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Stable isotope record of coexisting apatite and dolomite in Early Cambrian phosphorites, Meishucun section, South China

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The Precambrian-Cambrian transition forms one of the most dramatic time periods in Earth´s history, as global changes in tectonics, climate and chemistry in the atmosphere and oceans favoured the worldwide Cambrian Radiation and a concomitant ecosphere revolution. This time interval is paralleled by the first appearance of the widespread giant phosphorites. The well-known Meishucun section (South China), a former candidate section for the Pc-C boundary, documents phosphorite genesis amongst a rapid biodiversification, immediately following the end of the Precambrian in a low-latitude, shallow-water carbonate shelf.

This contribution aims to elucidate the relation between simultaneous phosphorite deposition and global environmental conditions at the Pc-C boundary by using stable carbon and oxygen isotope analyses. Accurate determinations of d13C and d18O values may allow conclusions about ancient ocean circulation, paleo-productivity, paleo-temperatures, and most prominently diagenetic processes. The investigated samples from the Meishucun section basically consist of apatite, dolomite, and quartz that may be further devided into a lower and upper phosphorite as well as an overlying dolostone intervall. Additionally, calcite and siderite occur as minor compounds in some samples.

Bulk d13C values of the carbonate fraction correlate with dolomite abundance throughout the section ranging from -4 to 1 per mil. Furthermore, several horizons suggest a relation between d13C values and apatite content, implying lower d13C values in apatites compared to coexisting dolomite. A slight negative d13C excursion at the top of the lower phosphorite coincides with the first appearance of small shelly fossils. Corresponding bulk d18O values generally show a stratigraphic-upward trend towards lower values throughout the record with slightly higher values in dolomite-rich sections. This may either indicate a warming trend during deposition, an isotopic shift in sea water composition, or an increasing contribution from carbonate apatite contents.

Tentative calculations of temperatures in the fluids responsible for carbonate and phosphate mineral formation are based on experimental calibrations of the respective isotope systems by using d18O values of the carbonate fraction. They reveal mean temperatures ranging from 9°C to 51°C or 50°C to 114°C considering potential d18O values of -8 per mil and 0 per mil vs. SMOW in the mother fluids, respectively. Maximum temperatures of about 52°C using -8 per mil vs. SMOW at the top of the lower phosphorite sequence possibly point towards a pronounced diagenetic influence. However, bulk isotope values are subject to mineralogical interferences. In particular, FTIR spectroscopic analyses show that the apatites also contain carbonate groups. Thus, bulk isotopic values of carbonates reflect a mixed signal of different phases of mineral genesis. This assumption is confirmed by petrographic observations that in most cases display apatite-coated dolomites suggesting an earlier onset of dolomite formation compared to apatite. Accordingly, d18O values of phosphate groups from the above mentioned phosphorite sequence indicate a mean temperature of only 31°C (water: -8 per mil SMOW). Assuming the same isotopic composition of dolomite and apatite precipitating fluids, lower temperatures are calculated for apatite formation.

In conclusion, a separation of the different carbonate groups is essential to obtain oxygen and carbon isotopic signals of the corresponding mineral phase, which is currently investigated by fractionation experiments.

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