THE GLOBAL GEOLOGY OF VENUS: CLASSIFICATION OF LANDFORMS AND GEOLOGIC HISTORY. D. A. Senske, R. S. Saunders, E. R. Stofan, and Members of the Magellan Science Team, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction. The Magellan Mission to Venus successfully imaged 98% of the surface of the planet at a resolution of 120 to 300 m [1]. To better understand the distribution of landforms and identify general stratigraphic relations, a geologic map (Fig. 1) is produced from a global image (scale of 1: 50,000,000).

Unit Classification. Global-scale geologic mapping of Venus has been carried out previously by several investigators [2,3,4]. These studies defined units on the basis of variations in radar backscatter, surface textures, topography, and morphology. Unit classification in this survey uses much of this criteria along with superposition and cross cutting relations to preserve as much stratigraphic information as possible. General age relations are identified, but in cases where units do not touch each other the stratigraphy is not always clear. Since the Magellan viewing geometry varied as a function of latitude during each of its three mapping cycles [1,5] care must be taken when identifying units at different latitudes.

Sixteen units are identified along with a variety of structural features. The most abundant units, plains, correspond to low land areas that cover in excess of 75% of the surface of the planet. Six classes of plains are mapped and distinguished stratigraphically as: (1) *lineated plains*, areas of moderate, homogeneous, radar brightness containing abundant fractures that in some places form a gridded or orthogonal pattern. (2) *Reticulate plains*, areas of intermediate, homogeneous, radar brightness that typically contain abundant, low, sinuous ridges. (3) *Dark plains*, localized areas of homogeneous, radar-dark, material found mainly adjacent to ridge belts and interpreted to be smooth pahoehoe-like lava flows. (4) *Bright plains*, areas of homogeneous, radar-bright, material typically found adjacent to fracture belts and interpreted to be associated with lava flooding related to extension and rifting. (5) *Mottled plains*, extensive areas of radar-bright and dark material found in the region bound by Atla Regio to the west, Themis Regio to the south, and Beta Regio to the north and east. The mottled texture is due to the presence of abundant small shields (diameters of several to 10's of km) and their associated deposits. (6) *Digitate plains* (lava flow fields), concentrations of radar-bright and dark deposits, arrayed in digitate patterns and generally associated with coronae. Centers of constructional volcanism include large edifices and shield/dome fields. Features mapped as *volcanic edifices* are isolated, circular to oval, areas of radar-bright and dark material that form a radial, digitate, pattern centered on a topographic rise. The largest concentration of these shields is found in an area bound by Beta, Atla, and Themis Regiones [6]. *Shield/dome fields* are isolated concentrations, 100's of km across, of small (several to 10's of km in diameter) shields and domes and their associated deposits.

Geomorphic units, defined by assemblages of structural features, include: (1) *complex ridged terrain* (CRT or tesserae), localized elevated areas made up of ridges and fractures with multiple directions of deformation [7]. (2) *Ridged and fractured terrain*, localized areas 100's of km across contain closely spaced fractures or ridges and are often associated with coronae. This unit differs from CRT in that there is a single, dominate, direction of deformation. (3) *Ridge belts* (including a sub unit of *mountain belts*) are distinguished by linear, elevated, zones of parallel to anastomsing ridges arrayed in belts 10's to 100's of km wide and 100's of km long. Like the ridge belts, mountain belts, located exclusively in Ishtar Terra, are collections parallel ridges forming boundaries with CRT. Unlike the ridge belts, the mountain belts typically have high values of Fresnel reflectivity. (4) *Fracture belts* are dense collections of parallel lineaments/fractures forming belts 10's to 100's of km wide and 1000's of km long. These zones, concentrated in the equatorial region and southern hemisphere, extend northeast from the south polar region, link up at Artemis with a belt that lies along the southern edge of Aphrodite and continues east toward Atla Regio where it splits to the northeast (Hecate Chasma) and to the southeast (Parga Chasma).

Deposits associated with impact events are identified as: (1) *crater material*, radar-bright (rough at the 12.6 cm radar wavelength) ejecta deposits. (2) *bright diffuse deposits* , made up of radar-bright material distributed asymmetrically about impact craters forming a "wispy" pattern. These deposits form gradational boundaries with adjacent units and are interpreted to be wind blown ejecta. (3) *dark diffuse areas* are radar-dark, parabola shaped, regions that typically open to the west and extend for 100's of km from an impact crater. These areas, including numerous dark "splotches", are sites where the surface has been smoothed by an impact event.

Discussion and Conclusions. Stratigraphic relations indicate that the oldest units on Venus, lineated plains, CRT, and ridged/fractured terrain preserve early episodes of deformation. These units are typically embayed by regionally extensive reticulate plains. Due to the absence of identifiable individual flows the reticulate plains are interpreted to be associated with widespread lava flooding. Plains emplaced more recently include, bright, digitate, dark, and mottled plains and are linked to volcanism associated with individual vents, fractures, and coronae. Other features associated with recent volcanism are large edifices and shield/dome fields. In a number of areas, ridge belts and fracture belts deform older plains, corresponding to some of the most recent tectonic activity. The distribution of units on Venus is not uniform. The region bound by Atla, Themis, and Beta Regiones is dominated by fracture belts (corona chains), mottled plains, and volcanic edifices. Occurrences of CRT are relatively minor in this area and

is found primarily along the periphery of the Beta rise and at Phoebe Regio. In comparison, the area bound by Ishtar Terra to the north and Aphrodite to the south contains large concentrations of CRT, fractured plains, and reticulate plains, with few large volcanic edifices present. Like the north polar region where there is a large concentration of ridge belts (longitudes 180° to 240°), a second major ridge belt province is located near the south pole (180° to 270°, Helen Planitia and 0° to 330°, Lavinia Planitia). In addition, this part of the planet contains the greatest concentration of large lava flow fields (digitate plains). This area, and the Beta, Atla, Themis area contain some of the stratigraphically most recent lava deposits. In general, many of the youngest features on Venus are found along fractures belts (corona chains) in these regions.

