

PHOTOCLINOMETRIC STUDIES OF LOBATE SCARPS ON MARS. T. R. Watters, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560, M. S. Robinson, U. S. Geological Survey, 2255 North Gemini Drive, Flagstaff, Arizona 86001

Lobate scarps are landforms on Mars that occur almost exclusively in highland material [1]. These scarps are morphologically similar to highland scarps observed on the Moon and Mercury [2, 3, 4, 5, 6, 7]. They are lobate, arcuate or linear and often segmented, in plan view, and appear to be generally one-sided. Based on their morphology and the fact that many clearly deform crater floors, they are interpreted to be compressional tectonic features resulting from thrust faulting [1]. Lobate scarps on Mars, like those on Mercury, appear to occur on at least two different scales, described here as moderate- and large-scale. Although lobate scarps are important tectonic features, reflecting significant compressional deformation of some of the oldest land masses on Mars, their morphology and dimensions have never been characterized in detail. Monoscopic photogrammetry is used in this study to extract elevation data across lobate scarps from Viking Orbiter images. From these data the amount of the crustal shortening across lobate scarps is estimated. Preliminary results indicate that large-scale scarps like Amenthes Rupes reflect at least several kilometers of crustal shortening and may be the largest compressional tectonic features on Mars.

Many different landforms on Mars have been characterized using photogrammetrically derived topography [8, 9, 10, 11, 12, 13]. Photogrammetric studies of wrinkle ridges have revealed that derived elevation profiles are extremely sensitive to small variations in horizontal digital number (HDN) that describes the brightness value of a horizontal surface [13, 14]. The sensitivity of photogrammetric profiles across lobate scarps to small variations in HDN is also analyzed.

Lobate scarps in the Noachian highland materials of Noachis Terra and Terra Cimmeria are representative of moderate-scale scarps. The results of an analysis of a typical moderate-relief scarp in Terra Cimmeria indicates that the structure has a maximum relief of ~320 m and the scarp face has a maximum slope of ~7° (Figure 1). A typical moderate-relief scarp in Noachis Terra has a maximum relief of ~180 m and, like its counterpart in Terra Cimmeria, the scarp face has a maximum slope of ~7° (Figure 2). A variation of ± 2 (Figure 1, 2) to ± 4 of the estimated HDN does not significantly change the shape of the profiles or result in a change in the direction of slope of the scarp face. Thus, photogrammetric profiles across lobate scarps are far less sensitive to changes in HDN than are wrinkle ridges. As seen in the case of the wrinkle ridges, however, gently sloping surfaces are the most sensitive to small variations in HDN. Profiles across a number of moderate-scale lobate scarps in Terra Cimmeria and Noachis Terra reveal some common morphologic elements. The scarp face has a relatively steep slope with a slightly convex, straight, or slightly concave shape. Often the scarp face transitions into a broad, low relief hill with much gentler slopes. Beyond this crest, the surface may be either level or gently sloping away from the scarp. Profiles across the large-scale scarp, Amenthes Rupes, reveal the same basic morphologic elements (Figure 3). Amenthes Rupes is one of the most well preserved large-scale scarps on Mars. It is over 400 km long, comparable in scale to the Discovery Rupes on Mercury, with a maximum relief of ~1,200 m and the scarp face has a maximum slope of ~14°.

Estimates of the crustal shortening reflected in moderate- and large-scale scarps are based on a simple kinematic model that involves deformation associated with a thrust fault that propagates upwards and breaks the surface. The amount of horizontal shortening can be estimated by assuming that it is a function of the dip of the fault-plane and the displacement on the fault. Given the elevation of the scarp (h) and the fault-plane dip (θ), the horizontal shortening (S) is given by $S = h/\tan \theta$. Shortening is being estimated for a range in θ ($25 \pm 10^\circ$) and a range in h consistent with variations in the HDN. Preliminary results for moderate-scale scarps indicate that the amount of shortening varies from hundreds of meters to over a kilometer. The amount of horizontal shortening in Amenthes Rupes is on the order of 2 to 5 km and may be greater. Amenthes Rupes and scarps of similar scale like Eridania Scopulus are the clearest examples of large-scale compressional deformation on Mars.

