CONSTRAINING SULFATE ABUNDANCES ON MARS USING CRISM SPECTRA AND LABORATORY MIXTURES. J. T. Clark[1], J. L. Bishop[2], M. Parente[3], A. J. Brown[2], and N. K. McKeown[4], [1]Dept of Physics, University of Calif., One Shields Avenue, Davis, CA 95616 (jtcclark@ucdavis.edu), [2]SETI Institute/NASA-ARC, Mountain View, CA, 94043 (jbishop@seti.org), [3]Stanford University, Stanford CA, 94305, [4]University of Calif., Santa Cruz, CA, 95064.

Introduction: We performed laboratory mixtures of the sulfate minerals kieserite and gypsum with altered basaltic ash in order to gain information on detection limits for these minerals on Mars. Visible/near-infrared (VNIR) hyperspectral images collected by the Observatoire pour la Minéralogie, L'Eau, les Glaces et l'Activité (OMEGA) instrument [1, 2] and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [3, 4, 5] have detected sulfate minerals in many locations on Mars. These detections include the monohydrated Mg sulfate mineral kieserite and the polyhydrated Ca sulfate mineral gypsum. Our results indicate that the spectral features characteristic of gypsum are much harder to detect in mixtures with basalt than those used to identify kieserite. This suggests that locations on Mars where gypsum features are identified in VNIR spectra have higher concentrations of sulfate present than the locations exhibiting spectral features due to kieserite. Our results indicate that as much as 50 wt.% kieserite could be present in the sulfate mounds of Juventae Chasma on Mars.

Methods: The altered volcanic ash is from Haleakala, Maui, and was dry sieved to <45 and <125 µm for a previous study [6]. The gypsum ($CaSO_4 \cdot 2H_2O$) sample is from M. Lane [7] and the kieserite ($MgSO_4 \cdot H_2O$) sample is from D. Dyar. Samples were weighed and mixed by gently stirring the particles then shaking them in a sieve. VNIR spectra were measured using an ASD spectrometer under ambient lab conditions of the particulate samples poured on to a black Teflon dish.

Continuum-removed lab spectra were prepared using Mr.PRISM software developed by A. Brown [8]. Band depths were determined by measuring the percent reflectance of the feature of interest in the continuum-removed spectrum.

Results: VNIR spectra of the gypsum mixtures are shown in Figs. 1 and 2. The gypsum spectrum exhibits characteristic features due to overtones and combinations of H_2O and SO_4 vibrations near 1500, 1760, 1930 and 2250 nm [e.g. 9]. These four bands are clearly present for mixtures containing 45 and 60 wt.% gypsum (Fig. 1). Another set of measurements of gypsum/basaltic ash mixtures showed that these features were poorly resolved at 30 wt.% and below.

Shown in Figs. 3 and 4 are VNIR reflectance spectra of kieserite/basaltic ash mixtures. Monohydrated sulfate spectra exhibit a unique strong H_2O band near 2100 nm. The kieserite spectrum also has a broad band near 1500-1700 nm and a sharp band near 2400 nm that are relatively uncommon and thus useful mineral indicators. The features near 2100 and 2400 nm are still evident in the 15 wt.% kieserite mixture although the reflectance is significantly darkened by the basaltic ash (Fig. 3).

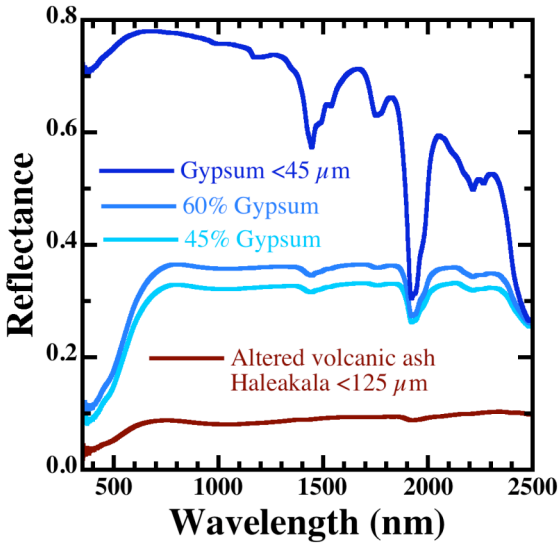

Fig. 1 VNIR reflectance spectra of mixtures of gypsum in altered volcanic ash.

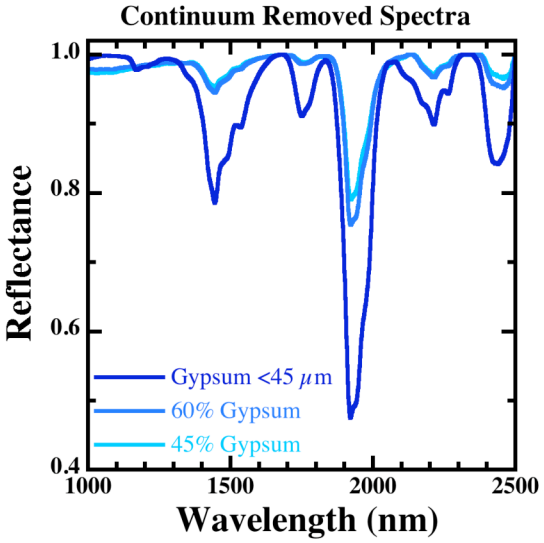

Fig. 2 Continuum-removed spectra of gypsum and gypsum/basaltic ash mixtures from Fig. 1. These spectra illustrate the significant masking effects of the gypsum bands by the basaltic ash in these mixtures.

