CHEMCAM INVESTIGATION OF THE PAHRUMP HILLS DRILL SITES. R. S. Jackson[1], R. C. Wiens[2], D. T. Vaniman[3], L.W. Beegle[4], M. Nachon[5], O. Forni[6], D. Blaney[4], H. E. Newsom[1], and the MSL Team; [1]Univ. of New Mexico (Albuquerque, NM 87131; rjacks04@unm.edu), [2]Los Alamos National Laboratory, [3]Planetary Science Institute, [4]Jet Propulsion Laboratory, [5]LPG Nantes, [6]Institut de Recherche en Astrophysique et Planetologie.

Introduction: This study utilizes ChemCam data for bedrock, drill hole walls, tailings, and unprocessed and sieved dump piles at the Pahrump Hills location to investigate chemical variations with depth in the drill holes and possible effects of the drilling and sample processing. The ChemCam instrument on the Mars Science Laboratory (MSL) rover includes a Laser Induced Breakdown Spectroscopy (LIBS) tool that allows ~400 µm spot chemical analyses on Mars. This microprobe device is designed for rapid remote analyses [1]. These abilities allow the ChemCam instrument to differentiate between the bulk composition of the host rock and composition of chemically distinct diagenetic materials such as veins. The Pahrump Hills locale is in the Murray formation which is the lowest portion of Mount Sharp, and it is composed of mudstone and siltstone at the bottom with cross-stratified siltstone and sandstone at the top [2]. The rover drilled 3 holes in the Pahrump Hills locale from sols 759 to 908.

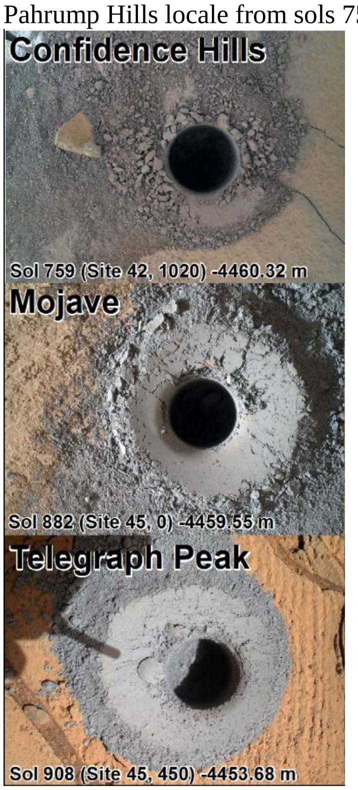

Figure 1: MaHLI of the three drill holes [7].

Analytical Details: The LIBS oxide weight percentages of Si, Ti, Al, Fe, Mg, Ca, Na, and K were calculated through a calibration method that combines the PLS1 and ICA algorithms [e.g., 3]. In this study S is not quantified, but is thought to make up most of a "missing component" when low major-element totals are reported. The missing component is the reported total subtracted from 100%; this is used as a proxy for S in graphs and is supported by the correlation of missing components with detection of sulfides and Ca-sulfates by CheMin and ChemCam [e.g., 4], and the presence of a sulfur line in high sulfur samples, but the missing component also includes H_2O, Cl, and other minor elements. The contribution of these minor elements are variable and can add up to several weight percent [5].

ChemCam analyses are planned and organized by individual sequences usually consisting of a line-scan or grid raster pattern of observation points, where each point is observed with multiple laser shots and where an emission spectrum was recorded for each laser shot. All data in this abstract use "averaged data" which utilizes a spectrum created by averaging the spectra of all LIBS shots at each point after the first 5 shots, and then this mean spectrum is used to calculate the oxide abundances.

The rover drill system is a rotary percussion drill head that bores to a depth of 6.5 cm. The drill fines collection system does not engage until a depth of ~2.0 cm is reached; materials from less than 2.0 cm depth are deposited on the surface as tailings. The material collected by the drill system is sieved to <150 µm and delivered to the CheMin and SAM instruments, the material (both sieved and unsieved) is later dumped back to the surface and is referred to as the dump pile. ChemCam also conducted sequences on the drill hole wall, but these sequences were only able to sample from the top third or less of the wall [6].

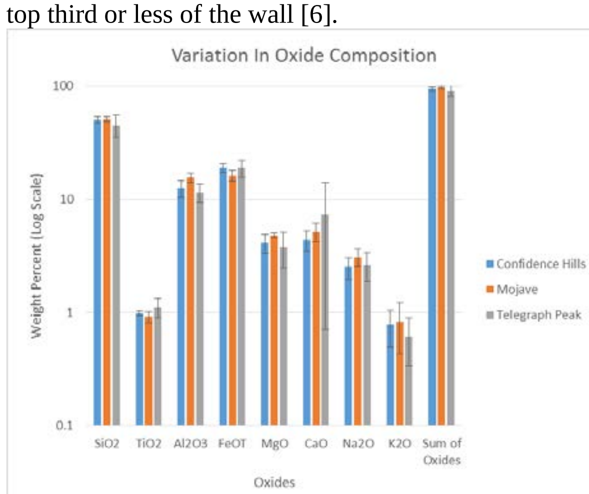

Figure 2: The mean of the averaged data for all values on the surface of the drill sites, in the drill tailings, in the drill hole

wall, and in the dump pile for the 3 drilling locations. Error bars are 1 standard deviation.

