USING MINERALOGY TO TRACE SAND SOURCES AND TRANSPORT HISTORIES IN THE NORTH POLAR SAND SEA, MARS.
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Introduction: The north polar sand sea is the largest sand sea on Mars, and encircles the north polar plateau, Planum Boreum (PB) [1]. The deposits within and around PB record diverse sedimentary and aqueous processes that likely reflect those that have been ongoing in the northern lowlands since the Hesperian [2-9]. In this study, we show that dune fields within the north polar sand sea of diverse mineralogies are directly sourced from specific layers within PB, and that these mineralogies also correspond to more extensive units within the northern lowlands. Thus, we hypothesize that the sediments that currently supply the sand sea were originally sourced from these larger units, and emplaced within PB via impact and aeolian processes.

Data Sets: We have used near-infrared spectra (~0.3-2.5 μm) from the Mars Express OMEGA and MRO CRISM imaging spectrometers. Initial interpretations were completed using calibrated summer OMEGA observations mosaicked into a 1 km/pxl polar stereographic mosaic above 70°N [9]. We are also constructing a new ~200 m/pxl CRISM multispectral mosaic [7] above 75°N with enhanced calibration techniques to investigate terrains near scarps and troughs that are compromised in OMEGA observations by mixing with plateau ice and slope-related phase effects. Finally, we are conducting a detailed investigation of PB scarps with full-resolution (18 m/pixel) CRISM enhanced MTRDR products [10].

Mineral detection methods: Hydrated minerals are mapped using the 1.9 μm band depth, modified to account for the presence of ice [6]. Water ice is mapped using the 1.5 μm band depth [4]. Iron-bearing minerals are detected based on the position and shape of the ~1 μm iron absorption band. Band position alone can be used to broadly differentiate minerals: iron oxides and low-Ca pyroxene (LCP) usually exhibit band centers between 0.88-0.94 μm, high-Ca pyroxene (HCP) 1.00-1.05 μm, olivine 1.04-1.09 μm, and iron-bearing glass 1.10-1.18 μm [11]. When these minerals mix, the band centers and shapes vary in predictable ways, and thus these parameters can be used to identify even small abundances of Fe-minerals and glass in mixtures [12].

Sand mineralogy: Based on our low-resolution OMEGA map, we have identified three major spectral endmembers in north polar sediments. *(1) Gypsum*: strong hydration and other diagnostic gypsum signatures throughout the Olympia Undae dune field [4], as well as weaker signatures on PB [6,13] associated with the north polar veneers [14]. *(2) HCP:* strong 1.01 and 2.10 μm iron bands in western Olympia Undae and

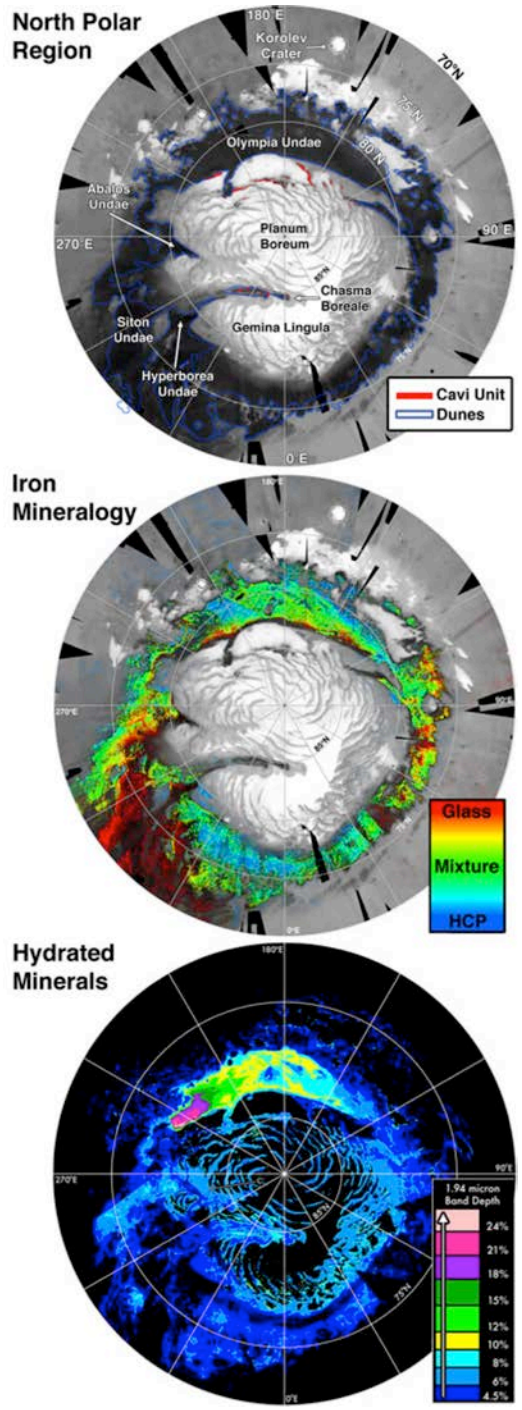

Figure 1: *OMEGA maps of north polar region. Top: major features on 1 μm albedo. Middle: Iron mineralogy derived from 1 μm band center. Bottom: 1.9 μm hydration band depth, mostly indicating gypsum.*

weaker signatures on and near PB associated with the veneers. *(3) Weathered iron-bearing glass:* weak 1.10-1.15 µm iron bands and a concave up spectral slope from 0.7-1.5 µm consistent with weathered glass in dune fields 260-300°N, far eastern Olympia Undae, and many of the chasmata [9].

