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Survey of the Martian LCP-rich lower crust C. Brustel[1,2], J. Flahaut[3], C. Quantin[2], M. Martinot[1,2], P. Thollot[2], G.R. Davies[1] Faculty of Earth and Life Science, VU University Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands, Email: c.brustel@vu.nl, [2]Laboratoire de Géologie de Lyon, CNRS/University Lyon 1, 69622 Villeurbanne Cedex, France, [3]CRPG, CNRS/Université de Lorraine, F-54500, Vandoeuvre-lès-Nancy

Introduction:

The Martian surface is composed of Noachian to early Hesperian higlands to the south and Hesperian to Amazonian low-lands plains to the north. The general crustal structure of Mars (thickness, lateral heterogeneities, as well as its chemical evolution) remains largely unclear [1]. Did the martian crust form in a magma ocean? Did the early martian mantle experience an overturn? [2]. Previous studies based on orbital and in situ data have determined that the surface is mostly basaltic in nature [3], although felsic minerals are detected sporadicall [4], [5]. Visible Near infrared (VNIR) data indicate the southern higlands to be spectrally dominated by rocks with low-calcium pyroxene/high-calcium pyroxene ratio (LCP/HCP) equal or superior to 1, whereas younger terrains are dominated by a ratio <1 (more HCP than LCP) [6] suggesting a change in the LCP composition with time.

This temporal change is also observed in the top 11 km outcrops of Valles Marineris. Massive and high-albedo rocks are spectrally enriched in LCP while layered of basaltic lava flows are enriched in HCP [7]. The mineralogical composition of this lower Noachian crust is still poorly constrained due to VNIR spectral limitation and its sporadic exposure only in Valles Marineris and central peaks of impact craters.

Based on gravimetric models [8] and Gamma Ray Spectrometer (GRS) data, [9] suggested that the highlands were composed of a low density material buried below the basaltic crust. These areas are consistent with anorthositic detections [4], [10]. Rocks from the lower crust are massive and have high albedo (massive light-toned), which could be explained by an high concentration of plagioclase [11]. In situ analyses by Curiosity revealed the presence of rocks with up to 80% plagioclase [5] and spectral detections of anorthosite by [4] suggest the sporadic existence of rocks with > 90% plagioclase at depth. If the high albedo of these rocks relates to an higher amount of plagioclase than surface rocks (which hold 10-20% of plagioclase, [12]) this rocktype could be the origin of the observed low density anomalies.

We combined a set of high resolution images and spectral data in order to better understand the stratigraphy of the crust and the extent of these high-albedo massive rocks.

The approach focused on central peaks of impact craters providing insight into the massive lighter-toned rocks as observed at the bottom of Valles Marineris and around the Tharsis dome [7] [13] [14].

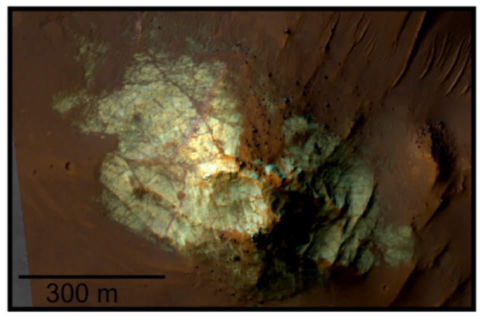

Figure 1 HiRISE image of an impact crater central peak excavating massive light-toned rock, associated with LCP spectral signatures.

Method :

Data: Images from the CTX (Contex camera) and HiRISE (High Resolution Imaging Science Experiment) have resolution of 6 m and 25 cm per pixel respectively were used to determine the rock morphology. Elevations of the central peaks were determined from MOLA (Mars Orbiter Laser Altimeter) altimetry data. CRISM data were processed with CAT pipeline (ref). Then, similarly to [15;16] we develop a pipeline to survey the pyroxene composition by retreaving the position of the 2 micron absorption bands. For that, the area of the 2 microns absorption band was maximized in order to remove a linear continuum between two tie-points. Due to the remanant CO_2 absorptions of the Martian atmosphere near 2 microns even after correction, a 4th order polynomial curve was fitted to each spectrum to remove the atmospheric effects.

Crater data base: All martian craters with diameters superior to 30 km with a central peak were selected with CRISM and HiRISE coverage. Central peaks offer insights into the Martian crust as they raise material from depth during the impact.

