Mineralogy of Mudstone at Gale Crater, Mars: Evidence for Dynamic Lacustrine Environments

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The Mars Science Laboratory *Curiosity* rover landed in Gale crater in August 2012 to assess the habitability of sedimentary deposits that show orbital evidence for diverse ancient aqueous environments. Gale crater contains a 5 km high mound of layered sedimentary rocks in its center, informally named Mount Sharp. The lowermost rocks of Mount Sharp contain minerals that are consistent with a dramatic climate change during Mars' early history. During the rover's traverse across the Gale crater plains to the base of Mount Sharp, *Curiosity* discovered sedimentary rocks consistent with a fluviolacustrine sequence. *Curiosity* studied ancient lacustrine deposits at Yellowknife Bay on the plains of Gale crater and continues to study ancient lacustrine deposits in the Murray formation, the lowermost unit of Mount Sharp. These investigations include drilling into the mudstone and delivering the sieved <150 μm fraction to the CheMin XRD/XRF instrument inside the rover. Rietveld refinement of XRD patterns measured by CheMin generates mineral abundances with a detection limit of 1-2 wt.% and refined unit-cell parameters of minerals present in abundances >~5 wt.%. FULLPAT analyses of CheMin XRD patterns provide the abundance of X-ray amorphous materials and constrain the identity of these phases (e.g., opal-A vs. opal-CT). At the time of writing, CheMin has analyzed 14 samples, seven of which were drilled from lacustrine deposits. The mineralogy from CheMin, combined with *in-situ* geochemical measurements and sedimentological observations, suggest an evolution in the lake waters through time, including changes in pH and salinity and transitions between oxic and anoxic conditions. In addition to a geochemically dynamic lake environment, the igneous minerals discovered in the lake sediments indicate changes in source region through time, with input from mafic and silicic igneous sources. The Murray formation is predominantly comprised of lacustrine mudstone and is 150-200 m thick, suggesting long history of lake environments in Gale crater. *Curiosity* has traversed through the lowermost ~30 m of the Murray formation, and each additional sample provides clues about the climate on early Mars.