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Imaging the subsurface from central peaks of impact craters

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Abstract

Based on the analysis of 31 central peaks of impact craters in the vicinity of Valles Marineris, we study the composition of the subsurface at different locations and different depths. Based on coupled CRISM and HiRISE data, we determine the composition and the nature of the rocks exhumed by the 31 impacts craters. The results allow to image the first 20 km of the subsurface in the vicinity of Valles Marineris and reveal a major crustal discontinuity.

1. 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) and HiRiSE (High Resolution Imaging Science Experiment). We analyze the composition and the nature of the rocks exhumed from depth on 31 impacts craters in the vicinity of Valles Marineris. The stratigraphic uplift forming the central peak depends on the size of the impact and would represent around 1/10 of the final diameter [1]. The studied impacts have emplaced over a large range of elevation from +6000 m to -2000 m (MOLA absolute elevation) and the impacts have a diameter of between10 km and 150 km. These large ranges of values give a remarkable sampling of the subsurface that allowed us to image the first 20 km of the subsurface.

2. Dataset and method

49 HiRiSE images and 30 CRISM observations are processed. We integrate 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 [2]. 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 are processed with CAT (CRISM Analysis Tool) [3]. 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 cleaned data cubes are then geo-projected. Spectral parameters typical of certain minerals are computed and mapped [4].

Our GIS allows us to collect relevant information for the 31 impact craters: their diameter, their geographic position and the elevation of the central peak, from MOLA data. We are so able to define the pre-impact elevation of the rocks exposed in the central peaks of the studied craters.

3. Results

Our analyses of both mineralogy from 35 CRISM hyperspectral data cubes and rock nature from 50 HiRISE pictures allow us to distinguish two kind of material exhumed in the central peak (see figure 1).

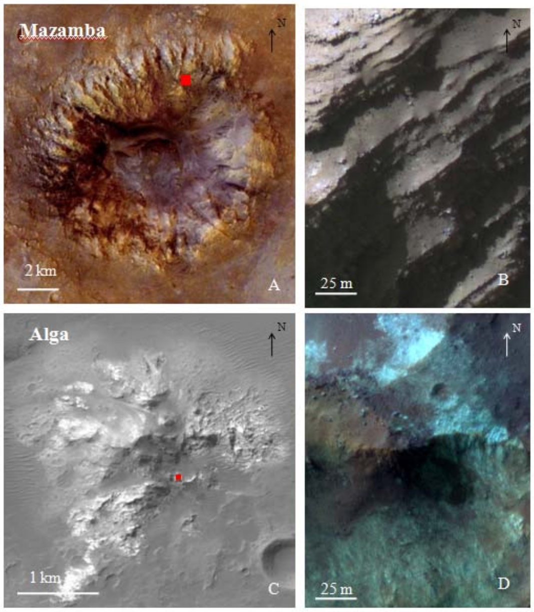

Figure 1 : A] HiRISE picture of the central peak of Mazamba crater, B] close up on the intact exhumed layers of Mazamba central peak, C] CTX picture of the central peak of Alga crater, D] close up on the massive light toned rocks exposed in the central peak of Alga crater.

Intact layers form the first group. The layers are intensely deformed, folded and fractured. The layers have the same thickness of around one meter from a crater to another,. The dominant composition of these layers is a mixture of olivine and high calcium pyroxene, which 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 typical spectrum. We also detecte smectites and hydrated glass in a less abundant amount. We interpret these layers to be a Noachian volcanic accumulation probably in relation to Tharsis activity.

Exhumed light toned massive rocks are the second group. These massive rocks are depleted of any recognizable structures and are highly fractured. The common composition of these central peaks is low calcium pyroxenes with olivine in some cases. Associated hydrated phases have also been detected: smectites, putative serpentines and hydrated glass. We interpret these rocks to be the volatile-rich, pre-Noachian Martian crust.

The spatial distribution as well as the in-depth distribution between the two group of rocks exhumed is not random and reveals a major geological discontinuity below the Tharsis lava plateau

4. Conclusions

The pre-impact elevation of the rocks analyzed here range from 0 to -20 km below the surface. We are so able to image the subsurface. The results reveal a major crustal discontinuity in the vicinity of Valles Marineris.

Acknowledgements

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