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Crater-size frequency distribution as a tool to investigate the uppercrust layering

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Abstract

The Model Production Function (MPF) for crater chronology can be also an useful tool to estimate crust layering and physical properties. We employed this model to derive the thickness of an uppermost fractured layer (H) for Rachmaninoff and Raditadli basins (Mercury), obtaining a value up to 3 km and 0.4-0.7 km respectively. In order to understand if the different H values obtained for the two basins are related to local rheological variable, inherited conditions or merely impact related fragmentation, Poincarè and Schrodinger lunar analogues have been taken into consideration.

1. Introduction

The Model Production Function (MPF) is a recent technique proposed by Marchi et al. [1] for the dating of the planetary surfaces. It is based on dynamical models describing the formation and evolution of the asteroids in the inner Solar System. This procedure depends on cratering physics, allowing a variable crustal layering of the target body to be taken into account. The MPF demonstrates that, if no other processes such as geological units superposition have intervened, the inflections in the crater-SFD (size frequency distribution) can be related to the rheological layering of the investigated portion of the crust. In particular, the inflection at lower crater diameters is mainly due to the transition from cohesive to hard rock scaling law of Holsapple and Housen [2] and consequently varies with the presence and thickness of an upper heavily fractured layer of the crust. This thickness is variable around the planet, depending on i) the rheology of a specific region, in turn related to the lithological variations and layering of the crust in that location, and ii) the age of the region itself, the fractured layer being presumably thicker in older regions.

2. Rachmaninoff and Raditladi basins

MPF was applied on Rachmaninoff and Raditladi basin in order to estimate their uppermost layering [3]. The 190-km-diameter Rachmaninoff basin is surrounded by a continuous ejecta blanket and includes an interior peak ring structure with smooth plains filling its floor. On the basis of WAC-color images and morphological evidences, smooth plains were distinguished into inner plain and annular plains. Crater statistics of annular units, inner plains and ejecta blanket was performed. A remarkable flexure point in the crater SFD of the ejecta blanket suggests a depth of transition (H) from the superficial fractured layer to the unfractured lower crust of 3 km. Unlike the ejecta crater-SFD, inner and annular plain ones did not show the presence of a flexure point. Since the annular units are composed of breccias which can be only partially strengthened by impact melts, it is reasonable to assume at least the same H of the crust beneath the ejecta. Concerning the inner plains, geological analysis suggests that they are younger volcanic flows. This would make possible two different scenarios: i) the former fractured horizon was completely hardened by the rising magmas (H=0 km)(Fig.1a), or ii) the magmatic activity was unable to totally strengthen the upper weak layer (Fig.1b). In this latter case we can consider H= 3 km, as for the annular units and ejecta.
Raditladi is a 265-km-diameter basin containing an interior peak-ring structure. A continuous ejecta blanket surrounds the basin. The floor is partially filled with smooth plains material [4]. Floor material was subdivided into two different units [5]: smooth and hummocky plains, that seem to be coeval and directly related to the impact [4]. We performed a crater count of the inner plains within the peak ring and the annular units enclosed between the basin rim and the peak ring. Counts were also performed on the ejecta blankets. The measured crater-SFD on the ejecta blanket shows a flexure suggesting an H of 0.4

km, whereas the best fit for the annular units is achieved using H = 0.7 km. As for the Rachmaninoff basin, SFD on the inner plains did not show flexures, therefore it cannot be used to constrain H. We derived the model age with both the same H of the annular units, and a negligible thickness. The former model age leads to a paradox, giving the annular units, which are coeval with the basin formation, younger than the inner plains, which can be due to the impact as well or to a subsequent magmatic activity. Hence, the most reliable result for the inner plains is to consider a solid target material. This could be due to: i) an emplacement of lavas leading to a complete hardening of the fractured and brecciated material within the basin (Fig.2a), or ii) a great amount of impact melts able to completely harden the impact breccias (Fig.2b).

