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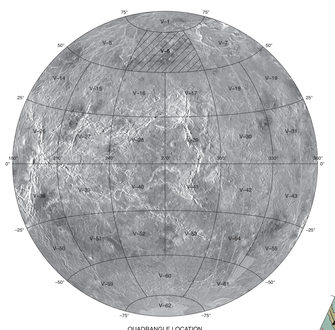
National Aeronautics and Space Administration

Scientific Investigations Map 3158
Atlas of Venus: Metis Mons Quadrangle (V–6)
Pamphlet accompanies map



QUADRANGLE LOCATION
Photomosaic showing location of map area. An outline of 1:5,000,000-scale quadrangles is provided for reference.

Descriptions of nomenclature used on map are listed at http://planetarynames.wr.usgs.gov/

SCALE 1:4 711 886 (1 mm = 4.712 km) AT 25° LATITUDE
1:5 000 000 AT 34° and 73° LATITUDES
LAMBERT PROJECTION

500 400 300 200 100 0 100 200 300 400 500 KILOMETERS
75 70 65 60 55 50

Prepared on behalf of the Planetary Geology and Geophysics Program, Solar System Exploration Division, Office of Space Science, National Aeronautics and Space Administration
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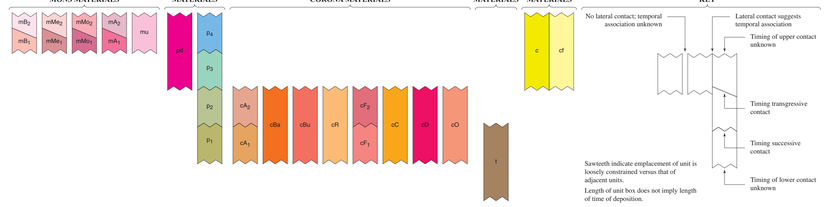
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

The units are grouped according to types and arranged from youngest to oldest in each grouping. Age relations are described in the text, portrayed in the correlation chart of map units, and documented in full detail in table 5. Structural associations are included in the following descriptions where they are integrally related to the definition and interpreted formation of the unit. Unit symbols are applied to denote unit group, physiographic name (where relevant), and stratigraphic order, as follows: (1) the unit group is shown by a lower-case letter (**m**, mons materials); (2) the physiographic feature that is discretely related to the unit is shown by an upper-case letter (**B**, Bagbartu Mons); (3) successive lower-case letters are used to differentiate between features that begin with the same letter (**Ba**, Bachue Corona, versus **Bu**, Bau Corona); and (4) subscript numbers denote sequential subdivisions based on crosscutting relations (see table 5 for details). Thus, the geologic symbol **mMo$_2$** denotes the younger Metis Mons material unit and the geologic symbol **cD** denotes the Demeter Corona material unit.

MONS MATERIALS

Materials predominantly defined by overlapping lobate margins and digitate terminations and generally confined to discrete physiographic features

mB$_2$ **Younger Bagbartu Mons material**—Low-backscatter plains-like material within summit caldera of Bagbartu Mons. Contains multiple small volcanic edifices and several north-south-trending lineaments of moderate to high backscatter. Laterally grades into older Bagbartu Mons material (unit **mB$_1$**). *Interpretation*: Smooth lava flows sourced from local small volcanic edifices and fractures and emplaced during and after evacuation of underlying magma chamber. Lateral gradations suggest time-progressive relations with adjacent, older Bagbartu Mons material. May represent youngest phase of magmatic activity at Bagbartu Mons

mMo$_2$ **Younger Metis Mons material**—High- to moderate-backscatter material with dense, complexly overlapping lobes oriented radial to the Metis Mons summit. Axis defined by northwest-southeast-trending lineaments of Ilbis Fossae, with superposed clusters of small volcanic edifices. Long lobes embay Ben Dorsa to the east and Coatlicue Corona to the north. *Interpretation*: Rough to smooth lava flows sourced from Ilbis Fossae and superposed small volcanic edifices. May represent a late-stage phase of edifice-building volcanic activity at Metis Mons

