CRISM Analysis of Graben in Terra Tyrrhena; A Search for Water in Equatorial Mars. A. Annex[1], M. Marion-Spencer[2], M. Jones[2], S. Guthrie[2], B. Grigsby[3], and D. Turney[4], [1]MONS, Saint Anne's-Belfield School, Charlottesville, VA, andrew.annex@gmail.com, [2]Durham Public Schools, Durham, NC, [3]Arizona State University, Mars Space Flight Facility, Tempe, AZ, [4]Johns Hopkins Applied Physics Laboratory, Laurel, MD.

Introduction: Tyrrhena Terra is a region of Mars in the southern high-lands, north of Hellas Planitia. Due to its close proximity to Tyrrhenian Patera, the region has experienced multiple lava flood events. This abstract focuses on a graben within Tyrrhena Terra. Due to the intriguing nature of the graben, our team, part of the outreach program MESDT, suggested a ROI to the CRISM team that data be collected on the northern wall of the graben using the CRISM, HiRISE, and CTX orbital imagers. After obtaining the data through our participation in the MESDT program, our team subsequently conducted an analysis of the region. This abstract is a follow up to the first abstract #1662 for LPSC 2008 in which we detailed our participation in the MESDT Program [1].

Grabens, otherwise known as rift valleys, are formed by parallel faults caused by crust stretching. Grabens are only known to be formed by plate tectonic processes which can be an indicator for how long Mars' core was hot enough to allow for convection under the crust. Due to the tectonic processes that form grabens, it is possible that some of the subsurface ice could have melted due to the geothermal processes that occur during graben formation. The resulting water could hydrothermally alter the rock [2]. This was one of the hypotheses we used to justify the targeting of our graben to MESDT. The rock could have weathered from the hot and possibly acidic water to form phyllosilicates which are only known to be formed by water related erosion on Earth. This would indicate if Mars had an environment that could have supported life for a time interval long enough for biology to take root on Mars. Grabens on Earth are formed more recently in a geological time relative to surrounding topography. MRO indicated that this was also the case with the graben we studied. MOLA (Mars Orbiter Laser Altimeter) indicates that the cliff edge of the graben is as much as 120 meters above the surrounding area. This shows that the graben floor should have been relatively well protected from lava flows that would have filled the interior. Hopefully this means that our target is of a clean cross section of the Martian crust in Tyrrhena Terra.

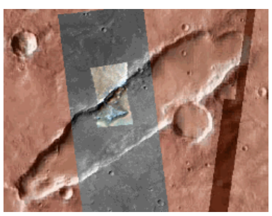


Figure 2: MOLA Context of Graben, with CTX and CRISM target overlay.

Data Acquisition: The data acquired for this abstract came from the authors' participation in the MESDT program in collaboration with the science teams of MRO. Assistance was also provided by the CRISM science team in the image analysis process.

Dimensions: Using MOLA elevation data, the floor of the graben is ~510meters below that of the surrounding plane. The graben is approximately 75.5 km long, and 21 km at the widest point. The center of the graben is located at 95.586° east, -17.418° north. Our CRISM target has a spatial resolution of 35 meter/pix, and is approximently 19km in length.

Hypothesis: Through our analysis of our CRISM and visible data we have observed interesting correlations and hypotheses. Inside of the graben there is a triangular plateau whose formation could be explained through two hypotheses [1]. Our first hypothesis is that plateau formed due to igneous intrusions. The second hypothesis is that the plateau was lava that flowed over the cliff and flooded into the graben. As per the original purpose of targeting the graben, the phyllosilicates could have formed from the hydrothermal processes that occur in graben formation. This could hydrothermally alter the rock, and the water could have formed phyllosilicates. Water dissolves minerals such as olivine, pyroxene, and feldspar. The products of the erosion which are less soluble become clay minerals. In low temperature environments, hydrothermal alteration produces monoclinic phyllosilicates such as mica, serpentine and chlorite. Kaolinite can also form due to weathering in an acidic environment [3]. If phyllosilicates are present in the graben, they should be located on the cliff face as well as in a higher concentration at the floor.

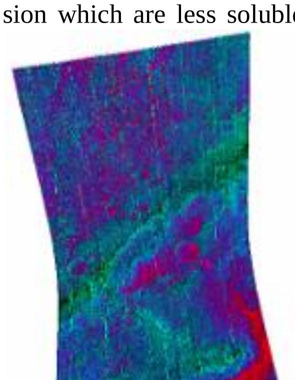
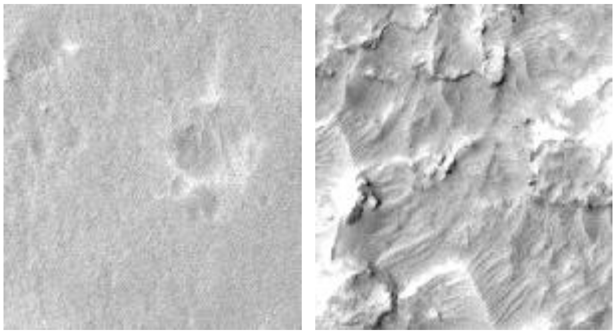


Figure 1: CRISM id: HRL00009CD4 Green is low-calcium pyroxene, Red is Olivine, Blue is High-Calcium pyroxene.

