SPHERICAL-SHELL VS. FLAT-PLATE MASCON LOADING MODELS FOR CALORIS;
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Planetary lithospheres support loads through two modes: shell or membrane stress and bending stress or flexure. The former applies principally at long wavelengths (low harmonic degrees) and the latter at short wavelengths (high degrees) [1]. Uncompensated surface loads (mascons) are generally regarded as being of finite enough extent that membrane support can be neglected [e.g., 2-4]. Relatively large central mascon structures exist on the Moon (Imbrium; a/R ~ 0.4, where a and R are mascon and planetary radius) and on Mars (Isidis; a/R ~ 0.2), but the largest would be that associated with Tharsis (a/R ~ 0.75). In this case membrane stresses dominate, with the consequence that rather than the prediction of central radial thrust faults and peripheral concentric normal faults on a flexural arch, the central thrusts should be concentric and the peripheral normal faults radial (the latter due to lithospheric stretching) [2-5].

Caloris Basin, Mercury is a unique tectonic structure [e.g., 6]. The basin floor has apparently subsided under a load, but compressive ridges there are predominantly concentric. This may be due to control by deeply-buried basement ring structure, if any, or it may be due to membrane stress. Because membrane stress becomes increasingly important at a given scale as lithosphere thickness decreases, the ridges could be due to a central mascon load on a very thin lithosphere, or to an effective loading on a larger scale than Caloris (a = 650 km). A broad withdrawal of magma to form the smooth plains exterior to the basin, postulated by [7], would have this effect and could be responsible. The culmination of tectonic activity at Caloris appears to have been uplift and extension of the basin floor, and it has been argued that any present mascon is most likely associated with the exterior smooth plains. These smooth plains extend approximately two basin radii away from the Caloris Montes, and it would seem that a membrane-stress calculation is appropriate. The spectral power in an idealized annular load about Caloris is plotted as a function of spherical harmonic degree in Fig. 1. For comparison, the spectral power of a basin-scale Gaussian load is also given. Despite the vast extent of the of the ring load, it has very little spectral power at low degrees other than 1 and 2. A bending stress model for the ring load using the thick-plate theory of [2] predicts normal faults within the basin and thrust faults beneath the load, which are observed. The basin normal faults are dominantly concentric, though, which is predicted only for lithospheres < 125 km thick. The relative amount of compensation due to membrane and bending support can be calculated for Mercury following [1]; the transition between each occurs near degrees 6, 9, and 13 for lithosphere thicknesses of 200, 100, and 50 km. Thus for thicker lithospheres (> 200 km), thick flat-plate theory (with curvature parameterized) [2] is accurate for Caloris. For thinner lithospheres I compare the surface deformation calculated from [5] (Fig. 2) with the flat-plate model (Fig. 3). The solutions are similar, and both show a relative upwarping of the basin floor. The spherical shell solutions are plotted with and without the degree 1 contribution; this corresponds to a uniform translation and does not affect the stresses. The important degree 2 term corresponds to an equatorial loading, and is thus formally equivalent to the tidal despinning problem. In this case, polar (i.e., basin-central) concentric normal faults are predicted [8].

I note in passing that the annular load should be sufficiently thick to initiate faulting, based on photogeological estimates of the basalt thickness [9], subsidence profiles determined by the Arecibo radar [10], and limits to the mascon's contribution to J_2 [11]. Further discussion of the stress solutions will be presented.

MEMBRANE vs. BENDING STRESS FOR CALORIS
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Fig. 1

SURFACE DISPLACEMENT (in units of L/pg)

Fig. 2

SURFACE DISPLACEMENT (in units of L/pg)

Fig. 3