ANOMALOUS PHYLLOSILICATE-BEARING OUTCROPS SOUTH OF COPRATES CHASMA: A STUDY OF POSSIBLE EMPLACEMENT MECHANISMS. D. L. Buczkowski1, K. D. Seelos1, C. E. Viviano1, S. L. Murchie1, F. P. Seelos1, E. Malaret2, and C. Hash2, 1Johns 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 [3]; 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, 4].

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 a single pedogenic episode must be at work.

Observations: HiRISE imagery shows a low-albedo circular feature surrounded by a ring of high-albedo material at 16.65°S, 307.9°E. The circular shape suggests that it was an impact structure, but MOLA topography shows that it is now effectively flat. CRISM hyperspectral targeted observations (20-40 m/pixel) indicate that the bright ring is Al-smectite, while the central material is Fe/Mg-smectite located below a cap material. HiRISE observations show that the polygonally fractured Al-smectites are just below the Fe/Mg-smectites.

A second high-albedo ring structure has been identified in CTX imagery at 15.5°S, 300.2°E. This ring is crossed by one of the Coprates Catena, allowing a view of the stratigraphy of the altered rock and showing Fe/Mg-smectites in the ring below the Al-phyllosilicates exposed at the surface. However, in the interior of the ring the catenae exposes only Fe/Mg-smectites, with no overlying Al-phyllosilicates, suggesting a similar pattern as at the first ring.

Unlike the first two rings of Al-phyllosilicates, CRISM mapping data shows that the semi-circular structure at 16.65°S, 307.9°E is encircled by an Fe/Mg-smectite “ring” just below a spectrally bland cap rock, which is then surrounded by an Al-phyllosilicate plains deposit. A cross-section of the structure shows that its stratigraphy includes a Fe/Mg-smectite layer just below the cap rock, an underlying Al-phyllosilicate layer, and a second Fe/Mg-layer under the Al-materials.

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 assume that this crater was then completely covered by basaltic ash or sands, these materials could 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-smectites that formed in crater fill material. However, this sequence of events would also have left behind Fe/Mg-smectites outside of the crater (formed in the overlying material that was deposited and altered). Since the Coprates circular feature does not display Fe/Mg-phyllosilicates on the surface outside of the Al-ring, 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, this does not match our observations. Therefore an alternate model which invokes alteration due to groundwater in addition to pedogenesis was explored.

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 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-smectites. This sequence of events would leave an aluminum phyllosilicate ring surrounding a circular Fe/Mg-smectite deposit, even if the exposure to water was only sufficient to weather the crater fill material to Fe/Mg-smectites.

If the impact crater formed before alteration, the permeable layer would be incorporated into the crater rim. Assuming that the crater was filled and later erosion then scoured the filled crater flat, meteoric water fall would alter both the crater fill and the exposed permeable layer to Fe/Mg-phyllosilicates. However, later groundwater flow through the permeable layer could cause further alteration of the ring smectites, but might not alter the crater fill phyllosilicates. This sequence of events would result in an Al-smectite ring surrounding a circular Fe/Mg-smectite deposit, with no Fe/Mg-phyllosilicates exterior to the ring.

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 either result in an Fe/Mg-phyllosilicate surface deposit exterior to the Al-phyllosilicate ring, which is not observed, or require more (deeper) alteration than is probable. However, by invoking groundwater alteration in conjunction with pedogenesis we can reconcile the pattern of altered material exposed by these features. Distinguishing between these scenarios has broad implications toward our understanding of the aqueous alteration and climate history on early Mars.