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Photogeological Mapping of Ancient Aqueous Outcrops at Libya Montes, Mars

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Abstract

We have performed photogeological mapping of a geologically diverse region at the border of Libya Montes and Isidis Planitia. This study focuses on the central portion of Libya Montes and extends the analyses of the regional geological history completed recently [1]. The detailed investigation here includes higher resolution geologic mapping and more extensive mineralogy enabled by additional CRISM coverage. Erosion and removal of caprock via aeolian processes has led to the exposure of aqueous minerals that were largely formed by hydrothermal alteration of ancient basaltic bedrock triggered by the Isidis impact [1]. Coordinated analyses of mineralogy from CRISM images and surface features from HRSC images are allowing us to extend the geologic mapping in this region to a finer scale.

1. Introduction

The Libya Montes are located at the southern rim of the giant Isidis impact basin on Mars. The region is characterized by Noachian and Hesperian aged highland rocks alternating with multiple sedimentary units of Noachian to Amazonian age, all of them heavily dissected by dense valley networks [1 - 5]. The region experienced a complex history of impact, volcanic, tectonic, fluvial and aeolian modification processes resulting in the view found today. Ancient aqueous outcrops have been identified by coordinated spectral and geological analyses at various locations in the region [1]. We concentrated on an area centered at 84.87° E and 3.44° S, comprising all of the geological units and processes found in the region. The great value of this photogeological mapping is that mineralogical information derived from the spectral data at a scale of tens of meters can be expanded to a regional meso-scale mineralogical and geological map of the larger region. This map provides clues about the geological history of our study site in context with regionally acting modification processes.

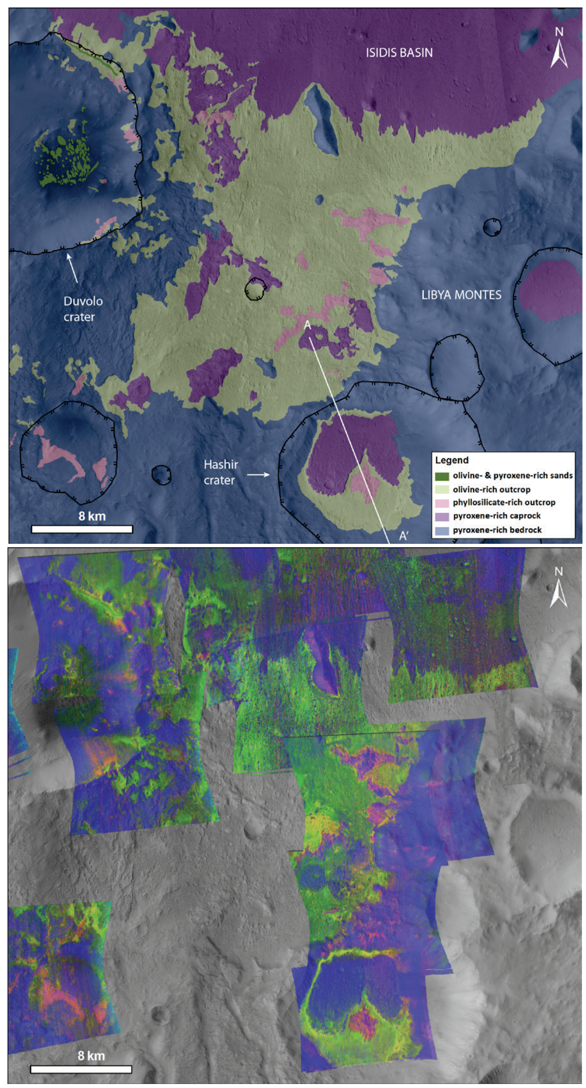

Figure 1: *Top*: Geological map of central Libya Montes as inferred from spectral and image data. *Bottom*: Mapping basis: CRISM mineral maps (R: BD2300, G: OLV, B: LCP), CTX imagery and HRSC topography. Fe/Mg-smectites are shown in pink, olivine in green and pyroxene in blue.

