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RESULTS FROM ONGOING MAPPING OF THE NEMESIS TESSERAE (V14) QUADRANGLE, VENUS.

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Introduction: The Nemesis Tesserae quadrangle (25-50°N, 180-210°E) is located within Ganiki Planitia, north of Atla Regio, south of Vinmara Planitia, and southeast of Atalanta Plantia. The region contains a diverse array of volcanic-, tectonic- and impact-derived features, and the objectives for the ongoing mapping effort are fivefold: 1) explore the formation and evolution of previously identified radiating dike swarms within the region, 2) use the diverse array of volcanic deposits to test further the neutral buoyancy hypothesis proposed to explain the origin of reservoir-derived features, 3&4) unravel the volcanic and tectonic evolution in this area, and 5) explore the implications of 1-4 for resurfacing mechanisms.

Approach: Ongoing mapping and analysis of the geology within the Nemesis Tesserae quadrangle builds upon integrated interpretation of multiple datasets. The primary mapping base is a single, georeferenced, 250 m/pixel[1], lambert conformal conic-projected Magellan radar image, co-registered in ArcGIS 8.3 with topography and remote sensing (e.g., emissivity, etc.) datasets. Complementing this mapping configuration, similar resolution synthetic stereo data (at 10x vertical exaggeration) viewed on an adjacent screen provide powerful topographic insight into material unit boundary locations and stratigraphy. Finally, georeferenced FMAP resolution (75 m/pixel) radar data, sinusoidally projected to a central meridian of 195°E and then digitally mosaicked within ArcGIS, are also employed; all units defined during mapping on the lower resolution lambert base can be reprojected "on the fly" during a simple cut-and-paste operation in ArcGIS so that they co-register with the sinusoidally projected FMAP images, yielding a quick and efficient way to use high resolution data to refine problematic unit boundaries and stratigraphic relationships.

A Comment on Involving Undergraduates. Extensive involvement of undergraduates during the past several years has been an important component of the "methods" employed for the project to date, and I report briefly on my experiences here in the hope that they will be of benefit to others who seek to involve undergraduates productively in their mapping efforts. To date I have leveraged student funding provided by my mapping grant more than fourfold (via PGGURP, funds from Pomona College, and via selected use of independent study credit), allowing me thus far to work with 4 students in the summer of 2001 (all of whom co-authored LPSC abstracts [1-3]), 1 in the fall of 2001, 7 in the spring of 2002 (3 of whom continued collaboration in the fall of 2002 to produce an LPSC abstract [4]), and 1 in the spring of 2003. The students, ~35% men and 65% women, have ranged in background from several with only one geology class (freshmen) to one who had just completed his senior year of college. My experiences to date suggest that the most productive way to involve undergraduate students is to engage a large group at a single time; there are pros and cons to doing this during the summer or within an academic semester [5]. Either configuration, however, allows the group to solve many problems (software issues, etc.) with minimal assistance. It also promotes a healthy and synergistic opportunity for the students to compare observations and test hypotheses—an important component of their education as science students—and allows me to focus my collaborative time with them upon exploring and helping to guide their scientific efforts and upon integrating the mapping and science results they produce, maximizing forward progress for the quadrangle mapping effort as a whole. Other configurations I have tried have not been as productive for the students and have generally hindered my ability during that period to make forward progress on the project as a whole, requiring as much or more of my time and yielding less science return. I would be happy to discuss these matters further with interested parties.

Selected Observations and Results: Mapping to date has providing insight into several interesting science questions, only a few of which are described here.

