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The triple oxygen isotope composition of Mesoproterozoic seawater

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The oxygen isotope composition of ancient seawater is a critical parameter for understanding past climate and tectonic evolution [1-4]. Despite various methods being employed to reconstruct the evolutionary history of seawater oxygen isotopes, conclusions remain elusive [2,5-7]. Stratiform chert, with its low porosity and resistance to diagenesis, is well-suited for preserving ancient seawater oxygen isotopes, but interpreting chert $\delta^{18}O$ values remains complex. Recent studies suggest that chert triple oxygen isotope composition ($\Delta^{17}O$) can provide additional constraints on seawater $\delta^{18}O$. However, $\delta^{18}O$ and $\Delta^{17}O$ values from Precambrian cherts often deviate from seawater equilibrium line, which is attributed to the polygenetic nature of these cherts. Here we propose that this deviation results from the co-precipitation of oxygen-bearing minerals, such as detrital silicates, authigenic clays, and barite, which carry distinct isotopic signatures. To test this hypothesis, we examine chert samples from the Mesoproterozoic Yangzhuang and Wumishan formations in North China.

Mineral compositions, element concentrations, and triple oxygen isotopes were measured in these samples. Our results show that chert $\delta^{18}O$ values correlate significantly with detrital silicate content, while the co-existing oxygen-bearing minerals cause deviations of $\delta^{18}O$ and $\Delta^{17}O$ from the seawater equilibrium line. The $\delta^{18}O$ and $\Delta^{17}O$ values of the purest, pristine chert samples suggest that Mesoproterozoic seawater had a $\delta^{18}O$ similar to that of modern seawater. This finding supports the idea of orogenic quiescence, subdued climate dynamics, and lower primary productivity during Earth's middle age.

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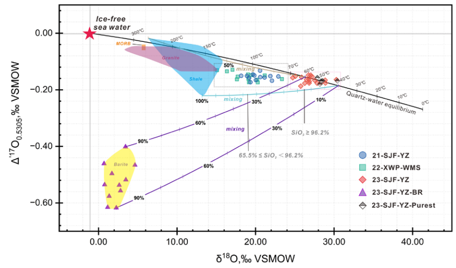

Fig. 1. Cross-plot of $\delta^{18}O_{VSMOW}$ (‰) and $\Delta'^{17}O_{VSMOW}$ (‰) showing the influence from different mixing end-member and mixing ratio.