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The internal structure of the large impact basins on Mars

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An impact phenomenon forming a large impact basin (D is more than 1,000km) excavates a deep part of a planet, which provides an indispensable window into the deep interior. In such a large impact basin, the materials of crust and mantle are lost through excavation and vaporization and resultant topography generates negative anomaly of gravity.

In the actual cases on Moon, Mars, and icy satellites, this gravitational imbalance causes various types of relaxations such as the uplift of the basin floor and re-distribution of materials beneath. Associated gravity anomalies provide useful information about the internal structures (Bratt et al. [1985], Solomon et al. [1982]).

In this study, we have focused on the largest three impact basins; Hellas, Isidis, and Argyre and conducted a comparative study of their gravity anomalies.

The data set used here is MOLA data for the topography and MGS75D gravity anomaly data, and those resolutions are 1 by 1 degree. We assume axial symmetry with respect to the basin center for both topography and gravity. Both data sets are plotted as a function of the distance from the center and averaged. This procedure eliminates heterogeneous, non-symmetric components. Hellas has been eroded much and rim material is most abundant in the northwestern part of the ring. I averaged Hellas data at northwest fanned region (fan span angle 90 degrees). Isidis is located at the boundary of topographic dichotomy, so its northern half part lacks clear rater rim structure. We averaged Isidis data at southwest fanned region (fan span angle 90 degrees). The eastern part of Argyre has been cratered by Galle and northwestern part is Tharsis region, so we used southwestern data of Argyre (fan span angle 90 degrees).

As is noted in the previous studies (Zuber et al. [2000], Lemoine et al. [2001], Yuan et al. [2001]), these large impact basins are all characterized by the positive anomaly at the center, although their magnitudes are quite different. We estimate axial-symmetric structure of density to explain this gravity anomaly with the topography. Homogeneous densities of the Martian crust and mantle are assumed as 2900, 3500[kg/m3] after Zuber et al. [2000]. Mean crustal thickness outside of the crater is 90km.

Topography at the basin floor of Hellas or Argyre exhibits a slight convex curvature, which can be interpreted as a small-scale relaxation of the topography. On the other hand, that of Isidis is completely flat. This indicates that erosional deposits buried the cavity.

Hellas, Isidis, and Argyre are all characterized by a significant amount of uplift of the Moho at the central region to explain the positive anomaly. Especially, the mantle beneath Isidis and Argyre has been uplifted about 90km. This model does not depend on the thickness of possible sediment burying the basin.

The uplift of the Moho is not a result of gravitational relaxation with long time scale, instead it may be related to the cratering event itself. Alternately it is associated with the induced volcanism in the mantle just after the impact. The anomalous structure of Isidis is consistent with its location, where the crust thickness abruptly thins.