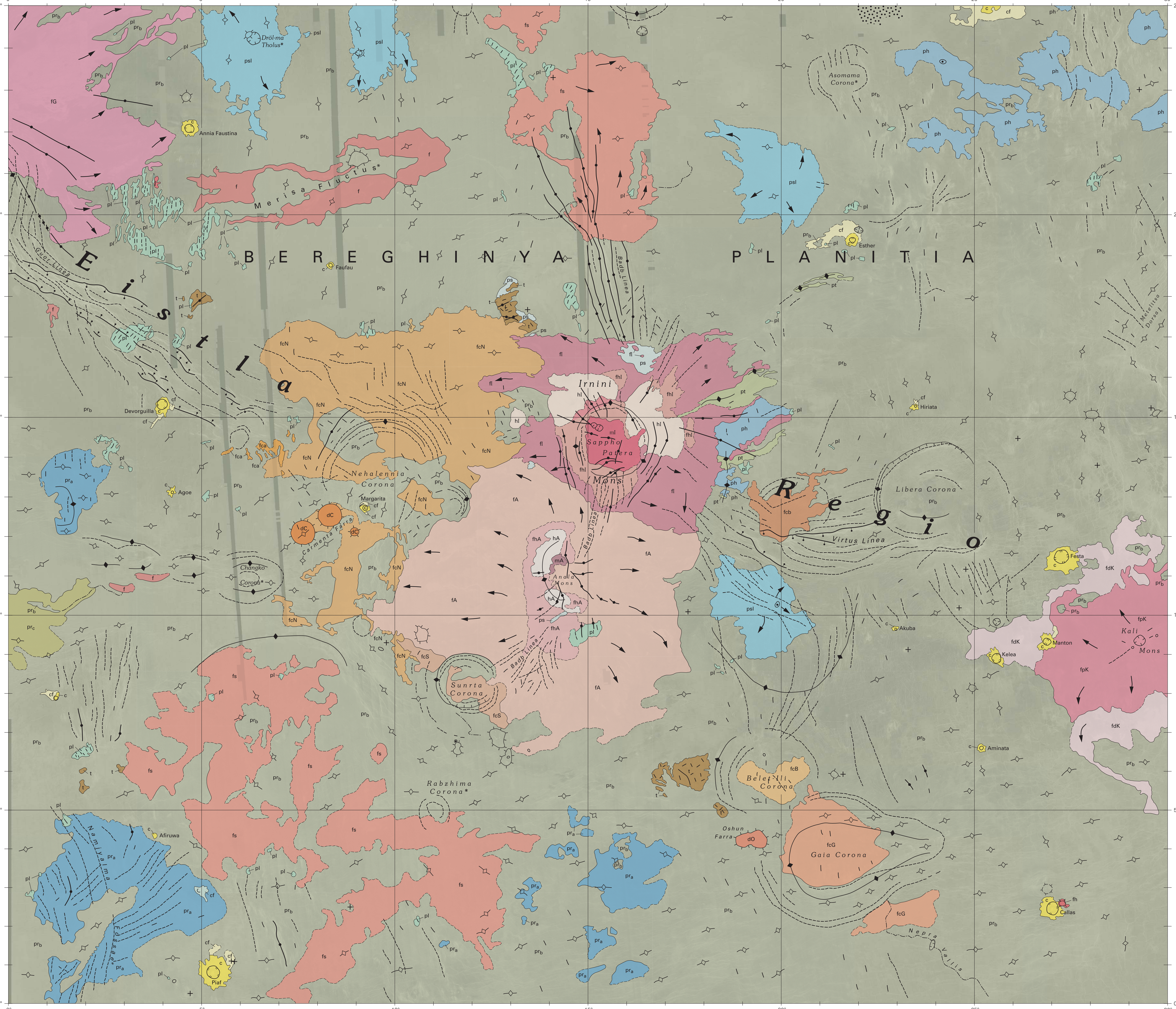
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

