MINERALOGICAL CHARACTERIZATION BY XRD OF GYPSUM DUNES AT WHITE SANDS NATIONAL MONUMENT AND APPLICATION TO GYPSUM DETECTION ON MARS. B. Lafuente[1], J. L. Bishop[2], L. K. Fenton[2], S. J. King[2], D. Blake[3], P. Sarrazin[2], R. T. Downs[1], B. H. Horgan[4], G. C. Garcia[2,5]. [1]Department of Geosciences, University of Arizona, Tucson, AZ, USA, barbaralafuente@email.arizona.edu, [2]Carl Sagan Center, SETI Institute, Mountain View, CA, USA, jbishop@seti.org, [3]NASA Ames Research Center, Mountain View, CA, USA, [4]Arizona State University, Phoenix, AZ, USA, [5]The University of Texas Pan-American, Edinburg, TX, USA.

Introduction: The presence of gypsum ($CaSO_4 \cdot 2H_2O$) in Olympia Undae was reported on the basis of OMEGA imaging spectrometer data [1]. Because gypsum is formed in the presence of liquid water, this discovery has important implications for the climatic and sedimentary history of the currently cold and dry north polar region of Mars.

The goal of this study is to clarify our understanding of the origin and history of the gypsum-rich sand dunes at Olympia Undae using the terrestrial analog White Sands dune field. Field and lab analysis of mineral abundance and grain size have been performed on White Sands material from several dunes (Fig. 1) using a visible/near –infrared (VNIR) spectrometer [2] and a X-ray diffraction (XRD) system.

Here we present the analysis carried out using a Terra (Olympus NDT) portable field XRD instrument.

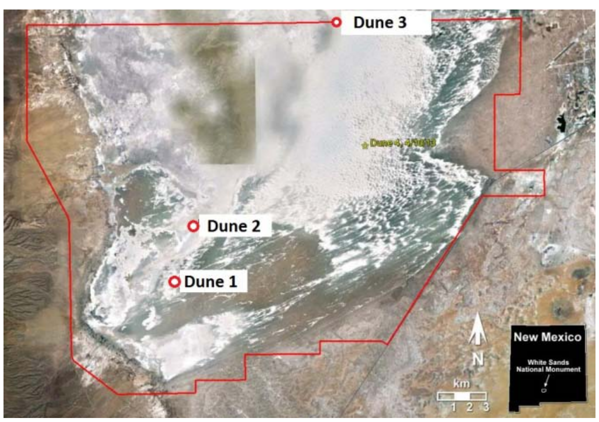

Figure 1. The White Sands dune field with the location of the dunes where samples were collected.

The Terra XRD instrument is based on the technology of the CheMin (CHEmistry and MINeralogy) instrument onboard the Mars Science Laboratory (MSL) rover Curiosity, which is providing the mineralogical and chemical composition of scooped soil samples and drilled rock powders collected at Gale Crater [3]. Using Terra at White Sands will contribute to "ground truth" for gypsum–bearing environments on Mars.

Background: The OMEGA imaging spectrometer data was collected at Olympia Undae, located in the northern hemisphere of Mars between 120-250° E and 77-84° N. It is characterized by a large dune field extended over more than 200,000 km^2 (see [4] for more details). In contrast, the White Sands dune field is a large gypsum dune (>400 km^2), much of which is contained within the White Sands National Monument, New Mexico, USA.

XRD analysis consists of interpreting the positional relationship of diffracted intensities. Each crystalline phase has a unique diffraction pattern, and consequently XRD is the gold standard for identifying materials. In particular, the calcium sulfates can be easily distinguished by their XRD patterns (Fig. 2). Depending on the amount of water within the crystal structure, calcium sulfates are found in three different phases: gypsum ($CaSO_4 \cdot 2H_2O$), bassanite ($CaSO_4 \cdot 0.5H_2O$), and anhydrite ($CaSO_4$), and the sulfite hannebachite ($CaSO_3 \cdot 0.5H_2O$).

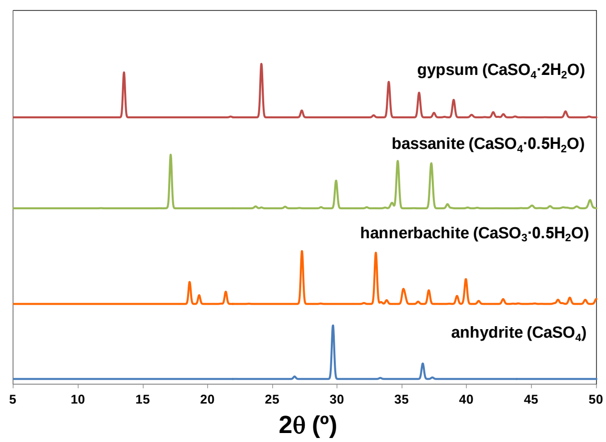

Figure 2. Calculated XRD patterns of three calcium sulfates and the sulfite hannebachite (from The RRUFF™ Project).

Experimental: Samples from the dunes at White Sands were analyzed in the field by XRD and VNIR spectroscopy, revealing quartz and dolomite, in addition to gypsum. Coarse grains were ground to ~150 µm grain size for XRD measurement. Relative mineral abundances were estimated using the Reference Intensity Ratio (RIR) method [3] which requires calibration against standards. Particulate samples of pure natural gypsum, quartz and dolomite were used to prepare calibration standards of gypsum-quartz and gypsum-dolomite with the 90-150 µm size fractions. All single phases and mixtures were measured by XRD (Fig. 3-4) and RIR factors were calculated for use in the quantitative analysis.

