VENUSIAN TECTONICS: CONVECTIVE COUPLING TO THE LITHOSPHERE?

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The relationship between the dominant global heat loss mechanism and planetary size has motivated the search for tectonic style on Venus. Prior to the American and Soviet mapping missions of the past eight years, it was thought that terrestrial style plate tectonics was operative on Venus because this planet is approximately the size of the Earth and is conjectured to have about the same heat source content per unit mass [e.g., *Phillips and Malin*, 1984]. However, surface topography mapped by the altimeter on the Pioneer Venus spacecraft did not show any physiographic expression of terrestrial style spreading ridges, trenches, volcanic arcs or transform faults, although the horizontal resolution was questionable for detection of at least some of these features [*Masursky et al.*, 1980; *Phillips et al.*, 1981; *Solomon and Head*, 1982; *Phillips and Malin*, 1983,1984]. The Venera 15 and 16 radar missions mapped the northern latitudes of Venus at 1 to 2 km resolution [*Barsukov et al.*, 1986] and showed that there are significant geographic areas of deformation seemingly created by large horizontal stresses [*Basilevsky et al.*, 1986]. These same high resolution images show no evidence for plate tectonic features [*Barsukov et al.*, 1986; *Basilevsky et al.*, 1986]. Thus a fundamental problem for venusian tectonics is the origin of large horizontal stresses near the surface in the apparent absence of plate tectonics. There have been a number of studies of venusian tectonics that, *given the existence* of (large) horizontal stresses or strain-rates in an elastic or viscous lithosphere, have predicted the *style* of deformation. Tectonic studies have modeled these terrains as extensional rifts, horsts and graben, imbricate normal faults, and necking or folding instabilities [*Solomon and Head*, 1984; *Zuber*, 1986; *Banerdt and Golombek*, 1986; *Parmentier*, 1986]. The interest here is in the development of viable models for the *creation* of large horizontal stress in the venusian lithosphere, from which the tectonic deformation presumably follows. *Basilevsky et al.* [1986] have suggested "drag of the lithospheric by asthenospheric currents or gravity-induced spreading of surface material over upwellings" as alternative means to plate tectonics for producing horizontal deformation.

The first of these processes, mechanically described as convective stress coupling into an elastic or viscous lithosphere, has been examined in a preliminary fashion. Spectral Green's function solutions have been obtained for stresses in thick elastic and viscous lithospheres overlying Newtonian interiors with an exponential depth dependence of viscosity, and a specified surface-density distribution driving the flow in the fluid [*Phillips*, 1986]. It is found for long wavelengths and for a rigid elastic/fluid boundary condition that horizontal normal stresses in an elastic lid are either purely tensional or purely compressional, are controlled by the vertical shear stress gradient in the lid, and are directly proportional to the depth of the density disturbance in the underlying fluid.

These theoretical solutions combined with information on the depth and strength of density anomalies in the venusian interior inferred by analyses of long wavelength gravity data [*Phillips and Malin*, 1983; *Sjogren et al.*, 1984; *Reagan*, 1986] and topography [e.g., *Bills and Kobrick*, 1985] suggest that stresses in excess of 100 MPa would be generated in a 10-km-thick [*Solomon and Head*, 1984] elastic lid. These results, if they apply to specific regions of Venus, would imply that the topography in these areas is dynamically maintained and the subsurface density anomalies are associated with viscous flow. These stress levels would be greatly diminished, however, if a low viscosity channel (LVC) or positive viscosity gradient occurs beneath the lid. This would uncouple the flow stresses. The great apparent depth of compensation of topographic features argues against this [see *Robinson et al.*, 1986] as does actual admittance spectrum modeling [*Kiefer et al.*, 1986], thus supporting the importance of the coupling mechanism. If there is no elastic lid, stresses will also be very high near the surface, providing also that the same conditions on viscosity gradient hold.

It is often stated, but yet to be demonstrated, that a LVC is a requirement for terrestrial seafloor spreading. The implication is that the lack of coupling of the oceanic lithosphere to the underlying mantle allows the domination of the necessary driving forces (ridge push, slab pull?). This leads to the following hypothesis regarding the difference in venusian and terrestrial tectonics: *The tectonic styles of Earth and Venus are determined by the presence and absence of a LVC, respectively.* If this hypothesis is correct, then the uncoupled nature of the oceanic lithosphere results in the direct focusing of convective effects only at the ridges, while on Venus mantle convection can be strongly coupled over large regions, leading to broad zones of intense deformation. Whether or not this concept might have application to the Archean Earth depends on when the terrestrial mantle became hydrated.

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