Sulfate and hematite stratigraphy in Capri Chasma, Valles Marineris. L.H. Roach[1], J.F. Mustard[1], S.L. Murchie[2], J.L. Bishop[3], B.L. Ehlmann[1], K. Lichtenberg[4], M. Parente[3], and the CRISM Science Team. [1]Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI 02912, Leah_Roach@brown.edu, [2]Johns Hopkins/APL, Laurel, MD 20723, [3]SETI Institute/NASA-ARC, Mountain View, CA 94043, [4]Dept. Earth Planetary Sciences, Washington University, St. Louis, MO 63031.

Introduction: Analysis of OMEGA and CRISM spectral data for sulfate-rich Interior Layered Deposits (ILDs) in Valles Marineris has revealed complex assemblages of iron oxides and multiple sulfates [1-7]. We have been developing stratigraphic assemblages to assess the similarities and differences among chasma [3, 5, 7]. Here we present sulfate and iron oxide stratigraphy within the central ILD of Capri Chasma.

Background: Ferric minerals have been previously identified in basinal chasmata throughout Valles Marineris with OMEGA data, but could not be definitively resolved as ferric oxide + sulfate or ferric sulfate [1]. TES discovered crystalline gray hematite throughout Valles Marineris and Meridiani Planum [12], and the MER rover Opportunity confirmed the detection in Meridiani [13]. Many of the OMEGA detections of “ferric oxide” can now be resolved as red hematite, often with kieserite, in CRISM data. The co-occurrence of red hematite with gray hematite from TES indicates a weathering process [3]. While VNIR instruments cannot resolve gray hematite, it could be present with the red hematite and darkening the spectra. The presence of sulfate and hematite together suggests an incomplete maturation process [14].

Datasets: OMEGA is a visible-near infrared hyperspectral imager on the ESA/Mars Express mission [9]. It has a 300m-4.8km spatial sampling, and a 7 to 20 nm spectral resolution in 352 spectral bands over 0.35-5.1 µm. CRISM, a visible-near infrared hyperspectral imager on Mars Reconnaissance Orbiter (MRO), has similar spectral characteristics and takes targeted observations at up to 18m/pixel [10]. The MRO HiRISE camera is capable of acquiring co-aligned imagery with CRISM and can resolve details down to ~30 cm/pixel [11].

Stratigraphic relationships: Hematite, kieserite, and PHS are found in consistent relationships across the Capri Chasma central ILD. Fig 1 shows well-exposed contacts along the northern edge of the ILD. Kieserite and PHS are clearly separated layers with different textures – bright fluted kieserite and dusty, more friable PHS. In the south of Fig 1, contacts between kieserite and PHS are complicated by a ~25 km diameter impact crater. PHS is found above kieserite in the thickest parts of the ILD in a sub-horizontal layer ~400m thick (dip is <2° to the SW). Thinner parts of the ILD do not show PHS above the kieserite, suggesting erosion removed the topmost material.

Hematite is found with both sulfate types, but is more commonly found with kieserite. This is similar to the hematite/sulfate relationships in West Candor Chasma [3] and Ophir Chasma. Fig 1b illustrates the common association of hematite with kieserite (purple color); kieserite without hematite appears blue. PHS with hematite is yellowish, while PHS without hematite is green. Hematite is found in the bedrock with kieserite and does not seem to collect at the base of the outcrop. Other CRISM observations within Capri show hematite sometimes concentrates at the base of kieserite-bearing outcrops too.

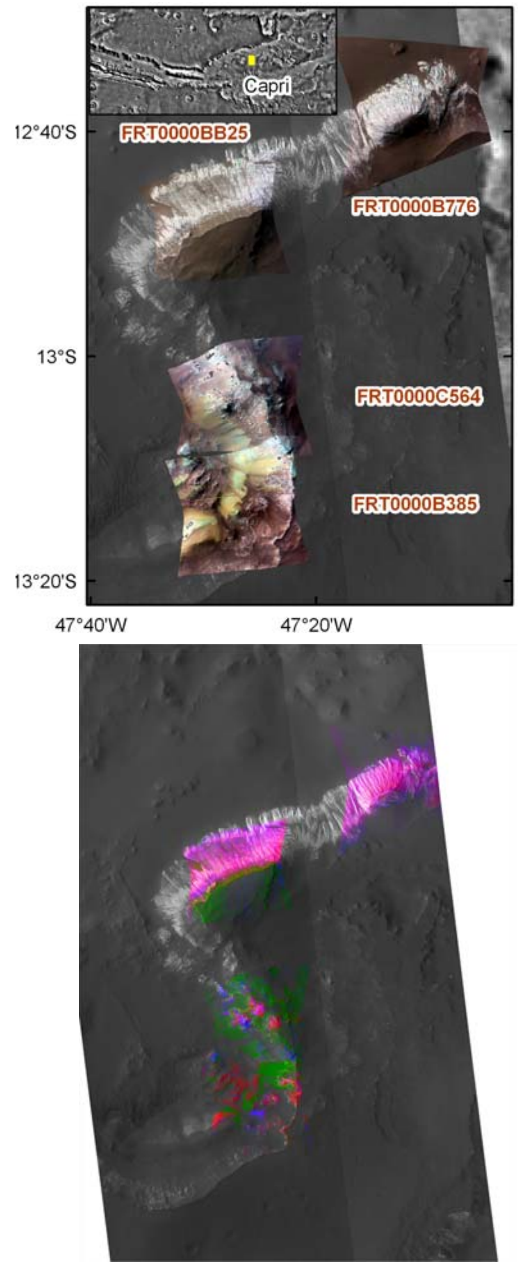

Figure 1. Northern edge of central ILD in Capri Chasma with CRISM targeted data over CTX. a) CRISM color RGB: 2.5, 1.5, 1.08 µm. b) CRISM parameter RGB: .86 µm band depth, 1.9 µm band depth, 2.1 µm band depth, in this case indicating hematite, polyhydrated sulfate, and kieserite, respectively.

