CHEMCAM PASSIVE REFLECTANCE SPECTROSCOPY OF FERRIC SULFATES AND FERRIC OXIDES NEAR THE BASE OF MT. SHARP. J.R. Johnson[1], R.C. Wiens[2], S. Maurice[3], D. Blaney[4], O. Gasnault[3], E. Cloutis[5], S. Le Mouélic[6], and S. Bender[2]. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, jeffrey.r.johnson@jhuapl.edu, [2]Los Alamos National Lab, [3]Research Institute in Astrophysics and Planetology, [4]Jet Propulsion Laboratory, [5]Univ. of Winnipeg, [6]Le Lab. de Planétologie et Géodynamique de Nantes.

Introduction: The Chemistry and Camera (ChemCam) laser-induced breakdown spectroscopy instrument on the Mars Science Laboratory (MSL) rover Curiosity [1,2] can be used in passive mode (without the laser) to obtain radiance observations of surface materials. By acquiring observations of calibration targets on the rover, such measurements can be transformed to relative reflectance spectra (400-840 nm) [1]. Here we report on newly acquired spectra of fresh surfaces and drill tailings near the base of Mt. Sharp that exhibit spectral features consistent with presence of ferric sulfates and iron oxides.

Methods. We used the onboard ChemCam calibration targets' housing as a reflectance standard, and employed the methods to collect, calibrate, and reduce radiance observations to relative reflectance as summarized in [1]. ChemCam LIBS observations include 3 msec-exposure "dark" spectra used to remove the background signal from the LIBS measurement. The dark exposures provide useful passive signal in the 400-840 nm region, although better optimization results from longer exposure times.

Data. At the Kimberley outcrop, drill tailings from the target Windjana were observed on Sols 619 (sequences ccam01619, ccam02619) and 626 (ccam02625). At the Bonanza_King drilling location near the entrance to Happy Valley, initial observations on Sols 725 and 726 were followed by longer exposure observations on Sol 728 (ccam02728) on the drill tailings and a freshly broken rock near a rover wheel named Perdido2 (ccam01728). At Pahrump Hills, the drill target Confidence_Hills was observed on Sols 762 of tailings Panum (ccam01762) and Stovepipe_Wells (ccam02762). Observations of the dumped sample both before and after sieving were acquired on Sols 773 (ccam01773) and 782 (ccam01782, ccam02782), respectively. A nearby rock target named Maturango was brushed and observed on Sol 776 (ccam01775).

Results. The passive spectra of all drill tailings observed to date and their spectral parameters [cf. 1] are compared in **Figure 1**. The Windjana drill tailings were distinct from other drill tailings by exhibiting: (*a*) the lowest peak relative reflectance of all tailings; (*b*) the largest 535 nm band depth and relatively high red-blue (670/440nm) ratio and slopes, consistent with a greater ferric crystalline component; (*c*) the least negative 750-840 nm slope, suggestive of either lesser amounts of Fe^{2+}-bearing olivine/pyroxene and/or an amorphous component; and (*d*) the smallest 600/840 nm ratio. All these observations suggest that the Windjana drill tailings likely contain a spectrally opaque material (e.g., magnetite, ilmenite). The Bonanza_King mini-drill tailings were also unique among all drill tailings: They were spectrally neutral, had relatively high reflectance, the lowest red/blue ratio and slope, the weakest band depth at 600 nm (weak ferric oxide absorption), and a possible band near 433 nm. This latter feature was more clearly present on location #5 on a nearby freshly broken rock surface (Perdido2) (**Figure 2**). This target also exhibited the largest 750-840 nm slope, and 600/840 nm ratio values yet observed by ChemCam on Mars. This spectrum is consistent with ferricopiapite +- jarosite, although near-infrared features expected for these minerals were only weakly observed in Mastcam (not reported here), which may imply the presence of nanophase components of these materials. The Stovepipe_Wells (Confidence_Hills) and Maturango targets at Pahrump Hills exhibited another unique set of reflectance spectra, with comparatively deep absorptions at ~560 nm and ~660 nm, and a flattening or dropoff in reflectance > 750 nm (**Figures 1 and 3**). These features were consistent with the presence of a combination of small amounts of nanophase and crystalline hematite, perhaps with additional other poorly-crystalline and/or nanophase ferric oxides or oxyhydroxides [cf. 6]. The pre-sieve dump pile exhibited higher reflectance and was slightly bluer than the post-sieve dump pile, implying slightly less ferric components in the pre-sieve pile.

