

DESCRIPTION OF MAP UNITS

Geologic units are identified according to morphology, stratigraphy, 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, laser maps were compiled and before the mapping that applied time-stratigraphic units. Next, Tanaka (1985) produced an informal map at 1:2,000,000 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 analyzed 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 hierarchical 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
[Common from these deposits along scarp]

- Aar** **Ridged material**—Large, thin lobes with long, even, concentric ridges and troughs extending westward from scarp of Olympus Mons. Interpretation: Flattened distal debris flows originating from collapse and degradation of scarp, perhaps accreted by melting of ground ice.
- Aah** **Hummocky material**—Rough top 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 debris 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 debris blocks detached from scarp by rotational and translational movements.
- Aai** **Smooth material**—Relatively smooth material having lineations parallel with upper margins. Occurs in high-relief areas of Achernon Fossae north of 18°N. Interpretation: Product of periglacial mass wasting of ice-rich slope materials.

NORTHERN PLAINS ASSEMBLAGE
[Materials deposited in northern lowlands]

- Amc** **Medusa Fossae Formation**—Consists of thick, extensive, low-lying flat sheets, smooth to grooved and gently undulating; albedo moderate; sparsely cratered; south and west of Olympus Mons. Members distinguished by morphology.
- Amr** **Rolling plains member**—Forms broad, low hills and smooth rolling surfaces; outcrops are flat topped, steep-sided 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 lavas. 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.
- Amu** **Striated member**—Forms broad rolling or level plains, characterized by sets of aligned streambed ridges and grooves; sparsely cratered. Buried parts of aureoles of Olympus Mons. Interpretation: May be extensive pyroclastic deposits formed by yardangs formed by eolian erosion along joints.
- Amv** **Pitted member**—Characterized by crescent-shaped pits. Buried part of lower aureole member of Olympus Mons Formation. Interpretation: Fragile eolian and perhaps pyroclastic material; pits may be eolian blowouts.
- Amw** **Arcadia Formation**—Low-lying plains material in Amazonis and Arcadia Planities west and north of Olympus Mons. Members distinguished on basis of morphology; members Z, A, and S, not mapped in this region.
- Amx** **Member Z**—Relatively flat, featureless surface; low-lying flows recognized in southern Amazonis Planitia; sparsely cratered; locally mantled. Interpretation: Lava flows interbedded with and locally overlain by eolian material.
- Am1** **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
[Blocks of Tharsis region most interesting to volcanist]

