FE/MG-SMECTITE, CARBONATE AND AL-SMECTITE IN ANCIENT AQUEOUS OUTCROPS AT LIBYA MONTES AND THEIR ASSOCIATION WITH FLUVIAL FEATURES AND MAFIC ROCKS.

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Libya Montes and the southern Isidis region are characterized by dense valley networks in terrain dating from the Noachian, Hesperian and Amazonian periods [1-4]. This region contains large outcrops of olivine- and pyroxene-bearing lithologies identified using data from OMEGA [5] and TES/THEMIS [6]. Analyses of CRISM data have shown phyllosilicate and carbonate signatures in rocks that exhibit layered textures in HiRISE imagery [7]. Here we describe the aqueous outcrops in more detail using recently available HiRISE and HRSC DTMs.

Introduction: Libya Montes lies at the border of Isidis Basin and Terra Tyrrhena (southern highlands) with Syrtis Major Planum towards the W in a region greatly modified by fluvial processes [1-4]. Parts of this region are particularly dusty, especially towards the E [6]. However, abundant exposures of olivine and pyroxene have been found here and in Nili Fossae to the NW of Isidis Basin [5,6,8,9]. The olivine-rich unit has been proposed to be impact melts [5] or primitive picritic lavas from Syrtis Major or the southern highlands following formation of Isidis Basin [6]. Fe/Mg-phyllosilicates as well as Al-phyllosilicates and carbonates have been observed in the Libya Montes region [7], although in less abundant variety and quantity compared to those observed at Nili Fossae [9,10].

Methods: Targeted CRISM images collect 544 wavelengths from 0.36 to 3.9 μm in ~10 km swathes [11]. Images are processed for instrumental effects, converted to I/F and atmospheric components are minimized using a ratio with a CRISM scene of Olympus Mons [11]. Ratios to spectrally unremarkable regions in the same column are employed to emphasize spectral bands due to minerals. Spectral parameters [11] were used to map trends in the mineralogy.

Results: A region of central Libya Montes near 3°N and 85°E exhibits abundant Fe/Mg-smectites, olivine and pyroxene in several CRISM images (Fig. 1). Some of this material was ejecta from impacts, and aeolian and fluvial activity likely also weathered the surface here. Multiple fluvial features are observed and current efforts are underway to date these (Fig. 1).

CRISM spectra of several typical units are shown in Fig. 2 for locations marked in Figs. 3-4. There are regions with distinct olivine signatures as well as many spots with olivine plus Fe/Mg-smectites. This varies from an OH combination band near 2.29 μm for nontronite and closer to 2.31 μm for saponite. In a few small locations where the Fe/Mg-smectite appears to be barely protruding through the olivine, additional bands are present near 2.52 and 3.42-3.50 μm that are most consistent with dolomite. A definitive carbonate type is difficult to identify due to spectral mixing [12] as smectite is present wherever the carbonate features are observed. Other small outcrops of beidellite were observed with bands near 1.4, 1.9 and 2.19 μm.

HiRISE analyses show the beidellite-rich regions just below the pyroxene-bearing caprock. Layering and polygonal cracking are

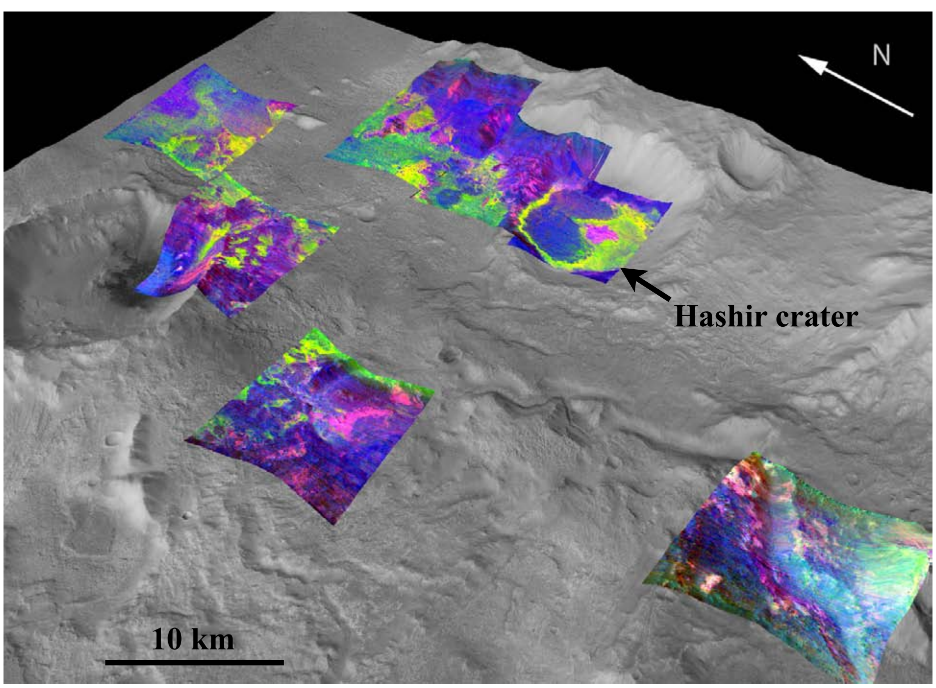


Figure 1 CRISM mineral maps over HRSC DTM in a region where aqueous outcrops are exposed on the surface. Fe/Mg-smectite is shown in pink, olivine in green-yellow, and pyroxene in blue.

observed for the Fe/Mg-smectite- plus carbonate-bearing regions and these layered morphologies appear strongest in the spots exhibiting carbonate-like spectral features along with the smectite (Fig. 5).

