MINERALOGY OF AEOLIAN SAND IN GALE CRATER, MARS.

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Introduction: The Mars Science Laboratory *Curiosity* rover landed in Gale crater in August 2012 to search for habitable enironments preserved in the rocks and sediments on the lower slopes of Aeolis Mons (i.e., Mount Sharp) [e.g., 1]. Along the traverse, *Curiosity* encountered an active aeolian sand sheet, informally known as the Bagnold dune field [2]. Orbital CRISM vis/near-IR data suggest that there are varying abundances of olivine and pyroxene across the dune field, where the barchan dunes on the edge of the dune field have stronger olivine signatures than the linear dunes [3,4]. To investigate these mineralogical variations *in situ*, *Curiosity* studied two areas of the dune field, one with barchanoid dunes (Phase 1 of the Bagnold campaign) in January 2016 and another with linear dunes (Phase 2) in April 2017 (Fig. 1). A sample at each site was scooped and delivered to the instruments inside of the rover, including the Chemistry and Mineralogy (CheMin) instrument. Results from Phase 1 have been reported previously [e.g., 4-8]. Here, we give a preliminary report on the mineralogy of the Phase 2 sample (named Ogunquit Beach, OG), compare it to mineralogy of the Phase 1 sample (Gobabeb, GB, collected from Namib dune), and discuss potential causes of mineralogical variability in the Bagnold dune field.

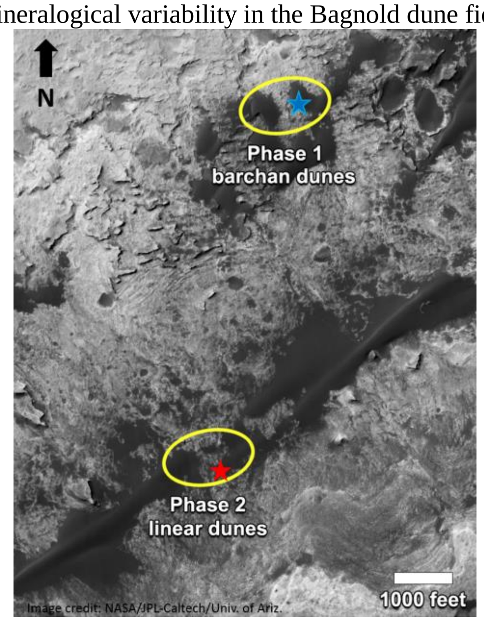

Fig. 1. HiRISE image of a portion of the Bagnold dune field showing the location of Phase 1 and Phase 2 of the campaign. Sample locations are denoted with stars.

Methods: OG was scooped from the Mount Desert Island sand patch and was sieved to <150 μm. This sample was delivered to the CheMin X-ray diffractometer and was analyzed over three nights (~22 hours of integration time). From the resulting XRD pattern, the proportions of crystalline phases were determined by Rietveld refinement using MDI Jade, and the abundances of X-ray amorphous materials and clay minerals were determined using FULLPAT [9]. Results presented here are preliminary. At the time of writing, OG remains in the CheMin instrument and additional nights of analysis are possible.

Mineralogy of OG (Preliminary): OG is dominated by basaltic igneous minerals and X-ray amorphous materials (Figs. 2 and 3). Plagioclase, olivine, augite, and pigeonite are the dominant crystalline phases, and X-ray amorphous materials comprise ~1/3 of the sample by weight. Minor phases include magnetite, hematite, anhydrite, quartz, and a 10 Å phyllosilicate.

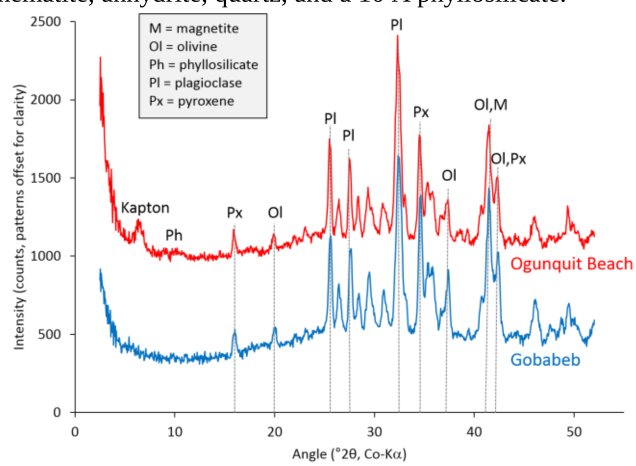

Fig. 2. CheMin XRD patterns of OG and GB, with major peaks labeled. Note: OG was analyzed in a cell with Kapton windows, producing an artifactual peak at ~6 °2θ.

