U.S. DEPARTMENT OF THE INTERIOR
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:1,000,000 GEOLOGIC SERIES
OLYMPUS MONS REGION
M 1M 19/134 G, 1994
MAP I-2327 (SHEET 2 OF 2)
Explanatory pamphlet accompanies map

NORTH

WEST

EAST

SOUTH

OLYMPUS MONS

SCALE 1:1 000 000 (1mm=1 km) AT LONGITUDE 134°
TRANSVERSE MERCATOR PROJECTION

25 0 25 50 75 100 KILOMETERS

CONTOUR INTERVAL 200 METERS
CONTOURS DASHED WHERE APPROXIMATE

Base (unpublished) by U.S. Geological Survey

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A A′
KILOMETERS

MAGMA CHAMBER

VERTICAL EXAGGERATION X2

SCHEMATIC CROSS SECTION

GEOLOGIC MAPS OF THE OLYMPUS MONS REGION OF MARS

By
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1994

CORRELATION OF MAP UNITS

APRON MATERIALS	NORTHERN PLAINS ASSEMBLAGE	THARSIS ASSEMBLAGE	HIGHLAND MATERIALS	SYSTEM	SERIES	NO. CRATERS LARGER THAN 1 KM DIAM. PER 10^6 KM²
Aar, Ash, Aab, Aas	MEDUSAE FOSSAE FORMATION: Amf, Ams, Amp; ARCADIA FORMATION: Aa3, Aa1	OLYMPUS MONS Caldera members: Aoc4, Aoc3, Aoc2, Aoc1; Plains member: Aop; Shield members: Aos4, Aos3, Aos2, Aos1; Aureole members: Aoau, Aoam$_c$, Aoam$_b$, Aoam$_a$, Aoal; Scarp members: AHosc, HNosc; THARSIS MONTES FORMATION: Atm; CERAUNIUS FOSSAE FORMATION: Acf; ALBA PATERA FORMATION: Aam, Hal; HALEX FOSSAE ASSEMBLAGE: Hhp, Hhh, Hhf	Fractured plains material: Hf; ACHERON FOSSAE ASSEMBLAGE: Nap, Nam, Naf	AMAZONIAN	Upper	10
					Middle	25, 50, 100
					Lower	200, 400, 800
				HESPERIAN	Upper	1600
					Lower	
				NOACHIAN	Upper	
					Middle	

DESCRIPTION OF MAP UNITS

Geologic units are identified according to morphologic, stratigraphic, and albedo characteristics following conventional techniques developed for planetary geology (Wilhelms, 1987, chapter 9; Tanaka and others, 1992). Many formal and informal geologic maps of the Olympus Mons region have been produced on a variety of map bases from either Mariner 9 or Viking images. Because of the great improvement in the quality and resolution of Viking images, we compare our map units only with those of Viking-based studies.

The earliest formal, Viking-based mapping was a 1:2,000,000-scale lava-flow map series of the Tharsis region (Scott and others, 1981). These maps were prepared before some of the photomosaic bases were compiled and before the Viking dataset was complete. However, the series contained the first detailed mapping that applied time-stratigraphic units. Next, Tanaka (1983) produced an informal map at 1:3,000,000 scale on a reduced version of the 1:2,000,000-scale map base used here and analyzed the geologic history of the region in detail. Finally, Scott and Tanaka (1986) mapped the entire western equatorial region of Mars and reanalyzed the stratigraphy of the units according to a new system based on crater densities; the system was further elaborated by Tanaka (1986). On Scott and Tanaka's map, the map units were organized in a hierarchal scheme and formal geologic names, such as the Olympus Mons Formation, were defined. We generally follow the conventions set forth on that map, except where modifications or added details are necessary. Our map unit symbols can be compared with those of the previous maps listed in table 1.

