

**SULFATES IN JUVENTAE CHASMA AS SEEN BY CRISM.** J. L. Bishop<sup>1</sup>, S. L. Murchie<sup>2</sup>, A. J. Brown<sup>1</sup>, S. M. Pelkey<sup>3</sup>, L. A. Roach<sup>3</sup>, J. F. Mustard<sup>3</sup>, J.-P. Bibring<sup>4</sup>, and the CRISM Team, <sup>1</sup>SETI Institute/NASA-ARC, Mountain View, CA, 94043 (*jbishop@arc.nasa.gov*), <sup>2</sup>JHU/Applied Physics Laboratory, Laurel, MD 20723, <sup>3</sup>Dept. of Geological Sciences, Brown University, Providence, RI 02912, <sup>4</sup>Institute d'Astrophysique Spatial (IAS), Orsay, France.

**Introduction:** We are investigating the presence and character of sulfate minerals observed in Juventae Chasma using hyperspectral visible/near-infrared (VNIR) CRISM images. Juventae Chasma is located just north of Valles Marineris, and the sulfate minerals kieserite and gypsum were identified here using Mars Express/OMEGA hyperspectral VNIR images [1,2]. Analyses of MOC and MOLA data suggest that subice volcanic eruptions occurred in this region [3]. Analyses of HRSC images indicate that interior layered deposits in a northern site within Juventae Chasma are deltaic deposits, while interior layered deposits in a site towards the south of the chasma formed via evaporitic processes [4]. We hope to contribute toward understanding the composition and genesis of this region through ongoing analyses of CRISM images.

**Image background:** Targeted MRO/CRISM images collect 544 wavelengths from 0.36 to 3.9  $\mu\text{m}$  [5]. Images are processed for instrumental effects, converted to I/F and the atmosphere is removed using a ratio with a CRISM scene of Olympus Mons, scaled to the same column density of  $\text{CO}_2$ . A similar atmospheric correction has been successfully used for OMEGA data [1]. One targeted image was collected in Juventae Chasma so far, located at  $\sim 3.4^\circ\text{S}$  and  $61.6^\circ\text{W}$  as shown in the THEMIS image [6] in Figure 1.

**Spectral Background:** Gendrin et al. [2] identified gypsum in the interior region of Juventae Chasma

using bands near 1.4, 1.75, 1.9, and a spectral dropoff at 2.4  $\mu\text{m}$ . Similarly, they used bands near 1.6, 2.1 and 2.4  $\mu\text{m}$  to identify monohydrated sulfate that best corresponded to the mineral kieserite.

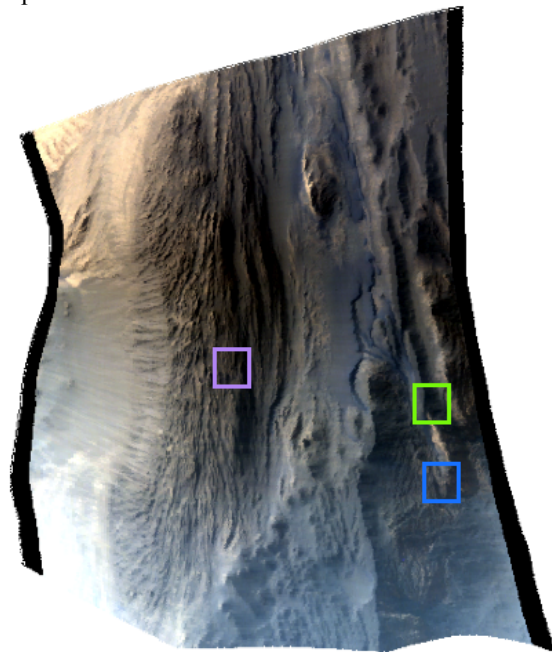


Fig. 2 Approximately true color view (red: 592 nm, green: 533 nm, blue: 442 nm) of the  $\sim 12$  km wide CRISM image HRL000028A6\_07 at 30-40 m/pixel scale; boxes refer to spectra in Fig. 3.

Fig. 1 (a) MOLA map of Valles Marineris, (b) expanded view of Juventae Chasma (blue box) as THEMIS mosaic with THEMIS track I07006001 overlaid. The CRISM image is located in the upper right corner (pink box).

