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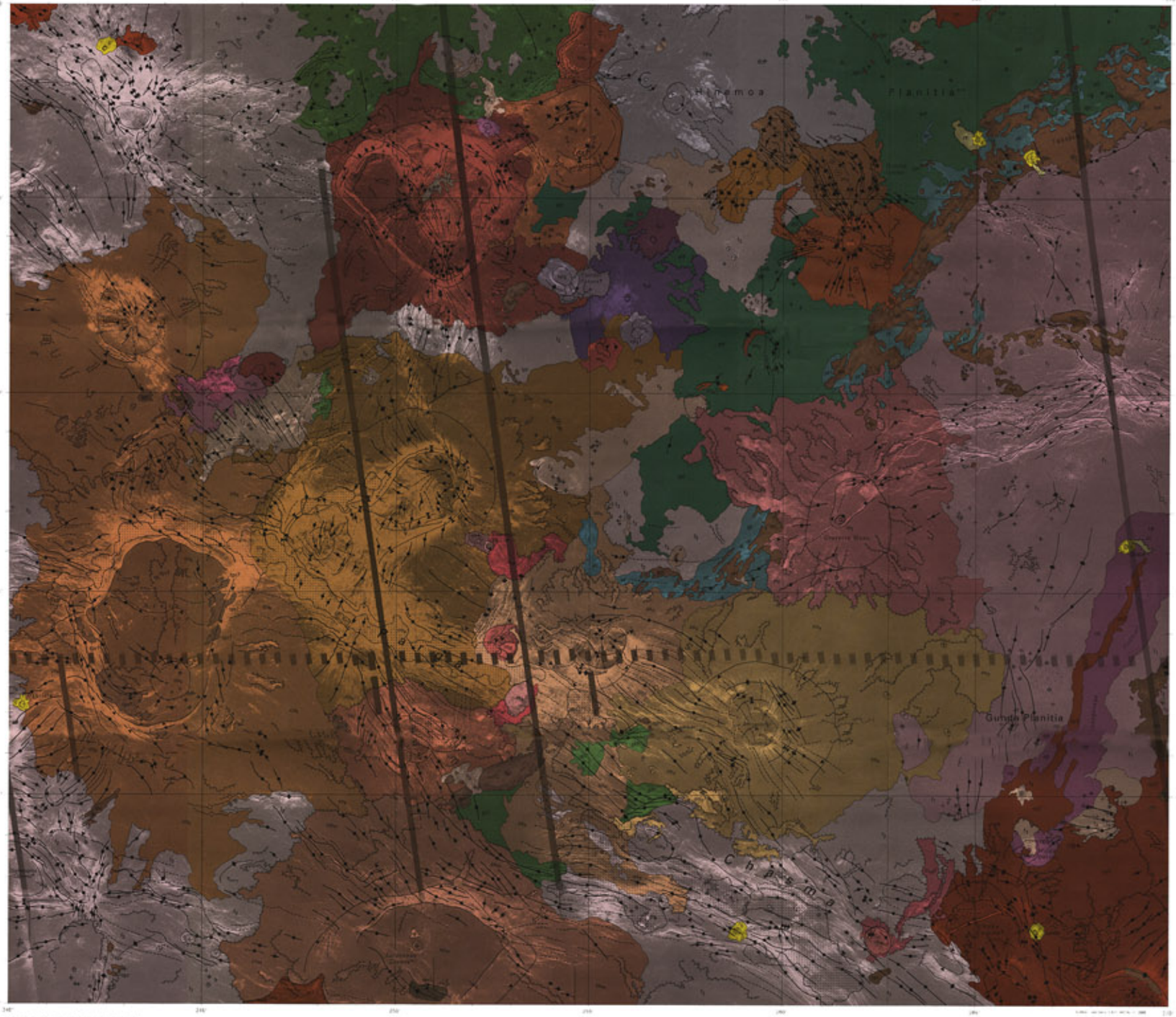
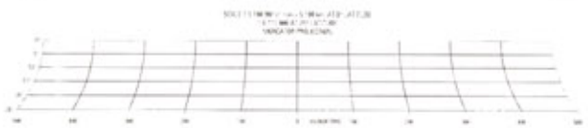
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

