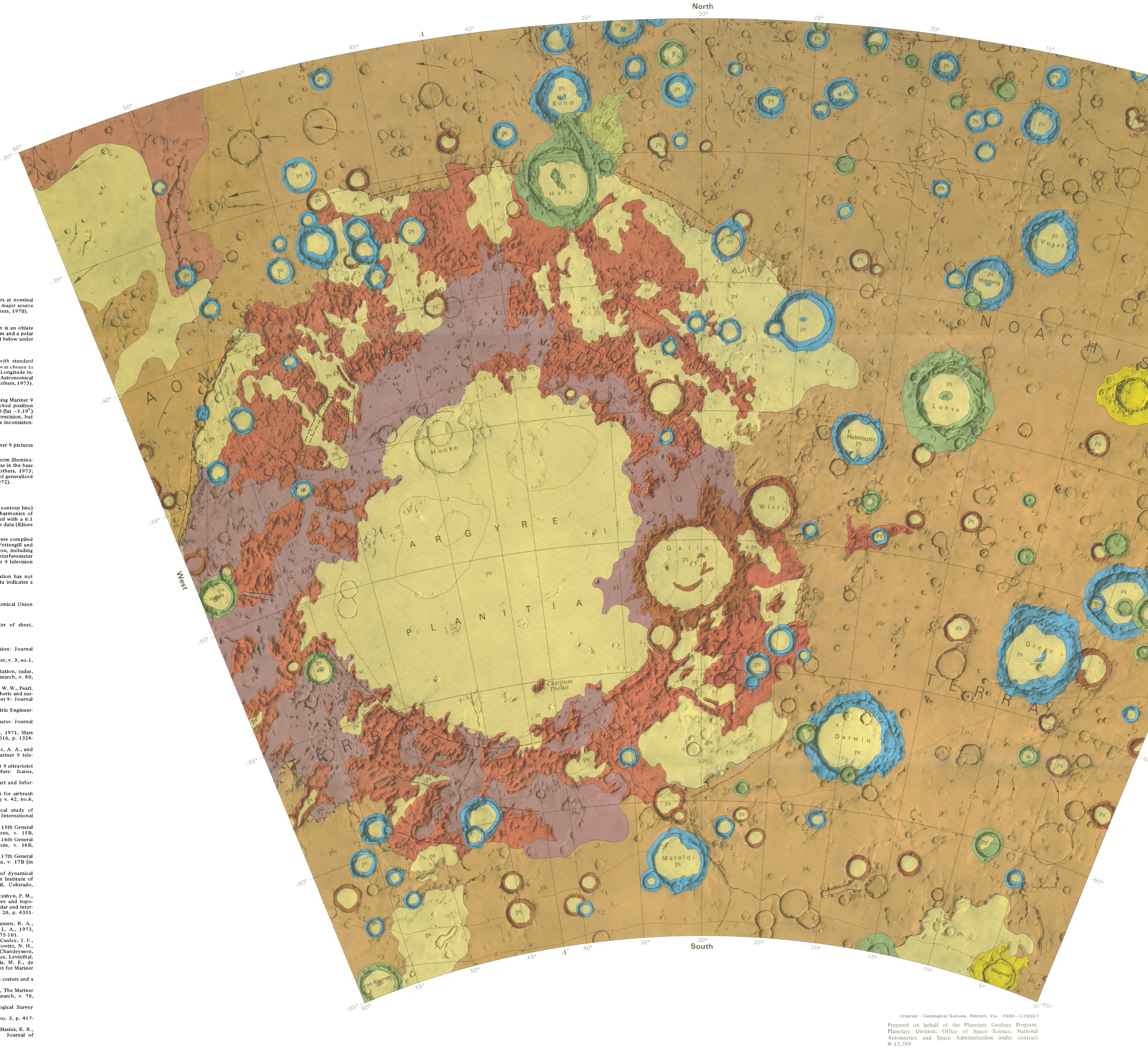
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF MARS
1:5 000 000 GEOLOGIC SERIES
ARGYRE QUADRANGLE
M 5M –48/30 G, 1980
I-1181 (MC-26)



within the crater Airy. No simple statement is possible for the precision, but local consistency is 10-15 km, except along the northern edge where inconsistencies as large as 20 km exist.

MAPPING TECHNIQUE

A series of mosaics of Lambert conformal conic projections of Mariner 9 pictures was assembled at 1:5 000 000.

