CRISM SPECTRAL SIGNATURES OF THE NORTH POLAR GYPSUM DUNES. L.H. Roach[1], J.F. Mustard[1], S. Murchie[2], Y. Langevin[3], J.-P. Bibring[3], J. Bishop[4], N. Bridges[6], A. Brown[4], S. Byrne[7], B.L. Ehlmann[1], K. Herkenhoff[7], P.C. McGuire[5], R.E. Milliken[6], S. Pelkey[1], F. Poulet[3], F.P. Seelos[2], K. Seelos[2], and the CRISM team. [1]Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI 02912 Leah_Roach@brown.edu, [2]JHU/APL, Laurel, MD 20723, [3]Institute d'Astrophysique Spatial (IAS), Orsay, France, [4]SETI Institute, Mountain View, CA 94043, [5]Washington University in St. Louis, St. Louis, MO 63130, [6]JPL/Caltech, Pasadena, CA 91109, [7]USGS, Flagstaff, AZ 86001.

Introduction: OMEGA discovered gypsum in the northern circumpolar dunes (Fig 1), with a decreasing concentration moving westward from Chasma Boreale [1]. The origin of this gypsum deposit is uncertain, however the gypsum in the dunes must be very young or continually replenished, as saltation would quickly break down the soft mineral [2]. One possible source is the basal unit underlying the polar layered deposits [3].

CRISM spectra also show gypsum signatures in Olympia Undae sand sea. CRISM's higher spatial resolution, especially when combined with HiRISE imagery, enables determination of variations in spectral signature in the northern gypsum dunes that hint of past geologic processes. We are searching for evidence of a gypsum source region in the underlying bedrock or in the nearby north polar basal unit.

Datasets: CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) is a VNIR hyperspectral 2-D imager on the Mars Reconnaissance Orbiter (MRO) mission capable of multiple mapping modes [4]. It can acquire high-resolution targeted observations at 544 wavelengths from 0.362-3.92 μm and 15-19 m/pixel. So far, we have acquired six targeted observations of the north polar gypsum dunes. Observations are photometrically corrected and provisionally atmospherically corrected, by a ratio with a CRISM scene of Olympus Mons, scaled to the same column density of CO_2. A similar atmospheric correction is used for OMEGA data [1]. Ratioing to a CRISM scene, rather than just a spectrum, is necessary to account for the spectral smile present in 2-D spectrometers.

The HiRISE (High Resolution Imaging Science Experiment) camera aboard MRO is capable of acquiring co-aligned imagery with CRISM and can resolve details down to ~30 cm/pixel [5].

OMEGA (Observatoire pour la Mineralogie, l'Eau, les Glaces et l'Activité) is a VNIR hyperspectral imager on the ESA/Mars Express mission [6]. It has a 1.2 mrad IFOV, a spatial sampling from 300 m to 4.8 km, and a 7 to 20 nm spectral resolution in 352 spectral bands over 0.35-5.1 μm.

Gypsum source hypotheses: While the Olympia Undae sand dunes are weathering from a paleo-erg (sand sea) layer under the north polar layered deposits [3], the origin of the gypsum in the dunes remains ambiguous. It is possible that the paleo-erg layer is also the gypsum source, which could have been originally emplaced by aeolian transport [3]. Other possibilities for local gypsum formation include: surface weathering during periods of higher obliquity [1], acidic alteration of basalt [7, 8], and evaporation of outflow brines from the ice cap [9]. We are looking for evidence that the polar basal unit, which is exposed at both the ice cap edge and underneath the dunes, is a plausible gypsum source.

Results: The distinguishing absorption features of gypsum are a triplet absorption between 1.44-1.54 μm, absorptions at 1.75 μm and 1.9 μm, and a doublet absorption at 2.25 and 2.265 μm, all due to combinations and overtones of H_2O vibrations and librations [10, 11]. Gypsum was identified in CRISM spectra (Fig 2) by a wide ~2.2 μm absorption and a drop off after 2.4 μm diagnostic of polyhydrated sulfates. A small absorption at 1.75 is also usually present. Atmospheric CO_2 absorptions complicate interpreting the 1.9 μm feature.

