

Mafic Polyhydrated Sulfates and Kieserite in Capri Chasma. L. Hutchison¹, J. F. Mustard¹, A. Gendrin¹, J-P. Bibring², Y. Langevin², B. Gondet², N. Mangold³, and the OMEGA Science Team. ¹Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI 02912 Leah_Hutchison@brown.edu, ²Institut d'Astrophysique Spatiale, Bâtiment 121, 91405 Orsay Campus, France, ³IDES, Bâtiment 509, 91405 Orsay Campus, France

Introduction: OMEGA spectra of interior layered deposits in Capri-Eos Chasma (Figure 1) show signatures consistent with kieserite and polyhydrated sulfates. The composition and formation of layered deposits in Valles Marineris is a source of debate; understanding the mineralogy of the layered deposits can give insight in to the mechanisms that formed them. OMEGA parameter maps identifying sulfates in Capri-Eos Chasma will be presented, together with RELAB library sulfate spectra and spectra from Rio Tinto, Spain. Rio Tinto is considered a martian analogue due to its acidic nature, high heavy-metal concentration and abundant, diverse microbial life. Understanding the mineralogy at Rio Tinto will enable us to better visualize how martian mineralogy forms and evolves.

Datasets: OMEGA is a visible-near infrared hyperspectral imager on the ESA/Mars Express mission [1]. It has a 1.2 mrad IFOV, a spatial sampling that varies from 300m (at pericenter) to 4.8km (at 4000 km altitude), and a 7 to 20 nm spectral resolution in 352 spectral bands over 0.35-5.1 μm . During its first year of operation, OMEGA has acquired spectra for over 50% of the martian surface.

In situ spectral measurements of Rio Tinto minerals will be taken with an Analytical Spectral Devices (ASD) FieldSpec FR with a spectral range of 0.35-2.6 μm and a 1 nm sampling (though with coarser spectral resolution). In situ measurements will be supplemented by laboratory spectral measurements on a bidirectional spectrometer (with similar resolution and sampling to the FieldSpec FR) in NASA's RELAB facility at Brown University. Both the in situ and laboratory spectrometers have a wavelength range sufficient to cover both the sulfate and iron oxide mineralogy at Rio Tinto and the spectral capabilities of present and future Mars remote sensing instruments.

Background: The interior layered deposits within the Valles Marineris have horizontal rhythmic layering of up to 5km thick and with great lateral continuity. McCauley [2] asserted that only deposition in standing water would produce such features. Water bodies in Valles Marineris would have been ice covered, so sediment would have to penetrate the ice cover by foundering or Rayleigh-Taylor instabilities [3]. A small amount of material could also come in at the sides through canyon wall mass wasting. However, not enough material has apparently been eroded from the canyon walls after Tharsis-related graben formation to account for all interior layered deposits.

Subaqueous volcanic eruptions are another potential material source [3,4] and volcanism would be expected given the chasmata's tectonic formation. Although vents and calderas have not been identified, if the volcanism was subaqueous, they may have been obscured by settling volcanic material [3].

MOC imagery suggests aeolian, fluvial and mass wasting processes were active in erosion of layered deposits; differential weathering forms benches of exposed layers [4,5]. Some layered deposits are mantled with dark units. These dark areas are interpreted as dunes, debris fans and debris in topographic depressions [5].

Results: Kieserite and polyhydrated sulfates have been previously identified in Capri-Eos Chasma by the OMEGA team [1,6]. Kieserite is identified because of its characteristic vibrational absorption features at 1.6, 2.1 and 2.4 μm . Polyhydrated sulfates are identified by plateaus in reflectance starting at 1.4 and 1.9 μm and a drop at 2.4 μm . The polyhydrated sulfates are highly localized, found in an exposed layered terrain but not in neighboring dusty regions, as shown in Fig 2. Deposit locations are indicated on Fig. 1. This finding is consistent with other sulfate deposits in Valles Marineris that are associated with layered deposits [7].

In this study area, preliminary results show polyhydrated sulfate spectra have deep 1 μm absorptions while kieserite spectra do not. This is evident in maps of OMEGA-derived parameters, shown in Figure 3. The leftmost parameter map in Figure 3 is an IR albedo image. The sulfate signatures are located on intermediate to bright surfaces. The kieserite deposit (shown Figure 2c) occurs on the brightest surface. This high reflectivity is likely the result of better exposure of the substrate (e.g. less dusty) than the polyhydrated sulfate deposits. The second parameter map is of an integrated 1 μm band depth, corrected for aerosols. The polyhydrated sulfates show up very well because of their deep iron absorption. The third parameter map shows mafic hydrated minerals and is calculated as: $(1 \mu\text{m integrated band depth}) * (\text{slope between } 2.25 \text{ and } 2.43 \mu\text{m})$. High values in this parameter can be interpreted as hydrated minerals with strong iron absorption bands (e.g. jarosite) or hydrated minerals mixed with other minerals with strong Fe absorption. It does not highlight the kieserite deposit because this lacks a strong 1 μm absorption. The right-most parameter map indicates kieserite. The parameter formulation is: $(2.2188\mu\text{m} + 2.0113\mu\text{m}) / (2.1501\mu\text{m} + 2.1225\mu\text{m})$. Kieserite selectively shows up because of its 2.1 μm

absorption feature. Polyhydrated sulfates generally have a convex slope between 2.0 and 2.2 μm , so they have negative (black) values in this parameter. A variety of parameters are needed to expose the spectral diversity in the area.

