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Orogeny and Large-Scale Strike-Slip Faulting on Venus: Tectonic Evolution of Maxwell Montes

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The Ishtar Terra highland region of Venus contains mountain belts morphologically similar to terrestrial orogenic belts. Akna Montes and Freyja Montes are long, linear mountain belts with about 4 km of relief above the 3- to 4-km-high Lakshmi Planum. The Maxwell Montes mountain belt, however, is more rectangular in plan view and has relief of approximately 8 km. We have investigated the nature of this latter range using complementary radar images obtained by the Arecibo Observatory and the Venera 15/16 spacecraft, as well as altimetry data obtained by the Venera 15/16 and Pioneer Venus spacecraft. Geological and structural maps have been compiled on the basis of these data, the individual features and their stratigraphic relationships interpreted, and a model for the origin and evolution of Maxwell Montes is proposed. The dominant features of this mountain range are long, parallel ridges and valleys that are intepreted to be anticlines and synclines and to have resulted from ENE-WSW oriented compression. Two major shear zones bound Maxwell Montes on the north and south, converging toward the west. Nine narrow linear parallel features several hundreds of kilometers long (identified as cross-strike discontinuities, CSDs) cut obliquely across the strike of the ridges and valleys in a NW-SE direction and disrupt the structural fabric of the mountain range, dividing Maxwell Montes into 10 crustal domains. Among several possible origins, we find that the data are most consistent with their interpretation as right-lateral strike-slip faults with offsets of up to 125 km. Retrodeformation and reconstruction of Maxwell Montes using the offsets determined for individual domains produces a long linear mountain range similar to Akna Montes. Using geologic unit maps and topographic maps of the present configuration of Maxwell, similar reconstructions were made; these reconstructions restored several linear tectonic elements, topographic trends, and sinuous unit boundaries to more contiguous positions. On the basis of these data and observations we suggest that Akna Montes may represent the initial form of compressional orogenic belts on Venus, while Maxwell Montes attained its present morphology through a second stage of deformation involving large-scale strike-slip faulting. We examine several models for this second stage and favor the interpretation that it occurred as the Akna Montes-like proto-Maxwell Montes was transported to the west between two converging shear zones, accompanied by rotation of the entire mountain range. Thirty percent shortening of the mountain range is implied by the geometries of the present and reconstructed Maxwell Montes. On the basis of the deformation in Maxwell Montes and the evidence for large-scale transport we conclude that large-scale horizontal movement of crustal materials is a significant aspect of the tectonics of Venus.

Introduction

The global tectonic style of Venus has yet to be defined. However, mountain belts which are morphologically and topographically similar to orogenic belts on Earth have been observed on Venus [*Masursky et al.*, 1980; *Campbell et al.*, 1983; *Barsukov et al.*, 1986]. Two of these mountain belts, Akna Montes and Freyja Montes, have previously been interpreted as orogenic belts based on the recognition of a number of diagnostic features analogous to those observed in terrestrial orogenic belts [*Crumpler et al.*, 1986]. A third mountain belt, Maxwell Montes, is the focus of this study. We present evidence that this range was initially formed compressionally as an Akna Montes-like linear mountain belt and that it experienced a later stage of large-scale strike-slip faulting accompanied by 30% shortening parallel to its long axis. We conclude that large-scale horizontal movement of crustal materials has been an intrinsic part of the tectonics of Venus.

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Data Sets and Approach

Our investigation involved a comparative analysis of radar images and altimetry from several sources. Images analyzed include those obtained by the Arecibo Observatory (Figure 1*a*) and the Venera 15 and 16 spacecraft (Figure 1*b*), both of which have spatial resolution in the range of 1-2 km. We have also used altimetry obtained by the Pioneer Venus orbiter (Figure 1*c*) and the Venera 15/16 orbiters (Figure 2*c*). The Pioneer Venus altimetry has a vertical accuracy of approximately 200 m, and footprint sizes for the area of interest are typically about 50 km by 50 km [*Pettengill et al.*, 1980]. The Venera altimetry has a precision of 50 m and footprint diameters of 40-50 km [*Rzhiga*, 1987].

The Arecibo and Venera 15/16 imaging radar systems provide complementary coverage of the Maxwell Montes area due to their differing look directions and incidence angles. The Arecibo system illuminated Maxwell Montes from the southwest at incidence angles between 59° and 65°, whereas the Venera system illuminated Maxwell from the east at incidence angles between 7° and 13°. From the scattering law of *Hagfors* [1964, 1970] it is predicted that at the given incidence angles, the Arecibo system is most sensitive to variations in small-scale (centimeter-meter) surface roughness and intrinsic