EVIDENCE FOR HYDRATED PHYLLOSILICATES IN HOLDEN CRATER, MARS USING HYPERSPECTRAL CRISM DATA.
R. E. Milliken[1], J. P. Grotzinger[2], S. Murchie[3], J. A. Grant[4], and the CRISM Team , [1]Jet Propulsion Lab/Caltech, 4800 Oak Grove Dr, Pasadena, CA 91109, [2]California Institute of Technology, Pasadena, CA, 91125, [3]Applied Physics Laboratory, Laurel, MD, [4]Smithsonian Institution, Center for Earth and Planetary Studies, 6th at Independence SW, Washington, DC 20560. Ralph.Milliken@jpl.nasa.gov

Introduction: Recent reflectance data returned by the high spatial/spectral resolution CRISM instrument onboard the Mars Reconnaissance Orbiter have provided the first evidence of hydrated materials in distinct stratigraphic units in Holden Crater, Mars. The full spectral resolution of the CRISM instrument utilizes 544 channels to cover a wavelength range of ~0.36 – 4 µm [1], a range that includes fundamental and overtone absorptions related to the presence of H_2O and OH^-. Here, we discuss observations of these absorptions, indicative of hydrated materials, detected in layered deposits in the southwest portion of Holden Crater in CRISM observation HRS000030AF_07. This image was acquired at full spectral resolution and half spatial resolution (~36 m/pixel).

Background: Holden Crater is approximately 154 km in diameter and was formed during the Noachian within the pre-existing Holden Basin [2-4]. MOC and THEMIS images reveal that light-toned layered sediments exist within the southwest portion of the crater (Figure 1) [5,6]. Major stratigraphic units within the SW portion of Holden Crater include a lower, layered unit that is heavily fractured and intermediate in albedo, a middle, less fractured, higher albedo unit that ranges from massive to finely layered, and an upper low-albedo unit that exhibits crude layering and lacks the conjugate joint sets present in the lower two units. Much of the upper unit is covered by eolian bedforms that may be currently active, indurated and inactive, or a combination of the two. The lower two units may be lacustrine in origin [3,4,6] and represent a depositional setting that is distinct from the upper unit, as described in detail by [4].

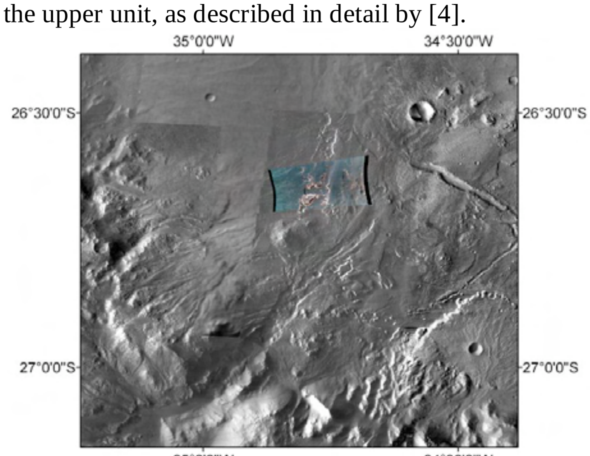

Figure 1. Regional view of the southwest portion of Holden Crater showing the location of CRISM image HRS000030AF_07. The image consists of a CRISM RGB composite (0.749, 0.501, and 0.449 µm, respectively) on top of a THEMIS VIS and day IR mosaic provided by [14].

Data Reduction & Methods: The CRISM image used for this study has been converted to I/F, photometrically corrected for the incidence angle, atmospherically corrected to a first order (following the method of [7]), and map-projected. The reduced data were then used to calculate band parameters, specifically the band depths near 1.9, 2.2, 2.3, and 2.5 µm, as described by [8]. These band parameters were examined to search for areas of unique or interesting mineralogy that corresponded to the three major stratigraphic units described above. An overlapping HiRISE image was also acquired for this region (image PSP_001468_1535) and was studied to provide a more detailed analysis of the relationships between mineralogy as seen by CRISM and stratigraphy.