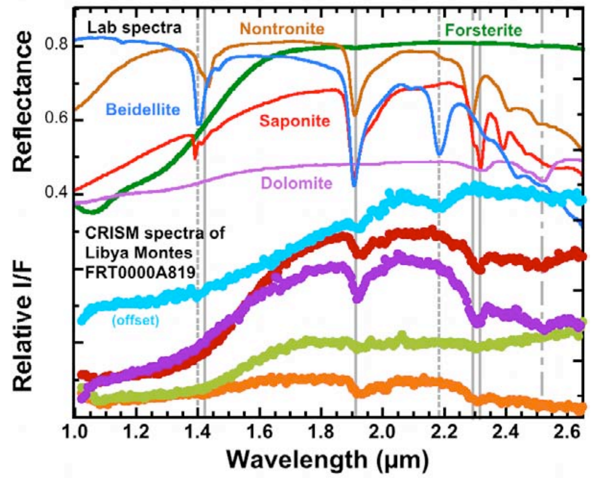


Figure 2 Ratioed CRISM spectra (5x5 pixels) from image FRT000A819 compared to lab spectra of likely minerals present. These were ratioed to a pyroxene-bearing region as that was the most spectally neutral spot available in the image. The Al-smectite exposures are much brighter than the other regions and were offset lower.

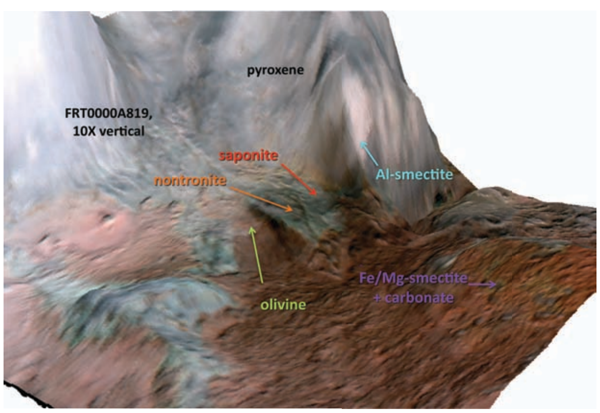


Figure 3 CRISM image FRT0000A819 draped over MOLA elevations with 10X vertical exaggeration. Spectral locations from Fig. 2 are marked and the image is ~8 km wide.

Summary: An olivine-rich unit is frequently exposed at Libya Montes below the pyroxene-bearing caprock. In many localities Fe/Mg-smectite outcrops are observed below the olivine as well. HiRISE images show the presence of dust and sand on many of the surfaces of the ancient phyllosilicate rocks and often the strongest Fe/Mg-smectite signatures are found at the edges of the olivine unit where dust/sand is less abundant. Carbonate signatures are observed in a few locations, always together with Fe/Mg-smectite. This appears to occur just below the surface of the olivine. A possible explanation is that the carbonate co-exists with the Fe/Mg-smectite, but that the carbonate is scoured off the surface faster when exposed for long periods of time. The Al-smectite beidellite is observed as bright patches and appears to have formed after the Fe/Mg-smectite unit. In some regions it is associated with fluvial features. Beidellite forms at higher temperatures than montmorillonite and could indicate hydrothermal processes or burial diagenesis.

Libya Montes is one of the most exciting regions of Mars, where surface rocks date from the Noachian to the Amazonian and there is ample evidence of ancient fluvial activity and chemical alteration.

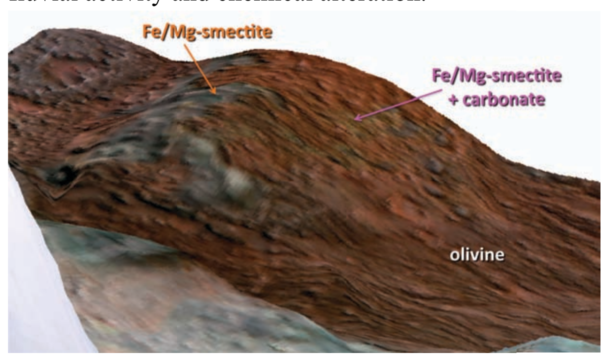
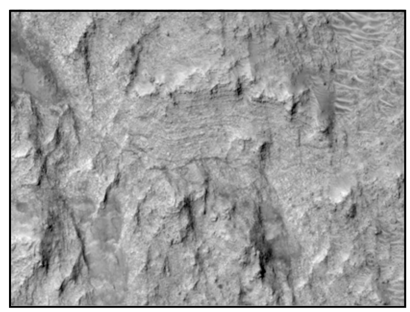


Figure 4 CRISM image FRT0000A819 draped over MOLA elevations with 10X vertical exaggeration. The image is ~5 km wide.

Figure 5 HiRISE image at location where carbonate plus Fe/Mg-smectite are exposed below olivine in Fig. 4. The image is 600 m across.



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