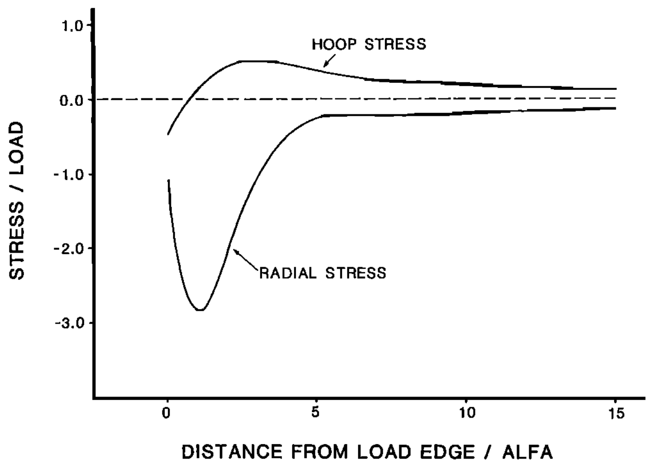


Fig. 15. Radial and hoop stresses as a function of distance from the load edge for uplift in response to an applied negative load. Stress is normalized to the applied load and distance is in units of α. Negative stress is compressional.

load could produce the distant Hellas canyons but requires an extremely thick lithosphere, a widespread but unobserved unit responsible for the load, and an exceptionally rapid mechanism for load emplacement.

Radial trough formation by elastic flexure during isostatic uplift further constrains the evolution of such a basin-filling load. Isostatic uplift (flexure due to a negative load) must occur soon after basin formation in order to allow time for stress concentration before radial fracture; therefore the negative load driving uplift must act in the brief time frame during and just after formation of the distant concentric canyons. Because formation of the HC by flexure requires a large positive load, a process must be invoked to transform this positive load into a negative load that allows radial trough formation by basin uplift. Gravity data from ancient impact basins on the Moon indicate that subcrustal erosion of an underlying mantle uplift could provide such a process [*Bratt et al.*, 1985*a*]. Both the inversion of the Hellas Bouguer gravity data [*Sjogren and Wimberly*, 1981] and the similarity of the observed Isidis gravity anomaly to the younger, larger lunar mascons [*Sjogren*, 1979], however, point to a significant preservation of the mantle uplifts beneath the basins of this study. Therefore, in the absence of subcrustal load removal, a surface process of load removal is required. While a load of basin-filling basalts would not facilitate such a process, a transient load of dust laden with water or ice emplaced in the basin structure after impact would allow later removal of the load by eolian processes. A load of this type could result from rapid reworking of ejecta soon after basin formation and perhaps subsequent climate change [*Schultz*, 1988*a*]. The modeled lithospheric thicknesses then indicate a load thickness of ~4 km in order to initiate fracture. At this thickness, the modeled loads represent less than half the volume of ejecta predicted for a Hellas transient cavity 600 km in radius with a diameter/depth ratio of 10:1. Although possible in principle, such a basin-confined load still requires a lithospheric thickness of 400–600 km, substantially greater than that expected for Mars at the time of HC formation.

Since the lithospheric thickness derived from the inversion of a load model primarily reflects the distance between the load edge and the outermost fracture, formation of the outermost HC by flexure for lithospheric thicknesses closer to 100 km can only occur if the basin-centered load extends past the basin scarp. A static load induced by basin ejecta provides such a load model and also provides a mechanism to emplace the required load near the time of basin formation. Further, while ejecta deposits are not confined by the basin scarp, most crater ejecta is deposited near the basin: ~2/3 within 2 crater radii of the transient cavity and nearly 90% within 3 crater radii [*Schultz et al.*, 1981]. If the ejecta deposit is primarily concentrated outside of the central basin cavity as an annular or ringlike load, then the models of deformation under similar loads around Caloris on Mercury [*McKinnon*, 1987; *Melosh and McKinnon*, 1988] indicate that failure will be dominated by thrust faults beneath this load and normal faulting in the basin center. Since the flexural stresses are much lower outside the ring load, extensive fracture and canyon formation in the HC appears unlikely for such a load model. Atmospheric effects, however, may disrupt the classic model of ejecta deposition during basin-scale impacts and lead to significant ejecta deposition within the central basin region [*Schultz*, 1988*a*], in which case the ejecta load can be roughly modeled as a cylinder 2–3 times the transient cavity in radius. For an assumed transient cavity radius of 900 km, the radius of the Hellas basin scarp is nearly twice that of the transient cavity; and an ejecta load model 2.5 times the cavity in radius (~2300 km) is consistent with formation of the HC in a 100-km-thick lithosphere (Table 4).

The required ejecta loads for these flexure models can then be inverted to constrain the transient cavity for the Hellas basin (Table 4). The estimated ejecta volume dictates a transient cavity volume; thus a successful flexure model should provide the diameter/depth aspect ratio of the transient cavity for a given cavity radius. If ejecta represents 50% of the total displaced mass in an impact event [*Stoffler et al.*, 1975], then for the model load developed above and a cavity radius of 900 km, the derived aspect ratio (Table 4) is much greater than the 5:1 value typically assumed for transient cavities [*Pike*, 1974], and is more consistent with alternative models of shallow transient cavity shapes for large craters [*Schultz*, 1988*b*]. Because the initial ejecta volume for this transient cavity model is based on the minimum load thickness required for fracture, however, greater ejecta thicknesses are not precluded theoretically and permit deeper transient cavity models. The absence of similar distant canyons around Isidis nevertheless limits this reduction in aspect ratio. For example, a transient cavity model for Isidis with a radius of 600 km and a 10:1