STRESS HISTORY OF THE THARSIS REGION, MARS

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The Tharsis topographic rise of Mars is roughly 5,000 km wide and 10 km high and is believed to have originated more than 3.5 by ago (Carr, 1984). Within its boundaries lie the four largest volcanoes on the planet. It is also the locus of a series of fracture traces which extend over approximately a hemisphere.

The events that led to the formation of the Tharsis region continue to generate debate. Three geophysical models for the formation of Tharsis are now in general contention and each of these models has been used to predict a characteristic stress-field. These models are: the volcanic construct model (Solomon and Head, 1982; Willemann and Turcotte, 1982), the isostatic compensation model (Sleep and Phillips, 1985; Banerdt et al., 1982), and the lithospheric uplift model (Banerdt et al., 1982). Each of these models has been used by its proponents to predict some of the features observed in the Tharsis region but none accurately accounts for all of the fracture features observed. This is due, in part, to the use of fractures which are too young to be directly related to the origin of Tharsis. To constrain the origin of Tharsis, as opposed to its later history, one should look for the oldest fractures related to Tharsis and compare these to the predictions made by the models.

In this study, the old terrains in and around the Tharsis rise have been mapped from 1:2,000,000 scale photomosaics. This mapping has revealed 175 old fracture features not previously used for stress history studies of Tharsis. These fracture features are scarps, block faulted regions, or grabens. When plotted stereographically, these features reveal systematic orientations with respect to Tharsis, either radial or concentric. These plots show that the tectonic center of the Tharsis region shifted from a very old position at 19° S, 107° W to a younger (but still relatively old) position at 8° S, 104° W. The latter position agrees with the starting position of Plescia and Saunders (1982) who used the young grabens to define a shift from 8° S, 100° W towards the present topographic center of Tharsis.

As a result of this work the Tharsis stress history has been expanded to include (oldest to youngest):

1) A radial system of grabens centered at 19° S, 107° W, oriented as predicted by the isostatic compensation model of Sleep and Phillips (1985).
2) A concentric system of scarps centered at 8° S, 104° W, too far from its center to be associated with the predictions of any present model.
3) A radial system of grabens centered at 8° S, 100° W, originating possibly as a response to volcanic loading such as predicted by Turcotte and Willemann (1982).
4) A radial system of grabens centered near present topographic center of Tharsis, with the same origins as stage 3.

Systems 3 and 4, the dominant grabens of the Tharsis region, have been the subjects of many past studies (Schultz, 1985; Plescia and Saunders, 1982; Wise, Golombek, and McGill, 1979). The features found in this study not only indicate a migration of tectonic activity in the Tharsis region, but the differing fracture patterns also demonstrate changes in the processes responsible for the Tharsis region.

References cited

Banerdt, W. B., R. J. Phillips, N. H. Sleep, and R. S. Saunders, Thick shell tectonics on one-plate planets: Applications to Mars, J. Geophys. Res., 87, 9723-9733, 1982.

Carr, M. H., The Geology of the Terrestrial Planets, NASA SP-469, U. S. Govt. Printing Office, pp 207-263, 1984.

Plescia, J. B., and R. S. Saunders, Tectonic history of the Tharsis region, Mars, J. Geophys. Res., 87, 9775-9792, 1982.

Schultz, R. A., Assessment of global and regional tectonic models for faulting in the ancient terrains of Mars, J. Geophys. Res., 90, 7849-7860, 1985.

Sleep, N. H., and R. J. Phillips, Gravity and lithospheric stress on the terrestrial planets with reference to the Tharsis region of Mars, J. Geophys. Res., 90, 4469-4489, 1985.

Solomon, S. C., and J. W. Head, Evolution of the Tharsis Province of Mars: The importance of Heterogeneous lithospheric thickness and volcanic construction, J. Geophys. Res., 87, 9755-9774, 1982.

Willemann, R. J. and D. L. Turcotte, the role of lithospheric stress in the support of the Tharsis rise, J. Geophys. Res., 87, 9793-9801, 1982.

Wise, D. U., M. P. Golombek, and G. E. McGill, Tharsis province of Mars: Geologic sequence, geometry, and a deformation mechanism, Icarus, 38, 456-472, 1979.