- Ao** **Olympus Mons Formation**—Consists of Olympus Mons caldera, plains, shield, aureole, and scarp members.
- Ao1** **Caldera members 1-4**—Floor materials of coalesced collapse craters that make up composite summit caldera of Olympus Mons. Mantled by grooves, pits, and wrinkle ridges. Interpretation: Subeffusive lavas associated with latest summit volcanism and magma-chamber collapse.
- Ao2** **Plains member**—Relatively smooth, lobate scarp and tongue-like flow features common in high-resolution (C300 m) images. Overlies 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 18° and 17°N; circular craters and depressions occur along fissures. Floods eastern and southern periphery of Olympus Mons and underlies area on east edge of Achernon Fossae. Interpretation: Among youngest lava flows of Olympus Mons, extruded from fissures east of volcano.
- Ao3** **Shield members**—Series of flow units exposed on shield of Olympus Mons. Equivalent to Olympus Mons shield materials (Wilhelms, 1987, chapter 9; Tanaka and others, 1992).
- Ao4** **Shield member 4**—Long, narrow, primitive, tongue-like flows having lobes and distinct margins and terminations; sparsely distributed over millidecades of shield. Interpretation: Youngest lava flows on flanks of Olympus Mons.
- Ao5** **Shield member 3**—Long, narrow, lobed flows hundreds of meters to several kilometers across and 10 to more than 100 m long. Relatively smooth radial ridges, as much as 10 cm wide and 60 cm long, occur in places. Sparsely cratered. Beginnings and terminations of most flows indistinct on flanks, but where flows have extended onto plains many flow terraces in lobate scarp. Flows form anastomosing networks and bury southwestern and northeastern parts of basal scarp. Interpretation: Lava flows of postscaric eruptions. Smooth ridges probably nucleate lava tubes formed during prolonged eruptions, which served as distributive centers for many lower flank flows.
- Ao6** **Shield member 2**—Flows have rough, hummocky surface and relatively low albedo (color enhancement, sheet 1). May be tongue-like with lobed 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.
- Ao7** **Shield member 1**—Flows have indistinct boundaries or vague, tongue-like outlines. Surface rough to smooth, hummocky. Many irregular to round pit craters (C300 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 undisturbed lava flows on Olympus Mons. Dark and light streaks may be due to thin covering of eolian material.
- Ao8** **Aureole members**—Sequence of broad, overlapping, lobate, corrugated sheets surrounding Olympus Mons. Origin controversial.
- Ao9** **Upper aureole member**—Characterized by series of longitudinal ridges. Ridge spacing parallel to shield rim. Individual ridge segments are 10 to 50 km long, estimated to be as much as 1 km high, thin, 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, S, and C, and lower aureole member.
- Ao10** **Middle aureole member**—Ridges more degraded and have different orientations than adjacent ones in upper aureole member. South half of unit partly buried by Medusa Fossae Formation; but terminal part of deeper member exposed in clear relief. North half of unit partly buried by upper aureole member, but terminus can be seen where upper member overlies.
- Ao11** **Lower aureole member**—Overlaps lower aureole member, but terminus can be seen where upper member overlies.
- Ao12** **Middle aureole member**—North of Olympus Mons, rests on middle member; its thin, upper aureole member, whose ridges overlap and truncate ridges of member C.
- Ao13** **Middle aureole member**—Overlies lower aureole member northeast of Olympus Mons, surrounded by flows of plains member.
- Ao14** **Middle aureole member**—Overlies lower aureole member east of Olympus Mons, surrounded by flows of plains member.
- Ao15** **Lower aureole member**—Ridges and knobs generally smaller than those in overlapping members, trends of some hills and knobs concentric with or perpendicular to outer edge of deposit. Where well exposed, ridges are closely spaced (10 to 40 ridges per 100 km). High-resolution images of ridges show anastomosing shapes similar to that in 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.
- Ao16** **Scarp members**—Form basal pedestal of Olympus Mons and covered by shield members; origin controversial (see text).
- Ao17** **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 members 3 or degraded as aeolian material.
- Ao18** **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 H) by Morris and others (1991).
- Ao19** **Tharsis Montes Formation**—Narrow to broad lobate flows, moderately cratered. Interpretation: Lava flows extruded from Anis Mons (fig. 1) or local fissures.
- Ao20** **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 Medusa Fossae Formation.
- Ao21** **Older member**—Flows southwest of Olympus Mons partly buried by Medusa Fossae Formation.
- Ao22** **Ceraninus Fossae Formation**—Long, lobate flows with lobes that extend southward from Olympus Mons from highly fractured and faulted region of Ceraninus Fossae (fig. 1). Found only near east house 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 Ceraninus Fossae.

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).

MIDLE MEMBER—Found near northeast corner of map area as distal parts of a few narrow, elongate flows, commonly with lobed 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.

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 Halles Fossae and Achernon Fossae assemblages.

HALLES FOSSAE ASSEMBLAGE—Materials of slightly elevated area cut by arcuate faults of Halles Fossae, northeast of Olympus Mons.

PLAINS UNIT—Relatively smooth, moderately cratered plains material. Tongue-like flows extend radially from center of Halles Fossae. Interpretation: Late-stage flows of old-volcanic-tectonic center.

HIP UNIT—Low, cone-shaped hills a few kilometers across, some having radial faults. Interpretation: Volcanic cones or shield.

FRACTURED UNIT—Shield material cut by concentric grabens; moderate relief. Interpretation: Part of shield, broad, deformed volcanic shield.