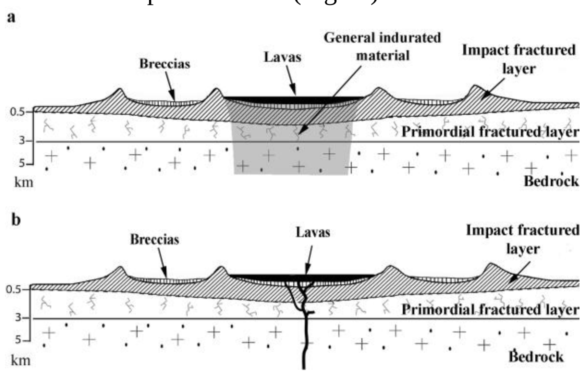

Fig.1 Possible geological sections of the Rachmaninoff basin hypothesized from the fit of MPF with the CSFD of ejecta, annular materials and inner plains. See text for details

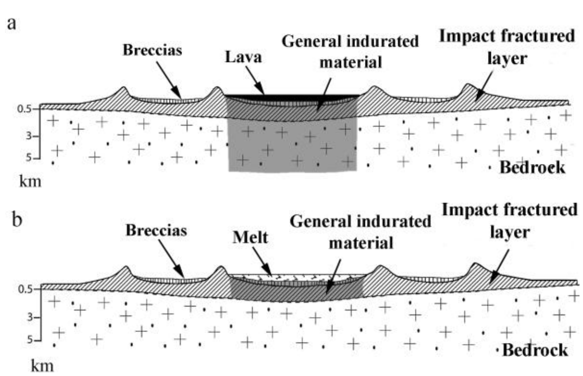

Fig.2 Possible geological sections of Raditladi basin hypothesized from the fit of MPF with the CSFD of ejecta, annular materials and inner plains. See text for details.

3. Possible lunar basin analogues

The analysis of the Rachmaninoff and Raditladi reveals a non uniform crustal layering in correspondence of these two basins, although they show similar diameters and morphologies. Lunar analogues of the two basins could give important insights to establish the causes of this discordance. In particular, a thicker H is expected for lunar analogues on the older and more craterized farside. This could be the case of Poincarè, a two ring basin of 319 km of diameter emplaced on the old pre-nectarian surface and with a floor almost completely filled by lavas. On the contrary a Raditadli analogue has to be located on younger area, where a thinner fractured layer is hypothesized. Schrodinger basins could meet this requirement since it is a two ring basin with a diameter of 312 km, located on Imbrium-dated surface of the southern farside.

Hence, the main goal of our work is the analyses of these two lunar basins with the most recent high-resolution data (Kaguya and LRO). In particular, the different geological units of the basins will be distinguished and dated trough the MPF. The derived crater-SFD will enable us to determine the H values and hence shed more light on the layering of the hermean and lunar crust and the amount of fracturing related to the formation of impact basins.

References

[1] Marchi, S., Mottola, S., Cremonese, G., Massironi, M., Martellato, E., A New Chronology for the Moon and Mercury. Astronomical Journal 137, 4936–4948, 2009.

[2] Holsapple, K. A., Housen, K. R., A crater and its ejecta: An interpretation of Deep Impact. Icarus,187, 345–356, 2007.

[3] Marchi S., Massironi M., Cremonese G., Martellato E., Giacomini L., Prockter L., The effects of the target material properties and layering on the crater chronology: the case of Raditladi and Rachmaninoff basins on Mercury. Planet. Space Sci. (in press).

[4] Prockter, L.M., Ernst, C.M., Denevi, B.W., Chapman, C.R., Head III, J.W., Fassett, C.I., Merline, W.J., Solomon, S.C., Watters, T.R., Blewett, D.T.,Cremonese, G., Marchi, S., Massironi, M., Barnouin, O.S., Evidence for young volcanism on Mercury from the third MESSENGER flyby, Science, 329, 668-671, 2010.

[5] Prockter, L.M., Watters, T.R., Chapman, C.R., Denevi, B.W., Head, J.W., Solomon, S.C., Murchie, S.L., Barnouin-Jha, O.S., Robinson, M.S.,Blewett, D.T., Gillis-Davis, J., The Curious Case of Raditladi Basin, Lunar Planet.Sci., 40, abstract 1758, 2009.