Shaded relief was copied from the mosaics and portrayed with uniform illumination with the sun to the west. Many Mariner 9 pictures besides those in the base mosaic were examined to improve the portrayal (Levinthal and others, 1973; Green and others, 1975; Inge and Bridges, 1976). The shading is not generalized and may be interpreted with nearly photographic reliability (Inge, 1972).

Shaded relief analysis and representation were made by Jay L. Inge.

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; 1978).

The contour lines on most of the Mars maps (Wu, 1975; 1978) 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 of 1-2 km.

NOMENCLATURE

All names on this sheet are approved by the International Astronomical Union (IAU, 1974, 1977, 1980).

MC-26: Abbreviation for Mars Chart 26.
M 5M –48/30 G: Abbreviation for Mars 1:5 000 000 series; center of sheet, lat –48°, long 30°; geologic map, G.

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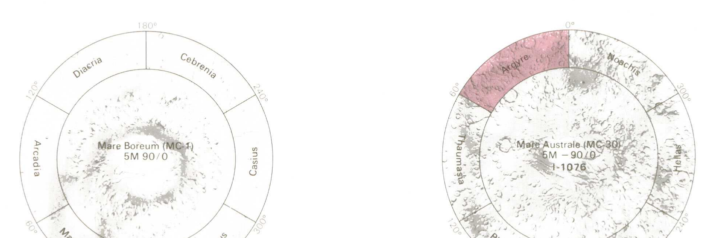
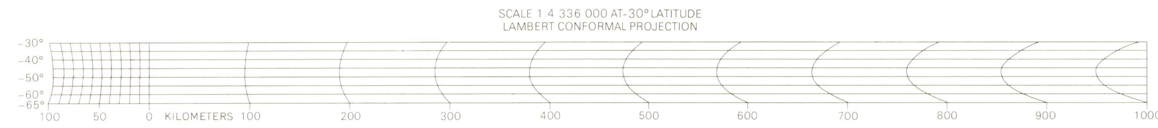
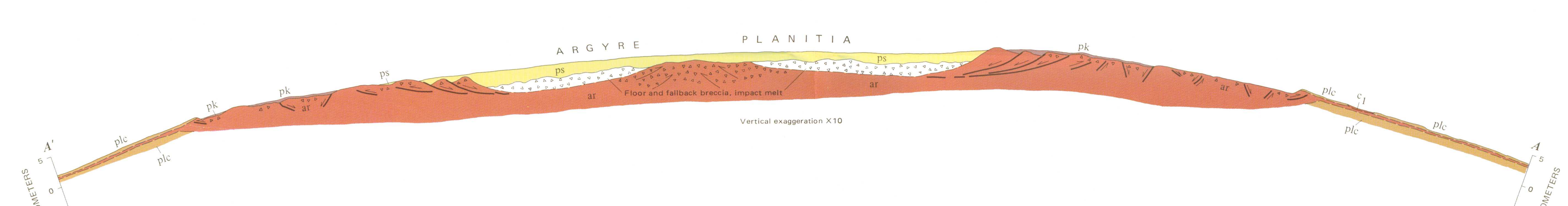
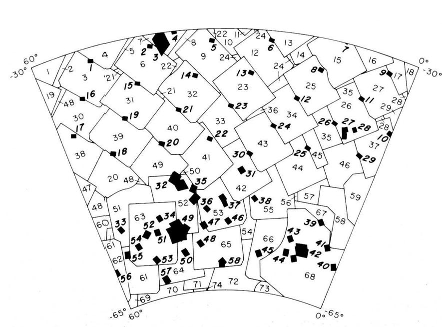








INDEX TO MARINER 9 PICTURES

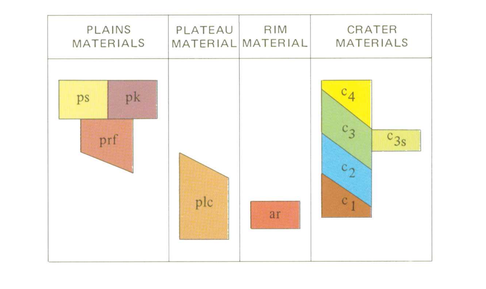
The mosaic used to control the positioning of features on this map was made with the Mariner 9 A-camera pictures outlined above. Also shown (by solid black rectangles) are the high-resolution B-camera pictures, identified by italic numbers. The DAS number may differ slightly (usually by 5) among various versions of the same picture.

