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Discovering Rembrandt basin's subsurface and Enterprise Rupes: 3D-model based on stratigraphic mapping and structural analysis

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Abstract

This work is part of the Horizon 2020 - PLANMAP project and in support of the Bepi-Colombo mission. It aims at realizing a geologic map of the Rembrandt basin and the surrounding area focusing on the stratigraphy of its interior plains, to finally reconstruct a subsurface 3D geological model of the basin itself and of the Enterprise Rupes cross-cutting it. This will allow to better infer the infilling history of the basin and the kinematic evolution of the scarp.

1. Introduction

The ~715-km-diameter Rembrandt basin is known as the second largest well-preserved basin on Mercury after the almost coeval Caloris basin (~1500 km). Rembrandt is peculiarly cross-cut by an extensive and possibly multi-phase lobate scarp, i.e. Enterprise Rupes, whose activity is thought to be initiated prior to the impact event and subsequently reactivated during the emplacement of the inner volcanic smooth plains [2]. The improvements of imagery data provided by NASA MESSENGER spacecraft offer the possibility to unravel this complex turn of events and observe a variety of spectrally distinct units within and outside the basin. Hence, in this work we propose a more comprehensive stratigraphic and geologic interpretation of these events.

2. Data and Methods

We have produced a map layer focused on geomorphology and morpho-stratigraphy (Figure 1) following the methods and symbology adopted by many authors while mapping the quadrangles of Mercury [4, 5, 6]; the second layer is based on the main chrono-stratigraphic units, which can be related to different events and therefore different ages (Figure 1B), distinguished by their model ages and spectral characteristics (i.e. different false colours based on MESSENGER MDIS 3-colour, 8-colour and PCA – enhanced colour images, which are consistent with a different composition of the material on the surface). Within the latter we took into consideration the colour units on the base of their stratigraphic position inferred by the crater excavations. For this reason, crater floors and ejecta are classified in function of the color-stratigraphic unit they are constituted of. In particular, the smooth plains were distinguished into two different units inside it, based on spectral distinctions as well as the thickness and age constraints described below.

We have estimated the thickness of the smooth plains units inside the basin with three methods. The first one used by [1] allows to link the depth of origin of spectrally distinct ejecta and central peak structures associated with impact craters. The second method applied on Mercury by [2] provides an estimation of the depth of boundary between two distinct volcanic plains inside the basin by performing a crater-age determination. The crater counting includes partially buried craters, and relates the deflection of an S-shaped kink that occurs at larger diameters with the minimum and maximum thickness of the younger unit. The third method allows to estimate the thickness of the upper smooth plains by comparing the measured rim heights of embayed craters with the rim heights expected by morphologic relationships for mercurian craters (following [7]).

These layers have provided the basis for subsurface 3D geological modelling, and additional map layers have been produced for surface features (such as secondary crater chains and bright rayed ejecta) and linear features (such as faults and crests of crater rims). In addition, new measurements of fault geometry and kinematic properties of Enterprise Rupes have been obtained by using the method of [3], analyzing three main craters cross-cut and deformed

by the lobate scarp. To this aim we used MESSENGER MDIS Global Basemap BDR and Global DEM data.
Finally, the 3D model has been developed using the Midland Valley's MOVE software.

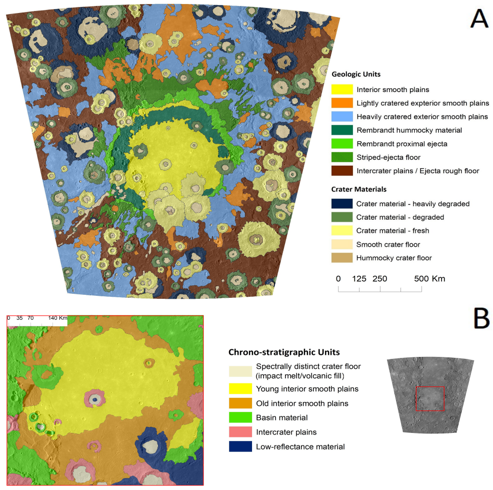

Figure 1: Preview of the map layers. A) Geomorphologic mapping. B) Close view within the Rembrandt basin showing the chrono-stratigraphic mapping, which displays the main stratigraphic units. (Lambert conformal conic projection)

3. Results and future work

After combining the map layers with the methods described above, we distinguished two different volcanic plains inside the Rembrandt basin and estimated the thickness of these two units: we obtained a maximum thickness for the younger smooth plains of 0.34-0.44 km (thickening towards the centre of the basin), which is consistent with the values observed from the S-shaped kink by [2], and a maximum depth for the older smooth plains of 1.73-2 km. Furthermore, we have modelled the fault plane of Enterprise Rupes (Figure 2) based on the measured fault parameters and interpolating multiple sections cross-cutting the basin and the lobate scarp. We measured low angles for the portion of the frontal thrust inside the basin (plunge 14-23°) and high angles for the lateral ramp outside the basin (up to 40°).
As a follow up of our work, we aim at modelling also the smooth plains inside the basin by using similar techniques, to provide not only a better understanding of the Rembrandt basin's evolution and stratigraphy, in connection with Enterprise Rupes.

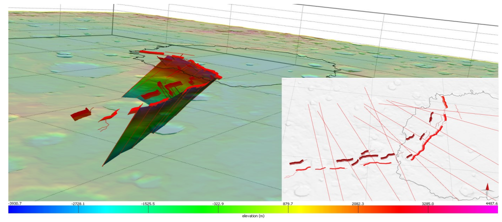

Figure 2. Preliminary 3D model of Enterprise Rupes, obtained with the MOVE software. Red ribbons represent the main fault segments of Enterprise Rupes, mapped on the surface and inclined by the measured angles, whereas brown ribbons are the main backthrusts (or "backscarp"). The vertical scale is exaggerated x2.5. Bottom right: cross sections drawn for modelling the scarp.

Acknowledgments

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