References. [1] Saunders, R. S., *et al.*, *JGR*, 97, 13067-13090, 1992. [2] Sukhanov, A. L., *et al.*, *U.S.G.S. Misc. Inv., Map I-2059*, 1989. [3] Senske, D. A., *et al.*, *Earth, Moon and Planets*, 55, 163-214, 1991. [4] Senske, D. A., *et al.*, *Earth, Moon, and Planets*, 55, 97-161, 1991. [5] Tyler, L. G., *et al.*, *JGR.*, 97, 13115-13139, 1992. [6] Head, J. W., *et al.*, *JGR*, 97, 13153-13197, 1992. [7] Barsukov, V. L., *et al.*, *JGR*, 91, D378-D398, 1986.

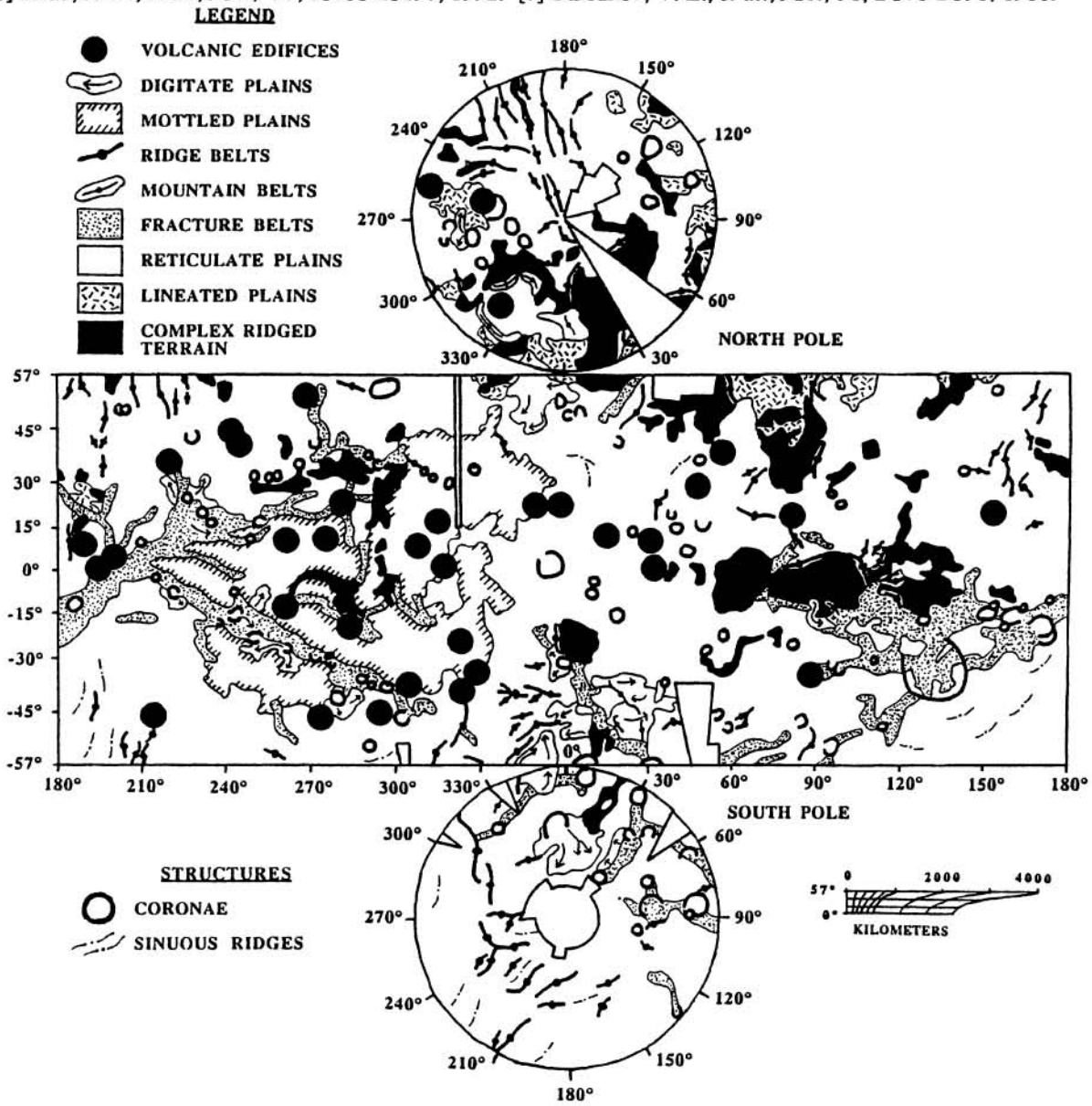

FIG. 1 Map showing the major units on Venus. In order to show the large-scale geologic patterns, units described in the text, but not shown on this map include: dark plains, bright plains, shield/dome fields, ridged and fractured terrain, crater material, bright diffuse deposits, and dark diffuse areas.