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Chemical Composition of Aqueous Sedimentary Rocks at Gale Crater, Mars

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The Curiosity rover has traversed 20 km from its landing to the layered rocks of Mt. Sharp (formally named Aeolis Mons), spending >2270 sols (Martian days) at the surface of Mars. In this overview, we provide a summary of the chemical composition along the Murray formation, a >300 m-thick pile of sedimentary rocks present at the base of Mt. Sharp, and dominated by mudstones and fine-grained sandstones interpreted as predominantly lacustrine deposits (Grotzinger et al., Science, 2015). The ChemCam instrument is a laser ablation spectrometer capable of measuring local chemistry (scale of $\sim$0.5 mm). Bulk chemistry is derived from the average of several observation points of a given target (after removal of points on soils and diagenetic features). ChemCam is also powerful for identifying the composition of diagenetic features (veins, nodules, concretions, etc.). Along the Murray section, especially the Karasburg and Sutton Island members (sols 1350-1650), the bulk chemistry of Murray Formation presents a low abundance of CaO of 1-2 wt.%, well below the average Mars crust (7-8 wt.%). The Chemical Index of Alteration (CIA) ranges from 50 to 63, suggesting a substantial weathering (as is the case for CIA>50), in agreement with the presence of di-octahedral smectites indicative of surface conditions (from CheMin data, Bristow et al., Science Advances, 2018). These observations indicate weathering in an open system, at or near the surface, contrasting with the results at Yellowknife Bay where mudstones formed in closed system (McLennan et al., Science, 2014). On sol 1750, Curiosity reached the Vera Rubin Ridge (VRR), which is associated with "red hematite" in orbital spectral data (Fraeman et al., JGR, 2013). At this location, ChemCam did not identify a significant enhancement in bulk FeOT abundance. ChemCam detects anomalously high iron abundances (>40 wt.% FeOT) on dark-toned nodules/veins/crystals, locally associated with light-toned Ca-sulfate veins, highlighting their diagenetic origin (i.e. formed during burial). Locally, some of these high-Fe locations have a crystal shape, highlighting the pseudomorphism of pre-existing crystals, likely gypsum. No detection of volatiles (S, H or C) was observed, limiting the potential mineralogical phases to iron oxides. ChemCam passive reflectance spectra (no laser) show only weakly ferric signatures associated with these features contrasting with typical hematite-like spectra associated with VRR host rocks, suggesting these features are composed of iron oxide phases other than red hematite (e.g. magnetite, specular hematite). In addition, bleached halos depleted in FeO (<10 wt.%) indicate local leaching of Fe postdating both depositional and early diagenetic phases. Overall, these variations in FeO abundance highlight the small scale mobility of iron during diagenesis, including through reducing fluids. Further traverse of the rover into the "clay unit" identified by orbit will help to substantiate these conclusions and provide a full context of the various transitions in composition encountered along the stratigraphy of these sedimentary rocks.