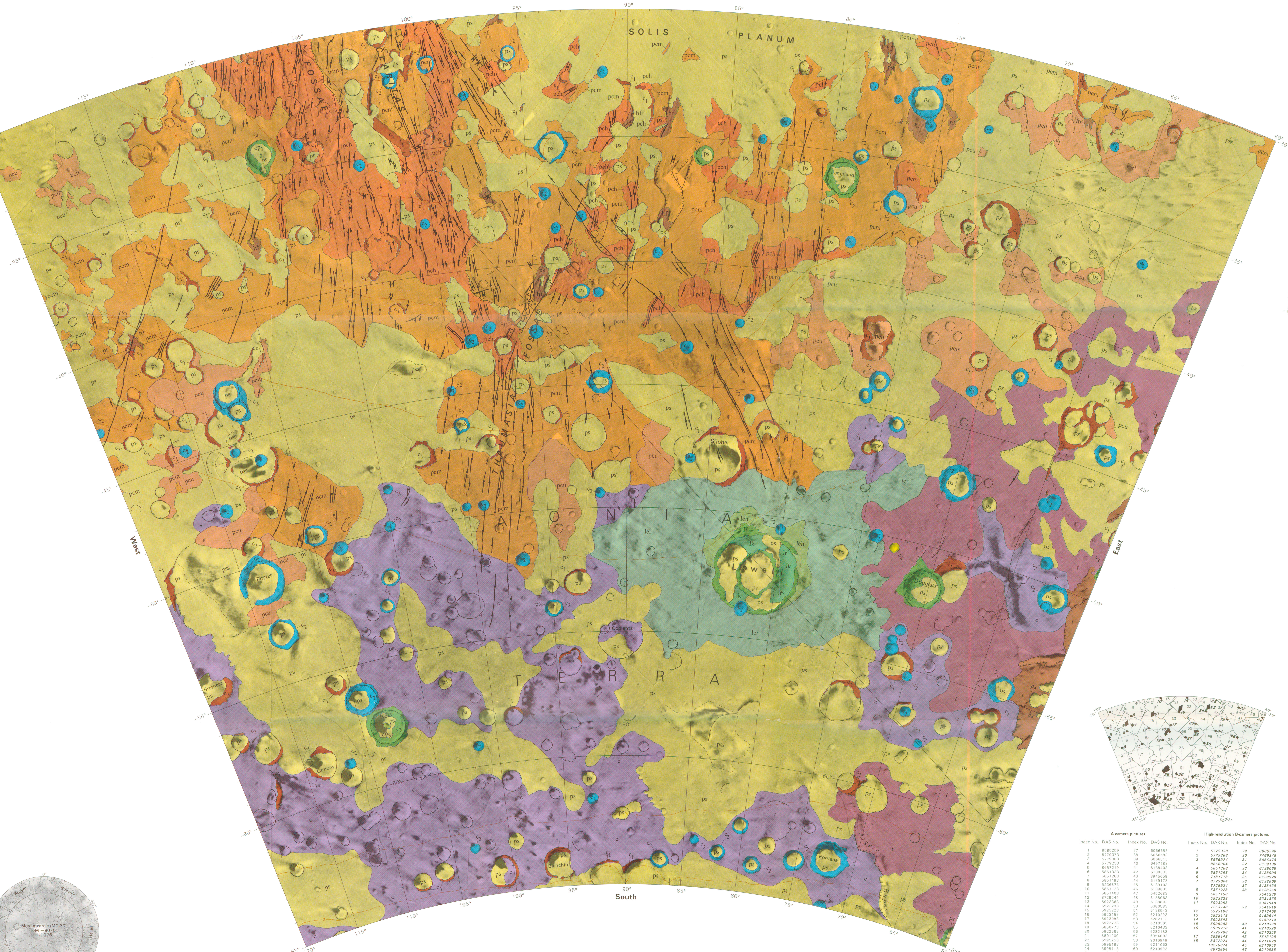
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in Cooperation with the
JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY
FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:5,000,000 GEOLOGIC SERIES
THAUMASIA QUADRANGLE
M 5M –48/90 G, 1978
I-1077 (MC-25)



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.

