LABORATORY SPECTROSCOPIC STUDIES OF JAROSITE AND OTHER HYDRATED MINERAL MIXTURES RELEVANT TO MARS.

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Introduction: Deposits of hydrated and hydroxylated minerals have been identified using visible-near infrared reflectance (VNIR) spectra acquired by various spectral payloads (e.g., Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard Mars Reconnaissance Orbiter (MRO)), indicating a complex history of water–rock interaction on Mars. Many of these spectra are often discussed in terms of single mineral. Although these deposits undoubtedly contain various minerals. Some visible-near infrared reflectance (VNIR) spectra exhibit enigmatic 'doublet' features with two absorptions at ~2210 and ~2270 nm (e.g. a doublet region from western of Jezero Crater as shown in Fig. 1) [1-4]. The band strengths of these two features vary independently, implying a mixture of two or more components [5].

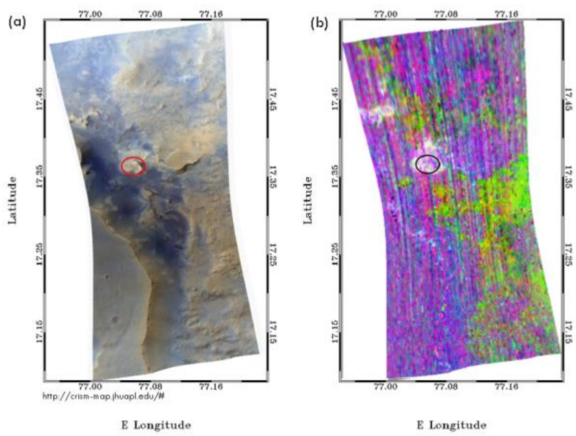

Fig. 1. False-color CRISM image with 'doublet' features (marked by circle) for hrl0000b8c2 from western of Jezero Crater. (a) red = 592 nm, green = 533 nm, blue = 492 nm; (b) red = BD2210, green = BD2265, blue = SINDEX.

Previous studies have proposed some hypotheses to explain materials consistent with 'doublet' features: (1) pure sulfates or their mixtures (structurally similar to gypsum and jarosite) [3]; (2) a combination of opal and Fe/Mg smectite [3]; (3) mixture of poorly crystalline Al-ferric clays and/or sulfate [3, 6-7]; and [4] mixture of Al-smectite, Fe/Mg-smectite, and/or jarosite [2, 7-9]. However, the exact assemblage resulting in 'doublet' features has remained ambiguous. Thus, laboratory synthesis and spectroscopic studies of pure endmember and their mixtures are necessary to characterize 'doublet' features in detail. In this work, we selected four samples (K-bearing jarosite, K-bearing alunite, gypsum and basanite) for the first-step mixture experiments and spectroscopic analysis with the intent to better understand 'doublet' features on Mars.

Sample Preparations: We synthesized jarosite and alunite under hydrothermal conditions in autoclaves at an incubator chamber. Details about the synthesis methods are given in Ref [10-12].Three mixed samples of jarosite and alunite (JaAl), (2) jarosite and gypsum (JaGy), jarosite and basanite (JaBa) were prepared in the proportion of 1:1 in weight, and ground in an agate mortar before VNIR spectroscopy measurement.

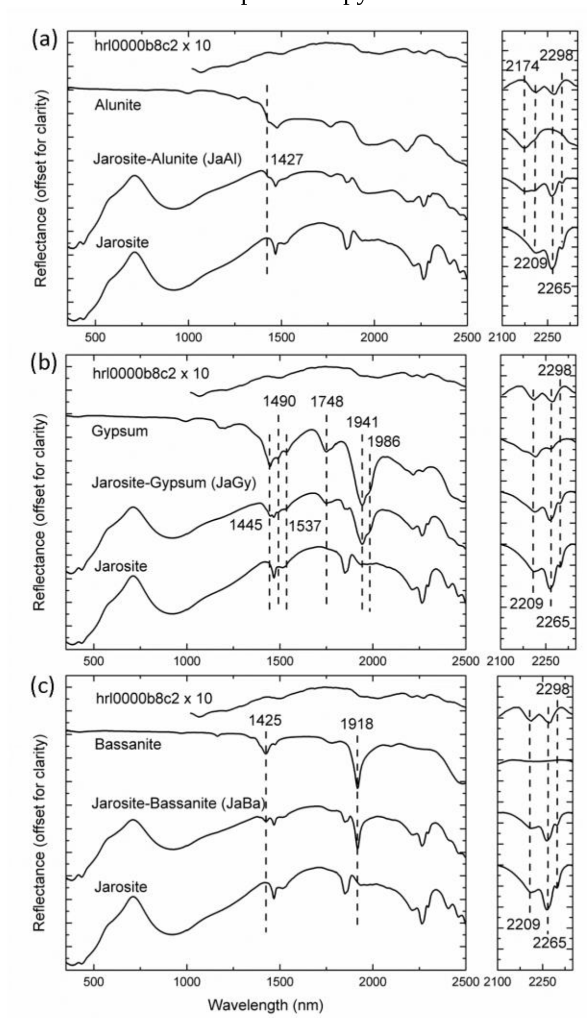

Fig. 2. VNIR and continuum-removed spectra of mixed samples between jarosite-alunite (a), jarosite-gypsum (b), jarosite-bassanite (c), and a spectrum with 'doublet' features from hrl0000b8c2.

