodic pCO_2 fluctuations and microbes facilitated primary dolomite formation. Enhanced weathering in the catchments led to leaching of alkaline bedrocks, studied in the Czech GEOMON network, which supplied Mg^{2+}, Na^+, K^+, and rare earths. These ions elevated paleolake alkalinity leading to notable europium anomalies in the dolomitic marls; without corresponding cerium anomalies. This latter feature points to a generally redox-stratified water column, overlying an anoxic ferruginous lakebed containing abundant ferric particles. Thus, a long-term cycle of iron (and manganese) was sustained, coupled with nitrogen respiration. Despite prominent Eu anomalies, dolomite locking temperatures are consistently below 30°C, as indicated by the Δ_{47} paleothermometer, while the mineral abundance has a chemostratigraphic association with terrigenous potassium and barium contents, contributing further to our understanding of past climate controls over the carbonate factory. There is also interesting evidence suggestive of recurrent early dolomite resuspension events. Overall, our exploration of metal cycling and biogeochemical dynamics within the Early Miocene Eger Graben provides valuable insight into the past and future of our changing environment.