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
AEOLIS QUADRANGLE
M 5M –15/202 G, 1978
I-1111 (MC-23)

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 3393.4 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 Mercator projection is used for this sheet, with a scale of 1:5,000,000 at the equator and 1:4,336,000 at lat 30°. Longitudes increase to the west in accordance with the usage of the International Astronomical Union (IAU, 1971). Latitudes are areographic (de Vaucouleurs and others, 1973).

CONTROL

Planimetric control is provided by photogrammetric triangulation using Mariner 9 pictures (Davies, 1973; Davies and Arthur, 1973) and the radio-tracked position of the spacecraft. The first meridian passes through the crater Airy-O (lat 5.19° S) within the crater Airy. No simple statement is possible for the precision, but local consistency is about 10 km.

MAPPING TECHNIQUE

A series of mosaics of Mercator projections of Mariner 9 pictures was assembled at 1:5,000,000.

Shaded relief was copied from the mosaics and portrayed with uniform illumination with the sun to the west. Many Mariner 9 pictures besides those in the base mosaic were examined to improve the portrayal (Levinthal and others, 1973; Green and others, 1975; Inge and Bridges, 1976). The shading is not generalized and may be interpreted with nearly photographic reliability (Inge, 1972).

Shaded relief analysis and representation were made by Jay L. Inge.

CONTOURS

Since 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) combined with a 6.1 millibar atmospheric pressure surface derived from radio-occultation data (Kliore and others, 1973; Christensen, 1975; Wu, 1975).

The contour lines on most of the Mars maps (Wu, 1975) were compiled from Earth-based radar determinations (Downs and others, 1971; 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).

MC-23: Abbreviation for Mars Chart 23
M 5M –15/202 G: Abbreviation for Mars 1:5,000,000 series; center of sheet, lat 15°S, long 202°; geologic map, G.

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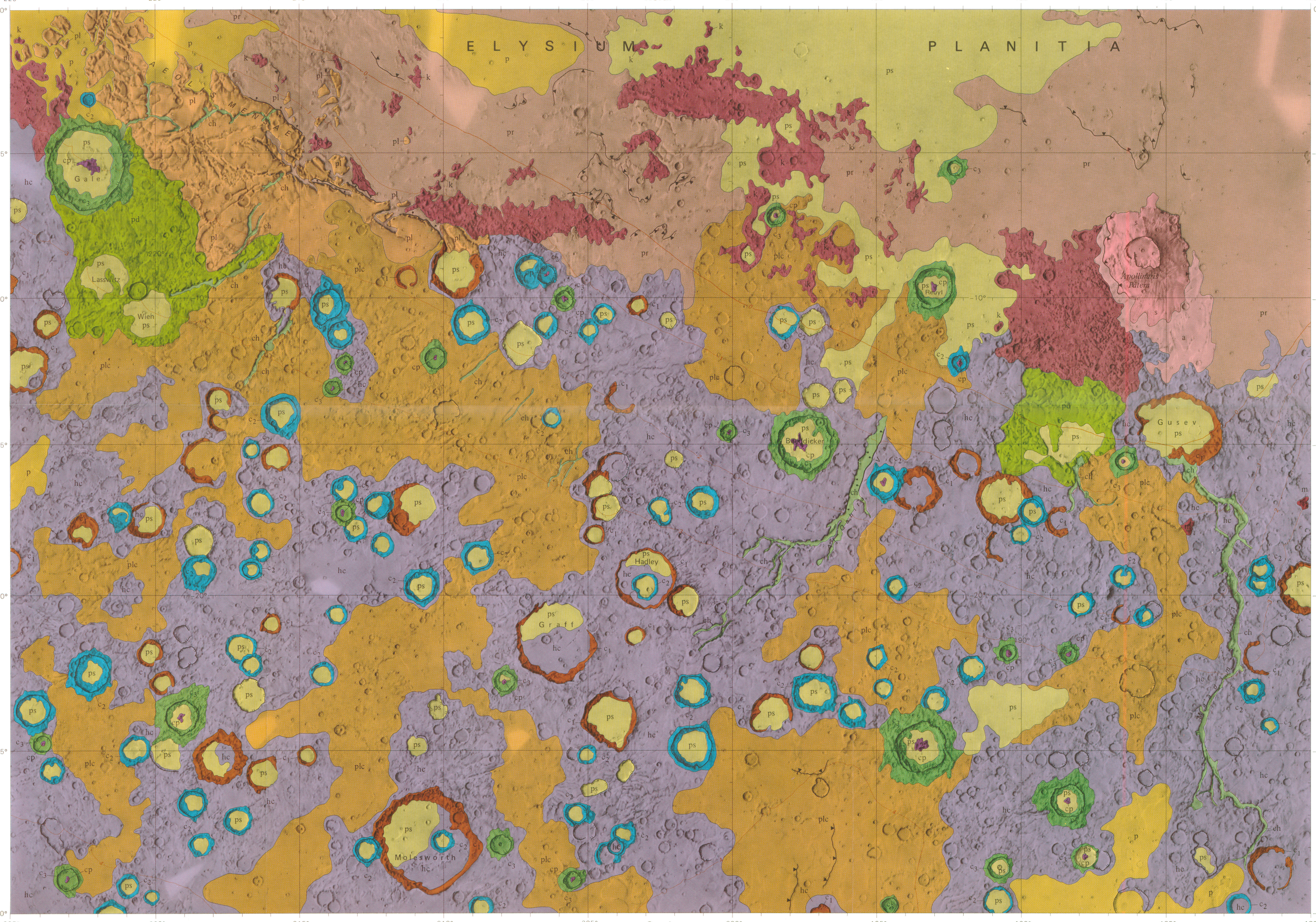

