Numerical modeling of Raditladi and Rachmaninoff basins.
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Introduction: Mercury stands among the other terrestrial planets for the largest population of peak-ring basins [1]. We selected for investigation two structures, Raditladi and Rachmaninoff.

In this work, we will present an update about numerical modeling of Raditladi and Rachmaninoff, carried out through the iSALE shock code [2]. In addition, we will discuss the comparison between modeling and MESSENGER observations, in order to shed light on the primary impactor source of these basins. In particular, we will focus on their differences, and the possible mechanisms or crust-mantle properties that could have led to such a diversification between two similar structures.

Description of the impact structures: Raditladi and Rachmaninoff are two Hermean peak-ring basins observed for the first time by the MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) spacecraft of the NASA Discovery Program. These two structures represent a challenge in the understanding of the impactors source, which should be a NEO-like population after the derived young age for such basins. However, their large dimensions limit to few objects the possible asteroids responsible of their formation [3].

Raditladi. Raditladi is a peak-ring basin located at 27.0° N, 119.0° W east of the Caloris basin. MESSENGER Digital Terrain Model (DTM) profiles show a diameter of ~270 km and a rim-to-floor depth of 4 km, while the peak-ring diameter is ~120 km in diameter [4]. The 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 [5]. The basin walls appear to be degraded, with terraces more pronounced within the north and west sides of the rim. The hummocky continuous ejecta blanket with no visible system of rays surrounds the basin and extends up to 225 km from the basin rim [6].

Rachmaninoff. Rachmaninoff is a peak-ring basin located at 27.6° N, 57.6° E. MESSENGER DTM profiles show a diameter of ~330 km and a rim-to-floor depth of 6 km, while the peak-ring diameter is ~150 km in diameter [4]. The floor is covered by extended smooth plains, which show high variability and clear stratigraphic relationships, while the center is characterized by discontinuous and concentric graben. The basin shows a rim crest crisp and well preserved, while most of the basin walls are modified into terraces [7].

iSALE shock code: Numerical modelling was performed through iSALE shock physics code (e.g., [8], [9], [10], [11], [12]), that is well tested against laboratory experiments at low and high strain-rates [12] and other hydrocodes [13].

For both the basins, we considered a similar setup. We hypothesize a rock projectile, strikes the surface at 30 km/s (typical velocity on Mercury’s orbit accounting for the 45° impact angle) [14]. 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 [9]. However, in the case of large impact crater formation, the ordinary strength model must be supplemented by a transient target weakening mechanism, called acoustic fluidization model, that facilitates the gravitational collapse responsible for the development of central peaks and terraced walls [15]. This one is implemented in iSALE using the “block-model”, which is mainly controlled by the viscosity and the decay time.

We had carried out a series of simulations over a broad parameters range with the goal to fit the DTM profiles obtained from the data acquired during the MESSENGER flybys [4].

Discussion and Conclusion: In this work, we have investigated via numerical modelling the impact process of two peak-ring basins on Mercury, Rachmaninoff and Raditladi, which were found to originate long after the Late Heavy Bombardment, at a time when the primary source of impactors was a NEO-like population.

The projectiles responsible for Raditladi and Rachmaninoff turned out to be 14 and 16 km in diameter, respectively. This is in quite well in agreement with the estimates, on projectiles dimensions made by [3] on the basis of scaling laws considerations.

The best-fit models nicely reproduce both the basins diameters derived from DTM. On the other hand, only Rachmaninoff model depth reproduces the DTM depth (Fig. 1), while in the case of Raditladi, the depth of the final crater is sensibly overestimated.
The different agreement of model and DTM for the two basins could be explained by different amount of melts infilling the basin and consequently by a variable internal structure (i.e. lithosphere-asthenosphere boundary) of Mercury thorough time and in regions charachterized by a different geological evolution.

Acknowledgements: We gratefully acknowledge the developers of iSALE, including Gareth Collins, Kai Wünne mann, Boris Ivanov, Jay H. Melosh, and Dirk Elbeshausen (see www.iSALE-code.de).