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
COPRATES QUADRANGLE
M 5M –15/68 G, 1978
I-897 (MC-18)

A series of mosaics of Mercator 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 Patricia M. Bridges.

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 of 1-2 km.

NOMENCLATURE

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

MC-18: Abbreviation for Mars Chart 18
M 5M –15/68 G: Abbreviation for Mars 1:5,000,000 series; center of sheet, 15° S latitude, 68° longitude; geologic map, G.

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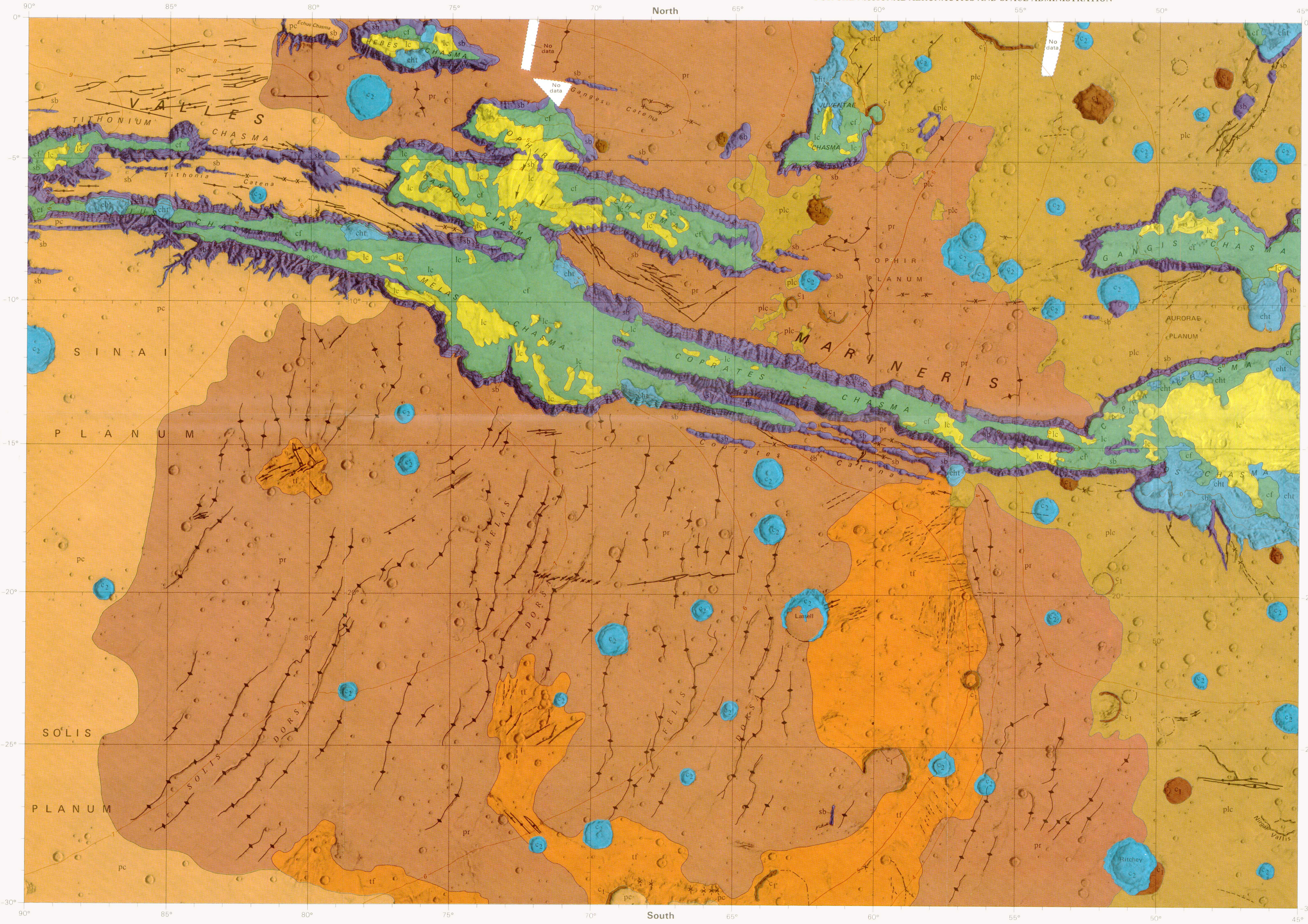
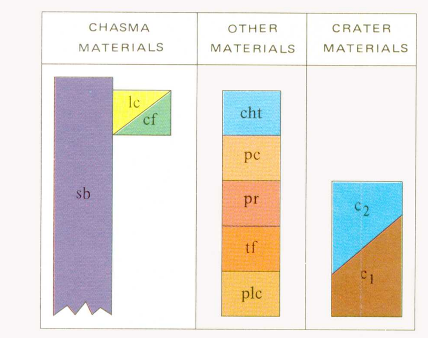


CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

CHASMA MATERIALS

sb — SLOPE AND BEDROCK MATERIAL—Composite unit that occurs on relatively steep slopes along walls of chasmas, chain craters, and collapse features. Layering in form of dark band about halfway up chasma wall seen on south side of Coprates. Slopes average 20° to 32° over most of the chasma walls. Walls of Valles Marineris show variety of erosional patterns that include steep headwalls, downward bifurcating ridges and gullies, and large alcoves below which lie great masses of jumbled debris. Gashlike grooves controlled by regional structure pattern present along with large incised bifurcating sidewall gullies. Upper slopes commonly marked by vertical ribs and grooves. Large flow lobes common at base of scarps. Representative locality near long 61°, lat -12.5° (DAS 7542498). *Interpretation:* Exposed bedrock and talus localized along steep walls. Formed and (or) exposed mostly by mass wasting or gravitational collapse of oversteepened slopes. Large bifurcating gullies produced by rapid flowage of water-saturated sediments after breeching of isolated lake basins within Valles Marineris. Lack of benching in chasma sidewalls suggests homogeneity in vertical section exposed

lc — LAYERED CHASMA MATERIAL—Occurs on floor of Valles Marineris as subdued-appearing stratified mesas. Representative locality in northern part of Gangis Chasma near long 49°, lat-7° (DAS 9017614, 10492584), where ten or more alternating light and dark layers are recognized; lighter layers near base of section extensively fluted. No B frames of other patches available, but they have same general characteristics at A-frame resolution. Largest patch occurs at mouth of Valles Marineris in Capri and Eos Chasmas, where Mariner 9 elevation data suggest a thickness of about 2 km. Patch in both Ophir and Candor Chasmas transects gullied slope and bedrock material. This occurrence not obviously stratified; has lobate form on south suggesting different mode of emplacement. *Interpretation:* Water-laid sediments deposited in large isolated lakes successively breached by wall erosion during enlargement of Valles Marineris chasma system. Drainage of lakes produced catastrophic floods that carried away most of original lake sediments. Remnants modified by later fluvial pulses and eolian activity. Ophir-Candor patch may consist of unconsolidated sediments that flowed southward after breeching of Ophir or relict mud slide from chasma walls. Fluting at base of representative locality result of wind erosion or sapping of water-saturated layers

cf — CHASMA FLOOR MATERIAL—Flat-lying, generally smooth-surfaced materials; occupy lowest parts of Valles Marineris and Hebes and Gangis Chasmas; characteristically streaked and mottled, particularly at western end of Candor Chasma. Sinuous ridges and grooves wrap around chasma walls and isolated highs on floors (DAS 1286557). Numerous small light-appearing streamlined forms present—best examples at east end of Gangis Chasma. Includes numerous flow lobes that originate in chasma walls. Crater frequency extremely low at Mariner 9 resolutions. Representative locality near long 70.4°, lat -11.2° (DAS 7470608). *Interpretation:* Mixture of mass-wasting debris, avalanche, and mudflow deposits from chasma walls, and ...

GEOLOGIC SETTING

The Coprates quadrangle lies to the east of the Tharsis volcanic complex and the Noctis Labyrinthus tectonic complex. To the north are the plains of Lunae Planum, to the east the vast patches of chaotic terrain and the large sinuous channels that trend northward into Chryse Planitia. On the southwest is the Thaumasia Fossae region of tectonically deformed cratered terrain, to the southeast, the Argyre Basin, the best preserved of the ancient martian impact basins.