mMo$_1$ **Younger Mokosha Mons material**—Low-backscatter, plains-like material at topographic summit of Mokosha Mons. Contains multiple small volcanic edifices and few north-south-trending lineaments of moderate to high backscatter. Laterally grades with older Mokosha Mons material (unit **mA$_1$**). *Interpretation*: Smooth lava flows sourced from local small volcanic edifices and fractures associated with surrounding high-standing fractured annulus (units **p$_1$** and **p$_2$**) and emplaced during and after evacuation of underlying magma chamber. Lateral gradations suggest time-transgressive relation with the adjacent, older Mokosha Mons material. May represent youngest phase of magmatic activity at Mokosha Mons

mA$_2$ **Younger Atira Mons material**—Low-backscatter, plains-like material located within the summit caldera of Atira Mons. Contains multiple small volcanic edifices and few moderate-backscatter wrinkle ridges oriental circumferential to summit caldera. Laterally grades with older Atira Mons material (unit **mA$_1$**). *Interpretation*: Smooth lava flows sourced from local small volcanic edifices during and after evacuation of an underlying magma chamber. May represent youngest phase of magmatic activity at Atira Mons

mu **Mons material, undivided**—High- and low-backscatter material formed primarily by overlapping lobes with digitate margins and terminations. Not strictly associated with major mons-forming edifices. Often occurs as localized patches with ambiguous stratigraphic relations with plains units. Contains small volcanic vents and lineaments. Largest outcrop forms unnamed mons-like edifice located south of Bagbartu Mons and east of Coatlicue Corona (at 61.7° N., long 280.3° E.). *Interpretation*: Rough to smooth lava flows sourced from local small volcanic edifices and fractures. May represent long lobes from major mons-forming edifices that were disconnected by burial from plains unit 4 (unit **p$_4$**)

mB$_1$ **Older Bagbartu Mons material**—High- to low-backscatter material with dense, complexly overlapping lobes oriented radial to the Bagbartu Mons summit. Long lobes extend to the east and west. Proximal to the summit, unit contains multiple north-south-trending lineaments of moderate to high backscatter and few small volcanic edifices. Distal to summit, unit contains multiple wrinkle ridges oriented in a reticulate pattern. *Interpretation*: Rough to smooth lava flows sourced from summit caldera, local fractures, and small volcanic edifices. Represents primary edifice-building phase(s) of volcanic activity at Bagbartu Mons. North-south-trending lineaments may be reactivated fractures associated with currently buried ridge and fracture belt that connected Feronia and Coatlicue Coronae

mMo$_1$ **Older Metis Mons material**—Moderate backscatter material that forms irregularly shaped and isolated outcrops near the summit of Metis Mons. Contains northwest-southeast-trending lineaments of Ilbis Fossae, as well as kilometer-scale hummocks and few small volcanic edifices. Bright to moderately dark radar backscatter; texture mottled to speckled. *Interpretation*: Kipukas of deformed lava flows likely sourced from Ilbis Fossae that formed during early phases of edifice-building volcanic activity at Metis Mons

mMo$_1$ **Older Mokosha Mons material**—High- to low-backscatter material with complexly overlapping lobes oriented radial and circumferential to the summit of Mokosha Mons. Long lobes extend to the northwest toward Okipeta Dorsa. Contains clusters of small volcanic edifices and north-south-trending lineaments. *Interpretation*: Rough to smooth lava flows sourced from small volcanic edifices and fractures. Lobe orientations implicate eruption from both high-standing fractured plains materials near the summit of Mokosha Mons and from a cluster of small volcanic edifices located to the northwest (lat 58.6° N., long 250.0° E.). Represents primary edifice-building phase(s) of volcanic activity at Mokosha Mons

mA$_1$ **Older Atira Mons material**—High- and low-backscatter material with dense, complexly overlapping lobes oriented radial to the summit depression of Atira Mons. Contains some wrinkle ridges oriented parallel to those that occur on surrounding plains. *Interpretation*: Rough to smooth lava flows sourced from the summit caldera. Represents primary edifice-building phase(s) of volcanic activity at Atira Mons

