First year of ChemCam passive reflectance spectroscopy at Bradbury Landing, Mars. J.R. Johnson[1], R.C. Wiens[2], S. Maurice[3], S. Bender[4], L. DeFlores[5], D. Blaney[5], O. Gasnault[3], E. Cloutis[6], J. Bell[7], B. Gondet[12], K. Kinch[10], M. Lemmon[11], S. Le Mouélic[13], B. Ehlmann[8], M. Rice[8], and the MSL Science Team, 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]Planetary Science Institute, Tucson, [5]Jet Propulsion Laboratory/Caltech, [6]University of Winnipeg, [7]Arizona State University, [8]California Institute of Technology, [10]University of Copenhagen, [11]Texas A&M University, College Station, [12]Institut d'Astrophysique Spatiale, [13]Le Laboratoire de Planétologie et Géodynamique de Nantes.

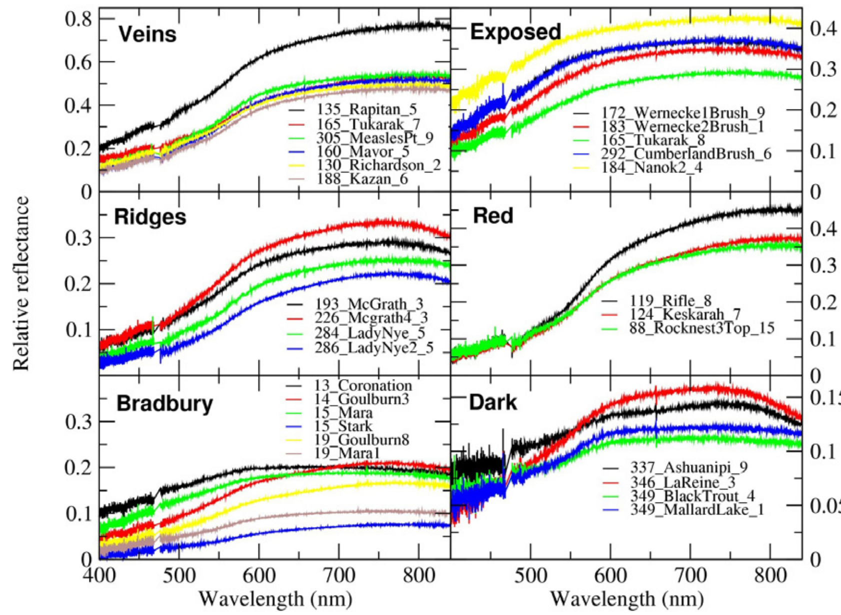
Introduction: The Laser-Induced Breakdown Spectrometer (LIBS) portion of the Chemistry and Camera (ChemCam) instrument on the Mars Science Laboratory (MSL) rover Curiosity uses three dispersive spectrometers to cover the ultraviolet (UV; 240-342 nm), blue-violet (VIO; 382-469 nm) and visible/near-infrared (VNIR; 474-906 nm) spectral regions at high spectral (< 1 nm) and spatial (0.65 mrad) resolution. In active LIBS mode, light emitted from a laser-generated plasma is dispersed onto these spectrometers and used to detect elemental emission lines [1]. During instrument development it was understood that the ChemCam spectrometers exhibited sufficient sensitivity to allow collection of potentially useful surface spectral reflectance in passive mode (i.e., without using the laser). However, the spectrometers were not radiometrically calibrated to a specific accuracy requirement for this purpose. Nonetheless, it was recognized that radiance observations of well-characterized Mastcam and ChemCam calibration targets on the Curiosity rover provided the opportunity to transform radiance spectra of surface targets to relative reflectance and thereby test the passive spectral capability of ChemCam on Mars. Here we report on passive radiance measurements calibrated to relative reflectance and preliminary spectra (400-840 nm) of surfaces observed during the first 360 sols of the Curiosity mission (August 5, 2012 – August 11, 2013), comprising ~2100 locations on ~260 separate targets.

Data and Methods. We used the onboard ChemCam calibration targets' housing as a reflectance standard, and developed methods to collect, calibrate, and reduce radiance observations to relative reflectance. ChemCam LIBS observations include 3 msec-exposure "dark" (passive) spectra used to remove the background signal from the LIBS measurement. Although better optimization resulted from longer exposure times (30, 400, and 5000 msec for the VNIR, VIO, and UV spectrometers, respectively), the "dark" exposures provided useful signal for VNIR and VIO detectors. Such measurements accurately reproduce the known reflectance spectra of other calibration targets on the rover, and represent the highest spatial resolution and spectral sampling visible/near-infrared reflectance spectra from a landed platform on Mars.