PROJECTION

The Lambert conformal conic projection is used for this sheet with standard parallels at 35.8° and 59.2°. A scale of 1:4,336,000 at lat 30° S was chosen to match the scale at lat 30° S of the adjacent Mercator projections. Longitudes increase to the west in accordance with usage of the International Astronomical Union (IAU, 1971). Latitudes are areographic (de Vacouleurs 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 20-40 km.

MAPPING TECHNIQUE

Selected Mariner 9 pictures were transformed to the Lambert conformal projection and assembled in a series of mosaics at 1:5,000,000

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 1-2 km.

NOMENCLATURE

All names on this sheet are approved by the International Astronomical Union (IAU, 1974), except Aonia Terra which is proposed.

MC-25: Abbreviation for Mars Chart 25.
M 5M –48/90 G: Abbreviation for Mars 1:5,000,000 series; center of sheet, 48° S latitude, 90° longitude; geologic map, G.

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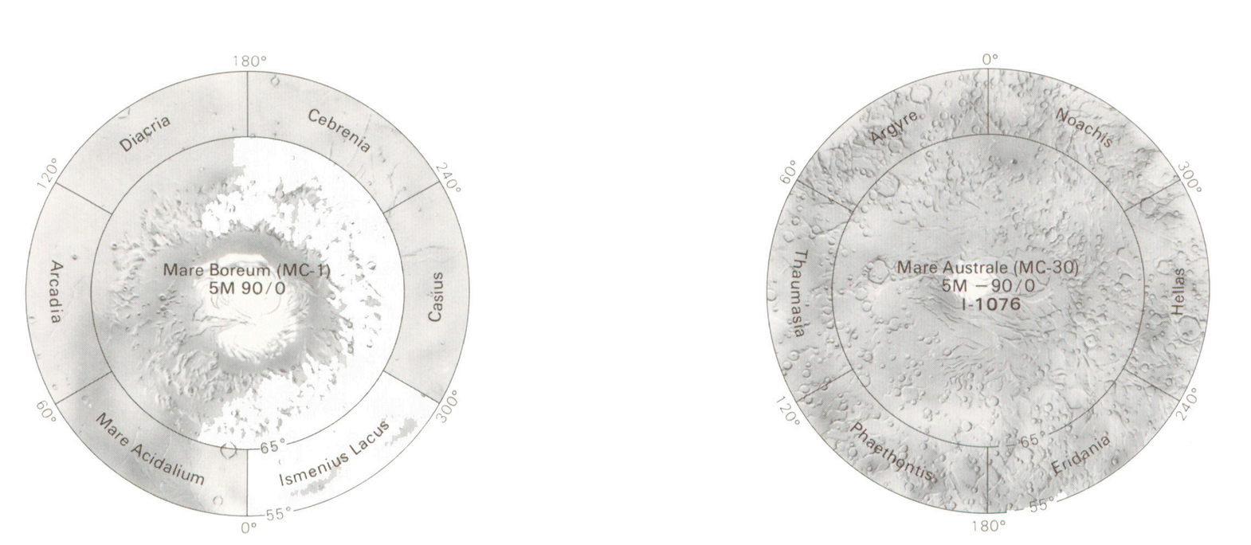

