THERMAL EFFECTS ON THE TECTONICS OF VENUS;

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It was early emphasized that the high temperature and low water content ($740^{o}K$ & 100 ppm at the surface) would lead to near melting around depth 40 km (or a mean lithospheric thickness of 20 km), inhibit subduction (through stiffening near surface rocks and deepening the basalt: eclogite phase transition about 40 km), and prevent granite formation (1,2,3). The principal observational confirmation of this conjectured absence of subduction is the lack of sufficient ocean rises to make sea-floor spreading a significant means of removing heat (4). Therefore the boundary layer of mantle convection on Venus must be at depth. If this convection were of equal vigor to the Earth's, it would bring up about 15 km^3 of crustal material per year. Hence a crust as thick as the depth to the basalt: eclogite transiion would develop. If Venus's thermal regime were minimally different from the Earth's (taking into account temperature dependence of viscosity: 4), this depth would be about 100 km, and hence develop within 2.0 Gy.

A Venerean crust of thickness D = 100 km would be convectively unstable in itself:

$$Ra \approx \langle g \alpha \rangle Q D^4 / \langle C \kappa^2 \eta_c \rangle \approx 10 Ra_c$$

where the mean viscosity $\eta_c \approx 10^{21}$ poises is obtained by iterating to a temperature profile consistent with boundary layer theory, holding fixed the thickness D. But this convection would lower temperatures enough to raise the basalt: eclogite transition 20-30 km, thus driving Ra toward marginal, but raising the temperature differential, thus driving it back again.

However, any isolated solution for convection in a thick Venerean crust is rather irrelevant, since the behaviour of such a crust would be dominated by its interaction with mantle convection, which must still have appreciable energy sources and significant lateral variation to account for the appreciable elevations of Ishtar, Aphrodite, and Beta. Evidences of a great crustal thickness are the confinment of such upthrusts to a few places, and the apparent depths of compensation (ADC) in excess of 100 km (5). The most important effect of the convecting crust is to increase the number of boundary layers, with steep temperature gradients, from one to three. The layer at the top of the mantle thus should cause an appreciable asthenosphere, which would dominate the compensation and perhaps be hot enough to lead to a coupling of mantle to crustal convection that is more thermal than mechanical.

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This hypothesis is contrary to most recent analyses of Venus's topography and gravity (6-10), which infer a more Earth-like crust and lithosphere. These analyses thus imply that dryness dominates over temperature in determining crust and upper mantle rheology (11), perhaps even to the extent of eliminating an asthenosphere (9-10). However, these solutions beg the question of how crustal material is recycled. Hence the consequences of a very thick crust should be explored.

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