

more highly modified by fluvial and sapping processes and sediment deposition. Coasts and log backs formed by differential erosion of filled beds of warped and extended crust.

**Older fractured material**—Similar to intermediate-age fractured material but more rugged, faulted, and colorized; deformation has destroyed primary morphologic characteristics.

**Basement complex**—Forms knobs, mesas, and broad areas of prominent relief similar to hilly unit but characterized by highly complicated structure of undifferentiated material; dissected in places, embayed and (or) partly buried by materials of several younger units of the plateau and high-plains assemblage and Syria Planum and Tharis Montes Formations. *Interpretation:* Assemblage of undifferentiated rocks of many origins, which may include igneous and metamorphic rock outcrops and impact breccia, comprising complicated tectonic structure.

**Dissected and etched materials**—Dissected and etched materials include the eroded rock and superposed sediment deposited by the resurfacing agent because they generally cannot be mapped separately; their relative-age ranges reflect both materials. The origin and rock type of the eroded rock are inferred in most instances because channels and furrows have modified original surface characteristics.

**Younger dissected material**—Areas of relatively young smooth materials along parts of the southern margin of the Thaumasia plateau; dissected by small, sinuous valleys and valley networks that trend down slope from the Thaumasia highlands and southern part of the Coprates rise toward low-lying regions. Type area: lat 34.5° S, long 71°. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Relatively young, alluvial and colluvial deposits, which may include older rock surfaces, modified by fluvial and sapping processes.

**Troughed material**—Moderately cratered, uneven surface dissected by numerous large troughs along the southeastern margin of the Thaumasia plateau centered at lat 29.5° S, long 61.0°; many troughs abruptly terminated on up-slope end at large grabens and depressions; marked in places by dissected wrinkle ridges. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Fluvial erosion and sapping of easily eroded volcanic (possibly pyroclastic) materials or rock outcrops of the plateau and high-plains assemblage, which may include intermediate dissected material (unit HNg2), fractured and dissected material (unit N2), older fractured material (unit N1), and basement complex (unit N0); troughs enlarged by fluvial and eolian activity and may include older rock surfaces.

**Intermediate dissected material**—Similar to younger dissected material but more well-defined drainage systems. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Fluvial erosion and sapping of materials, which largely include fractured and dissected material (unit N0), older fractured material (unit N1), and basement complex (unit N0), and structures along parts of the southern margin of the Thaumasia plateau.

**Older dissected material**—Similar in occurrence and appearance to subdued cratered and cratered units but more highly dissected by channels and troughs; also occurs in places on ancient impact crater rims and near older flow and construct materials. *Interpretation:* Origin same as that of subdued cratered and cratered units but more eroded by fluvial and sapping processes.

**Etched material**—Irregular surface furrowed by sinuous, circular, and rectangular grooves and troughs exhibiting irregular scarp edges. *Interpretation:* Material probably same as troughed material but groove and trough enlargement influenced more by eolian activity and mass wasting than fluvial erosion.

**High-plains materials**

**Younger ridged plain material**—Forms smooth plains marked by long, nearly parallel, linear to sinuous wrinkle ridges resembling those of lunar maria in Sinai and Coprates east provinces; moderately cratered; flow margins visible in places; ridges generally trend north-northeast, are tens of kilometers apart, and extend as much as 100 km; partly buries the rock surfaces and associated structures of older ridged plain material (unit H0) in the western part of the Thaumasia Planum province, which includes part of the ejecta blanket of impact crater centered at lat 21.25° S, long 73.25°; intermediate fractured material (unit H0) in the northern part of the Sinai province, and eroded material (unit H0) in the northeastern part of the Thaumasia highland province; gradational with the overlapping older flows of the Syria Planum Formation (unit H0). *Interpretation:* Low-viscosity lava flows from local and regional centers, which may include the Syria Planum region; ridges mainly compressional features.

**Older ridged plain material**—Similar to younger ridged plain material but cut by grabens and more densely cratered; partly buries subdued cratered unit (unit N2), older fractured material (unit N1), older flow and construct material (unit N0), and material of degraded craters (unit C1) along the western margin of the Coprates province, but overlapped by younger ridged plain material (unit H0) of Sinai province; small occurrence centered at lat 43.5° S, long 86.5°. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Similar to that of younger ridged plain material (unit H0).

**Terraced material**—Forms rugged, uneven plains marked by irregular scarps; also includes subdued wrinkle ridges and grabens. Partly buried by younger ridged plain material (unit H0) and gradational, in places, with older ridged plain material (unit H0). Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Older ridged plain material stripped and degraded by wind erosion and possible tectonic activity and fluvial modification (sapping) eroding older basal materials in places.

