Coordinated HiRISE/CRISM observation on Gypsum Signature in Martian polar dunes. H. Lahtela[1], T.N Titus[2], P.E. Geissler[2], L.H. Roach[3], C.A. Verba[2], J.F. Mustard[3], S.L. Murchie[4], A.J. Brown[5], F. Seelos[4], K. Seelos[4], W.M. Calvin[5], M. Parente[16], C. Cornwall[2]. [1] Div. of Astronomy, Dep. of Phys. Sciences, P.O. BOX 3000, FI-90014 University of Oulu, Finland (hlahtela@student.oulu.fi). 2U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, USA. [3]Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI 02912. [4]Johns Hopkins/APL, Laurel, MD 20723. [5]SETI Institute/NASA-ARC, Mountain View, CA 94043. [6] Department of Electrical Engineering, Stanford University, Stanford, CA 94305, USA.

Introduction: The OMEGA (Observatoire pour le Mineralogie, l'Eau, les Glaces et l'Activite´) imaging spectrometer first observed gypsum in the north polar Olympia Undae sand sea based on absorptions at wavelengths of 1.45, 1.75, 1.94, 2.22, 2.26, and 2.48 micrometers [1]. Gypsum is a hydrated Ca sulfate ($CaSO_4 \cdot 2H_2O$) and its presence provides evidence for liquid water, as it is common evaporation product on Earth [2]. Due to its softness (1.5-2 on the Mohs scale), gypsum is prone to erosion; Fishbaugh et al. [2] points out that therefore the gypsum in the dunes must be very young or be replenished as saltation would rapidly erode it.

The Olympia Undae sand sea region is a young complex system of layered deposits of ice and dust, plains, and dark longitudinal dunes [3]. The gypsum signature is spatially correlated with the dunes in Olympia Planitia. The OMEGA signature diminishes westwards across the dune field, and is the strongest at the upwind side [1, 2]. The gypsum signature is spatially correlated with the dunes in Olympia Planitia, with the strongest gypsum absorptions in the dune crests [5].

Feldman et al. [4] concluded that the dunes contain a relatively desiccated top layer which overlays an ice-cemented lower layer. They also proposed that the composition of the lower layer may be comprised of: (a) an indurated, hydrated mineral such as gypsum, (b) pore-volume water ice emplaced by vapor diffusion, or (c) multiple layers of water ice and dust delivered as snow combined with sand during previous obliquity cycles.

In High Resolution Imaging Science Experiment (HiRISE) observations, bright patches were identified among these dunes. Based on recent geologic mapping, the gypsum-bearing dunes are part of the Olympia Undae unit while the bright polygonally-fractured unit immediately beneath the dunes is either the Planum Borean unit 2 or Planum Boreum cavi unit [6]. This material is interpreted as consisting mostly of atmospherically transported dust with interstitial ice [6]. Fishbaugh et al. [2] suggested that this underlying unit might be the origin for the gypsum signature. Roach et al. [5] discovered that the lighter-toned material has a weaker gypsum signature than the darker dunes. It might mean there is less gypsum in the light-toned lower layer, or that differences in grain size, texture, and/or surface albedo between the two units create consistent differences in the gypsum absorption features.

Approach: The goal of this study was to analyze the Martian north polar dunes and the underlying bright bedrock component found by HiRISE observations. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) data was used in addition to HiRISE to verify whether the observed gypsum signature response is due to the dark dunes or the bright bedrock. In addition to this, we compared the difference between the CRISM reflectance spectrums of these two units identified from available HiRISE images. We also looked to answer the question of whether the observed westward decrease in gypsum signature is due to the change in dune/bedrock ratio or to a gradual change in the composition of the dunes or bedrock.

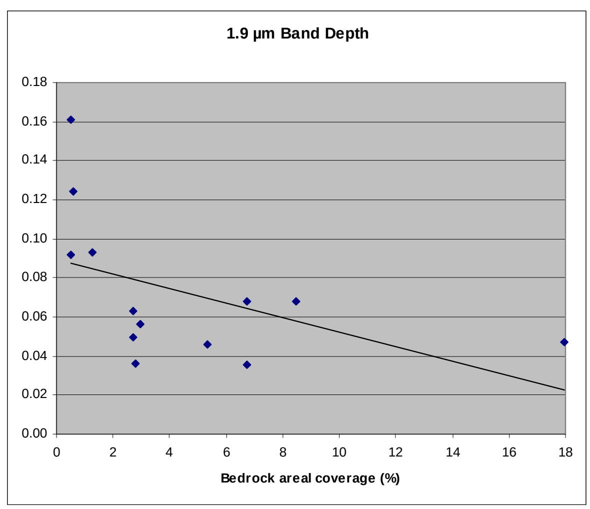

Fig 1: 1: Average CRISM 1.9 µm hydration band depths over the coverage of individual HiRISE images and plotted against HiRISE-derived white bedrock coverage. These results show clear anticorrelation with R= -0.43 suggesting white bedrock is not strongly hydrated (gypsum bearing).