Glass sources: Our analysis suggests that the bulk of the sand sea is composed of weathered glass. Glass-rich dunes demark apparent transport pathways that lead back to exposures of the PB cavi unit, an ancient ice-indurated dune field that comprises up to 1.5 km of the PB basal unit [15]. Similar weathered glass surficial deposits cover much of Acidalia and Utopia Planitiae [9], so we hypothesize that the cavi unit sands were created via deflation and aeolian transport of these units sometime after the Late Hesperian or Early Amazonian, based on the age of underlying PB units [5].

Pyroxene sources: Strong HCP signatures appear in dunes adjacent to and apparently sourced from within the icy outliers to the south of Olympia Undae, which may contain a similar set of units to the upper layers of PB [16]. HCP is also detected within the north polar veneers that drape PB and emanate from the PB 2 unit [14], a lithic unit located between the upper and lower NPLD. It has been proposed that these sediments are a dusty sublimation lag [15]; however, this is inconsistent with their HCP mineralogy. An aeolian origin is also unlikely on top of the plateau. We propose that these sediments may instead be a layer of impact ejecta [17], which is consistent with our observations of HCP in some impact ejecta elsewhere in the northern plains. HCP from the veneers is also incorporated into dunes near 0°E, where the dark veneers partially obscure the underlying terrain below the ice cap.

Gypsum sources: There is at least one obvious source of gypsum in the north polar region: the concentrated gypsum deposit sourced from far eastern Olympia Undae and transported via wind throughout that dune field [4]. However, hydrated minerals, usually identifiable as gypsum, appear to also be present at lower abundances in all aeolian source units – both the veneers and cavi unit [6,13,17]. This is reflected in the low abundance of gypsum present throughout the north polar dune sea, and may suggest that some process of aqueous alteration has been common in this region during the Amazonian.

CRISM hi-res analysis: Preliminary analysis of CRISM MTRDR observations over the Chasma Boreale scarp appears to generally support the inferences made from the lower resolution OMEGA map. The cavi unit exhibits spectral signatures similar to that of the OMEGA weathered glass unit, and the north polar veneers exhibit HCP-like signatures. Interestingly, the strongest hydration signatures at this location are associated with sand dunes on the chasma floor, potentially sourced from the cavi unit. More detailed analysis with methods like those used on the OMEGA map will help to confirm the hypotheses discussed above.

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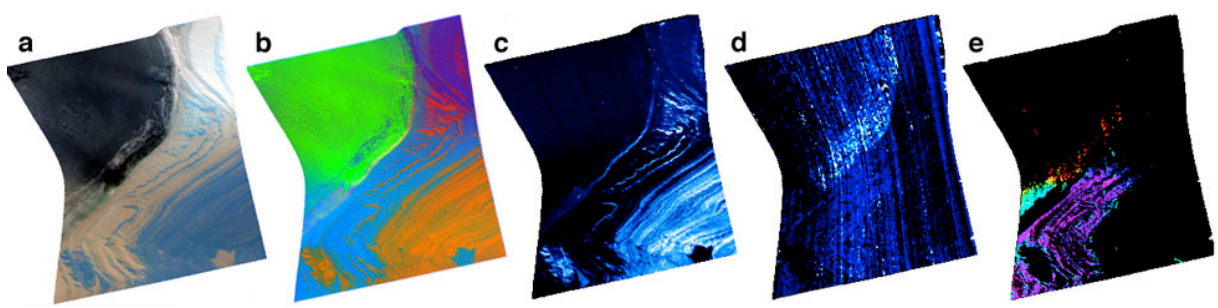

Figure 2: *CRISM FRT0000C093 at the head scarp of Chasma Boreale, with the plateau to the bottom right and floor to the upper left, separated by an exposure of the lower PLD and the cavi unit. (a-b) False color RGB composites of VNIR and IR parameters (a: 2.5/1.3/0.77µm; b: BD1500/BDI1000VIS/RBR), only possible with joined MTRDR data [10]. (c) 1.5 µm ice band depth [6] showing ice on plateau. (d) 1.9 µm band depth (corrected for ice), indicating hydrated minerals on chasma floor. (e) Concavity [9], low values (purple/blue) indicate pyroxene on the plateau, high values (green/red) indicate weathered glass in the cavi unit.*