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Oxygen isotope of authigenic clay in cap carbonate evidence for plume world after the Snowball Earth

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The Neoproterozoic snowball earth event, characterized by extensive low-latitude glaciations, represents the most extreme icehouse climate in the unstable period of Earth's habitable evolution. The snowball Earth predicts that the termination of ice sheets leads to the forming of a warm meltwater plume on salty seawater, resulting in stable density stratification. Metal isotope evidence from cap carbonates, including Ca, Mg, Sr, and Li isotopes, has been used to test the plume world hypothesis. While those isotope ratios are sensitive to the continental chemical weathering intensity, the direct proxy for the hydrological cycle is lacking.

In this study, we propose a new approach to test the meltwater plume hypothesis using the oxygen isotope composition of authigenic clay hosted in cap carbonate, which directly records the isotopic composition of seawater. A 2.8-meter-thick Marinoan cap carbonate section deposited in a shallow water environment from AKSu city in Xinjiang Province was studied. By digesting the carbonate minerals using HCl acid, we found the residual consisted mainly of clinochlore, an authigenic clay synthesized in marine conditions through X-ray diffraction (XRD) analysis. Subsequently, we analyzed the oxygen isotope composition of these authigenic clays and our results showed that the $\delta^{18}O$ values of authigenic clays range from 4.6‰ to 8.1‰ (VSMOW), with an overall increasing trend in $\delta^{18}O$ values from bottom to top. Given the large oxygen isotope fractionation between authigenic chlorite clay and the parent water (21-23‰ at 20-35°C in equilibrium), we infer that the $\delta^{18}O$ value of water depositing the authigenic clays was as negative as -15~-17‰, representing the typical oxygen isotopic signal of meltwater.