**Undivided material**—Forms rugged walls interrupted by spurs and gullies of Valles Marineris and other deep depressions; moderate relief of map region. *Interpretation:* Similar to that of plateau sequence, intermediate fractured material, and ridged plain materials exposed by faulting and erosion including stamping, mass-wasting, and sapping.

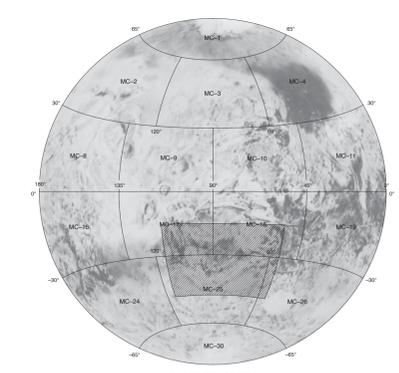
**CIRCUM-ARGYRE MATERIALS**

(Consists of units in northwest part of Argyre Planitia)

**Smooth floor unit**—Forms relatively featureless plains in valleys that trend down slope toward basin floor of Argyre Planitia. Embays and partly buries basin-rim unit of Argyre (unit N0). Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Probably sedimentary deposits of eolian, mass-wasted, fluvial, and possibly glacial origin in structurally controlled valleys primarily formed by the Argyre impact event.

**Dissected and etched unit**—Moderately cratered plateau surface marked by large valley forms, irregular depressions, drainage basins comprising valley networks, and highly subdued ridges of all shapes and sizes. Surface also furrowed in places by sinuous, intersecting, curved to flat-bottomed gullies, producing an etched or sculptured surface. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Centered unit, which may locally include ejecta materials related to the Argyre impact, partly mantled by eolian, alluvial, and colluvial deposits that have been modified by eolian, mass-wasting, sapping, fluvial, and (or) possibly glacial resurfacing.

**Knobby unit**—Forms irregular, abundant small, knoblike hills that in part resemble chaotic material. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Knobby material formed by eolian, fluvial, and possibly glacial erosion of basin-rim unit (unit N0) or cratered unit (unit N1) or by tectonic activity related to impact-basin formation.



QUADRANGLE LOCATION  
Photocentric location is shown in the western hemisphere of Mars. An outline of 1:5,000,000-scale quadrangles is provided for reference.

**DESCRIPTION OF MAP UNITS**

[Though the origin and composition of many units are obscure or controversial, interpretations are based on objective descriptions of morphologic characteristics visible on Viking images. Age relations are determined by stratigraphic positions and crater counts (table 1). Many of the units were previously described and mapped at 1:5,000,000 scale by Scott and Tanaka (1986); we preserve their nomenclature and interpretation where possible.]

**CHANNEL-SYSTEM AND EOLIAN MATERIALS**

**Linear material**—Forms linear, ripplelike features in topographic low centered at lat 50.0° S, long 66.7°; wavelengths of ripples about 1 km. Unit originally recognized by Scott and Tanaka (1986) as unit A0. *Interpretation:* Dune field.

**Channel and flood-plain material**—Forms smooth channel and crater floors and outwash plain in discharge area centered at lat 39.5° S, long 104°; partly buries intermediate fractured material (unit H0); abruptly terminated on upslope end near graben. *Interpretation:* Channel material deposited by discharge of ground water via graben.

**Chaotic material**—Forms irregular patches of closely spaced knobs of similar heights; occurs near highly faulted and dissected areas and within impact crater. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Erosional remnants formed by disruption of terrain by ground-water release and tectonic activity or by mass wasting.

**VALLES MARINERIS INTERIOR DEPOSITS**

**Smooth floor material**—Occurs along canyon floors as smooth to undulatory materials of low relief. *Interpretation:* Primarily eolian and colluvial deposits.

**Rough floor material**—Forms rough surface of canyon floor centered at lat 16.0° S, long 57.3°. *Interpretation:* Mixture of landslides and debris flows from canyon walls and eolian deposits.

**WESTERN VOLCANIC ASSEMBLAGE**

**Tharis Montes Formation**—Includes lava flows of large shield volcanoes of Tharis Montes; members 4 and 6 (Scott and Tanaka, 1986) not present in map area.

**Member 4**—Forms light-colored, elongated flows with frontal lobes; overlaps member 3 (unit A0); occupies small area in northwest part of the map region. *Interpretation:* Lava flows of the Arvia Mons region; high albedo may be produced by eolian mantle.

**Member 5**—Forms light-colored, elongated flows with frontal lobes; overlaps member 4 (unit A0); occupies small area in northwest part of the map region. *Interpretation:* Lava flows of the Arvia Mons region; high albedo may be produced by eolian mantle.

