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Excavation of Altered Sediments in the Northern Plains of Mars

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1. Introduction

We present a compositional analysis of a set of large impact craters in the Northern Lowlands of Mars and morphologic evidence that sedimentary material, in this case phyllosilicates, were uplifted from great depth, showing striking similarities to southern highland material.

2. Background

Hydrated silicates in large impact craters in the Northern Plains were described by [1] on the basis of hyperspectral data acquired by the OMEGA instrument (Observatoire pour la Minéralogie, l'Eau, les Glaces, et l'Activité) [2] on board Mars Express and CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) [3] on board Mars Reconnaissance Orbiter. We revisited a set of impact sites described in [1] for further investigation because the coverage with high resolution data has drastically increased since the time of that study.

3. Data Sets and Methods

HRSC, CTX, and HiRISE data was used for visual interpretation. Digital terrain models (DTM) were produced from HRSC data [4, 5] (orbits h7540-Bamberg and h3304-Micoud) with a resolution of 50 m per pixel, to better assess the stratigraphic context. The data were incorporated into a Geographic Information System (GIS)-project using the ESRI ArcGIS software. Processed HRSC DTMs, geometrically corrected CTX and HiRISE image data, and CRISM spectral parameter maps were displayed in ArcScene. We used CRISM image FRT0000942F with a spatial resolution of 18 m/px [6]. The analyses are focused on spectra from 1-2.6 µm where hydrated minerals such as phyllosilicates exhibit representative absorptions. The band near 1.9 µm is indicative of H_2O in minerals, whereas OH combination bands and overtones in clay minerals have diagnostic absorptions at 2.1-2.5 µm [7]. CRISM Analysis Toolkit (CAT) and its associated tools were used in ENVI to minimize instrumental and atmospheric effects and convert the data to I/F [6, 8]. Spectra were collected for 5x5 pixel spots and ratioed in column to emphasize the mineral features. Laboratory spectra RELAB available in the CAT were used for comparison with the Martian spectra.

4. Observations & Results

The 55 km large *Bamberg crater* is located at 39.5 °N and 357 °E roughly 60 km north of the highlands/ lowlands transition in the southern Acidalia Planitia region, close to the transition to Arabia [9]. The impact crater has well preserved terraced walls and a distinct ejecta blanket. Most prominent feature of the crater is the central uplift, displaying an asymmetric central pit. Some sporadic outcrops of breccia can be recognized on the northern wall of the pit. At closer inspection, layered strata can be found, displaying a phyllosilicate signature in the CRISM observations (Fig.1). Ratioed spectra of the hydrated outcrops show absorptions at ~1.41, 1.91 and 2.29 µm, best matching the Fe-smectite nontronite. HiRISE imagery also reveals irregular layering within isolated blocks a few 100s of meters in size, with layers as thin as 1-2 meters visible (Fig. 2). Chlorite and mixed-layered smectite/ chlorite (S/C) [10] are also observed at the central peak, but are not associated with the layered blocks. The phyllosilicates appear to be bound to horizons, often following the morphologic profile like escarpments and spurs (Fig. 1).
Micoud crater is a ~52 km wide impact crater, located at 50.5 °N and 16.3 °E in the east of Acidalia Planitia. The crater is heavily manteled and describes a peak-ring structure [1, 11, 12, 13]. Like Bamberg, Micoud also shows spectral signals indicative of phyllosilicates (here chlorite or S/C, prehnite and Fe/Mg-rich clays) [1, 11, 13]. The presence of prehnite hints at a formation temperature of 200-

400 °C and would hence point to a hydrothermal formation or the excavation of low grade metamorphic material. As in Bamberg, we also detected blocks with layered strata in Micoud, unfortunately not covered by CRISM observations. However, the scattered detection of prehnite in association with chlorite in the central uplift of the peak ring structure could represent a case of excavation of pre-existing clay-bearing rocks as described in [1, 14] if the well exposed stratigraphy of the southern highlands also stretched towards the northern lowlands.

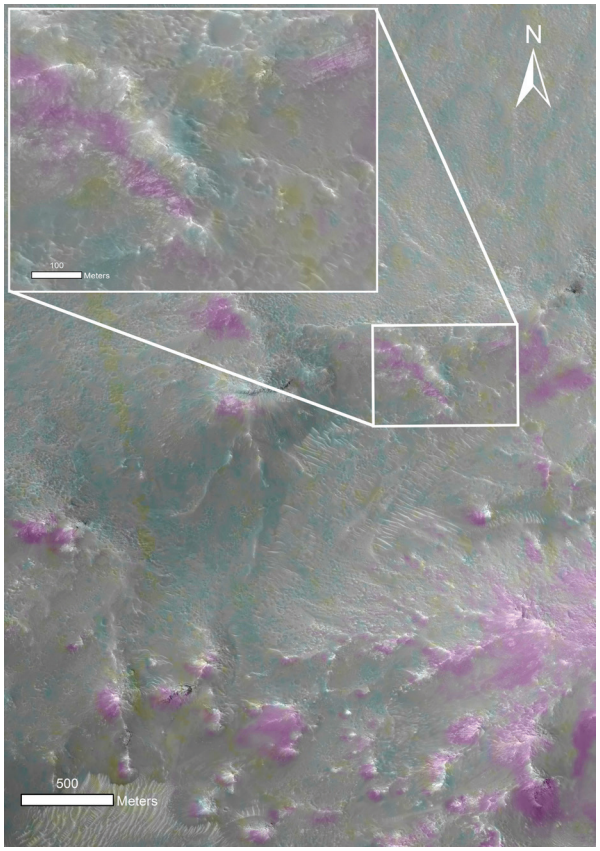

Figure 1: Pan-sharpened image of CRISM observation FRT0000942F and HiRISE observation PSP_006794_ 2200 showing the northern wall of the central pit in Bamberg crater. The inset shows a magnification of the scene. Note the isolated layered block in the upper right corner of the inset. BD2300 index is represented in purple. HCPINDEX + BD1900 band is shown in turquois. Yellow colors represent BD2300 + HCP-INDEX.

In general, the deepest materials exhumed by an impact crater are present in the central peak structure. The stratigraphic uplift of a central peak exhumes material from roughly ~1/10 of the final crater diameter [15, 16]. The observed layered strata would then derive from ~5 km depth, if not caused by other processes like fall-back after the impact.

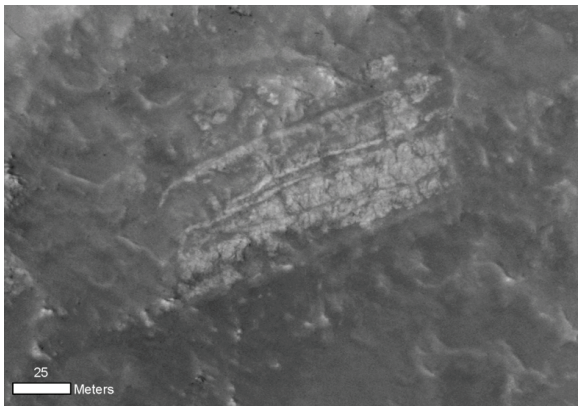

Figure 2: HiRISE observation PSP_006794_ 2200. Magnification of the isolated layered block described in Figure 1.

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