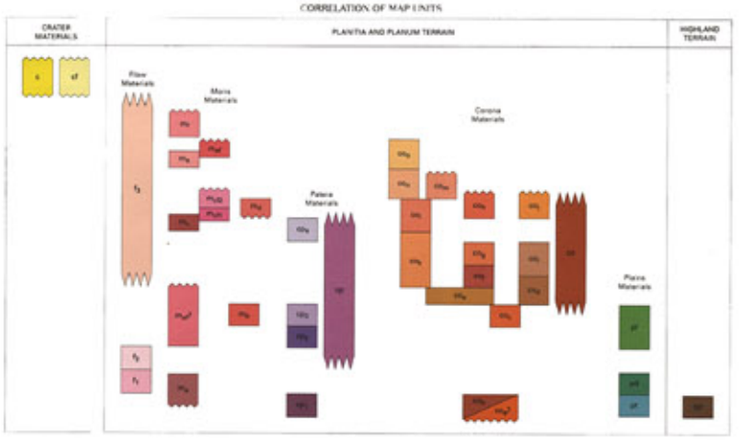
ATLAS OF VENUS
1:5,000,000 GEOLOGIC SERIES
GALINDO QUADRANGLE—VENUS
(V-40) I-2613
Pamphlet accompanies map





QUADRANGLE LOCATION
Photomosaic location is shown in the western hemisphere of Venus. An outline of 1:5,000,000-scale quadrangles is provided for reference.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

CRATER MATERIALS

Crater material—Material of radar-bright, basal-dusted craters having complete rim crests, steep walls, exterior rugged and hummocky ejecta, and no flows superposed on other materials. Some craters may have flat radardark floors; some craters may be deformed by subsequent fracturing. Interpretation: Young impact craters; impact melt ponded on some crater floors.

Outflow deposit—Radar-bright, digitate lobes leading away from apertu of impact craters. Interpretation: Impact-melt flows.

PLANITIA AND PLANUM TERRAINS

Flow materials—Consist of outcrops of curved radar reflectance, basally buried by lobate edges and containing numerous scattered small shall. Average surface properties quantified on figure 8. Interpretation: Volcanic flows and associated small cones.

Unit f_3—Occurs locally in patches superposed on material units as old as corona unit e and flow unit 2

Unit f_2—Occurs over much of the map area underlying younger units; it shows one embayment relation with flow unit 1 at lat 28.5° S., long 264.5°

Unit f_1—Embays Pioneer Regio tessera material and tessera-embaying plains material on east part of map area. Overlain by flow unit 2 and other mons, corona, and patera units

Mons materials—Consist of interdigitate lobes an of curved radar reflectance bound by lobate edges that can be traced to dome- or dome-shaped structures. Interpretation: Flank and radial lavas associated with and corresponding shield volcanoes

Unit m_3—Traceable to 2-km-high cone for 13 °S., long 262°; containing central pit. Flows on flan, Pioneer Regio tessera material and corona units e and o

Unit m_2 flow material—Relatively radar bright lobate flows traceable to fan cone-shaped mounds mapped as unit m_3. Superposed on corona units e, f, and o

Unit m_2—Occurs as two cone-shaped mounds near center of map area having heights between 0.5 and 2 km. Superposed on corona units e, f, and o

Unit m_1—Forms a fractured, 1-km-high mound at lat 16° S., long 253°; embraced by corona material o

DESCRIPTION OF MAP UNITS

CRATER MATERIALS

c **Crater material**—Material of radar-bright, basal-dusted craters having complete rim crests, steep walls, exterior rugged and hummocky ejecta, and no flows superposed on other materials. Some craters may, have flat radardark floors; some craters may be deformed by, subsequent fracturing. Interpretation: Young impact craters; impact melt ponded on some crater floors.

cf **Outflow deposit**—Radar-bright, digitate lobes leading away from aperta of impact craters. Interpretation: Impact-melt flows.