PLAINS MATERIALS

Widespread patches of variable backscatter materials in low-lying plains between major topographic features (for example, mons and coronae); lobate flows rare and (or) indistinct

pd **Plains dome material**—High- to moderate-backscatter features composed of isolated circular to subcircular domes with gently sloping, steep-sided, and scalloped margins. Occurs in moderate- to low-backscatter plains and younger mons units. Contains no discernible tectonic structure. Includes Nertus Tholus. *Interpretation*: Constructs possibly formed through a range of primary and (or) secondary volcanic processes, such as localized effusive volcanism and (or) caldera collapse

p$_4$ **Plains unit 4**—Moderate- to low-backscatter materials that form parts of low-lying plains between major topographic features, including Guinevere Planitia, as well as regions surrounding Varma-Ava and Ben Dorsa and Bugharitu Mons. Also occurs in a high-standing plain that forms the center of Bau Corona. High-backscatter surfaces occur locally, mostly in proximity to older plains units. Outcrops range from tens of kilometers to >1,000 km in diameter. Contains sparse to dense collections of wrinkle ridges and lineaments (oriented in intersecting, reticulate, and anastomosing patterns), a few isolated and clustered small volcanic edifices, and subdued topographic warps. Includes parts of Utrenitsa Vallis and isolated, high-backscatter outcrop of hummocky material adjacent to plains dome material (unit **pd**). Locally forms floors of impact craters. *Interpretation*: Moderately deformed lava plains of recent relative age. Chiefly composed of complexly overlapping flows with low to moderate surface roughness and sourced from multiple features throughout the quadrangle, including mons, coronae, ridge and fracture belts, and small volcanic edifices. Likely includes surficial materials including volcaniclastic and impact-related materials, microdunes, and landslide deposits. Structures likely represent late-stage or waning extensional and contractional deformation, perhaps related to regional and (or) global stresses. Outcrops on crater floors clearly postdate crater formation and may be lava plains emplaced by eruption along impact-related fractures.

p$_3$ **Plains unit 3**—High- to low-backscatter materials that form the areal bulk of low-lying plains between major topographic features, including Kawelu, Guinevere, and Libuse Planitiae, as well as regions surrounding Atropos, Virilis, and Senecus Tesserae and Okipeta Dorsa. Outcrops range from tens of kilometers to >1,000 km in diameter. Occurs as small outcrops in older, heavily deformed plains units around most coronae. Contains dense collections of wrinkle ridges and lineaments (oriented in intersecting, reticulate, and anastomosing patterns, commonly around major topographic features), multiple clusters of small volcanic edifices, and topographic warps. Forms the ellipsoidal annulus of Demeter Corona. Includes parts of Utrenitsa Vallis. Locally appears to grade with older plains units. *Interpretation*: Moderately to highly deformed lava plains of intermediate relative age. Chiefly composed of complexly overlapping flows with highly variable surface roughness and sourced from multiple locations throughout the quadrangle, including mons, coronae, ridge and fracture belts, and small volcanic edifices; broad textural and morphologic homogeneity limits confident association with particular source of eruption or center of tectonic deformation. Structures likely represent intermediate-stage extensional and contractional deformation, which partly contributed to the growth of ridge and fracture belts and topographic warps, including Demeter Corona

p$_2$ **Plains unit 2**—High- to moderate-backscatter materials that form irregularly shaped outcrops both within and adjacent to major topographic features, including Raananeida and Fersona Coronae, Lampedo Linea, Mokosha Mons summit depression, Atropos Tessera, and most ridge and fracture belts. Outcrops typically tens to hundreds of kilometers in diameter. Contains dense collections of wrinkle ridges and lineaments and a few small volcanic edifices. Includes sparse outcrops of low backscatter. *Interpretation*: Highly deformed lava plains of intermediate to old age. Tectonic deformation has almost entirely obliterated evidence of the unit's primary composition, morphology, and (or) source. Occurrence of intersecting extensional and contractional structures implicates diverse, long-lived, and repeated tectonism, perhaps related to initial growth and subsequent deformation of major ridge and fracture belts, corona, and topographic warps

