SYNTHESIS OF GLOBAL THEMATIC MAPPING, VENUS: GEOLOGIC CORRELATIONS / QUESTIONS FOR THE MAGELLAN GRAVITY MISSION;

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INTRODUCTION. An important characteristic of the Magellan mission and the resulting data [1] is that it is both global in coverage as well as extremely high in resolution. As a result, global questions may be addressed based on the constraints of extremely detailed geological evidence. An important first step in the task of interpreting the global geological record well be a synthesis of the primary geological characteristics and their relationship to significant questions [2]. The following is a brief synthesis based on a comparison of mapped distributions, initial interpretations, and some questions that these results raise.

METHODS AND TYPES OF MAPS PREPARED. Global maps showing the distribution of fundamental geological characteristics have been prepared of fracture belts and rifts (Figure 2); ridge belts, mountain belts, and ridged plains (Figure 3); tesserae (Figure 4).; and the distribution and magnitudes of gravity anomalies (Figure 5). Global mapping of these geological features was done at a scale of 1:8 M for ~90% of surface.

Fractures are frequently resolved as graben or simple scarps, consistent with the general geological interpretation that fractures belts are the sites of crustal extension and rifting [3]]. Both ridge belts and mountain belts are interpreted to be the results of focused, belt-like styles of crustal shortening. Ridged plains were identified on the basis of the presence of numerous, sub-parallel, frequently uniformly-spaced, and sinuous ridges analogous to ridges common on the lunar mare and plains surfaces of Mars ("wrinkle ridges"). Ridged-plains are common on Venus in many of the topographically low-lying and morphologically uniform plains [3] and often exhibit uniform orientations over areas hundreds to thousands of kilometers across [4]. By analogy with similar plains deformation elsewhere in the Solar System [5], mare-type ridged plains on Venus are interpreted to represent the presence of crustal shortening of a few percent. Tessera distribution is adapted from the results of Ivanov et al [6]. Tessera are the sites of generally elevated topography, often plateau-like, complex, multi-phase deformation, including evidence for both extension and compression and evidence for long-lived development [7; 8]. Tessera are the oldest local, and perhaps global, stratigraphic units. The high elevation and gravity signatures associated with extensive areas of tessera imply that they are sites of greater than nominal crustal thicknesses [9].

REGIONAL/GEOLOGICAL DISTRIBUTIONS/CORRELATIONS. Comparison of the different thematic maps indicates that interconnected regions of distinctive regional geological characteristics occur and correlate with patterns of both altimetry and volcanic concentration.Volcanic centers are least abundant where ridged plains are common, including Helen Planita, Lavinia Planitia, and Aino Planitia in the southern hemisphere, and Snegurochka Planitia and Atalanta Planitia in the northern hemisphere. Most of the lowland regions are characterized by broad plains consisting of vast sheets of lava and associated sinuous channels [10; 11]. Anomalously low concentrations of volcanic centers also occur in tesserae. The large volcanic centers which do occur in this setting are frequently characterized by geological evidence for large subsurface magma reservoirs (calderas, concentric depressions, etc.).

DISCUSSION. There are apparent global-scale correlations between altimetric, geologic, and geophysical characteristics. Our maps agree with other recent results [9] and suggest that mass anomalies corresponding to anomalously positive geoid anomalies are correlated with concentrations of volcanic centers. This includes the major volcanic rises Atla Regio, Beta Regio, Themis Regio, and Eistla. On the other extreme, the largest negative geoid anomalies occur in areas characterized by low volcanic center concentrations, such as Lavinia Planitia and Atalanta Planitia. Although it is well-known that the geoid is strongly correlated with topography on Venus, the magnitude of the anomalies in many of these areas frequently exceeds that attributable to topography alone [12], and a significant dynamic (upwelling and downwelling) component to the geoid signal is implied under certain assumptions. Two origins for the regional compressional stresses responsible for both ridged plains and ridge belts include stresses related to (1) regional topographic slopes [4], or (2) sub-crustal mantle convergence and downwelling [13; 14; 15]. While elements of both models are likely, the absence of volcanic centers in lowlands might reflect cooler mantle, lower regional heat flow, and relative inhibition of melting in areas of mantle downwelling. Because tessera represent likely areas of greater crustal thickness, magma ascending into tessera will attain neutral buoyancy at the base of a relatively thicker crustal column and at correspondingly greater depths. Additional factors in the altimetric correlations in occurrence of volcanic centers might relate to altitude-induced differences in magma density such that neutral buoyancy of the magma may be attained at greater depths in the areas of greatest elevation [16].