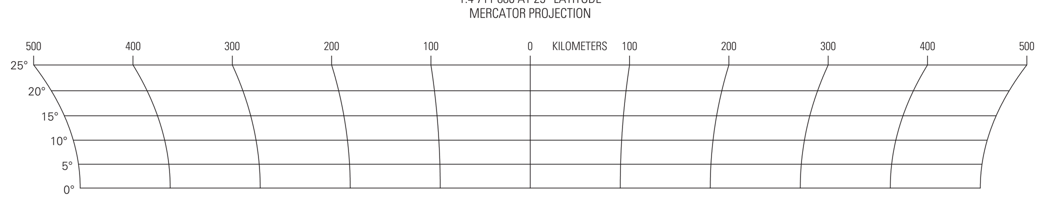
Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEOLOGIC INVESTIGATIONS SERIES I–2637
ATLAS OF VENUS: SAPPHO PATERA QUADRANGLE (V–20)
Pamphlet accompanies map



* Asterisk indicates provisional names which have not been approved by the International Astronomical Union.

SCALE 1:5 198 991 (1 mm = 5.199 km) AT 0° LATITUDE
1:4 711 886 AT 25° LATITUDE
MERCATOR PROJECTION



Prepared on behalf of the Planetary Geology Program, Solar System Exploration Division, Office of Space Science, National Aeronautics and Space Administration
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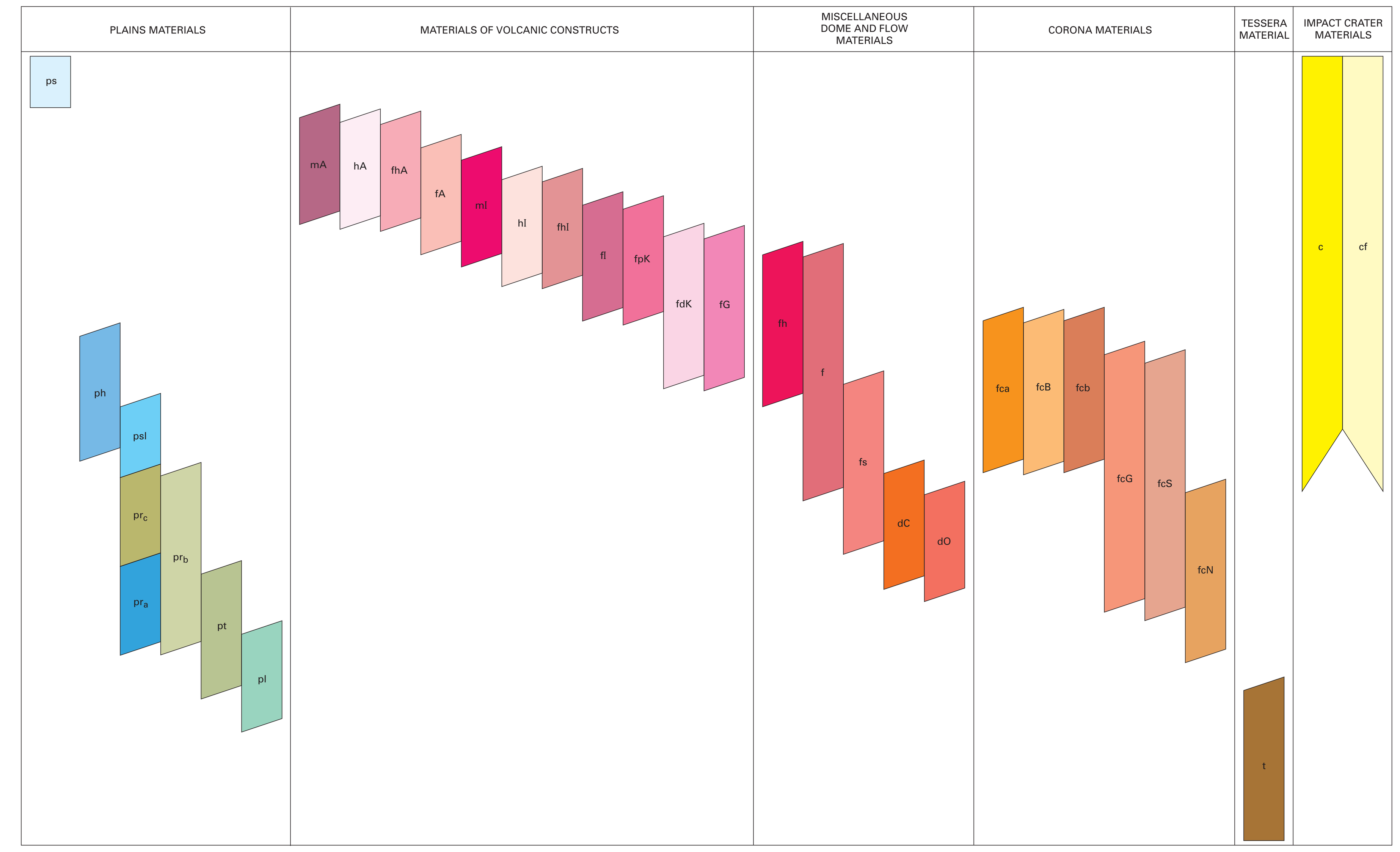
INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—2000

