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

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The uranium isotope composition ($^{238}U/^{235}U$, commonly denoted as $\delta^{238}U$) in carbonate sediments has been developed as a paloeredox proxy to quantitatively reconstruct variation of global seafloor anoxic area in geological history. However, the uranium isotope fractionation in different diagenetic environments is poorly constrained, partly causing ambiguous interpretation of $\delta^{238}U$ records and poor quantification accuracy. Here we use a large number of samples derived from muti-species modern corals and two deep drill cores (XK-1 and NK-1) in South China Sea which experienced a range of diagenesis, including meteoric vadose, meteoric phreatic and marine phreatic diagenesis.

Our results indicate that $\delta^{238}U$ of modern corals (-0.39 ± 0.05 ‰, 2SD, N = 10) is consistent with that of modern seawater, but the carbonate sediments in XK-1 and NK-1 cores are higher than contemporaneous seawater with an average of 0.22 ± 0.22 ‰ (1SD, N = 130), which is similar to that of Bahama carbonates. In the meteoric zone, $\delta^{238}U$ of carbonate increase from -0.39 to -0.1 ‰ with depth in vadose zone but then decrease in phreatic zone. In the marine phreatic zone, the dolomitization stage of NK-1 contains at least three dolostone cycles, as recorded by petrological observation, oxygen and carbon isotopes. Each cycle is composed of porous dolostone with low $\delta^{238}U$ and U concentrations in the upper layer and consolidated dolostone with high $\delta^{238}U$ and U concentrations in the lower layer. Variation of $\delta^{238}U$ displays a significantly positive correlation with U(IV) fraction rather than U concentrations. Combined with numerical models, our results indicate the redox condition variation in different diagenetic environment control the authigenic accumulation of reduced U(IV) in early diagenesis, resulting in the change of $\delta^{238}U$ in bulk carbonate. However, the diagenesis process, such as dissolution, recrystallization, dolomitization, cause vertical migration of U but hardly alter $\delta^{238}U$.