CONCLUSIONS. Some preliminary results of the thematic geologic mapping are summarized in Table 1. Altimetrically, extensional characteristics and high concentration anomalies both appear to occur in uplands, whereas compressional deformation and low concentration anomalies occur at both the lowest and highest altitudes. Geologically, the distribution of volcanic centers is globally correlated with the areas over which the crust has been extended (fracture belts), and anti-correlated with areas characterized by compressional deformation (ridge/mountain belts and ridged plains) and greater crustal thickness (tesserae) [17]. The BAT anomaly is almost encircled by low plains characterized by compressional ridges, anomalous geoid lows, and other characteristics previously interpreted as potential indicators of mantle down welling [15; 13; 14; 9]. This together with the abundance of extensional fracture belts and rifts in the BAT region supports the interpretation that it is a probable region of broad mantle upwelling and corresponding peripheral mantle return flow.

Tessera are not strongly correlated with these global distribution characteristics and do not appear to be correlated with areas interpreted to be present sites of mantle upwelling or downwelling. Not all tessera may identify sites of current

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formation. They could represent the end result of continuing processes of downwelling [8], in which some represent relics of thickened crust and no corresponding evidence remains in the gravity signal for mantle downwelling. Alternately, they may have all formed at a given time in a catastrophic overturn related to global lithospheric [18] or depleted mantle layer [19] instabilities, with subsequent deformation being largely related to gravitational relaxation [20]. Global high-resolution gravity data will help to resolve these issues.

REFERENCES. [1] Saunders et al, 1992, JGR, 97, 13067; [2] Saunders et al., 1992, EOS, 73, 178;[3] Solomon et al. 1992, JGR, 97, 13199;[4] Bilotti and Suppe, 1992,GSA Abstracts, 24, A195; [5] Watters, 1988, JGR, 93, 10236;[6] Ivanov et al., 1992, LPSC 23, 581;[7] Bindschadler and Head, 1991, JGR, 96, 5881; [8] Bindschadler et al., 1992, JGR, 97, 13495; [9] Herrick and Phillips, 1992, JGR, 97, 16017; [10] Baker et al. 1992, 97, 13421;[11] Guest et al. 1992, 97, 15949; [12].G. Bills et al., 1987, *JGR*, **92**, 10351; [13] Bindschadler and Parmentier, 1990, JGR, 95, 21329; [14] Phillips et al. 1991, Science, 252, 651; [15] Zuber, 1990, GRL, 17, 1369; [16] Head and Wilson, 1992, JGR, 97, 3877; [17] Crumpler et al, this volume; [18]Turcotte, 1992, Int.Coll.Venus, 127; [19]Parmentier and Hess, 1992, GRL, 19, 2015; [20]Smrekar and Solomon, 1992, JGR, 97, 16121.

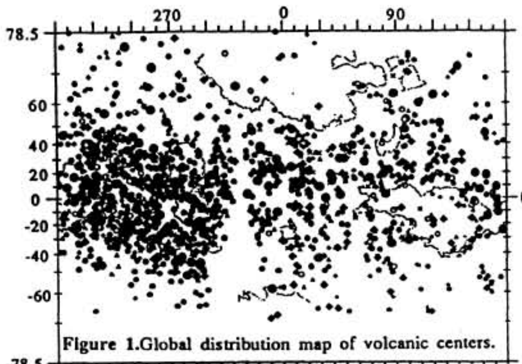


Figure 1.Global distribution map of volcanic centers.

