LOBATE THRUST SCARPS AND THE THICKNESS OF MERCURY's LITHOSPHERE; P. Schenk, Lunar and Planetary Institute, Houston, TX; and H.J. Melosh, Lunar and Planetary Lab, Univ. of Arizona, Tucson, AZ

The thermal history and structure of the lithosphere of the planet Mercury is still a matter of some conjecture [1]. Despite its Moon-like appearance, Mercury has had a complex geologic history and probably has had an unusual thermal history as well. Constraints on thermal history can be obtained by determining lithospheric thicknesses at discrete times. Deformation that penetrates the lithosphere can be used to constrain lithospheric structure, especially thickness. Mariner 10 revealed numerous lobate scarps on Mercury (Fig. 1), and shortening of craters across these ridges indicate they are thrust scarps, generally attributed to lithospheric shortening during a period of global contraction [e.g., 2]. If so, these thrusts probably penetrate the lithosphere. Thrust faulting of this type produces a flexural response in the lithosphere. The wavelength of this topographic response is governed by the flexural parameter $\alpha = (4D/\rho g)^{1/4}$ where D is the flexural rigidity, $D = Eh^3/12(1-\nu^2)$, E is Young's modulus, ν is Poisson's ratio, and h is lithospheric thickness. The observed topography of many of these scarps is consistent with such a flexural response (Fig. 2).

Although thin-plate flexure models give some qualitative insight into the flexure induced by thrust faulting, they cannot be used in detailed modeling because of the loading conditions created by the fault extending over a horizontal distance comparable to the plate thickness, and thus violates the approximations made in deriving thin-plate theory. We have used the finite element code TECTON [e.g., 3] to model thrust scarp topography on Mercury. The code is designed for tectonic problems and includes well-tested methods for introducing fault discontinuities (here using 'slippery nodes' which permit free slip on a specified fault plane). Also, isostatic restoring forces are automatically developed in the large strain formalism employed by TECTON.

Mercury is one of the few places in the solar system where this type of modeling can be attempted, because the thrust scarps are well developed here and have not been seriously degraded by erosion. We selected Discovery Rupes (Fig. 1) for modeling. The scarp is several hundred kilometers long and ~2 kilometers high. The topography of Mercurian lobate scarps has been determined using photoclinometric profiles from calibrated Mariner 10 images. Our finite-element grid incorporated a fault dipping at 30°. Horizontal shortening of 20 kilometers was introduced into the 900 km wide grid, which was then allowed to relax over several Maxwell times. Lithospheric thicknesses of 10, 20, and 50 km were modeled, with faults penetrating the lithosphere either fully or halfway through. The best match to the actual topography of Discovery Scarp is given for the case of a fault dipping at 30° extending 10 km into a 20 km thick lithosphere (Fig. 3), subject to a final analysis of scarp topography on Mercury. The flexural parameter for this case is α=61 km, close to the wavelength of the scarp topography.

Lobate thrust scarps are relatively young features, geologically, although occasional young craters are superposed on them [e.g., 2, 4]. The present lithosphere of Mercury is probably >100 km thick [4]. Our modeling of lobate thrust scarps on Mercury indicates that the lithosphere was ~20 km thick at the time of faulting, and is the first observational support that the early lithosphere of Mercury was rather thin (much less than 100 km thick). This is consistent with indirect arguments that the lithosphere was <100 km thick at the time of despinning [5], prior to thrust fault formation. In contrast, the Moon's lithosphere was at least 25 to >75 km thick at the end of mare basalt flooding [6]. Implications of these results for Mercury's thermal history will be discussed.

REFERENCES: [1] Schubert, G., et al., in *Mercury*, p. 429, 1988. [2] Strom, R., et al., *J. Geophys. Res.*, 80, 2345, 1975; Dzurisin, D., *J. Geophys. Res.*, 83, 4883, 1978. [3] Melosh, H.J., and A. Raefsky, *Geophys. J. R.A.S.*, 60, 333, 1980. [4] Leake, M., NASA TM-84894, 1982. [5] Melosh, H.J., and W. McKinnon, in *Mercury*, p. 374, 1988. [6] Solomon, S., and J. Head, *Rev. Geophys. Space Phys.*, 18, 107, 1980.