p$_1$ **Plains unit 1**—Very high backscatter to high-backscatter materials that form densely lineated, irregularly shaped outcrops both within and adjacent to major topographic features, including Lampedo Linea and all larger coronae, dorsa, and tesserae. Outcrops typically tens to hundreds of kilometers in diameter. Contains dense collections of wrinkle ridges and lineaments and a few small volcanic edifices. Includes sparse outcrops of low backscatter. *Interpretation*: Highly deformed lava plains of intermediate to old age. Tectonic deformation has almost entirely obliterated evidence of the unit's primary composition, morphology, and (or) source. Occurrence of intersecting extensional and contractional structures implicates diverse, long-lived, and repeated tectonism, perhaps related to initial growth and subsequent deformation of major ridge and fracture belts, corona, and topographic warps

CORONA MATERIALS

Isolated, densely lineated materials that make up individual coronae. Due to structural complexity of corona material and its defining nature to that unit, symbols depicted within the boundaries of the unit are intended to convey the local type and trend of tectonic structure

cA$_2$ **Younger Azham Corona material**—High- to moderate-backscatter material composed of lineated material interspersed with moderate- to low-backscatter material. Makes up core and bulk of annulus and topographic warps that define Azham Corona. Contains abundant lineaments and one topographic depression. *Interpretation*: Lavas sourced from fractures of Azham Corona, partly deformed by extension, perhaps related to late-stage corona uplift

cF$_2$ **Younger Feronia Corona material**—Moderate- to low-backscatter material within topographic lows that centered on Feronia Corona. Grades in places with adjacent, older Feronia Corona material (unit **cF$_1$**). Contains some lineaments generally oriented radial to underlying corona. *Interpretation*: Moderately deformed lava plains sourced from fractures within Feronia Corona

cBa **Bachue Corona material**—Very high backscatter material chiefly composed of dense systems of ridges and lineaments. Makes up entirety of ridge and fracture belts that define northern annulus of Bachue Corona. Ridges oriented circumferential to Bachue Corona. *Interpretation*: Lava plains heavily deformed by contraction and extension of the corona annulus

cBu **Bau Corona material**—Very high backscatter material chiefly composed of dense systems of ridges and lineaments of the southwestern and central parts of Bau Corona. Partly forms topographic warp that defines southern part of corona annulus. Includes few irregularly shaped outcrops within younger plains material. *Interpretation*: Lava plains heavily deformed by contraction and extension of corona annulus

cR **Raananeida Corona material**—Very high backscatter to high backscatter material chiefly composed of dense systems of ridges and lineaments. Forms southern and southeastern parts of annulus of Raananeida Corona. Irregularly shaped outcrops form core of corona. *Interpretation*: Lava plains heavily deformed by corona contraction and extension

cC **Coatlicue Corona material**—Very high backscatter to high backscatter material that makes up the irregular annulus of Coatlicue Corona. Contains dense systems of ridges and lineaments. Grades in places with adjacent older plains units. *Interpretation*: Lava plains heavily deformed by corona contraction and extension

cO **Demeter Corona material**—Moderate-backscatter material that makes up eastern annulus of Demeter Corona. Contains multiple north-south-trending lineaments generally oriented circumferential to the corona. *Interpretation*: Lava plains heavily deformed by corona contraction and extension

cO **Otau Corona material**—High-backscatter material that makes up the bulk of Otau Corona. Contains dense systems of radial and concentric ridges and fractures. *Interpretation*: Lava plains heavily deformed by corona contraction and extension

cA$_1$ **Older Azham Corona material**—Very high backscatter to high backscatter material that makes up northeastern and part of western margins of Azham Corona. Grades in places with adjacent, younger Azham Corona material (unit **cA$_2$**). Forms broad, northwest-southeast-trending topographic warp and contains elongate outcrops of relatively younger plains materials. *Interpretation*: Lava plains heavily deformed by corona contraction and extension

cF$_1$ **Older Feronia Corona material**—Very high backscatter to high backscatter material that makes up bulk of Feronia Corona. Defined by dense systems of ridges and lineaments, some of which contain narrow outcrops of low-backscatter material. Grades in places with adjacent, younger Feronia Corona material (unit **cF$_2$**). *Interpretation*: Lava plains heavily deformed by corona contraction and extension