APRON MATERIALS

[Commonly form lobate deposits along scarps]

Aar **Ridged material**—Large, thin lobes with long, even, concentric ridges and troughs extending westward from scarp of Olympus Mons. *Interpretation:* Fluidized distal debris flows originating from collapse and disintegration of scarp, perhaps activated by melting of ground ice

Aah **Hummocky material**—Rough parts of lobate deposits extending westward from Olympus Mons scarp; includes irregular longitudinal ridges, grooves, pits, and hummocky terrain. Generally near head or center of lobate deposits. *Interpretation:* Proximal slide deposits made up of large blocks of scarp material

Aab **Blocky material**—Large blocks or hummocky masses; some outcrops have transverse ridges. Mapped along base of northwestern and northern parts of Olympus Mons scarp. *Interpretation:* Landslide slump blocks detached from scarp by rotational and translational movements

Aas **Smooth material**—Relatively smooth material having lineations parallel with upper margins. Occurs in high-relief areas of Acheron Fossae north of lat 35° N. *Interpretation:* Product of periglacial mass wasting of ice-rich slope materials

NORTHERN PLAINS ASSEMBLAGE

[Materials deposited in northern lowlands]

Medusae Fossae Formation—Consists of thick, extensive, relatively flat sheets; smooth to grooved and gently undulatory; albedo moderate; sparsely cratered; south and west of Olympus Mons. Members distinguished by morphology

Amf **Rolling plains member**—Forms broad, low hills and smooth rolling surfaces; outliers form flat-topped, steepsided mesas, some roughly circular with irregular central pits or depressions; sparsely cratered. Embays and overlies aureole materials; grades into and overlies striated member and is overlain by some landslides. *Interpretation:* Possibly eolian material, but irregularly shaped and elliptical craters several kilometers long may be source vents for some pyroclastic material. Surfaces both depositional and erosional

Ams **Striated member**—Forms broad rolling or level plains; characterized by sets of aligned streamlined ridges and grooves; sparsely cratered. Buries parts of aureoles of Olympus Mons. *Interpretation:* May be extensive pyroclastic deposits marked by yardangs formed by eolian erosion along joints

Amp **Pitted member**—Characterized by crescent-shaped pits. Buries part of lower aureole member of Olympus Mons Formation. *Interpretation:* Friable eolian and perhaps pyroclastic material; pits may be eolian blowouts

Arcadia Formation—Low-lying plains material in Amazonis and Arcadia Planitiae west and north of Olympus Mons. Members distinguished on basis of morphology; members 2, 4, and 5 not mapped in this region

Aa3 **Member 3**—Relatively flat, featureless surface; few lobate flows recognized in southern Amazonis Planitia; sparsely cratered; locally mantled. *Interpretation:* Lava flows interbedded with and locally overlain by eolian material

Aa1 **Member 1**—Broad, rugged, incised lobate flows partly buried by mantle of smooth material. *Interpretation:* Relatively thick volcanic flows, possibly pyroclastic. Mantle probably eolian

THARSIS ASSEMBLAGE

[Rocks of Tharsis region; most interpreted to be volcanic]

Olympus Mons Formation—Consists of Olympus Mons caldera, plains, shield, aureole, and scarp members

Aoc4, Aoc3, Aoc2, Aoc1 **Caldera members 1–4**—Floor materials of coalesced collapse craters that make up composite summit caldera of Olympus Mons. Marked by grooves, pits, and wrinkle ridges. *Interpretation:* Solidified lava lakes associated with latest summit volcanism and magma-chamber collapse

Aop **Plains member**—Relatively smooth; lobate scarps and tonguelike flow features common in high-resolution (<100 m/pixel) images. Overlaps all adjacent units except perhaps some lower flank flows of Olympus Mons; sparsely cratered. Flows and narrow channels originate from fissures east of Olympus Mons between lat 14° and 17° N.; circular rims and depressions occur along fissures. Floods eastern and southern periphery of Olympus Mons and smaller area on east edge of Acheron Fossae. *Interpretation:* Among youngest lava flows of Olympus Mons, extruded from fissures east of volcano