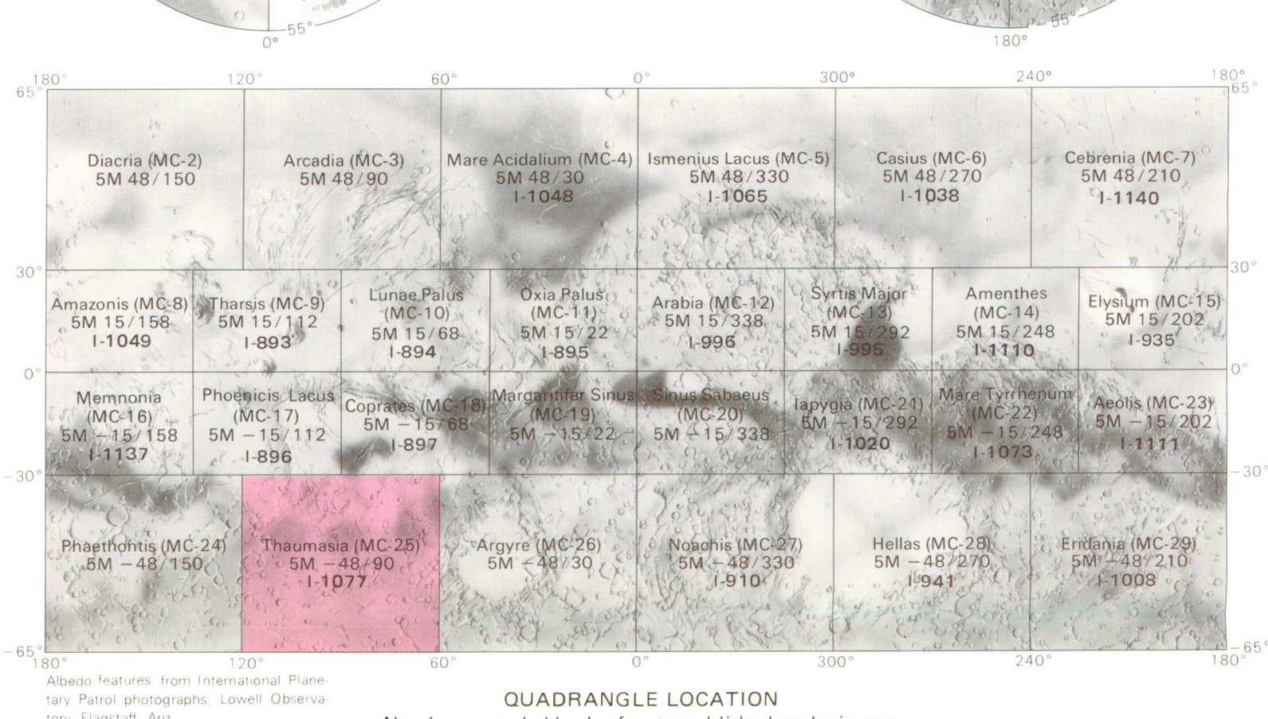

QUADRANGLE LOCATION
Number preceded by I refers to published geologic map

SCALE 1:4 336 000 AT 30° LATITUDE
LAMBERT CONFORMAL 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 in cooperation with University of Massachusetts (NASA grant NGR-22-010-076).

A-camera pictures

Index No.	DAS No.	Index No.	DAS No.
1	[illegible]	37	[illegible]
2	[illegible]	38	[illegible]
3	[illegible]	39	[illegible]
4	[illegible]	40	[illegible]
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6	5851333	42	6138333
7	5851263	43	8945059
8	5851193	44	6139173
9	5236873	45	6139103
10	5851123	46	6139033
11	5851403	47	5452683
12	8729249	48	6138963
13	5923363	49	6138893
14	5923293	50	5380583
15	5923223	51	6138543
16	5923153	52	6210293
17	5923083	53	6282113
18	5922733	54	6210363
19	5850773	55	6210433
20	5922663	56	6282183
21	8801209	57	6354003
22	5995253	58	9016949
23	5995183	59	6211063
24	5995113	60	6210993
25	5995043	61	6210923
26	5994693	62	6210853
27	5994623	63	6210783
28	5994553	64	6282323
29	6066443	65	6354073
30	5995323	66	6425893
31	8873169	67	6282813
32	6067283	68	6282743
33	6067213	69	6282673
34	6067143	70	6354143
35	6067073	71	6426033
36	6067003	72	6425963