HIGHLAND MATERIALS

- Fractured plains material**—Forms smooth plains cut by closely spaced fractures and grabens trending mainly northwest-southeast. Occurs south of Ceraninus Fossae. Overlain by lower aureole and plains members of Olympus Mons Formation and Tharsis Montes Fossae. Interpretation: Forms older lava plains of Tharsis region.
- Achernon Fossae assemblage**—Materials of and eroded by Achernon, heavily fractured mountain chain north of Olympus Mons.
- Plains unit**—Smooth, rolling plains material marked by subradial crater rims and wrinkle ridges; well cratered. Recognized within basin surrounded by Achernon Fossae. Overlain by lower aureole and plains members of Olympus Mons Formation. Interpretation: Eolian or pyroclastic mantle may be in part eroded from volcanics of mountain unit.
- Mountain unit**—Three basins (1) irregular small mesas and domes commonly with summit craters along northern and western margins of Achernon Fossae; (2) long, north-south trending ridge with central pit in western Achernon Fossae; and (3) hills overlying structurally complex terrain for example, at lat 30°N, long 131°E. Later, sparsely cratered unit of assemblage. Interpretation: Volcanics formed during fracturing of Achernon Fossae or eroded remnants of thick mantle.
- Fractured unit**—Rugged, mountainous, heavily cratered material; most craters superposed on fractures. Small channels cut crater walls, flanks of ridges, and rough, hummocky area. 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 tectonic activity.

CONTACT—Dashed where approximately located

FAULT OR GRABEN—Dotted where buried or inferred; bar and ball on downthrown side. On narrow grabens, ball either centered between bounding faults or on single line representing closely spaced faults

