

SULFATE $\delta^{34}\text{S}$ FROM THE NEOPROTEROZOIC TO THE CAMBRIAN: IMPLICATIONS FOR MARINE SULFATE AND A “GLOBAL” SULFUR ISOTOPIC SIGNAL. S.J. Loyd¹, F.A. Corsetti¹, J.W. Hagadorn², A.J. Kaufman³, and T.W. Lyons⁴. ¹Department of Earth Sciences, University of Southern California, 3651 Trousdale Pkwy, Los Angeles CA 90089, loyd@usc.edu, fcorsett@usc.edu, ²Department of Geology, Amherst College, Amherst MA 01002, jwhagadorn@amherst.edu, ³Department of Geology, University of Maryland, College Park MD 20742, kaufman@geol.umd.edu, and ⁴Department of Earth Sciences, University of California Riverside, 900 University Ave, Riverside CA 92521, timothy.lyons@ucr.edu.

The transition from the latest Precambrian into the early Phanerozoic represents a critical time interval in Earth history. During this period the Earth experienced massive glacial episodes, exhibited chemically dynamic oceans, and crossed major evolutionary thresholds including the advent of biomineralization and the radiation of complex, multicellular life. The geologically instantaneous appearance of large body forms in the fossil record suggests that Earth's oceans underwent chemical changes, possibly associated with increased oxygen concentrations. Of course there is no direct geologic reservoir for O_2 , and the oxygenation hypothesis must be explored through indirect proxies. Recent studies have utilized one such proxy termed carbonate-associated sulfate (CAS). CAS is trace sulfate that gets incorporated into the carbonate crystal lattice and although trace in quantity, can be extracted, quantified and isolated for sulfur isotopic analysis. CAS provides a unique opportunity to explore the sulfate characteristics of Earth's early oceans because carbonates (limestones and dolostones) are both stratigraphically and spatially more continuous than evaporite counterparts. The preservation of sulfate in carbonates allows high-resolution sampling of a redox sensitive compound which when used in conjunction with $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{34}\text{S}_{\text{pyrite}}$ provides insight into Earth's early marine environments.

In general, previous studies have focused on stratigraphic trends at individual localities, however unlike $\delta^{13}\text{C}$, $\delta^{34}\text{S}_{\text{CAS}}$ has not been rigorously shown to exhibit a homogeneous global signal in pre-Phanerozoic times. Thus, data must be compiled from multiple localities in order to develop a more detailed and rigorous characterization of the Earth during this time interval.

Here, we present new CAS concentration and $\delta^{34}\text{S}_{\text{CAS}}$ data from northwestern Mexico and southwestern United States and compare these with previous analyses from Oman, Namibia, Siberia and South China. The entire interval from the Neoproterozoic to the Cambrian exhibits high variability in $\delta^{34}\text{S}_{\text{CAS}}$, with contemporaneous values differing by up to 50‰ (VCDT). In addition, individual sections display ~20‰ variation over relatively short time scales (less than 15 Ma). CAS concentrations are consistently low in the Neoproterozoic with values below 200 ppm. In the southwestern United States and northwestern Mexico a slight increase occurs across the Precambrian-Cambrian boundary (PCB) with values generally exceeding 300 ppm.

These data suggest that while a marginal increase in seawater sulfate may have occurred locally in some regions across the PCB, it was not sufficient to create a globally homogeneous seawater $\delta^{34}\text{S}$ signal. The low dissolved sulfate concentrations of the Neoproterozoic likely continued well into the Cambrian when abundant macro fauna evolved and radiated. This implies that: 1) these organisms evolved in

low sulfate and low oxygen environments, 2) sulfate concentrations were not closely tracking O_2 concentrations as in modern oceans, or 3) consumption of sulfate was high during this time interval to preclude sulfate buildup. Regardless, these findings show that $\delta^{34}\text{S}$ values were not globally homogeneous and likely reflect localized perturbations in sulfur cycling or diagenetic modification.