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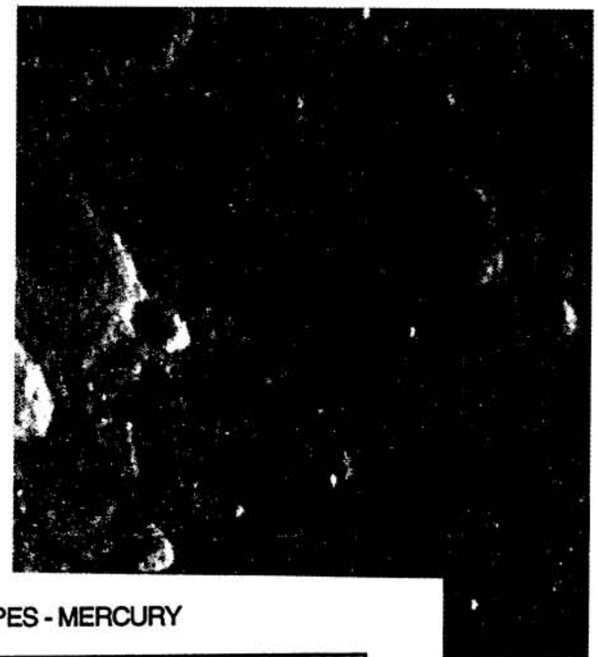

Figure 1. Mariner 10 image (FDS 27399) of Discovery Rupes. Image is ~300 kilometers across. Black line indicates location of topographic profile in Figure 2.

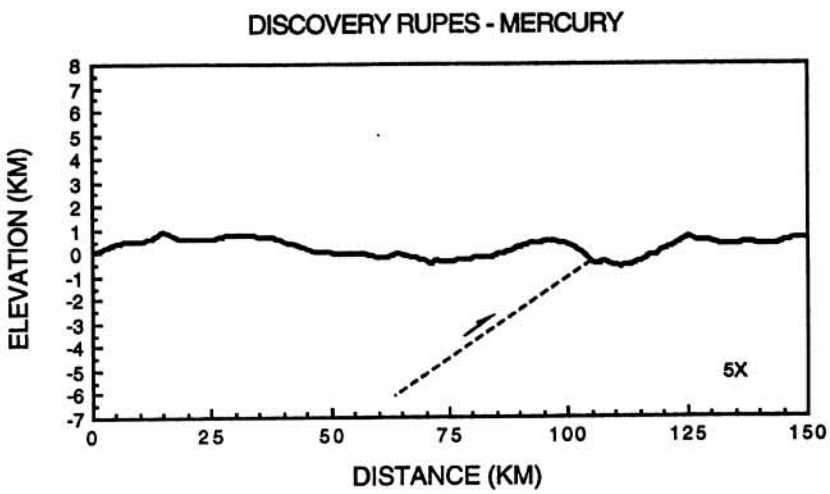

Figure 2. Topographic profile of Discovery Rupes, Mercury. Dashed line indicated inferred location and orientation of thrust fault. Upthrown block is to the left.

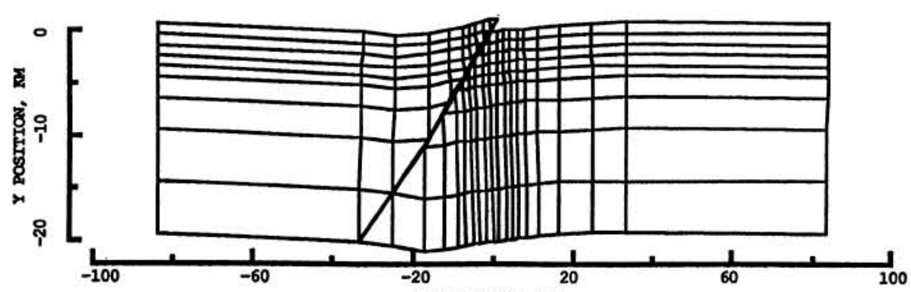

Figure 3. Finite-element grid for 20-kilometer thick lithosphere. Grid is shown after thrust faulting has occurred along a 30° dipping fault extending to a depth of 10-kilometers. Surface topography clearly shows a flexural response that matches well the actual topography of Discovery Rupes in Figure 2.