**Member 6**—Forms a relatively smooth plain unlike overlying younger flows of lower member 5 of the Tharis Montes Formation; cut by few northwest-trending grabens. *Interpretation:* Lava flows of the Arvia Mons region; contrasting albedo may represent distinct lava flow types typified by surface texture or the presence or lack of eolian mantles.

**Member 7**—Forms a relatively smooth plain of flows having broad, subdued, lobate fronts; fewer lobes than the overlying member 6 of the Tharis Montes Formation; cut in few places by northwest-trending grabens; overlaps member 1 (unit H0) and intermediate fractured material (unit H0) and embays highland materials along part of the western margin of the Thaumasia highland province. *Interpretation:* Lava flows of the Arvia Mons region.

**Member 8**—Forms a relatively smooth to hummocky plain in southwest part of the map region that is cut by northeast-trending grabens; flow fronts rare; partly buries intermediate fractured material (unit H0) and in places, wrinkle ridges of an older, underlying surface. *Interpretation:* Lava flows of the Arvia Mons region.

**Syria Planum Formation**—Includes lava flows that originated from northern Syria Planum and Nectis Labyrinthus regions (north of the northwest part of the map region). Lower member of Scott and Tanaka (1986) divided into younger and older flows.

**PLATEAU AND HIGH-PLAINS ASSEMBLAGE**

(From ancient highland terrain and local tracts of younger deposits)

**Plateau sequence**

**Smooth unit**—Occurs mainly in southern half of map region as large areas of flat, relatively featureless plains; in places forms smooth to moderately rough floors of some impact craters, cut by grabens, and marked by subdued wrinkle ridges; embays rock outcrops of several older units

**Upper member**—Mottled light and dark flows form complex, interfingering, elongated tongues with distinct lobe fronts in northwest part of map region; overlaps younger flows of lower member (unit H0) and younger and older fractured materials (units H1 and H2, respectively); cut by few northwest-trending grabens of Claritas Fossae and several northeast-trending and curvilinear grabens; marked in few places by chains of pit craters. *Interpretation:* Lava flows of the Thaumasia highlands province; radial channels and dissecting grabens common, central depression less common; lobate fronts in places; flat-floored troughs and lobate scarps may be present on or near some of the mountain flanks as at lat 40.5° S, long 101.0° similar to those of Apollinaris and Hadriava Pateta. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Volcanoes and lava flows and (or) eroded high-standing outcrops of plateau material in places.

**Older flow and construct material**—Forms conical mountains in parts of the Thaumasia highlands that partly resemble younger flow and construct material (unit H0), but larger relief and more highly cratered; may be embayed by Noachian and (or) Hesperian materials. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Ancient volcanoes and (or) eroded high-standing outcrops of plateau material in places.

**Flow and construct materials**—Forms relatively smooth surfaces of moderate relief with the Thaumasia highlands province; radial channels and dissecting grabens common, central depression less common; lobate fronts in places; flat-floored troughs and lobate scarps may be present on or near some of the mountain flanks as at lat 40.5° S, long 101.0° similar to those of Apollinaris and Hadriava Pateta. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Volcanoes and lava flows and (or) eroded high-standing outcrops of plateau material in places.

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**Fractured and dissected material**—Similar to older fractured material but dissected by small valleys, valley networks, and troughs; marked in places by triangular-shaped scarps, tilted beds, and ridges along parts of southern margin of the Thaumasia plateau. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Origin same as that of older fractured material but

of the plateau and high-plains assemblage. *Interpretation:* Probably various materials having smooth surfaces at image resolution, including lava flows, and eolian, mass-wasted, and fluvial deposits that bury most underlying rocks.

**Subdued cratered unit**—Forms highland plains characterized by subdued and partly buried older crater rims; cut in places by grabens; rare flow fronts; locally grades into younger (unit H0) and older (unit H1) ridged plain materials. *Interpretation:* This layer of lava flows and fluvial and eolian deposits that partly bury underlying rocks; colluvial materials may also be present as at lat 42.0° S, long 55.5°.

**Cratered unit**—Consists of highly cratered, rough, irregular material of moderate relief; grabens, channels, and large scarps in places. *Interpretation:* Mixture of impact breccia, crater-rim materials, lava flows, and sedimentary deposits, which include eolian and fluvial materials.

**Hilly unit**—Forms mesas, knobs, and broad areas that rise above surrounding materials; marked in few places by large ridges and scarps as at lat 28.0° S, long 110.0°. Embayed and (or) partly buried by material of several younger units of the plateau and high-plains assemblage. *Interpretation:* Impact breccia, volcanic materials, and possibly older crustal materials; high elevation caused by tectonic uplift and impact-basin formation during period of heavy bombardment.

