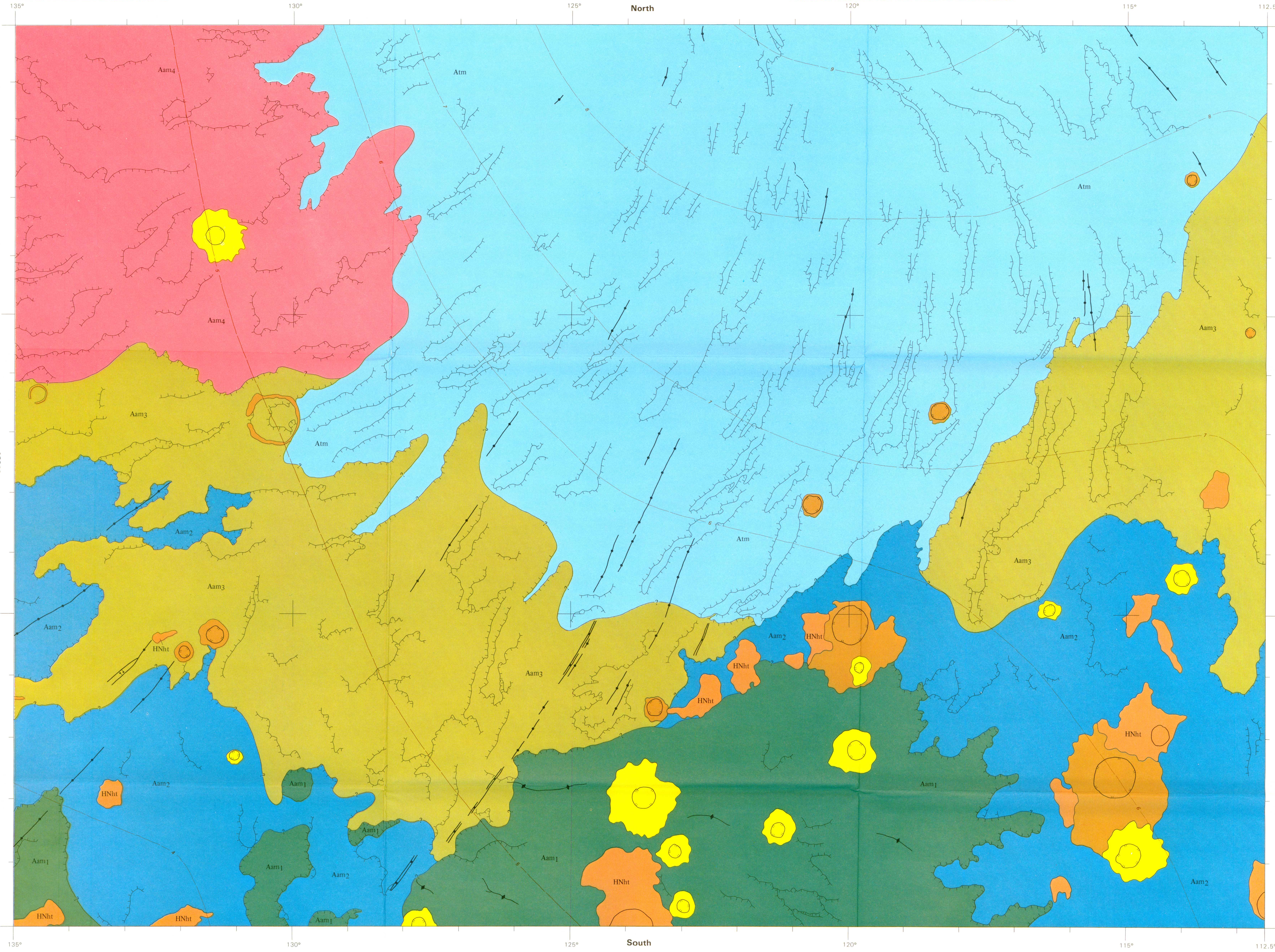
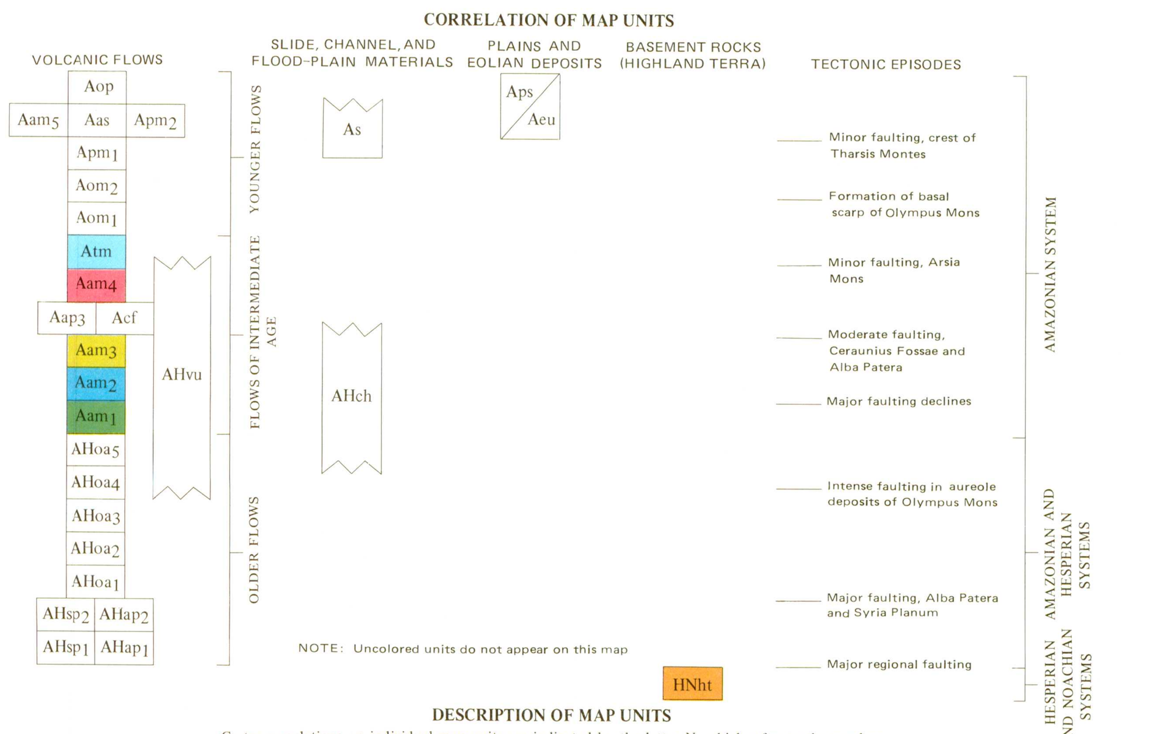
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:2,000,000 GEOLOGIC SERIES
PHOENICIS LACUS SOUTHWEST
I-1275 (MC-17 SW)