High-resolution B-camera pictures

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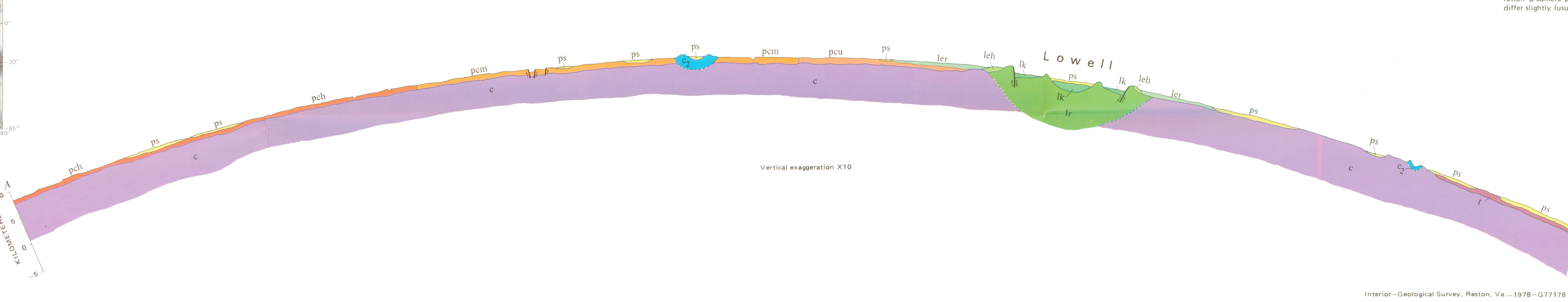
5	5851298	34	6138998
6	7181718	35	6138928
7	8729004	36	6138508
	8728934	37	6138438
8	5851228	38	6138368
9	5851158		7541238
10	5923328		5381878
11	5923258		5381948
	7253748	39	7541518
12	5923188		7613408
13	5923118		9159644
14	5922698		9159714
15	5995288	40	6210398
16	5995218	41	6210328
	7325708	42	6210258
17	5995148	43	7613128
18	8872924	44	6211028
	10276074	45	6210958
	8872854	46	6210888
	10276004	47	6210818
	10275934	48	7685018
19	5995078	49	6282218
20	5994658	50	6282148
21	7397388	51	6282708
	7397668	52	7685298
22	6067248	53	6282288
23	7469628	54	6354038
24	6067178	55	6354178
25	6067108	56	6354108
26	9016634	57	7756908
	9016704		6425928
27	6067038	58	7828798
28	7972018		6425998
	6066618		7972368
	7972088		7972438
	7971948	59	6497818

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. Useful coverage is not available in cross-hatched areas. Also shown (by solid black rectangles) are the high-resolution B-camera pictures, identified by italic numbers. The DAS number may differ slightly (usually by 5) among various versions of the same picture.



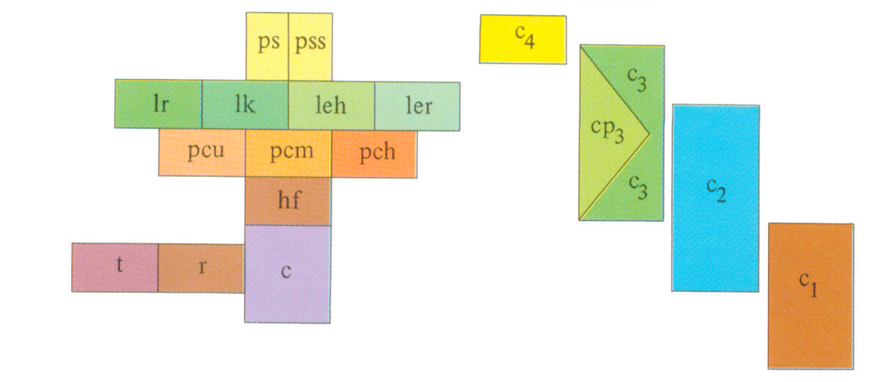
Vertical exaggeration X10

Interior—Geological Survey, Reston, Va.—1978—G77118

GEOLOGIC MAP OF THE THAUMASIA QUADRANGLE OF MARS

By
George E. McGill
1978

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

ps, pss — SMOOTH PLAINS MATERIALS—Smooth, apparently featureless plains except near craters and gradational contacts with other units. Few craters over 20 km in diameter. Albedo either uniform and higher than adjacent units (ps) or variable with discrete dark, fan-shaped streaks originating at small craters (pss). At one locality (lat -52°, long 68°), unit ps contains rectangular pits. Reference area: ps lat -45°, long 105° (DAS 05923088) and pss lat -35°, long 65°. *Interpretation:* Mostly eolian deposits burying older units to various depths; streaked variant probably thinner than unstreaked variant

