

LOCALIZED ALTERATION OF THE CAPPING UNIT IN NILI FOSSAE, MARS: EVIDENCE FOR MULTIPLE EPISODES OF AQUEOUS ALTERATION. E. S. Amador¹ and J. L. Bandfield², ¹University of Washington, Department of Earth and Space Sciences (esamador@uw.edu), ²Space Science Institute.

Introduction: The Nili Fossae region of Mars contains some of the most mineralogically diverse bedrock on the planet. Near-infrared (NIR) and thermal-infrared (TIR) spectral imaging data have independently, and in collaboration, identified a wide-range of primary and secondary mineral phases in the region [e.g., 1-3]. Here, we present evidence for the localized alteration of the NE Nili Fossae capping unit, previously considered to be unaltered. This was accomplished through the in-depth analysis of complementary NIR and TIR spectral datasets and the application of a method for determining the relative abundance of bulk-silica in a rock, to full TIR Thermal Emission Imaging System (THEMIS; 6.5-15 μm wavelengths) images. This application produced more directly interpretable maps that aided in the rapid identification rock units with elevated bulk-silica compositions.

Background: Previous studies of NE Nili Fossae have identified three distinct, Noachian-aged, rock units in stratigraphic section (Figure 1). A basement basaltic unit bearing Fe/Mg-phyllsilicate phases; overlaid by an olivine-rich basalt with local exposures of Mg-carbonate and Mg-phyllsilicates; and lastly, a capping unit that is typically spectrally featureless in the NIR [e.g., 2]. The capping unit has been interpreted to mark the end of sustained aqueous alteration in the NE region of Nili Fossae given its lack of hydrated mineral signatures in the NIR spectral data [e.g., 1].

Analyses of decorrelation stretch (DCS) [4] image sets from THEMIS, which are highly sensitive to the bulk-rock composition of the martian surface, indicate the presence of elevated bulk-silica surfaces in NE Nili

Fossae [5]. The work presented here aims to determine whether the elevated bulk-silica units are associated with the previously identified phyllosilicate-bearing units in the region or if they represent a separate unit, and therefore process, altogether.

Datasets and Methods: *THEMIS Weighted Absorption Center Index.* The interpretation of THEMIS DCS images can be difficult in spectrally diverse regions given the range of surface compositions and other contributing factors (e.g., temperature variations). In order to produce a more easily interpretable image set, we reduced the THEMIS multispectral dataset to a single, quantitative parameter; the weighted absorption center or “center of gravity” wavelength [6]. THEMIS is sensitive to the bulk-silica abundance of surface materials as its wavelength range covers the diagnostic Reststrahlen Si-O asymmetric stretch absorption band between 8 and 12 μm . As SiO_2 abundance increases in surface materials, the Reststrahlen absorption minimum shifts to shorter wavelengths [e.g., 7, 8] and can therefore be used as a proxy for bulk-silica concentration. Smith et al. [6] showed that even given the coarse spectral resolution of the THEMIS dataset, the *weighted* center for the integrated Reststrahlen feature can be used instead of the *true* band minimum in order to determine bulk-silica abundance [6].

We have further developed this procedure and applied it across full THEMIS atmospherically corrected surface emissivity images to create quantitative, bulk-silica indices (Figure 2). In this manner, we are able to identify and map the occurrences of the elevated bulk-silica units of interest.

We used NIR spectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM; $\sim 1.0\text{--}3.0$ μm wavelengths) to determine the spatial distribution of the phyllosilicate-bearing surfaces in the region and their spatial relationship to the elevated bulk-silica units. CRISM data were also used to characterize the NIR spectral features of the elevated bulk-silica units, specifically the presence or absence of absorptions typical of secondary alteration minerals (i.e. hydration and/or metal-OH absorptions). CRISM MSP images (72 spectral bands at 200 m/pixel sampling) were relied upon for this study as they provide a broad, regional coverage.

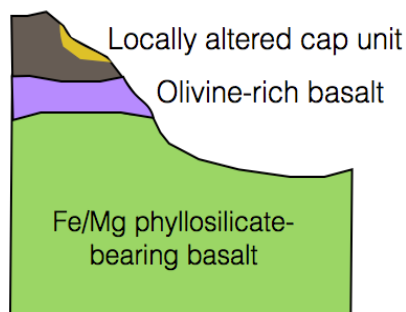


Figure 1. Generalized stratigraphy of NE Nili Fossae, yellow unit on cap rock represents local elevated bulk-silica unit.

Results: Spatial Distribution of elevated bulk-silica units. Weighted absorption center indices clearly highlight the presence of distinct elevated bulk-silica units centered around $\sim 23.5^\circ\text{N}$, 76.9°E (Figure 2). Mapping of both the elevated bulk-silica and the phyllosilicate-bearing surfaces indicate that the two units are not spatially co-located and represent two separate surface-types in the region. The phyllosilicate-bearing surfaces are more broadly distributed across Nili Fossae than the elevated bulk-silica units. Their only spatial similarity being their regional association with the olivine-rich basalts. However, elevated bulk-silica units are spatially co-located with surfaces that have been identified as *part* of the regional cap unit in NE Nili Fossae [1].

