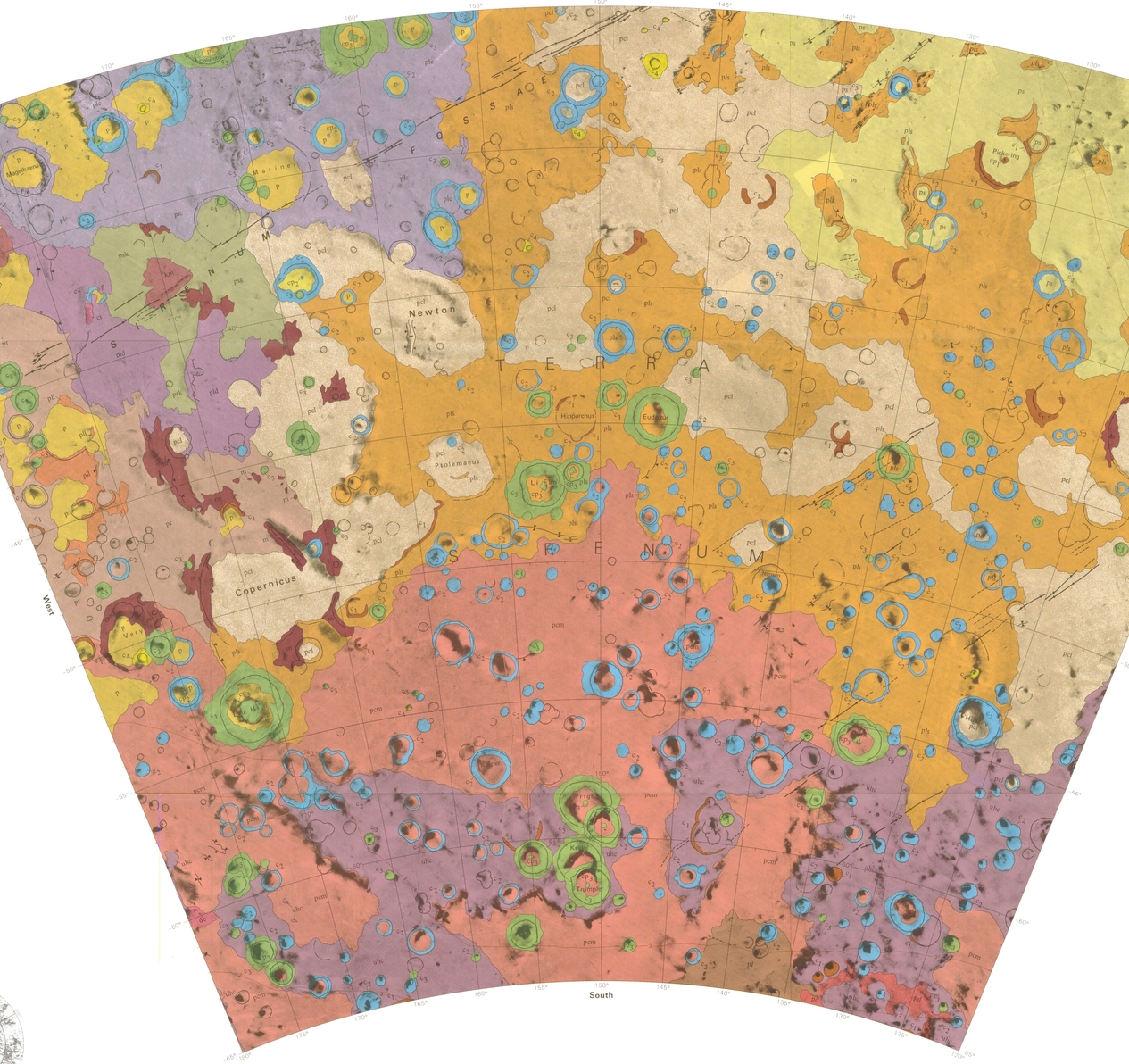
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:5,000,000 GEOLOGIC SERIES
PHAETHONTIS QUADRANGLE
M 5M –48/150 *G*, 1979
I-1145 (MC-24)



Interior—Geological Survey, Reston, Va.—1979—G78497

Prepared on behalf of the Planetary Geology Program, Planetary Division, Office of Space Science, National Aeronautics and Space Administration under contract W-13,709 in cooperation with University of Georgia (NASA grant NGR-11-003-037)

SCALE 1:4336000 AT –20° LATITUDE
LAMBERT CONFORMAL PROJECTION

KILOMETERS 100 0 100 200 300 400 500 600 700 800 900 1000

CONTOUR INTERVAL 1 KILOMETER

NOTES ON BASE

This map sheet is one of a series covering the entire surface of Mars at nominal scales of 1:25,000,000 and 1:5,000,000 (Batson, 1973, 1976). The major source of map data was the Mariner 9 television experiment (Masursky and others, 1970).

