TRANSITION FROM PLATE TECTONICS TO STAGNANT LID CONVECTION ON VENUS 500 M.Y. AGO; V. S. Solomatov (Seismological Laboratory, 252-21, California Institute of Technology, Pasadena, CA 91125)

Cratering record suggests that resurfacing on Venus ended around 500 million years ago [1,2]. Possible explanations of this event involve some change in global convective style of the interior of Venus [3-6]. I assume that this was a transition from plate tectonics to stagnant lid convection and suggest that the cessation of plate tectonics is likely to be a relatively fast process caused by the drop of ratio of the stresses to the yield strength in the lithosphere. A drop of the rate of magma production and cessation of generation of the magnetic field on Venus are among consequences of this event.

To describe convection in the interior of Venus in various convective regimes, scaling relations for temperature- and stress- dependent viscosity convection [7,8] are combined with a brittle/ductile model of plate dynamics [9] rheological data for olivine [10], a simple model of melting to calculate the change in the rate of magma production [11] and a model of crystallization of the Venusian core to calculate the change in the intensity of the magnetic field [12].

Cessation of plate tectonics occurs because during secular cooling of Venus the stresses in the lithosphere drop below the yield strength of the lithosphere. For a single plate it occurs as a transition from a plate tectonics regime with no other significant convective modes beneath the plate, except plumes, to a regime in which lithospheric instabilities start playing some role in the heat transport and global dynamics, to a completely stagnant lid regime in which there is no plate motion and convection is dominated by hot and cold plumes. The last transition is important because it is likely to be an abrupt stagnation of the plate as a result of the relative drop in the stress level (Fig. 1). The model is constrained by the present day lithospheric thickness suggested by topography and gravity data, the timing of resurfacing and the estimates of the magmatism rate [13,14] and its decay with time [15,16].

Magmatism and crustal recycling rates were high during plate tectonics regime but dropped after the cessation of plate tectonics as a result of lithospheric thickening (the upwelling mantle undergoes a lesser degree of adiabatic decompression and melting) and reduced vigor of the convective flow (Fig. 1).

Cessation of plate tectonics causes a drastic drop in the cooling rate of Venusian mantle and core. This stops convection in the core and implies cessation of generation of the magnetic field on Venus.

The Earth could also be close to the moment when plate tectonics stops unless the plates are substantially weaker than on Venus due to the presence of water.

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References. 1. Phillips, R. J., et al., *J. Geophys. Res., 97,* 15,923-15,948, 1992. 2. Schaber, G. G., et al., *J. Geophys. Res., 97,* 13,257-13,301, 1992. 3. Steinbach, V., and D. A. Yuen, *Geophys. Res. Lett., 19,* 2243-2246, 1992. 4. Turcotte, D. L., *J. Geophys. Res., 98,* 17,061-17,068, 1993. 5. Arkani-Hamed, J., *J. Geophys. Res., 99,* 2019-2033, 1994. 6. Solomatov, V. S., and L.-N. Moresi, *J. Geophys. Res.,* 1996, in press. 7. Solomatov, V. S., *Phys. Fluids, 7,* 266-274, 1995. *J. Geophys. Res.*, in press, 1996. 8. Moresi, L.-N., and V. S. Solomatov, *Phys. Fluids, 7,* 2154-2162, 1995. 9. Solomatov, V. S., *AGU 1994 Spring Meeting*, Baltimore, May 23-27, pp. 325. 10. Karato, S.-I., and P. Wu, *Science, 260,* 771-778, 1993. 11. Zharkov, V. N., and V. S. Solomatov, in *Venus Geology, Geochemistry and Geophysics*, pp. 280-319, Univ. of Ariz. Press, Tucson, 1992. 12. Stevenson, D. J., T. Spohn, and G. Schubert, *Icarus, 54,* 466-489, 1983. 13. Price, M., and J. Suppe, *Nature, 372,* 756-759, 1994. 14. Head, J. W. et al., *J. Geophys. Res., 97,* 13,153-13,197, 1992. 15. Price, M., and J. Suppe, *Nature, 372,* 756-759, 1994. 16. Namiki, N., and S. C. Solomon, *Science, 265*, 929-933, 1994.

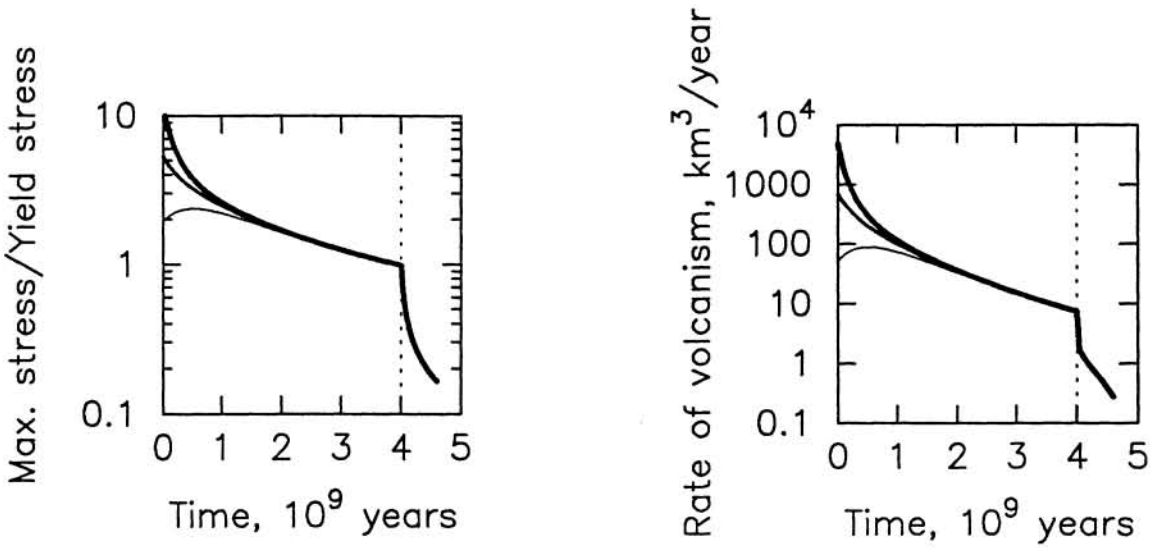

Fig. 1. A model with an abrupt transition from plate tectonics to stagnant lid convection. The ratio of the maximum stress in the lithosphere to the yield stress of the lithosphere (left) to the rate of magma production on Venus (right) are shown. The friction coefficient (0.5) in the Byerlee's law for the yield stress is chosen for the stress ratio to be unity at the moment of cessation of plate motion. The scaling law for melt generation is normalized to obtain the rate of magma production of the order of ~ 10 km^3 year^{-1} at the moment of cessation of plate motion. The three curves correspond to three different initial temperatures of Venus.

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