Six targeted observations of 15-19 m/pixel were analyzed to study changes in gypsum signature concentration with distance from Chasma Borealis. They showed a general decrease in the overall strength of the gypsum signature with clockwise distance along Olympia Undae. In some observations, spectra of dune crests also show deeper hydration bands and stronger gypsum-related absorptions than spectra of dune troughs (Figs 2, 3). This may indicate coarser grain sizes [12], cementation of grains, or more gypsum in the dune crests.

We investigated two potential source regions with CRISM imagery. OMEGA indicated that the polar basal unit does not contain gypsum [2]. CRISM spectra confirm a lack of gypsum in the basal unit exposed at the edge of the polar cap. Small patches of exposed bedrock underlying the gypsum-rich dunes are resolved by CRISM, and overlapping CRISM and HiRISE imagery show a light-toned, polygonally-fractured unit beneath the sand dunes whose raw spectra have a weaker gypsum signature (Fig 4). Its weak signature indicates it either contains small amounts of fine-grained gypsum or is covered by a thin layer of gypsum-rich sand grains. However, the compositional and physical properties of the basal unit may be laterally variable. Beneath the gypsum-bearing dunes, it could consist of an eroded friable (gypsum-containing) layer over a more resistant layer (gypsum-poor light-toned bedrock). Thus, the exposed bedrock is a possible gypsum source. The stronger gypsum signatures on the dune crests and the decreasing concentration in a clockwise (downwind) direction along the circumpolar dunes suggest a dynamic process controlling the gypsum distribution.

Further work: Combining CRISM observations with OMEGA data will aid in planning additional targets to acquire in key areas. Joint OMEGA-CRISM analyses can provide context to these high-resolution detections.

Acknowledgements: We wish to acknowledge the CRISM and HiRISE science teams for all their dedication and hard work. We thank the OMEGA team for cooperation in data analysis and targeting. Processed HiRISE images are available at http://marsoweb.nas.nasa.gov/HiRISE/.

References: [1] Langevin Y. et al. (2005) *Science, 307*, 1584-1586. [2] Fishbaugh K.E. et al. (2006) *LPSC XXXVII*, Abst #1642. [3] Byrne S. and Murray B.C. (2002) *JGR, 107*, doi:10.1029/2001JE001615. [4] Murchie S. et al. (in press) *JGR*. [5] McEwen A. et al. (in press) *JGR*. [6] Bibring J.-P. et al. (2004) *ESA SP 1240*, 37. [7] Bibring J.-P. et al. (2005) *Science 307*, 1576-1581. [8] Gendrin A. et al. (2005) *Science 307*, 1587-1591. [9] Pathare A.V. and Paige D.A. (1998) *1st Int. Conf. Mars Polar Sci. and Expl.*, Abst #953. [10] Hunt G.R. et al. (1971) *Modern Geology, 3,* 1-14. [11] Cloutis E.A. et al (2006) *Icarus, 184*, 1, 121-157. [12] Ghrefat H.A. et al. (2006) *Geomophology*, doi:10.1016/j.geomorph.2006.10.013.

