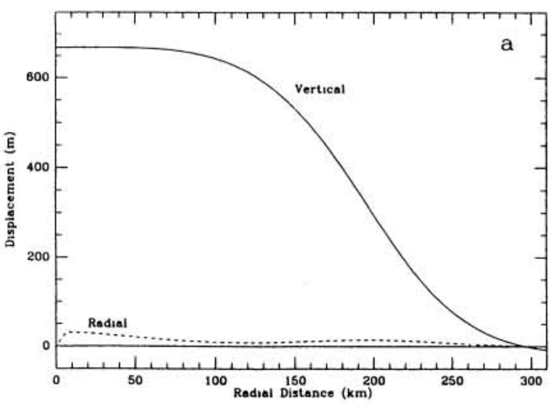
LITHOSPHERIC CONTROL OF PLATEAUS ABOVE VENUSIAN DIAPIRS Daniel M. Janes and Steven W. Squyres, Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853

Models of the formation of coronae on Venus involve a three-stage process: 1) a rising mantle diapir produces a domical uplift and radial extensional fracturing, 2) flattening of the diapir against the base of the lithosphere results in a plateau-shaped uplift, and 3) relaxation of the plateau takes place to form the characteristic central bowl, raised rim, and encircling moat as well as concentric extensional fracturing [1,2,3]. The initial uplift and final relaxation processes have been well studied, but the intermediate phase, the development of plateau-shaped topography, has not. Both layered viscous models [2,4] and elastic/viscous layered models [3] of a rising spherical diapir produce domical uplift and radially oriented extensional fracturing consistent with observed radially fractured domes. Similarly, both purely viscous [2,3] and visco-elastic [5] modeling of gravitational relaxation produce the final topography of coronae and concentric extensional fracturing on the outer wall of the surrounding moat. However, these relaxation models require that relaxation begin with a flat-topped uplift, formation of which has not been explored. Moreover, neither the initial uplift models nor the relaxation models produce the concentric extensional fracturing observed on the upraised rim [2].

Purely viscous modeling of a diapir as it reaches the underside of the lithosphere [4] indicates that it will spread to form a disk of low density material, raise the overlying lithosphere to a broad, flat plateau, and produce concentric extensional fracturing at the edge of the plateau. We examine the effects of an elastic lithosphere over the disk-shaped diapir to determine whether it prevents or enhances these results and whether limits may be placed on the thickness of the effective elastic lithosphere. In our modeling, developed in spherical coordinates, the diapir is treated as a swarm of point masses spread uniformly through the volume of the diapir, the mantle is taken to be a constant viscosity fluid, and the lithosphere is an elastic shell [3,6]. To model a disk-shaped diapir, the point masses are placed at a constant depth in the mantle in a circular pattern. The model is relatively insensitive to the exact depth at which the point masses are located as long as the depth is small compared to the radius of the disk. All examples shown here are for a point mass depth of 10 km.



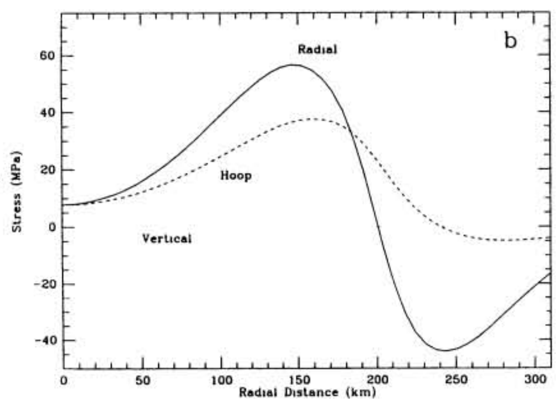


Fig. 1: a) Topography and b) Stresses due to a disk-shaped diapir below a 20 km thick elastic lithosphere.

Figure 1 shows the surface topography (a) and stresses (b) for a 33 km thick diapir 200 km in radius with a density 50 kg/m^3 lower than the surrounding mantle below a 20 km thick lithosphere. The dimensions of the diapir are chosen to be equivalent in volume to an initial spherical diapir 100 km in radius. The flattened diapir raises a 650 m high plateau and produces stresses consistent with concentric extensional fracturing at a radial distance of 150 km from the center. There is also a region of predicted concentric compressional tectonics at a radial distance of approximately 250 km. These results generally agree with viscous modeling [4], however there are some noticeable differences due to the introduction of the elastic lithosphere. The major topographic difference is in the extent of the flat-topped region of the plateau. Viscous modeling predicts that, for diapirs that have spread to form a disk whose radius is greater than about two times the original spherical radius, the extent of the plateau is essentially equal to the extent of the disk-shaped diapir below it. However, the distances required for the bending of the elastic lid produces a plateau which is considerably narrower, here approximately half the disk radius. In addition, the region beyond the plateau where the lithosphere flexes convexly to form the shoulder of the plateau and concavely to rejoin with the plains is much broader than indicated by viscous modeling. Stresses are also more broadly distributed with the addition of lithospheric rigidity.