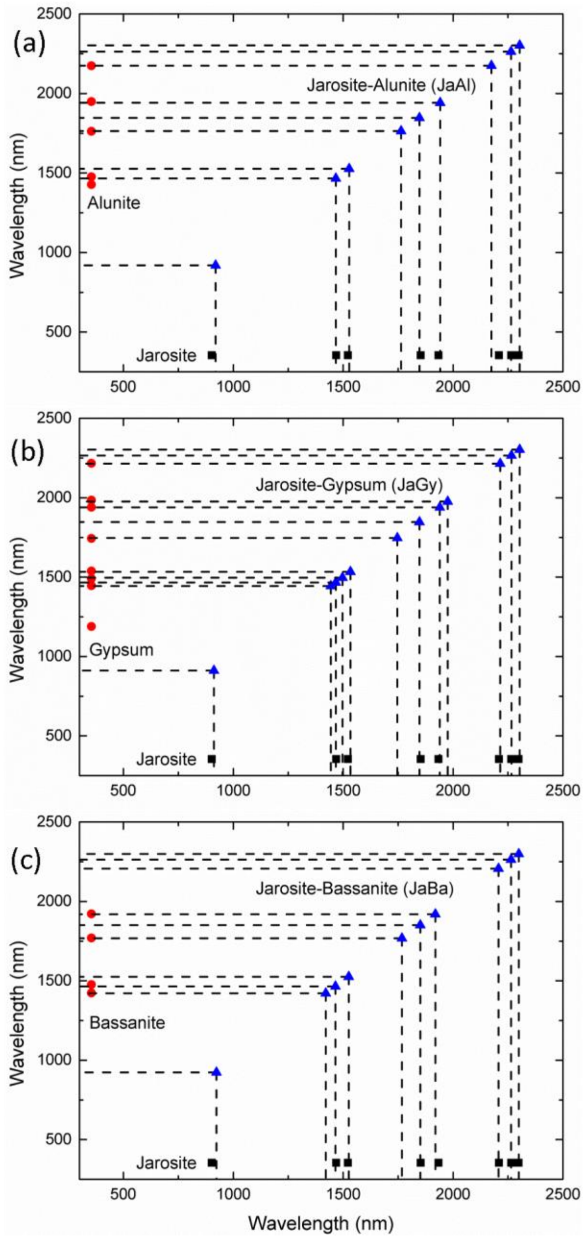

Fig. 3. Absorptions in the 350-2500 nm range for endmembers (red and black dots) and two-phase mixtures (blue dots).

VNIR spectroscopy measurement: VNIR spectra were collected with FieldSpec® 4 Hi-Res VNIR spectrometer (Analytical Spectral Devices., Inc) from 350 to 2500 nm with the spectral resolutions of 3 nm at visible region (350 to 1000 nm) and 8 nm at near-infrared region (1000 to 2500 nm) respectively. All measurements were made using a Spectralon® panel as the reflectance standard. The continuum from 2100 nm to 2350 nm was removed by a straight line method.

Results and Discussion: As shown in Fig. 2, all endmembers show the characteristic absorption of sulfates at ∼2400 nm due to $3\nu_3$ S–O stretch and/or $\nu_{OH/H2O}$ + $\gamma/\delta_{OH/H2O}$, and demonstrate OH/H_2O-combinations at ∼1750 nm [10]. The H_2O-bearing phases (gypsum and bassanite) demonstrate H_2O overtones at ∼1400 nm, and H_2O combinations at ∼1900 nm. The OH-bearing phases (jarosite and alunite) display OH stretching overtones at ~1400 nm.

All mixed samples demonstrate overlapped features of endmembers (Fig. 3), particularly for JaGy, leading variation of 'doublet' feature. Jarosite and all mixtures share similar spectral features at ~950 nm arising from iron electronic transitions.

The absorption feature of JaAl at ~2210 nm is visually much broader than the other one (at ~2270 nm), which is inconsistent with CRISM (shown in Fig. 1). The 'doublet' features of bassanite is absent. Bassanite accordingly may not be the candidate of 'doublet' features. The relative intense of two distinct absorption features of JaGy at ~2210 and ~2270 nm is different from endmembers, indicating JaGy samples with different proportions of endmembers may exhibit independently-varying 'doublet' features. Thus, mixtures of jarosite and gypsum may be spectral candidate for the remotely-detected doublet features on Mars.

Future Work: We will focus on analyzing 'doublet' features of mixtures quantitatively and extend our laboratory mixture experiments (e.g., jarosite mixed with Al-phyllosilicates). Furthermore, we will compare our results with CRISM data for detailed VNIR mineralogical mapping (particularly mixtures of sulfates) and better understand the past water-rock interactions processes on Mars.

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