GEOLOGIC MAP OF THE ARGYRE QUADRANGLE OF MARS

By

Carroll Ann Hodges

1980



DESCRIPTION OF MAP UNITS

PLAINS MATERIALS

ps — SMOOTH PLAINS MATERIAL—Sparsely cratered, nearly featureless (at Mariner A-frame resolution) deposits; most conspicuous on floor of Argyre basin but also mapped in low areas of rugged basin rim, in craters of all ages, and adjacent to cratered plateau material (unit plc). Reference locality: lat 50° S, long 48° W. *Interpretation:* Largely eolian debris, but partly fluvial origin indicated by branching channels draining into Argyre, specifically at south rim. Probably unconsolidated and thus subject to disturbance and transport during atmospheric storms; wind streaks superposed on unit in northwest corner of map area. Preexisting topography largely obscured, indicating substantial thickness of deposits, although some local surface obscuration probably due to atmospheric dust

pk — KNOBBY PLAINS MATERIAL—Sparsely cratered deposits grading into smooth plains material (unit ps) but with numerous small hillocks. Confined to lowlands within and at inner margins of Argyre basin rim material (unit ar). Reference locality: lat 42° S, long 43° W. *Interpretation:* Deposits of smooth plains material through which bedrock blocks protrude; knobs probably erosional remnants of rugged Argyre basin rim material or possibly fallback ejecta

prf — RIDGED AND FURROWED PLAINS MATERIAL—Exposed mainly in Coprates quadrangle to northwest, where mapped as two subunits: 1) ridged plains, characterized by numerous elongate and sinuous ridges similar to those of lunar maria; and 2) furrowed subunit of moderately undulating terrain (McCauley, 1978). Small exposures combined as one unit in this quadrangle include narrow, branching channels and one major northeast-trending ridge. Reference locality: lat 31° S, long 55° W. *Interpretation:* Ridged subunit possibly flood basalts, like lunar maria (McCauley, 1978), or other stratified material deformed tectonically. Furrowed subunit apparently older than and embayed by ridged subunit (McCauley, 1978); fluid erosion of channels suggested by branching pattern

PLATEAU MATERIAL

plc — CRATERED PLATEAU MATERIAL—Relatively smooth intercrater areas on Mariner A-frame images, but variably textured on Mariner B-frame and Viking images. Complex network of closely spaced, branching channels, apparently draining northward, visible where good Viking coverage exists north of lat 40° S. Mare-type wrinkle ridges and lobate scarps characterize much of unit. Reference locality: lat 40° S to lat 50° S, long 0° W to 10° W. *Interpretation:* Geomorphic unit including old cratered terrain impacted by Argyre and largely "resurfaced" by Argyre basin ejecta, as well as post-Argyre crater ejecta (shown in section A-A'). Concentric scarp around Argyre probably formed during basin excavation. Mare-type ridges and scarps possibly indicative of basaltic plains, but no evidence of volcanic edifices observed. Textures in high-resolution B-frame and Viking pictures suggest fluidized ejecta blankets around some craters; if ground ice does or did exist, much of plateau could be composed of coalescent mudflows emanating from impact craters.

PHYSIOGRAPHIC SETTING

south half of the quadrangle, and Viking orbiter pictures, where available, better portray details of the topography. A partial mosaic of vertical Viking images north of lat 40° S provided the base for mapping the channel network shown here. Viking pictures also were used to check and in some cases to modify relative crater ages, designated according to morphologic criteria. Details of channels and rim materials around Argyre also were somewhat modified by reference to Viking images, but no attempt was made to map geologic contacts precisely according to the Viking data. The geology shown here, based on Mariner 9 images, is clearly subject to considerable revision as Viking data are further analyzed.

GEOLOGIC SUMMARY

The Argyre basin is the predominant feature and probably the oldest recognizable impact scar within the quadrangle, although some large mantled craters on the adjacent plateau may have predated it. Interpretation of the basin's origin and morphology is based largely on analogy with the youngest multiringed impact basins on the Moon, although topographic characteristics of Argyre are not nearly so distinct. Radial and concentric ejecta facies comparable to those around the lunar basin Orientale (McCauley, 1968; Moore and others, 1974; Scott and others, 1977) are not discernible, although minor radial and concentric patterns are delineated by ridges and troughs within the blocky, irregular rim materials. These rim materials include large, coherent massifs as well as more dispersed and fractured blocks and are here interpreted as predominantly uplifted bedrock of the raised basin rim, perhaps also including remnants of ejecta. The somewhat scalloped outlines of a few radial valleys suggest an origin similar to that of the conspicuous secondary crater chains around lunar basins and craters (Wilhelms, 1974). Such valleys were formed mainly by successively impacting projectiles from primary craters, but some may be attributable to gouging by single projectiles along low-angle trajectories. Some radial faulting may also have occurred, as suggested by a few linear escarpments in the Argyre rim materials, but evidence for such faulting is not prominent either here or around lunar basins. Narrow concentric troughs, 10 to 20 km wide, are conspicuous in some parts of the basin rim, notably on the northwest; these may be segments of concentric graben similar to those around some other martian and lunar basins, specifically Isidis (Mars) and Humorum (Moon).