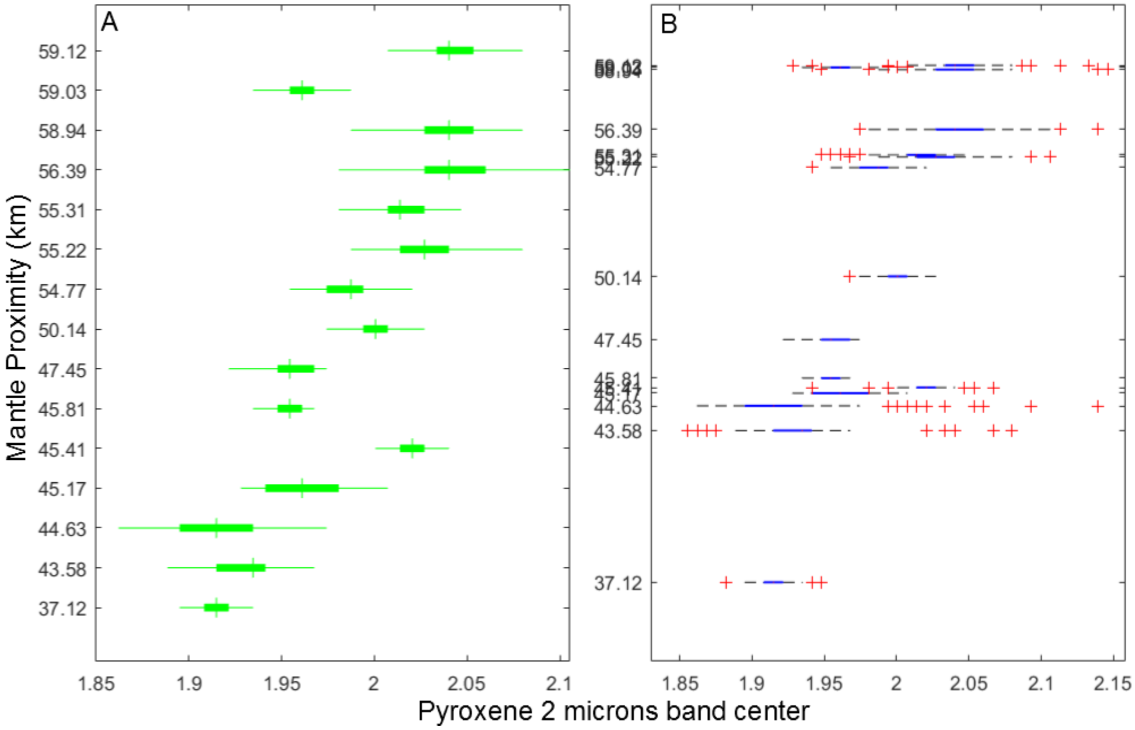

Figure 2 Central peaks of impact craters excavating massive light-toned rock. The pyroxene median 2 microns band center is represented as a function of mantle proximity (in km). (A) The y axis is offset for clarity. (B) The y axis is at scale with extreme values of the band position in red.

Results and Discussion

Spectral analyses of light-toned massive rocks show occurrence of LCP with sporadic detections of olivine while the upper crust is HCP rich, consistent with previous studies. The massive and high-albedo rocks characterise central peaks throughout the highlands, suggesting that these rocks are globally distributed. Based on the modelled stratigraphic uplift of each crater, the thickness of the upper crust is estimated. The upper volcanic layers are between 2 and 4 km thick, similar to the thickness of the basaltic lava flows observed in the upper walls of Valles Marineris. Figure 2 illustrates the pyroxene 2 micron band position measured in 15 craters excavating a greater proportion of massive light-toned rocks as a function of proximity to the mantle (crustal thickness minus the crater uplift). Only craters with no or little alteration (presence of hydrated minerals) are presented. A trend in the band position from 2.1 microns to 1.85 microns is observed with depth. These observations could be interpreted as a decrease of calcium content through time.

This result is consistent with the work of [17] who predicted a decrease of the LCP/(LCP+HCP) ratio over time during the Noachian and a sharp compositional change from LCP to HCP during the Noachian/Hesperian transition. The progressive change in pyroxene composition in the light-toned rocks may reflect a continuous volcanic activity through time during the Noachian.

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