EXPERIMENTAL MAPPING OF THE V36 QUADRANGLE OF VENUS, BASED ON MAGELLAN DATA:
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Introduction: We produced this experimental geologic map of the V36 quadrangle of Venus during the summer of 1991 to assist in development of the Venus Geologic Mapping (VGM) program, whose goal is to produce a global map series of the planet at 1:5,000,000 (1:5M) scale. Innovative mapping techniques are required to represent the complex structure of the Venusian surface as revealed by Magellan data.

Magellan SAR images illustrate that fracturing in many regions has been intense with complex cross-cutting relations, which makes determination of deformational history difficult. In some cases, fracture sets can readily be classified. In most cases, however, fractures of different sets meet and become sympathetic in trend, precluding clear delineation of fracture sets. Extensive examination of the various structural relations in highly fractured areas is necessary to sort out and deduce relative ages and structural origins. Additional data sets, particularly topographic, assist in understanding the geology. Our task was to experiment with different methods of unit definition and structural mapping to determine ways to map the geology clearly and concisely, with a focus on highlighting key structures and fracture systems.

Geologic setting: Quadrangle V36 in Aphrodite Terra was chosen primarily because of its tectonic complexity. It is bordered to the south by Artemis Chasma and to the north by a tessera, Thetis Regio. The surface is dominated by fractures associated primarily with chasmata and coronae. There are some plains areas that are thought to be contemporaneous with the last volcanic resurfacing, interpreted to have occurred prior to about 0.5 by ago[1]. The variety of terrains and structures in this quadrangle provided the opportunity to meet many of the challenges in representing the geologic complexity of Venus.

Data sets available: The mapping was done on C1-MIDR (225 meters/pixel resolution) SAR backscatter image mosaics (15S129 and 15S146), at a scale close to 1:5M. Originally, the only altimetry data set available this far south was from Pioneer Venus (PV). Later, a merged data set of PV, Venera, and Magellan altimetry became available at improved resolution. Further knowledge was gained from study of a point perspective view of part of C1-MIDR 15S129. This image is a computer-generated oblique view from calibrated SAR data and altimetry, and it provides a general sense of the relief of the area. Synthetic parallax stereoimage mosaics were also produced by merging Magellan altimetry data with Magellan SAR imagery. This work was done by the U.S. Geological Survey, Flagstaff, using methods originally developed for use with Landsat imagery[2].

Methods developed: We experimented with a method partly based on a study of the Tharsis region of Mars[3]. A series of four map overlays was generated that individually show (i) tectonic units, (ii) local structures/centers of tectonism, (iii) regional structures/major fracture orientations, and (iv) generalized topography.

On bodies such as the Moon and Mars, stratigraphic relations among different types of materials can, in many cases, be readily observed. However, most surface rocks on Venus are broadly contemporaneous, relatively young basaltic flows. Thus determination of relative ages by crater density is impossible. Superposition relations can be determined only in a broad manner and the determination of map units must be based on other surface characteristics whose interpretation is more complex.

At first, units were distinguished solely on the basis of SAR brightness characteristics and visible fracture relationships seen on the C1-MIDRs. When stereoimages became available, we modified the descriptions and contacts of some of these units and defined several new ones. Basically, two types of criteria were used to discriminate of units: (i) structural characteristics, including orientation, style, and density of lineations, and (ii) topographic features such as plains, troughs or ridges, which are thought to be of geologic significance. Application of the latter criterion requires stereoimages for optimal results.

Because fracture density was found to be a useful characteristic in the definition and description of tectonic units, we developed a measurable fracture index (FI). A systematic but blind sample is used: looking through a small, transparent line defining a circle on an opaque medium, we counted all brightness anomalies, interpreted to be fractures. This negates some bias caused by an attempt to define what is or is not a fracture.

Unit names and descriptions were kept separate from interpretations, a procedure well-established in planetary geology. Once units are defined, the interpretive value of the map can be enhanced by grouping the units into broader assemblages (Fig. 1) based on terrain associations. Although age relations among individual units are generally lacking at this point, relations between assemblages are sufficient for determining a more general history based on broad age relations. We mapped eight assemblages on the two C1-MIDRs (Fig. 1). A good example of the value of such an approach is the Global Disruption Zone assemblage group (Selene Chasma, Diana Chasma, and Fractured Hills assemblages) which corresponds to a disruption zone noted from PV data[4].
The structural maps are much more interpretive than the unit maps. The map of local structures shows relatively short fractures and smaller fracture sets, many of which can be traced to their sources. Representative fractures are traced to show their basic orientation and sources. The structures in figure 1 are representative of those on this map. The regional structural map (not shown), on the other hand, shows the more widespread fracturing significant at quadrangle scale. An attempt is made to trace at least one fracture of every orientation that can be recognized. When compared with the unit map, these structural maps should aid in clarifying the deformational history.

Finally, the synthetic stereodata enable the creation of a map of the major topographic features. Bold lines are drawn at the junctions between plains and major rises or depressions, and a line symbol denotes the apex of the feature. Line weight distinguishes relative sizes of these features. The largest are surrounded by heavy lines, and are identified by a symbol. Thinner lines denote features that are small but significant enough to display.

Because all of these maps are on clear overlays, it is necessary to decide which should be presented together. A composite of all four overlays is too cluttered. The units, local structures, and generalized topography are best shown together on a full-scale base. Over a subdued base at reduced scale, separate maps can be created to show the regional structures and more detailed topography.

**Results:** We found that it is helpful to simplify and isolate distinct groups of similar fractures. Thus one can more readily see relations among the complex fracture sets. In this capacity, the map acts as a filter, losing the noise of individual fractures, but allowing major trends to be shown. The major problem is that, when grouping fractures together to define a unit, the age of fracturing may involve multiple episodes of deformation that are not easily distinguished.

Studying Venus using Magellan imagery is of great value because such imagery has high resolution and nearly global coverage, so it will be possible to truly appreciate the geology on a global scale. Some units may correlate globally, but assemblages are of the most value at present. The relations between topography and surface features are also enhanced by this type of mapping. A prime example is the correspondence of coronae with fractured trough systems. Every corona in these two C1-MIDRS falls within a trench, creating an anomalous rise. We interpret this relation to indicate that the coronae are locally forming along and/or creating crustal weakness zones where the surface is easily rifted open, thus creating large-scale linear disruption zones.

The results of this experimental mapping have shown that, with innovative mapping techniques, the most complex tectonic regions of Venus can be satisfactorily summarized at 1:5M scale.

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**Figure 1:** Simplified geologic map of C1-MIDRs 15S129 and 15S146, which make up most of the V36 quadrangle of Venus. **t=**Thetis tessera assemblage, **bh=**Broken highlands assemblage

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**References:**

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