ADOPTED FIGURE

The figure of Mars used for the computation of the map projection is an oblate spheroid (flattening of 1/192) with an equatorial radius of 3,393.4 km and a polar radius of 3375.7 km. This is not the height datum which is defined below under the heading "Contours".

PROJECTION

The Lambert conformal conic projection is used for this sheet with standard parallels at 35.8° and 59.2°. A scale of 1:4,336,000 at lat 20° S was chosen to match the scale at lat 30° S of the adjacent Mercator projections. Longitudes increase to the west in accordance with usage of the International Astronomical Union (IAU, 1973). Latitudes are areographic (de Vaucouleurs and others, 1973).

CONTROL

Planimetric control is provided by radio-tracked positions of the spacecraft and telemetered camera-pointing angles. The first meridian passes through the crater Airy-0 (lat 5.19° S) within the crater Airy. No simple statement is possible for the precision, but local consistency is 20-40 km.

MAPPING TECHNIQUE

Selected Mariner 9 pictures were transformed to the Lambert conformal projection and assembled in a series of mosaics at 1:5,000,000.

CONTOURS

Because Mars has no seas and hence no sea level, the datum (the 0 km contour line) for altitudes is defined by a gravity field described by spherical harmonics of fourth order and fourth degree (Jordan and Lorell, 1973) and a reference multilinear atmospheric pressure surface derived from radio-occultation data (Kliore and others, 1973; Christensen, 1975; Wu, 1975, 1978).

The contour lines on most of the Mars maps (Wu, 1975, 1978) were compiled from Earth-based radar determinations (Down and others, 1973; Pettengill and others, 1971) and measurements made by Mariner 9 instrumentation, including the ultraviolet spectrometer (Hord and others, 1974), infrared interferometer spectrometer (Conrath and others, 1973), and stereoscopic Mariner 9 television pictures (Wu and others, 1973).

Formal analysis of the accuracy of topographic elevation information has not been made. The estimated vertical accuracy of each source of data indicates a probable error of 1–2 km.

NOMENCLATURE

All names on this sheet are approved by the International Astronomical Union (IAU, 1974, 1977, 1980).

MC-24 Abbreviation for Mars Chart 24.
M 5M –48/150 G Abbreviation for Mars 1:5,000,000 series; center of sheet, lat 48° S., long 150° . geologic map, G.

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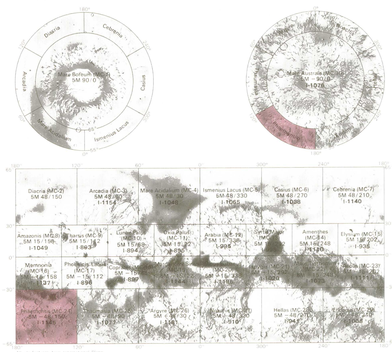
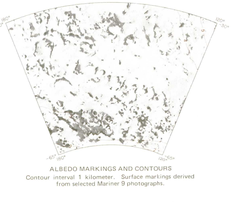


Albers Rectrix from Topological Photo
Very Rough Areographic Lowell Observatory Flagstaff AZ

QUADRANGLE LOCATION
Number preceded by *I* refers to published geologic map



ALBEDO MARKINGS AND CONTOURS
Contour interval 1 kilometer. Surface markings derived from selected Mariner 9 photographs.