Because Argyre appears to represent the martian equivalent of lunar basins, exemplified by Orientale and Imbrium, it too is presumed to have had several concentric rings; their exact locations, however, are problematic inasmuch as only remnant segments can be identified. The wider and deeper basin Hellas, about 4800 km due east, is partly obscured by volcanic deposits on its rim, but three to five concentric rings have been postulated (Peterson, 1977; Potter, 1976). A much better martian analog of lunar basins is the smaller (200 km) and fresher two-ring basin Lowell, with its conspicuous central peak ring, about 1200 km to the west in the Thaumasia quadrangle (McGill, 1978); this basin is nearly an exact duplicate of the lunar basin Schrödinger (Wilhelms, 1973). A similar but much more degraded small basin, Galle, is superposed on the east rim of Argyre.

Well-defined concentric escarpments or circles of peaks neither exist within nor surround Argyre Planitia; however, several possible linkages of rugged blocks and scarps that would allow different families of concentric rings to be drawn are visible. Wilhelms (1973) circumscribed three complete rings with diameters about 800, 1000, and 1200 km and segments of still larger fourth and fifth rings. The somewhat different set shown here deletes the innermost ring of Wilhelms (1973) but adds another larger one, and is basically an attempt to connect the most obvious ridges and escarpments, indicated on the map by arcuate dashed lines. The three rings have diameters of about 900, 1200, and 1600 km, and thus the spacing ratio is about 1:3.

The mechanism of ring production on the Moon has aroused considerable controversy and is unlikely to be solved in the Argyre quadrangle. Contending theories for the lunar ring structures include the megaterrace model and variants thereof, according to which large concentric fault blocks were dropped successively downward and inward (McCauley, 1968, 1977; Mackin, 1969; Hartmann and Wood, 1971; Short and Forman, 1972; McGetchin and others, 1973; Dence and others, 1974; Gault, 1974; Head, 1974; Howard and others, 1974; Moore and others, 1974; Head and others, 1975, Schultz and Gault, 1975; Scott and others, 1977); and a nested-crater model, in which each ring represents strata uplifted from depth (Hodges and Wilhelms, 1976, 1978; De Hon, 1977; Wilhelms and others, 1977). The peak rings of Lowell and Galle, like those of lunar basins such as Schrödinger, are here interpreted as rebounded central peaks that "grew" into rings (Head, 1976; Hodges and Wilhelms, 1976, 1978; Wilhelms and others, 1977) so that the rock exposed is stratigraphically lower than that of the surrounding rim.

The ring candidates at Argyre, however, unlike the Lowell rings or the concentric rings at Orientale, Imbrium, and Nectaris on the Moon, are not everywhere separated from one another by discrete troughs, nor is topographic control adequate to establish elevation relations among them. As shown by the contours, total relief between massifs and basin floor is about 3 km. In Viking oblique pictures a gradual slope appears to extend outward from the innermost massifs to the base of the third ring; the slope is interrupted, however, by a fairly well defined trough between the first and second rings on the north and northeast. The outermost (third) ring is inferred solely from discontinuous concentric escarpments that occur on the northwest (Bosporos Rupes), north and northeast sides and shorter segments on the southwest and southeast, shown on the map by dashes. The broad expanses of topographic lows and radial valleys bounded ultimately by these outermost scarps suggest at least three possible interpretations: (1) The process of crater excavation included partial stripping of thin surficial materials from around the central crater as deeper bedrock was uplifted, thus the inner main ring would be analogous to the peak ring of Lowell, and the outer ring scarp analogous to the smaller basin's topographic rim. This mechanism is favored here and depicted in Figure 1. Inner stripping was incomplete, however, for between the outer scarp segments, notably between Bosporos Rupes and its extension to the north, Argyre basin rim material appears to merge with the surrounding plateau materials. Alternatively, (2) the rim crest of the basin was near the present inner ring, and subsequent fluvial, eolian, and perhaps periglacial erosion formed the outer ring by scarp retreat as debris was transported into the basin. In this case the second ring shown would be the outer side of a circumferential graben. Still another interpretation (3) would attribute the outer scarp to faulting, contemporaneous with radial scouring and ejecta deposition. If a more centrally located peak ring formed, it now is buried beneath fluvial, eolian, and possibly volcanic deposits thick enough to obscure a post-basin crater population that would be equivalent to that on the surrounding plains.

