FORMATION OF CLAYS AND FERRIHYDRITE IN HYDRAE CHASMA, MARS. C. M. Weitz[1] and J. L. Bishop[2], [1]Planetary Science Institute, 1700 E. Fort Lowell, Tucson AZ 85719 (weitz@psi.edu), [2]SETI/NASA AMES, 515 N. Whisman Rd., Mountain View, CA 94043.

Introduction: Hydrae Chasma is one of the smaller isolated chasma of Valles Marineris, ~55x50 km in length and ~4 km deep. It is located to the south of Juventae Chasma and east of Candor Chasma, centered at -6.8°N, 298°E. Clay deposits were identified previously along the Valles Marineris plateau [1], but not near Hydrae Chasma. Hydrae Chasma consists of a larger outer depression, with a deeper but slightly smaller inner depression (Fig. 1). The southern portion of the chasma contains upper plateau materials (the Early Hesperian lava plains [2]) that have dropped down ~1 km in elevation to form a flat upper floor (Fig. 1). The rest of the chasma is much deeper with steeper walls exhibiting groove and gully morphology, and debris more characteristic of the larger chasmata wall rock [e.g., 3]. Inside the central portion of the chasma are several interconnected pits. Within and adjacent to these pits along the lower floor are numerous light-toned clay-bearing deposits (Fig. 1) [4] that are the focus of this research.

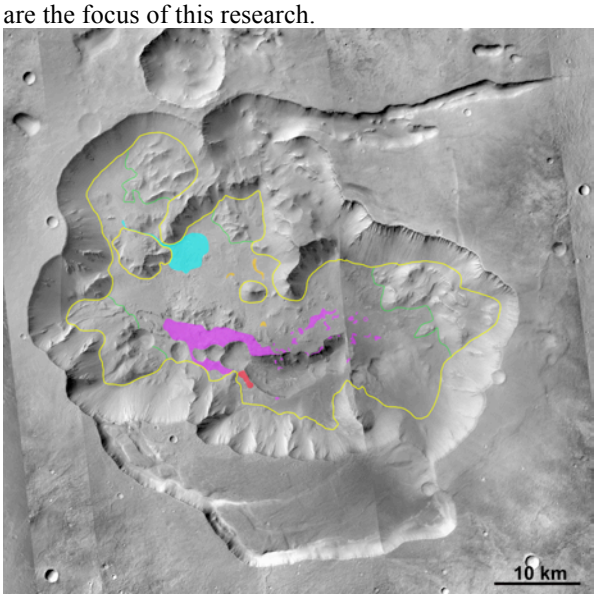

Figure 1. CTX mosaic of Hydrae Chasma with the locations of Fe/Mg-smectites, ferrihydrite, and smectites+perchlorate mapped in color (magenta, orange, and red, respectively). The fan deposit along the northern floor is shown in blue. The bottom portion of the intact wallrock unit is noted by the yellow line whereas the edge of mass wasting deposits along the wallrock are shown by the green line.

In this study, we used several orbital data sets to study the composition, morphology, and stratigraphy of the clays and other minerals within Hydrae Chasma. Our goal is to understand if the clays represent older deposits that have been exposed within the chasma during its formation, or if the clays are younger deposits emplaced after the chasma had already formed. Both scenarios have important implications for understanding aqueous processes in this region of Mars.

Spectral Results: We analyzed three CRISM images that cover the central portion of Hydrae Chasma. Most of the spectra have an absorption centered around 2.29 µm (Fig. 2), but some spectra show the absorption shifted to longer wavelengths, ~2.31 µm, indicating that both Fe and Mg may be present in the octahedral sites. Other spectra exhibit the 1.4 and 1.9 µm absorptions characteristic of smectites, but instead of an FeOH or MgOH feature between 2.28-2.31 µm, a drop in reflectance is observed near 2.3 µm, suggesting the presence of ferrihydrite (Fig. 2).

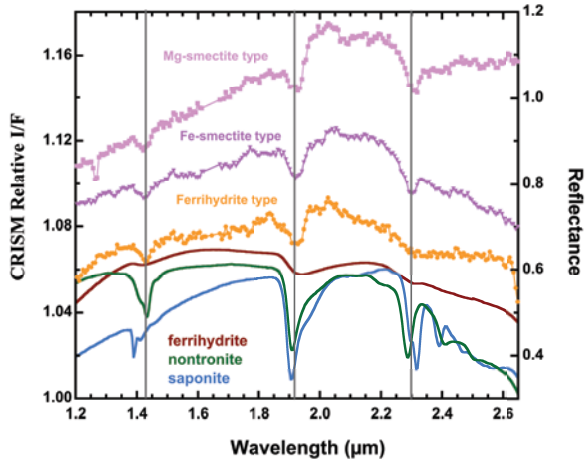

Figure 2. Spectra collected from image 1B9A8 of light-toned outcrops are consistent with Fe/Mg-smectites and ferrihydrite. Lab spectra of these minerals are shown for comparison.

