

Reconstruction of marine redox landscape during the Cryogenian interglacial oceans using thallium isotopes

LULU WANG¹, MENGCHUN CAO¹, YI-BO LIN¹, FEI WU²,
QING TANG¹ AND FEIFEI ZHANG¹

¹Nanjing University

²China University of Geosciences

The change in marine redox chemistry between the Cryogenian Sturtian and Marinoan glaciations (ca. 663–654 Ma) is crucial for understanding the potential relationship between environmental conditions and the emergence and diversification of early animals. The Nanhua Basin in South China provides a nearly complete sedimentary record of Cryogenian interglacial sedimentation, commonly referred to as the Datangpo Formation. In this study, we present high-resolution thallium isotope ($\epsilon^{205}\text{Tl}$) records from the basal Datangpo Formation using two drill cores in the Nanhua Basin (South China) to constrain changes in marine redox chemistry during the Cryogenian interglacial period. Our $\epsilon^{205}\text{Tl}$ values range from -4.9 to -0.7 with a mean of -2.8 , which is lower than the upper continental crust value ($\epsilon^{205}\text{Tl}_{\text{UCC}} = -2.1 \pm 0.3$) but higher than the modern seawater value ($\epsilon^{205}\text{Tl}_{\text{seawater}} = -6 \pm 0.6$). We observed a negative excursion in the lower part of both drill cores and suggest an episode of ocean oxygenation in the basal Datangpo Formation. The $\epsilon^{205}\text{Tl}$ values shifted from lower to higher values upsection in both the Gaodi and Changxingpo drill cores, suggesting a return to widespread anoxic conditions. A simple mass-balance model suggests that well-oxygenated, Mn-oxide-rich sediments acted as a significant sink for Tl in the Nanhua Basin (Gaodi: $f_{\text{oxic}} = 7\text{--}14\%$, Changxingpo: $f_{\text{oxic}} = 13\text{--}20\%$). Our new $\epsilon^{205}\text{Tl}$ data also provide insights for interpreting black shale-hosted Mn-carbonate deposits in the basal Datangpo Formation. The $\epsilon^{205}\text{Tl}$ values from the Mn-carbonate-hosted interval indicate that the Mn-carbonates were transformed from Mn-oxide precursors. The precipitation of Mn oxides during the deglaciation of the Sturtian Snowball Earth further supports the occurrence of a short-lived oxygenation event during the Cryogenian interglacial period. This transient oxygenation event coincides with the first significant radiation of algae, which likely laid the ecological foundation for the emergence of multicellular organisms. These findings highlight the intricate link between marine redox fluctuations and early biological evolution during the Cryogenian interglacial period.