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Understanding trace element mobility during early diagenesis using several in situ techniques

DANIEL DAVID GREGORY[1], ANTHONY CHAPPAZ[2], NICOLE E ATIENZA[1], LIBOR KOVARIK[3], JOHN CLIFF[3], DANIEL PEREA[3], SANDRA TAYLOR[4] AND TIMOTHY W. LYONS[5]

[1]University of Toronto

[2]STARLAB - Earth and Atmospheric Sciences - Central Michigan University

[3]Environmental Molecular Sciences Laboratory, Pacific National Laboratory

[4]Pacific Northwest National Laboratory

[5]University of California, Riverside

Presenting Author: daniel.gregory@utoronto.ca

Both whole rock and in situ trace elemental analyses of mineral phases such as pyrite are frequently used to understand past ocean chemistry and by proxy, atmospheric chemistry on Earth. However, these interpretations are complicated by a lack of understanding of the mechanisms of trace element incorporation during early diagenesis. Components of this uncertainty include rates of element mobility in the sediment, relative timing of incorporation during the diagenetic process, and the particular mineral phase in question. In this study we summarize the results of several of our complimentary analytical strategies. Specifically, we examine different aspects of early diagenetic trace element pathways in sediments from the Cariaco Basin, the second largest euxinic basin on the modern Earth. We utilize a wide variety of techniques: laser ablation inductively coupled plasma mass spectrometry, nanoscale secondary ion mass spectrometry, atom probe tomography, X-ray absorption near edge spectroscopy, X-ray absorption fine structure, transmission electron microscopy, and scanning electron microscopy. With a focus on pyrite framboids, these data, in combination, provide unprecedented chemical and spatial resolution of trace element incorporation in euxinic sediments. This integrated approach provides for a greater understanding of the timing of formation of pyrite in the sediments, the redox state of the trace elements, and the relative incorporation of those elements in the pyrite compared with the bulk sediment. Further, this methodology allows for a better understanding of the deposition of trace elements in euxinic settings with implications for interpreting chemistry of sedimentary rocks deposited in similar settings in the rock record and by extension chemistry of the paleo-ocean and atmosphere.