TOPOGRAPHY OF LARGE-SCALE LOBATE SCARPS IN THE SOUTHERN HEMISPHERE OF MERCURY.
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Summary: A regional-scale digital elevation model of an area in the southern hemisphere of Mercury (Discovery quadrangle), derived from digital stereo-analysis of Mariner 10 images, is used to examine the topography of three large-scale lobate scarps, Adventure Rupes, Resolution Rupes, and Discovery Rupes. The thrust faults that formed these landforms occur along a rough arc that extends for over 1000 km. The new topography shows that vertical uplift occurred on the same side of the three structures, suggesting that the fault-planes all dip to the concave side of the arc. These data also indicate that Adventure and Resolution Rupes are topographically continuous, suggesting the two features were formed by a single thrust fault. Analysis of the inferred stresses that formed these thrust faults suggest that they were influenced by regional, nonhydrostatic horizontal stresses or by mechanical discontinuities in the crust, possibly caused by buried impact basins. The new topographic data indicate a broad topographic low in this area. Thus the Discovery and Adventure-Resolution Rupes thrust faults may have been localized by mechanical discontinuities in the mercurian crust introduced by one or more ancient buried impact basins.

Introduction: One of the remarkable characteristics of the surface of Mercury imaged by Mariner 10 is the presence of hundreds of landforms described as lobate scars and interpreted to be the surface expression of thrust faulting [1, 2, 3, 4, 5]. The distribution, orientation, and geometry of thrust faults on Mercury is important in constraining models for the origin of the compressional stresses that formed these structures. New topographic data for Mercury is being derived from digital stereoanalysis [4, 6] using updated Mariner 10 camera orientations [7, 8].

Topography and Analysis: Discovery Rupes, Resolution Rupes, and Adventure Rupes occur along a rough arc that extends for over 1000 km (Figure 1). The topographic data indicates that Discovery Rupes has the greatest relief (~1.5 km), followed by Adventure Rupes (~1.3 km) and Resolution Rupes (~0.9 km). The topography of Discovery, Resolution, and Adventure Rupes indicates that the scarp faces of the three landforms occur on their southern-side (Figure 1). This suggests that the fault-planes of the three thrust faults all dip to the concave side of the arc formed by the structures. Our DEM shows that the topographic expression of the scarp face of Adventure and Resolution Rupes is continuous except where it is interrupted by the presence of a prominent high-relief ridge that appears to crosscut the Adventure-Resolution Rupes trend (Figure 1). The displacement-length relationship of the thrust faults associated with Adventure and Resolution Rupes also supports the interpretation that the two features are segments of a single structure. The ratio of maximum displacement to fault length $\gamma$ for the Adventure and Resolution Rupes thrust faults are both $\sim 1.2 \times 10^{-2}$, where the displacement is given by $D = h \sin \theta$ and where $h$ is the measured relief of the scarp and $\theta$ is the dip of the fault-plane [5]. These are almost a factor of 2 higher than $\gamma$ for other mercurian thrust faults ($6.5 \pm 3.2 \times 10^{-3}$, $n = 10$) using estimates of $D$ based on $\theta = 25^\circ$ [5]. If Adventure and Resolution Rupes were formed by a single thrust fault, the combined fault has a value of $\gamma$ of $\sim 6.3 \times 10^{-3}$, consistent with that of the Discovery Rupes thrust fault and other mercurian thrust faults. This would make the Adventure-Resolution Rupes thrust fault second only to the Discovery Rupes thrust fault in scale with lengths of $\sim 500$ km and $\sim 550$ km, respectively. In an effort to determine the geometry of the compressional stresses that formed the three rupes, a beta analysis [see 9] was performed. The orientation of the scarps was approximated by 20 digitized segments. The beta analysis indicates a maximum concentration of 23.2% per 1% area ($\alpha = 190$) located at approximately $45^\circ$S, $55^\circ$W, roughly 600 km northwest of Discovery Rupes. The results of this analysis are consistent with the hypothesis that the formation of the thrust faults associated with Discovery, Resolution, and Adventure Rupes were influenced by either regional nonhydrostatic horizontal stresses or preexisting mechanical discontinuities in the crust. Examination of the topography near the stress center suggested by the beta analysis indicates the presence of a broad, shallow depression. If the thrust faults were localized by a preexisting mechanical discontinuity in the crust, the most likely source is a buried impact basin. Spudis and Guest [10] mapped 20 pre-Tolstojan multiring basins randomly distributed over the mercurian hemisphere imaged by Mariner 10. One of these basins, the Andal-Coleridge basin, is...
centered at 43°S, 49°W, just east of Schubert crater. The center of the Andal-Coleridge basin is located near the stress center indicated in the beta analysis of the inferred stresses (45°S, 55°W). The broad topographic low in this area may be explained by the presence of an ancient impact basin. However, the proposed outer ring of the Andal-Coleridge basin, about 875 km from the basin center, is not parallel to the arcuate trend of Adventure and Resolution Rupes. The proposed inner rings of the Andal-Coleridge basin are subparallel to northern segments of Discovery Rupes, but not the southern segments. This may reflect the influence of more than one ancient basin. Thus it is possible that mechanical discontinuities introduced by one or more ancient buried multiring impact basins localized the thrust faults that formed Adventure, Resolution, and Discovery Rupes.

References:

Figure 1. Color-coded regional-scale digital elevation model (DEM) in the Discovery quadrangle. This subsection (25°W to 80°W, 50°S to 75°S) was extracted from a larger DEM mosaic generated using over 260 individual stereo pairs and is overlaid on an image mosaic. Shades of blue to black are lows, and shades of red to white are highs. White arrows indicate the location of Adventure Rupes, Resolution Rupes, and Discovery Rupes. Elevations are relative to the 2439.0 km Mercury radius reference sphere.