Bosporos Rupes on the northwest is composed of linear and angular segments that appear to be faults. Relation of the Bosporos scarp to Argyre is somewhat ambiguous, however. A crater about 30 km in diameter appears either to have been deformed by the scarp or to reflect a preexisting scarp by an offset on one side of its rim. The preservation of so small a crater older than Argyre seems unlikely at best, and therefore either the scarp is younger than the basin (which also seems unlikely), or the crater postdated but was morphologically influenced by the scarp, as indicated by the map designations. Rejuvenation of the scarp at the time of the small impact is also plausible.

Terraces undoubtedly formed by downfaulting on the walls of at least the inner basin ring. Terrace remnants may include Charitum Tholus and other blocks on the margins of the central plains. Alternatively, these discontinuous materials may be part of yet another uplifted inner ring (Wilhelms, 1973).

Because of the dynamic geologic history of Mars as compared to that of the Moon, crustal development of the planet at the time of postaccretional bombardment by large planetesimals was likely quite different from that prevailing later as the impact flux declined. Furthermore, the planet's climatic regime and degree of ground ice development have probably changed considerably through time. If the formation of basin rings were to some extent dependent on crustal stratigraphic or structural discontinuities (Hodges and Wilhelms,

[...] western part of the plateau evidently is surfaced by eolian debris, [...] conspicuous wind streaks. Several large craters are thickly mantled, probably [...] debris that composes the bulk of smooth plains material. A scarp [...] contact between the cratered plateau and Argyre basin rim material [...]

[...] smooth plains deposits occupy not only the Argyre basin but also [...] (except c_4) craters in the quadrangle as well as the large topographic [...] rugged rim of Argyre. Similar plains grade into the cratered plateau [...] of the basin. At the southeast corner of the map area, the smooth [...] cratered plateau material at an escarpment.

[...] of smooth plains material in topographic lows indicates a depo[...] wind streaks, identified as variable features (Sagan and others, 1972), [...] unconsolidated debris. Eolian transport is likely the pervasive mechanism [...], but several channels at the south rim of Argyre suggest that water [...] was also an effective erosional and depositional agent, transporting [...] Argyre basin. Periodic planetwide dust storms attest to the effective-

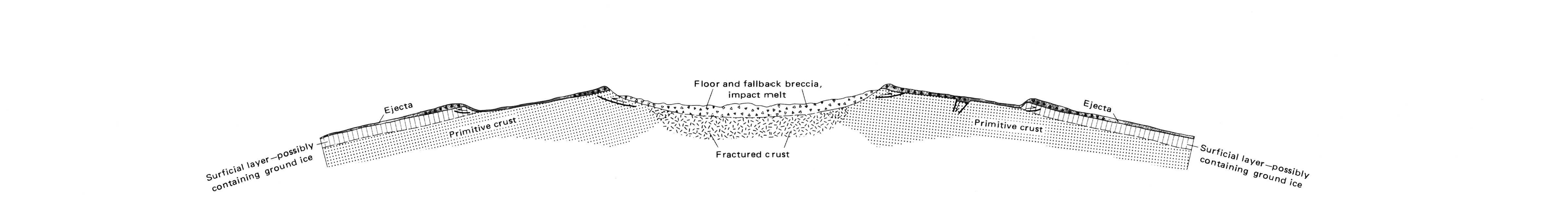
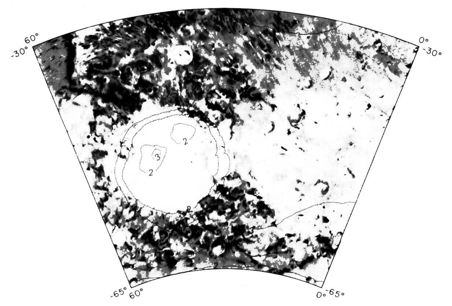


Figure 1.—Schematic north-south cross section (not to scale) through Argyre basin



ALBEDO MARKINGS AND CONTOURS