MINERALOGICAL DIVERSITY IN XANTHE TERRA, MARS. E. Noe Dobrea¹ and N.H. Warner², ³Planetary Science Institute, Tucson, AZ 85719; ²Department of Geological Sciences, SUNY Geneseo, 1 College Circle, Geneseo, NY 14454. eldar@psi.edu

Introduction: The Xanthe Terra region of Mars forms part of the equatorial Martian highlands and displays geomorphic evidence for a temporally and spatially extensive fluvial history that may have extended from the late Noachian up to the early Amazonian [1], and which ranged from precipitation-fed activity to groundwater-sourced activity [2]. Current investigations have focused on developing a chronostatigraphic model of aqueous activity using superposition relationships and crater-derived age determinations [3].

In this investigation, we conducted a spectroscopic survey of the Xanthe Terra region, covering the area ranging between 6.7ºS – 17.8ºN and 322ºE - 302ºE in order to better understand the alteration history of the region and how it relates to the timing of the observed fluvial landforms. This area includes single order to multi-order, theater-headed fluvial systems such as Nanedi Vallis, Shalbatana Vallis, Hypanis Vallis, and Sabrina Vallis. It also includes other previously studied landforms related to aqueous processes, including lake strandlines, deltas, and fan-shaped deposits [4, 5]. Past spectral analyses of the region have revealed the presence of phyllosilicates and sulfates [6,7]. We used targeted MRO/CRISM data, focusing our spectroscopic studies primarily on the 1-2.6 µm range, but extended our analysis into the 3-µm region when confirmation of carbonates warranted the analysis. The THEMIS Day/IR global mosaic was used as a basemap, and CTX and HiRISE data were used to correlate mineralogical distribution with geomorphology.

Methods and Results: CRISM data were processed via standard pipeline methods, which include atmospheric and photometric correction, correction for spurious column-to-column variations (destriping), correction for spurious channel-to-channel variations (despiking), and spectral parameterization to map the distribution of spectral features such as Fe/Mg smectites, hydrated silica, Al-phyllosilicates, carbonates, and potentially sulfates.

Fe/Mg smectites were the most commonly detected hydrous minerals. They were identified primarily on the basis of a combination H-O-H band at 1.91-1.92 µm and a combination Fe-OH band or steep dropoff at 2.29-2.31 µm. Based on the location of the 2.3 µm band, we interpret these to be Fe/Mg smectites or mixed-layer smectite/chlorite (S/C), where smectites exhibit a well-defined 2.29-2.31 µm band and S/C exhibit a steep dropoff. They are found in massive outcrop in the upper walls of valleys and craters, in landslide deposits, in finely layered intracrater deposits, and in depositional fans within craters.

Hydrated silica was identified by an asymmetric, rounded band centered around 2.2 µm as well as a sharp band centered at 1.92 µm. Hydrated silica is found on the floors of Maumee and Nanedi Valles; and on the floors of Balvicar Crater, Orson Welles Crater, and Camichel Crater. In each case, the hydrated silica-bearing unit exhibits massive bedding.

Al-phyllosilicates were primarily identified by sharp absorption features at approximately 1.92 and 2.20 µm. Where present, the 2.20 µm feature is superposed on a broader feature, suggesting that the material is mixed with hydrated silica. In one instance, a unit whose spectra exhibit doublets at 1.38/1.41 and at 2.16/2.20 µm is interpreted to contain kaolin-group minerals.

Carbonates are identified by absorptions at 2.32 and 2.52 in one case, and by absorptions at 2.52, 3.36, 3.44, and 3.47 in another case. Identification of a band in the 2.3-2.4 µm region of the spectra in the latter case is confounded by the presence of steep dropoff and sharp band at 2.30 µm, suggesting mixing with Fe/Mg phyllosilicates. The spectra from the former case are consistent with either dolomite or magnesite, and occurs on the headwall of a landslide in the region. The latter detection is consistent aragonite or calcite and...
occurs near the top of an escarpment in the headwater region of Shalbatana Vallis.

Sulfates are identified ambiguously by the pre-
cence of an H$_2$O combination band at 1.93 µm. In con-
trast with phyllosilicates, sulfates have their H$_2$O com-
bination band displaced to the 1.93-1.94 region. It is
important to note, however, that in none of these cases
was a 2.4 µm band detected. Hence, we label these as
“tentative” sulfates because their detection is ambig-
ous. These tentative sulfates are found in deposis on
the floors of valleys and craters. Some of these depos-
its exhibit fine layering.

Discussion and Conclusion: The Xanthe Terra
region of Mars exhibits a surprising diversity in the
mineralogy of aqueous alteration products as well as in
their distribution, placement, and bedding. Fe/Mg
phyllosilicates are by far the
most common of these altera-
tion products. Their precense
in massive outcrops in the
upper 10s of meters of crust
suggests their formation in
groundwater systems. The
lack of evidence other for
hydrothermal products such as
chlorite, serpentine, or
prehnite suggests that the
groundwater temperatures
were not elevated at the time
of the phyllosilicates’ for-
amation. Additional Fe/Mg phyl-
losilicates found in fan-shaped
deposits and finely layered
intracratcr units suggest that at
least some of these phyllosili-
cates are sedimentary in ori-
gin, although it is not possible
to determine whether they
precipitated in a standing
body of water or whether they
represent reworked material
eroded from the altered crust.
In contrast, the appearance of
hydrated silica in massive
outcrops on the floors of va-
leys and craters strongly sug-
gests that these deposits are
evaporitic in origin, perhaps
precipitated from acidic wa-
ters. Finally, carbonates ap-
pear to be part of the shallow
crust, and may be pedogenic
or hydrothermal in origin. If
hydrothermal in origin, the
presence of at least one car-
bonate-bearing outcrop at the headwater region of
Shalbatana Vallis supports the hypothesis that water
may have escaped to the surface as a consequence of a
thermal trigger.

References: [1] Eckes et al. (2016) 47th Lunar Planet
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![Figure 1 - Mineral detections](image-url)