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

PLAINS MATERIALS

ps — **Smooth plains material**—Very dark on SAR images; radar backscatter coefficient lower than other plains materials; texture generally homogeneous; superposed on all other units and most structural features; no wrinkle ridges. *Interpretation*: Relatively young lavas or pyroclastics with very smooth surfaces at centimeter scale

ph — **Homogeneous plains material**—Moderately bright on SAR images; emissivity higher than for other plains materials; homogeneous texture; wrinkle ridges sparse to moderately abundant; contacts commonly diffuse and wispy; locally surrounds small shields on regional plains. *Interpretation*: Aeolian(?) deposit superposed on regional plains; wispy contacts due to local modification by wind

psl — **Low-relief shield plains material**—Moderately bright on SAR images; characterized by subdued digitate flow shapes, commonly with an apparent source caldera; one or more sets of wrinkle ridges generally present. *Interpretation*: Low-viscosity lava flows forming barely perceptible rises on the plains

pr_c — **Regional plains material, member c**—Bright on SAR images; texture homogeneous; wrinkle ridges abundant; age relative to adjacent member b ambiguous; occurs in only one locality. *Interpretation*: Lava flows

pr_b — **Regional plains material, member b**—Moderately bright to moderately dark on SAR images, with brightness variations commonly on a scale of scores to hundreds of kilometers; texture generally homogeneous, but locally characterized by intricate fabric of sinuous to straight lines down to limit of resolution; small volcanic edifices locally very abundant; wrinkle ridges generally abundant, and present as two or more sets with different orientations; apparently older than all impact craters; most widespread unit in the quadrangle. *Interpretation*: Lava flows

pr_a — **Regional plains material, member a**—Moderately bright on SAR images; similar to regional plains material member b, but with greater density of lineaments. *Interpretation*: Lava flows

pt — **Textured plains material**—Moderately bright on SAR images; texture characterized by irregular radar-bright lines and spots at kilometer scale; commonly deformed by long, narrow, gently curved ridges; occurs locally on and adjacent to northeast flank of Irnini Mons. *Interpretation*: Deformed plains volcanic rocks older than adjacent regional plains material

pl — **Lineated plains material**—Bright to very bright on SAR images; radar backscatter coefficient higher than for other plains materials; texture homogeneous to mottled at sub-kilometer scale; generally highly deformed by closely spaced fractures or ridges with a single dominant trend; materials and related structures generally embayed and sharply truncated at contacts with surrounding plains; occurs as isolated, generally small inliers in younger plains throughout area. *Interpretation*: Relatively old, deformed plains volcanic rocks

