MINERAL ASSEMBLAGES OF DECCAN BASALTS AND Al-PHYLLOSILICATE DEPOSITS ON MARS: IMPLICATIONS FOR LEACHING PROCESSES ON MARS. R. N. Greenberger[1], J. F. Mustard[1], P. S. Kumar[2], M. D. Dyar[3], E. A. Speicher[3], and E. C. Skulte[4], [1]Dept. of Geological Sciences, Brown University, Providence, RI, 02912, Rebecca_Greenberger@brown.edu; [2]National Geophysical Research Institute, Council of Scientific & Industrial Research, Hyderabad, India; [3]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA, 01075; [4]Dept. of Geoscience, Stony Brook University, Stony Brook, NY 11794.

Introduction: Layers enriched in kaolinite and montmorillonite that overlie crustal sections enriched in Fe/Mg smectite clays have been found on Mars. One leading hypothesis is that this stratigraphy formed through *in situ* leaching or pedogenesis [1-7]. Other hypotheses for the formation of these Al phyllosilicates include alteration of volcanic ash [3-5, 7], impact-driven hydrothermal systems [1, 8], formation of Al phyllosilicates elsewhere followed by deposition in these layers [2, 5], and interaction of layered phyllosilicates with acidic fluids [9]. Previous studies of visible and near infrared spectroscopic data from Mars focus on the presence or absence of particular minerals, but the mineral assemblages present may reveal more about the mineral formation environments.

We are testing the leaching hypothesis with samples from an extensively leached vertical section of Deccan basalts; it is a mineral assemblage analog for Al phyllosilicate-bearing sections on Mars [10-11]. Major element chemistry results show that the basalt has been partially leached in the process of altering to smectite-bearing saprolite. The saprolite lies stratigraphically below a laterite cap, which has a characteristic kaolinite and hematite assemblage that is spectrally unique from the other units. This mineralogy and chemistry and the basalt to smectite to kaolinite and Fe oxide pathway is consistent with other reported laterites and weathering profiles formed from basalts [e.g. 12-13]. Based on these analog results, we are surveying Mars data to see if this kaolinite and hematite assemblage is present, consistent with the leaching hypothesis.

Methods: Data from the visible and infrared detectors of the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) were analyzed over regions of Mars with reported Al phyllosilicate detections (Fig. 1) [1-4, 7, 14-29]. Data were corrected for atmospheric effects and the geometry of observation. Spectral parameters indicative of Al phyllosilicates, Fe/Mg smectites, and Fe oxides were calculated to identify spectrally distinct regions [1, 30]. Spectra of interesting regions were ratioed to spectra of bland regions in the same column to remove residual atmosphere and instrument noise. Mineral assemblages were determined from absorption features in the spectra that are diagnostic of individual minerals. Only 2-3 minerals could be positively identified from absorption features in each assemblage. However, other minerals such as Ti-oxides or residual mafic minerals are probably present. Kaolinite deposits are identified spectrally by doublets near 1.4 µm from the first overtone of the OH stretch and 2.2 µm from Al-OH combination bands, and Fe/Mg smectites are identified by absorption features at 1.9 µm from an H-O-H bend and OH stretch and at ~2.3 µm from the Fe/Mg-OH combination band [31]. Fe-oxides have broad crystal field absorptions below 1 µm [32].

Results: In Nili Fossae, kaolinite has been found as isolated patches and in a distinct stratigraphy over Fe/Mg smectite [1]. In both types of deposits, kaolinite is not associated with Fe oxides, although kaolinite and Fe oxides have been identified in the same images (Fig. 2). Fe/Mg smectites are sometimes associated with Fe oxides in Nili Fossae. Across the planet in Mawrth Vallis, previous work has found that Al phyllosilicates (kaolinite and montmorillonite) occur in a layer over Fe/Mg smectite and are associated in places with Fe-oxides [2-3, 5, 7]. A review of these deposits shows that Al phyllosilicates and Fe oxides are more widespread than in Nili Fossae and are sometimes associated with each other but not always (Fig. 2). In addition to differences in Fe oxide association, Mawrth Vallis has both kaolinite and montmorillonite, while there is only kaolinite in Nili Fossae.

Conclusions and Implications: Al phyllosilicates on Mars are often interpreted to have formed through leaching. Pathways appear to exist that alter basalt to smectite to kaolinite on both Earth and Mars, but the resulting mineral assemblages are different on the two planets. While the more common Fe-oxide associations in Mawrth Vallis seem to fit the leaching model better, the leaching hypothesis does not fully explain the mineral assemblages detected by CRISM in either region. In Nili Fossae, there are fewer crystalline Fe-oxides with kaolinite than with other minerals. A comparison of laboratory spectra of saprolite and laterite analog samples acquired in RELAB [33] shows that crystalline Fe-oxides (hematite) are present in the laterite sample but are seen less clearly in the saprolite samples, in contrast with what is seen on Mars (Fig. 2). On Earth, basaltic ash and tephra and ultramafic rocks altered through leaching also appear to form assemblages containing Fe oxides [34-36]. The differences in Fe oxide association may be due to variations in the pH, Eh, or chemistry of the fluids that leached the surfaces on Earth and Mars. Fe is more soluble at low pH values [37]. Fe(II) is more soluble than Fe(III) over a range of pH values, so temporary or long-term reducing conditions in either the atmosphere or the subsurface could mobilize and remove the Fe [37]. On Earth, classic leaching of basalt eventually leads to a mixture of kaolinite and hematite, but this model does not fit the observations of Al phyllosilicates on Mars. As a result, different models for how the Martian deposits formed must be sought to determine what mineral assemblages would be expected and if those mineral assemblages better fit the observations on Mars.

