Introduction: The region west of the Isidis basin hosts the greatest mineral diversity yet mapped from orbit. Terrains bearing olivine [1, 2], low- and high-calcium pyroxene [3], and iron-magnesium smectites [4] can be mapped over thousands of kilometers in a well-defined regional stratigraphy. Both west and south of the Isidis basin in Nili Fossae and Libya Montes, phyllosilicates in the lowermost stratigraphic unit are overlain by unaltered mafic materials [5-8]. High resolution targeted observations (~18-36 m/pixel) from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [9] allow mapping small exposures of phyllosilicates and show great regional diversity in hydrated, alteration minerals. To date, these include nontronite, saponite, kaolinite, chlorite, illite or muscovite, zeolites, and hydrated Si-OH bearing phases whose spectra are consistent with altered, vitrified volcanic products or opaline silica [6, 10-13] (Fig. 1)

While the regional Fe/Mg smectite-bearing deposit was likely formed by the time of the Isidis impact [14, 15], outstanding questions remain as to the nature of the alteration process(es) responsible for the hydrated minerals and whether a single episode of aqueous alteration can explain all observed diversity. Potential processes include phyllosilicate deposition in sedimentary basins, weathering in near surface pedogenic conditions, near surface hydrothermal activity, or deep crustal metamorphism. Below we detail the locations, mineral associations, and geomorphology of hydrated minerals west of the Isidis basin (Fig. 1).

“Provinces” of alteration: Based on the spatial distribution of alteration mineral assemblages (Fig. 1), three distinct provinces are tentatively identified:

1) Western: In heavily cratered terrain in exposures usually associated with crater central peaks and walls, Fe/Mg smectite, chlorite and hydrated Si-OH bearing phases are found. In central peaks of two craters, the zeolite analcime is also detected (one is shown in Fig. 2). These craters are those identified by Bandfield et al. [16] based on TES/THEMIS data as containing quartzofeldspathic (QF) material. Chlorite, zeolite, and smectite occur in small knobs within the crater central peak, while the Si-OH phase is associated with aeolian deposits at the base of the peak which also contain the QF material.

2) Central: Phyllosilicates are associated with small eroded knobs and ridges in the ejecta field of a 40 km crater [10]. Chlorite dominates over smectites and a mica, illite or muscovite, is present.

3) Eastern: Where in rock units, phyllosilicates underlie a cap of spectrally neutral mesa-forming material in erosional terrain around the concentric Nili Fossae grabens [6, 8]. Fe/Mg-smectite, the dominant alteration mineral, usually occurs as a ridged or polygonally fractured bright unit. Small exposures of kaolinite occasionally overlie the Fe/Mg smectite. Some phyllosilicates have been fluvially transported within a regional watershed [14] as in the delta of Jezero crater [17, 18]. For both in-situ and transported phyllosilicates, an additional 2.5 µm absorption feature often is associated with the smectite deposits, which are identified based on characteristic absorptions at 1.4, 1.9, and 2.3 µm. A single mineral cannot explain all the ob-

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Figure 1. Phyllosilicate diversity west of the Isidis basin on a Viking image basemap. Outlines of CRISM targeted observations are shown and colored orange if iron-magnesium smectite is identified within the scene. Colored dots indicate detections of additional hydrated minerals. Dashed boxes indicate the potential mineralogic provinces discussed in the text.
served spectral features (see [10] for further discussion). Examination of spectral libraries and acquisition of spectra of mixtures containing smectite, zeolite, and carbonate are being used to constrain the composition of this material.

Implications: Distinct regional assemblages of minerals suggest that the nature of aqueous activity varied in space and time across the region west of the Isidis basin. Smectites within the Eastern province are exposed as the lowermost stratigraphic unit in images sampling over 100,000 km² of terrain. The great spatial extent of this unit seems to exclude lacustrine or hydrothermal alteration in terrestrial craters [20]. Indeed, such a formation process provides a solution to the enigma of grantoid intrusions on Mars [16], namely that the origin of the QF material is not igneous but hydrothermal. The low TES-modeled abundances of quartz and K-spar and association with hydrated Si-OH bearing phases (e.g. altered impact glass [22]) are consistent with such a formation process. Experimental data show smectite-zeolite assemblages result from glasses and or basalt powders and are stable at temperatures <150°C [21] while illite-chlorite assemblages are stable at T>200°C [20]. Hence, variation in the temperature of the hydrothermal system may result in the distinctive Central and Western assemblages.

An alternative hypothesis is that these alteration materials associated with craters reflect changes in underlying crustal materials westward of the Isidis basin and that aqueous alteration pre-dated formation of the 10s of km-diameter impact structures in which these minerals are mapped. Further CRISM high resolution imaging of the region—especially the HiRISE and CTX teams for coordinating with CRISM, enabling high resolution studies combining geomorphology and mineralogy.

References:  