PLANITIA AND PLANUM TERRAINS

Flow materials—Consist of outcrops of curved radar reflectance, basally buried by lobate edges and containing numerous, scattered small shall. Average surface properties quantified on figure 8. Interpretation: Volcanic flows and associated small cones.

f_3 **Unit 3**—Occurs locally in patches superposed on material units as old as corona unit e and flow unit 2

f_2 **Unit 2**—Occurs over much of the map area underlying younger units; it shows one embayment relation with flow unit 1 at lat 28.5° S., long 264.5°

f_1 **Unit 1**—Embays Pioneer Regio tessera material and tessera-embaying plains material on east part of map area. Overlain by, flow unit 2 and other mons, corona, and patera units

Mons materials—Consist of interdigitate lobes an of curved radar reflectance bound by lobate edges that can be traced to dome- or dome-shaped structures. Interpretation: Flank and radial lavas associated with and corresponding shield volcanoes

m_3 **Unit 3**—Traceable to 2-km-high cone for 13 °S., long 262°; containing central pit. Flows on flan, Pioneer Regio tessera material and corona units e and o

m_2 **Unit m_2 flow material**—Relatively radar bright lobate flows traceable to fan cone-shaped mounds mapped as unit m_3. Superposed on corona units e, f, and o

m_2 **Unit m_2**—Occurs as two cone-shaped mounds near center of map area having heights between 0.5 and 2 km. Superposed on corona units e, f, and o

m_1 **Unit m_1**—Forms a fractured, 1-km-high mound at lat 16° S., long 253°; embraced by corona material o

Unit **c_1 flow material 2**—Radar-dark material traceable up the slope of a 1.5-km-high crescent-unit rise at lat 9 °S., long 242°; superposed on unit c flow material 1 and corona material k

Unit **c_1 flow material 1**—Radar-bright lobate flows traceable up the slope of a 1.5-km-high crescent-unit rise at lat 9 °S., long 242°; superposed on corona material k

Unit **c_1**—Forms a 1.5-km-high crescent at lat 9 °S., long 242° with a central crater; superposed on flow unit 2

Unit **b_2**—Forms 500-m-high mound at lat 9 °S., long 253.5°; no rides adjacent scarf crater. Embayed by corona unit e and overlies patera unit 2

Unit **a_2 flow material**—Radar-bright, lobate flows traceable to 500-m-high mound on, southeast corner of map area; overlies flow unit 2 and, in places, embayed corona material

Unit **a_1**—On southeast corner of map area, radar-bright 500-m-high mound cut by, radial and concentric grabens; embayed by, flow unit 2

Patera materials—Interregional lowlands of material having variant radar reflectance and textural fe; lobate edges, outcropping shallow, weight-ion craters. Interpretation: Lava flows erupted from, volcano/tectonic caldera depressions

Unit **d_4**—Material, radar-bright material and radar-dark flows traceable to 500-m-deep crater at lat 5 °S., long 262°. Ass ociated flows arcuate, corona units d, g, and c; overlaid by, corona units b, and i

Unit **d_3**—Occurs on, and around two craters near lat 8° S., long 255°. Superposed on unit 2; overlain by corona units e and i

Unit **d_2**—Relatively radar-bright, lobate materials associated with crater 20 km wide and 500 m deep at at 3 5° S., long 256°. Overlies material of unit 1 and flow unit 2

Unit **d_1**—Material forms ring-ceiling crater 30 km wide and 500 m deep at lat 6 °S., long 256°. Overlain by radar-dark plains material

Patera material, undivided—Relatively, lower-bright material traceable to 1-km-deep crater in southeast part of map area, overlain by, radar-dark corona material, undivided

Corona materials—Digitate lobes of curved radar reflectance traceable to material fractured in roughly, concentric ring patterns; some materials are dissected into radar terraces; or moats. Described characteristics include walls between bounding annular fractures or rings, cluster of rings, number of rings, and topographic change in elevation between rings. Interpretations: Lavas erupted from circular, arcuate/circle, and zones of volcanic/tectonic origin (fed), related to uprooting of mantle plume material

Unit **o_3**—Material forming a 160-km-diameter, concentric, multiple ring 500-m-high mound dat 18 S., long 259.5°; overlies material of corona unit o

Unit **o_2**—Material forming a 150-km-diameter, slightly asymmetric, single ring 1.5-km-high mound dat 16.5° S., long 268.5°; overlies material of corona units e and

Unit **m_2**—Material forming a 600-km-diameter, asymmetric, single ring 1,500-high, mass dat 28° S., long 254.5°; overlies material of corona unit 1, may contain arcuate/ trough-mas es of radar-bright, ridged terrain (see tgr)?