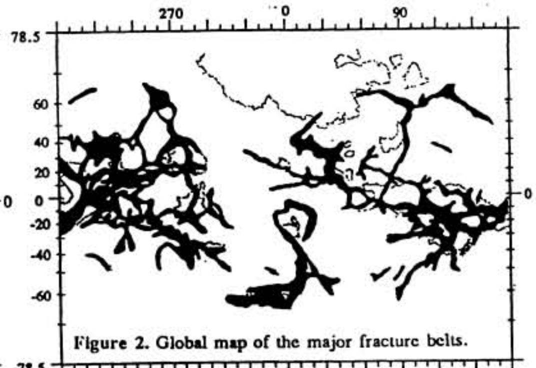


Figure 2. Global map of the major fracture belts.

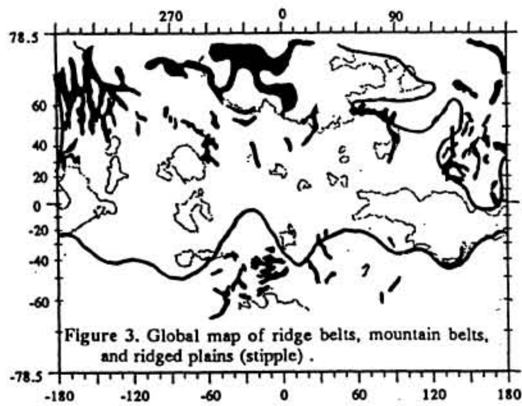


Figure 3. Global map of ridge belts, mountain belts, and ridged plains (stipple) .

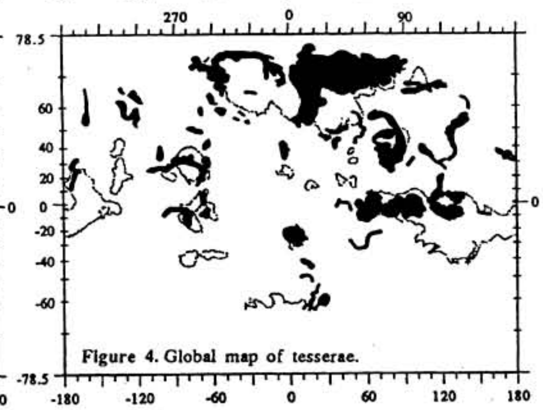


Figure 4. Global map of tesserae.

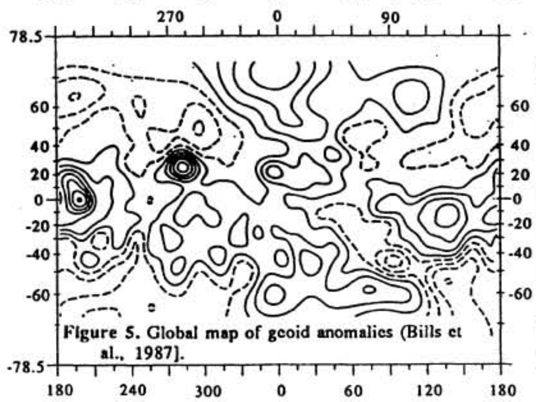
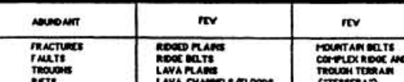


Figure 5. Global map of geoid anomalies (Bills et al., 1987).

Table 1. Summary of the global occurrence and geologic setting of volcanic and magmatic centers on Venus.

Altitude Setting	UPLANDS	LOWLANDS	HIGHLANDS
2 KM 0			
Volcanic Centers	ABUNDANT	FEW	FEW
Geologic Charac-teristics	FRACTURES FAULTS TROUGHS RIFTS	RIDGED PLAINS RIDGE BELTS LAVA PLAINS LAVA CHANNELS/FLOODS	MOUNTAIN BELTS COMPLEX RIDGE AND TROUGH TERRAIN ("TESSERA")
Geologic Interpre-tation	REGIONAL EXTENSION RIFTING	REGIONAL COMPRESSION REVERSE FAULTING FOLDING	REGIONAL COMPRESSION CRUSTAL THICKENING SHALLOW EXTENSION FOLDING
Geologic Signifi-cance	MANTLE UPWELLING	MANTLE DOWNWELLING?	GLOBAL DOWNWELLING, REGIONAL UPWELLING ?