Interior—Geological Survey, Reston, Va.—1978—G78132
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SCALE 1:5 000 000 AT 0° LATITUDE
MERCATOR PROJECTION

CONTOUR INTERVAL 1 KILOMETER

CORRELATION OF MAP UNITS

PLAINS MATERIALS	HIGHLAND MATERIALS	CHANNEL AND VOLCANIC MATERIALS	CRATER MATERIALS
ps, p, pr, pd	pl, plc, hc, m, k	ch, s, a	c3, c2, c1, cp

DESCRIPTION OF MAP UNITS

PLAINS MATERIALS

ps SMOOTH PLAINS MATERIAL–Covers large parts of Elysium Planitia in north part of quadrangle; partly fills interiors of many craters, especially craters older than c_3. Flat, featureless surface at low resolution; subjacent topography visible in places at high resolution. Gradational with plains material (unit p). Crater density low. *Interpretation:* Eolian deposit, moderately thick cover over lava flows

p PLAINS MATERIAL–Occurrence and characteristics similar to smooth plains material (unit ps), but crater population larger and topography of underlying material visible on most high-resolution frames. *Interpretation:* Relatively thin eolian deposit over lava flows

pr ROLLING PLAINS MATERIAL–Smooth undulating surface, low to moderate crater density. Embays plateau, cratered plateau, hilly and cratered, and knobby materials (units pl, plc, hc, and k, respectively). Lobate scarps, wrinkle ridges, and mottled appearance in places. *Interpretation:* Lava flows, postdates highland units (hc, plc, pl)

pd DEFLATED PLAINS MATERIAL–Extends southeast from crater Gale in northwest part of map area; small patch in east-central map area. Has hackly surface formed by numerous pits and irregularly shaped depressions. Stratigraphic position uncertain, may be superposed on, embayed by, or gradational with plateau materials (units pl, plc). Crater density similar to cratered plateau material (unit plc); crater Gale (c_3) superposed. *Interpretation:* Origin unknown; possibly wind-deflated lava surface with some collapse depressions