Interior—Geological Survey, Reston, Va.—1981—G80232



DESCRIPTION OF MAP UNITS

Crater populations on individual map units are indicated by the letter N, which refers to the number of craters counted larger than 1.0 km in diameter, normalized to an area of 1 million km^2.

VOLCANIC FLOWS

YOUNGER FLOWS

Aop — OLYMPUS PLAINS FLOWS—Occur around basalt scarp of Olympus Mons. Surfaces relatively smooth with many lobate scarps; crater density very low (N ~ 90). Overlap all adjacent units including flows from Olympus Mons (units Aom$_1$, Aom$_2$). In places elongate tongues are centered along fissure systems in plains east of Olympus Mons. *Interpretation:* Youngest lava flows in Tharsis region; extruded from faults and fissures in high plains east of Olympus Mons

Aam5 — ARSIA MONS FLOW UNIT 5—Forms smooth mantles on northeast and southwest upper slopes of Arsia Mons and partly fills caldera. Overlaps Tharsis Montes flows but boundaries between units poorly defined. Crater density very low (N< 100). *Interpretation:* Youngest lava flows from Arsia Mons originating from faulted vents near summit and within caldera

Aas — ASCRAEUS MONS FLOWS—Similar in appearance and occurrence to youngest flow units from Arsia Mons and Pavonis Mons. *Interpretation:* Youngest flows from Ascraeus Mons

Apm2 — PAVONIS MONS FLOW UNIT 2—Occurs on northeast and southwest sides of Pavonis Mons and inside caldera. Similar in appearance and occurrence to Arsia Mons flow unit 5. *Interpretation:* Youngest flows from Pavonis Mons

Apm1 — PAVONIS MONS FLOW UNIT 1—Occurs on northwest side of Pavonis Mons. Lobate flow fronts visible in places. Overlies Tharsis Montes flow unit but is overlapped by slide material. Crater density low (N = 100-200). *Interpretation:* Young fissure flows from Pavonis Mons; older than landslide deposits