The geology of the Coprates quadrangle is dominated by the Valles Marineris chasma system, which stretches in an east-southeast direction for about 2,500 km across the quadrangle. Its maximum width is about 600 km from the north rim of Ophir Chasma to the south rim of Melas Chasma. The terminus of Valles Marineris at the eastern edge of the map is about 500 km wide in the north-south direction. Individual segments of the chasma system are 100 to 150 km wide and 2 to 4 km deep.

Much of the geology described here is common to other regions of Mars and has been discussed previously not only in summary papers but by other quadrangle mappers. Preliminary attempts at the regional geology of Mars have been made by McCauley and others (1972) and Carr and others (1973). Those units and features common to other parts of Mars are discussed first. The focus of this discussion is on Valles Marineris and those features that are unique to this quadrangle.

GENERAL STRATIGRAPHY

Moderately cratered plateau material occurs along the eastern edge of the mapped area and marks the beginning of the cratered hemisphere of Mars. This unit bears some resemblance to the lunar terrae but is not saturated with large craters, and the intercrater areas are smoother and more extensive. Coincident with the appearance of this terrain, the Valles Marineris chasma system widens markedly, the chasma walls become lower in height, and chaotic terrain is abundant. Sinuous channels are numerous, and the floors of many of the large craters such as that south of Ganges Chasma (10° S, 51° W) appear to have collapsed. Subsurface sapping and fluvial activity are more widespread in this unit than elsewhere in the quadrangle. Sharp (1973) and Sharp and Malin (1975) along with Milton (1974a) have suggested mechanisms by which such processes operate on Mars.

The central part of the quadrangle is mostly occupied by ridged plains that are continuous with, and similar to, the materials of Lunae Planum described by Milton (1974b). These plains do not extend much beyond the southern boundary of the map area but patches may be present in the Thaumasia (McGill, 1978) and Argyre quadrangles. In surface morphology and crater frequency, these plains here and elsewhere on Mars are similar to the lunar maria (Soderblom and others, 1974; Meyer and Grolier, 1977). The ridged plains of the Coprates quadrangle and of Lunae Planum to the north are not clearly related to large multiring basins or to craters, as are most of the lunar maria. The ridged plains embay and overlie older cratered terrains as on the moon. Along the walls of Valles Marineris and in Lunae Planum, they are, unlike the Moon, eroded into complex scarps by fluvial, eolian, and mass-wasting processes.

Several large prongs of trough-and-furrow material embayed by the ridged plains extend northward into the central part of the quadrangle. They appear to be extensions of the tectonically deformed terrain of the Thaumasia quadrangle described by McGill (1978). Although characterized by intense fracturing within Coprates, this unit appears more subdued than that identified as troughed and furrowed hills material in the Thaumasia quadrangle. It appears to occupy zones of gently upwarped terrain with the deformation imprinted on earlier materials that have escaped burial by the marelike ridged plains.

The western part of the quadrangle is underlain by cratered plains material that is almost featureless except for scattered large and small craters. This unit is, however, the most heavily cratered of a sequence of plains of varying crater density and subtle volcanic morphology that surround the Tharsis region and extend westward and northward into Amazonis (Carr, 1975; Masursky and others, 1978). The contact between the cratered plains and the ridged plains is diffuse and highly generalized on the map. The lack of any diagnostic landforms within the unit suggests that it is either an eolian loess blanket or volcanic ash of sufficient thickness to obscure most subjacent topography except for a few 100-km-size craters. The materials below the surface of the cratered plains unit may be volcanic flows that lap onto the ridged plains and are related to the martian volcanic centers to the west.

The frequency of degraded craters decreases from east to west across the quadrangle, whereas the frequency of fresh-appearing craters is almost uniform except for the almost craterless floors and walls of Valles Marineris. This relation indicates progressively deeper westward burial of the cratered plateau unit; relatively early in martian history. Within the vast expanse of Valles Marineris are younger slope and floor units that post-date the chasmas and the plains materials that bury older cratered terrain.

VALLES MARINERIS

Valles Marineris has no known terrestrial or planetary counterpart. This structure in its entirety resembles neither a major rift system nor a valley produced by fluvial downcutting. It is characterized by several long linear segments such as Ius Chasma and Coprates Chasma separated by the broad arcuate expanse of Melas Chasma. Candor Chasma and Ophir Chasma to the north are more boxlike and are connected with the main part of Valles Marineris by gaps in the chasma walls. Hebes, Juventae, and Gangis Chasmas are separate large depressions that are not integrated into the main system. ...