Gendrin et al [8] have investigated the relationships among surfaces with deep iron absorptions and sulfate deposits and note a common spatial association, though not always a correlation. They postulate a possible connection with the hematite spherules and sulfate such as observed at the Opportunity landing site. For the deposits in Capri-Eos Chasma, the 1 μm band in the polyhydrated sulfates is very deep. Similar to [8], we find that these absorptions are not associated with olivine or pyroxene. It is not yet possible to distinguish if the iron is in the polyhydrated mineral crystal structure or in a separate ferric oxide component (as suggested by [8]). However, this will be the subject of focused investigations, including sampling Rio Tinto deposits, to resolve this issue.

Further work: Spectra of iron and sulfate minerals from Rio Tinto will be presented, allowing for comparison with OMEGA spectra from Capri Chasma and RELAB library spectra. Expected minerals include Fe oxyhydroxides, Fe oxyhydroxysulfates and Fe sulfates.

Acknowledgements: We wish to acknowledge the OMEGA science team for all their dedication and hard work. Mars Orbiter Camera images were processed by Malin Space Sciences Systems and are available at http://www.msss.com/moc_gallery/.

References: [1] Bibring, J.-P. et al. *ESA SP 1240*, 37, 2004. [2] McCauley, J.F. *USGS Map I-897*, 1978. [3] Nedell, S.S. et al. *Icarus*, 70, 409-414, 1987. [4] Komatsu, G. et al. *LPSC XXXII*, Abst #1048, 2001. [5] Weitz, C.M. et al. *LPSC XXX*, Abst #1629, 2001. [6] Bibring, J.-P. et al, (submitted) 2005. [7] Mangold, N. et al, *LPSC XXXVI*, 2005. [8] Gendrin, A. et al, *LPSC XXXVI*, 2005.

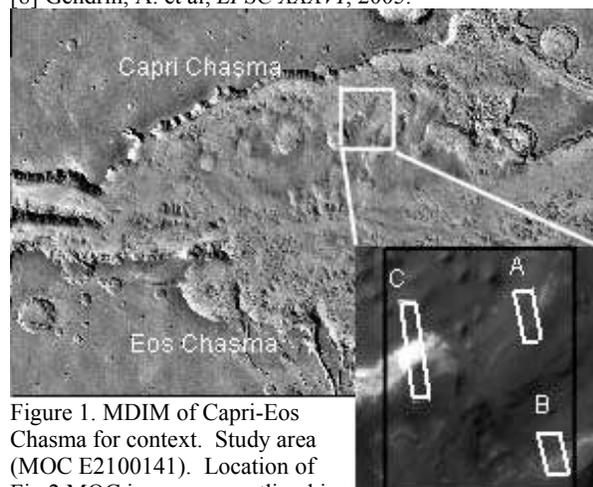


Figure 1. MDIM of Capri-Eos Chasma for context. Study area (MOC E2100141). Location of Fig 2 MOC images are outlined in white and Fig 4 location shown as black outline on inset.

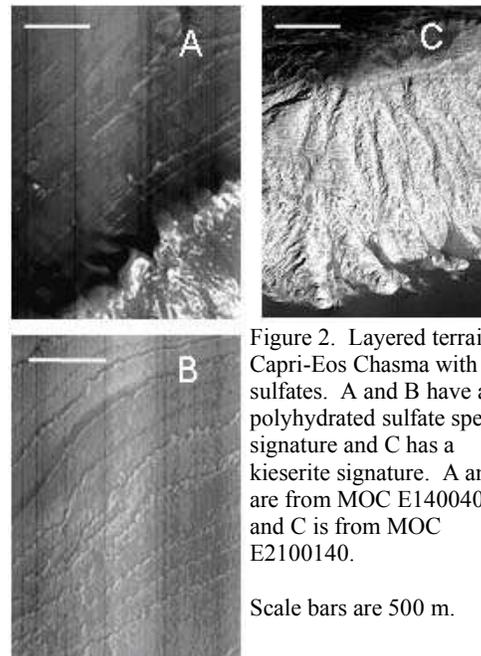


Figure 2. Layered terrain in Capri-Eos Chasma with sulfates. A and B have a polyhydrated sulfate spectral signature and C has a kieserite signature. A and B are from MOC E1400402 and C is from MOC E2100140.

Scale bars are 500 m.

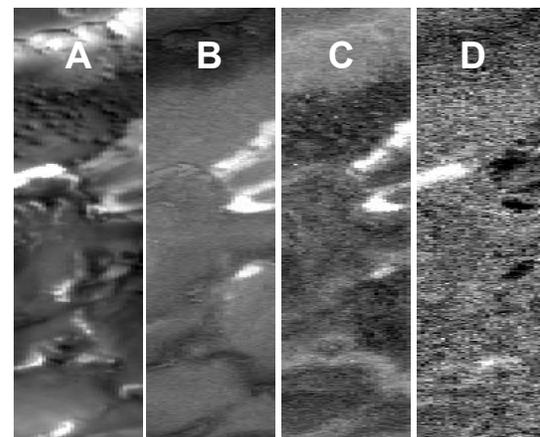


Figure 3. Parameter maps for (A) IR albedo, (B) 1 μm band depth (mafic minerals), (C) mafic hydrated minerals, and (D) kieserite. Kieserite and polyhydrated sulfates have high albedo because they are located in layered terrain. Polyhydrated sulfates show up in (B) and (C), but the kieserite does not because its 1 μm absorption is not deep enough. Each map is 32 km across.