TABLE 2. Constants Used in Calculations of Flexure

Symbol	Constant	Assumed Value
E	Young's Modulus	7×10^{10} Pa
ν	Poisson Ratio	0.25
ρ	mantle density	3400 kg/m³
g	gravitational acceleration	3.72 m/s²

bars (on the conservative side of the 200–400 bar range in terrestrial rock strengths cited by *Comer et al.* [1979]), then $q>= 141$ bars. For a basalt load with density 3.0 g/cm³, this then implies a load thickness of at least 1.26 km for the Martian gravity of 3.67 m/s². Comparison of this required load thickness to limits on basin-filling units permits fitting flexural deformation to the observed basin history. The minimum load thicknesses used in subsequent discussions are derived on this basis, and all assume the same lithospheric yield strength of 400 bars, as used in this example.

In the next three sections on structure origin, the origins of the massif ring graben, the basin radial troughs, and the Hellas concentric canyon systems are treated separately, in keeping with their differing relative ages and locations about the basins. Much of the discussion is based on four load models derived from observed basin structures and units (Figure 12). Inside the massif rings, the outer margins of the central basin plains provide the load diameters for models I and II. Two additional load models (loads III and IV) are constructed from basin-centered scarp elements outside the Hellas massif ring, supplemented by changes in average regional elevation to the west, northwest, and east of the basin.

Origin of the Massif Ring Graben

Graben formation in the basin massif rings appears to be fully consistent with a flexural origin as outlined above. The average lithospheric thickness derived from the Isidis massif ring graben (87 km) correlates with the thickness obtained from the HMG and is reasonably close (Figures 13 and 14) to predictions of lithospheric thickness in the 3.0–3.8 b.y. time frame [*Schubert et al.*, 1979]. Although significantly smaller than the value of 125 ±25 km derived by *Solomon et al.* [1979], this difference probably reflects a difference in application to the the interpretation of the I-AF fractures to the flexure models. Specifically, a single fault trend 200 km east of the rest of I-AF faulting (I-AF* in Table 3 and Figure 12) yields a lithospheric thickness of 143 km, whereas the position of the I-NF indicates a thickness of 107 km. These values match the lithospheric thickness determination of Solomon et al. quite well. Nevertheless, if enhanced cooling in basin regions can cause lithospheric thickening as proposed by *Arkani-Hamed* [1974], even a thickness of 150 km as derived by *Solomon et al.* [1979] can be consistent with a flexural origin.

The loads modeled for these lithospheric thicknesses are also compatible with observed surface units. The load sizes were defined from the extent of observed basin-filling units, and the minimum required load thicknesses for basalt are not unreasonable, 1.25 km and 1.2 km for Isidis and Hellas, respectively. The surface of both basin interiors,

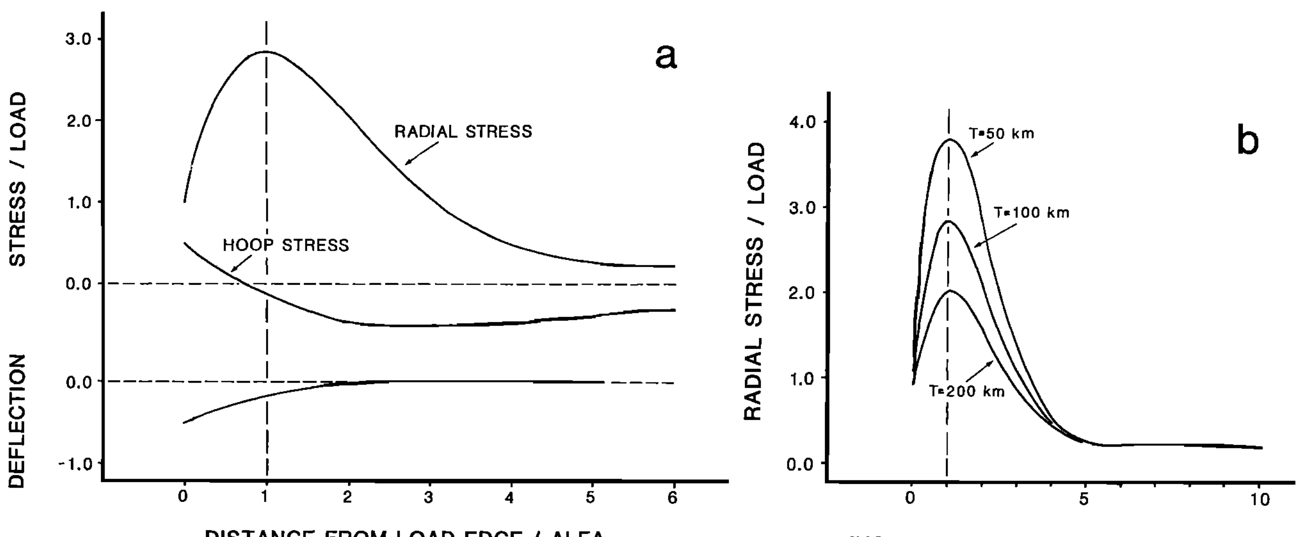

Fig. 11. (*a*) Plots of deflection, radial stress and hoop stress about a cylindrical load as a function of distance from the load edge. The horizontal axis is in units of the flexural parameter α, and the vertical axis has both deflection and stress normalized to the applied load. Dashed line shows peak radial stress at a distance 1α from the load edge. (*b*) Plots of modeled radial stress as a function of distance from the load edge for lithospheric thicknesses of 50, 100, and 200 km. Radial stress is normalized to the applied load and distance from the load edge is expressed in units of α, which is also a function of lithospheric thickness. Despite the varied lithospheric thickness, peak radial stress remains fixed at a distance 1α from the load edge (dashed line).