RIDGES AND SCARPS IN THE EQUATORIAL BELT OF MARS. B. K. Lucchitta and J. L. Klockenbrink, U. S. Geological Survey, Flagstaff, AZ 86001.

A survey of ridges and lobate scarps that have affinities with mare ridges on the Moon was conducted for the Martian quadrangles MC-1 through MC-23 comprising the ±30 latitude region. The survey was restricted to the areas covered by Viking orthophotomosaic subquadrangles of scale 1:1,250,000 and 1:2,000,000. No Mariner coverage was included in order to assure uniformity of image resolution.

The survey showed that ridges and lobate scarps on Mars consist of several distinctive types with characteristic morphologies. These types, however, may grade into each other regionally and are transitional morphologically, which suggests a common denominator for their origin.

The type that most resembles mare ridges on the Moon consists of ridges that are long, broad swells with superposed irregular, crenulated, narrow crests. The type is well represented in the Chryse basin, in Lunae Planum, and in the plains south of Coprates Chasma. A second type consists of ridges that are subdued, irregular and short swells, and of similar scarps. Both are bifurcating or anastamosing and locally have thin crenulated crests. They occur mostly in highland areas that appear smoothed, and they reflect subjacent topography such as buried crater rims and ejecta blankets. A third type consists mostly of well defined lobate scarps with a rolling top and a sharp break in slope at the base. Crenulated crests on top or below the scarp occur locally. This type occurs in places at the boundary between cratered highland terrain and adjacent low-lying plains.

Erosion of ridges on Mars may shed light on their internal structure. Where ridges intersect erosional scarps tributary valleys have developed, indicating that the ridges occupy zones of weakness susceptible to erosion. Locally, however, prongs or spurs may be developed indicating resistance to erosion. Fault zones, associated with less resistant breccia in some places, or with more resistant indurated breccia or dikes in others may explain the differential erosion. Some ridges transgress erosional scarps, and appear to have developed after the erosion that formed the scarps. Erosion across ridges in the Chryse basin has exposed a series of ledges on the channel floor. The ledges could be beveled edges of upturned lava layers and support an origin by buckling.

Ridges on Mars of the anastamosing type appear to be preferentially associated with Noachian hilly and cratered materials and cratered plateau materials of Scott and Carr (1). Well defined ridges that are similar to those on the Moon occur preferentially on the Hesperian ridged plains, some Amazonian crater plains (1), and inside young volcanic calderas. Ridges generally are not found on smooth plains units that have distinctive flow lobes, such as the plains surrounding the Tharsis volcanoes, and on the flanks of volcanic shields. They also do not appear to occur on rough topography, such as the aureole deposits (2) or the fractured plains (3). They do not occur on fresh thick ejecta blankets, but locally transgress thin ejecta blankets. They usually do not occur on sedimentary layers such as are found in the southern part of Amazonis Planitia, and on the floors of the chasmas, the chaotic terrain, and some channels. Ridges seem to be developed mostly in areas flooded by lavas, and with the exception of flow-lobe lavas, are best developed in the areas where the flooding appears to have been deep.

Ridges occur on units of all ages ranging from those resulting from early highland flooding to those on the floors of young calderas. Their formation seems to post-date the emplacement of the units as they locally transgress units of different ages, or transgress erosional scarps.

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Structural observations of the ridges on Mars revealed a dominance of northerly trends in the investigated regions. This trend is particularly obvious in the long, continuous ridges that most resemble those on the Moon. Orthogonal grid patterns occur locally, especially in highland areas where buried craters may have angular shapes. Many graben trends are at angles to those of ridges, such as south of the chasmas where graben trends are westerly and ridge trends northerly. In places, however, graben trends are parallel to those of ridges or ridges merge with grabens.

The origin of ridges on Mars is probably diverse, as that suggested for ridges on the Moon (4). In support of a structural origin for ridges on Mars it can be cited that many ridges and scarps occur along offsets in the regional surface level, and that some are continuous with grabens, which imply association with faults. Grid patterns or dominance of certain trends suggest structural influence. Preferential erosion along ridges implies structural zones of weakness, and erosion into ledges may reflect upturned beds. Expression of subjacent topography implies draping, which may have been accentuated by settling and compaction. If ridges are structures, the long continuous ones may be anticlines resulting from regional stresses; the anastamosing ones in highlands may reflect draping over subjacent topography. A volcanic origin for ridges is suggested by their association with apparent lava plains and their development inside calderas. Prongs or spurs on erosional scarps could be caused by resistant dike rock. Ridges are not likely to be eruptive fissures, as known fissures in the Tharsis area (5) and on earth (6) are remarkably linear cracks locally punctuated by craters, or, on earth, cratered constructional features. However, some ridges could be elongate domal uplifts over laccolithic intrusive bodies along faults.

Mare ridges on the Moon are similar to ridges on Mars, and both have some resemblance to anticlinal ridges on the Columbia River Plateau near Yakima in south-central Washington. These ridges were discussed as analogs for lunar mare ridges by Greeley and Spudis (7), who considered mostly planimetric details and size relations. Additionally, the Yakima ridges resemble planetary ridges, as a) they are developed in thick competent units of flood basalts; b) the deformation of the top-most layers took place near the surface, that is, without thick layers of overburden (9); c) they are arranged en echelon across a major structural trend (10); d) they have varying symmetry along their trends, with steep limbs or faults occurring on alternate sides of the folds; e) they are anticlines that have the form of box folds with flat tops and steeply dipping limbs, which is similar to the cross-sectional shape of lunar mare ridges; f) they are paralleled by tight subsidiary anticlines and synclines, some of which occur on the downthrown side of the faults; crenulations on planetary ridges behave similarly; and g) they are interpreted to be over basement faults expressed at the surface as either faults or monoclinal warps similar to the interpretation given to mare ridges that developed along faults on the Moon (11).

Even though the Yakima ridges have much larger structural relief than ridges on the Moon and Mars, and their origin may be linked to plate tectonics (12), the morphologic resemblance suggests that the mechanics of deformation may have been similar. The reason for this could be that both developed in thick competent stacks of flood basalts near the surface. Therefore, all ridges on planetary basalts may have analogous shapes regardless whether their origin is updoming over a linear intrusive, surface buckling under compressional stresses or stresses from gravitational gliding, anticlinal draping over subsurface compressive upthrusts, or passive settling over subsurface topography due to compaction.

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