Results: CRISM spectra corresponding to exposed regions of the lower, intermediate-albedo unit commonly exhibit absorption features centered near ~1.9 and ~2.3 µm (Figures 2, 3). These features are consistent with the presence of hydrated Mg-Fe bearing phyllosilicates and have been observed in other locations on Mars by the OMEGA experiment [9,10] These hydrated materials are associated primarily with the reddish-brown outcrops in the RGB composite in Figure 2, whereas spectral features of hydrated phases are weak or absent in the brighter, middle unit (Figures 4, 5). The presence of hydrated materials in the lower unit suggests that this unit 1) represents reworked, previously altered material, 2) deposition of the lower unit in an aqueous environment, possibly lacustrine [4], or 3) post-depositional aqueous alteration of the lower unit via groundwater interaction.

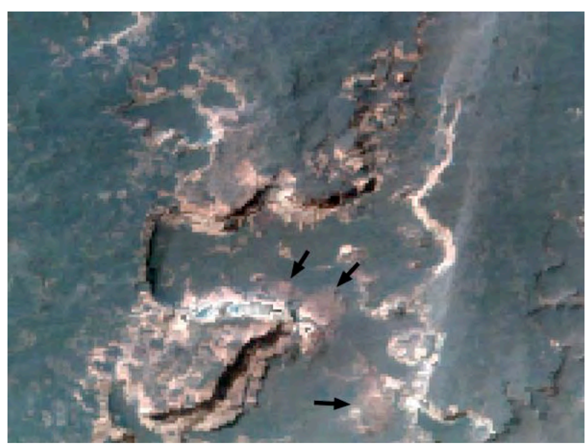

Figure 2. Close-up view of the CRISM RGB composite in Figure 1. The black arrows point to the deposits corresponding to the highest concentrations of hydrated materials (largest 2.3 µm band depth values).

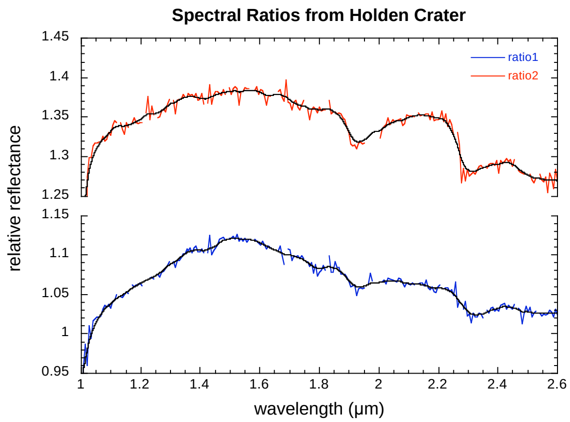

Figure 3. Examples of spectral ratios from CRISM image HRS000030AF_07. Both ratio spectra were created by dividing a 3x3 pixel average spectrum from the lower unit (yellow in Figure 5b) by a 3x3 pixel average spectrum from the middle unit (clear, pale blue in Figure 5b). Black lines represent smoothing functions applied to the spectral ratios to minimize noisy channels. Absorptions centered near 1.9 and 2.3 are consistent with hydrated Mg-Fe bearing phyllosilicates.

The spectral features of the upper unit are more consistent with mafic minerals (likely pyroxene and olivine) and could represent the composition of the superimposed eolian bedforms, the composition of the upper unit, or spectral mixing between the two. The detection of mafic materials in these low-albedo materials is consistent with observations by THEMIS and TES for this region [11].

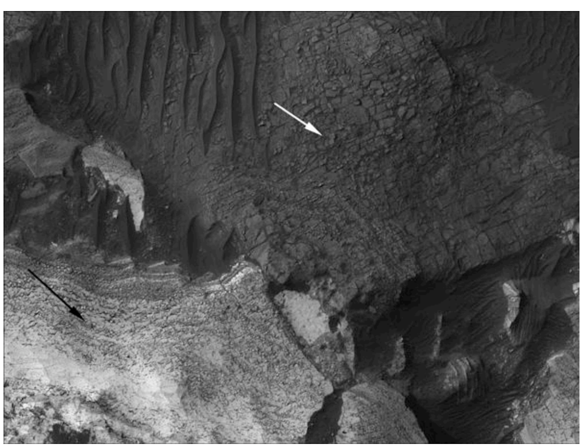

Figure 4. A portion of HiRISE image PSP_001468_1535 showing the geomorphologic differences between the lower unit (white arrow), which exhibits spectral features associated with hydrated materials, and the middle unit (black arrow), which lacks these features. The lower unit has a lower albedo and is more fractured than the brighter, middle unit, possibly representing differences in the physical properties of these units related to their chemical (mineralogical) differences.

