THE STRUCTURE OF THE ISIDIS BASIN, MARS, FROM GRAVITY ANOMALIES.

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Introduction. The Isidis basin on Mars is a large multi-ring impact structure lying astride the transition between the cratered southern uplands and the northern lowland plains [1]. The multi-ring basin structure has been substantially modified by the later emplacement of plains material which has filled much of the central depression, buried the northeast basin rim, and embayed the southwestern rim. Presumably at least partly because of this infilling, the basin is the site of a prominent positive free-air gravity anomaly with a signature similar to that of lunar mascons [2].

Several factors have prompted us to look more closely at the gravity anomaly over Isidis: (i) Since the initial analysis [2] of Doppler radio-tracking measurements from the low altitude orbits of Viking Orbiter 2, additional data were obtained, including one orbit (620) with periapsis centered over Isidis. (ii) Recent Earth-based radar measurements [3,4] have defined more accurately the topographic characteristics of the Isidis region. (iii) Ongoing efforts to infer the thickness of the elastic lithosphere of Mars beneath Isidis from the radial positions of circumferential graben [5,6] require an accurate determination of the geometry of the mascon load. (iv) The deep structure of the pre-fill basin is of current interest in the context of several problems ranging from the nature of isostasy at early stages in planetary history to the excavation volume of large impact basins [e.g., 7-9].

Procedure. To model the signature of the Isidis gravity anomaly in the Viking Orbiter Doppler data we use the orbit simulation procedure described by Phillips and others [10]. Doppler data are first reduced by a complex orbit determination program which accounts for all dynamical effects and for the 4th degree and order planetary gravity field. The Doppler residuals are fit with patched cubic splines, which are then differentiated to yield line-of-sight (LOS) accelerations. For a given model of the mass distribution for Isidis, the LOS accelerations are simulated by integrating a spacecraft trajectory in the presence of the force field of the mass model [10], and these simulated LOS accelerations are compared directly to those observed. For simply parameterized mass models, this procedure may be cast as a formal inverse problem to solve for the model parameters [7].

We have considered a variety of simple models for the Isidis basin structure, and inverted LOS accelerations from orbits 620 and 505 (the latter used in [2]) to obtain best-fitting model parameters. Models included: (a) single-disc masses to simulate the mascon; (b) concentric surface-disc masses; and (c) combinations of surface and buried disc masses to simulate the basin topographic depression, its compensation by Moho relief, and the excess mass of the mascon.

Model Results. The single-disc models for the Isidis mascon produce poor fits to other than very short arcs of LOS data. This is because the positive free-air anomaly is surrounded by a broad region of negative free-air anomaly (substantially more negative than would be introduced by the orbit determination procedure [e.g., 10]). While a regional negative free-air anomaly extends for some distance to the north, northwest and east of Isidis and appears to be related to the upland-lowland transition, a portion of the negative anomaly is

clearly annular with the mascon high [2].

The best fitting models to date are those with a surface-disc excess mass representing the mascon and an approximately concentric ring of mass deficiency representing partially or deeply compensated basin topography. For discs of constant thickness curved to follow the external shape of the planet, the mascon disc has a best-fitting radius of about 250 km and a surface density of 1.0 to 1.5 × 10^6 g/cm^2. The annular ring has a radius of 550 km, equal to the radius of the present basin depression, and a surface density of -0.6 to -0.8 × 10^6 g/cm^2. The LOS accelerations over the basin are well matched if the mascon disc is offset about 50 km southward from the negative-mass basin ring; this result may reflect the asymmetric state of preservation of the multi-ring basin structure. The magnitude of the surface density for the outer ring is about half that contributed by the 5 km of present relief for the basin depression, indicating at least partial compensation of basin topography.

Several types of more complex models have been considered in order to model explicitly the effects of partial to complete isostatic compensation of initial basin topography and of subsequent basin fill. Efforts are also continuing toward finding models which fit as well as or better than the surface-disc models. Preliminary results indicate that compensation of initial basin topography was either incomplete or was accomplished at a depth of 150 km or greater; a somewhat similar result has been obtained for the Hellas basin [11]. A variety of models for the excess mass of the mascon are possible, but the lateral extent of the majority of this excess mass does not exceed half the diameter of the present basin depression, and the best fit is obtained if a substantial portion of the excess mass is shallow.

Conclusions. The Isidis mascon is substantially smaller in horizontal dimension than the present topographic basin. It probably is due at least partly to infill of a now-buried central depression by basalts greater in density than surrounding crust. The degree of initial compensation of the basin remains open; but unless the Martian crust is very thick, local compensation of the initial basin was likely precluded by the strength of the Martian lithosphere.

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