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Mineralogy of Rocks and Sediments at Gale Crater, Mars

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The Mars Science Laboratory rover, Curiosity, is providing in situ mineralogical, geochemical, and sedimentological assessments of rocks and soils in Gale crater. Since landing in 2012, Curiosity has traveled over 15 km, providing analyses of mudstones and sandstones to build a stratigraphic history of the region. The CheMin X-ray diffraction (XRD) instrument is the first instrument on Mars to provide quantitative mineralogical analyses of drilled powders and scooped sediment based on X-ray crystallography. CheMin identifies and determines mineral abundances and unit-cell parameters of major crystalline phases, and identifies minor phases at abundances >1 wt%. In conjunction with elemental analyses, CheMin-derived crystal chemistry allows for the first calculations of crystalline and amorphous material compositions. These mineralogy, crystal chemistry, and amorphous chemistry datasets are playing central roles in the characterization of Gale crater paleoenvironments.

CheMin has analyzed 17 rock and sediment samples. In the first phase of the mission, Curiosity explored the sedimentary units of Aeolis Palus (Bradbury group), including two mudstones from Yellowknife Bay. CheMin analyses of the Yellowknife Bay mudstones identified clay minerals among an overall basaltic mineral assemblage. These mineralogical results, along with imaging and geochemical analyses, were used to characterize an ancient lacustrine setting that is thought to have once been a habitable environment.

Following the investigations of the Bradbury group, Curiosity arrived at the lower reaches of Aeolis Mons, commonly called Mt. Sharp. A strategic sample campaign was initiated, drilling bedrock at <25 m elevation intervals in order to compile a comprehensive stratigraphic column of Mt. Sharp sedimentary units. Two formations have been sampled thus far, the lower-most Murray formation and the Stimson formation, which lies unconformably over the Murray.

The Stimson formation is a cross-bedded sandstone interpreted as ancient, lithified eolian dunes. The mineralogy of this sandstone is dominated by plagioclase, pyroxene, magnetite and X-ray amorphous phases. Adjacent to fractures, light-toned, halo-like zones are thought to result from significant aqueous alteration of the primary sandstone and show decreased abundances of feldspar and pyroxene, and an increase in the amorphous component, specifically high-silica phases.

The Murray formation is the most sampled stratigraphic unit in Gale crater. Composed mainly of finely laminated mudstones and interpreted as lacustrine deposits, the mineralogy of Murray rocks reveals a complex aqueous history. Within the lower Murray strata, CheMin identified clay minerals, crystalline and amorphous silica, hematite, magnetite, and jarosite. The mineralogy suggests a paleolake that experienced variable redox conditions and sediment influx from multiple sources. Younger Murray strata have high abundances of clay minerals, hematite, and calcium sulfate but show lower variability in mineralogy compared to the older bedforms. CheMin's identification of tridymite in one of the Murray mudstone samples led to the first in situ identification of silicic volcanism on Mars.

This presentation will discuss the mineralogy of sedimentary samples analyzed by CheMin and how these data are used to characterize the depositional and diagenetic environment of Gale crater's long-lived lake system.