ON THE THERMAL EVOLUTION OF VENUS, Jafar Arkani-Hamed and M. Nafi Toksöz, Dept. of Earth and Planetary Sciences, Massachusetts Inst. of Technology, Cambridge, MA 02139

A theory of non-linear, finite-amplitude, non-symmetric and three-dimensional convection is developed in an incompressible and viscous spherical shell with temperature and pressure dependent physical parameters. The parameters viscosity, thermal diffusivity and the thermal expansion coefficient are assumed radially dependent, whereas density is taken constant in accordance with the Boussinesque fluid assumption. Using the spherical harmonic representations of the variables and the properties of the Green's function of Laplacian operator in a spherical coordinate, the governing equations are reduced to second order and coupled integro-differential equations which are then solved numerically. The theory is then applied to the thermal evolution calculations of different models of Venus. The models contain a liquid core of radius 2940 km whose temperature distribution retains the adiabatic gradient and adjusts to the temperature variations at the core-mantle boundary instantaneously. It is also assumed that the core has been formed within the first billion years of the planet's history and the thermal evolution calculations were concerned with the last 3.6 billion years. The main conclusions achieved in this study are the following:

1) A considerable amount of the present heat flow at the surface is due to the decay of a high temperature distribution established by the core formation event.

2) The high internal temperature makes it possible for low order modes of convection to transfer heat efficiently and to maintain almost adiabatic temperature distribution in the mantle.

3) Since the core-mantle boundary is assumed to be spherical and no allowance is made to have radial displacement there, the thermal energy transfer from the core into the mantle is mainly by conduction which cannot keep up with the high rate of cooling of mantle by convection. Consequently, a higher temperature gradient is developed near the boundary. Such a gradient is, however, reduced considerably by increasing the thermal conductivity near the boundary which may be achieved by having some percentage of iron there.

4) The velocity field obtained has an oscillatory behavior with an avalanche type feature. The oscillation period is about 0.15 billion years. This in turn makes the surface heat flux as well as the thickness of lithosphere oscillatory. This is the characteristic of all of the models considered in this paper, with or without internal heat sources, higher modes of convection and subduction of the lithosphere.

5) A possible subduction of lithosphere has a pronounced effect on the thermal evolution model, since it allows the hot material to reach near the surface and to get cool rapidly.

6) The inclusion of higher modes of convection tends to cool the model faster. Their effect, however, will not be very pronounced unless the subduction of lithosphere occurs, in which case higher modes of convection tend to stir the upper mantle rapidly and cool it efficiently.