MATERIALS OF CRATER LOWELL

lr — Rim material—Forms blocky to massive mountains of inner and outer crater rings; most slopes show high apparent albedo. Reference area: lat -52.5°, long 80°; DAS 06210438. *Interpretation:* Megabreccia of structurally raised and fractured pre-crater bedrock

lk — Knobby material—Forms equidimensional low rounded hills about 1.5 km in diameter scattered as individuals or in clumps on apparently smooth plain. Irregular albedo, generally lower than that of adjacent units. Reference area: lat -52°, long 79.5°; DAS 06210438, 09159649. *Interpretation:* Fallback ejecta, analogous to Montes Rook Formation (McCauley, 1968) of lunar Orientale basin

leh — Hummocky ejecta material—Forms irregular topography with closely spaced equidimensional to slightly elongate hills. Irregular albedo. Reference area: lat -50.5°, long 83°; DAS 06210438. *Interpretation:* Thick blocky impact ejecta; possibly some primary structural relief as well

ler — Radial ejecta material—Forms a surface without visible relief except where older features are visible through the thinner distal part. Characterized by light and dark streaks radial to center of crater. Distal part includes clusters of small craters. These materials grade into all adjacent older materials. Reference area: lat -54°, long 78°; DAS 06210438. *Interpretation:* Ejecta blanket deposited by radial debris flow or ground surge; thick near crater rim, thinning to wedge edge at distance of about one crater diameter from rim

pcu, pcm, pch — CRATERED PLAINS MATERIALS—Form planar surfaces except near craters and faults. Moderate density of craters larger than 20 km in diameter. Variable albedo, generally lower than that of smooth plains materials. Divided into three tectonic members on basis of density of superposed faults. Unfaulted cratered plains materials (pcu); reference area, lat -42°, long 72°; DAS 06210858. Moderately faulted cratered plains materials (pcm); reference area, lat -49°, long 98°; DAS 06066658. Highly faulted cratered plains materials (pch); reference area, lat -38°, long 104°; DAS 05923228. *Interpretation:* Dominantly lava flows and pyroclastic deposits; possibly some eolian deposits

hf — FURROWED HILLS MATERIAL—Underlies elongate rounded hills and low mountains separated by narrow rounded furrows. Furrows mainly subparallel but locally anastomosing. Albedo similar to that of smooth plains materials. Areas of exposure too small to determine crater density; age determination based on apparent embayment by cratered plains materials. Reference area: lat -37.5°, long 109°; DAS 05851268, 08729009. *Interpretation:* Possibly volcanic constructs, or ejecta deposits of a large, now-obscured basin

t — TEXTURED PLAINS MATERIAL—Exhibit many low-relief features barely resolvable at A-frame resolution, such as remnants of crater walls, small scarps and hills, and irregular depressions and furrows. B-frames show many roughly equidimensional low rounded hills separated by smooth plains. Mottled albedo and abundant small relief features give unit characteristic textured appearance. Moderate density of generally degraded craters. Unit occurs in band concentric to Argyre basin (Argyre quadrangle). Reference area: lat -61.5°, long 68°; DAS 06425968, 07756913. *Interpretation:* Unknown origin. Location and characteristics of exposures suggest that textured materials are eroded and partly buried deposits of Argyre basin. However, moderate crater density suggests younger age, comparable to that of cratered plains

r — RUGGED MOUNTAIN MATERIAL—Forms rugged scarps and isolated mountains and hills in a zone concentric to Argyre basin. Includes small areas of smooth plains materials between isolated mountains and hills. Albedo very irregular and blotchy. Reference area: lat -56°, long 60°; DAS 06426038. *Interpretation:* Eroded rim materials of Argyre basin; included plains materials between hills and mountains probably much younger

c — CRATERED MATERIAL—Underlies regions characterized by abundant large craters but almost no craters smaller than about 10 km in diameter. Intermediate-sized craters generally rimless. Surface generally smooth to gently rolling and coarsely streaked by contrasts in albedo. Reference area: lat -60°, long 115°; DAS 05994558. *Interpretation:* Ancient crater ejecta deposits modified by erosion and thin discontinuous cover of eolian deposits

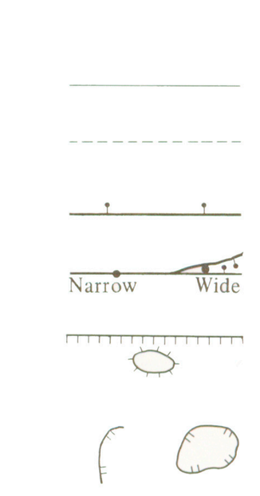
CRATER DEPOSITS—Underlie rims, walls, floors, ejecta blankets, and central peaks of craters more than about 20 km in diameter. Subscripts refer to degradation sequence from c_1 (most degraded) to c_4 (least degraded), inferred to represent an age sequence (c_1, oldest, to c_4, youngest). However, degradation varies significantly with crater diameter and may also vary with geographic location because of differences in erosion and deposition from place to place. *Interpretation:* Impact craters. A few irregular craters, particularly those linked in chains, may be endogenic

