TECTONIC FACIES IN VENUS TESSERA TERRAIN: CLASSIFICATION AND INTERPRETATION OF SEQUENCE OF DEFORMATION: James W. Head, III, Department of Geological Sciences, Brown University, Providence, RI 02912 USA

Abstract: Tectonic structures in northern Ovda Regio tessera are identified and classified, their origin interpreted, and their chronologic relationships established. Using this as a basis, combinations of structures are related to tessera facies, and facies position and sequence are related to processes of formation and evolution of tessera in Ovda and elsewhere. Margin parallel shortening, accompanied by shear, builds the fundamental linear and augen-like ridge and valley fabric of the tessera. This facies is then disrupted by pervasive scribing, at various but usually high angles, by extensive wide graben to produce the distinctive orthogonal or complex disrupted structure of tessera interiors. These facies and this sequence of deformation can be identified in all the major tesserae, suggesting that shortening initially characterized the tessera cores, and thus favoring an origin by downwelling.

Introduction: The tessera terrain on Venus is complexly deformed by multiple cross-cutting deformational structures[1] and its basic characteristics are reviewed elsewhere[1-5]. Tessera terrain is of significant importance in understanding the geologic history of Venus because of the apparent near-synchroneity of its surface age with the emplacement of the vast volcanic plains of Venus[6]. Among the important issues in further understanding the formation and evolution of the tessera terrain[7] is the deconvolution of the complex tectonic signature that comprises the tessera fabric. In this contribution, one component or facies of a classification scheme of tessera terrain structures and elements[8] is presented, similar but more complex facies are described, possible paths of evolution and modification between these are discussed, and implications for tessera formation and evolution are outlined.

Definition of Tectonic Facies: Several approaches to the mapping of tessera have been undertaken, including delineation of individual structures[4], subunits[1-2], tectofacies[9], and combinations of these. In this study, on the basis of regional[10-11] and global[3] analyses, tectonic structures and units or facies, are defined using basic principles of geologic mapping[12] and then compared in terms of stratigraphic sequence and increasing complexity of deformation. A wide range of data were utilized (altimetry; stereo images and available look directions and incidence angles). After extensive global survey, attention was focused on northern Ovda Regio (F-MIDRP 00N, 82 and related data) because of the wide range of terrains preserved, and the following structures were defined. A related study, using a somewhat different approach was undertaken for an area to the west (65^o)[13].

Structural Elements and Fabrics: Ridge and valley structure: Parallel rounded ridges and troughs giving surface wrinkled appearance; ridges 2-4 km wide and 50-150 km long, terminating in taper or en echelon arrangement with adjacent ridge; valleys approximately complementary, sometimes flooded by dark plains. Oriented parallel to tessera margin, minor cross-cutting structure; similar to structure of Freyja Montes; type area 0.6N, 80.1-80.9. Interpretation: Primary folds and compressional deformation. Lens or augen structure: Eye-shaped features 75-150 km in length and 20-25 km wide, enclosed within bounding ridge/valley structure, tapering to zero where ridges converge; internal structure complex and formed of smaller ridges oriented at various angles to long axis, often in sigmoidal orientations; broad topography appears dome-like; small, often en echelon graben seen on crests and making large angle to long axis of structure; type area 0-1N, 79-81. Deformation seems contemporaneous with ridge and valley structure. Interpretation: Primary broad anticlinal domes deformed by internal shear deformation. Narrow trough structure, linear orthogonal: Linear steep-sided troughs, commonly less than ~2 km wide and spaced ~3-5 km apart, oriented generally normal to the ridges and valleys and cutting across both; variable length, sometimes tapering toward ends; type area 0.6 N, 81-81.9. Width and spacing can vary across different adjacent terrains. Interpretation: Graben, formed generally parallel to shortening direction. Narrow trough structure, s-shaped orthogonal: Similar to linear orthogonal structures but pattern of troughs is wavy to s-shaped; type area 1N, 82; 2.2N, 84. Interpretation: Graben formed in presence of shear; similar to tension gashes. Wide trough structure, broadly sinuous: Larger (typically 4-6 km wide) and more throughgoing troughs

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with multiple faults on floor of trough; usually oriented at small angles to small troughs and superposed on them; forms dense network ranging from regularly spaced examples (10-20 km apart) to high density and almost complete obscuration of preexisting terrain. Interpretation: Complex graben structures with multiple faults. Radar dark plains: A wide range of generally dark, but variable units of plains, often with superposed wrinkle ridges, and associated channels, depressions, and small domes, occur throughout the area in topographic lows. Structural and embayment relationships show that plains were emplaced during at least several parts of the sequence of deformation. Interpretation: Volcanic plains flooding locally lowlying areas throughout sequence of deformation.