GEOLOGIC MAP OF THE PHAETHONTIS QUADRANGLE OF MARS

By
J. Hatten Howard III
1979

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

p PLAINS-FORMING MATERIAL—Occurs as generally light, smooth-appearing surface in low areas of plateau materials (units plc, pld, and pll) and as flat floors of intermediate- to large-size craters in western part of mapped area. Crater density very low (except for some very small bowl-shaped craters), similar to that of smooth plains-forming material (unit ps); small and local areal extent makes cratering characteristics uncertain. *Interpretation*: Eolian deposits; may be equivalent in age to smooth plains-forming material (unit ps)

ps SMOOTH PLAINS-FORMING MATERIAL—Occurs over wide areas in northeastern part of quadrangle, appearing to overlap subdued plateau material (unit pls) and to grade into cratered-plateau material (unit plc). Fills very large circular basins or craters. Resembles plains-forming material (unit pr), with very low crater density, but has numerous dark wind-plumes and streaks associated with craters. *Interpretation*: Widespread lava flows or ash flows from Tharsis Montes volcanic regions to northeast, subsequently smoothed by eolian erosion and deposition

psk KNOBBY AND SMOOTH PLAINS MATERIAL—Forms smooth plains in low area between two plateau terrains (units plc and pld) and surrounding one area of knob and mesa material (unit km). Only observable relief, except for small craters and gently undulating surface, consists of small (< 1 km), bright, isolated hills (B-frame DAS 05347223), which may be only of local extent. *Interpretation*: Composite unit; possibly blanket of eolian debris lying on erosional surface, of which small bright hills may be erosional outliers of formerly more widespread plateau unit, perhaps knob and mesa material (unit km). Alternately, bright hills may be volcanic domes or small plutonic masses within crust exposed by erosion

pr ROLLING PLAINS MATERIAL—Forms gently rolling surfaces of very low relief. Moderately cratered; some small-scale, low, sinuous ridges. Topographically lower than adjacent plateau material (units pld, pll, and pls). *Interpretation*: Low areas of old cratered crust covered by volcanic ash or lava flows to form present widespread unit; subsequently cratered by moderate meteoritic influx, then modified by eolian activity

pcl LIGHTLY CRATERED PLAINS-FORMING MATERIAL—Moderately light tone, as some places mottled light and dark or with dark streaks. Generally smooth surface of low relief, although relief of underlying buried surface is apparent as faint crater outlines and gently hilly surface. On B-frame pictures, surface shows gentle, subdued hills. Forms extensive plains, probably covering low areas of crustal plateau materials (units pls and pld) and floors of large (> 100 km) craters. Small craters, commonly fresh in appearance, moderately abundant; medium- and large-size craters lacking (except on underlying buried surface). *Interpretation*: Low-lying areas of old, heavily impacted crust now buried beneath eolian or volcanic shallow plains, subsequently lightly cratered and continually modified by eolian erosion and deposition

pcm MODERATELY CRATERED PLAINS-FORMING MATERIAL—Moderately light tone and smooth, level topography. Occurs in low areas of heavily cratered terrain and, in places, gradational with highly cratered uplands material (unit uhc). Population and size of craters larger than on lightly cratered plains-forming material (unit pcl). Craters have flat floors and high walls, with rims very subdued and many nearly level with interstitial plain. Small craters (< 15 km) absent. Dark areas common on crater floors. *Interpretation*: Erosional or depositional plain, probably of eolian origin, which occupies and covers low-lying parts of primitive crust (unit uhc). Large craters may be remnants of highly cratered plateau material and merging gradationally with the lightly cratered plains-forming material. The smooth plains-forming material is the youngest in the quadrangle and is probably still being moved and deposited by winds. Wind directions of the 1971 dust storm, determined from dark wind-formed streaks, suggest that the material of the smooth plains-forming deposit, and perhaps of the lightly cratered plains, derives from the east or northeast.

The northwestern part of the Phaethontis quadrangle comprises several plains, plateau, and knob and mesa terrains that represent unique crustal units, erosional modification of old crustal material, and burial of low areas. The knob and mesa material is localized within the crust, occurring as two isolated, closely clustered groups of knobs and some mesas, unlike other described areas of knobs (McCauley and others, 1972; Carr and others, 1973, 1976; Scott and Carr, 1978). Possibly this knob and mesa material represents regionally fractured plutonic masses exposed by erosion and rounded by wind.

