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Diagenetic effects on cerium isotope fractionation in shallow carbonate sediments from the South China Sea

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The cerium isotope ratios ($^{142}Ce/^{140}Ce$, commonly denoted as $\delta^{142}Ce$), have emerged as promising tracers to complement the traditional Ce anomaly proxy for reconstructing the redox state of marine environments throughout geological history. While marine carbonates have been proposed as crucial archives for seawater Ce isotopic compositions, the effects of various diagenetic processes on Ce isotope fractionation in marine carbonates remain poorly understood. Here, we present high-precision and high-resolution $\delta^{142}Ce$ data from marine carbonates collected from two deep drill cores in the South China Sea, which have experienced nearly all typical carbonate diagenetic conditions. Our results indicate that $\delta^{142}Ce$ values in these carbonates range from −0.10‰ to 0.35‰, with a mean of 0.19±0.08‰ (1 SD), which is similar to contemporary surface seawater (~0.20‰) within analytical uncertainty. Additionally, $\delta^{142}Ce$ variations across different diagenetic zones are minimal. In the meteoric diagenetic zone, $\delta^{142}Ce$ values range from 0.04‰ to 0.34‰, with a mean of 0.20±0.08‰ (1 SD). In the marine diagenetic zone, $\delta^{142}Ce$ values range from −0.10‰ to 0.28‰, with a mean of 0.15±0.10‰ (1 SD). In the dolomitization zone, $\delta^{142}Ce$ values vary from 0.07‰ to 0.32‰, yielding a mean of 0.19±0.07‰ (1 SD). These trends suggest no significant fractionation compared to the syn-depositional unconsolidated carbonate precipitates (0.10‰ to 0.35‰; mean=0.20±0.07‰, 1 SD), implying that early diagenetic processes have limited influence on Ce isotope ratios. Within the marine diagenetic zone, we observed a correlation between $\delta^{142}Ce$ and both Ce content and Ce/Mn ratios, which we attribute to redox-driven Ce^{3+}/Ce^{4+} cycling and the subsequent adsorption and desorption of CeO_2 from Fe-Mn oxides during early diagenesis. Our findings demonstrate that Ce isotopes in shallow carbonates are resistant to diagenetic alteration, preserving primary depositional signals even under different diagenetic conditions. This study underscores the utility of Ce isotopes in marine carbonates as a reliable proxy for reconstructing ancient marine redox environments.