Structural and Age Relationships: Ridge and valley terrain is interpreted as primary anticlines and synclines formed by shortening oriented normal to the northern margin of Ovda Tessera. Augen lenses are interpreted to represent broad anticlinal domes influenced by shear, causing sigmoidal disruption within the lenses. Narrow trough structures are graben oriented parallel to the azimuth of shortening and in sigmoidal fashion where shear is involved. Narrow graben generally form after, or perhaps contemporaneous with the ridge and valley, and augen structure. The broadly sinuous wide trough structures are interpreted to be complex graben, are superposed on these other structures, occur in terrain further inboard of the edge of the tessera, and are generally at higher elevations; they are interpreted to be related to uplift of basic ridge and valley structure and its variants, and gravitational relaxation in a manner similar to that seen in the Tibetan Plateau[14].

Definition of Facies and Occurrences in Other Tessera Locales: The mapped individual structures can be classified into two facies, 1) Ridge and valley facies (equivalent to linear ridge terrain[2, 9]) and 2) Disrupted facies[2] (equivalent to interior block terrain[9]). Preliminary mapping of facies planetwide shows that the ridge and valley facies occurs along the margins of Ovda, Thetis, Tellus, Laima, Western Ishtar, and Fortuna, and that disrupted facies commonly occurs in the interior of Tellus, Alpha, Ovda, Thetis, and Fortuna. On the basis of tracing of ridge and valley structural elements and trends within the disrupted facies, it appears that the disrupted facies forms largely by gravitational relaxation of previously accreted ridge and valley facies.

Discussion and Implications for Tessera Formation and Evolution: Mapping of individual structural elements and their interpretation provides a basis for the understanding of more complex facies and the deconvolution of the complex multiple deformation that defines the tessera. Preliminary analyses shows that the relatively simple ridge and valley facies can be traced into the interior of many of the major tessera occurrences where it is modified by pervasive graben interpreted to be related to gravitational relaxation of earlier accreted terrain. These facies and this sequence of deformation can be identified in all the major tesserae, suggesting that shortening initially characterized the tessera cores, and thus favoring an origin by downwelling. Detailed mapping and deconvolution of the basic facies in larger tessera occurrences is underway to delineate the sequential accretion of individual tessera terrains and to determine if it the interior of some tesserae represent previous discrete accretion events[15], or are part of a single phase of tessera formation.

References: 1. V. Barsukov et al. (1986) *JGR, 91*, D378; A. Basilevsky et al. (1986) *JGR, 91*, 399; A. Sukhanov (1992) *Venus Geology, Geochemistry, and Geophysics*, V. Barsukov *et al.*, eds., University of Arizona Press, Tucson, p.82. 2. D. Bindschadler and J. Head (1991) JGR, 96, 5889. 3. M. Ivanov and J. Head, *EMP*, in press. 4. D. Bindschadler et al. (1992) *JGR, 97*, 13563. 5. S. Solomon *et al.*(1991) *Science, 252*, 297; (1992) *JGR, 97*, 13199. 6. M. Ivanov and A. Basilevsky (1993) *GRL, 20*, 2579; R. Strom *et al.* (1994) *JGR, 99*, 10899. 7. J. Head (1995) *LPSC 26*, this volume. 8. J. Head, Classification of Structures in Tessera Terrain and Deconvolution of Its Complex Structural Deformation, in preparation. 9. R. Saunders, in Solomon *et al.* (1992) *JGR, 97*, 13199. 10. J. Head (1990) *Geology, 18*, 99; J. Head *et al.* (1990) *GRL, 17*, 1337. 11. R. Vorder Bruegge and J. Head (1990) *EMP, 50/51*, 251. 12. K. Tanaka (1994) *USGS Open File Rept. 94-438*. 13. M. Ivanov and J. Head (1995) *LPSC 26*, this volume. 14. R. Armijo *et al.* (1986) *JGR, 91*, 13803. 15. D. Chadwick and G. Schaber (1994) *LPSC 25*, 229.