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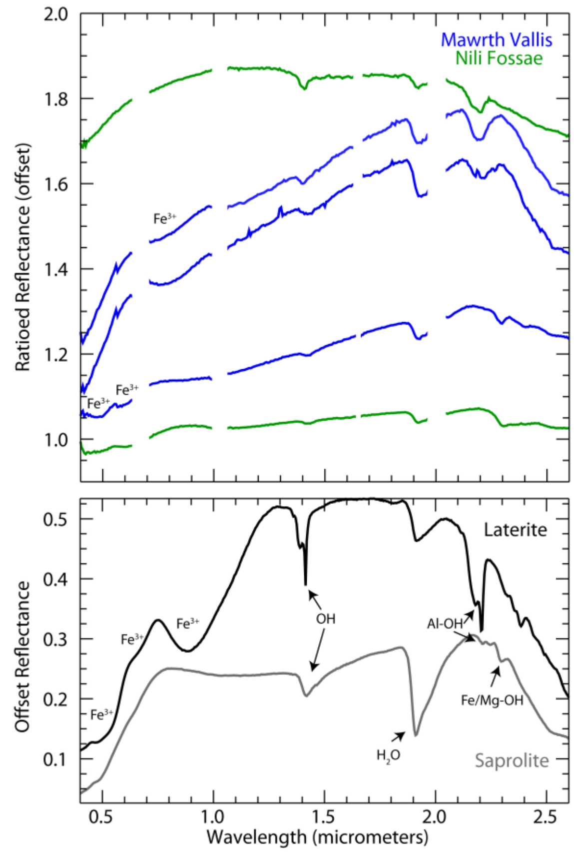

Fig. 2: Example ratioed CRISM spectra (top) from Mawrth Vallis (blue) and Nili Fossae (green). The top three spectra in the top plot are Al phyllosilicates, and the bottom two are Fe/Mg smectite clays. Spectra of two samples from the Deccan analog are shown in the bottom plot for comparison.

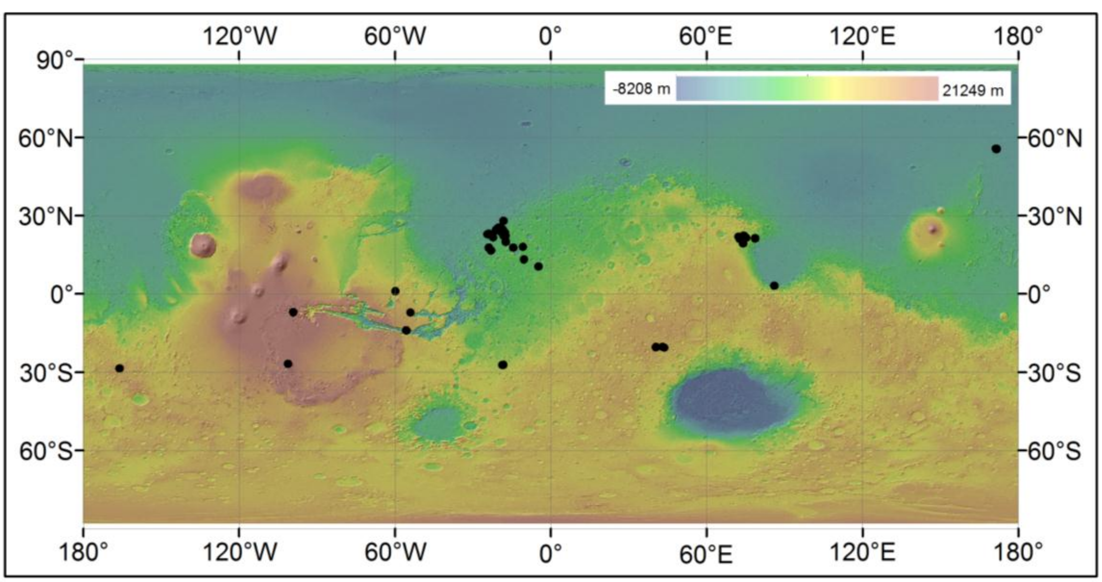

Fig. 1: Global distribution of reported Al-phyllosilicate occurrences (black dots) on Mars. Background image is a topographic map of Mars. [1-4, 7, 14-29]