Chemical imaging approaches to untangle depositional and post-depositional processes in ancient rocks on Earth and Mars

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One of the major reasons that the history and evolution of dioxygen on Earth and Mars remains poorly understood results from biases inherent to the sedimentary record—all samples have witnessed post-depositional processes that can complicate and erase the information captured at the time of deposition. To arrive at a deeper understanding of how these processes might have impacted geochemical data, we have developed a range of complementary techniques to evaluate the quality of paleoenvironmental proxy data generated from ancient rocks.

At its core the concept is simple: connect chemistry and mineralogy to the ordinal information provided by cross-cutting relationships in petrographic textures, using a suite of both classical and neoteric chemical imaging modalities. We use light and electron microscopy for petrography and mineralogy, electron microprobe and synchrotron XRF for elemental composition, synchrotron X-ray spectroscopy for redox imaging, scanning SQUID microscopy for magnetic mineral identification and timing of iron mineralization, and secondary ion mass spectrometry (SIMS) to make isotope ratio measurements and inform bulk rock isotope data. A similar logic but with different instrumentation can also be applied to rover exploration of the ancient fluviodeltaic and lacustrine sedimentary rocks currently being studied by Mars Science Laboratory in Gale Crater, Mars and in the landing site of the future Mars 2020 rover. This chemical imaging approach is ultimately valuable for untangling the complex histories associated with ancient sedimentary rocks and recovering more accurate paleoenvironmental signals.