Plateau-forming materials within this area exhibit various morphologies and are thought to be old units superposed on or emplaced within older, densely cratered crustal material. The dissected plateau material, which may be composed of indurated ash flows or eolian deposits, abuts the lower surrounding plains in many places with an escarpment. Sapping, possibly by mass wasting and collapse accompanying release of entrapped volatiles to the atmosphere, has produced cornices and lateral retreat of the escarpment and the formation of isolated pits and steep-walled gorges within the plateau. The scarp has retreated to the east with the removal of material into the plains. Similarly, the light plateau material rises above surrounding plains along steep escarpments (lat 43°S., long 177°W.), some of which correspond to crater outlines. This plateau unit may be either strata superposed on, or a localized plutonic mass within, old crust. Subsequent erosion has removed plateau material brecciated by impacts.

The subdued-plateau material bears, in this area, quasi-parallel and branching furrows, 1-3 km wide, and surface pattern suggestive of sinuous and branching furrows. In some areas a more planar surface, which abuts lower plains with a steep escarpment, is cut by parallel grooves (lat 34°S., long 148°W.). Either the escarpments, canyons, pits, and grooves of plateau terrains represent different types of erosional etching, stripping, or collapse processes, or they exhibit the various responses of different lithologies and structures to similar processes. Furrows may be primary features associated with the formation of the unit, such as lava channels or collapsed tubes, or they may be the result of erosion.

Two units, the knobby and smooth plains material and the rolling plains material, which are adjacent to the plateau and knob and mesa materials, seem to be related geologically to the neighboring higher terrains. The knobby and smooth plains material, from the center of which rises a cluster of knob and mesa material, has as its only relief in B-frame resolution (except for small craters) small (< 1 km), bright, isolated hills (lat 0°S., long 171°W.); the hills may be volcanic domes or small plutonic masses exposed by erosional stripping of the overlying crustal material. The cluster of knobs and mesas may be a large remnant of this stripped unit. The rolling plains material, of greater area and extending into the Tharsis quadrangle, surrounds the light plateau material and abuts the dissected plateau material. Low sinuous ridges on these plains may be indicative of lava sheets subsequently modified by cratering and wind activity.

VOLCANISM AND STRUCTURE

No features of certain volcanic origin have been identified in the Phaethontis quadrangle. Some hills and scarps seen in a few high-resolution frames of the smooth plains-forming material in the northeastern part of the map area may be the fronts of lava flows. Also, small branching furrows on channels on the subdued-plateau material and on adjacent low-lying plains may be lava channels or collapsed lava tubes. Two other small areas of volcanism may be the domelike hills and small cones (at 60°S., long 179°W.) in the plains in the southwestern part of the quadrangle and the local hilly material (at 32°S., long 145°W.) superposed on a crater within the northern subdued-plateau material.

The major tectonic feature in the quadrangle is Sirenum Fossae, a belt of narrow grabens and fault escarpments extending almost 2,000 km west-southwest across the cratered plains and plateaus from Tharsis Montes. The cratered plains and plateaus in the eastern part of the quadrangle are also transected by north-east-trending grabens and lineaments (interpreted as eroded or mantled grabens). All the grabens are components of the southern fan of fractures produced by crustal upwarp in the Labyrinthus Tharsis region possibly 1 by. ago (Carr, 1974).

GEOLOGIC HISTORY

Impact cratering dominated the early history of the Phaethontis quadrangle; the crater-saturated surface of early Bombardment may have been removed by some late-contemporaneous obliterating process and repopulated with the presently observed crater density by a decreasing flux of late-accretionary bombardment (Soderblom and others, 1974). Successive, or perhaps overlap, plains-forming events have since filled low areas of the heavily cratered surface. The plains were probably formed by eolian and volcanic processes, although only the youngest smooth plains in the northeast show possible volcanic-flow features. The origin and time of formation of small furrows and channels that dissect some of the plateau terrains are uncertain; these channels may represent one or more volcanic or fluvial events. Tectonism, forming systems of extension fractures, has affected all but the smooth plains.

Wind activity now predominates in the major geologic agent. Dark streaks associated with small craters are common in the northeastern smooth plains, and dark patches occur on part of the floors of large craters throughout the area (lat 48°S., long 164°W.) and on plains at the base of adjoining uplands (at 56°S., long 167°–170°W.). At least some dark areas are dune fields (high-resolution Bframe DAS 05850743) that have accumulated in the lee of uplands, mountains, and crater walls, rims, and central peaks.