Giant Radiating Dike Swarms. The V14 quadrangle contains three features interpreted as radial dike swarms. Extensive study of similar features preserved in the geologic record on Earth has revealed a great deal about how such swarms originate, but because of poor preservation little is known about the detailed configuration of the magma source regions (beyond the general statement that they are normally mantle plume sites) or the scale/nature of any associated surface volcanism [6]. Observations in V14 indicate that both the magma source regions and surface expressions of similar dike swarms on Venus are highly diverse. For example, one (previously unidentified) swarm, with lineaments extending fairly uniformly to lengths of ~200-400 km and radiating through ~180° of arc, emanates from a broad topographic dome 250 km in radius, the crest and flanks of which are characterized principally by a cluster of small shield volcanoes and associated lava flows. These characteristics suggest a

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[1] This translates, when viewed at full resolution, to an effective mapping scale of about 1:1M.

small, deep-seated (sub-crustal?) plume, with dike alignments governed in large part by the stresses associated with formation of the dome [cf 6 and references therein]. The second swarm, which radiates through 360° of arc and is similar in size, has a single, unnamed volcano at the focus, and the flanking flows from this edifice both cover and are cut by dike-related fracturing suggesting an interplay between intrusive and extrusive volcanism characteristic of a shallow crustal magma reservoir [cf 7]. Finally, the third dike swarm contains at least two distinct radial lineament sets, the focal regions of which are separated by ~200 km [8]. The oldest, centered upon a subdued annular structure, fans across ~270 degrees of arc out to distances of at least 150 km, but one prominent subswarm extending northeast toward Bellona Fossae exceeds 1000 km in length. The younger radial system, centered upon an unnamed volcano, is characterized by dikes fanning through ~360 degrees of arc across at least 125 km (a small handful of dikes extend twice this distance). In this case, the flows from the edifice cover but are not cut by the dikes, suggesting that the intrusive phase of volcanism ceased prior to when the most recent surface deposits were emplaced. Considered together, it appears that lateral migration of the magma source region has occurred with time and interestingly, unlike what has been documented for novae on Venus [9,10], the older center has longer continuous fractures and greater fracture-to-fracture spacing than the younger one, suggesting the possibility that there is further information to be gleaned about the subsurface plumbing from the character of the surface record. Study of the radiating dike systems and comparison with the terrestrial record and other swarms on Venus is continuing.

Neutral Buoyancy. Mapping to data has revealed well over thirty major reservoir-derived features in the quadrangle, but the total number of features in the quadrangle is too small for a meaningful Chi-squared test of the neutral buoyancy hypothesis [7]. Our results do indicate, however, that criteria used to define volcano and dike swarm elevations in previous studies [e.g., 11,12] may not be effective if the amount of post-emplacement deformation observed in the pseudostereo data for V14 is at all typical.

Structural Deformation. Prominent extensional and compressional lineaments occur throughout the quadrangle, but in general several patterns are observed. Extensional lineaments occur in three primary forms: 1) sets which are geometrically linked to specific volcanic features, such as the dike swarms described above and several coronae and smaller annular features, 2) sets concentrated into linear, topographically elevated belts, and 3) those which significantly deform (and in many cases define) the tessera in the region. While very small-scale distributed fracturing pervades the plains, no distinctive regional tectonic patterns are otherwise observed. Compressional lineaments also occur in several primary configurations: 1) as regional, often arcuate systems of wrinkle ridges in low-lying plains areas, 2) as sets concentrated into linear, topographically elevated belts, and 3) as narrow sets immediately adjacent to the edges of areas with steeply elevated topographic boundaries. The stratigraphic and tectonic implications of the observed deformation continue to be a focus of intense study.

Pyroclastic Deposits? An intriguing region of homogeneous, rough, radar-bright "feathery" deposits—similar to units interpreted by others as pyroclastic materials [13]—occurs within V14. As with previously mapped examples no vents are observed and the materials blanket and bury tectonic lineaments in the area; however, the deposits mapped in V14 are not spatially affiliated with a corona rim. They do lie, however, along the southeast edge of the 500 km dome and complex magmatic center with which the first dike swarm described earlier is affiliated, suggesting that volatile-rich eruptions on Venus may derive from small, deep-seated plumes.

Impact Cratering. The V14 quadrangle contains 11 impact craters and 4 "splotch" craters. Two of the craters—Yablochkina and Akiko—are affiliated with areally extensive radar dark haloes that blanket the surrounding plains and make unit differentiation in the affected areas quite challenging; only one large crater (Nadira) has no halo deposit whatsoever. One of the most interesting craters, however, is also one of the smallest: Unitkak has a diffuse-appearing, radar-dark streak several kilometers wide that extends away from the crater in a straight line across more than 500 km.

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