MINERALOGY OF LIBYA MONTES, MARS AND APPLICATIONS OF PHYLLOSILICATE-CARBONATE-OLIVINE MIXTURES. K. A. Perry[1,2], J. L. Bishop[1], and N. K. McKeown[1,3]; [1]SETI Institute (Mountain View, CA 94043), [2]Department of Earth and Soil Sciences (California Polytechnic State University, San Luis Obispo, CA 93401), [3]Department of Earth and Planetary Sciences (University of California, Santa Cruz, Santa Cruz, CA 95064), Contact: kaysea2021@gmail.com.

Introduction: Spectral analysis of the Libya Montes/Isidis Planitia region using OMEGA spectra noted outcrops of olivine [1]. Observations by CRISM revealed a range of minerals in Libya Montes including olivine, pyroxene, and phyllosilicate minerals [2, 3]. Our spectral analyses of CRISM images in Libya Montes have identified carbonates as well [here and in 4]. We have also prepared laboratory mixtures of phyllosilicate-carbonate, carbonate-olivine, phyllosilicate-olivine, and ternary samples and measured their spectra in order to better understand the Libya Montes spectra containing these compounds.

Libya Montes is located on the southern rim of the Isidis Basin. Both the Isidis Basin and the mountains of Libya Montes formed in response to a large impact 4.6 – 3.5 Ga [5]. The rocks of Libya Montes are therefore very old and this site was chosen as the study area because it may hold clues for early Martian history. Different mineralogical units are exposed in Libya Montes due to the influences of wind, water, and smaller impact craters. We discuss these mineralogical units and their relationships.

Methods: CRISM acquires spectral images ~10 km wide from 0.4 – 4.0 µm in 544 wavelengths with two detectors, one in the visible and one in the infrared, to produce images of 18 meter per pixel [6]. CRISM images were then processed to remove noise [7]. Mineral indicator maps were generated using band parameters selected to highlight specific mineral types [8] in order to identify likely minerals.

Results and Discussion: Phyllosilicates, carbonates, olivine, and pyroxene were identified in CRISM images of Libya Montes in this study (e.g. Fig. 1).

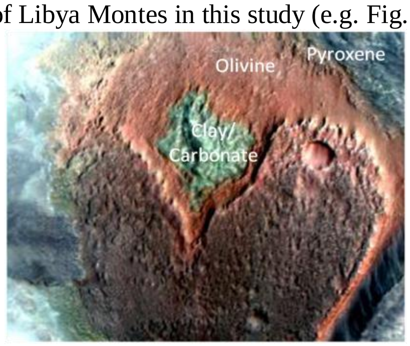

Figure 1. CRISM image 47D8 showing outcrops of clay/carbonate mixture (cyan), olivine (red), and pyroxene (blue).

Phyllosilicate-bearing rocks in Libya Montes have spectral bands at 2.30 µm and 2.39 µm (Fig 2). Nontronite, an iron (Fe) – bearing smectite, has bands centered at 2.29 µm and 2.39 µm [9]. Saponite, a magnesium (Mg) – bearing smectite, has bands centered at 2.31 µm and 2.39 µm. We propose that the clays found in Libya Montes are Fe – and Mg – bearing smectites, similar to those found at Mawrth Vallis [10]. The mixture of Fe and Mg in Libya Montes may be within the mineral structure of the clay or within the CRISM pixel. Because the pixels have 18 meter resolution, it is possible that the 2.30 µm band is an average of the 2.29 µm nontronite band and the 2.31 µm saponite band, implying that both minerals are present.

Carbonates found in Libya Montes are similar to those found by Ehlmann in Nili Fossae [11]. The carbonates have bands centered at 2.30 µm and 2.52 µm (Fig 2). When compared to laboratory spectra, Libya Montes carbonates are similar to the magnesium carbonate, magnesite; however the band near 2.52 µm is more consistent with siderite. Thus, this carbonate may contain both Mg and Fe.

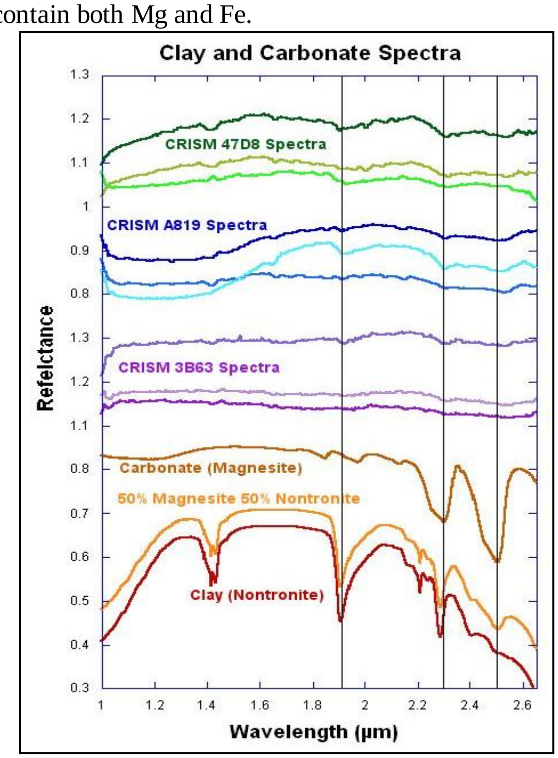

Figure 2. The presence of bands centered at 1.90µm, 2.30µm, and 2.52 µm suggests a mixture of clays and carbonates in CRISM spectra, possibly similar to the 50% magnesite – 50% nonronite laboratory mixture shown.

