INVESTIGATION OF NOACHIAN CRUSTAL STRUCTURE USING CRISM MULTISPECTRAL MAPPING DATA. A.M. Dapremont[1], C.E. Viviano-Beck[2], A.W. Beck[2], K.D. Seelos[2], S.L. Murchie[2], & F.P. Seelos[2], [1]Georgia Institute of Technology (adap@gatech.edu), [2]Johns Hopkins University Applied Physics Laboratory.

Introduction: This study addresses regional heterogeneity in alteration and vertical structure of the ancient Noachian highlands of Mars. The Noachian crust is primarily basaltic, as evidenced though spectral signature identifications (e.g. low-Ca pyroxene (LCP), olivine) [1]. Alteration products are also present in Noachian geologic units. Aqueous alteration has been suggested as the formation mechanism for widespread clay minerals in early and middle Noachian rocks [2]. Chloride salts, present in middle Noachian highland units, may have been produced from evaporation of briny water that formed valley networks [3]. Formation of phyllosilicates slowed beginning in the middle Noachian and extending into the final epoch of this geologic period [4]. Studies of altered Noachian crust using the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) have also revealed low-grade alteration mainly at depth with little water-rock interaction, and greater water-rock interaction only in localized settings [2]. CRISM data have been used to deduce the following key findings pertaining to the Noachian highlands: (a) greater extent of crustal alteration than previously known; (b) greater diversity in mineral assemblages than previously identified; (c) fine-scale stratification and compositional heterogeneity within Noachian deposits that reveal characteristics of past environments; and (d) spatial and temporal uncertainty in the division of neutral and acidic environments [2, 3]. Significant outstanding questions include: 1) How do mineralogy of the Martian crust and alteration products vary regionally?, 2) What, if any, regions lack alteration?, 3) Is higher-grade alteration concentrated in particular provinces?, and 4) Are there regional differences in the structure of primary and secondary mineralogy that reflect large-scale processes?

To address these questions, we are systematically investigating exposed Noachian crust in an ongoing effort to constrain composition across a globally distributed 15° latitude band, divided longitudinally into 12 ‘quadrants’. Thus far, we have mapped primary and alteration mineralogies north of the Argyre (quadrant 1) and Hellas (quadrant 5) impact basins.

Methods: Spectral signatures were mapped using CRISM multispectral data (~200 m/pixel) [5] overlain on a Thermal Emission Imaging System daytime IR basemap (Fig. 1). Summary products and spectral ratios [6] were used to identify mineral signatures. Those signatures were plotted as a function of MOLA-derived elevation. Where deposits are associated with craters, we used relationships of crater diameter with excavation depth (for crater ejecta units), stratigraphic uplift (for complex crater central peak units), and rim uplift (for simple and complex crater rim units) to identify the original depth of both primary and altered crust. Our initial results represent an interpreted stratigraphic section averaged over each mapped area.

Results and Interpretations: In the region north of Argyre, a distinct layer of high-Ca pyroxene (HCP) dominates material in the shallow crust. It overlies a laterally heterogeneous mixture of LCP and olivine-dominated signatures, as well as material altered to phyllosilicates. HCP signatures span the widest original elevation range extending into some of the deepest mapped material, which is consistent with later-stage HCP-rich flows that occupy topographic lows. Depth of alteration appears relatively shallow in this region, extending ~0.7 km below the local surface (Fig. 2A). In contrast, in the reconstructed stratigraphy of the region north of Hellas, HCP-, LCP-, and olivine-dominated signatures appear at similar depths within the crust. Alteration signatures were mapped in the shallow crust and extend to a depth of ~6 km (Fig. 2B). While initial mapping near Argyre suggests that HCP-dominated material postdates emplacement of LCP, olivine, and phyllosilicate-bearing units, we observe greater heterogeneity north of Hellas. Altered units are more frequently exposed in the southern portion of the study area closer to Hellas (Fig. 2B). Our preliminary interpretation of regional differences in crustal structure is that they may result from disruption of original stratigraphy by impacts, including the Hellas-forming impact, or from differences in post-impact alteration.

Geologic Age. An additional study objective was to determine the presence of any observable trends in mineral detections with geologic time. Presentation of these results is limited by space but in summary, we observed a decrease in LCP abundance from the early to late Noachian in quadrant 5.

References: [1] Mustard, J.F. et al (2005) *Science, 307*, 1594-1597. [2] Ehlmann, B.L. et al. (2011) *Nature, 479,* 53-60. [3] Murchie, S.L. et al. (2009) *JGR, 114*, E00D06. [4] Bibring, J.P. et al. (2006) *Science, 312*, 400-404. [5] Murchie, S.L. et al. (2009) *JGR, 114*, E00D07. [6] Viviano-Beck, C.E. et al. (2014) *JGR, 119,* 1403-1431.