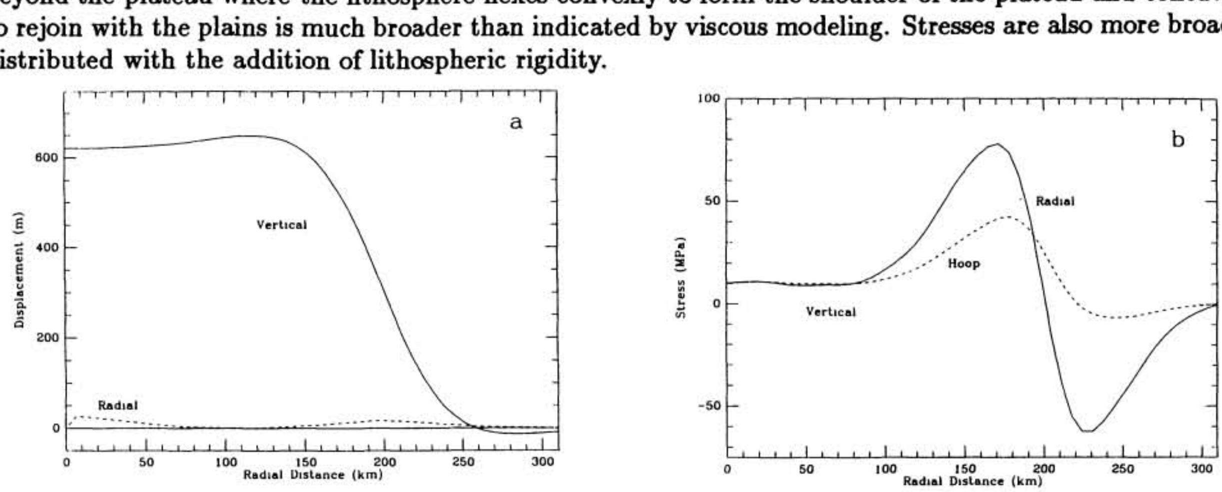


Fig. 2: a) Topography and b) Stresses due to a disk-shaped diapir below a 10 km thick elastic lithosphere.

Thinner lithospheres produce slightly different results. Figure 2 shows the surface topography (a) and stresses (b) for the same model parameters as Figure 1 except that the lithospheric thickness is only 10 km. The flat-topped portion of the uplift is wider and the plateau wall steeper than in the case of the 20 km thick lithosphere. In addition, a low ridge forms on the outer portion of the plateau similar to the forebulge formed on lithospheres when subjected to bending under subduction. Peak stresses are more narrowly confined than for the thicker lithosphere and are also larger in magnitude reflecting the sharper bending.

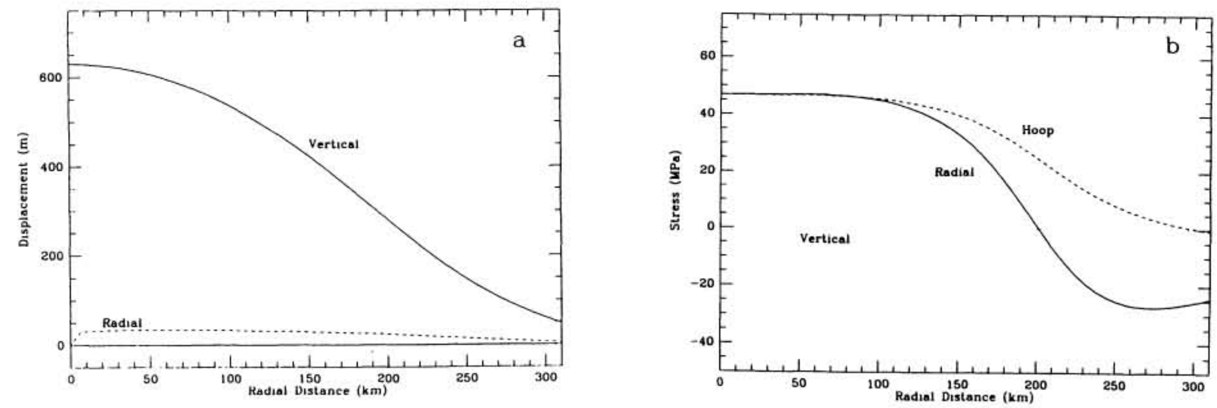


Fig. 3: a) Topography and b) Stresses due to a disk-shaped diapir below a 45 km thick elastic lithosphere.

With increasing lithospheric thickness, plateaus and concentric extensional fracturing both become less evident. Figure 3 shows the surface topography (a) and stresses (b) for the same model parameters as Figure 1 except that the lithospheric thickness is 45 km. There is no level area at the top of the uplift but rather the uplift exhibits the gently sloping topography associated with radially fractured domes. The stress pattern also shows a marked change in that there is no region of predicted concentric extensional fracturing, but rather a prediction of radial extensional fracturing out to the radius of the disk.

As the radius of the disk-shaped diapir decreases, the upper limit of lithospheric thickness that will allow production of both a plateau shape and concentric radial fracturing of the rim also decreases. For a diapir which flattens to a disk that is 50 km in radius, lithospheres thicker than 10 km will prevent their formation. Thus, even if there is a continuum of diapir sizes available for corona formation, the flexural rigidity of the lithosphere will place a lower limit on the diameter of coronae.

References 1) Barsukov, V.L., et al., *J. Geophys. Res.*, 91, D378–D398, 1984. 2) Stofan, E.R., et al., *J. Geophys. Res.*, 96, 20933–20946, 1991. 3) Janes, D.M., et al., *J. Geophys. Res.*, 97, 16055–16067, 1992. 4) Koch, D.M., *J. Geophys. Res.*, 99, 2035–2052, 1994. 5) Janes, D.M. and S.W. Squyres, submitted to *J. Geophys. Res.*, 1995. 6) Janes, D.M. and H.J. Melosh, *J. Geophys. Res.*, 93, 3127–3143, 1988.