

SURVEYING CLAY MINERAL DIVERSITY IN THE MURRAY FORMATION, GALE CRATER, MARS.

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The CheMin XRD instrument aboard Mars Science Laboratory (MSL) has documented clay minerals in various drill samples during its traverse of Gale Crater's floor and ascent of Mt. Sharp. The most recent samples, named Marimba, Quela and Sebina were acquired from the Murray Formation in the Murray Buttes region of lower Mt. Sharp. Marimba and Quela come from a ~30 m package of finely laminated lacustrine mudstones. Sebina comes from an overlying package of heterolithic mudstone-sandstones.

Clay minerals make up ~15-25 wt.% of the bulk rock with similar contributions to XRD patterns in all three samples. Broad basal reflections at ~10° 2θ CoKα indicate the presence of 2:1 group clay minerals. The 02l clay mineral band lies at ~22.9° 2θ, a region typically occupied by Fe-bearing dioctahedral 2:1 clay minerals like nontronite or Fe-illite. The low humidity within the CheMin instrument, which is open to the martian atmosphere, promotes loss of interlayer H₂O and collapse of smectite interlayers making them difficult to distinguish from illites. However, based on the low K content of the bulk samples, it appears that smectitic clay minerals are dominant. Peak dehydroxylation of the Marimba sample measured by the SAM instrument on MSL occurred at 610°C and 780°C. Fe-bearing smectites are not consistent with these dehydroxylation temperatures. Thus, we suggest that a mixture of dioctahedral and trioctahedral smectite phases are present giving the appearance of intermediate octahedral occupancy in XRD.

Dioctahedral smectites have not previously been reported in Gale Crater by MSL. Earlier in the mission, relatively clay mineral rich samples (~20 wt.%) from lacustrine mudstones in Yellowknife Bay (YKB) were found to contain ferrian saponites. It is proposed that YKB saponites formed via isochemical aqueous alteration of detrital olivine close to the time of sediment deposition, under anoxic to poorly oxidizing conditions.

In terrestrial settings where alteration sequences of basaltic rocks or sediments are observed, first-stage alteration clay minerals are typically trioctahedral smectite species, as reported from YKB. In later alteration stages trioctahedral clay minerals are replaced by dioctahedral clays as a result of removal and/or oxidation of Fe²⁺ and Mg. Observed changes in clay mineralogy between YKB and Murray Buttes samples correspond with differences in bulk mineralogy, including: 1) a transition from magnetite to hematite as the main Fe-oxide, 2) increasing abundances of Ca-sulfates and 3) a reduction in the quantity of reactive mafic minerals. This mineralogical change indicates an increasing degree of aqueous alteration and oxidation of mafic detritus in the upper part of the Murray Formation.

These results broaden the spectrum of mineralogical facies documented by MSL. Together sedimentology and mineralogy indicate a long-lasting, dynamic fluvial-lacustrine system encompassing a range aqueous geochemical processes under varying redox conditions. Future work is needed to unravel the influence of global and local controls on the range of ancient conditions observed at Gale Crater.