Shield members—Series of flow units exposed on shield of Olympus Mons. Equivalent to Olympus Mons shield materialsunits Aom$_{1-3}$ and Aom$_4$ of Morris and others (1991)

Aos4 **Shield member 4**—Long, narrow, pristine, tonguelike flows having levees and distinct margins and terminations; sparsely distributed over midflanks of shield. *Interpretation:* Youngest lava flows on flanks of Olympus Mons

Aos3 **Shield member 3**—Long, narrow, leveed flows hundreds of meters to several kilometers across and 10 to more than 100 km long. Relatively smooth radial ridges, as much as 10 km wide and 60 km long, occur in places. Sparsely cratered. Beginnings and terminations of most flows indistinct on flanks, but where flows have extended onto plains many flows terminate in lobate scarps. Flows form anastomosing networks and bury southwestern and northeastern parts of basal scarp. *Interpretation:* Lava flows of postcaryr eruptions. Smooth ridges probably enclose lava tubes formed during prolonged eruptions, which served as distributive centers for many lower flank flows

Aos2 **Shield member 2**—Flows have rough, hummocky surface and relatively low albedo (color enhancement, sheet 1). May be tonguelike with leveed channels, in broad sheets, or indistinct. Sparsely cratered. Member covers most of upper flank of shield. *Interpretation:* Lava flows whose dark color may be due to composition, weathering, or lack of eolian cover

Aos1 **Shield member 1**—Flows have indistinct boundaries or vague, tonguelike outlines. Surface rough to smooth, hummocky. Many irregular to round pit craters (<100 m to 1 km in diameter) in chains and clusters. Dark and light streaks and patches. Moderately cratered. Forms summit of Olympus Mons and some terraces nearby; cut by caldera walls. *Interpretation:* Oldest undeformed lava flows on Olympus Mons. Dark and light streaks may be due to thin covering of eolian material

Aureole members—Sequence of broad, overlapping, lobate, corrugated sheets surrounding Olympus Mons. Origin controversial (see text)

Aoau **Upper aureole member**—Characterized by series of ridges and grooves that roughly parallel outer boundary of deposit. Individual ridge segments are 10 to 50 km long, estimated to be as much as 1 km high, form anastomosing patterns that differ in length and width over different parts of deposit. Ridge patterns interrupted by several sets of intersecting linear or sinuous grooves, which may be grabens or erosional valleys, and long, linear fractures with little displacement. Overlies middle aureole members a, b, and c and lower aureole member

Aoam$_a$ **Middle aureole member a**—Ridges more degraded and have different orientations than adjacent ones in upper aureole member. South half of unit partly buried by Medusae Fossae Formation, but terminus of deposit stands out in clear relief. North half of unit partly buried by upper aureole member, but terminus can be seen where upper member apparently has been eroded away. Overlaps lower aureole member

Aoam$_b$ **Middle aureole member b**—North of Olympus Mons; rests on lower aureole member, overlain by middle member c, and partly buried by upper aureole member; embayed by plains member of formation

Aoam$_c$ **Middle aureole member c**—North of Olympus Mons; rests on middle member b; abuts upper aureole member, whose ridges overlap and truncate ridges of member c

Aoam$_d$ **Middle aureole member d**—Overlies lower aureole member northeast of Olympus Mons; surrounded by flows of plains member

Aoam$_e$ **Middle aureole member e**—Overlies lower aureole member east of Olympus Mons; surrounded by flows of plains member

Aoal **Lower aureole member**—Ridges and knobs generally smaller than those in overlying members; trends of some hills and knobs concentric with or perpendicular to outer edge of deposit. Where well-exposed, ridges are closely spaced (30 to 40 ridges per 100 km). High-resolution images of ridges show aerodynamic shapes similar in form to terrestrial yardangs. Degradation most intense southwest of Olympus Mons. Most extensive aureole deposit; virtually surrounds Olympus Mons. Large areas buried under mantle of plains member south of Olympus Mons