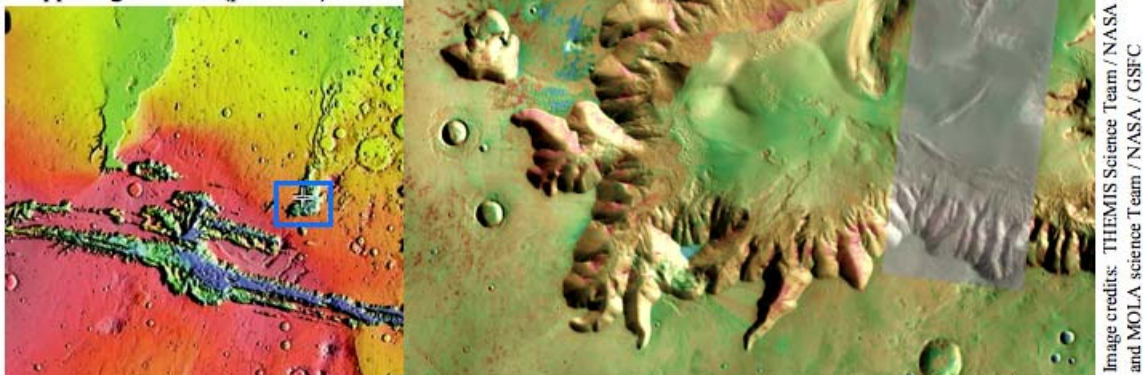


Image credits: THEMIS Science Team / NASA / JPL / ASU and MOLA science Team / NASA / GSFC

**Discussion:** Features attributed to sulfate minerals were observed throughout image HRL000028A6\_07 of Juventae Chasma at  $\sim 1.45, 1.57, 1.78, 2.05, 2.08, 2.41,$  and  $2.52 \mu\text{m}$ . Example spectra are shown in Fig. 3 that are typical of what is observed. These spectra are consistent with hydrated minerals and likely contain a mixture of hydrated sulfates and other phases, although clear evidence of mafic minerals was not observed here as in Candor Chasma [7]. Some of the strongest sulfate features were observed in darker albedo terrains as in the Candor Chasma region [7].

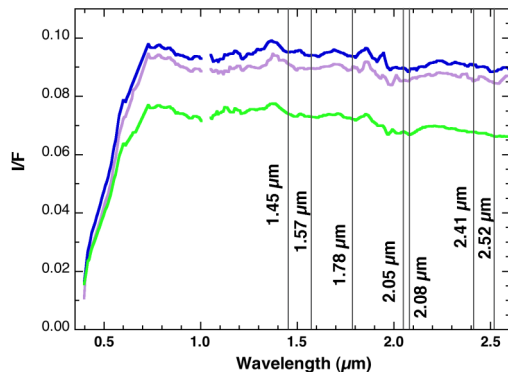


Fig. 3 CRISM spectra from regions marked on Fig 2. Spikes were removed from the data and 5-point smoothing was performed. Some noise is still present near  $1.9 \mu\text{m}$  and  $2.7 \mu\text{m}$  from imprecise atmosphere separation.

Table 1

Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
Kieserite	$\text{MgSO}_4 \cdot \text{H}_2\text{O}$
Starkeyite	$\text{MgSO}_4 \cdot 4\text{H}_2\text{O}$
Szomolnokite	$\text{Fe}^{2+}\text{SO}_4 \cdot \text{H}_2\text{O}$
Kornelite	$\text{Fe}^{3+}_2(\text{SO}_4)_3 \cdot 7\text{H}_2\text{O}$
Copiapite	$\text{Fe}^{2+}\text{Fe}^{3+}_4(\text{SO}_4)_6(\text{OH})_2 \cdot 20\text{H}_2\text{O}$

Lab spectra of several particulate sulfate minerals (Table 1) and a neutralized acid mine drainage (AMD) material containing gypsum and ferrihydrite are shown in Fig. 4. These spectra were selected due to features near  $1.78$  and/or  $2.1 \mu\text{m}$  and are part of a combined multiple technique spectroscopy study of sulfate minerals for analysis of Martian data [8,9,10]. None of these sulfate spectra alone can explain all of the features observed in the Juventae Chasma spectra, rather a mixture of these sulfates and/or other components are necessary. Features due to  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  are also observed in these CRISM spectra, which could be in a sulfate mineral or other phase.