MATERIALS OF VOLCANIC CONSTRUCTS

mA — **Anala Mons mottled material**—Moderately bright to moderately dark on SAR images; texture mottled at kilometer to several kilometer scale; small (1–5 kilometer) shields and domes very abundant; in summit region of Anala construct; cut by grabens of ~north-trending set; no wrinkle ridges. *Interpretation*: Lava flows, shields, and domes, probably basaltic

hA — **Anala Mons halo material**—Very bright on SAR images; radar backscatter coefficient relatively high; texture homogeneous to faintly granular at kilometer to sub-kilometer scale; no flow features visible; occurs peripheral to summit of Anala edifice; cut by grabens of ~north-trending set and by set radial to Anala center; no wrinkle ridges. *Interpretation*: Pyroclastic deposit sufficiently coarse grained to be rough at centimeter scale

fhA — **Haloed Anala Mons flow material**—Similar to Anala Mons flow material (unit fA), but individual flows appear partially obscured by a bright, diffuse halo; texture faintly granular at kilometer to sub-kilometer scale; transitional between Anala Mons flow material and Anala Mons halo material; cut by grabens and bright lineaments; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic, overlain by thin pyroclastic veneer

fA — **Anala Mons flow material**—Dark to bright on SAR images; complex of overlapping digitate and lobate flow forms radial to center of Anala edifice; texture granular to mottled at kilometer to sub-kilometer scale; superposed on Irnini flow material, on structures associated with Nehalennia and Sunrta Coronae, and on all adjacent plains materials; locally cut by grabens and bright lineaments; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic

mI — **Irnini Mons mottled material**—Moderately bright to moderately dark on SAR images; texture mottled at kilometer to several kilometer scale; small (1–5 kilometer) shields and domes very abundant; within Sappho Patera on the summit of Irnini edifice; cut by grabens of ~north-trending set and by set radial to Irnini center; no wrinkle ridges. *Interpretation*: Lava flows, shields, and domes, probably basaltic

hI — **Irnini Mons halo material**—Very bright on SAR images; radar backscatter coefficient relatively high; texture homogeneous to faintly granular at kilometer to sub-kilometer scale; no flow features visible; occurs peripheral to summit of Irnini edifice; cut by grabens of ~north-trending set and by set radial to Irnini center; no wrinkle ridges. *Interpretation*: Pyroclastic deposit sufficiently coarse to be rough at centimeter scale

fhI — **Haloed Irnini Mons flow material**—Similar to Irnini Mons flow material (unit fI), but individual flows appear partially obscured by a bright, diffuse halo; texture faintly granular at kilometer to sub-kilometer scale; transitional between Irnini Mons flow material and Irnini Mons halo material; cut by grabens and bright lineaments; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic, overlain by thin pyroclastic veneer

fI — **Irnini Mons flow material**—Dark to bright on SAR images; complex of overlapping digitate and lobate flow forms radial to center of Irnini edifice; texture granular to mottled at kilometer to sub-kilometer scale; superposed on all adjacent plains materials except smooth plains material (unit ps); locally cut by grabens and bright lineaments; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic

fpK — **Kali Mons proximal flow material**—Bright to moderately dark on SAR images; digitate and lobate flow forms radial to center of Kali edifice at 9.3° N., 29.3° E.; texture granular at sub-kilometer scale; cut by grabens with east-northeast trend passing through center of construct; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic

fdK — **Kali Mons distal flow material**—Bright to dark on SAR images; texture homogeneous to granular at sub-kilometer scale; local digitate forms; distal contact obscure in places; superposed on regional plains and variegated plains; wrinkle ridges sparse to absent. *Interpretation*: Lava flows, probably basaltic

fG — **Gula Mons flow material**—Bright to dark on SAR images; complex of overlapping digitate and lobate flow forms radial to Gula Mons (west of Sappho Patera quadrangle); texture mottled to granular at kilometer to sub-kilometer scale; superposed on regional plains; both cut by and superposed on faults of Guor Linea; no wrinkle ridges. *Interpretation*: Lava flows, probably basaltic