Aom2 — OLYMPUS MONS POSTSCARP FLOWS—Form complex interdigitated lobes and tongues with channels and levees; extend down flanks of Olympus Mons and across prominent basal scarp on north, east, and south sides of volcano; overlapped by Olympus plains flows in places. Crater density low (N < 300). *Interpretation:* Lava flows originating from crestal area and flanks of Olympus Mons after formation of basal scarp

Aom1 — OLYMPUS MONS PRESCARP FLOWS—Small patches largely inferred along upturned edges of basal scarp on northwest and southeast side of Olympus Mons. Mapped where lava flows extending down flanks of volcano are sharply truncated in places along scarp, or where older appearing surfaces occur as windows within younger flows (unit Aom$_2$). *Interpretation:* Lava flows extruded before scarp formed at base of Olympus Mons

FLOWS OF INTERMEDIATE AGE

Atm — THARSIS MONTES FLOWS—Form elongate lobes extending downslope from upper parts of Arsia, Pavonis, and Ascraeus Montes (collectively referred to as Tharsis Montes). Overlap and appear topographically sharper than other flows (units Aam$_2$, Aam$_3$, Aam$_4$) exposed on lower flanks of Arsia Mons. Cut by few faults. Crater density range, N = 430-570. *Interpretation:* Late-stage lava flows extruded from Arsia, Pavonis, and Ascraeus Montes

Aam4 — ARSIA MONS FLOW UNIT 4—Occurs on flanks and lower western and northern slopes of Arsia Mons. Similar to Tharsis Montes flows (unit Atm) but more subdued and lobate tongues broader; minor faulting. Albedo variable, low to high. Very high resolution frames show surface ridges subparallel to lobate frontal scarps. Crater density range, N = 660-840. *Interpretation:* Relatively young lava flows extruded from flanks and possibly crestal area of Arsia Mons

Aap3 — ALBA PATERA FLOW UNIT 3—Occurs around and within central caldera. Flows bury and partly bury many ring and radial structures but are cut by others. Channels with levees common along crests of narrow elongate flows. Crater density range, N = 675-1000. *Interpretation:* Youngest lava flows erupted from caldera and fissures during period of intense faulting around central part of Alba Patera

Acf — CERAUNIUS FOSSAE FLOWS—Extend southwesterly from highly fractured and faulted region of Ceraunius Fossae. Flows cover or partly cover large areas within fracture zones and overlie Alba Patera flow unit 2 (AHap$_2$) but are overlapped by Olympus plains and Tharsis Montes flows. Crater density range, N = 850-1150. *Interpretation:* Lava flows extruded from fissures of Ceraunius Fossae and probably other fissure systems northwest of Pavonis Mons

Aam3 — ARSIA MONS FLOW UNIT 3—Embays highland terrain along west basal slopes of Arsia Mons and along Claritas Fossae. Lobate fronts and ridges less prominent but faults more common than those in Arsia Mons flow unit 4. Crater density range, N = 1300-1500. *Interpretation:* Lava flows of intermediate age extruded from fissures in flanks of Arsia Mons

Aam2 — ARSIA MONS FLOW UNIT 2—Occurs on south and southeast flanks of Arsia Mons. Embays highlands and is partly overlapped by unit above and by Tharsis Montes flows. Crater density range, N = 1370-1630. *Interpretation:* Lava flows of intermediate age extruded from fissures in flanks of Arsia Mons

Aam1 — ARSIA MONS FLOW UNIT 1—Occurs as relatively small narrow patch on southwest side of Arsia Mons; embays highland terra. Crater density range, N = 1730-1970. *Interpretation:* Oldest exposed lava flows from Arsia Mons

OLDER FLOWS

AHvu — VOLCANIC MATERIAL, UNDIVIDED—Forms central prominences of large and small low-relief volcanoes in Tharsis region. Stratigraphic relations indicate a wide range in age for the group. Some small volcanoes may be relatively young, whereas moderate and larger sizes are overlain in places by several flow units. Crater density determinations are not reliable because small volcanic craters and pits occur on the host structures. *Interpretation:* Shield volcanoes formed by the accumulation of lava flows around a central vent throughout extended periods of volcanism in the Tharsis region