Spectral Characterization. Phyllosilicate-bearing surfaces do not show spectral characteristics consistent with elevated bulk-silica concentrations in the TIR, but

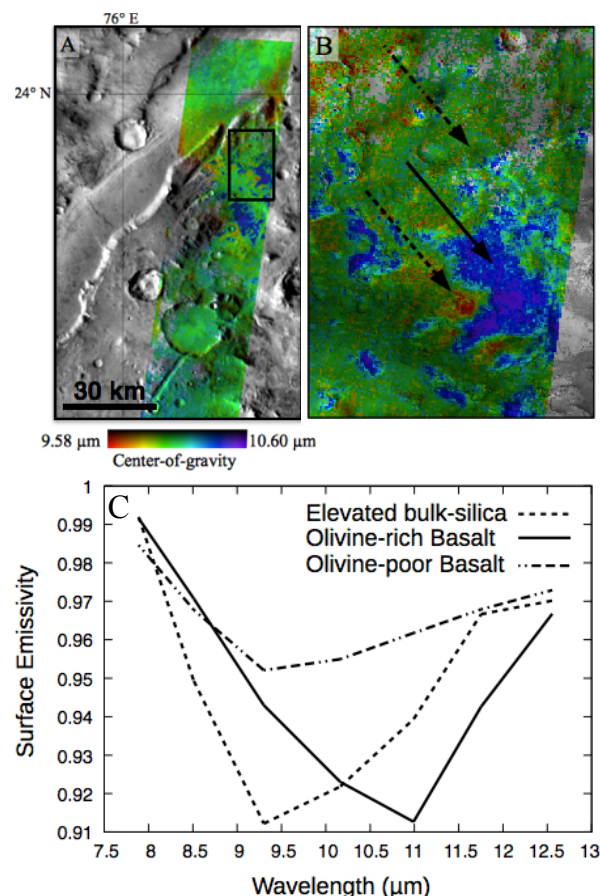


Figure 2. (A) Weighted absorption center index map. Low values (red) are proxy for higher abundances of bulk-silica. (B) Enlargement of black box in A, arrows indicate where spectra were collected for C (C) THEMIS surface emissivity spectra from B.

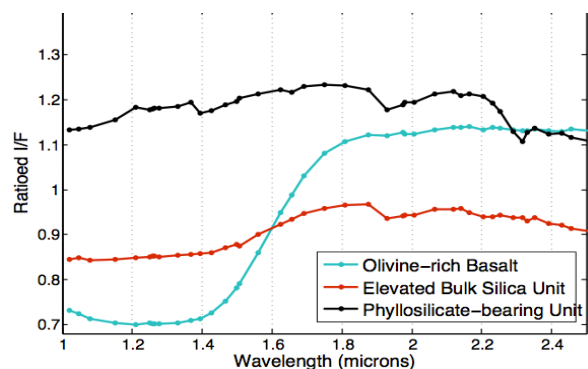


Figure 3. Near-infrared CRISM spectra from MSP 366C.

rather, show emissivity spectra typical of an olivine-poor basalt indicating that the phyllosilicate phases are not a dominant constituent in the unit. NIR reflectance spectra for the elevated bulk-silica units sometimes show weak signatures of hydration ($1.9\ \mu\text{m}$ absorption; Figure 3) but no other long-wavelength absorptions consistent with phyllosilicate, zeolite, sulfate, or hydrated silica phases.

Implications: The detection of the elevated bulk-silica units in TIR emissivity data indicates that the degree of aqueous alteration was sufficient enough to alter the bulk-rock composition of these surfaces [9]. However, it was not sufficient to alter the silica phases to higher order crystalline structures, as in hydrated silica, which would have been identifiable in NIR reflectance spectra [6].

The NE Nili Fossae capping unit, which was previously thought to be unaltered, shows spectral signatures consistent with localized aqueous alteration. This extends the timeline in which sustained water activity was present in the region to the stratigraphically youngest unit.

References: [1] Mustard et al., (2009) *JGR*, 114, E00D12. [2] Ehlmann et al., (2009) *JGR*, 114, E00D08. [3] Hamilton and Christensen, (2005) *Geology*, 33, 433-436. [4] Gillespie et al., (1986) *Remo. Sens. Env.*, 20:209-235. [5] Amador and Bandfield, (2012) *LPSCXLIII*, 2508. [6] Smith et al., (2013) *Icarus*, 223, 633-648. [7] Vincent and Thomson, (1972) *JGR*, 77(14), 2465-2472. [8] Walter and Salisbury, (1989) *JGR*, 94(B7), 9203-9213. [9] Tosca and Knoll, (2009) *EPSL*, 286, 379-386.