Unit **l_1**—Material forming a 360-km-diameter, concentric, double ring depression of 1.5-km between arcuit flat 29° S., long 250°; overlies corona units e and k

Unit **k_1**—Interbedded material, forming a 450-km-diameter, asymmetric, partial double ring, mostly, 1 km-high mesa flat 36° S., long 244° and about a 200-km-diameter, concentric, radial, fractured, 500-m-high mound flat 8° S., long 263°; Overlies corona unit e, may contain, embayed patches of radar-bright, ridged terrain (unit tgr)?

Unit **j_1**—Material forming a 70-km-diameter, concentric ring depression of 500 m flat 4.5° S., long 259°; overlies material of corona unit c and patera unit 4

Unit **i_1**—Material forming a 70-km-diameter, concentric, 500-m-high ring flat 3 °S., long 260°; overlies corona unit d

Unit **h_1**—Material forming a 100-km-diameter, concentric, partial, double ring depression or 2 km flat 2.5° S., long 250°; overlies corona unit g and patera unit 3

Unit **g_1**—Material forming a 200 km-diameter, concentric, 500 m-high ova flat 1° S., long 254.5°; overlies corona unit f

Unit **f_1**—Material forming a 160-km-diameter, asymmetric, partial double ring, mostly, 1-km-high mesa, Corona Cat flat 5° S., long 253.1°; Overlies material of corona unit e

Unit **e_1**—Material forming a 525-km-diameter, asymmetric, single ring, radially fractured 3- to 8-km-high mesa flat 12.5 °S., long 259°; overlies flow unit 2

Unit **d_1**—Material forming a 140-km-diameter, asymmetric, slightly elevated double ringed mound flat 4 °S., long 261.5°; overlies corona unit e

Unit **c_1**—Material forming a 450-kmdiameter, concentric, single ring, 1-km-high mound flat 6° S., long 261.5°; Unlerlies material of corona unit d and overlies older plains materials

Unit **b_1**—Forms material of partially buried single ring of an apparent 70-km-diameter, concentric, shallow depression; flat 8.5° S., long 259°; Underlies radar-dark plains material and cut by, south-trending fractures

Unit **a_1**—Forms material of ridges, lobate, annular ring of an approximate 70-km-diameter, concentric, 500-m depression flat 9.6° S., long 256°; Southeast of, buried none than, and having a depression deeper than corona unit b. Underlies radar-dark plains material

Corona material, undivided—Outcrops as lobate flows of curved radar reflectance about several concave, those se crossly off map area. Overlies plains material; may contain embayed patches of radar-bright, ridged terrain (unit tgr)?

Plains materials—Intermountain plains differing only in relative radar reflectance and stratigraphic age. Average surface properties quantified in table 1. Interpretation: Lava flood deposits

pl **Radar-light plains material**—Forms plains in northern part of map area having a relatively light or radar bright appearance. Underlies flow unit 2 superposed by corona units l o

pd **Radar-dark plains material**—Forms plains of relatively radar dark appearance. Embays tessera units pf and h. Pioneer Regio tessera material and tessera-embaying plains material

pf **Tessera-embaying plains material**—Forms plains that embay tessera material. Is superposed by radar-dark plains material and flow units 3 and 2