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Note: Mismatches of crators and other features across quadrangle boundaries may result from errors inherent in the semicontrolled bases provided for geologic mapping.

pls SUBDUED-PLATEAU MATERIAL—Mottled tone, intermediate to dark. Rough topography, but more subdued and with less relief than mountainous material (unit m). Locally shows sinuous parallel furrows, 1-3 km wide, branching and anastomosing; elsewhere, surface patterns are suggestive of sinuous and branching furrows. Many faintly outlined, moderate-size craters (< 50 km); no small (< 5 km) craters. In some areas, occurs as level surface cut by parallel grooves. *Interpretation*: Old crustal unit, possibly of lava-flow or ash-flow origin. Surface eroded and subdued, probably by eolian erosion and deposition

pld MATERIAL OF DARK PLATEAU—Forms moderately dark, rolling surface of gently hilly scarps seen in a few high-resolution frames of the smooth plains-forming material in the northeastern part of the map area may be the fronts of lava flows. Also, small branching furrows or channels on the subdued-plateau material and on adjacent low-lying plains may be lava channels or collapsed lava tubes. Two other small areas of volcanism may be the domelike hills and small cones (at 60°S., long 179°W.) in the plains in the southwestern part of the quadrangle and the local hilly material (at 32°S., long 145°W.) superposed on a crater within the northern subdued-plateau material.

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The northwestern part of the Phaethontis quadrangle comprises several plains, plateau, and knob and mesa terrains that represent unique crustal units, erosional modification of old crustal material, and burial of low areas. The knob and mesa material is localized within the crust, occurring as two isolated, closely clustered groups of knobs and some mesas, unlike other described areas of knobs (McCauley and others, 1972; Carr and others, 1973, 1976; Scott and Carr, 1978). Possibly this knob and mesa material represents regionally fractured plutonic masses exposed by erosion and rounded by wind.

Plateau-forming materials within this area exhibit various morphologies and are thought to be old units superposed on or emplaced within older, densely cratered crustal material. The dissected plateau material, which may be composed of indurated ash flows or eolian deposits, abuts the lower surrounding plains in many places with an escarpment. Sapping, possibly by mass wasting and collapse accompanying release of entrapped volatiles to the atmosphere, has produced cornices and lateral retreat of the escarpment and the formation of isolated pits and steep-walled gorges within the plateau. The scarp has retreated to the east with the removal of material into the plains. Similarly, the light plateau material rises above surrounding plains along steep escarpments (lat 43°S., long 177°W.), some of which correspond to crater outlines. This plateau unit may be either strata superposed on, or a localized plutonic mass within, old crust. Subsequent erosion has removed plateau material brecciated by impacts.

The subdued-plateau material bears, in this area, quasi-parallel and branching furrows, 1-3 km wide, and surface pattern suggestive of sinuous and branching furrows. In some areas a more planar surface, which abuts lower plains with a steep escarpment, is cut by parallel grooves (lat 34°S., long 148°W.). Either the escarpments, canyons, pits, and grooves of plateau terrains—represent different types of erosional etching, stripping, or collapse processes, or they exhibit the various responses of different lithologies and structures to similar processes. Furrows may be primary features associated with the formation of the unit, such as lava channels or collapsed tubes, or they may be the result of erosion.

Two units, the knobby and smooth plains material and the rolling plains material, which are adjacent to the plateau and knob and mesa materials, seem to be related geologically to the neighboring higher terrains. The knobby and smooth plains material, from the center of which rises a cluster of knob and mesa material, has as its only relief in B-frame resolution (except for small craters) small (< 1 km), bright, isolated hills (lat 0°S., long 171°W.); the hills may be volcanic domes or small plutonic masses exposed by erosional stripping of the overlying crustal material. The cluster of knobs and mesas may be a large remnant of this stripped unit. The rolling plains material, of greater area and extending into the Tharsis quadrangle, surrounds the light plateau material and abuts the dissected plateau material. Low sinuous ridges on these plains may be indicative of lava sheets subsequently modified by cratering and wind activity.

