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Limitations and opportunities for Permian-Triassic carbonate-carbon isotope stratigraphy posed by microbial-controlled diagenetic mineral additions

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Bulk-carbonate stable carbon isotope records are used to proxy the ancient biogeochemical carbon cycle as well as aid in determining the age of sedimentary deposits. However, the multicomponent nature and the component-specific diagenetic potential of bulk-rock pose limits on the applicability of this proxy in recording ancient seawater chemistry and its usability as a stratigraphic aid. The aim of this study is to disentangle primary trends from diagenetic signals in carbonate-carbon isotope records traversing the Permian-Triassic boundary in marine carbonate-bearing sequences of Iran and South China.

We observe, 1) a global first-order trend towards depleted carbon isotope values across the Permian-Triassic transition, 2) second-order carbon isotope variability superimposed on the first-order trend, and 3) a temporal trend in the amplitude of the second-order carbon isotope fluctuations. By application of a diagenetic model, we show that microbial-steered carbonate additions can introduce diagenetic carbon isotope signals to the carbonate archive. Organic carbon sedimentation has the potential to fuel this (sub)seafloor microbial pathway of carbonate stabilization and determines trajectories of diagenetic bulk-rock carbon isotope alteration. Moreover, we identified through this numerical exercise that lowered marine sulfate levels makes the sedimentary system vulnerable to diagenetic modulations of the primary carbon isotope signal, by modest changes of organic carbon supply. This approach suggests that latest Permian reduced bioturbation, consequential heterogeneous organic matter accumulation and authigenic mineralization can explain the temporal trend of increased second-order carbon isotope scatter, whilst retaining the first-order trend.

In conclusion, the combined dataset and calculations suggest that the application of carbon isotope chemostratigraphy of the Permian-Triassic boundary is at present limited to the recognition of broad temporal patterns, rather than serving as a high-resolution stratigraphic tool. On the other hand, this signal of increased carbon isotope variability concurrent with the largest mass extinction of the Phanerozoic may inform us about local C-cycling mediated by spatial heterogeneous (sub)seafloor microbial communities, under suppressed bioturbation.