c_4 — Crater material, undivided—Forms craters with complete and well-defined rims and floor deposits

cp_3, c_3 — Crater materials—Form craters with complete and well-defined rims and small remnants of ejecta blankets, floor deposits, or central peaks. c_3: undivided rim, floor, and ejecta materials. cp_3: central peak materials

c_2 — Crater material, undivided—Forms craters with complete but subdued rims and ejecta blankets and floor deposits eroded or covered by younger deposits

c_1 — Crater material, undivided—Forms craters with incomplete and very subdued rims; all other related materials and features completely obliterated



Contact

Approximate contact between albedo variants of smooth plains materials

Fault—Bar and ball on downthrown side

Graben (Narrow / Wide)

Scarp—Hachures point downslope; coincident with contact in places

Crater rim crest, or wall if crater is rimless; also used to outline ghost craters. Hachures point toward crater center; coincident with contact in places

INTRODUCTION

The Thaumasia quadrangle lies on the south flank of the Tharsis dome (Hord and others, 1974), a large bulge in the crust of Mars extending more than 5,000 km northward from the center of the quadrangle. This major structure imposes a generally southward slope across the entire quadrangle. Topography along the east-central border of the Thaumasia quadrangle exhibits curved scarps and lowlands concentric with the Argyre basin.

Four regions within the Thaumasia quadrangle are defined on the basis of the dominant geologic unit exposed. Three of these regions form arcuate patterns around the south flank of the Tharsis dome, and the fourth is an arcuate region concentric with the Argyre basin:

1. The north-central part of the quadrangle consists dominantly of cratered plains and associated furrowed hills. The remnants of a few large ancient craters show through the younger cratered plains. All these units are extensively faulted. This region occupies the highest part of the quadrangle.
2. The southwest part of the quadrangle is dominated by eroded and partly buried cratered terrain that has been interpreted as primordial crust by Carr, Masursky, and Saunders (1973).
3. A wide arc from the northeast to the northwest corner of the quadrangle consists of young smooth plains and older cratered plains. Although some faults extend southward into this region, most die out or are overlapped by smooth plains deposits.
4. Along the eastern border are rough and textured deposits probably related to the formation of the Argyre basin.

Superposed on parts of regions 2, 3, and 4 are deposits radial to the double-ringed crater Lowell, one of the freshest large craters on Mars, and one of the few that preserves the concentric, hummocky, and radial structures characteristic of large lunar craters. Isolated patches of smooth plains materials occur throughout the quadrangle.

STRATIGRAPHY

The most important stratigraphic units are cratered materials, cratered plains materials, furrowed hills material, textured plains materials, and smooth plains materials. More detailed subdivision of units would be possible with only a modest improvement in photographic resolution. Local transitional units, particularly between the youngest deposits and all older units, were not mapped because they could not be identified consistently throughout the quadrangle. Consequently, the resulting stratigraphic scheme is a compromise between the very generalized ones of McCauley and others (1972) and Carr, Masursky, and Saunders (1973), and the detail potentially possible in local areas.

Cratered materials

Both McCauley and others (1972) and Carr, Masursky, and Saunders (1973) mapped extensive terrains characterized by closely spaced large craters, most of which are highly degraded. On the basis of superposition relations and density of large craters, cratered materials must be the oldest in the quadrangle. The surface appears to be smooth except where rims of large craters stand above it. Small-scale features are notably absent or degraded; most craters smaller than 30 km in diameter are rimless, and the Mariner B frames show little fine detail and almost no kilometer-size craters.

Cratered materials probably consist of ejecta of various types that are analogous to the materials of the lunar terrae (Wilhelms and McCauley, 1971). However, these materials have been severely eroded or buried so that the surface of the unit appears relatively young. With the better resolution of the Viking images, this unit undoubtedly can be subdivided into a complex of units.