AHoa5, AHoa4, AHoa3, AHoa2, AHoa1 — OLYMPUS MONS AUREOLE UNITS 5-1—Occur as a series of large overlapping semicircular lobes surrounding Olympus Mons. Described and interpreted by Morris and Dwornik (1978) as lava flows extruded prior to construction of Olympus Mons. Flows are transected by numerous grooves; therefore, relative ages based on normal crater-retention rates are unreliable. Considered as a group they are older than Arsia Mons flow unit 4 but younger than Alba Patera flow unit 1. Their stratigraphic placement among other flows is based partly on morphology and is somewhat arbitrary. Recent studies by Morris (oral communication, 1980) support an ash-flow origin for the aureoles

AHsp2 — SYRIA PLANUM FLOW UNIT 2—Occurs around depression in crestal area of Syria Planum. Long narrow flows and sheet type flows common; few channels. Partly covers fault systems associated with Claritas Fossae. Transected in places by troughs of Noctis Labyrinthus. Gradational with Syria Planum flow unit 1. Crater density range, N = 1800-2400. *Interpretation:* Lava flows younger than fault systems associated with Claritas Fossae but older than fractures of Noctis Labyrinthus. Flows may have been extruded from caldera near present summit of Syria Planum

AHap2 — ALBA PATERA FLOW UNIT 2—Extends more than 1000 km in places from younger flows (unit Aap$_3$) covering central part of Alba Patera. Sheet type flows common; some channels with levees. Transected by many radial and ring fractures. Embays terra of Acheron and Ceraunius Fossae. Gradational with Alba Patera flow unit 1. Same relative age as unit above. Crater density range, N = 1800-2400. *Interpretation:* Volcanic flows from early eruptions of Alba Patera

AHsp1 — SYRIA PLANUM FLOW UNIT 1—Occurs around base of Syria Planum. More highly fractured and flow lobes more subdued but similar in appearance to Syria Planum flow unit 2; boundary only approximately located. Crater density range, N = 2400-3200. *Interpretation:* Older flows from flank and crestal areas of Syria Planum

AHap1 — ALBA PATERA FLOW UNIT 1—Similar to Alba Patera flow unit 2 but flow lobes less defined. Boundary with plains materials in northern lowlands not distinct. Embays terra of Acheron Fossae but is overlapped by Olympus Mons aureole unit 3. Originates primarily at Alba Patera where it is cut by peripheral fissure and fault systems, but includes localized, coeval flows apparently extruded radially from the center of a concentric volcano-tectonic feature at 28° N., 126° W. About same relative age as unit above. Crater density range, N = 2400-3200. *Interpretation:* Earliest exposed lava flows from Alba Patera and possibly from other northern eruptive center(s)

SLIDE, CHANNEL, AND FLOOD-PLAIN MATERIALS

As — SLIDE MATERIAL, UNDIVIDED—Occurs on northwest slopes of Olympus Mons, Arsia Mons, Pavonis Mons, Ascraeus Mons, and within Noctis Labyrinthus. Forms large thin lobes having many concentric ridges and troughs. Lava flows clearly visible beneath slide deposits at some places but partly cover slide material elsewhere. Consists of smooth and rough facies but mapped as undivided unit. *Interpretation:* Landslide and debris flows; around volcanoes mass movement activated by melting of ground ice and thixotropy induced by seismic shaking associated with volcanism

AHch — CHANNEL AND FLOODPLAIN DEPOSITS—Cover floor of Mangala Vallis and adjacent floodplains; smaller occurrences elsewhere. Smooth, relatively flat, with raised tear-shaped forms oriented subparallel to valley. Buries partly or completely the faults and fractures that transect adjacent highlands. No lobate fronts observed. Crater density range, N = 850-1150. *Interpretation:* Alluvial deposits of Mangala Vallis and its tributary channels, and restricted occurrences elsewhere

PLAINS AND EOLIAN DEPOSITS

Aps — SMOOTH PLAINS MATERIAL—Occurs chiefly in low areas and forms light, relatively flat surfaces. In places textural characteristics of substrate visible on high-resolution images. *Interpretation:* Thin mantle of windblown material

Aeu — EOLIAN MATERIAL, UNDIVIDED—Forms broad low hills north and west of Mangala Vallis; smooth rolling surfaces, striated in places along margins. Encroaches on and partly buries adjacent units and landforms. In other areas occurs as broad, relatively level plains that appear rough and striated on moderate-resolution images. Crater density low. *Interpretation:* Includes both depositional and erosional surfaces formed by wind; may have originated as ash-flow deposits