Olivine spectra in Libya Montes are characterized by a positive slope near 1.5 µm and are consistent with pervious identifications using TES, OMEGA, and CRISM [1, 3, 5]. There are many large olivine outcrops detected in Libya Montes, one of which is shown in Fig. 1. This is an interesting discovery because olivine in large outcrops is relatively rare on Mars [12]. This implies that fresh bedrock has been recently exposed because olivine weathers readily compared to pyroxene and feldspar [12].

Pyroxene in Libya Montes resembles Ca – rich clinopyroxene [5, 13] and is characterized by a broad band centered longwards of 2.0 µm.

The stratigraphy proposed for Libya Montes is shown in Fig 3. Pyroxene-rich material occupies the highest elevations and is stratigraphically the highest in the region (Fig 3). The olivine-rich unit lies below the pyroxene and above the carbonate-bearing layers. The carbonates are located between the olivine and the clay-bearing units. The clay unit is the lower-most exposed unit observed in Libya Montes.

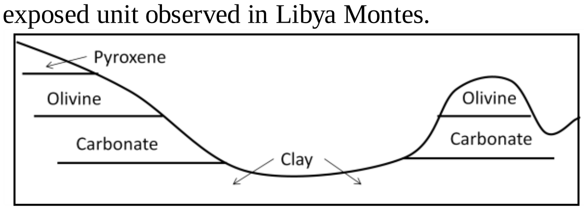

Figure 3. Proposed stratigraphy of Libya Montes.

The clays and carbonates in Libya Montes may be two distinct units (although many CRISM spectra have a combination of clay and carbonate features) that both lie stratigraphically below the olivine. It is likely that both units formed during the Noachian epoch during the same wet period. Conditions during the Noachian would have changed slightly to produce a carbonate unit above the clay unit, but the formation of both minerals require the wet conditions like those thought to have prevailed during the Noachian. Contrary to observations in Nili [11], it appears that the carbonates found in Libya Montes are not weathering products of olivine, but formed prior to the deposition of olivine.

The olivine in Libya Montes directly overlies both the clay unit and the carbonate unit in multiple outcrops. This implies that the olivine may have been draped over the entire landscape after the clays and carbonates had been partially eroded.

Due to the relationship of olivine with the clays and carbonates in Libya Montes, laboratory research was conducted in an attempt to further understand this relationship (Fig 4). When combined with magnesite or nontronite in even small amounts, the characteristic olivine slope is evident in the spectra. In ternary mixtures, the magnesite is almost completely overshadowed by the nonronite and olivine characteristics.

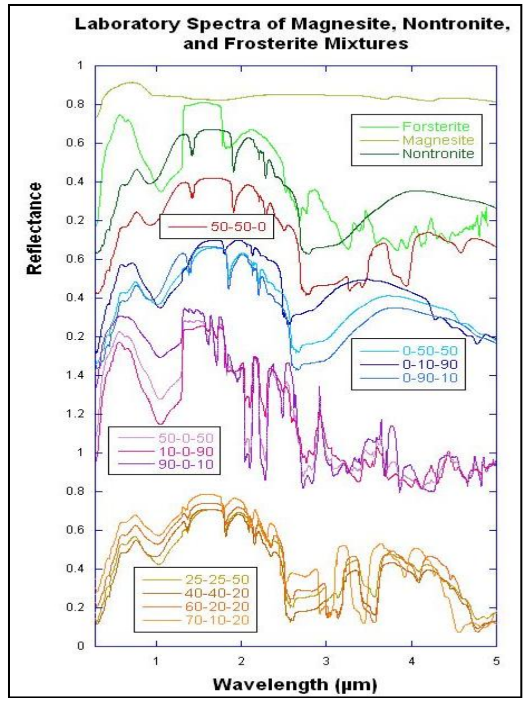

Figure 4. Laboratory mixtures are given in %magnesite-%nontronite - %forsterite. Characteristic magnesite bands are much more difficult to see in ternary mixtures. Ternary mixtures may easily be mistaken for nontronite-olivine mixtures.

The discovery of clays and carbonates in Libya Montes reveals information about the environment of the area during mineral formation. Clays and carbonates form in aqueous environments with neutral pH. In addition, water needs to be relatively still and deep for the small particles to precipitate out and form into the minerals.

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