Materials related to Argyre basin

Along the east border of the Thaumasia quadrangle are two map units exposed in an arcuate pattern concentric to the Argyre basin in the neighboring Argyre quadrangle. One of these, rugged mountain materials, occupies a very small area of the Thaumasia quadrangle but is extensively exposed in the Argyre quadrangle (C. A. Hodges, written commun., 1976). It is a mixed unit and characteristically forms terrain with many small rounded hills rising above intervening smooth plains, and many scarps, most of which face toward the Argyre basin. The small hills are interpreted as eroded remnants of the uplifted rim of the Argyre basin and the intervening plains as material similar to smooth plains material. The intermingling of these two landforms is on a scale too small for separation on the map.

The other unit related to the Argyre basin, textured plains material, is more widely exposed in the Thaumasia quadrangle. Textured plains are characterized by much fine detail, some of which is just visible at A-frame resolution. At B-frame resolution, the unit resembles degraded Montes Rook Formation, a hummocky ejecta facies of the lunar Orientale basin (McCauley, 1964; Head, 1974). On the basis of appearance and position relative to the Argyre basin, the textured materials are interpreted as ejecta from the Argyre basin.

Superposed craters larger than 20 km in diameter are less densely distributed than on cratered plains. Ordinarily, this distribution would imply that textured materials, and thus the Argyre basin, postdate the formation of cratered plains, a rather surprising conclusion considering the degree of degradation of the Argyre basin rim and the large size of craters superposed on the rim. Because the latter evidence is less subject to alternate explanations, the Argyre basin deposits are considered to be older than cratered plains materiais.

Furrowed hills material

Furrowed hills material occurs as isolated patches over much of the northern third of the quadrangle. They are higher than the surrounding terrain and typically occur as isolated rounded or elongate hills that are intricately cut by short furrows with smooth, rounded edges and floors. Within an outcrop area, many of the furrows are nearly parallel, imposing a gross linear pattern on the unit, but in detail the furrows converge and diverge slightly so that they interconnect.

Furrowed hills terrain is closely related spatially to cratered plains and has a somewhat higher apparent albedo. In places, cratered plains materials appear to embay furrowed hills, suggesting that the cratered plains are generally younger. Because individual exposures of furrowed hills materials are small, it is not possible to verify the relative ages by means of crater densities.

The partially anastamosing complex of furrows is reminiscent of topography developed on terrestrial lava domes and sheets by lava channels and collapsed lava tubes (Green and Short, 1971). On the other hand, the absence of any radial or concentric patterns of furrows around isolated hills of this unit does not seem consistent with such an interpretation. Furrowed hills material also resembles lunar terrain covered by basin ejecta such as the Fra Mauro Formation (Hackman, 1966). The exposures of furrowed hills material roughly follow an arc about 1,500 km in radius centered near -20° lat, 90° long.

Cratered plains materials

Much of the northern part of the quadrangle is underlain by a plains-forming unit characterized by a moderate density of craters 20 to 50 km in diameter but without superposed larger craters. The surface of the unit appears smooth and planar except where modified by faulting or by ejecta from superposed craters.

Most exposures of cratered plains in the Thaumasia quadrangle are extensively faulted. However, in the northwest and northeast corners of the quadrangle, outside the area of faulting, are exposures of cratered plains that appear similar to the faulted plains in surface texture, albedo, and crater density. McCauley and others (1972) mapped "cratered plains" and "fractured plains" as separate units. Within the Thaumasia quadrangle, at least, this distinction is purely tectonic rather than stratigraphic, and faulted and unfaulted cratered plains are mapped as one stratigraphic material unit divided by degree of faulting into three tectonic members. I believe that the variable density of faults results from areal differences in tectonic activity rather than from different ages of the members.

McCauley and others (1972) and Carr, Masursky, and Saunders (1973) included cratered plains materials in a more extensive unit with the same name characterized in many places by long narrow ridges resembling the wrinkle ridges of lunar maria. With one or two local exceptions, these ridges are not visible on the mapping pictures for the Thaumasia quadrangle. McCauley and others (1972) suggested a volcanic origin for cratered plains and associated terrains in other areas. Such an interpretation would be more tentative in the Thaumasia quadrangle than in other places, where wrinkle ridges exist.