Drill Sites: The CheMin instrument detected 22.2% plagioclase, 7% augite, 7.8% hematite, 5.7% K-spar, 4.4% orthopyroxene, 3.8% pigeonite, 2.5% magnetite, 1.9% forsterite, 1.7% cristobalite, 0.9% ilmenite, 0.2% jarosite, 0.4% quartz, 11% phyllosilicate, 31% amorphous component [4]. Figure 2 demonstrates that the Confidence Hills and Mojave drill sites are similar in composition as would be expected due to their proximity. However, there is a large variation of values for Telegraph Peak, these are likely due to the four Ca rich outliers (Figure 4). All the drill sites here have greater Si, Al, and K, and lower Mg than the drill sites at Yellowknife Bay [6].

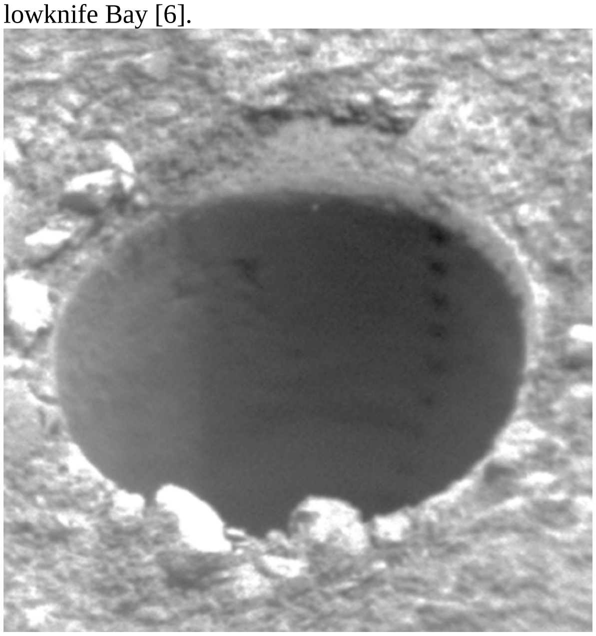

Figure 3: RMI of the Confidence Hills drill hole with the ChemCam laser points visible on the wall. The contrast of this image has been altered to make the laser pits more visible.

The jarosite that CheMin detected at Confidence Hills was at the detection limit [4]. Figure 4 displays variation in FeO_T and the missing component in addition to displaying the CaO weight percent for the four outliers and the average CaO weight percent for the rest of the points. The four outliers to the top-left were collected during an attempt to sample a vein seen in the Telegraph Peak drill hole wall, thus these points demonstrate a trend from the bulk composition towards the ca-sulfate vein material. The rest of the material shows a large amount of spread in missing component, which is to be expected as this component would contain all signal from elements besides the 8 oxides reported. However, a trend is present in the data towards increasing FeO_T and missing component; this likely evinces increasing contribution of jarosite as well as hematite and magnetite.

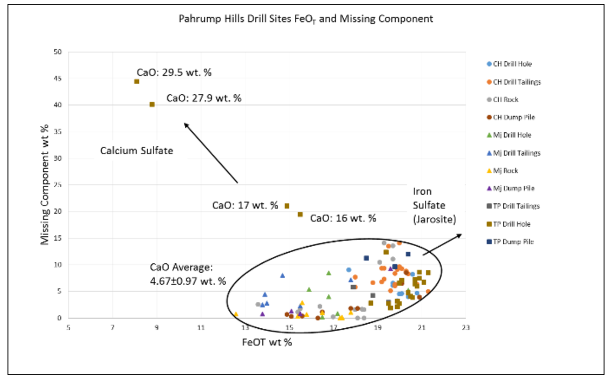

Figure 4: Averaged ChemCam point data for sequences at the three drill sites with variation in FeO_T and Missing Component. The CaO wt % is also displayed for the 4 points at top left which targeted a light-toned vein, and the average CaO wt % is given for the rest of the points.

Conclusion: Given the observation from orbital spectra of sulfates on Mt. Sharp, finding iron sulfates in the Pahrump drill holes is not a surprise. Overall, the observation of Mg- and Fe-sulfates has continued to be relatively sparse as the rover has traversed farther up the foothills of Mt. Sharp. The role of these sulfates (and corresponding acids) in the alteration of pre-existing sediments is a major question in understanding the recently-traversed terrain.

References: [1] Wiens R. C. et al. (2012) *Space Science Review*, 170, 167, Maurice, S. et al. (2012). *Space Science Review*, 170(1-4), 95-166.. [2] Stack K.M. et al. LPSC XLVI. [3] Clegg S.M. et al. (2016) in prep., Anderson, R. B., et al. (2011). *Icarus*, 215(2), 608–627., Forni O. et al. (2013) *Spectrochimica Acta Part B: Atomic Spectroscopy*, *86*, 31-41. [4] Cavanagh P.D. et al. LPSC XLVI, Nachon, M. et al. (2014). *Journal of Geophys. Res.*: Planets, 119(9), 1991-2016. [5] Schröder S., et al. (2015) *Icarus*, 249, 43–61, Cousin A. et al. EMSLIBS #P-037 (2015) , Payre et al., LPSC XLVII. [6] Jackson R. S. et al. (2016) *Icarus*, in press. [7] Vasavada, A. R., et al. J. Geophys. Res., doi:10.1002/2014JE004622, 2014.