HIGHLAND TERRAIN MATERIAL

h **Tessera material of Pioneer Regio**—Occurs as [illegible] of Pioneer Regio and contains 10s narrow hills separated from the region by gentler, folded. Material forms closely spaced, relatively radar bright ridges and lineations having variable widths and lengths averaging 1 to 10 km apart. Occurs with tectonic, perpendicular ridge set having spacing of 1 to 30 km. Overlain by other tectonic types in map area. Interpretation: Oldest unit in map area, consists of complex ridged terrain material. Brisbin[illegible] and Head, 1991); some related hills may have been lifted from Pioneer Regio

Contact—Dashed where approximately located; queried where uncertain

Lobate front—Tick-point downslope; dashed where approximately located. Interpreted as a lava or impact-melt flow front

Narrow channel—Arrows point in direction of flow. Interpreted as lava channel

Linear scarp—Line marks top of scarp; barbs point downslope

Graben—Many are schematic and representative of numerous unmapped features

Lineament—Radar-bright linear feature of indeterminate morphology. Interpreted as a fracture

Ridge—Fairly wide (>5 km), symmetric highs, extending several tens to hundreds of kilometers. Many are schematic and representative of numerous unmapped features

Wrinkle ridge—Narrow, sinuous highs having asymmetric profiles

Corona annulus ridge—Sinusoidal concentric, asymmetric ridge following trend of arcuate ridge; shows steel trace and plunge. Short arrow indicates steeper limb or scarp bounding corona trough

Corona trough—Barbs point to trough axis

Large cone—More than 25 km diameter. Interpreted as volcanic crater

Small depression—Depth <2 km; some interpreted as calderas

Large depression—Depth greater than or equal to 2 km. Most form part of Parga Chasma

Splotch—Circular, radar-bright halo on surface. Interpreted as result of subsurface surface changes due to atmospheric shock waves from a impacting body

Small shield—Conical hill, diameter 5 km to 9 km. Interpreted as small volcano and/or, sun or circle volcanos size and shape of cone

Impact crater—Shows rim, lobate deposit denotes impact melt outflow

Vents

The Magellan Mission

The Magellan spacecraft orbited Venus from August 10, 1990, until it plunged into the tenuous atmosphere on October 12, 1994. Magellan had the objectives of (1) improving knowledge of the geology, processes, surface properties, and geologic history of Venus by analysis of surface radar characteristics, topography, and morphology and (2) improving knowledge of the gravitational Venus by, analysis of tracking[illegible].

The Magellan spacecraft carried a 12-foot radar system to map the surface of Venus. The transmitter and receiver systems were used to collect three domestic synthetic aperture radar (SAR) images of the surface, passive microwave thermal emission observations, and [illegible] data. Radar emitted a [illegible] and subsequently received the returned surface wave done in [illegible] modes 1, 2, and 3. From September 1990 until September 1992, Nearly, eight percent of the surface was mapped with radar resolution of approximately 120 meters. The SAR observations were presented in a Tyro nominal horizontal resolution; these full-resolution data overshoot the image base used to geologic mapping. The primary polarization mode was horizontal/vertical. Incidental receive 0.81, but additional data for selected areas were collected for the vertical polarization sense. Incidence angles varied from about 20° to 45°.

High-resolution Doppler tracking of the spacecraft was done from September 1992 through October 1994 nineteen cycles 4, 5, 6). High-resolution gravity observations from about 900 orbits were obtained between September 1992 and May 1993. While Magellan was in an elliptical orbit with a periapses near 115 kilometers and an apoapsis near 8,000 kilometers. Observations from an additional 1,200 orbits were obtained following orbit circularization in mid-1992. These data exist as a 75° by 75° harmonic field.

Magellan Radar Data

Radar backscatter power is determined by the morphology of the surface at a broad range of scales and by the intrinsic reflectivity, or dielectric constant, of the material. Topography at scales of several meters and larger can produce quasi-specular echoes with the strength of the return greatest when the local surface is perpendicular to the incident beam. This type of scattering is most important at very small angles of incidence, because natural surfaces generally have too large tilted facets at high angles. The exception is in areas of steep slopes, such as ridges or rift zones, where favorably tilted terrain can produce very bright returns in the radar image. For most other areas, diffuse echoes from roughness at scales comparable to the radar wavelength are responsible for variations in the SAR return. In either case, the echo strength is also modulated by the reflectivity of the surface material. The density of the upper few wavelengths of the surface can have a significant effect. Low-density layers, such as crater ejecta or volcanic ash, can absorb the incident energy and produce a lower observed echo. On Venus, a rapid increase in reflectivity exists at a surface critical elevation, above which high-dielectric minerals or coatings are thermodynamically stable. This effect leads to very bright SAR echoes from virtually all areas above that critical elevation.