MISCELLANEOUS DOME AND FLOW MATERIALS

fh — **Hummocky flow material**—Very bright on SAR images; small, lobate flows emanating from a dome in southeastern part of quadrangle; surface very hummocky at a scale of hundreds of meters. *Interpretation*: Lava flows, probably more silicic than other mapped flow units; or mass-wasting deposit due to partial collapse of adjacent small dome

f — **Flow material, undifferentiated**—Dark to bright on SAR images; digitate flows not associated with an apparent source; superposed on regional plains; includes 700 x 170 kilometer hairpin-shaped flow complex centered at 21° N., 8.5° E. which has bright (rough) edges around a dark (smooth) interior. *Interpretation*: Lava flows, probably basaltic

fs — **Shield field flow material**—Bright to dark on SAR images; digitate flow patterns; derived from clusters of small shields (shield fields). *Interpretation*: Lava flows, probably basaltic

dC — **Carmenta Farra dome material**—Moderately bright on SAR images; texture homogeneous; abundant small bright linear features; sparse wrinkle ridges; occurs as three round steep-sided domes adjacent to Nehalennia Corona. *Interpretation*: Lava constructional forms

dO — **Oshun Farra dome material**—Moderately bright on SAR images; texture homogeneous; very abundant small bright linear features; occurs as four overlapping steep-sided domes adjacent to Gaia Corona. *Interpretation*: Lava constructional forms

CORONA MATERIALS

fca — **Flow material of corona a**—Bright on SAR images; homogeneous texture; occurs as small digitate flows peripheral to corona; no wrinkle ridges. *Interpretation*: Lava flows derived from small corona a

fcB — **Flow material of Belet-Ili Corona**—Moderately bright on SAR images; homogeneous texture; subdued lobate flow forms; abundant small volcanic edifices; no wrinkle ridges; confined to interior of corona. *Interpretation*: Lava flows derived from Belet-Ili Corona

fcb — **Flow material of corona b**—Moderately dark to moderately bright on SAR images; lobate and digitate flow patterns; abundant small volcanic edifices; wrinkle ridges sparse; both interior and peripheral to corona. *Interpretation*: Lava flows from corona b

fcG — **Flow material of Gaia Corona**—Moderately dark to moderately bright on SAR images; homogeneous texture; subdued flow forms; abundant small volcanic edifices; wrinkle ridges sparse; confined to interior and part of north rim of corona. *Interpretation*: Lava flows from Gaia Corona

fcS — **Flow material of Sunrta Corona**—Moderately dark to moderately bright on SAR images; texture variable; lobate and digitate flow forms; wrinkle ridges abundant; interior and exterior to corona. *Interpretation*: Lava flows from Sunrta Corona

fcN — **Flow material of Nehalennia Corona**—Moderately bright to bright on SAR images; texture variable; subdued to sharp lobate and digitate flow patterns; wrinkle ridges very abundant; in interior and widespread around corona. *Interpretation*: Lava flows from Nehalennia Corona

TESSERA MATERIAL

t — **Tessera material**—Bright on SAR images; radar backscatter coefficient relatively high; highly deformed by fractures, grabens, and ridges with at least two dominant trends at high angles to each other; structural features dominate texture down to resolution scale; unit and related structures embayed and sharply truncated at all contacts with surrounding materials; occurs as isolated inliers within younger materials throughout the area. *Interpretation*: Relatively old, highly deformed terrain of unknown origin

IMPACT CRATER MATERIALS

c — **Crater material, undifferentiated**—Very bright to dark (some floor materials) on SAR images; includes floor, central peak, wall, rim, and ejecta materials; texture hummocky to granular. *Interpretation*: Deposits and structures created by hypervelocity meteorite impact; radar dark floor material ponded impact melt

cf — **Crater flow material**—Bright on SAR images; texture granular at kilometer to sub-kilometer scale; occurs as flowlike deposits associated with some impact craters. *Interpretation*: Impact melt or fluidized ejecta created by hypervelocity meteorite impact

