COMMENTS ON THE TECTONISM OF VENUS

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Preliminary tectonic mapping of Venus from Venera 15/16 images shows unquestionable evidence of at least limited horizontal tectonism. Gravity-induced spreading and/or sliding has been suggested as the mechanism which caused the motion of Laima Tessera (fig. 1) [1,2]; the downslope movement of the Laima terrane was probably induced by a rifting event along Sigrun Fossae.

However, the majority of tectonic features on Venus have no similar relation to topography. In fact, many axes of disruption interconnect, and cross sharp topographic boundaries at large angles (commonly near 90°), thereby discounting gravity as the driving force. One type of disruption zone, interpreted as extensional, is chain-like series of paterae, such as one that follows a NNW-trending topographic low near 0°E, 50°N. The morphology and tectonic setting of these paterae chains outwardly resemble models of propagating rifts [3]. These and other types of extensional zones (EZ's) that include Bezlea and Hera Dorsa, Sigrun Fossae, fractures north of Kamari Dorsa, and two branches roughly paralleling Lasdonna and Aranyani Chasmata (fig. 1) form part of a regional network. The network is difficult to follow beyond its east end, near Allat Dorsa; however, south of Bezlea/Hera Dorsa, beyond the Venera coverage, Pioneer Venus altimetry indicates that this system of EZ's may continue as far south as westernmost Aphrodite Terra, probably linking with the near-equatorial rift system [4]. Arecibo images of the southern hemisphere (near 325°E) also suggest the presence of EZ's, further implying a global distribution and a closer analogy to multi-plate tectonism than to single-plate tectonism. The idea that EZ's reflect deep crustal movements, therefore suggesting that mantle drag is at work, is bolstered by their tendency to coincide with relative lows even where they cross lowlands -- a situation inconducive to gravity tectonism. Quantitative analysis of stress fields within the EZ's may be derivable from "arachnoids" [5] which are interpreted as volcanoes whose radial dikes conformed to the differential stress field associated with the extension.

Compressional zones (CZ's), unlike EZ's, tend to be discontinuous, and, whereas EZ's cross tectonic and topographic boundaries at various angles, many CZ's on Venus are subparallel to these boundaries. Many of the large fold belts (Itzpapalotl Tessera; Semuni, Kamari, and other dorsa) occur at, and parallel to, the boundary between tesserae and adjacent plains, which is similar to the tendency of Earth's mobile belts to make a shallow angle with continental-oceanic crust boundaries [6]. If this analogy is carried one step further, the quiltwork appearance of Fortuna Tessera is reminiscent of the accretionary growth model for continents [7]. Also, many major tectonic features intersect at, or trace out, ~120° angles, a common angle of intersection for rift systems and junctions on multi-plate Earth. In the study area, EZ's and CZ's tend to occur in pairs at ~60° angles to one another (Sigrun Fossae and Ausra Dorsa, for example), but the significance of this is unclear at present.

Strike-slip faulting is curiously lacking from our mapping, possibly due to the steep incidence angle of the radar, which is far from optimal for detecting faults of small throw. A probable right-lateral fault occurs in western Clotho Tessera. Possible shear zones include the southwest terminus of Fortuna Tessera, and the southwest boundary of Itzpapalotl Tessera. The chasmata of Laima Tessera may also delineate zones of relative displacement; these chasmata are similar in many respects to oceanic fracture zones (R.

Kozak, work in prgress).

A chronology of horizontal crustal movements, and hence the analysis of Venus' thermal development, is largely dependent on understanding the crater-form features. The Venera SAR and altimeter resolutions are insufficient to permit accurate distinction between impact and volcano-tectonic craters based solely on morphometry [8,9]. Therefore ancillary data must be used to achieve an accurate analysis of Venus' tectonic history: data such as morphologic details, geologic associations, chronostratigraphic position, and distribution. This type of approach was used to argue a volcanic origin for Cleopatra Patera [10]. Based on similar arguments, several other craters (15-100 km in diameter) previously suggested as impact [11; Ivanov, B.A., personal comm.] may not be; Zhilova, Koidula, Potanina, Josefina, Jadwiga, Gloria, Tsvetayeva, and Dashkova, for example. Also, there is an unusual density of volcano-tectonic depressions and impact-like craters within the EZ's where they cross the low plains. Depressions are gradational from broad shallow paterae to sharp-rimmed impact-like craters, including some paterae with central peaks. This suggests that some of the impact-like craters may be endogenic. It is unlikely that the EZ craters are remnants of an older population of impact craters, as at least one segment of the EZ network disrupts, and is therefore younger than, tessera conspicuously void of craters. Other surfaces also exhibit unusual size-density distributions of craters: craters on Lakshmi Planum are unusually small (19 km mean diameter) and limited in size (σ = 7.2 km) for an area with such a relatively high crater density. Likewise, the mean diameter of craters on fold belts is 33 km (σ = 11 km), and on large volcanic constructs is 73 km (σ = 32 km). The few craters available so far for counting make these comparisons very preliminary and subject to further testing; but even if the number of these craters that are volcanic is only a small fraction of the total, impact crater densities within small tectonic regions are nonetheless so low that their use for relative dating will be of marginal use on Venus, requiring a heavy reliance on careful image interpretation.