**Fractured materials**—The origin and rock type of these units are only inferred because fractures and grabens have obscured original surface characteristics in most instances. *Interpretation:* The units consist of impact breccia, crater-rim materials, lava flows, and sedimentary deposits, which include eolian and fluvial materials. Faults caused by crustal extension and warping.

**Younger fractured material**—Forms relatively smooth surfaces in northwest part of the map region; moderately cut by northwest-trending grabens. Embays older fractured material (unit N0), basement complex (unit N0), and flow and construct material (unit N0) but partly buried by lava flows of the Syria Planum Formation.

**Intermediate fractured material**—Forms relatively smooth surfaces of moderate relief with fractures and grabens; moderately cratered. Overlies other highly deformed terrain material but is embayed and partly covered by older flows of lower member of Syria Planum Formation (unit H0), younger ridged plain material (unit H0), members 3, 2, and 1 of Tharis Montes Formation (units A0, H0, and H1, respectively), and smooth unit of plateau sequence (unit H0). Unit not recognized by Scott and Tanaka (1986).

**Older fractured material**—Similar to older fractured material but dissected by small valleys, valley networks, and troughs; marked in places by triangular-shaped scarps, tilted beds, and ridges along parts of southern margin of the Thaumasia plateau. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Origin same as that of older fractured material but

more highly modified by fluvial and sapping processes and sediment deposition. Coasts and log backs formed by differential erosion of filled beds of warped and extended crust.

**Older fractured material**—Similar to intermediate-age fractured material but more rugged, faulted, and colorized; deformation has destroyed primary morphologic characteristics.

**Basement complex**—Forms knobs, mesas, and broad areas of prominent relief similar to hilly unit but characterized by highly complicated structure of undifferentiated material; dissected in places, embayed and (or) partly buried by materials of several younger units of the plateau and high-plains assemblage and Syria Planum and Tharis Montes Formations. *Interpretation:* Assemblage of undifferentiated rocks of many origins, which may include igneous and metamorphic rock outcrops and impact breccia, comprising complicated tectonic structure.

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**Etched material**—Irregular surface furrowed by sinuous, circular, and rectangular grooves and troughs exhibiting irregular scarp edges. *Interpretation:* Material probably same as troughed material but groove and trough enlargement influenced more by eolian activity and mass wasting than fluvial erosion.

**High-plains materials**

**Younger ridged plain material**—Forms smooth plains marked by long, nearly parallel, linear to sinuous wrinkle ridges resembling those of lunar maria in Sinai and Coprates east provinces; moderately cratered; flow margins visible in places; ridges generally trend north-northeast, are tens of kilometers apart, and extend as much as 100 km; partly buries the rock surfaces and associated structures of older ridged plain material (unit H0) in the western part of the Thaumasia Planum province, which includes part of the ejecta blanket of impact crater centered at lat 21.25° S, long 73.25°; intermediate fractured material (unit H0) in the northern part of the Sinai province, and eroded material (unit H0) in the northeastern part of the Thaumasia highland province; gradational with the overlapping older flows of the Syria Planum Formation (unit H0). *Interpretation:* Low-viscosity lava flows from local and regional centers, which may include the Syria Planum region; ridges mainly compressional features.

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**Terraced material**—Forms rugged, uneven plains marked by irregular scarps; also includes subdued wrinkle ridges and grabens. Partly buried by younger ridged plain material (unit H0) and gradational, in places, with older ridged plain material (unit H0). Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Older ridged plain material stripped and degraded by wind erosion and possible tectonic activity and fluvial modification (sapping) eroding older basal materials in places.

**Undivided material**—Forms rugged walls interrupted by spurs and gullies of Valles Marineris and other deep depressions; moderate relief of map region. *Interpretation:* Similar to that of plateau sequence, intermediate fractured material, and ridged plain materials exposed by faulting and erosion including stamping, mass-wasting, and sapping.

**CIRCUM-ARGYRE MATERIALS**

(Consists of units in northwest part of Argyre Planitia)

**Smooth floor unit**—Forms relatively featureless plains in valleys that trend down slope toward basin floor of Argyre Planitia. Embays and partly buries basin-rim unit of Argyre (unit N0). Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Probably sedimentary deposits of eolian, mass-wasted, fluvial, and possibly glacial origin in structurally controlled valleys primarily formed by the Argyre impact event.

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**Knobby unit**—Forms irregular, abundant small, knoblike hills that in part resemble chaotic material. Unit not recognized by Scott and Tanaka (1986). *Interpretation:* Knobby material formed by eolian, fluvial, and possibly glacial erosion of basin-rim unit (unit N0) or cratered unit (unit N1) or by tectonic activity related to impact-basin formation.

**GEOLOGIC MAP OF THE THAUMASIA REGION, MARS**  
By James M. Dohm, Kenneth L. Tanaka, and Trent M. Hare 2001