Results: Samples from dune 1 and 2 show quartz abundance at 5.6 and 2.6 wt.% respectively, while dolomite has been detected in some locations at dune 3 as high as 80 wt.%. (Fig. 5).

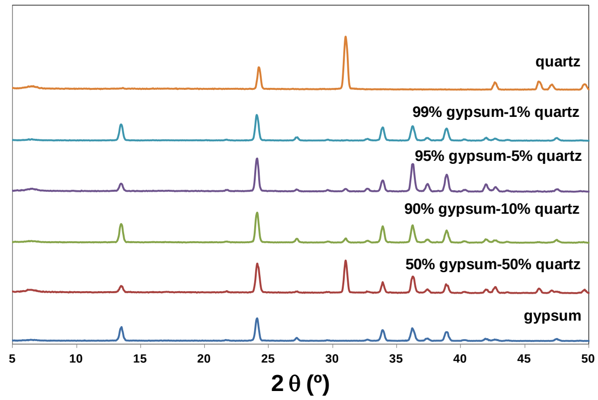

Figure 3. Measured XRD patterns of gypsum-quartz mixtures.

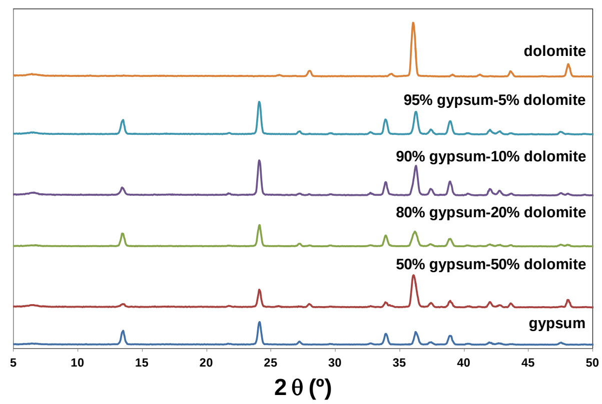

Figure 4. Measured XRD patterns of gypsum-dolomite mixtures.

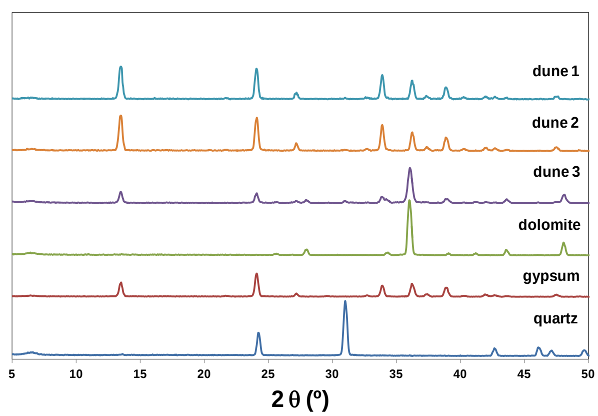

Figure 5. Measured XRD patterns of field analysis for dunes 1, 2 and 3.

In order to analyze the grains in dune 3 in more detail, size fractions were prepared in the lab from selected samples [2].

Grains sieved to <1000 μm and >1000 μm of a sample collected at dune 3 were analyzed by XRD (Fig. 6). We discovered that the finer grains contain only gypsum and quartz, while grains over 1000 μm in size are composed of gypsum, quartz, dolomite and calcite. Carbonates are harder than gypsum and are not as prevalent among the finer grains.

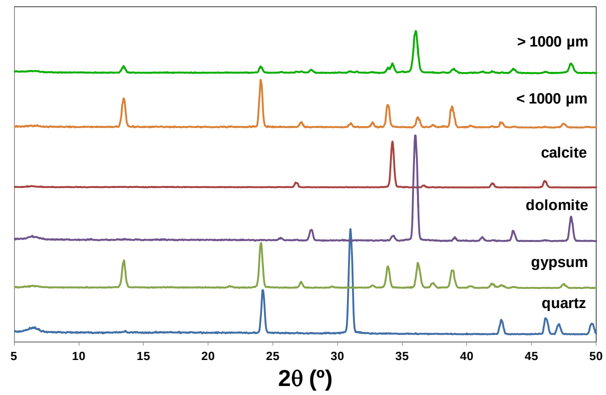

Figure 6. Measured XRD patterns of two grain size fractions for dune 3.

Summary: The results obtained from the field analyses performed by XRD and VNIR spectroscopy revealed the presence of quartz, and dolomite in addition to gypsum. Quartz appears to be present in all dunes in low amounts (2-5 wt.%), while dolomite is present at percentages up to 80 wt.% in dune 3. Both dolomite and calcite were detected in grains over 1000 μm in size from dune 3. The identification of gypsum by XRD is unambiguous even when it is mixed with these other phases. No other Ca sulfates were observed in the dune samples. Future XRD analysis will be carried out to estimate the composition of additional dune samples and illustrate the changes in mineralogy with respect to location and grain size.

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References: [1] Langevin et al. (2005) *Science*, *307*, 1584–1586. [2] King et al. (2014) LPSC 45, submitted. [3] Blake et al. (2012) *Space Sci. Rev.*, *170*, 341-399. [4] Fenton et al. (2014) LPSC 45, submitted