Microscale x-ray spectroscopic imaging as a tool to examine complex diagenetic processes

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The sedimentary rock record documents the history of Earth's redox and chemical evolution through time. As geochemists, we rely on these strata to record information in a discernable manner; for example, the measurement of sulfur isotope ratios of sulfide and sulfate phases to reconstruct the history of oxygen in the atmosphere and oceans and the measurement of iron and manganese mineralogy and speciation to determine ancient redox budgets. This geochemical record, however, is rarely pristine as many millions of years of post-depositional processes contribute to a complex assemblage of diagenetic relationships.

A common limitation of virtually all proxy measurements employed to date is that they operate on "bulk" samples, typically grams of powder. As such, these measurements loose the ability to relate the geochemistry to the petrography at the scale of the mineral grains that actually contain the paleo-environmental data. Petrography on a micro-scale contains a rich history that can often be overlooked from bulk measurements.

X-ray spectroscopic imaging provides an important glimpse in the chemical heterogeneity that can exist on the micro-scale. The underlying chemical phase information that can be obtained on this spatial scale, including a wide range of mineralogy, elemental coordination environments and/or redox states, can provide and important context of the depositional and diagenetic histories that is critical for the interpretation by other micro- or nano-scale methods, such as scanning electron microscopy (SEM) and secondary ion mass spectrometry (SIMS). The coupling of these fine-scale tools allows in essence "images" of the proxy data at the micrometer scale, giving a wide array of textural and mineralogical information designed to inform and untangle the complicated histories of ancient sedimentary rocks.