TESSERA MATERIAL

Densely lineated materials with irregular margins that make up regional tesserae. Due to structural complexity as the defining nature of tesserae, symbols depicted within the boundaries of the unit are intended to convey only local type and trend of tectonic structures

t **Tessera material**—Very high to high-backscatter material that forms relatively higher standing Virilus and Atropos Tesserae and Okipeta Dorsa, as well as densely lineated material in Libule Planitia. Contains complexly intersecting structures with multiple orientations, including ridges and fractures. Forms topographic warps in Atropos Tessera. Margins irregularly shaped. *Interpretation*: Highly deformed materials that represent multiple phases of extension and contraction centered at contrasting locations. Irregular shape implicates significant embayment by younger plains materials. May grade in places with plains unit 1 (unit **p$_1$**)

CRATER MATERIALS

c **Crater material**—High- to moderate-backscatter material discretely associated with crater rims, blankets, and floors (see table 3). Can surround low-backscatter material. Texture hummocky to granular. Superposes multiple plains units throughout the map region. *Interpretation*: Crater rim, ejecta deposits, and floor deposits formed by surface impact. Morphology may represent local deformation related to relaxation of crater rim. May include crater flow material

cf **Crater flow material**—High- to low-backscatter material associated with some impact craters. Contains lobate margins and digitate terminations with narrow, anastomosing surfaces. Locally speckled at kilometer to subkilometer scales. *Interpretation*: Flows of fluidized impact melt

EXPLANATION OF MAP SYMBOLS

- **Contact**—Dashed where character is uncertain or where approximately located
- **Wrinkle ridge crest**
- **Lineament**—Interpreted as narrow graben or fracture
- **Ridge and fracture belt (width >15 km wide)**
- **Topographic warp**
- **Volcanic edifice (diameter >5 km)**
- **Volcanic edifice (diameter <5 km)**
- **Flow direction**
- **Channel-form**
- **Scarp**—Barbs point downslope
- **Impact crater**—Rim diameter >15 km
- **Impact crater**—Rim diameter <15 km