Conclusion. The spectral features associated with Bonanza_King and Perdido2 provide evidence of ferric sulfates near the base of Mt. Sharp. As noted by [3] jarosite and copiapite indicate the presence of acidic waters associated with acid sulfate alteration. At Pahrump Hills, the presence of hematite-bearing materials also suggests a more oxidizing environment than heretofore sampled by Curiosity. Combined, these samples are likely harbingers of environments yet to be explored further up the slopes of Mt. Sharp.

References: [1] Johnson, J.R., et al., Icarus, http://dx.doi.org/10.1016/j.icarus.2014.02.028, 2014; [2] Wiens, R., et al., Space Sci Rev., 170, 167-227, 2012; Maurice, S., et al., Space Sci Rev., 170, 95-106, 2012; [3] Farrand et al., Icarus, 241, 346–357, 2014; [4] Cloutis, E. et al., Icarus, 184, 121-157, 2006; [5] Clark, R. et al., USGS Spectral Library, USGS Data Series 231, 2007; [6] Cavanagh, P., et al., this issue.

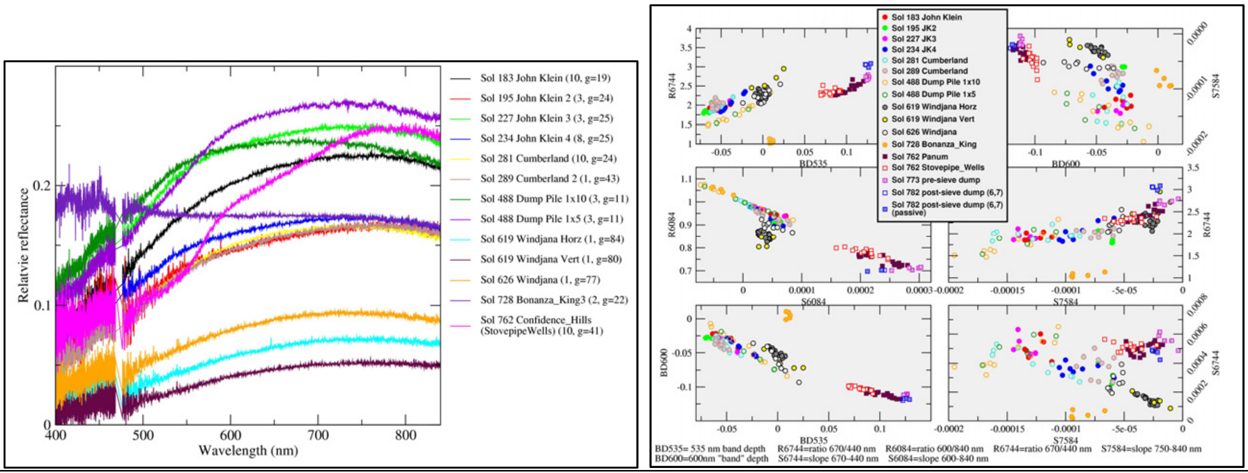

Figure 1. (***left***) ChemCam reflectance spectra of all drill tailings (with location # and phase angle (g)); (***right***) spectral parameter plots (defined on bottom [1]) of all drill tailings data, showing unique nature of Pahrump Hills (Sols 762+; square symbols).