Materials of crater Lowell

Lowell (lat -52.5°, long 81.5°) is one of the least degraded large craters on Mars. It has a continuous raised inner ring 100 km in diameter and a raised outer ring 200 km in diameter interrupted in two places on the north and northeast margins. The material units related to Lowell correspond closely in appearance and relative position to similar units around large lunar craters and basins (Schmitt and others, 1967; Howard and others, 1974). Continuous hummocky or radial ejecta deposits extend outward about one crater diameter from the ring, as is the case with large craters on the Moon. Like the lunar basin Schrödinger, Lowell probably is a double-ring impact basin (Wilhelms, 1973).

Smooth plains materials

Superposed on all other map units and partly or completely filling most craters larger than 20 km in diameter are deposits forming smooth, apparently featureless plains with no superposed craters larger than about 20 km in diameter. Some B-frames show moderate densities of generally sharp kilometer-size craters; other frames appear featureless. There are two albedo variants: smooth plains with a generally uniform gray tone on the Mariner images, and streaked smooth plains with many small dark streaks fanning out from tiny craters superposed on a gray background similar to the unstreaked variant. The streaks are probably superficial and variable over short time spans (Sagan and others, 1973) and thus do not indicate any important differences in the underlying materials.

Almost without exception, areas that are topographically lower than their immediate surroundings are covered by smooth plains materials. In addition, gradational contacts of plains with older units and the local gradual termination of crater rims and grabens by smooth plains indicate that the plains materials fill low areas to various depths. These characteristics suggest that most of the material is of eolian origin, deposited preferentially in low areas and overlapping all older units.

In one small area (lat -52°, long 68°), materials that resemble smooth plains exhibit rectangular pits characteristically a few kilometers on a side. These materials have been included with the smooth plains materials.

STRUCTURAL GEOLOGY

The most obvious structural feature in the Thaumasia area is the complex of grabens in the north-central part of the quadrangle. Although most of these grabens define a fan converging northward toward the Syria Planum region, in some areas there are other sets crossing this pattern. Unlike the situation in the Arcadia quadrangle to the north (D. E. Wise, oral commun., 1976), clear evidence for relative ages of sets of graben is rare in the Thaumasia quadrangle. At one locality (lat –42°, long 84°), however, northeast-trending grabens appear to be oldest, north-trending grabens next oldest, and the representatives of the fanning set, trending northwest at this locality, youngest. Most grabens are older than smooth plains materials, but a few cut these deposits. Without exception, the grabens cutting smooth plains deposits belong to the fanning set.

The age and origin of the Tharsis dome are of major interest to students of martian history. A constructional origin seems untenable because the remains of faulted and nearly buried large craters visible through younger materials (cratered plains and smooth plains) suggest that the ancient cratered surface of the planet is not deeply buried in the part of the Tharsis dome within the Thaumasia quadrangle. The grabens, which are probably related to formation of the dome, date the structural movements as mostly younger than cratered plains and older than smooth plains. The variable age relations between grabens and craters in the 20- to 40-km diameter range and the local faulting of smooth plains deposits by grabens of the fanning set indicate a long history of faulting and presumably of related uplift.

GEOLOGIC HISTORY

The earliest events of which any record is preserved in the Thaumasia quadrangle are related to the formation of the large craters whose degraded remains dominate the southwest part of the quadrangle. By analogy with lunar history, these craters probably date from 3-4 billion years ago (Hartmann, 1973; Soderblom and others, 1974). The Argyre basin and related deposits were probably formed during this ancient cratering episode.

Overlying the ancient cratered terrain are widespread deposits mapped as cratered plains. Associated with these plains on the south flank of the Tharsis dome are materials forming furrowed hills. Both units are extensively cut by grabens areally related to the Tharsis dome. Most of the grabens probably are related genetically to the Tharsis dome, and thus cratered plains and furrowed hills units must predate formation of the dome. Both units could be products of a major episode of volcanic activity early in martian history. On the other hand, furrowed hills terrain resembles some lunar basin deposits, hence it may represent the remnants of a large ancient basin. Both interpretations must be considered highly speculative until more evidence is at hand.

Ejecta from the crater Lowell is superposed on all adjacent units except smooth plains materials. In addition, few craters are superposed on Lowell, suggesting that the crater is not much older than the smooth plains.

Since the formation of Lowell, low areas in the quadrangle have been filled with smooth plains deposits, most of which appear to be of eolian origin. These eolian materials were probably deposited for a long period of time, and most likely they still are being transported today.

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