Sedimentary Petrology of the Murray Mudstone, Gale Crater, Mars

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The Curiosity Mars Science Laboratory rover (MSL) has traversed over 12 km across Gale Crater, covering more than 100 m of stratigraphy, about half of which is composed of lakebed mudstones. The Sheepbed mudstone, exposed at the lowest elevation of the traverse, is an alkali-rich basaltic mudstone with authigenic phyllosilicates formed in a mostly circum-neutral pH, anoxic, closed-system environment. The Murray mudstone begins 60 m higher in elevation, and records a more complex history of paleoenvironmental chemistry. Over 75 Alpha-Particle X-Ray Spectrometer measurements of bulk composition, combined with 6 XRD-determined mineralogy observations of drilled samples were used to analyze the source and diagenesis of the mudstones.

The source for the Murray mudstones was likely also alkaline basalts. However, the Murray has higher Chemical Index of Alteration (CIA) values, indicating that feldspars in the source area were chemically weathered and slightly depleted in Ca, Na, and K, relative to Al. Murray samples are also enriched in SiO_2, TiO_2, P_2O_5, Al_2O_3, and K_2O relative to the Sheepbed, and depleted in FeO, MgO, CaO, and Cl. Mineralogically, the base of the Murray formation contains fewer phyllosilicates and more redox-sensitive iron oxides than the Sheepbed, and samples higher in the Murray have no phyllosilicates but significant amounts of tridymite and amorphous silica, associated with enrichments in TiO_2, P_2O_5, and some K_2O—a pattern that reverses itself at higher stratigraphic levels in the Murray.

No simple model of depositional authigenesis or diagnetic alteration explains all of the compositional changes in the Murray formation. The mudstone source was chemically weathered, and may have shifted irregularly through time. The silica enrichment coupled with both TiO_2 and P_2O_5 enrichment observed in certain intervals within the Murray does not appear to reflect acidic weathering, but could record silica authigenesis in an evaporating lake. Variation in redox-sensitive iron mineralogy indicates alternating intervals of lake water anoxia, and/or later diagenetic events. Multi-component geochemical models are used to deconvolve these trends.