BASEMENT ROCKS

HNht — TERRA MATERIAL, UNDIVIDED—Occurs as both rough- and smooth-fractured areas of relatively elevated terrain throughout Tharsis region; forms semicircular ring of Acheron Fossae. Embayed by all other units. Generally highly cratered, but apparent density of craters varies with degree of fracturing. *Interpretation:* Rough surfaces represent ancient crustal material consisting of volcanic flows and ejecta debris from unknown sources. Smooth surfaces probably mantled by older flows before fractures formed. Around Acheron Fossae represents rim material of old caldera predating Alba Patera

NOTE: INDIVIDUAL MAPS MAY NOT SHOW ALL SYMBOLS

Contact—Queried where location uncertain

Individual flow unit—Line marks crest; hachures extend down lobate frontal scarp. Dashed where mantled by slide material. Represents contact in places

Fault or narrow graben—Bar and ball on downthrown side. Dashed where partly buried

Streamlines—Indicate flow directions where individual units not mapped

Small channel—Volcanic or fluvial origin

Escarpment around Olympus Mons—Line marks crest; dashed where buried. Represents contact in places

Scarp—Line at base, barb points downslope. Represents contact in places

Ridge crest—Represents contact in places

Trough

Caldera or rimless depression

Impact crater rimcrest—Represents contact in places

Impact crater larger than 10 km diameter—Relative age not determined but younger than map unit on which superimposed

Impact crater larger than 10 km diameter—Older than surrounding map unit

Impact crater outline on terra material

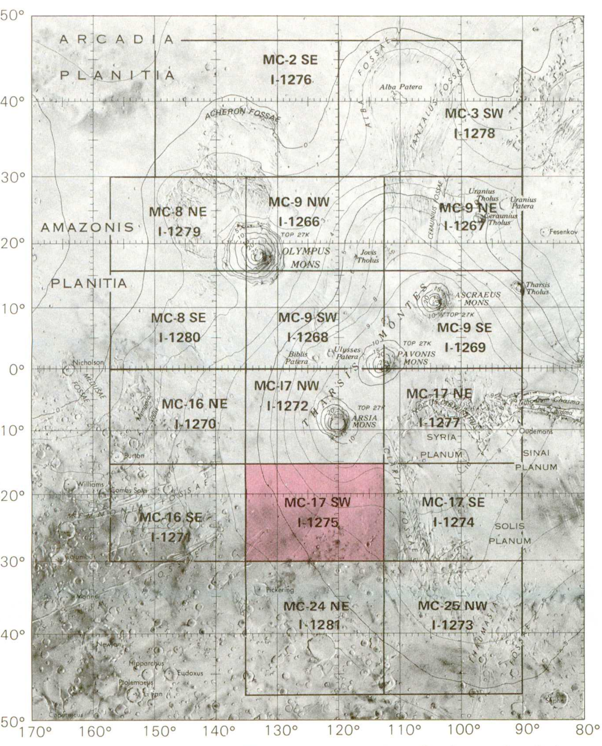
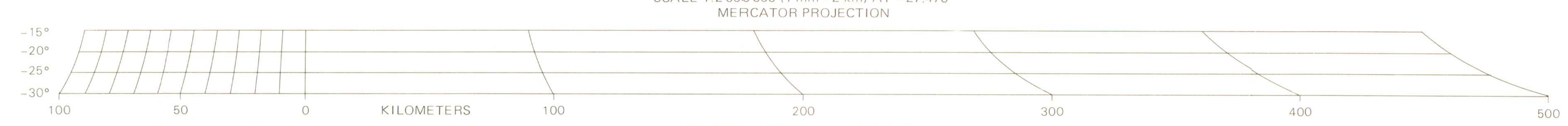


FIGURE 1—Index map of the Tharsis volcanic province showing quadrangle locations. The number preceded by I refers to published 1:2,000,000 geologic map

SCALE 1:2 000 000 (1 mm = 2 km) AT −27.476°
MERCATOR PROJECTION



CONTOUR INTERVAL 1 KILOMETER

Prepared on behalf of the Planetary Geology Program, Planetary Division, Office of Space Science, National Aeronautics and Space Administration under contract W-13,709

Geology mapped in 1979-1980

Topography generalized from 1976 data

INTRODUCTION

The systematic mapping of lava flow units in the Tharsis region has been compiled into a series of 16 maps at 1:2,000,000 scale. This work provides information on the sources and areal extent of the lava flows, on their eruptive sequences and relative ages, and on relations between the flows and geologic structure in the largest, most active tectonic and volcanic province on Mars. Some of the maps were made from controlled Viking photomosaics published as quarter quadrangles in the Atlas of Mars Topographic Series (U.S. Geological Survey, 1979) and tied to the Viking control net. Where these photomosaics were not available, larger scale catalog photomosaics tied to the Mariner 9 control net were used. These maps were subsequently reduced to the 1:2,000,000 scale, but slight discrepancies may occur in places between features referred to coordinates on the two types of bases.