Results. Relative reflectance spectra of surface rocks and soils match those from orbital observations and multispectral data from the MSL Mastcam camera. Most observations occurred after the LIBS laser shot, which reduces dust contamination in the passive spectra. Preliminary analyses of the band depths, spectral slopes, and reflectance ratios demonstrate at least six spectral classes of materials distinguished by variations in ferrous and ferric components (Figures 1 and 2). Initial comparisons of ChemCam spectra to laboratory spectra of minerals and Mars analog materials demonstrate similarities with palagonitic soils and indications of orthopyroxene in some dark rocks. Magnesium-rich "raised ridges" tend to exhibit distinct near-infrared slopes. The ferric absorption downturn typically found for martian materials at < 600 nm is greatly subdued in brushed rocks and drill tailings, consistent with their more ferrous nature. Calcium-sulfate veins exhibit the highest relative reflectances observed, but are still relatively red owing to the effects of residual dust. Such dust is overall less prominent on rocks sampled within the "blast zone" immediately surrounding the landing site. These samples were likely affected by the landing thrusters, which partially removed the ubiquitous dust coatings. Increased dust coatings on the calibration targets during the first year of the mission were documented by the ChemCam passive measurements as well. Ongoing efforts to model and correct for this dust component should improve calibration of the relative reflectance spectra. This will be useful as additional measurements are acquired during the rover's future examinations of hematite-, sulfate-, and phyllosilicate-bearing materials near the base of Mt. Sharp that are spectrally active in the 400-840 nm region. Initial long-distance (> 4km) observations of this region show promising results, such as variations in near-infrared reflectance, which should assist in traverse planning.

References:[1] Wiens, R., et al., Space Sci Rev., 170, 167-227, 2012; Maurice, S., et al., Space Sci Rev., 170, 95-106, 2012; [2] Johnson, J.R. et al., LPSC 44, #1374, 2013; Johnson, J., et al., submitted to Icarus, 2013; [3] Johnson, J., and W. Grundy, GRL, 28, 2101-2104, 2001.

Figure 1. Example ChemCam relative reflectance spectra of representative rock target types (cf. Figure 2), demonstrating range of spectral variability. Legend descriptors correspond to sol number, target name, and location number for multiple-location rasters. Note variable reflectance scales on each plot.



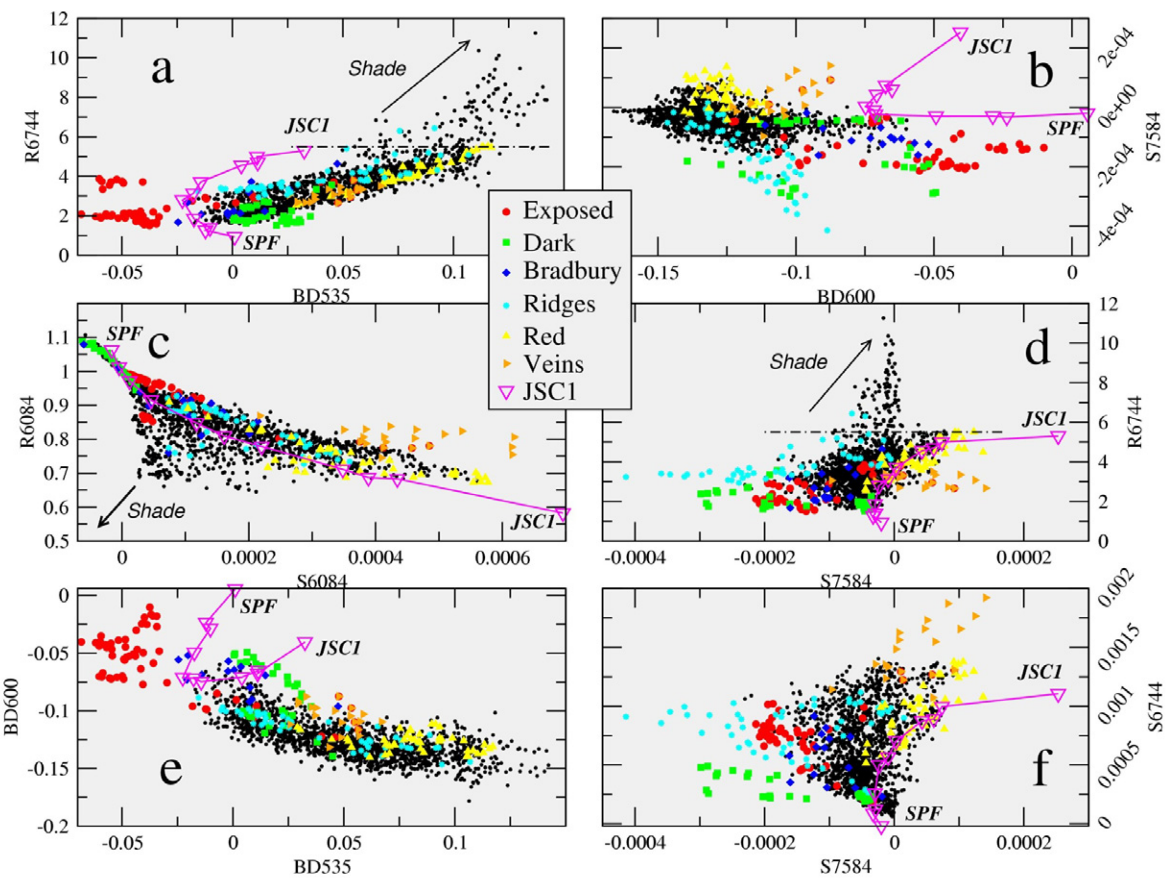


Figure 2. Comparisons of spectral parameters for all rock targets up to Sol 360: 535 nm and 600 nm band depths (BD535, BD600), 670/440 nm, 600/840 nm ratios (R6744, R6084), 600- or 750-to-840 nm slope (S6084, S7584), 440-to-670 nm slope (S6744). Colored points are representative spectral classes shown Figure 1. Arrows point toward trends of shadows ("shade", e.g, R6744 > 5.5). Also shown are parameter values for a basaltic rock (*SPF*) and a suite of samples coated with variable average thicknesses (17 to 122 μm) of Mars analog soil (*JSC1*) from [3].