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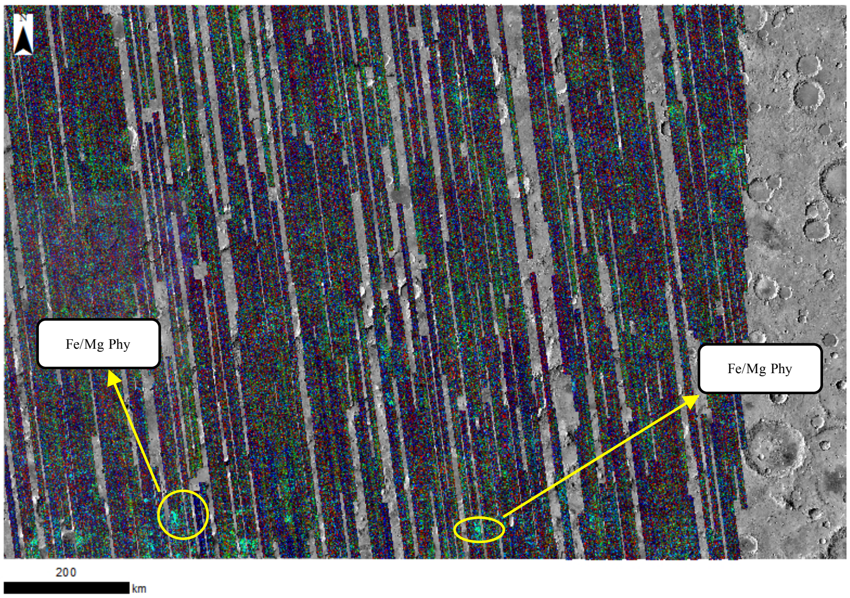
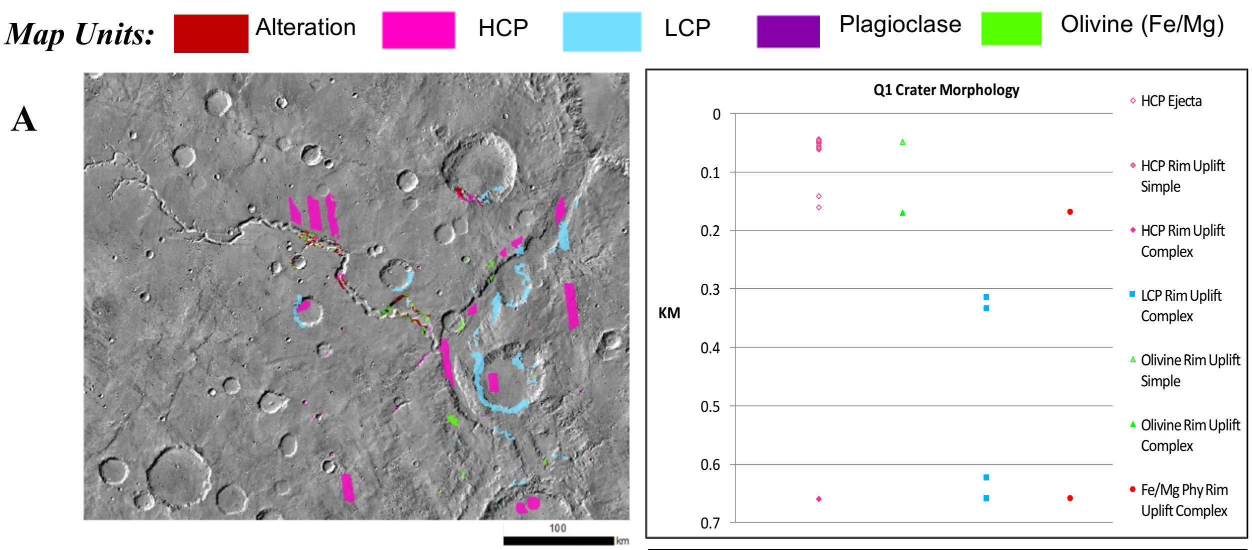


Figure 1. Example RGB band parameter combination used to identify alteration minerals in Quadrant 5 with labels denoting phyllosilicate mineral identifications. Parameter sensitivities are as follows: R: BD2355 (chlorite/prehnite/pumpellyite); G: D2300 (hydroxylated Fe/Mg silicates); B: BD2290 (Fe-OH phyllosilicates).



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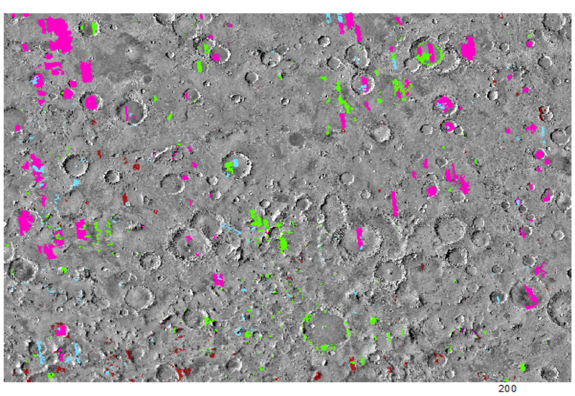

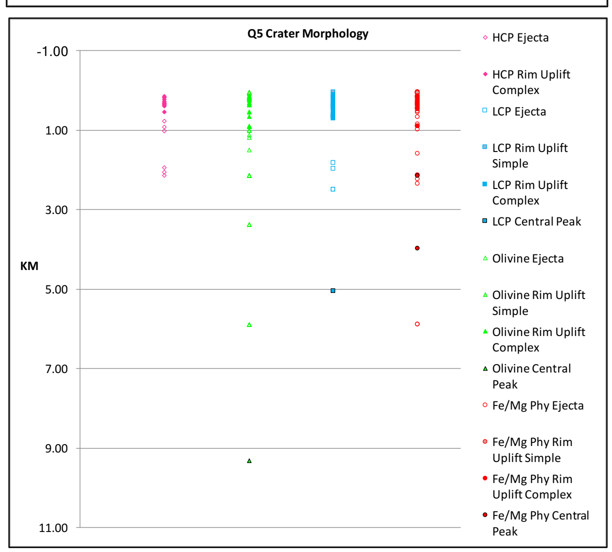

Figure 2A. Quadrant 1 geologic map (left) with depth from local surface plot (right). Figure 2B. Quadrant 5 geologic map (left) with depth from local surface plot (right).