Mariner 9 orbital images of the region show a few major flow units, mapped around Olympus Mons by Carr (1975) and by Morris and Dwornik (1978), around Arsia Mons by Masursky, Dial and Strobell (1978), and around Alba Patera by Wise (1979). However, flow lobes characteristic of individual lava extrusions were difficult to recognize on the wide-angle A-camera frames used for geologic mapping. With the acquisition of moderate- and high-resolution pictures from the Viking mission, numerous individual lava flows in the Tharsis region were identified and mapped in detail over large areas (Schaber and others, 1978; Scott and others, 1979). Although the geologic investigation was mostly directed toward the mapping of lava flows and the determination of their eruptive sequences, structural features such as faults, fractures, and the basal scarp around Olympus Mons were also mapped and dated relative to the flow units. In this way a sequence of tectonic episodes was determined in conjunction with the major volcanic events.

The Tharsis volcanic province as defined in this study covers some 18 million square kilometers. It is approximately rectangular, extending from lat 40° S. to lat 45° N. between long 90° and long 155° (fig. 1). Within this province occur the four largest and youngest volcanoes on Mars: Olympus Mons, Arsia Mons, Pavonis Mons, and Ascraeus Mons; the latter three collectively form the large elevated area named the Tharsis Montes. Other major physiographic and structural features are Alba Patera, an ancient low-relief volcano of great size; Acheron Fossae, thought to be a volcano-tectonic structure, possibly similar to Alba Patera, but older; and Syria Planum, a very large domical uplift southeast of the Tharsis Montes.

The relative ages of major eruptive sequences were determined mainly by their stratigraphic relations and by morphology of the flows. Crater counts on the various units were made to verify these age relations and to obtain some degree of correlation between flows in widely separated areas where overlap relations could not be established. Crater size-frequency distributions were calculated from crater counts on moderate-resolution (180-280 m/pixel) frames. In general, counts were made only within units having boundaries defined by standard photogeologic techniques. Craters with subdued or modified morphologies possibly indicative of preflow origin were not counted. Sources of error in crater counts included variations in cloud cover, sun-elevation angle, and resolution in images of different scales. Statistically valid data were obtained by counting craters within large areas of individual flows or geologic units; these areas range from about 36,000 km^2 to 176,500 km^2. All units have been assigned to the martian time-stratigraphic systems shown on the 1:25,000,000- scale map of Mars (Scott and Carr, 1978). Differences between these assignments and those on the small-scale map of the planet reflect revisions introduced by the detailed mapping.

GEOLOGIC SUMMARY

Martian lava flows are similar in morphology to those on Earth and the Moon. They commonly exhibit overlapping, lobate, and crenulated margins and occur chiefly as sheet flows or as channel- and tube-fed flows (Carr and others, 1977). Sheet flows are more common on the plains and on the lower, more gentle slopes of volcanoes. Their surfaces appear flat and smooth at moderate resolution, but at high resolution they exhibit concentric ridge-and-trough patterns subparallel to flow margins. Channel and tube flows are more prevalent on the steeper slopes around volcanoes such as Olympus Mons and Arsia Mons, but also occur on relatively low-relief surfaces at Alba Patera and Ceraunius Fossae. Younger flows have rougher textures than older ones that have been smoothed by erosion and mantled to various degrees by eolian deposits. The martian flows, like those on Earth, originated from the central vents of volcanoes or from radial fissures on their flanks, or from fissures in plains areas far removed from the volcanic edifices. Of the 24 major lava-flow sequences mapped in the Tharsis region of Mars, 13 emanated mostly from two large source volcanoes, Olympus Mons and Arsia Mons. The youngest recognized flows were extruded from large fissures in the high plains east of Olympus Mons and from the summit areas of the Tharsis volcanoes. The oldest flows erupted from calderas and associated fissures in two widely separated localities at Alba Patera (40° N., 110°) and Syria Planum (15° S., 100°): respectively, a large ancient shield volcano and a high-elevation but low-relief dome of regional proportions.

