ANOMALOUS PHYLLOSILICATE-BEARING OUTCROP SOUTH OF COPRATES CHASMA: A STUDY OF POSSIBLE EMPLACEMENT MECHANISMS. D. L. Buczkowski[1], K. Seelos[1], C. Viviano[1], S. Murchie[1], F. Seelos[1], E. Malaret[2], and C. Hash[2], [1]Johns Hopkins University Applied Physics Lab, Laurel, MD 20723, Debra.Buczkowski@jhuapl.edu, [2] Applied Coherent Technology, Herndon, VA 20170.

Introduction: A widespread phyllosilicate-bearing near-surface layer has been identified in northwest Noachis Terra [1, 2]. These phyllosilicates were included as part of the "Plateau Phyllosilicates formation" by [2], which was proposed to be formed by pedogenesis, a process of weathering basaltic soils by continued exposure to meteoric water percolating down from the surface. During pedogenesis iron-magnesium phyllosilicates form first, followed by aluminum phyllosilicates in a top-down progression as further leaching occurs; Fe/Mg-phyllosilicates can appear alone if only minimal leaching occurs (an immature pedogenic profile). The southern wall of Coprates Chasma exposes Al-smectites directly above a Fe/Mg-smectite layer, a typical pedogenic profile. However, shallow phyllosilicate layers found to the south and east in the walls and ejecta of numerous impact craters and along the length of Her Descher and Nirgal Vallis are almost exclusively Fe/Mg-smectites [1, 2, 3].

Although previously it was thought that Al-smectites comprised the upper member of this formation and Fe/Mg-smectites the lower member [2], here we present evidence of a second distinct Fe/Mg-smectite bearing layer located stratigraphically above the Al-phyllosilicates south of Coprates Chasma. Occurrence of Al-phyllosilicates below Fe/Mg-phyllosilicates suggests that some process in addition to pedogenesis must be at work.

Observations: HiRISE and THEMIS imagery show a circular outcrop at 16°S, 305.6°E, a short distance south of Coprates Chasma (Fig. 1). This outcrop consists of an intermediate-albedo circular feature surrounded by a ring of high-albedo material (Fig. 1b). The circular shape suggests that it was an impact structure, but MOLA topography shows that it is now effectively flat, likely signifying extensive erosion and/or infilling. In THEMIS data the entire circular feature exhibits elevated thermal inertia, suggesting induration.

CRISM derived MTRDR products [4] were analyzed to determine the mineralogic stratigraphy of this feature. The data show that the bright ring is Al-smectite, while the central material is Fe/Mg-smectite (Fig. 1c) located below a stripped-back, spectrally-bland cap material. A HiRISE observation that crosses through the center of the circular feature shows that the Al-smectites are polygonally fractured, while the Fe/Mg-smectites have a sculpted appearance, consistent with the cap rock having been stripped off. The presence of a small ridge at the extent of the Fe/Mg-phyllosilicate deposits suggests that the Fe/Mg-smectites are stratigraphically above the Al-smectites, though the elevation difference is below MOLA resolution.

Discussion: One possible explanation for the observed sequence of phyllosilicates is that the overlying Fe/Mg-smectites represent a second pedogenic profile, forming in a younger unit deposited over an older surface that had already undergone pedogenesis. In this scenario, two separate layers of Fe/Mg-smectites bracket the Al-smectite layer, but the underlying Fe/Mg-smectites are not exposed.

We examined this hypothesis in two configurations: one in which the first pedogenic event occurred before the impact event, and a second in which the impact crater formed before both periods of pedogenesis.

In the first scenario, layers of basaltic soil are pedogenically altered when the soils are exposed to meteoric water. When the impact event occurred the crater that formed would have incorporated the pedogenically altered soils into its rim and ejecta. This sequence of events could explain the circular ring of Al-phyllosilicates, but the crater would have had to be completely filled with a basaltic regolith material that was subsequently altered to account for the Fe/Mg-phyllosilicates we observe inside the Al-ring.

If we then assume that this crater was completely covered by basaltic ash or sands, these materials could then have been pedogenically altered during a second period of meteoric water exposure. Erosion of this altered overlying layer would reveal the Al-phyllosilicates in the underlying crater wall as a circular deposit surrounding the Fe/Mg-phyllosilicates that formed in crater fill material. However, this sequence of events would also have left behind Fe/Mg-phyllosilicates that should have formed in the overlying material that was deposited (and altered) outside of the crater. Since the Coprates circular feature does not display Fe/Mg-phyllosilicates on the surface outside of the Al-phyllosilicate ring (only inside), it seems unlikely that this sequence of events is responsible for the feature we see today.

The second scenario supposes that the impact event occurred before pedogenesis. Impact-induced brecciation of the crater rim, walls and floor would facilitate preferential alteration of preexisting basaltic material. As with the previously described sequence of events, the crater would then be completely filled with sand or ash, which was altered in a second period of meteoric water fall. However, as with the previous sequence of events, this scenario would also result in Fe/Mg-phyllosilicate surface deposits outside, as well as inside, the exposed Al-phyllosilicate ring.

