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Tessera Terrain, Venus: Characterization and Models for Origin and Evolution

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Tessera terrain is the dominant tectonic landform in the northern high latitudes of Venus mapped by the Venera 15 and 16 orbiters and is concentrated in the region between the mountain ranges of western Ishtar Terra and Aphrodite Terra. Tesserae are characterized by regionally high topography, a high degree of small scale surface roughness, and sets of intersecting tectonic features. Available Pioneer Venus line of sight gravity data suggest that tessera terrain is compensated at shallow depths relative to many topographic highs on Venus and may be supported by crustal thickness variations. Three types of tessera terrain can be defined on the basis of structural patterns: subparallel ridged terrain (T_{sr}), trough and ridge terrain (T_{tr}), and disrupted terrain (T_{ds}). Observed characteristics of tessera terrain are compared to predictions of models in order to begin to address the question of its origin and evolution. Formational models, in which high topography is created along with surface deformation, include (1) horizontal convergence, (2) mantle upwelling, (3) crustal underplating, and (4) a seafloor spreading analogy. Modificational models, in which deformation occurs as a response to the presence of elevated regions, consist of (1) gravity sliding and (2) gravitational relaxation. We find that horizontal convergence and late stage gravitational relaxation are the most consistent with basic observations for subparallel ridged terrain and disrupted terrain. Understanding of the basic structural characteristics of trough and ridge terrain is more tentative, and models involving a spreading process or convergence and relaxation merit further study.

INTRODUCTION

Some of the large topographic uplands in northern Venus, such as eastern Ishtar Terra and Tellus Regio, were noted to possess distinctive radar properties in data gathered by the Pioneer Venus (PV) orbiter [*Head et al.*, 1985]. Subsequent investigations by the Venera 15 and 16 orbiters [*Kotelnikov et al.*, 1985; *Rzhiga*, 1984] revealed that these areas and numerous other regions are characterized by a complexly deformed surface called tessera terrain (also known informally as parquet terrain). The mapped distribution of tesserae, adapted from *Barsukov and Basilevsky* [1986], is shown in Figure 1. Tessera terrain was subsequently defined as regions of ridges and troughs that intersect at a variety of angles ranging from orthogonal to oblique [*Basilevsky et al.*, 1986]. Tesserae lie at higher elevations than most other surface units [*Bindschadler and Head*, 1989] and appear to have undergone extensive horizontal deformation, resulting in a complex pattern of ridges and troughs. The complexity of tessera terrain is typified by a portion of central Tellus Regio (Figure 2). Individual ridges and troughs tend to be short and to vary greatly in appearance along strike and are typically spaced of the order of 10 km apart. *Basilevsky et al.* [1986] referred to the deformation in the tesserae as areal deformation so as to distinguish it from more linear or arcuate features such as ridge belts and the mountain belts of western Ishtar.

Mapped tessera terrain covers approximately 10% of the region imaged by the two Venera orbiters [*Sukhanov*, 1986; *Bindschadler and Head*, 1989], more area than any of the other tectonic units observed on the surface (coronae, ridge belts [*Barsukov et al.*, 1986], and mountain belts or banded terrain [*Campbell et al.*, 1983]). In addition, *Sukhanov* [1986] interprets structures within some plains regions as tessera terrain partially buried beneath plains units, thus increasing the area of the tessera terrain to ~15% of northern Venus (or ~17×10^6 km^2). Tesserae are found in association with a number of units and are a major part of several geologic unit assemblages in the northern hemisphere of Venus: the plains-corona-tessera, tessera-ridge belt, and tessera-mountain belt assemblages [*Head*, 1990*a*]. Tesserae are strongly concentrated between longitudes 0°E and 150°E (Figure 1), between a proposed center of crustal extension and divergence in Aphrodite Terra [*Schaber*, 1982; *Head and Crumpler*, 1987] and a proposed region of compressional deformation and crustal convergence in western Ishtar Terra [*Campbell et al.*, 1983; *Pronin*, 1986; *Crumpler et al.*, 1986]. The broad distribution, location, and apparently intense deformation recorded by the tessera terrain all suggest that it is an integral part of Venus tectonics.

The process or processes by which tessera terrain is formed are not well characterized or understood. Several modes of origin have been suggested, including deformation driven by horizontal flow within the asthenosphere of Venus [*Basilevsky*, 1986] and gravity sliding over "gentle upwellings" in the mantle [*Sukhanov*, 1986]. These qualitative models are described principally to suggest their ability to create complex patterns of ridges and troughs similar to those observed in the tessera terrain. However, tesserae are also characterized by properties measured by the PV spacecraft, including relatively high topography, rough surfaces at meter and sub-meter scales, and relatively small line of sight (LOS) gravity anomalies (where such data are available). In addition, we observe three distinct morphologic types of tessera terrain: subparallel ridged terrain (T_{sr}), trough and ridge terrain (T_{tr}), and disrupted terrain (T_{ds}), each of which represents a particular sequence and style of deformation. Successful models for the origin and evolution of tessera terrain must be consistent with these basic characteristics of tessera terrain.

Tessera terrain is characterized by a relatively broad range of elevations [*Bindschadler and Head*, 1989] but in virtually all

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