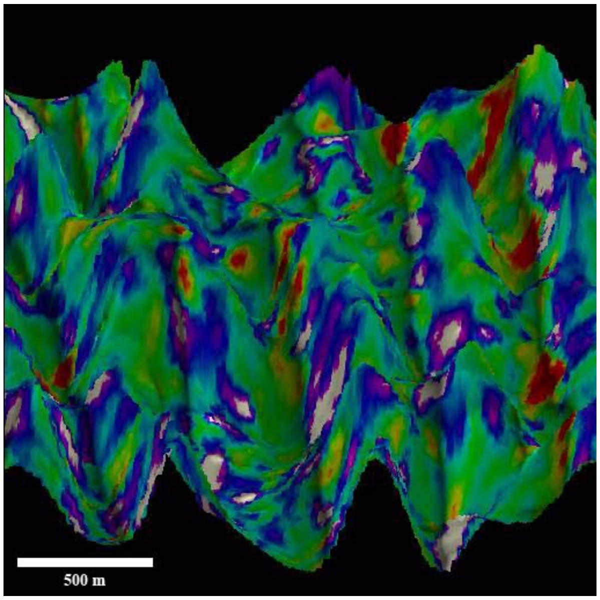

Fig 2: A 3D view of the 1.9 hydration feature of the linear gypsum dunes in Mars north polar area. This type of dunes has lowest coverage of bright bedrock (0.5%). In this image, the 1.9 hydration spectral index derived from CRISM (HRS C2A7) is overlaid with HiRISE intensity (PSP_009733_2795) and these are draped over MOLA 3D. This shows that the dunes have an overall gypsum signature that is strongest (red) in troughs between the dunes.

Preliminary results: Our preliminary view of Martian north polar dunes is based on 17 HiRISE images and selected overlapping HiRISE/CRISM data pairs. We found distinct anticorrelation (R= -0.43) between the CRISM-derived average 1.9µm hydrated band depths over each HiRISE image and the bright bedrock coverage of these images (Fig. 1). This indicates that the spectral signature of gypsum is indeed originating from the dark dunes, not from the white bedrock. However, the nonlinear relationship seen in Figure 1 suggests some compositional variation within the dunes. The dunes also have a general spectral response of olivine. In addition, a tentative analysis of the spectral indice of the bright bedrock material suggests that it has a notable, although minor, monohydrated sulfate constituent. However, this still needs to be verified through more detailed spectral analysis. The major components remain unidentified, although water ice can reliably be ruled out.

The average areal coverage of bright bedrock is less than 5% in the 17 HiRISE images. In all images located eastwards of 200°E, the bedrock coverage was less than 2%, and westwards of 200°E all were in the range 2-22%. This distribution is in agreement with westward decreasing of gypsum content in dunes, but most likely is not strong evidence to fully explain it.

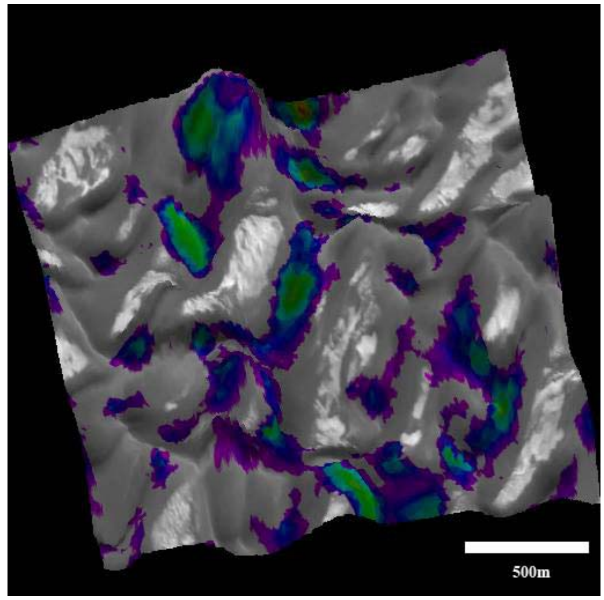

Fig 3: A 3D view of the 1.9 hydration feature of the unoriented gypsum dunes in the Martian north polar area. This type of dunes has relatively large coverage of bright bedrock (8%). In this image, the 1.9 hydration spectral index derived from CRISM (HRS C47E) is overlain with HiRISE intensity (PSP_009832_2615) and these are draped over MOLA 3D. The spectral signature of gypsum is highest in the troughs.

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