Both models that invoke two instances of pedogenesis result in a ring of Al-phyllosilicates surrounding Fe/Mg-phyllosilicates, but also result in a surface Fe/Mg-phyllosilicate deposit surrounding the Al-ring. However, what we observe is a ring of Al-phyllosilicates enclosing a circle of Fe/Mg-phyllosilicates, but without the Fe/Mg-phyllosilicates surrounding the ring. An alternate model to explain the Al-ring encircling the Fe/Mg-phyllosilicates without creating exterior surface Fe/Mg-phyllosilicates, invokes groundwater rather than meteoric water.

Groundwater flowing through a sub-surface ash layer or layer of brecciated basaltic rock could result in alteration to Fe/Mg-phyllosilicates. If an impact event occurred after this alteration, the altered materials would be incorporated into the crater rim. The proposed model would then invoke complete filling of the crater with ash or sand, followed by extensive erosion of the overlying material and the crater rim, until the altered materials in the buried crater rim were exposed. Subsequent meteoric water fall would have enabled further weathering of the exposed rim to Al-phyllosilicates, even if the exposure to water was only sufficient to weather the crater fill material to Fe/Mg-phyllosilicates. This sequence of events would leave an Al-smectite ring surrounding a circular Fe/Mg-smectite deposit, with no regional Fe/Mg-phyllosilicates exterior to the ring.

Distinguishing between these scenarios has broad implications toward our understanding of the aqueous alteration and climate history on early Mars.

Conclusions: All of the models we present result in an aluminum phyllosilicate ring surrounding a circular iron-magnesium smectite deposit at the same topographic level, and all require multiple periods of basalt alteration to result in the observed pattern. However, those models which only invoke two (or multiple) periods of pedogenesis also result in a Fe/Mg-phyllosilicate surface deposit exterior to the Al-phyllosilicate ring, which is not observed. Only by invoking groundwater alteration in conjunction with pedogenesis can we reconcile the pattern of altered material exposed by this feature.

References: [1] Buczkowski D.L. et al. [2010] *LPSC XLI*, abs. 1458. [2] LeDeit L. et al. [2012] *JGR* doi:10.1029/2011JE003983. [3] Seelos, K. D. et al (2017), *LPSC XLVIII*, abs. 2846. [3] Seelos F.P. et al. [2012] *Planet. Data Wkshp*., abs. 120430.

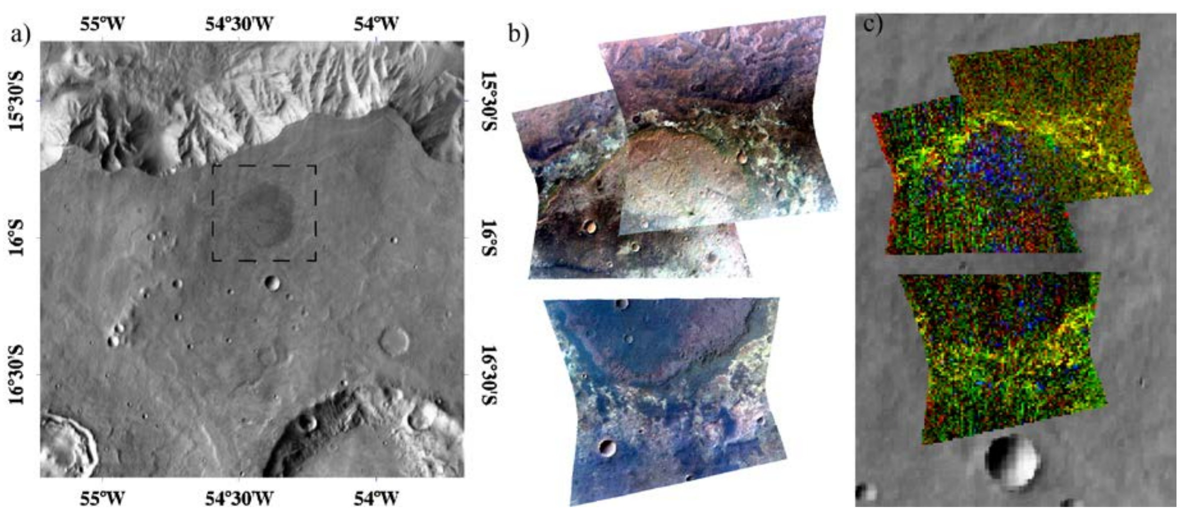

Figure 1. a) Context image of circular feature, showing coordinates and its location south of Coprates Chasma. The background image is THEMIS daytime IR. b) Mosaic of CRISM FRT16F51 (upper left), FRTA514 (upper right) and FRT2424C (lower). c) Summary parameter image of circular features indicates that the bright ring is Al-phyllosilicates (yellow) while the pinkish material in the center is Fe/Mg-phyllosilicates (blue). The dark-toned capping material observed in the center is spectrally bland, as is the material found outside the ring.