2. Methods

We used a complex database of HRSC topography (50 m/px), CTX imagery (6 m/px), and CRISM spectral data (18/33.8 m/px) to reveal the geological setting of the region. Specific geologic units indicated by CRISM spectral parameter products have been evaluated mineralogically using analyses in ENVI and comparison with lab spectra of known composition. Spectral ratios were used to emphasize absorption features due to surface outcrops. Geological mapping was performed using the mapping tools of ArcGIS and a mapping scale of 1:40.000. Geological units are deduced from spectral and morphological interpretation of the spectral and image data. Hence, morphological units are associated with their major mineralogical compounds. Areas lacking CRISM coverage have been interpreted solely on the basis of their morphological expression. Their mineralogy was assigned by careful extrapolation from nearby units of similar morphology/texture and known mineralogical information from CRISM. The minimum crater diameter used for mapping is 1.3 km.

3. Results and Discussion

The geological units identified by the mapping process include olivine- and pyroxene-rich strata that are superimposed on ancient basaltic bedrocks. Smaller outcrops of phyllosilicate-rich materials are located where subsurface facies are exposed to the surfaces, e.g. at the central peak of Hashir crater, at areas of high erosion, or at the walls of Duvolo crater (Fig. 1). Figure 2 shows a geologic cross section though parts of the region that clarifies the stratigraphy of the units.

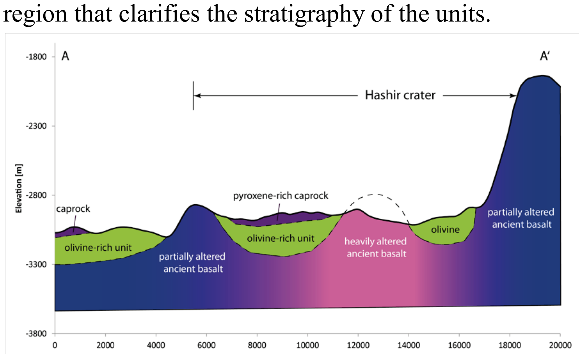

Figure 2: Geological cross section of an area in and north of Hashir crater showing the exposition of ancient outcrops in the central peak of the crater and the relation of olivine- and pyroxene-rich units to ancient basaltic basement rocks. The course of the profile is marked in Fig. 1 by the white line (A-A').

The olivine-rich outcrops show distinct abrasion textures indicating surface erosion by wind. Their surface shows yardang-like linear erosion features aligned to the prevailing wind direction from south to north. The whole region between Duvolo and Hashir craters might be a zone of katabatic winds blowing from the Libya Montes into Isidis Planitia. The eroded olivine-rich unit abruptly ends at a geologic contact to the extended pyroxene-rich unit covering the Isidis Basin in the north. This contact again shows typical features of wind erosion. This extended top unit might either represent lava layers, presumably originating from the Syrtis Major province [4], or indurated flows emplaced by mud volcanism [6]. The latter would be subject to aeolian erosion more easily due to their lower hardness. Remnants of this layer cover the likewise eroded olivine-rich unit in Hashir crater and in the region north of it (Fig. 1). The olivine-rich unit might also represent ancient lava, which was emplaced during an earlier phase of volcanic activity, enriched in olivine. We can suggest that the erosion process also led to the exposure of the phyllosilicate-rich units in the region that might have been covered by the caprock unit prior to erosion. [1] identified Fe/Mg-rich phyllosilicates and Al-smectites (e.g., beidellite) that indicate high-temperature alteration of the basement rocks, presumably triggered by the Isidis impact.

6. Summary

The regional view provided by the recently completed geologic map led to the assumption that ancient basaltic basement rocks, previously altered by hydrothermal processes, have been vastly covered by at least two generations of lava and/or mud flow layers. These covering units have been heavily eroded by wind, which finally led to the exposure of the aqueous minerals at the Libya Montes site.

Acknowledgements

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References

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