HIGHLAND MATERIALS

pl PLATEAU MATERIAL–Forms smooth, flat, elevated surfaces standing above rolling plains (unit pr). In places dissected to form mesas and buttes gradational with knobby material (unit k) and cratered plateau material (unit plc). Crater density moderate. Resembles terrestrial lava plains and ashflow surfaces. *Interpretation:* Lava flows

plc CRATERED PLATEAU MATERIAL–Forms high, relatively flat areas similar to plateau material (unit pl) but less smooth and more densely cratered. *Interpretation:* Same as plateau material but older

hc HILLY AND CRATERED MATERIAL–Highly cratered rough terrain; craters larger than those on other units, many have dark patches on floors. Light streaks in lee of craters common. *Interpretation:* Ancient terrain consisting largely of impact breccia. Eolian cover thin and patchy

m MOUNTAIN MATERIAL–Forms two steep rough-sided mountains 20–30 km across projecting above hilly and cratered material (unit hc) in east-central map area. Summit crater on larger westernmost mountain appears flat-floored, shallow. *Interpretation:* Possibly volcanoes

k KNOBBY MATERIAL–Forms clusters and individual subrounded knobs up to several kilometers across. Gradational with plateau materials (units pl and plc) and hilly and cratered material (unit hc). *Interpretation:* Erosional remnants of plateau and hilly and cratered units

CHANNEL AND VOLCANIC MATERIALS

ch CHANNEL MATERIAL–Forms floors of Ma'adim and Al-Qahira Valles and other smaller channels. Channels show combinations of linear and sinuous segments, some discontinuous. Tributary patterns common. Transect plateau material (unit pl) and partly buried by cratered plateau material (unit plc). *Interpretation:* Fluvial and eolian deposits within channels formed by running water; courses structurally controlled in places

s SHIELD MATERIAL–Forms Apollinaris Patera, a broad low-relief mountain surmounted by a large composite depression. Flanks radially lineated, lobate scarps in places; discontinuous scarp at base. *Interpretation:* Basaltic volcano with summit calderas

a AUREOLE MATERIAL–Smooth, outward-sloping apron extends southward across basal scarp of Apollinaris Patera. Gradational with rolling plains (unit pr). *Interpretation:* Lava flows originating from fissures on lower flanks of volcano

CRATER MATERIALS

Most craters shown on map believed to be of impact origin. Their rims, walls, and floors (where not covered by younger material) consist of highly brecciated, shocked, and partly melted country rock. Craters with rim crest diameters less than about 30 km not mapped.

c_3 MATERIAL OF SHARP-RIMMED CRATERS–Rims complete, highly raised, rough appearing. Floors lower than adjacent terrain; rough in larger craters where not buried by smooth plains material (unit ps); bowl-shaped in smaller craters. Central peaks prominent

c_2 MATERIAL OF SUBDUED CRATERS–Similar morphology to c_3 craters, but rims narrower, floors shallower, central peaks small to absent

c_1 MATERIAL OF DEGRADED CRATERS–Rims incomplete, floors like those of c_2 craters but more nearly level with adjacent terrain. Central peaks absent

cp CENTRAL PEAK MATERIAL–Forms prominent hill near center of c_3 craters and some c_2 craters. *Interpretation:* Brecciated floor material uplifted during shock decompression stage following impact

Contact

Fault scarp – Bar and ball on down thrown side

Narrow depression or graben

Scarp – Line at base. Barb points down slope. *Interpretation:* Flow front or fault scarp

Crater rim crest – Not shown around small craters or where indistinct; also marks remnant rim outlines of highly degraded unmapped craters

Caldera rim or depression

PHYSIOGRAPHIC SETTING

Two principal physiographic provinces of Mars are represented in the Aeolis quadrangle: (1) Elysium Planitia in the north is part of a broad planet-encircling belt of relatively young lowland plains, and (2) cratered highlands in the south consist of rough primitive terrain that extends to polar deposits around the southern ice cap (Condit and Soderblom, 1978; Scott and Carr, 1978). These two terrains are separated by an irregular discontinuous northwest-trending scarp that becomes less conspicuous and more segmented toward the east part of the map area. Two large channels transect the highlands; they widen northward downslope and have other features characteristic of terrestrial river beds. However, no fans or deltaic forms are visible at their mouths, and their floors merge with the plains. One large shield volcano, Apollinaris Patera, projects above the plains adjacent to the highlands in the northeast part of the quadrangle. More than 4 km of relief occur across the region from the high plateau in the south and west, downslope northward to the plains.