Spectra of small, bright mounds in the layered deposits on the southwestern side of the pit craters have absorptions consistent with smectites, but display an additional narrow absorption at 2.4 µm (Fig. 3). The 2.4 µm absorption appears to be associated with surface features, although it could also be due to noise. We searched through spectral libraries and identified the perchlorates $NaClO_4$ and $MgClO_4$ as possible minerals mixed with the nontronite. Spectra of some sulfates have a band at 2.4 µm, but they also have additional features not observed here. We mapped this new material separately in Figure 1 and label it as smectite+perchlorate mixture.

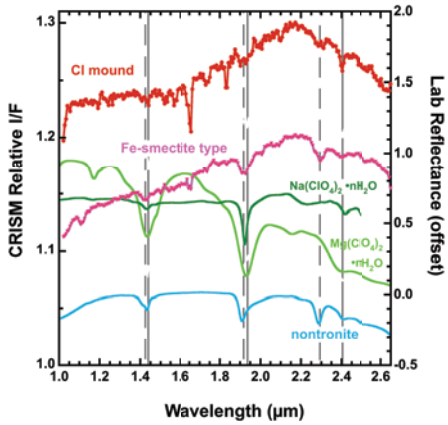

Figure 3. Spectra taken from image 236e6 showing smectites and smectite+perchlorate mixtures. Lab spectra of these minerals are shown for comparison.

Morphologic and Stratigraphic Results: In order to further explore the clays and ferrihydrite we identified from the CRISM data, we examined CTX, HRSC, and HiRISE visible images of these deposits and their surroundings. All the clay deposits occur within the lower floor materials of Hydrae Chasma. There are two distinct Fe/Mg-smectite units that vary in their morphologies. The upper clay unit, Uc, is ~2-3 m thick and appears slightly brighter in reflectance than the lower clay unit, Lc (Fig. 4). There are also eroded ledges indicating layering within Uc due to differences in strength properties between the layers. The lower clay unit is a massive ~170 m thick and slightly darker deposit with extensive fracturing that gives the unit a blocky appearance.

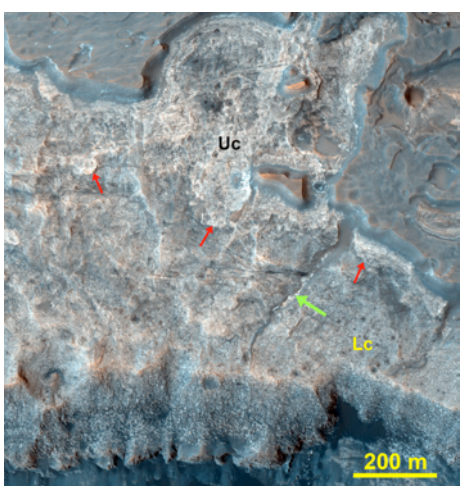

Figure 4. Portion of enhanced color HiRISE image ESP_013033_1730. Shown are the upper clay unit Uc, and the lower clay unit Lc. Red arrows point out examples of the contact between Uc and Lc. Green arrow shows where Uc unit fills in a valley along the surface of Lc.

There is a small spectral difference between Uc and Lc in the CRISM data, with Uc having an absorption at ~2.29 µm and Lc at 2.30-2.31 µm. This spectral difference appears to reflect a more Fe-rich smectite in Lc and a more Mg-rich smectite in Uc. Uc appears to unconformably overlie Lc, and small patches of Uc are observed in depressions within Lc, as shown in Figure 4. Both Uc and Lc are exposed along the northern and southern sides of the central pit, indicating they covered much of the chasma floor prior to the formation of the pit depressions.

Although not directly associated with the clays, a debris fan located to the north of the clays (Fig. 1) may provide clues to possible water sources within Hydrae Chasma. The fan exhibits striations that can be traced back to the distal end of a valley that dissects through older wallrock. Terraces are also visible within the fan. There are no light-toned deposits or hydration signatures associated with the fan. The valley only occurs within the chasma but not along the adjacent plateau. Hence, any water that formed the valley and terraced fan must have been sourced from within the chasma.

We used Digital Terrain Models in combination with the CRISM spectral results and HiRISE morphologies to determine the stratigraphy of the clays throughout the chasma. The highest elevation of the clays on the northern side of the chasma occurs at -825 m and the lowest at -1100 m. On the southern side, -375 m elevation is the highest clay and -800 m is the lowest. Thus, there is a range of elevations for the clays across the chasma floor.

Discussion: Because the clays in Hydrae Chasma occur across multiple elevations, they most likely formed by alteration from hydrothermal activity and/or melting ice/snow rather than in a lacustrine environment. The thicker massive Fe/Mg-smectite (Lc) unit could represent an older Noachian aged clay that formed either in the subsurface by warm hydrothermal activity, or on the surface under milder temperatures before being buried beneath the Early Hesperian lava plains. In contrast, the upper clay (Uc) unit, ferrihydrite, and perchlorate appear to be younger deposits that post-date formation of Hydrae Chasma. The valley and debris fan to the north of the clays could have formed from melting snow/ice within the chasma, which supplied water to lower elevations where the hydrated minerals are now observed.

References: [1] Le Deit, L. et al. (2012) *J. Geophys. Res. 117*, doi: 10.1029/2011JE003983. [2] Tanaka, K.L. et al. (2014) USGS Sci. IM 3292. [3] Lucchitta et al., 2010. [4] Weitz C.M., and J.L. Bishop (2015) LPSC 46th, Abstract 1383.