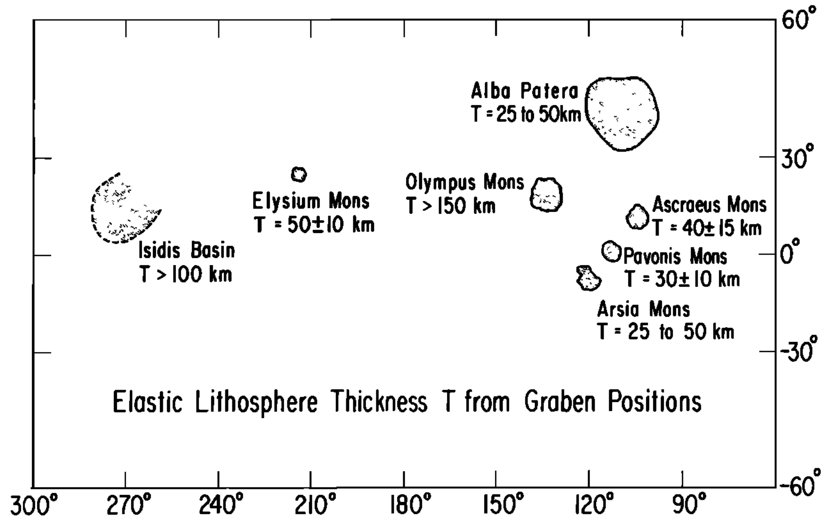

Fig. 7. Estimates of the thickness of the elastic lithosphere beneath major volcanic loads on Mars from the radial distance of prominent circumferential graben, from *Comer et al.* [1980]. The thicknesses shown correspond to the time at which the respective graben formed.

stages of activity in the Tharsis and Elysium volcanic provinces. By contrast, a thick elastic lithosphere (>100 km) is indicated for regions at greater distances from volcanic province centers, including the areas surrounding both the comparatively older Isidis mascon [*Sjogren*, 1979] and the geologically more youthful Olympus Mons shield [*Thurber and Toksöz*, 1978; *Comer and Solomon*, 1981].

The regions on Mars of locally thinnest elastic lithosphere, and by implication of greatest near-surface thermal gradients, are thus also the regions of most recent major volcanic activity and the centers of the best developed fracture systems. The moon similarly displays contemporaneous heterogeneities in lithosphere thickness and near-surface thermal gradients that correlate strongly with tectonic and volcanic activity [*Solomon and Head*, 1980*a*] and, at earlier times, with the extent of ring development in multiring basins [*Head and Solomon*, 1980] and the subsequent viscous relaxation of basin topographic relief [*Solomon et al.*, 1982]. We believe that lithospheric heterogeneity on Mars played an essential role in the development and sustained activity of the Tharsis province.

THARSIS AS A CONSEQUENCE OF LITHOSPHERIC FAILURE AND VOLCANIC CONSTRUCTION

In view of the difficulties encountered by the various uplift models for the origin and evolution of the Tharsis province, we have been led to propose an alternative physical model [*Solomon and Head*, 1980*b*] that is compatible with the geological history of the region, the pattern of tectonic features, and the present topographic and gravity anomalies. We invoke for this model geological processes that are evident in the Tharsis region and elsewhere on Mars, namely, volcanic construction, lithospheric loading, and lithospheric failure caused by load-induced stresses. The unusually large scale and duration of Tharsis volcanic and tectonic activity are attributed to the influence of lithospheric heterogeneity early in the history of Mars. In this section we describe our model for the evolution of the Tharsis region in greater detail. We note several testable consequences of this model, and we refute objections to this model that have appeared in the literature. Finally, we enumerate several advantages of the model presented here that are not all shared by Tharsis evolutionary models previously proposed.

Tharsis evolutionary model. The starting premise of the model is that the effective thickness of the elastic-brittle lithosphere of Mars was laterally heterogeneous early in Martian history, just as it was during the later era represented by Figure 7. Stresses produced on global or regional scales would then be greatest in the regions of thinnest lithosphere, and fracturing in response to those stresses would likewise be concentrated in such regions. Possible sources of stress on global scales include thermal stress associated with planetary warming or cooling [*Solomon*, 1978] and changes in lithospheric shape associated with changes in spin rate [*Melosh*, 1977] or polar wander [*McAdoo and Burns*, 1975; *Melosh*, 1980]. Sources of stress on regional scales include loading [*Solomon et al.*, 1979; *Comer et al.*, 1980] and local thermal stress [*Bratt et al.*, 1981], among others.

In a region of anomalously thin lithosphere, the concentrated fracturing produced by enhanced lithospheric stress would increase the accessibility of mantle-derived magma to the planetary surface. Regions of concentrated fracturing should also therefore be regions of enhanced volcanic activity. Intense igneous activity would serve to maintain anomalously high temperatures at shallow depths and therefore a locally thin lithosphere. The region would continue to be the preferred site for fracturing in response to global lithospheric stress or to the additional local stresses generated by volcanic loading. Thus once a region of locally thin lithosphere develops, fracturing and volcanism can maintain the lithospheric heterogeneity for as long as such activity continues.

We hypothesize that Tharsis was the site of locally thin lithosphere dating from a time before the end of heavy bombardment. Elysium was a similar region of either a lesser horizontal scale or a lesser magnitude anomaly in lithospheric thickness. The concentration of lithospheric stress in the Tharsis and Elysium regions led to extensive