GEOLOGIC SUMMARY

Geologic units are classified and relatively dated on the basis of physical characteristics observable on Mariner 9 A-frame images. High-resolution B-frame pictures do not cover all of the mapped units but are used where available to aid in their identification and interpretation.

Highland Materials

The oldest rocks in this quadrangle include hilly and cratered material and probably the small mountains near the east margin of the map area. Craters up to 50 km in diameter and more are common in the hilly and cratered material. This unit probably consists primarily of the interbedded and brecciated impact ejecta blankets of the large craters. Although these rocks constitute much of the highlands, other large areas in this region are covered by materials exhibiting smooth surfaces. In these areas large craters are also common, but their outlines appear subdued and their rims less pronounced, suggesting partial burial by lava flows and pyroclastic deposits. These materials have been subdivided, according to variations in crater densities, into plateau material and cratered plateau material; both units are gradational. High-resolution pictures indicate that in some areas crater population differences result from wind erosion, whereas in others they reflect variations in lava thickness and amount of burial.

Knobby material occurs along or near the boundary between the plains and plateau units including hilly and cratered material. In this region of Mars the knobby terrain is produced by the erosional retreat of the boundary scarp, leaving remnants of highland rocks surrounded by materials of the plains. Rounded knobs of low relief probably consist of rocks in the lower part of the stratigraphic section such as hilly and cratered material. Where knobs are high and nearly flat topped, their upper surfaces probably are plateau material.

Plains Materials

Plains deposits commonly occupy the extensive lowlands in the northern part of the quadrangle, but smaller patches occur within some crater floors and local depressions throughout the highlands. The plains are generally featureless at low-resolution but exhibit a variety of forms on B-frames such as linear ridges and grooves sculptured by the wind, hillocks and conical mounds, light and dark mottling, pits and depressions, fractures, and wrinkle ridges and lobate scarps characteristic of lava flows, particularly the basaltic flows of the lunar maria. Crater densities are low, and most of the superposed craters are less than 10 km in diameter.

Deflated plains material, probably the oldest of the units, is ambiguous both in origin and composition. The large tongue-like deposit extending southeast from crater Gale (lat 5° S, long 222° W) has the shape and corrugated surface appearance of some terrestrial debris flows. The pits and depressions that characterize its surface, however, are mostly oriented normal to the long axis and in the direction of prevailing winds. Another, smaller occurrence in the east part of the map area more nearly resembles deflated plains material mapped elsewhere on Mars (Underwood and Trask, 1977; Condit and Soderblom, 1978).

A large part of the northern plains consists of rolling plains material. This unit has many features indicative of a volcanic origin, such as lobate scarps and wrinkle ridges that are visible on both A-frame and B-frame pictures. The rolling plains material appears to be gradational with the aureole material around part of Apollinaris Patera.

Plains and smooth plains materials differ only in their small crater populations and in their degree of subdual of underlying topography. Both units are believed to be an eolian mantle of varying thickness resting upon lava flows (Scott and Allingham, 1976). Where the mantle is thin, the volcanic substrate with its identifying forms is visible.