STRATIGRAPHY

Basement and Nonvolcanic Units

Basement rocks (unit HNht) are undivided. They consist of both rough and smooth, highly fractured terrain; hilly and cratered material; and cratered plateau and cratered plains materials that form a large part of the ancient martian highlands (Scott and Carr, 1978). They occur mostly as relatively large blocks embayed and partly buried by various flows. Around the periphery of Olympus Mons, however, these older rocks may be exposed in the basal scarp and as uplifted blocks projecting above the lava flows in places. Some of this material may also represent segments of overlapping aureoles that formerly covered the present site of this volcano and Olympus Mons flows that predate the basal scarp. However, these various units cannot be separately distinguished in such small areas, and most exposed parts of the scarp complex have been mapped as basement material.

Channel and flood-plain deposits and large accumulations of eolian material have been mapped in a few places. They have been relatively dated—stratigraphically and by crater counts—with respect to the Tharsis lava flows and contribute information on climate in the evolutionary history of the region.

Landslides are common around the large volcanoes in the Tharsis region. They occur along and below the basal scarp on the west side of Olympus Mons and on the northwest flanks of Arsia, Pavonis, and Ascraeus Montes. Although the slide material is undivided on the lava flow maps, it consists chiefly of two end members, 1) rough, blocky rockfalls and rockslides near the head of a dislocated area that grade downslope into 2) debris or mudflow deposits that form thin lobate tongues with many narrow ridges concentric to the outermost flow front. These deposits at Arsia Mons and Pavonis Mons are older than flows from the crestal areas of these volcanoes but overlap slightly older flows on their flanks.

Tharsis Lava Flows

The major flow units are grouped very generally into broad relative-age categories. The eruptive sequence appears to have been continuous throughout the volcanic history of the region. Crater densities cited below are the number of craters larger than 1 km in diameter normalized to an area of 1 million km^2.

Older Flows—Alba Patera, Syria Planum, and the Aureoles of Olympus Mons—The flows from Alba Patera and Syria Planum have the highest crater densities, ranging from about 1800 for the youngest to 3200 for the oldest flows at each location. These figures are roughly comparable to those of younger and older lunar maria at the Apollo 11 and 12 sites respectively (Neukum and Wise, 1976). Estimates of the absolute ages of these and other flows vary widely, however, because of inherent uncertainties in the models postulated for martian integrated flux curves used to establish correlations between crater frequency and geologic age (Neukum and Wise, 1976; Hartmann, 1977; Soderblom, 1977).

The younger flows from Alba Patera partly bury some of the radial and concentric fault systems that transect the older lavas. This burial is particularly noticeable within and around the caldera at the crest of the ancient volcano where the late and waning eruptive stages yielded decreasing volumes of lava. The older flows from Alba Patera embay the highly dissected terrain around the east edge of Acheron Fossae in the Diacria quadrangle (MC-2SE). These lavas also might have penetrated the arcuate central part of this volcano-tectonic structure where they may have been overlapped by very young lavas of the Olympus plains and possibly also by the oldest aureole unit surrounding Olympus Mons.

At Syria Planum in the Phoenicis Lacus quadrangle (MC-17SE), the younger flows also occur near the crest of the structural dome. They probably issued from a partly buried calderalike depression or from fissures subsequently obscured by the numerous flows. These lavas also appear to have buried many of the faults and fractures associated with or preceding chasma development along Noctis Labyrinthus. The older flows of Syria Planum embay and partly bury the landforms and faults of Claritas Fossae but are transected by some of the more recent faults. No contacts can be clearly distinguished between the older and younger flow units at either Syria Planum or Alba Patera. The mapped boundaries are speculative and are based mostly on slight variations in morphology as well as crater densities.

The aureoles of grooved and ridged terrain surrounding Olympus Mons are classified with the older group of flows. Their relative ages with respect to most other flow units in the Tharsis region can be only broadly determined. Stratigraphic relations clearly show that the aureoles are overlapped by the flows of Olympus plains and the postscarp extrusives of Olympus Mons. There is some evidence, but less certain, that the aureole deposits may be overlapped in places (MC-9SW) by the Tharsis Montes flows. Craters are of little value as age determinants because the ridged and grooved surfaces of the aureoles promote rapid deterioration of crater forms by mass wasting; their crater densities are abnormally low, for example, compared with younger adjacent plains that embay the aureoles in places. Morphologically, the aureoles seem to be older than most flows in the Tharsis region. On the basis of stratigraphic evidence and morphology, the aureole units of Olympus Mons are provisionally placed just above the Alba Patera and Syria Planum lavas in the eruptive sequence.