Contact—Dashed where gradational or approximate

Graben

Major rift fault—Bar and ball on downthrown side

Radar-bright lineament

Fabric of short radar-bright lineaments—Schematic

Ridge

Wrinkle ridge—Schematic

Lava flow direction

Channel

Dome or shield
- 10<D<20 km
- D>20 km

Endogenic crater—Interpreted as caldera
- 5<D<10 km
- 10<D<20 km
- D>20 km

Airburst spot

Crater rim—Showing crest
- D<20 km
- D>20 km

The Magellan Mission

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

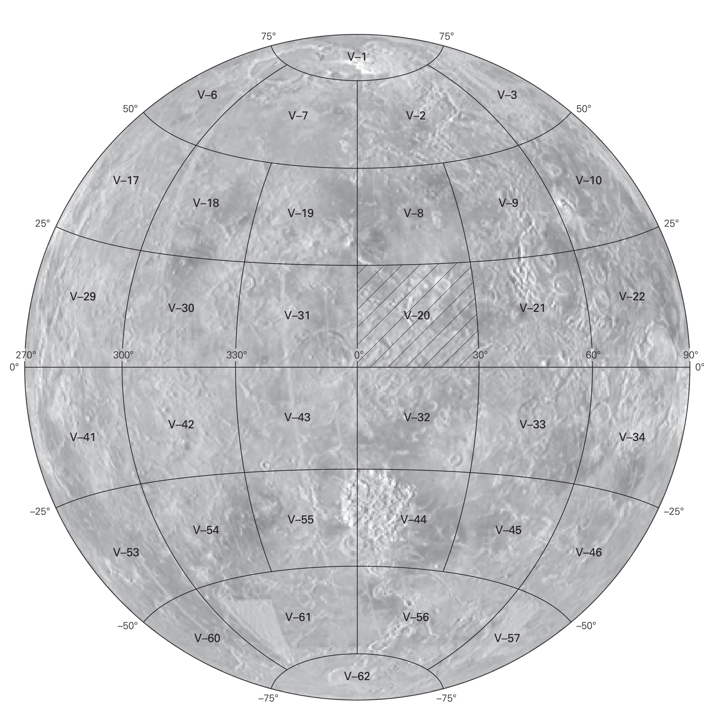
The Magellan spacecraft carried a 12.6-cm radar system to map the surface of Venus. The transmitter and receiver systems were used to collect three datasets: synthetic aperture radar (SAR) images of the surface, passive microwave thermal emission observations, and measurements of the backscattered power at small angles of incidence, which were processed to yield altimetric data. Radar imaging and altimetric and radiometric mapping of the venusian surface were done in mission cycles 1, 2, and 3, from September 1990 until September 1992. Ninety-eight percent of the surface was mapped with radar resolution of approximately 120 meters. The SAR observations were projected to a 75-m nominal horizontal resolution; these full-resolution data compose the image base used in geologic mapping. The primary polarization mode was horizontal-transmit, horizontal-receive (HH), 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 (mission cycles 4, 5, 6). High-resolution gravity observations from about 950 orbits were obtained between September 1992 and May 1993, while Magellan was in an elliptical orbit with a periapsis near 175 kilometers and an apoapsis near 8,000 kilometers. Observations from an additional 1,500 orbits were obtained following orbit-circularization in mid-1993. 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 few 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 signatures 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 certain 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 discriminate between roughness and reflectivity effects. Observations of the near-nadir backscatter power, collected using a separate smaller antenna on the spacecraft, were modeled using the Hagfors 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 10 km near periapsis 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.



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

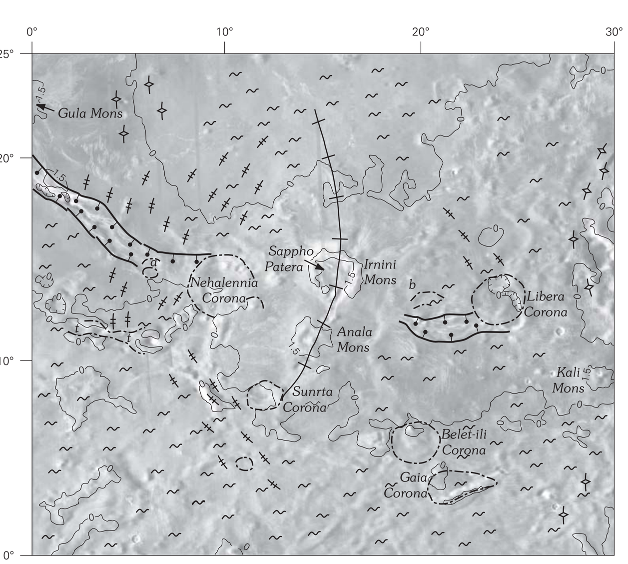


Figure 2. Tectonic elements of V–20, plotted on a SAR background.

