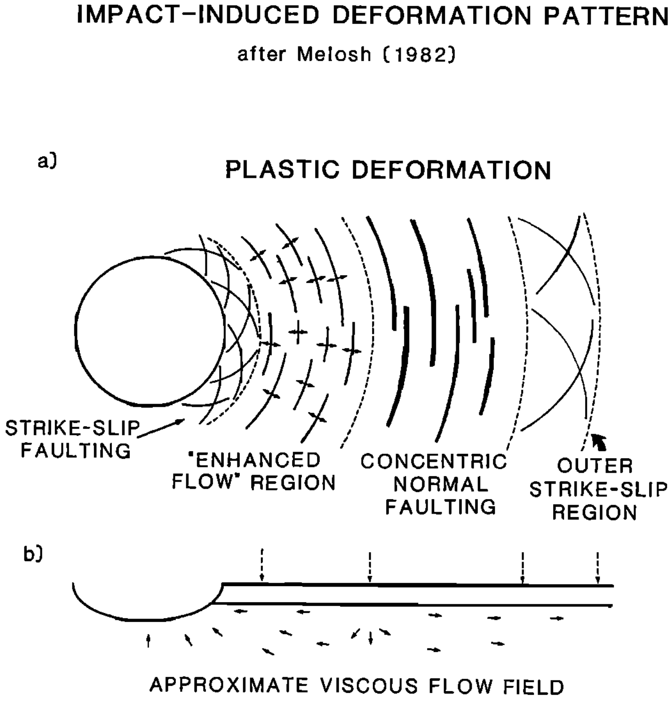

Fig. 16. (*a*) The pattern of plastic deformation predicted by *Melosh* [1982*b*] for a rapid influx of asthenosphere during transient cavity collapse. Dashed lines separate regions of different deformational style and plastic deformation does not extend beyond the limit of the outer strike–slip region. (*b*) A schematic view of asthenospheric flow beneath the deforming lithosphere [after *Melosh*, 1982*b*]. Arrows indicate approximate bounds of the deformation regimes identified in Figure 16*a*.

tion from required plastic behavior to an elastic stress regime.

The radial and azimuthal stresses about the basin can be characterized by a single dimensionless strength parameter γ that characterizes the extent of deformation about an impact [*Melosh*, 1982b]:

$$\gamma = \frac{\sqrt{3}}{2} \frac{S a}{Y T} \qquad (5)$$

where S is the applied basal traction; a is the crater radius, T is the lithospheric thickness, and Y is the modeled lithospheric yield strength. The extent of observed fracturing about an impact, therefore, can be used with reasonable assumptions about S, a, and Y to estimate the lithospheric thickness at the time of impact from equation (5). In this application, however, two interpretations for γ are possible. First, if the distant concentric canyons correlate with the observed graben of Valhalla, the HC indicate the transition between enhanced and stable plastic flow and the outermost scarp delineates the limit of enhanced flow. Alternatively, the edge of the HC correlates with the limit of fracture due to impact and thus the limit of the stable flow regime. Because enhanced flow for a realistic viscous asthenosphere is unlikely to extend more than one crater radius from the cavity rim [*Melosh*, 1982*b*], deformation by enhanced flow should extend no more than 100–200 km beyond the basin scarp, and the first interpretation appears to be unlikely.

Inversion of a 900-km Hellas radius with an assumed aspect ratio for the transient cavity of 5:1 (Figure 17) yields lithospheric thicknesses on the order of 300 km, about 3 times the thickness expected from planetary thermal modeling [*Schubert et al.*, 1979]. Acoustic fluidization, however, can subsequently enlarge the transient cavity by over 50% [*Melosh*, 1982*a*]. Consequently, Figure 17 shows a range of inversions for smaller cavity radii that incorporate varied amounts of acoustic fluidization extending out to twice the transient cavity radius in order to produce the 900-km central basin radius defined by the massif ring. If the lithosphere is now assumed to approach the 100-km thickness predicted by *Schubert et al.* [1979], then a transient cavity radius of ~550 km (61% of the 900-km maximum) is predicted for formation of the HC. This value, however, is dependent on the asssumed aspect ratio of the transient cavity. Increasing the aspect ratio to 20:1 yields a larger transient cavity radius of ~750 km, a value only 83% smaller than the massif ring radius.

An impact origin for the HC is also compatible with observed deformation nearer the basin. If the concentric canyons indicate deformation by stable plastic flow, then the region of enhanced flow should lie well within the HC and should be separated from them by a transition zone of relatively low deformation [*Melosh*, 1982*b*]. Although lower elevation, later ejecta, and/or erosion after impact obscure features in this region, a thin dis-

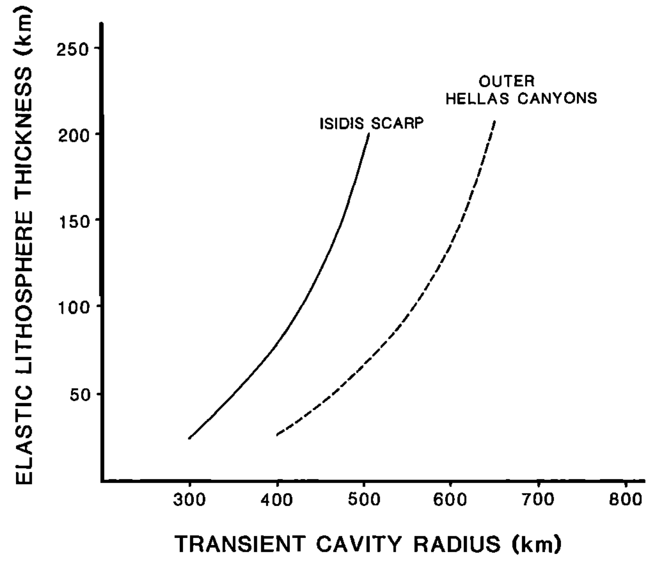

Fig. 17. Inversion of impact–fracture model to lithospheric thickness as a function of transient cavity radius for the outermost Isidis–concentric and Hellas–concentric structures. Model assumes a 5:1 transient cavity aspect ratio, Martian gravity (g = 3.72 m/s^2), a material density of 3.0 g/cm^3, and a yield strength of 400 bars.