Scarp members—Form basal pedestal of Olympus Mons and covered by shield members; origin controversial (see text)

AHosc **Western scarp member**—Capped by bright, smooth material that in several areas has been stripped off to reveal a layer with corrugated surface similar to that of aureole material but at much smaller scale. At top of scarp, material is exposed at several places dipping toward center of Olympus Mons. In places buried by shield member 3 or degraded as apron material

HNosc **Eastern scarp member**—Consists of rugged blocks bounded by cliffs and ledges. Surface locally planar and cut by grabens. Mapped as fractured plains material (unit HNf) by Morris and others (1991)

Tharsis Montes Formation—Narrow to broad lobate flows; moderately cratered. *Interpretation:* Lava flows extruded from Arsia Mons (fig. 1) or local fissures

Atm **Younger member**—Flows southeast of Olympus Mons; cut by few grabens and faults. Overlies fractured plains material, embays lower aureole member, and is partly buried by Medusae Fossae Formation

AHtm **Older member**—Flows southwest of Olympus Mons partly buried by Medusae Fossae Formation

Acf **Ceraunius Fossae Formation**—Long, lobate flows with levees that extend southwesterly from highly fractured and faulted region of Ceraunius Fossae (fig. 1). Found only near east border of map area. Unit overlies lower member of Alba Patera Formation and is partly buried by plains member of Olympus Mons Formation in map area. *Interpretation:* Lava flows extruded from fissures of Ceraunius Fossae

Aam **Alba Patera Formation**—Extensive flows in northeastern part of map area; upper member not present in map area. *Interpretation:* Lava flows from Alba Patera (fig. 1)

Middle member—Found near northeast corner of map area as distal parts of a few narrow, elongate flows, commonly with leveed channels, that extend nearly 500 km from west flank of Alba Patera. Overlies lower member of formation; cut by few grabens of Alba Fossae (fig. 1); moderate crater density

Hal **Lower member**—Extensive field of lobate flows; moderately cratered. Some flows extend nearly 1,000 km from Alba Patera. Cut by several grabens of Alba Fossae. Embays Halex Fossae and Acheron Fossae assemblages

Halex Fossae assemblage—Materials of slightly elevated area cut by arcuate faults of Halex Fossae; northeast of Olympus Mons

Hhp **Plains unit**—Relatively smooth, moderately cratered plains material. Tonguelike flows extend radially from center of Halex Fossae. *Interpretation:* Late-stage lava flows of old volcanotectonic center

Hhh **Hilly unit**—Low, cone-shaped hills a few kilometers across, some having summit pits. *Interpretation:* Volcanic cones or shields

Hhf **Fractured unit**—Shield material cut by concentric grabens; moderate relief. *Interpretation:* Part of old, broad, deformed volcanic shield

HIGHLAND MATERIALS

[Materials that form or occur on ancient highland crust of Mars]

Hf **Fractured plains material**—Forms smooth plains cut by closely spaced fractures and grabens trending mainly northwest; few flow fronts; moderately well cratered. Occurs southeast of Olympus Mons; overlain by lower aureole and plains members of Olympus Mons Formation and Tharsis Montes flows. *Interpretation:* Forms older lava plains of Tharsis region

Acheron Fossae assemblage—Materials of and encircled by arcuate, heavily fractured mountain chain north of Olympus Mons

Nap **Plains unit**—Smooth, rolling plains material marked by subdued crater rims and wrinkle ridges; well cratered. Recognized within basin surrounded by Acheron Fossae. Overlain by lower aureole and plains members of Olympus Mons Formation. *Interpretation:* Eolian or pyroclastic mantle; may be in part extruded from volcanoes of mountain unit