Spectral Results: Hydrated sulfates have an absorption near 2.4 µm due to H_2O and OH combinations and sulfate bending overtones [15]. Kieserite is identified in Capri Chasma by characteristic vibrational absorption features at 1.6 and 2.1µm. PHS (such as epsomite and copiapite) is identified by absorptions near 1.4 and 1.9 µm due to H_2O. Well-crystalline red hematite can be resolved from other ferric oxides by absorptions at ~0.54 and 0.88 µm, and a peak at 0.76 µm with a shoulder near 0.62 µm [8]. We are confident we are detecting the coexistence of kieserite and hematite, and not szomolnokite, a monohydrated Fe sulfate, based on spectral features.

The spectral character of kieserite at Capri Chasma, and throughout Valles Marineris, is more consistent with spectra of natural kieserite samples, which have a boxy shape over 1.9-2.1 µm (Fig 2), than synthetic kieserite samples. The polyhydrated sulfate spectra, not shown here, do not always have an iron absorption, so cation chemistry cannot be further refined. The kieserite spectrum in Fig 2 has very strong hematite features, which are further accentuated in a continuum-removed spectral plot (Fig 3).

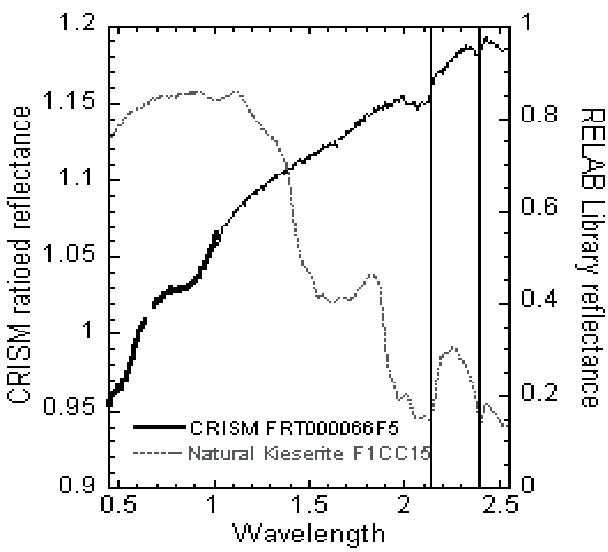

Fig 2. CRISM spectrum of typical kieserite/hematite location in Capri. NIR absorptions match library natural kieserite spectra, while visible absorptions are characteristic of hematite.

Conclusions: Capri Chasma's geologic history may be similar to other basins with significant ILD volume, such as Melas, Ophir, and Candor Chasmata. Polyhydrated sulfate (PHS) is generally located above kieserite, except where disturbed by cratering. Hematite occurs with mono- and polyhydrated sulfates in Capri, but is more commonly associated with kieserite. Hematite is identified by its visible spectral features, and can be separately resolved from the presence of sulfates [8]. The kieserite and hematite could have formed by diagenesis of sulfate-bearing sediments as a consequence of burial and/or a higher heat flow early in the chasma's history. There are several possibilities for PHS formation: it could have been the original sulfate precipitated that never altered to kieserite, it could have formed from kieserite by later interaction with near-surface groundwater or sulfate snow/water ice or dissolution and re-precipitation, or it could be a later precipitate after the kieserite and hematite were emplaced.

A large part of central Capri Chasma has stratigraphy consistent with a subhorizontal, massive PHS unit ~400m thick overlying a massive kieserite and hematite-bearing unit. There are several regional processes that could explain this: (1) a Meridiani-like thick sequence of Mg sulfate evaporite with interspersed weathering red hematite, capped by a later-stage PHS evaporite; (2) thermal maturation of the bottom of a thick sulfate stack and hematite precipitation by hydrothermal activity. PHS is either a later deposit or unaltered. The tight correlation of kieserite and hematite and the lack of hematite with PHS suggests a close genetic relationship between sulfate and iron oxide that will be important to further define. The mechanism may be important not just in Capri Chasma, but also in other basinal chasmata.

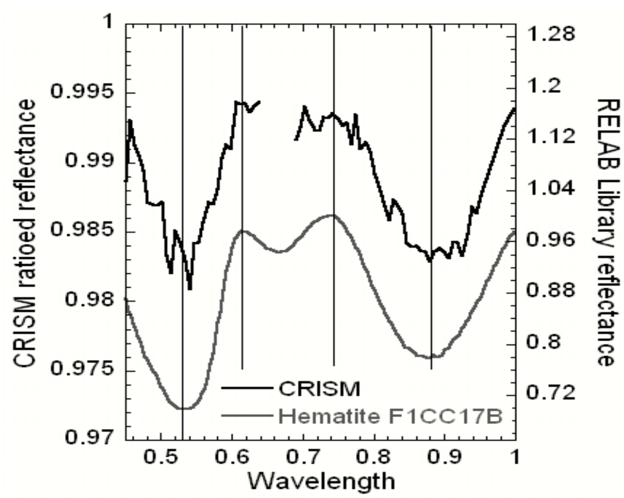

Fig 3. Continuum removed CRISM visible spectrum of hematite-bearing material with RELAB hematite spectrum. Diagnostic hematite absorptions at 0.54 and 0.88 µm, 0.62 µm shoulder and 0.74 µm relative peak. Same CRISM spectrum as shown in Fig 2.

Acknowledgments: We are grateful to the CRISM, HiRISE, and OMEGA science teams for all their dedication and hard work.

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