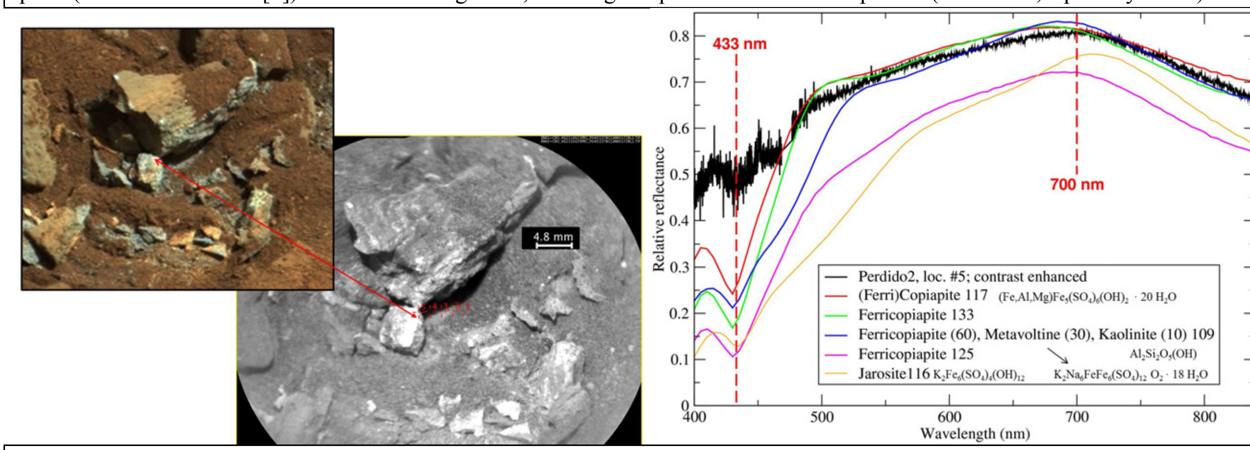

Figure 2. (***left***) Portions of Mastcam image (Sol 721, mcam03084) and RMI mosaic (Sol 728, ccam01728) showing locations of five passive spectra on Perdido2; arrow points to location #5 on each image; (***right***) ChemCam spectrum of Perdido2 (location #5) shown with enhanced contrast for comparison to laboratory spectra of several ferric sulfate minerals [4] that exhibit characteristic 433 nm bands (similar to that in Bonanza_King (Fig. 1) and near-infrared downturns near 700 nm.

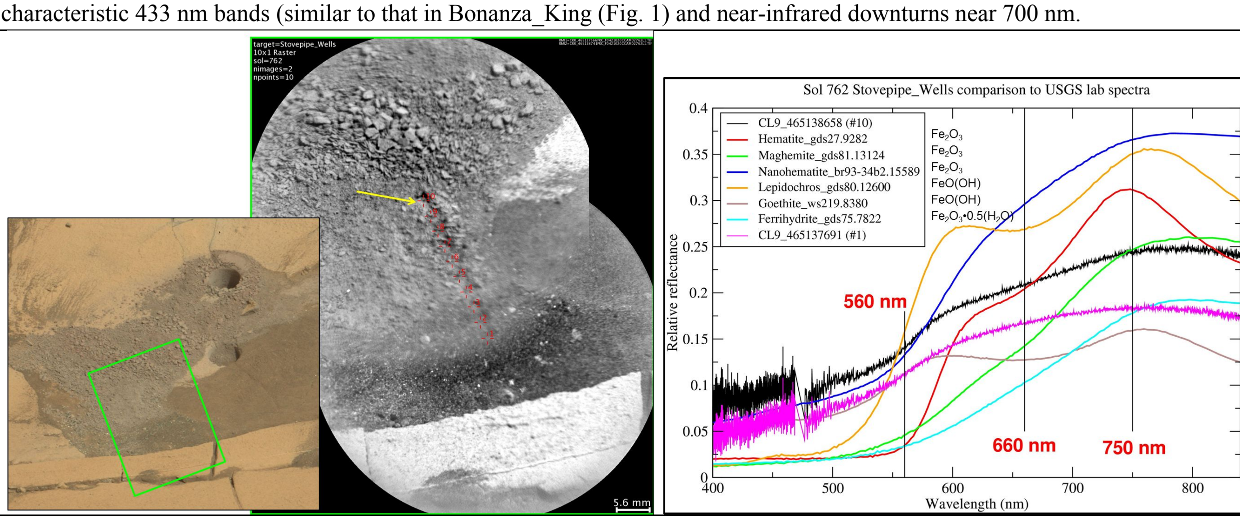

Figure 3. (***left***) Portions of Mastcam image (Sol 759, mcam03268) and RMI mosaic (Sol 762, ccam02762) showing locations of passive spectra on Stovepipe_Wells; arrow points to location #10; (***right***) ChemCam spectra of location #10 (drill tailings) and #1 (loosened, dusty soils vibrated from rock surface during drill activities) compared to laboratory spectra of several ferric oxides [5] that also exhibit similar features near 560 nm, 660 nm and 750 nm.