Flows of Intermediate Age—Tharsis Montes, Alba Patera, and Ceraunius Fossae—This group of lava flows has the greatest range in crater densities—from about 430 to 1970, overlapping slightly with those in the older category. Many of the flow units originated from Arsia Mons (fig. 1) and are exposed from the upper to the lower slopes of the volcano. These flows show the greatest diversity in surface characteristics as well as in relative ages. The lower, older flows around Arsia Mons are more subdued by erosion and eolian mantles than the younger and generally higher units. It is not known if this condition applies at higher elevations where thermal inertias and residual temperatures decrease rapidly and are possibly indicative of fine particulate dust blankets (Kieffer and others, 1977). The most extensive lavas mapped from Tharsis Montes are relatively featureless, and boundaries between flows originating from Arsia Mons, Pavonis Mons, and Ascraeus Mons cannot be recognized. Crater counts indicate that they are approximately the same age and they are mapped as a single unit (Atm).

The most recent volcanic activity at Alba Patera has occurred within the broad, relatively flat, summit area. Flows from within and around the caldera have buried many fissures developed from earlier tectonism.

The Ceraunius Fossae lavas originated from the complex fracture systems of that region and subsequently buried many of the fissures from which they were extruded. They extend southwesterly from their source area across the lava flows from Alba Patera and embay part of the highland terrain between Olympus Mons and Tharsis Montes. Some may have erupted from fissures in this highland region. They are overlapped, in turn, by younger flows from Tharsis Montes and from Olympus plains.

Younger Flows—Olympus Mons, Olympus Plains, and the Volcanoes of Tharsis Montes—Crater densities for this group of extrusives range from about 90 to 350. They originated from the flanks and summit of Olympus Mons, from fissures in the plains east of the volcano, and from the crestal areas of Arsia, Pavonis, and Ascraeus Montes. Stratigraphic relations are clearly defined between the flows of Olympus Mons and those of the adjacent plains. These plains partly encircle Olympus Mons on the east within a topographically low area between the volcano and its aureole deposits. To the west of Olympus Mons no evidence exists of well-defined young flow fronts. Prescarp flows in this area are either buried by eolian material or are so deeply eroded as to be unrecognizable. Postscarp lava flows either did not occur on the west side of Olympus Mons or were of such small volume that they were unable to surmount the upturned edges of the scarp. Boundaries between pre- and postscarp flow units on Olympus Mons are not distinct. Crater counts indicate that two slightly different age groups may be present, but the validity of the data is limited by difficulties in selecting representative areas for each unit and errors inherent in distinguishing between small impact and indigenous craters on the flanks of a volcano. Evidence that prescarp lava flows exist is shown in places by flow lines sharply truncated at the scarp and by exposures of more mature surfaces in windows along its raised edge. Alternatively, vertical displacements producing the basal scarp around Olympus Mons may have occurred episodically. Intermittent lava flows down the flanks of the volcano throughout the interval of scarp formation could result in the present configuration of prescarp and postscarp flows in different places.

Flows from near the summits of Arsia Mons, Pavonis Mons, and Ascraeus Mons are among the youngest in the Tharsis region. They appear to be relatively thin, with smooth surfaces and indistinct flow fronts; their boundaries with other units are difficult to define. These lava flows originated from large fractures and fissures along northeast—southwest faults transecting the crestal areas of the Tharsis Montes volcanoes.

STRUCTURE

Tectonism, as expressed by fractures and faults, culminated before the bulk of the lava flows in the Tharsis region were extruded. It did not cease altogether, however, but continued with diminishing intensity into the period of the youngest flows (Scott and Tanaka, 1980). Early episodes of major faulting were responsible for the highly disrupted surfaces at Claritas, Acheron, Ceraunius, and Memnonia Fossae. Faulting continued in these areas at lesser scales and also at Alba Patera, on the Olympus plains, and on the flanks of Arsia Mons. The density of faults associated with individual flow units, like crater density, reflects their relative ages. A summary of tectonic episodes as they relate to major volcanic events is shown in the Correlation of Map Units.

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MAP SHOWING LAVA FLOWS IN THE SOUTHWEST PART OF THE PHOENICIS LACUS QUADRANGLE OF MARS

By
D.H. Scott, G.G. Schaber, and A.L. Dial, Jr.
1981

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