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Raditladi: numerical modeling of a Hermean peak-ring basin

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Abstract

Mercury has remained an "enigmatic body" among the terrestrial planets for more than three decades, caused by the paucity of data collected by the NASA Mariner 10 spacecraft in the Seventies. The recent flybys of the Discovery mission MESSENGER with Mercury updated our knowledge about this planet, in particular new areas of Mercury have been imaged, revealing structures never observed before.

One new feature, a double-ring impact basin named Raditladi, soon appeared very interesting for the small number of craters detected either on its floor and its ejecta, suggesting a very young age. The peculiarity to have a very young age estimate in the case of such a large impact crater is the starting point for a deepen analysis on this structure. In this work we will show the result of the hydrocode simulations of the basin to be used to investigate the layering, at the basis of the age determination, and the impactor size.

1. Introduction

Raditladi is a 257 km-diameter Hermean peak-ring basin, observed for the first time on September 2008 during the 1st fly-by of MESSENGER with the planet and located located at 27.0° N, 119.0° E west of the Caloris basin. Its floor is partially filled with smooth, bright plains material that embays the rim and the central peak ring, inside which troughs are arranged in a partially concentric pattern.

Raditladi soon appeared to be remarkably young because of the small number of impact craters seen within its rims ([1], [2]), in particular it was proposed to be as young as 1 *Ga* ([1]). The presumed young age of Raditladi together with its large sizes poses some interesting questions regarding the impactor population responsible for its formation, since very few asteroids are presently known to have sizes large enough to originate such a basin.

In this context, our group performed both crater retention age analysis to better constrain the timing of the impact event and numerical modeling to deepen the impact process and give some constraints on the impactor dimensions.

2. Crater Retention Age

Our group adopted the recent chronology model proposed by [3], based on the dynamical models of both the Main Belt Asteroids and Near Earth Objects (e.g., [4], [5]). The derived impactor flux is then converted via scaling law into the Model Production Function (MPF), in turn calibrated using the lunar rocks radiometric ages. One strength point of this model, that is the implementation of a layered planetary-like crust, is at the basis of our crater retention age investigation.

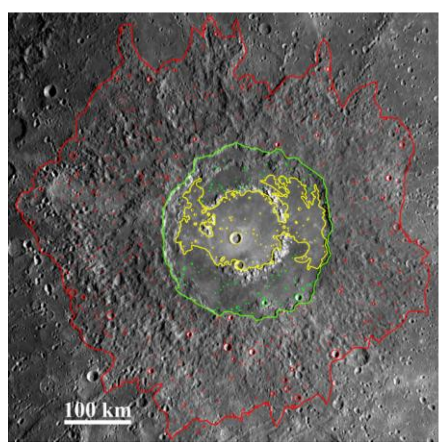

Figure 1: Raditladi Basin, where there are indicated the units and the craters counted.

The starting point to infer crater retention age is crater counting on the basin's floor and ejecta (Fig.

1). Raditladi floor was subdivided into two units, the Inner and the Annular Plains, that have been identified mostly on the basis of surface texture and albedo, as no clear stratigraphic relation has been found among them. This observation suggests that the different terrains of Raditladi basin may be coeval, hypothesis that is confirmed also by the age analysis ([6]) (Fig. 2).

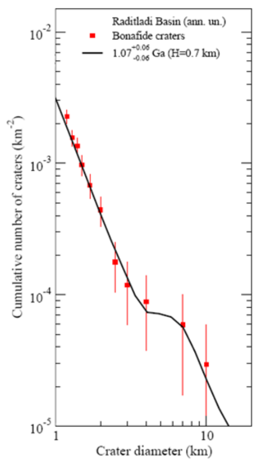

Figure 2. MPF age determination of the basin

3. Numerical Modeling

The layered stratigraphy used in the age analysis is adopted as well in the modeling of the impact event generating the Raditladi basin. The numerical modeling was performed through iSALE shock physics code (e.g., [7], [8], [9]), that is well tested against laboratory experiments at low and high strain-rates ([9]) and other hydrocodes ([10]).

We hypothesize a rock projectile, about 15 km in diameter, that strikes the surface at 30 km/s (typical velocity on Mercury's orbit accounting for the 45° impact angle) [11]. The target is made up by a 40-km basaltic layer, overlying a dunite 70-km thick mantle. The thermodynamic behavior of each material is described by tables generated using the Analytic equation of state (ANEOS). In addition, a constitutive model is necessary to account for changes in material shear strength resulting from changes in pressure, temperature and both shear and tensile damage ([8]). However, in the case of large impact crater formation, this must be supplemented by a transient target weakening model, called acoustic fluidization model, that facilitates the gravitational collapse responsible for the development of central peaks and terraced walls ([12]). This one is implemented in iSALE using the "block-model", which is mainly controlled by the viscosity and the decay time.

We carried out a series of simulations over a broad parameters range with the goal to fit the DTM profiles of Raditladi basin obtained from the data acquired during the MESSENGER flybys ([13]).

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