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Regional variations in Early Triassic carbonate geochemistry in the Thaynes Group (USA) influenced by multiple diagenetic modes

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The Smithian–Spathian boundary (SSB) interval is characterized by a significant $\delta^{13}C$ excursion, marine ecosystem collapse, and the resurgence of microbiolite facies. Traditionally, these records have been inferred to capture global, secular carbon-cycle behavior, driven by fluctuations in organic carbon burial and/or seafloor anoxia. These interpretations fundamentally rely on the faithful preservation of $\delta^{13}C$ values – or, more broadly, carbonate-bound geochemical records – with respect to global oceanic reservoirs. However, local variations in seawater chemistry and the ubiquity of early marine diagenesis in shallow-water carbonates may have an appreciable effect on carbonate geochemistry, often overprinting global and/or primary signals and obscuring inferred paleoenvironmental patterns. Recent workers have suggested the geochemical expression of the SSB may be influenced by regional and/or authigenic processes, and therefore decoupled from global records, although the underlying mechanisms through which these would have affected carbonate geochemistry have not been widely explored. Here, we leverage a multi-proxy carbonate geochemical framework ($\delta^{13}C$, $\delta^{18}O$, $\delta^{44/40}Ca$, $\delta^{26}Mg$, trace-metals) to decipher potential local, diagenetic, and global drivers of the SSB excursion in the Thaynes Group.

In the northern Thaynes Group (Georgetown, Idaho), the SSB $\delta^{13}C$ record is largely modulated by variations in the extent of dolomitization, as identified through systematic variations with Mg/Ca ratios and $\delta^{26}Mg$ values. Early marine and meteoric diagenetic modes – fingerprinted by $\delta^{44/40}Ca$ values and extensive karstification, respectively – are also prominent within particular lithostratigraphic units. However, in the southern Thaynes Group (Mineral Mountains, Utah), geochemical constraints – e.g., a 1‰ decrease in $\delta^{44/40}Ca$ values, 4– 6x increase in Sr/Ca ratios, and 80% decrease in Mn/Ca ratios – indicate that the observed $\delta^{13}C$ excursion is primarily driven by a transition from fluid- to sediment-buffered conditions and decreased pore-water anoxia during early marine diagenesis, suggesting diagenetic evolution was the dominant control on local geochemical records. Given these differences, we suggest that Thaynes Group strata do not capture regionally or globally coherent geochemical trends during the SSB, and instead reflect local variations in the dominant modes of carbonate diagenesis. We argue that there is a need for careful reconsideration of SSB geochemical records to examine potential local and diagenetic influences.