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High-Resolution Analysis of Clay Minerals and Amorphous Materials in Martian Analog Sedimentary Environments

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In sedimentary environments, clay minerals and secondary X-ray amorphous materials provide a comprehensive view of the sedimentary history from source-to-sink (e.g., *1*). However, these phases are inherently small in particle size, tend to reside in the smallest grain size fraction of sedimentary deposits, and are difficult to characterize. For example, on Earth, extended sample preparation methods are required to concentrate the finest fraction, and even still, traditional benchtop techniques lack the resolution necessary to fully characterize the composition and structure of these materials. This limitation is compounded when we bridge the gap to planetary sciences and attempt to unravel the sedimentary rock record of other terrestrial planets like Mars. Fluvial and lacustrine rocks explored by the Mars Science Laboratory (MSL) *Curiosity* rover in Gale crater, Mars are enriched with these secondary alteration products (e.g., *2-6*) and highlight just how important understanding these materials are throughout the solar system. Here, we explore the basaltic terrains of Iceland as a modern-day analog for ancient environments of Mars. We focus on the clay-size fraction (<2 mm) of fluvial sediments and interrogate these fine-grained particulates with both rover-like capabilities (e.g., bulk geochemistry and X-ray diffraction (XRD)) and high-resolution analytical techniques (e.g., Transmission Electron Microscopy, Synchrotron XRF and XRD). Results demonstrate that the clay size fraction of sediments from Martian analog environments is composed of an intimate mixture of multiple clay minerals (e.g., Fig. 1) and multiple X-ray amorphous phases (e.g., ferrihydrite) with different morphologies. Moreover, the geochemistry of the clay size fraction alters from source-to-sink and is variable on the sub-micron scale (Fig. 2). These results suggest that the clay mineral and X-ray amorphous composition of sedimentary rocks in Gale crater, Mars may be equally complex, and that the sedimentary history may only truly be unraveled with Mars Sample Return and high-resolution analysis.

References

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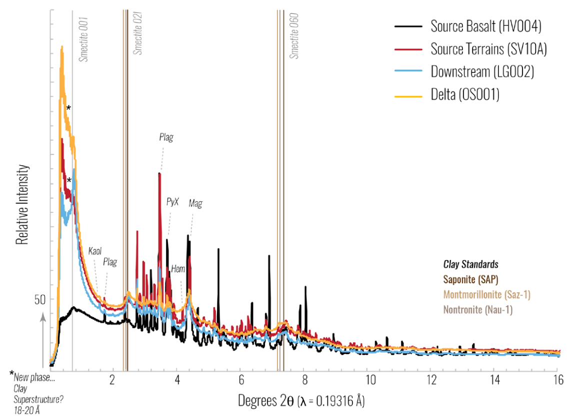

Figure 1. Synchrotron XRD patterns. Abbreviations: Kaol (Kaolinite), Plag (Plagioclase), PyX (Pyroxene), Hem (Hematite), and Mag (Magnetite).

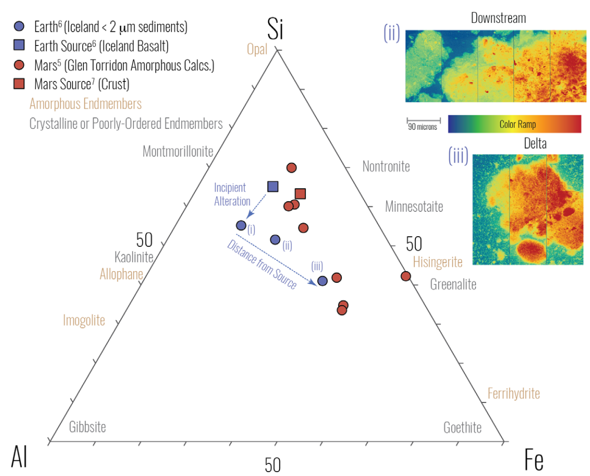

Figure 2. Bulk geochemistry of Iceland source rock and clay size fraction sediments compared to recent rover analysis of sedimentary rocks in Gale crater. Synchrotron XRF intensity maps are displayed for select sediment samples from Iceland.