Composition and Structures of the Subsurface in th e Vicinity of Valles Marineris as Revealed by Central Uplifts of Impact Craters C. Quantin[1], J. Flahaut[1], H. Clenet[1], P. Allemand[1], P. Thomas [1]. [1]Laboratoire de Géologie de Lyon, Terre, Planètes, Environnements, UMR CNRS 5276, Université Claude Bernard/Ecole Normale Supérieure de Lyon, 2 rue Raphaël Dubois, 696222 Villeurbanne Cedex, France (cathy.quantin@univ-lyon1.fr).

Introduction: Despite recent efforts from space exploration to sound the Martian subsurface with RADARs, the structure of the Martian underground is still unknown. Major geological contacts or discontinuities inside the Martian crust have not been revealed. Another way to sound the subsurface is to analyze the central peaks of impact craters that have been exhumed from depth at the time of impact. The last Martian mission, MRO (Mars Reconnaissance Orbiter), did a real effort in targeting the central peaks of impact craters with both its high resolution instruments: CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) [1] and HiRiSE (High Resolution Science Experiment) [2]. We analyzed the composition and the nature of the rocks exhumed from depth by impact processes on 16 impacts craters in the vicinity of Valles Marineris. Our results allow us to propose a cross section of the underground of this area.

Geological Setti ng: We analyzed the impact craters central peaks that have been imaged by both the CRISM and HIRISE instruments. In the surroundings of Valles Marineris and the chaos, 16 impact craters have this co-registered data covering their central peak. 14 impact craters are located in the south rim of Valles Marineris, one in the north rim and one inside the canyon. The studied area presented in figure 1 includes both Noachian and Hesperian terrains. The Western part of this area is composed by Hesperian terrains corresponding to Tharsis budge edge, whereas the Eastern part of Valles Marineris, as well as the chaos, are emplaced on Noachian terrains [3]. The 16 impact craters studied here are not all named; we therefore proposed a succession of letters to name them. The diameters of studied impacts range from 12 km (Unnamed H) to 155 km (Holden) and are located at different elevations ranging from approximately +6000 m (Oudemans) to -2000 m (Unnamed F). These large ranges allow a good sampling of the subsurface.

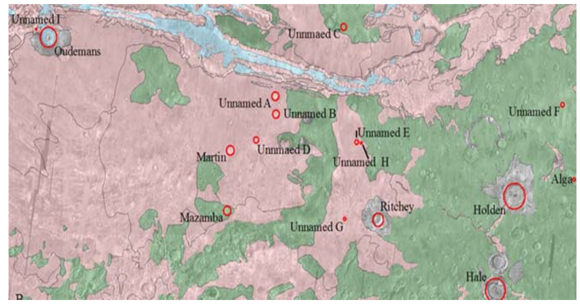

Figure 1: Location map of the impact craters whose central peaks have been studied. The background map is a simplified geological map from [3] where green represents Noachian terrains and pink, the Hesperian terrains.

Methods: 35 HiRiSE images and 32 CRISM observations were processed. We integrated these data as well as derived products from these data to a Geographic Information System (GIS). Our GIS also includes data with a global coverage such as a MOLA elevation map, THEMIS infrared mosaics, geological maps, TES global map and OMEGA mineralogical maps. CTX images were also included to provide a context for HiRiSE data.

CRISM is the hyperspectral imager onboard MRO that measures the reflectance at visible and near-infrared wavelengths [1]. Targeted MRO/CRISM images collect 544 wavelengths from 0.36 to 3.9 µm in ~10-12 km wide swaths at 18-36 m/pixel resolution. The data were processed with CAT. The CRISM data are first corrected from the atmosphere effect using a ratio with a CRISM scene of Olympus Mons, scaled to the same column density of CO_2. Then, the data are filtered in order to remove the spectral spikes and the spatial stripes. The clean data cubes are next geo-projected. Spectral parameters typical of certain minerals are computed and mapped [4].

Our GIS allows us to collect relevant information for the 16 impact craters: their diameter, their geographic position and the elevation of the central peak, from MOLA data. Empirical formulae exist from terrestrial studies relating the diameter of the impact crater and the stratigraphic uplift forming the central peak [5]. From terrestrial examples, the following empirical relationship has been proposed [5]:

$$SU= 0.086D^{1.03}$$

where SU is the stratigraphic uplift and D the crater diameter. Lacking adapted relationship on Mars, we used this relationship to estimate the depth of origin of the rocks exposed in the central peak. From the elevation of the central peaks of the 16 Martian craters and the above relationship, we estimated the absolute elevation of origin of the rocks exhumed in the central peaks.

Results: The nature of the material exposed in the central peaks of the 16 craters was carefully examined on HiRiSE images. All central peaks reveal highly deformed rocks, mixed with melt part and impact breccias. Almost all impacts exposed breccias involving clasts of exhumed material in a melted matrix. However, we clearly identified two main types of exposed material in the 16 central uplifts. Some expose intact layers while others expose massive light toned rocks (figure 2).

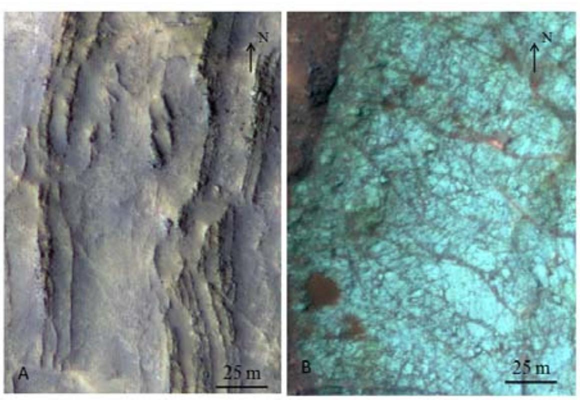

Figure 2: A) HiRiSE imaging intact layers; B) HiRiSE imaging massive light toned rocks.

Eight central peaks are made of preserved layers. These layers are intensely deformed, folded and fractured, probably by the impact. Some layers seem to be vertical. The nature of the layers is very homogeneous from a crater to another. The layers have the same thickness, of around one meter. They appear in visible images either dark toned or light toned. The dominant composition of these layers is a mixture of olivine and high calcium pyroxene, what is a typical basaltic composition. A significant part of these basaltic-type layers are hydrated adding a sharp 1.9 µm feature to the basaltic type spectrum. We also detected smectites-bearing outcrops (4 peaks) and hydrated glass in a few isolated locations (2 peaks).

Light toned massive rocks are exhumed in eight central peaks. These massive rocks are highly fractured and are depleted in any recognizable structures. The composition of these central peaks is also homogenous as Low Calcium Pyroxenes are detected in all the peaks. In 5 peaks olivine is found in association. Associated hydrated phases have also been detected: smectites (2 peaks), serpentine (2 peaks) and hydrated glass (2 peaks).

The spatial distribution as well as the in-depth distribution between the two main rocks exhumed is not random and allowed us to draw the subsurface structure below the Tharsis lava plateau.

Conclusion: The study of the central peaks of impact craters with different diameter sizes and different elevations allowed us to sound the Martian subsurface in the vicinity of Valles Marineris. That allowed us to reconstruct the subsurface structure of the region and to reveal a major geological discontinuity.

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