Ogunquit Beach vs. Gobabeb Mineralogy: Although the mineral assembleges in OG and GB are similar, there are distinct differences (Fig. 3). OG contains a larger fraction of plagioclase; has greater abundances of magnetite, hematite, anhydrite, and quartz; and shows evidence for phyllosilicate (a broad peak near 10 Å). GB contains a greater fraction of mafic minerals olivine, augite, and pigeonite, and contains no phyllosilicate.

The mineralogy of OG and GB are broadly similar to the mineralogy of the Rocknest (RN) sand sample (Fig. 3), which was scooped from an inactive sand shadow near the rover's landing site. In general, the mineral abundances in RN are between those measured in OG and GB. This suggests a similar source for the sediments in RN.

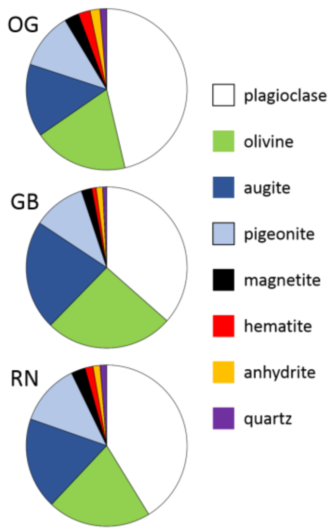

Fig. 3. Mineral pie diagrams for the crystalline component only for all loose sediment samples measured by CheMin to date.

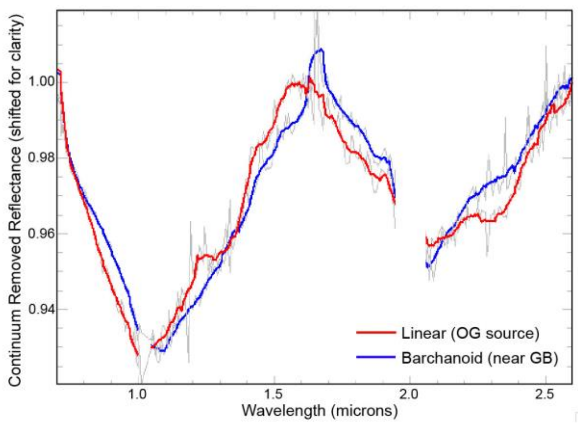

Fig. 4. CRISM spectra from the linear dune from which OG was sampled and a barchanoid dune south of the dune from which GB was sampled.

The CheMin data from the Bagnold dune field are consistent with orbital near-infrared data collected by CRISM, which show variations in relative abundances of olivine vs. pyroxene. The spectrum from a barchanoid dune near the site of the GB sample has a 1 μm band shifted to slightly longer wavelengths and a slightly weaker ~2 μm band compared to the spectrum from the linear dune that sourced the OG sample (Fig. 4). These subtle differences are consistent with a higher olivine-to-pyroxene ratio in the barchanoid dune. Variability in the 2 μm band may imply differences in the relative abundances of two pyroxene minerals, which is compatible with CheMin data from OG and GB that show different augite-to-pigeonite ratios.

Potential causes of mineral variability. Mineral variability within the Bagnold dune field could be caused by aeolian sorting, where the sediment-starved barchanoid dunes would be enriched in denser, coarser-grained minerals (i.e., olivine) compared to the linear dunes because of aeolian deflation and removal of less dense minerals, although grain shape also plays a role in grain mobility [3,4]. Alternatively, the variability may be a result of mixing from different sediment sources [4]. We suggest that the mineralogy of the barchanoid and linear dunes is consistent with a combination of both aeolian sorting and mixing of different sediment sources. MAHLI images from Phase 1 of the campaign demonstrated that the larger grain sizes are comprised of more olivine and pyroxene, whereas the smaller grain sizes contain more feldspar [7]. OG is located further downwind from GB, which may explain the higher abundances of plagioclase relative to olivine and pyroxene in OG; however, both felsic and mafic grains should be mobilized by the observed winds [7]. The presence of clay minerals in OG and the greater abundances of hematite, magnetite, and anhydrite may reflect a contribution from local bedrock. CheMin analyses of mudstone samples from the upper Murray formation, which underlies the linear dunes of Phase 2, show abundant smectite, hematite, and Ca-sulfate [10]. Smectite and Ca-sulfate, in particular, are relatively soft minerals, and may be easily incorporated into the active aeolian sand by abrasion of the underlying Murray formation. Furthermore, these phases are less dense than mafic minerals and may accumulate downwind. Alternatively, clay minerals identified in OG may be a result of contamination from previous smectite-bearing mudstone samples in the sample handling system.

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