Conclusions: Hyperspectral reflectance data acquired by the CRISM instrument reveals that hydrated minerals, likely phyllosilicates, are preferentially concentrated in a stratigraphically lower, intermediate-albedo unit in SW Holden Crater, Mars. This lower unit may represent reworked sediments derived from layers deposited in Holden Basin prior to the formation of Holden Crater or deposition and alteration of sediments in an aqueous environment. Compositional and morphological differences between the lower and middle units suggest a change in depositional setting over time [4]. The exposure of layered materials, interesting mineralogical signatures, and geomorphology of SW Holden Crater make it an excellent candidate for the MSL landing site, as proposed by [12,13]. Future work will continue to focus on integrating CRISM, OMEGA, HiRISE, CTX, TES, and THEMIS data to determine the geologic history of this region.

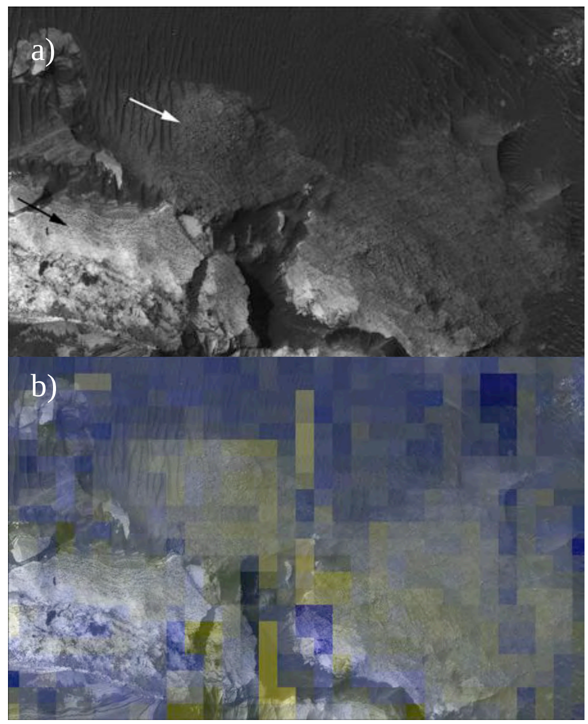

Figure 5. a) Portion of HiRISE image covering the lower (white arrow) and middle (black arrow) units in SW Holden Crater. b) Portion of the corresponding CRISM observation with yellow representing the band depth at 2.3 μm ('strength' of phyllosilicates) and blue representing mafic materials overlaid on the HiRISE image. Bright blue and yellow vertical lines of pixels in b) are instrumental artifacts.

References: [1] Murchie, S. et al. (2007) *JGR, in press*; [2] Scott D. H., and Tanaka K. L. (1986) *USGS Map I-1802-A*.; [3] Pondrelli M. et al. (2005) *JGR, 110*, 2004JE002335; [4] Grant et al., LPSC 38, *this issue*; [5] Malin M. C., and Edgett K. S. (2000) *Science, 290*, 1927; [6] Grant J. A., and Parker, T. J. (2002) *JGR, 107*, 10.1029/2001JE001678; [7] Bibring, J.-P. et al. (2005) *Science*, vol. 307, 1576-1581; [8] Pelkey, S. et al., (2007) *JGR, in press*; [9] Poulet, F. et al. (2005) Nature, vol. 438, 623-627; [10] Mustard, J. et al. (2007) *JGR, in press*; [11] Glotch, T. et al. (2006) AGU Fall Meeting, abstract #10074; [12] Irwin, R. and J. Grant (2006) MSL Landing Site Workshop; [13] Malin, M. and K. Edgett (2006) MSL Landing Site Workshop; [14] Christensen et al., *THEMIS public data release*, http://themis-data.asu.edu