FAULT ON CROSS SECTION (sheet 2)—Arrow shows relative movement

THRUST FAULT—Dotted where buried or inferred; southwest on upper plate

SCARP—Dotted where buried; line at top; both points downslope

EDGE—Line at crest

LAVA-FLOW FRONT—Fluctures point away from flow

DEPRESSION

IMPACT CRATER RIM

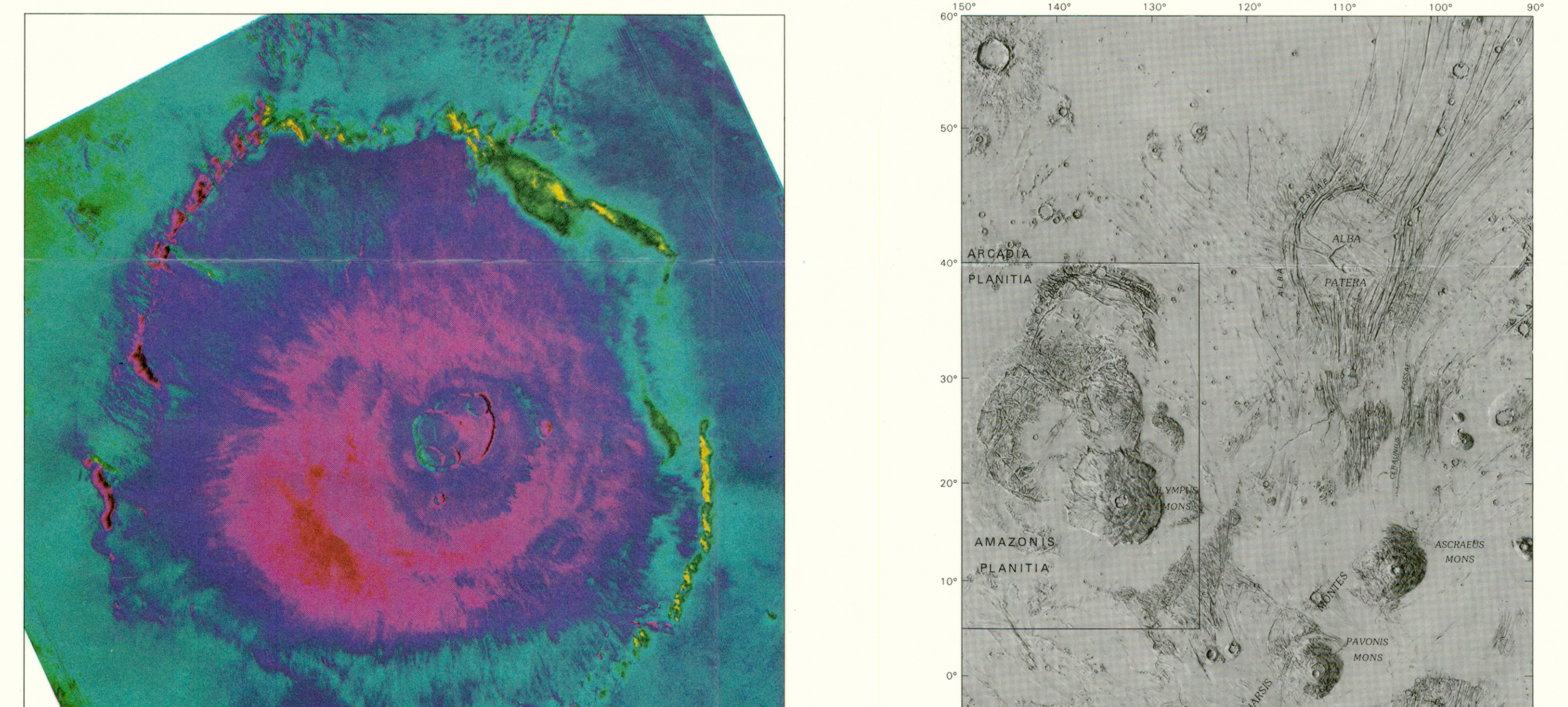
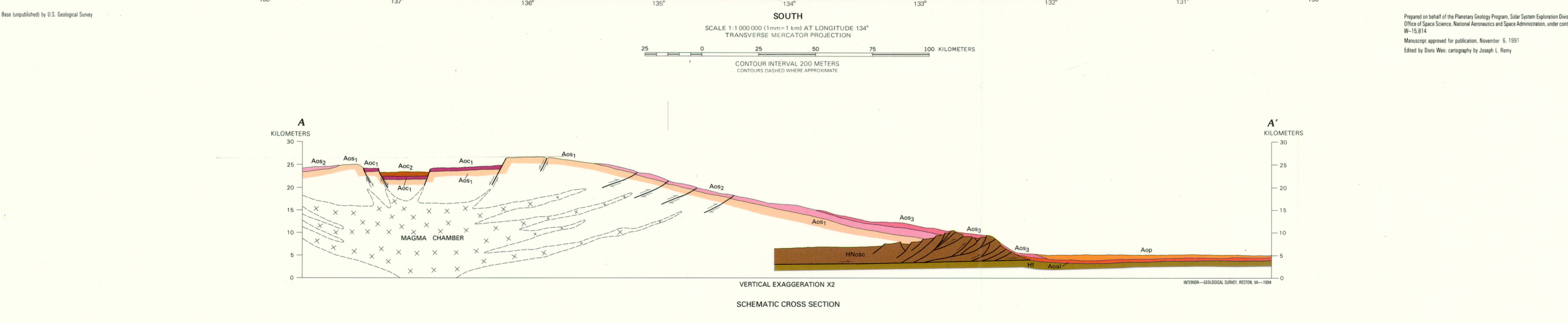
CRATER MATERIALS—Craters having rims larger than 10 km in diameter are mapped and classified on the basis of their morphologic characteristics. More highly degraded craters are excluded or are either older or formed in more erodible material than less degraded craters. Crater materials are interpreted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

MATERIAL OF SHARP-THEADED CRATERS—Rims complete, raised, and clearly identifiable; hummocky peaks or secondary ray craters first mapped around 1 km crater diameter from center of crater. Central peaks conspicuous.

MATERIAL OF ROUNDED-RIMMED CRATERS—Rims complete, raised, and rough where diameter is greater than 30 km. Floor lower than adjacent terrain, rough in craters greater than 10 km and bowl-shaped in craters less than 10 km. Conspicuous central peaks common.

MATERIAL OF SUBSIDED CRATERS—Rims similar to 10 km crater rims but generally have narrow, smooth walls. Floors smooth, flat, or low in adjacent terrain. Central peaks small or absent.

MATERIAL OF HIGHLY DEGRADED CRATERS—Rims incomplete, largely knobby material. Floors like those of 10 km craters but about same elevation as adjacent terrain. Central peaks absent.



GEOLOGIC MAPS OF THE OLYMPUS MONS REGION OF MARS

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