- **Guor and Virtus Lineae rifts**
- **Badb Linea**
- **Coronae and corona-like structures**:
  - a = unnamed corona a
  - b = unnamed corona b
  - t = chain of corona-like rimmed pits
- **Wrinkle ridges** of dominant, and oldest, set; schematic
- **Wrinkle ridges** concentric to Irnini and Anala Montes; schematic
- **Wrinkle ridges** of other sets; schematic
- **Contour lines**, 0 and 1.5 km (0 = 6050 km radius)
- **Major volcanic features**: Irnini Mons, Gula Mons, Kali Mons, Sappho Patera, Anala Mons

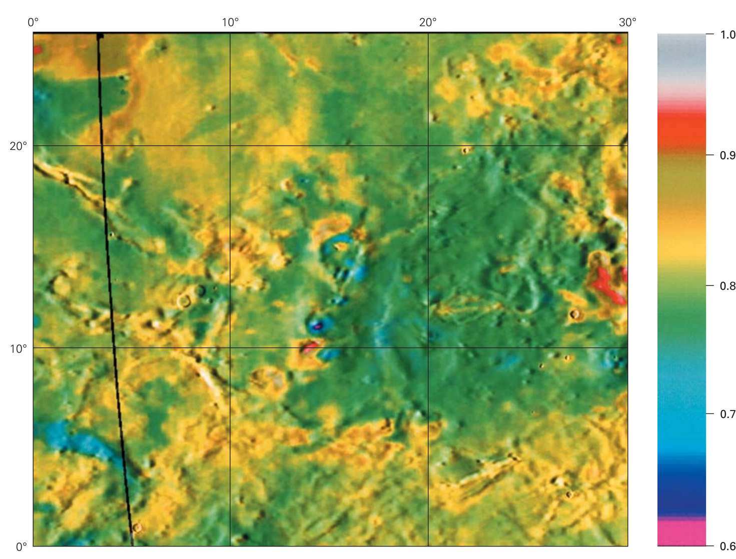


Figure 3. Emissivity map of V–20. High emissivity arc in northwest corner is associated with crater Annia Faustina; low emissivity arc in southwest corner is associated with an unnamed crater; large, irregular area of moderately low emissivity in east-central part of map is associated with the crater cluster that includes Festa, Kelea, and Manton.

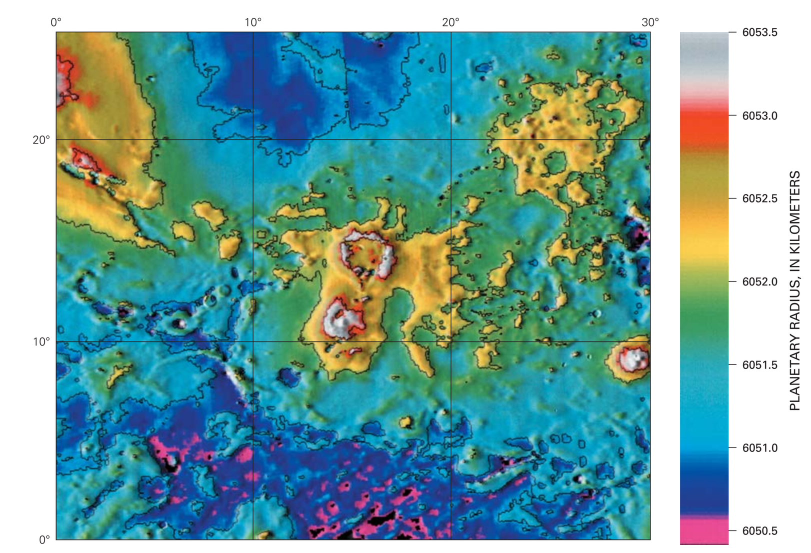


Figure 4. Topographic map of V–20.

GEOLOGIC MAP OF THE SAPPHO PATERA QUADRANGLE (V–20), VENUS

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