Nam **Mountain unit**—Three types: (1) irregular small mesas and domes commonly with summit craters along northern and western margins of Acheron Fossae; (2) long, north-northeast-trending ridge with central rift in western Acheron Fossae; and (3) hills overlying structurally complex terrain (for example, at lat 36° N., long 131°). Latter types overlie fractured unit of assemblage. *Interpretation:* Volcanoes formed during fracturing of Acheron Fossae or eroded remnants of thick mantle

Naf **Fractured unit**—Rugged, mountainous, heavily cratered material broken by long, narrow grabens commonly in parallel sets; most craters superposed on fractures. Small channels cut crater walls, flanks of ridges, and rough, hummocky areas. Forms semicircular mountain range more than 700 km long north of Olympus Mons that encloses basin covered by plains unit of assemblage; also embayed by lower aureole member of Olympus Mons Formation. *Interpretation:* Ancient volcanic rocks intensely deformed and fractured by local volcanotectonic activity

Contact—Dashed where approximately located

Fault or graben—Dotted where buried or inferred; bar and ball on downthrown side. On narrow graben, ball either centered between graben-bounding faults or on single line representing closely spaced faults

Fault on cross section (sheet 2)—Arrows show relative movement

Thrust fault—Dotted where buried or inferred; sawteeth on upper plate

Scarp—Dotted where buried; line at top; barb points downslope

Ridge—Line at crest

Lava-flow front—Hachures point away from flow

Depression

Impact crater rim crest

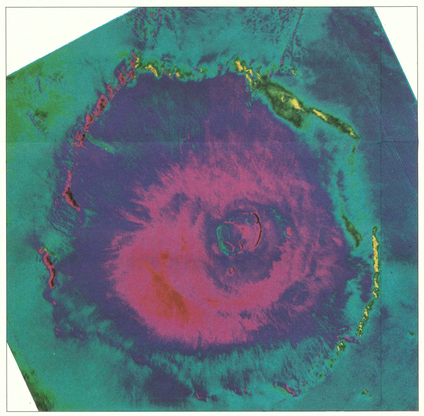
Crater materials—Craters having rims larger than 10 km in diameter are mapped and classified on the basis of their morphologic characteristics. More highly degraded craters are exhumed or are either older or formed in more erodible material than less degraded craters. Crater materials are interpreted to have formed by impacts

c_p **Material of sharp-rimmed craters**—Rims complete, raised, and clearly identifiable; hummocky ejecta or secondary ray craters (not mapped) extend at least one crater diameter from center of crater. Central peaks conspicuous

c_b **Material of rounded-rimmed craters**—Rims complete, raised, and rough where diameter is greater than 30 km. Floors lower than adjacent terrain, rough in craters greater than 30 km and bowl-shaped in craters less than 10 km. Conspicuous central peaks common

c_d **Material of subdued craters**—Rims similar to c_b crater rims but generally have narrow, smooth walls. Floors smooth, flat, lower than adjacent terrain. Central peaks small or absent

c_d **Material of highly degraded craters**—Rims incomplete, largely knobby material. Floors like those of c_c craters but about same elevation as adjacent terrain. Central peaks absent



False-color computer enhancement of Viking Orbiter image 646A28, Olympus Mons. Colors correspond to range of albedo values, from red (lowest albedo) through blue and green to yellow (highest albedo).

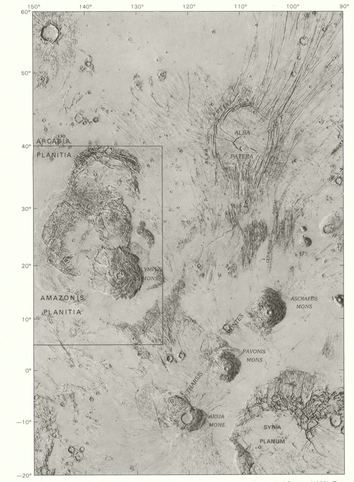


Figure 1. Major features of Olympus Mons region; base from U.S. Geological Survey (1982). Box indicates approximate boundary of geologic map (sheet 1).