Channel and Volcanic Materials

Ma'adim Vallis and Al-Qahira Vallis are more than 500 km long and as much as 20 km wide; they compare in size to some of the other major channels on Mars. Both have morphologic characteristics of terrestrial river beds, including the well-developed dendritic tributaries that constitute an integrated river system. Topographic contours (U.S.G.S., 1976) also suggest that separate drainage basins once existed for each of these large channels. Gradients for each channel are high, about .007 over the central 300 km of their length; this is about two times that of the Colorado River, over 450 km of its upper course. In places, some tributaries and smaller channels are discontinuous, perhaps indicating burial by more recent material or possibly subsurface diversion through fissures or lava tubes.

Apollinaris Patera is morphologically intermediate in age between the large shield volcanoes of the Tharsis region (Carr, 1975) and those around the Hellas basin (Potter, 1976). The large summit caldera (75 km) of Apollinaris is complex, consisting of at least three coalescing collapse depressions. The outer flanks of the volcano are relatively gentle but steepen abruptly toward the crest. They show the characteristic striated radial texture formed by many lava channels. A prominent scarp partly encloses the structure except on the south side where, if it once existed, it is now covered by later and possibly less viscous flows.

Crater Materials

Craters are classified by their morphologic characteristics into relative age groups. Like other topographic features on the surface of the planet, they become subdued by erosional processes with time. Small craters are degraded more rapidly than are larger ones. For this reason, together with the probable variation in the intensity and rate of erosion from place to place, direct correlations between relative age and crater morphology cannot be made. In general, however, young craters have sharp, fresh-appearing, continuous rim crests and relatively wide ejecta blankets; their floors are bowl shaped or have rough surfaces commonly marked by a large peak or group of hills near their centers. With time, these attributes are modified, and old craters have smooth floors produced by infilling of eolian deposits and debris slides from crater walls. Central peaks are eroded away or buried, and rim crests become rounded and discontinuous. Some craters are so completely degraded that only vague circular outlines remain; these are shown on the map by a special symbol.

Several craters in the southern part of the map area have small depressions rather than peaks near the central part of their floors. They otherwise resemble normal impact craters in this region and elsewhere on Mars; the origin of the depressions, unless they are themselves impact craters, is not known.

STRUCTURE

The boundary between plains and plateau materials in the Aeolis Mensae region of the quadrangle is marked by a series of northwest-trending linear escarpments. They are parallel to major faults mapped in the Elysium quadrangle to the north (Scott and Allingham, 1976). The scarps probably represent fault and fracture systems along which the highlands are being eroded and retreating to the southwest. A subordinate set of northeast-striking fractures have produced blocky, rectangular tablelands as isolated remnants of the main plateau. The northeast structural trends are better developed elsewhere on the plateau, as shown by the straight parallel walls of Al-Qahira Vallis and other smaller channels whose courses are probably controlled by faulting.

GEOLOGIC HISTORY

A cratering episode early in the post-accretional history of Mars is recorded in the hilly and cratered terrain of the southern highlands. This episode presumably occurred after any early melting stage of the planet's surface had taken place, as the crustal rocks had sufficient strength to retain crater forms and other local variations in relief. Volcanism on a regional scale occurred after the period of high impact flux. Large areas within the hilly and cratered material were buried by lava flows and ash, leaving smooth, flat intercrater surfaces and the projecting rims of many large craters. These surfaces are represented by the cratered plateau and plateau materials. Sources of the lava flows are unknown; probably they were extrusions from fissures. Tectonism during and after this period of volcanic activity produced crustal extension and uplift of the present highlands along a northwest-trending zone; initially this fault zone separating the lowlands and highlands was farther to the northeast. Subsequent erosion and scarp retreat concomitant with deposition of the highlands left large areas of the lowlands covered by rolling plains and the shield, Apollinaris Patera.

The later stages of martian history in the Aeolis region are distinguished only by a light flux of small impacts and continuous erosion and deposition by the wind.