Regardless of their uncertain origin, the craters still could hold the answer to whether, and to what extent, crustal shuffling is occurring on Venus. Recent interpretation of about 150 of the craters as impact features may translate to a ~750-m.y. mean surface age for Venus [5,11,12]. However, such age determinations are sensitive to estimates of the asteroid flux rate, selection of an appropriate crater-production curve, and the relative contribution of comets to the cratering record, all of which are currently in dispute; Schaber et al. (this volume) suggest a mean surface age possibly as low as ~100 m.y. The older age would vindicate models that suggest tectonism on Venus shut down about 500 m.y. ago, wheras the younger age would clearly imply ongoing resurfacing -- a view implied by our mapping.

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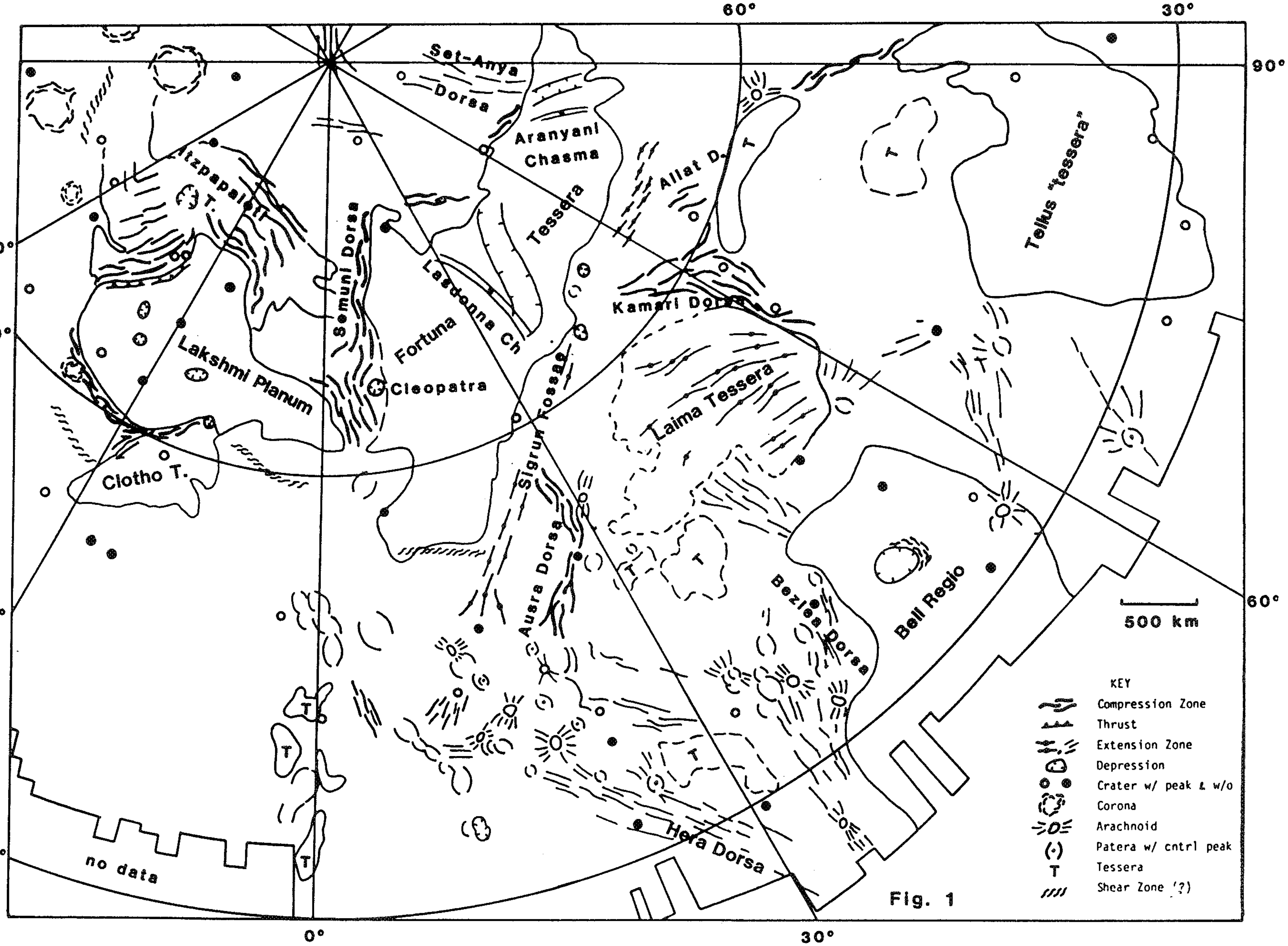

60°
30°
90°
300°
60°
330°
30°
0°
30°
60°
Set-Anya
Dorsa
Aranyani
Chasma
Allat D.
Tellus "tessera"
Tessera
Semuni Dorsa
Fortuna
Lakshmi Planum
Cleopatra
Clotho T.
Kamari Dorsa
Laima Tessera
Sigrun Fossae
Ausra Dorsa
Bezlea Dorsa
Bell Regio
Hera Dorsa
500 km
no data
T
KEY
Compression Zone
Thrust
Extension Zone
Depression
Crater w/ peak & w/o
Corona
Arachnoid
Patera w/ cntrl peak
Tessera
Shear Zone (?)

Fig. 1