A thallium isotope record of ocean oxygenation during the Lomagundi Event

ZIJIAN LI[1*], JEREMY D. OWENS[2] , NOAH J. PLANAVSKY[3], KAZUMI OZAKI[1], CHRISTOPHER T. REINHARD[1*]

[1]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA (*correspondence: zijian.li@eas.gatech.edu) (*correspondence: chris.reinhard@eas.gatech.edu)

[2]Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL, USA

[3]Department of Geology and Geophysics, Yale University, New Haven, CT, USA

The Paleoproterozoic Lomagundi Event is characterized by a markedly positive carbon isotope excursion (>10‰) recorded in carbonates deposited worldwide between ~2.2-2.0 billion years ago (Ga). This enigmatic event represents one of the largest carbon cycle perturbations in Earth's history. The enhanced organic carbon burial implied by the positive $\delta^{13}C$ values would have resulted in the production of vast quantities of oxygen, with atmospheric oxygen values potentially approaching or exceeding those seen in the modern atmosphere. However, the magnitude of this perturbation is poorly constrained, as are changes to ocean redox conditions during the Paleoproterozoic more broadly.

Thallium (Tl) stable isotopes are a new and potentially powerful paleo-redox proxy. Thallium adsorbs to manganese (Mn) oxides with a large positive isotope fractionation, with the burial of Mn oxides in marine sediments rendering seawater isotopically light. For short-term events (million year), the marine Tl isotopic composition is thus primarily controlled by global Mn oxide burial. Thallium isotope ratios obtained from the authigenic portion of euxinic black shales has been proposed to capture the $\varepsilon^{205}Tl$ values of contemporaneous seawater, providing the potential to reconstruct ocean oxygenation on a global scale. Here, we present Tl isotope compositions of organic-rich pyritiferous shales from the Sengoma Argillite Formation, deposited in the Bushveld Basin, Botswana, which was deposited in a persistently euxinic environment during the Lomagundi Event. Our data show systematic changes in Tl isotopic composition with carbon and sulfur isotope variations. The lightest samples show $\varepsilon^{205}Tl$ values lighter than modern seawater, suggesting a signficant oxic Tl sink and extensive marine Mn oxide burial during the Lomagundi Event. Our results, therefore, indicate ocean oxygenation and the prevalence of oxic seafloor in mid-Paleoproterozoic.