References Cited: [1] Watters T.R. (1993) *JGR*, 98, 17049. [2] Lucchitta B.K. (1976) *Geochim. Cosmochim. Acta*, 3, suppl., 2761. [3] Howard K.A. and Muehlberger W.R. (1973) *NASA SP-330*, 31-32. [4] Binder A.B. (1982) *Earth Moon Planets*, 26, 117. [5] Binder A.B. and Gunga H.-C. (1985) *Icarus*, 63, 421. [6] Strom R.G., Trask N.J. and Guest J.E. (1975) *JGR*, 80, 2478. [7] Cordell B.M. and Strom R.G. (1977) *Phys. Earth Planet. Inter.*, 15, 146. [8] Davis P.A. and Soderblom L.A. (1984) *JGR*, 89, 9449. [9] Pike R.J. and Davis P.A. (1984) *LPSC XV*, 194. [10] Tanaka K.L. and Davis P.A. (1988) *JGR*, 93, 14893. [11] Golombek M.P., Plescia J.B. and Franklin B.J. (1991) *Proc. LPSC XXI*, 679. [12] Plescia J.B. (1993) *JGR*, 98, 15,049. [13] Watters, T.R. and Robinson M.S. (1994) *LPSC XXV*, 1473. [14] Watters T.R. and Robinson M.S. (1996) submitted to *JGR-Planets*.

PHOTOCLINOMETRIC STUDIES OF SCARPS: T.R. Watters and M.A. Robinson

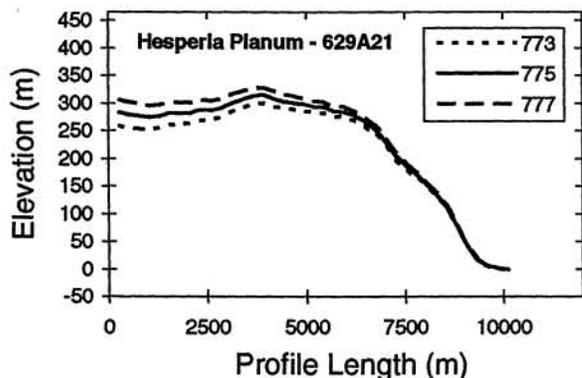


Figure 1. Lobate scarp in Hesperia Planum. Photoclinometric profiles were generated for three different values of the HDN (shown in legend) holding all other parameters constant. Profile are located at ~ 5.66°S, 237.18°W (Viking Frame 629A21).

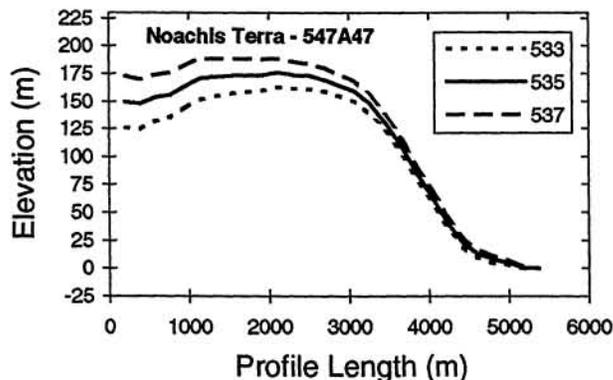


Figure 2. Lobate scarp in Noachis Terra. Photoclinometric profiles were generated for three different values of the HDN (shown in legend) holding all other parameters constant. Profiles are located at ~ 40.26°S, 321.18°W (Viking Frame 547A47).

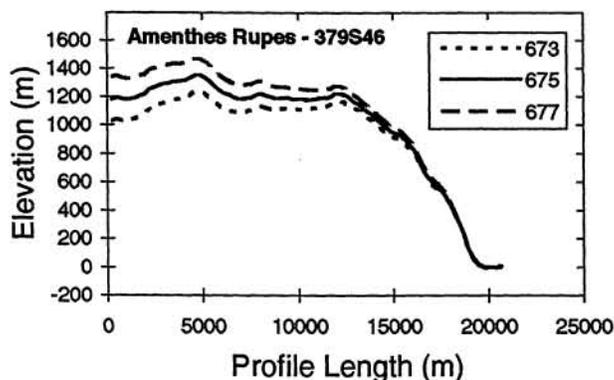


Figure 3. Large-scale scarp Amenthes Rupes. Photoclinometric profiles were generated for three different values of the HDN (shown in legend) holding all other parameters constant. Profiles are located at ~ 1.5°N, 249.46°W (Viking Frame 379S46).