Results: For the triangular plateau, we can observe that the bedrock in the region is made from low calcium pyroxene as is the rock face of the graben cliff (figure 2). As indicated by CRISM tile 750 the bedrock of the region is mainly igneous material such as low and high calcium pyroxene. This hypothesis is supported by proximity of the region to the large volcano, Terra Tyrrhena, and by THEMIS imagery [7].



Figures 3 and 4: HiRISE image id: PSP_007173_1625, the surrounding crust on the right, and the graben floor on the left.

Since the plateau is of the same composition as the surrounding crust, this may indicate that the plateau is an exposed laccolith, a feature caused by igneous intrusions that push out and deform the strata. Igneous intrusions are created during crustal stretching due to events similar to the formation of grabens and are composed of mafic materials. Minerals that are often associated with mafic features include olivine and pyroxene. Throughout its geologic history, the calcium-content of Mars's mantle has changed. This phenomenon is manifested on the surface of mars in the calcium content of minerals. The low calcium pyroxene in figure 2 indicates that it formed during the Noachian epoch [9]. During that time the mantle in the region was depleted in calcium and aluminum, causing the melts to have low calcium content [9]. The high calcium pyroxene occurs across the spectrum in the age range of geological units, but is more likely younger than the low calcium pyroxene as it appears to be part of the dust (figure 2). This relationship also appears to be correlated to the topography of the graben. This explains the slanted shape of the plateau and it also shows that intrusive igneous bodies are present. We also observed interesting differences in topography between the floor of the graben and the land surrounding it. The highlands around the graben are relatively smooth in appearance in our HiRISE data; while the floor appears to be very rocky and uneven (see figures 3, 4). In the past year significant phyllosilicate features have been found within many of the craters to the north of the graben in Tyrrhena Terra. Phyllosilicates seem to correlate with ejecta deposits around medium sized craters and as layers in the walls of larger craters. This suggests that impacts may have penetrated clay-rich layers at depth. Such distribution of clays seem to be consistent with what is observed in other regions of Mars where clays occur, such as Holden Crater [4], Marwth Vallis [6] and Libya Montes [3]. In addition, there is spectral evidence indicating that occurrences of clays might be associated with tectonic features, such as in the graben. Unfortunately the data for the phyllosilicates appears to not be consistent with the topography of the graben (figure 5). However right side of the image does at first appears to have data for BD2210 that is consistent with the topography. The "noise" in this image indicates that CRISM is possibly detecting small amounts of phyllosilicates but the vertical lines of data are just mathematical artifacts. If there was a significant phyllosilicate deposit it would have been consistent with the topography and it would not have shown as much static in the image. Since the graben did not show phyllosilicate deposits like the craters to the north, it indicates that the graben is "younger" in geologic time relative to the phyllosilicates in the north. This is also consistent with the general hypothesis of Martian water that disappeared in liquid form around the end of the Noachian epoch and the low calcium pyroxene in the graben.

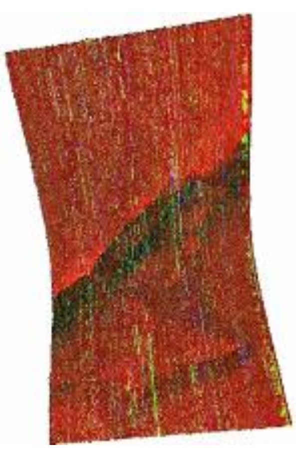


Figure 5: CRISM id: HRL00009CD4 Red is infrared albedo, Green is BD2210, Blue is BD2290

Future work: Although this is the final publication from MONS relating to the graben, it is not the end of our work with the MESDT program. MONS is currently a participant in the 2009 MESDT program and we are looking forward to our future work together.

Acknowledgements: Brian Grigsby, coordinator of the project made MESDT a complete success for us and other students. We also thank the participating members of the CRISM Team, who dedicated their time in helping us make this a reality.

References: [1] Lineberger H, et al (2008) LPSC XXXIX, Abstract #1662. [2] Lineberger H UNC Master Thesis (1983). [3] Alian Wang R. B. (2002) LPSC XXXIII, Abstract #1370. [4] S. Murchie and A. McEwen, (2008) LPSC XXXIX, Abstract #4035. [5] S. M. Pelkey and J. F. Mustard, (2007) LPSC XXXVIII, Abstract #1994. [6] V.R. Baker, S. Maruyama and J.M. Dohm, (2002) LPSC XXXIII, Abstract #1586. [7] Christensen P.R. et al. (2004) Space Science Reviews. [8] S. W. Anderson, LPSC XXXIX (2008) [9] J.F. Mustard, et al. (2005) Science.