The measurements of passive thermal emission from Venus, though of much lower spatial resolution than the SAR data, are more sensitive to changes in the dielectric constant of the surface than to roughness. As such, they can be used to augment studies of the surface and to deconvolute backscatter roughness and reflectivity effects. Observations of the same radar backscatter power, collected using a separate smaller antenna on the spacecraft, were reviewed using the Hughes expression for echoes from gently undulating surfaces to yield estimates of planetary radius, Fresnel reflectivity, and root-mean-square (rms) slope. The topography data produced by this technique have horizontal footprint sizes of about 20 km, near-tangential and a vertical resolution of approximately 100 m. The Fresnel reflectivity data provide a comparison to the emissivity maps, and the rms slope parameter is an indicator of the surface tilts, which contribute to the quasi-specular scattering component.

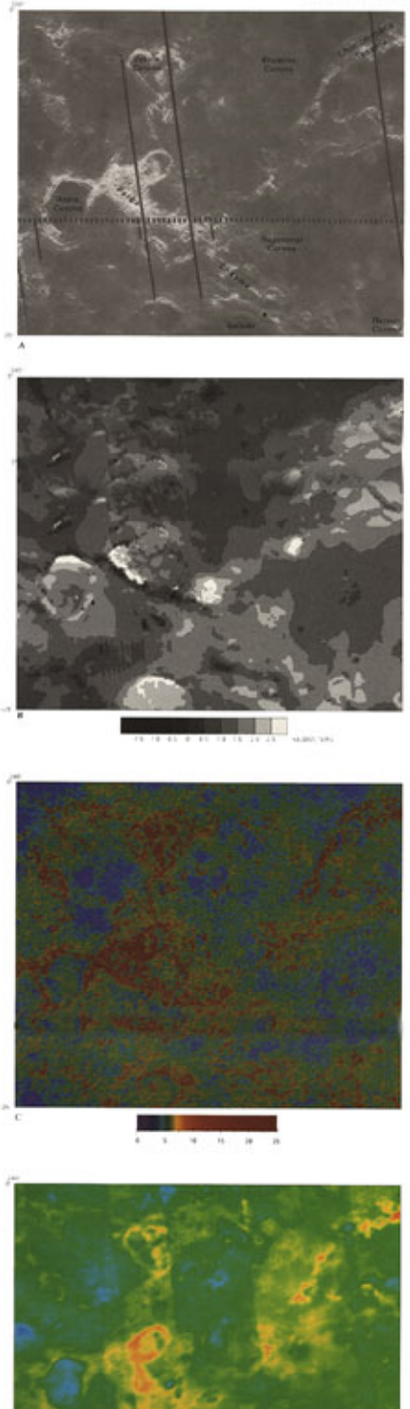


Figure 1. Magellan datasets for the Galindo quadrangle; north is toward top; quadrangle is approximately 2,300 km wide. **A**, Synthetic aperture radar backscatter images generated from all-looking images used to compare with **B**-**E**. corona geographic names. **B**, Altimetry shows depth of Parga Chasma and heights at Pioneer Regio and volcanic features. **C**, Root-mean-square is not slope shows highly fractured terranes having rms slopes 2.10 degrees. **D**, Emissivity shows rough areas and low dielectric content materials to have higher-brighter values. **E**, Reflectivity shows efficiency of surface materials in reflecting electron radiation. Most plains units having a reflectivity, of about 0.1 shown as blue.

GEOLOGIC/GEOMORPHIC MAP OF THE GALINDO QUADRANGLE (V–40), VENUS

By
Mary G. Chapman

1999

[illegible]
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