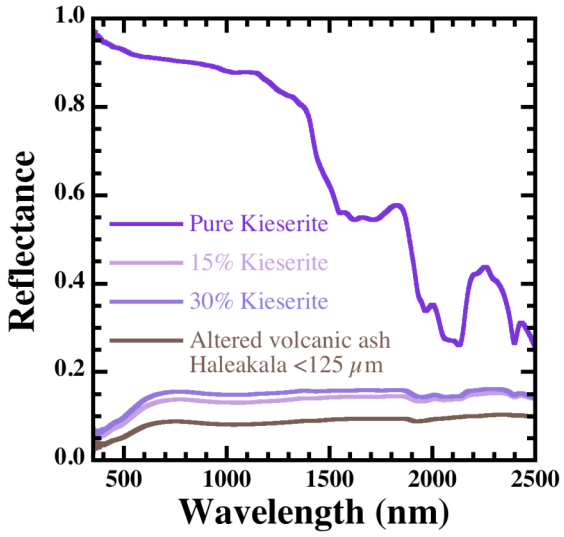

Fig. 3 VNIR reflectance spectra of mixtures of kieserite in altered volcanic ash.

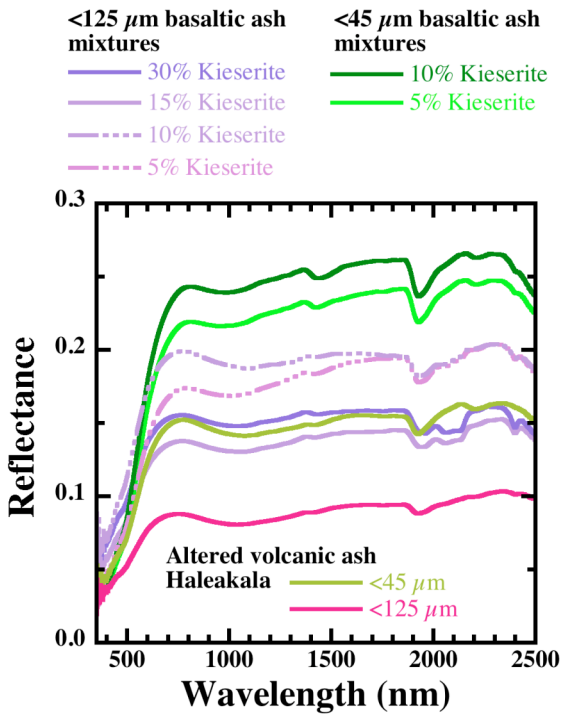

Fig. 4 VNIR reflectance spectra of mixtures of kieserite in two grain sizes of altered volcanic ash.

Mixtures were prepared with both <45 and <125 µm basaltic ash for the lower % kieserite mixtures to test the influence of grain size on these features. The kieserite mixtures with <45 µm basaltic ash have a brighter reflectance and show only a hint of the ~2100 and 2400 nm bands. In contrast the kieserite mixtures with the <125 µm basalt have a darker reflectance and still exhibit weak, but clearly present bands near 2100 and 2400 nm at the 5 wt.% kieserite level.

Band depths. Band depths are displayed in Fig. 5 for the characteristic kieserite bands near 2100 and 2400 nm in the mixture spectra. The shapes of these two curves are internally consistent suggesting that the slight non-linearities are due to mixing or abundance issues with the samples rather than incorrect band depth measurements.

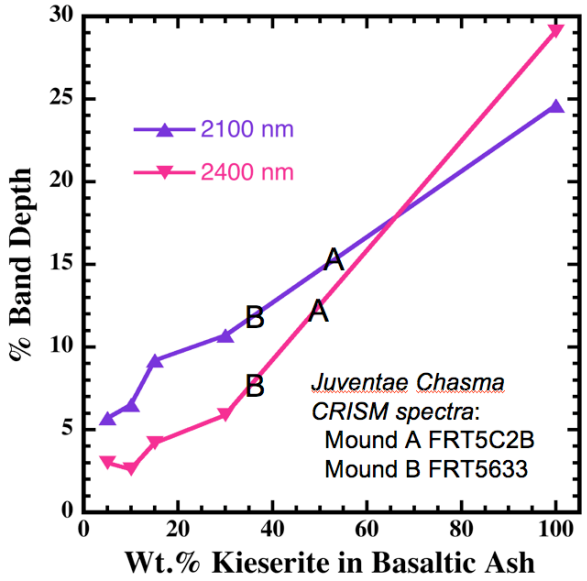

Fig. 5 Band depths of kieserite versus % composition in altered volcanic ash. CRISM spectra from the sulfate mounds in Juventae Chasma [10] are shown for comparison.

Relation to CRISM spectra. Band depths of CRISM spectra bearing kieserite signatures are shown in Fig. 5 for comparison. These spectra represent examples of the strongest kieserite detections in the sulfate mounds of Juventae Chasma [5,10]. The band depths derived for the 2100 and 2400 nm bands in each spectrum compare well with each other. These data are consistent with 50-53 wt.% kieserite in mound A and ~37 wt.% kieserite in mound B. Future experiments are planned to test the effects of varying the mixture substrate and the grain size.

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