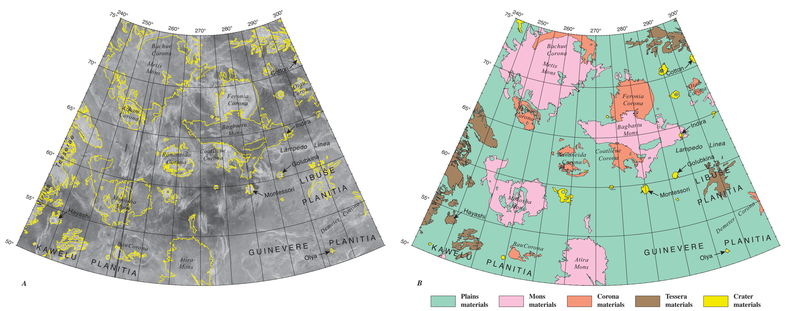


Figure 1. Context figures of the entire Metis Mons (V–6) quadrangle (lat 50° to 75° N., long 240° to 300° E.), Venus. North is to the top. Projection is in Lambert Conformal Conic with a planetary radius of 3025.5 km. *A*, Magellan synthetic aperture radar (SAR) mosaic showing the relative intensity of 12.6-cm-wavelength radar backscatter. Mosaic is superposed with geologic contacts in yellow, which have been grouped into material suites for maximum clarity. Generally, tessera, densely lineated plains, craters, and some of the younger flow fields make up the brightest surfaces (highest relative backscatter). Darkest surfaces are associated with lowland plains materials, particularly where they are overlain by dark parabolic haloes or associated with Cotton, Montessori, and Hayashi craters, which dominate the central, northeastern, and southwestern areas of the quadrangle. Small, dark splotches surround Golubkina, Indira, and Olya craters. Crater locations and characteristics are summarized in table 3. ***B***, Unit groupings, as delineated in the Correlation of Map Units, and major physiographic features within the Metis Mons quadrangle (see map for all approved nomenclature located within V–6). Large impact craters are denoted with black arrows.

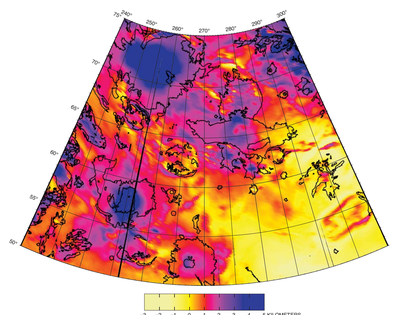


Figure 2. Magellan altimetry and contacts of map-unit groupings (black lines) of the Metis Mons quadrangle (V–6), Venus. Large volcanic shields, tesserae, and some densely lineated areas make up pronounced topographic highs, whereas ridge and fracture belts and corona annuli and cores make up most moderate high areas. Lowland plains make up much of southeastern quadrant and southwestern corner of map region. See table 4 for summary of unit elevation.

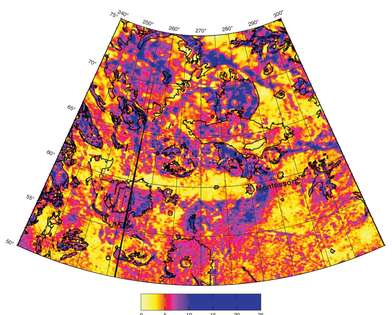


Figure 3. Magellan root-mean-square (rms) slope and contacts of map-unit groupings (black lines) of the Metis Mons quadrangle (V–6), Venus. The rms slope relates to meter-scale roughness. Rougher materials include coronae and tessera materials, as well as some mons materials. Most homogeneous and moderately lineated plains have moderate to low rms slope. Note smooth halo and tail of low rms slope extending west of Montessori crater. See table 4 for summary of unit rms slope.

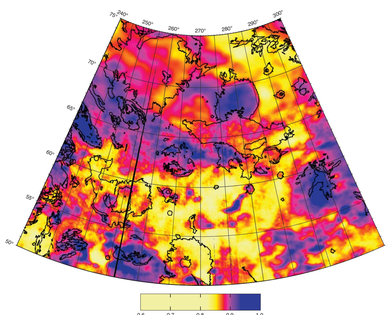


Figure 4. Magellan emissivity and contacts of map-unit groupings (black lines) of the Metis Mons quadrangle (V–6), Venus. In general, higher values represent rough surfaces and (or) low dielectric content materials. High emissivity ranges occur in coronae and tesserae materials and low ranges are largely confined to plains materials. There is not a clear association of emissivity with any of the mapped craters. See table 4 for summary of unit emissivity.

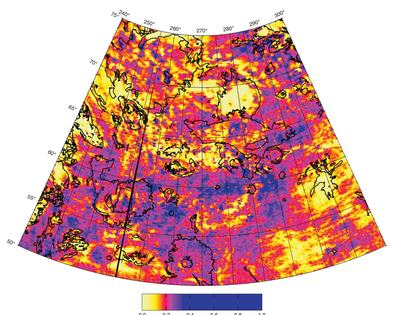


Figure 5. Magellan reflectivity and contacts of map-unit groupings (black lines) of the Metis Mons quadrangle (V–6), Venus. Low reflectivity areas include some of the tesserae and coronae outcrops. Plains areas and large volcanoes dominated by higher reflectivity.

Geologic Map of the Metis Mons Quadrangle (V–6), Venus

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2011

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