Restricted marine deposition in the Neoproterozoic Chuar Group

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Here, we present new iron speciation and elemental data from the Chuar Group (~780-742 Ma) of the eastern Grand Canyon. The richly fossiliferous Chuar Group hosts a diverse assemblage of beautifully preserved acritarchs throughout the 1600 m succession. In the upper Chuar (Kwagunt Formation), in phase with a large positive excursion in organic carbon isotopes, acritarch diversity decreases and gives way to the first appearance of vase-shaped microfossils (VSMs). A similar trend in the carbon isotope data accompanying the appearance of VSMs has been identified in many locations on multiple continents, suggesting that these successions were, at least intermittently, connected to the open ocean and thus had the potential to capture signals of changing ocean chemistry.

Focusing primarily on the organic-rich black shales of the upper 400 m, we have found an overall increase in total sulfur content coincident with a transition from variegated to black shales in the Awatubi Member. This transition is initially echoed by an increase in total iron content; however, this enrichment is transient. The overlying Walcott Member is characterized by Fe concentrations significantly lower than the crustal average, suggesting local controls, and the partitioning of that small Fe pool indicates that it was largely not reactive toward sulfide on diagenetic timescales. Instead, the heightened sulfur levels observed in the Walcott Member appear to largely reflect sulfidation of organic matter, consistent with the notion of limited supplies of reactive Fe.

Most redox sensitive trace elements show only slight enrichments in the upper Chuar. Molybdenum concentrations, however, average 2-3 times the crustal value with a maximum observed concentration of 32 ppm. Mo concentrations are typically elevated at this level only in sediments underlying a water column bearing free hydrogen sulfide (euxinia). Despite the vanishingly small amounts of pyrite found in this study, we interpret the heightened Mo concentrations together with the observed sulfidation of organic matter to be reflecting euxinic deposition of the Walcott Member—under highly restricted marine conditions. Collectively, these data provide an essential environmental context for early and pronounced eukaryotic diversification.