The existence of a well-developed radial fracture pattern and wrinkle ridges that are roughly orthogonal to Tharsis have led to several models for the formation and longevity of this topographic bulge (1,2,3). Since the numerous ridges surrounding Tharsis are used as evidence for compressional stress (particularly in the Lunae Palus and Coprates quadrangles), the isolation of those due to Tharsis from those due to other causes is important for geophysical and geological modeling of the bulge. In particular, the separation of local and perhaps global "noise" from structures dominantly related to Tharsis are important for: 1) More accurate determination of a center (or centers) for Tharsis structural features; 2) Recognition of pre- or post-Tharsis events if relative age relations can be determined; 3) More accurate determination of the spatial extent of Tharsis-related deformation; and 4) Estimation of Tharsis-related strain based on ridge and rille morphometry.

In order to separate Tharsis from non-Tharsis related ridges, we have compared the orientations of 1414 ridge segments in four quadrangles on either side of the center of the topographic high. Ridge segments with orientations within 20° of being normal (70° to 110°) to a projection from the ridge center of Wise et al. (4) were plotted for the Amazonis, Memnonia, Lunae Palus and Coprates quadrangles. The location and orientation of ridge segments outside this range in the Lunae Palus and Coprates quadrangles are shown in Fig. 1.

A significant number of ridge segments is not apparently related to a single center of the Tharsis bulge. By the number of ridge segments measured, 51% are not within 20° of orthogonal. By length of ridges, those of other orientations comprise 40% of the total length measured (40,364 km). Rose diagrams of non-orthogonal ridges in these quadrangles indicate a predominance of generally northerly orientations. Although Amazonis and Memnonia display a remarkably unimodal distribution centered about North, Lunae Palus and Coprates have strong peaks at NNE and NNW respectively. In addition, secondary peaks occur at NW in Lunae Palus, and at ENE in Coprates.

The number and absolute length of ridge segment orientations indicate that not all ridges surrounding the Tharsis region can be related to a single (or possibly even several) point source for radially symmetric stress. Other causes for the formation of non-orthogonal ridges include: 1) Draping and faulting over subsurface structure (5), 2) Other centers of Tharsis-related stress (3), 3) Reorientation of the martian lithosphere (6), and 4) A non-radially symmetric model for the loading of Tharsis. Evidence for each of these modes of origin exists in the Lunae Palus and Coprates quadrangles. The role of pre-existing basement fractures or faults in controlling ridge location may be underestimated, particularly in the Coprates quadrangle south of Valles Marineris. Here, the NNE orientation of regularly spaced ridges is the same as that of the relatively old graben exposed 1500 km southwest of Marineris in the Thaumasia highlands.
Figure 1. Non orthogonal ridge segments east of Tharsis in Lunae Palus (top) and Coprates (bottom half of map). Segments indicate considerable excess of northerly orientations and secondary eastern trends in Coprates.

Although the eastern graben of the Thaumasia fossae trend generally N-S, older NNE trends are present west of the N-S rilles, and similar orientations are present as "resistant points" in the walls of Valles Marineris (5). Subsurface control of ridges by Thaumasia faults is an attractive explanation, since it helps to explain the great number of ridges in the Coprates region relative to other regions equidistant from Tharsis. In addition, quasi-curvilinear NW trending segments in Lunae Palus suggest a center at the highly fractured northern end of the Claritas Fossae (approximately 15°S, 110°W).

Based on reorientation of the martian lithosphere due to Tharsis loading, Melosh (6) predicted NNW and ENE strike-slip faults east of Tharsis, and NNE and WNW faults west of Tharsis. These predicted orientations are identical to those of the non-orthogonal ridges in the Coprates quadrangle, but are not apparent in other areas. Strike-slip motion is supported to some extent by the en echelon appearance of some martian (and lunar) ridges, although several problems exist with this interpretation.

REFERENCES