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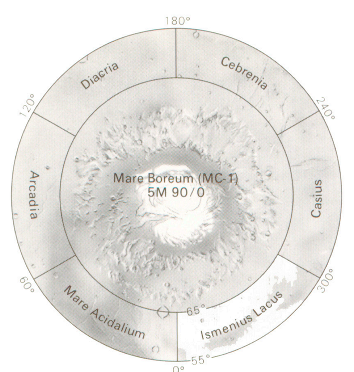
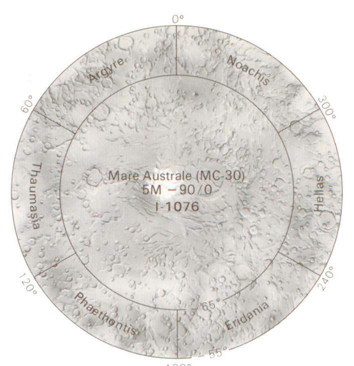
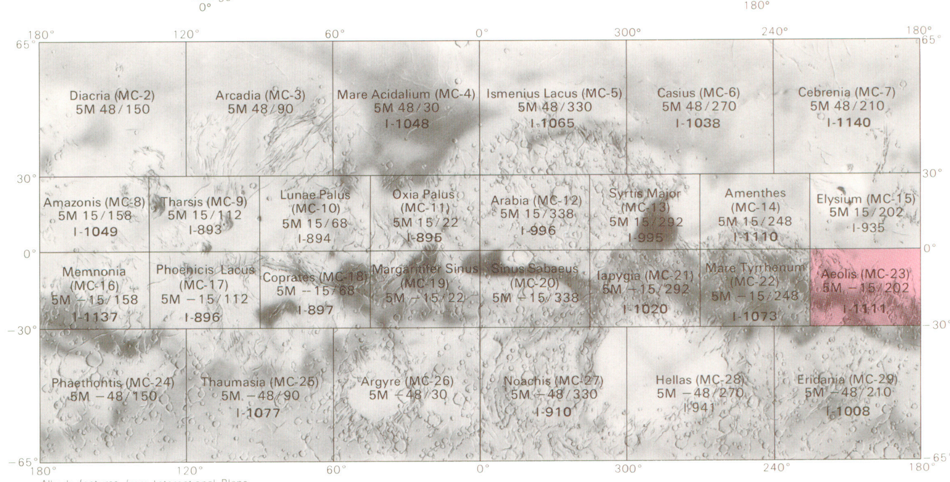
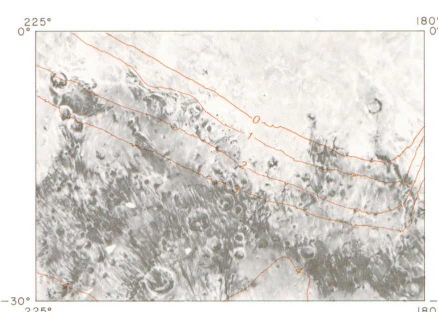


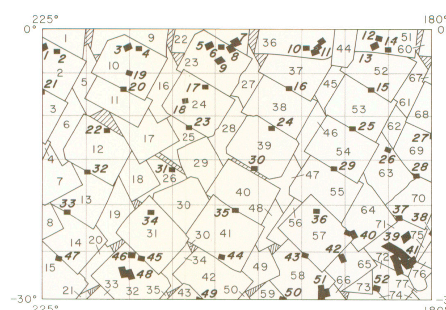




QUADRANGLE LOCATION
Number preceded by I refers to published geologic map



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



INDEX TO MARINER 9 PICTURES
The mosaic used to control the positioning of features on this map was made with the Mariner 9 A-camera pictures outlined above, identified by vertical numbers. Also shown (by solid black rectangles) are the high-resolution B-camera pictures, identified by italic numbers. Useful coverage is not available in the cross-hatched areas. The DAS numbers may differ slightly (usually by 5) among various versions of the same picture.

A camera pictures

High-resolution B camera pictures

GEOLOGIC MAP OF THE AEOLIS QUADRANGLE OF MARS

By

David H. Scott, Elliot C. Morris, and Mareta N. West

1978

For sale by Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202, and Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225