Many low-albedo regions (e.g. green spectrum) of this interior section of Juventae Chasma exhibit spectral features consistent with kieserite. Other iron sulfate minerals such as szomolnokite and kornelite could be contributing to the band near  $2.08 \mu\text{m}$ . The kornelite and copiapite spectra both have a feature near  $1.78 \mu\text{m}$  and a spectral droffoff near  $2.4 \mu\text{m}$ . The band

near  $1.45 \mu\text{m}$  in this low-albedo Juventae Chasma spectrum is attributed to bound water in a hydrated mineral. Some of the higher albedo region spectra exhibit bands near  $2.41$  and  $2.52 \mu\text{m}$  (purple) that can be explained by the presence of starkeyite, plus some kieserite, szomolnokite and/or kornelite. Other high albedo region spectra (blue) that have a band closer to  $2.5 \mu\text{m}$ , and no band near  $2.4 \mu\text{m}$ , are better explained by gypsum, plus some kieserite or other sulfate.

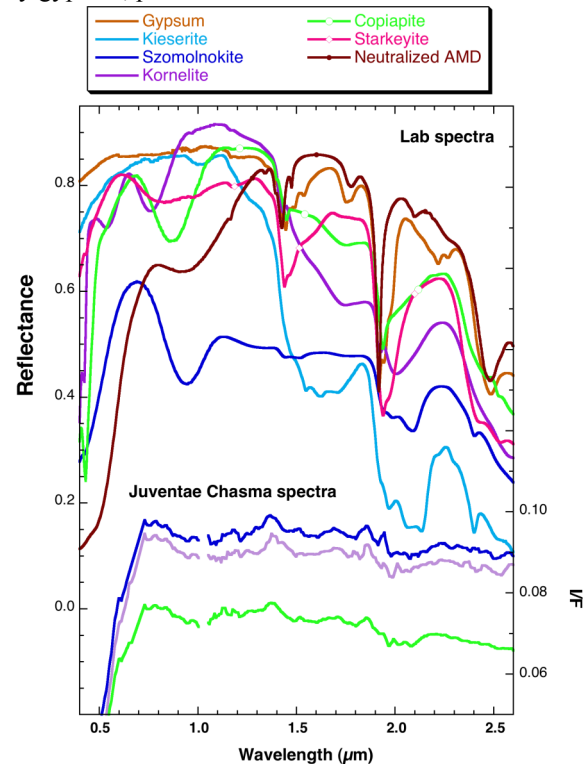


Fig. 4 Lab spectra of sulfate minerals from [8,9,10] compared with CRISM spectra.

**Conclusions:** Many low-albedo regions of this interior section of Juventae Chasma are consistent with the sulfate minerals kieserite, szomolnokite and kornelite. High albedo regions are consistent with polyhydrated sulfate minerals such as starkeyite or gypsum. Continued analysis of this and future images will focus on more comprehensive mineral assignments.

**Acknowledgments:** Lab spectra were measured at Brown/RELAB.

**References:** [1] Bibring J.-P. et al. (2005) *Science*, 307, 1576-1581. [2] Gendrin A. et al. (2005) *Science*, 307, 1587-1591. [3] Chapman M. G. et al. (2003) *JGR*, 108, 5113, doi:10.1029/2002JE002009. [4] Ori g. g. et al. (2006) *LPS XXXVII*, Abstract #1247. [5] Murchie S. (2007) *LPS XXXVIII*. [6] Christensen P.R. et al. THEMIS Public Data Releases, PDS node, ASU, <http://themisdata.asu.edu>. [7] Murchie S. et al. (2007) *LPS XXXVIII*. [8] Lane, M. D. et al. (2004) *GRL*, 31, L19702, doi: 1970.11029/12004GRL021231, [9] Bishop, J. L. et al. (2005) *IJA*, 3, 275-285, [10] Lane M. D. et al. (2007) *LPS XXXVII*.