VOLCANISM AND STRUCTURE

No features of certain volcanic origin have been identified in the Phaethontis quadrangle. Some hills and scarps seen in a few high-resolution frames of the smooth plains-forming material in the northeastern part of the map area may be the fronts of lava flows. Also, small branching furrows or channels on the subdued-plateau material and on adjacent low-lying plains may be lava channels or collapsed lava tubes. Two other small areas of volcanism may be the domelike hills and small cones (at 60°S., long 179°W.) in the plains in the southwestern part of the quadrangle and the local hilly material (at 32°S., long 145°W.) superposed on a crater within the northern subdued-plateau material.

The major tectonic feature in the quadrangle is Sirenum Fossae, a belt of narrow grabens and fault escarpments extending almost 2,000 km west-southwest across the cratered plains and plateaus from Tharsis Montes. The cratered plains and plateaus in the eastern part of the quadrangle are also transected by north-east-trending grabens and lineaments (interpreted as eroded or mantled grabens). All the grabens are components of the southern fan of fractures produced by crustal upwarp in the Labyrinthus Tharsis region possibly 1 by. ago (Carr, 1974).

GEOLOGIC HISTORY

Impact cratering dominated the early history of the Phaethontis quadrangle; the crater-saturated surface of early Bombardment may have been removed by some late-contemporaneous obliterating process and repopulated with the presently observed crater density by a decreasing flux of late-accretionary bombardment (Soderblom and others, 1974). Successive, or perhaps overlap, plains-forming events have since filled low areas of the heavily cratered surface. The plains were probably formed by eolian and volcanic processes, although only the youngest smooth plains in the northeast show possible volcanic-flow features. The origin and time of formation of small furrows and channels that dissect some of the plateau terrains are uncertain; these channels may represent one or more volcanic or fluvial events. Tectonism, forming systems of extension fractures, has affected all but the smooth plains.

Wind activity now predominates in the major geologic agent. Dark streaks associated with small craters are common in the northeastern smooth plains, and dark patches occur on part of the floors of large craters throughout the area (lat 48°S., long 164°W.) and on plains at the base of adjoining uplands (at 56°S., long 167°–170°W.). At least some dark areas are dune fields (high-resolution Bframe DAS 05850743) that have accumulated in the lee of uplands, mountains, and crater walls, rims, and central peaks.

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Note: Mismatches of craters and other features across quadrangle boundaries may result from errors inherent in the semicontrolled bases provided for geologic mapping.

pll LIGHT PLATEAU MATERIAL—Generally light tone. Plateau form results from accordance of summits and low relief of rolling or hummocky topography. Stands higher than surrounding regional plains materials (units pr and pl) and abuts with steep escarpment against plains-forming material (unit pl) that fills large craters. *Interpretation*: Localized unit within old crust, exposed by large, early impact events and subsequent erosion; absence of craters smaller than 30 km in diameter suggests extensive stripping of overlying material. May be equivalent in age to dissected and cratered plateau materials to north (units pld and plc)

km KNOB AND MESA MATERIAL—Bright, rounded to flat-topped, steep hills, 1-4 km in diameter. Occurs as two clusters (at 35°S., long 177°W., and lat 38°S., long 171°W.) of about 10,000 km² each, within and rising abruptly above plains (units p and psk). *Interpretation*: Localized unit within old crust, different in composition and erosional characteristics from nearby surrounding crustal materials (units pld and plc). Light tone, rounded nature of individual hills, and alinement of some valleys suggest silicic plutonic masses, regionally fractured and eroded by eolian activity

pls SUBDUED-PLATEAU MATERIAL—Mottled tone, intermediate to dark. Rough topography, but more subdued and with less relief than mountainous material (unit m). Locally shows sinuous parallel furrows, 1-3 km wide, branching and anastomosing; elsewhere, surface patterns are suggestive of sinuous and branching furrows. Many faintly outlined, moderate-size craters (<50 km); no small (<5 km) craters. In some areas, occurs as level surface cut by parallel grooves. *Interpretation*: Old crustal unit, possibly of lava-flow or ash-flow origin. Surface eroded and subdued, probably by eolian erosion and deposition

pl MATERIAL OF DARK PLATEAU—Forms moderately dark, rolling surface of gently hilly scarps seen in a few high-resolution frames of the smooth plains-forming material in the northeastern part of the map area may be the fronts of lava flows. Also, small branching furrows or channels on the subdued-plateau material and on adjacent low-lying