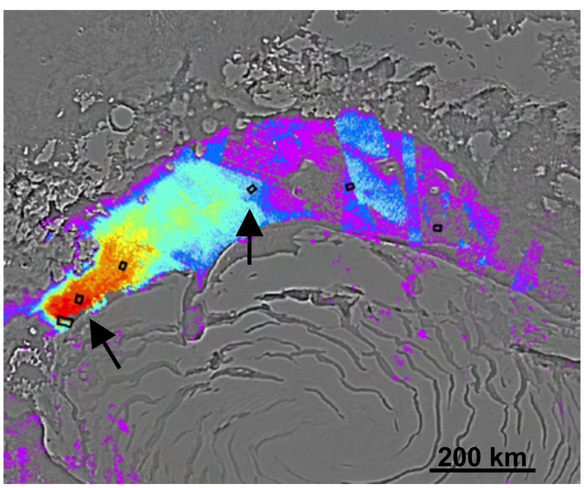

Fig 1. Map of North Pole with outlines of six CRISM targeted observations overlain on MDIM. 1.9 µm band depth from OMEGA gridded data, plotted from red (high) to purple (low), is shown as an indicator of sulfate presence. The left arrow points to the outline of the CRISM image shown in Fig 3 (its representative spectrum is shown in Fig 2) and the right arrow to the outline of the HiRISE image shown in Fig 4.

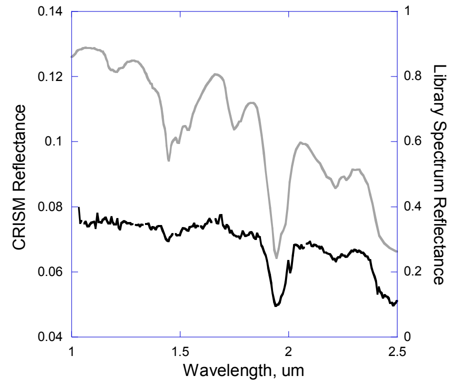

Fig 2. Representative CRISM spectra of gypsum (black) with library spectrum (gray). From obs FRT0000285F_07.

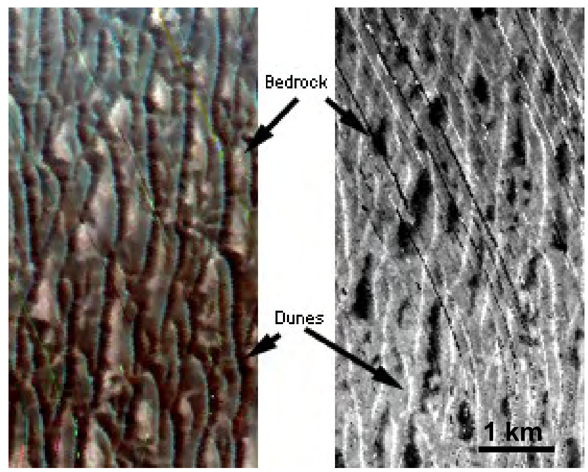

Fig 3. CRISM false color RGB (left) (2.528, 1.564, and 1.078 µm) and 1.9 µm band depth (right) indicating hydration in dune crests due to gypsum. The bedrock has very low hydration. From obs FRT0000285F_07.

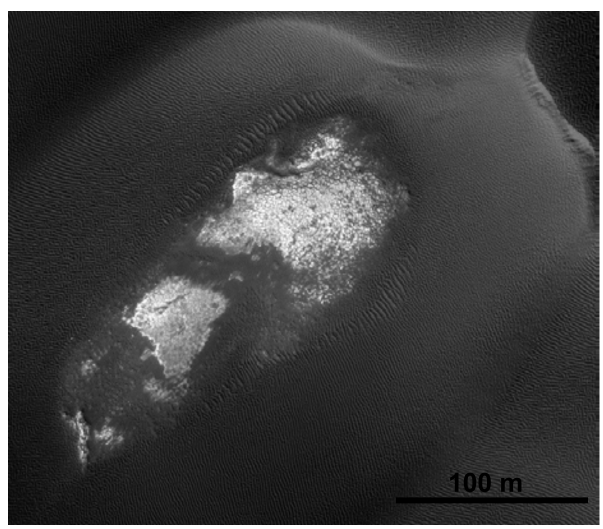

Fig 4. Subset of HiRISE image PSP001432_2610 showing polygonal cracks in bedrock exposed in interdune area. Dune crest in upper right.