... or shortly after drainage of each basin. The rapid lowering of base level and the resulting loss of lateral support caused the water-saturated wall materials within each lake to fail in different ways dependent on their lithologies. The apparent fluvial scouring seen on the floors of Valles Marineris and many of the immense outflow channels of the Margaritifer Sinus and Oxia Palus quadrangles can be explained by episodic floods that originated within Valles Marineris. This chasma lake hypothesis also alleviates the problem of the volumes of water necessary to produce the great outflow channels. The analogy to the channeled scablands of Washington state produced by the failure of the natural dam retaining Lake Missoula, then, may be more valid for Mars than previously recognized (Baker and Milton, 1974).

OTHER FEATURES

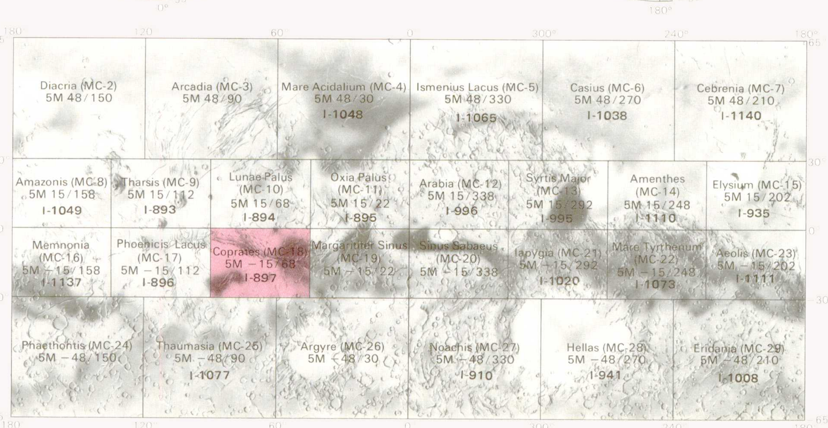
Structural trends in the Coprates quadrangle were studied by Masson (1977), who prepared structure diagrams for each 5° square. The features analyzed consist of ridges, furrows, graben, and the trend lines of chasma and crater-wall segments. Three different types of patterns can be recognized: (1) along Valles Marineris the predominant structural trend is west-northwest/east-southeast; (2) in the ridged plains of the Solis Dorsa and Melas Dorsa regions, the trends are mostly north-northeast/south-southwest; (3) the trough-and-furrow material east of the crater Lassel shows trends that are mostly east-northeast/west-southwest and north-northwest/south-southeast. Thus there appears to have been a change with time of the regional stress conditions, the west-northwest/east-southeast direction that controls Valles Marineris being the youngest, the orthogonal pattern of the ridge and furrow materials the oldest.

Surficial light and dark streaks are not as prominent as in other parts of Mars. As seen in figure 1, however, the Sinai Planum-Solis Planum area has numerous bright streaks that curve in a southeast direction away from Valles Marineris. The cratered plateau unit in the southeast part of the quadrangle has bright streaks that trend south-southeast. In the same unit in the northeast part of the map area, they trend south-southwest toward the lower ends of Valles Marineris. The dark blotches of the Felis Dorsa region have a general trend that is west-southwest. Many of these markings appear to follow topography in the downslope direction, suggesting that slope winds may be a factor in their development.

GEOLOGIC HISTORY

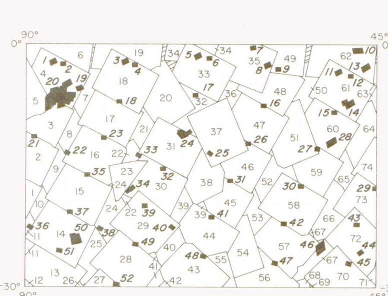
The earliest recognizable geologic events in the Coprates quadrangle are associated with the formation and modification of the cratered plateau material on the east side of the map area. This region is part of the more heavily cratered southern hemisphere of Mars consisting of scattered large impact craters separated by large tracts of smooth to rolling plains or hilly terrain. The origin of these plains is not understood, although considered by some workers to be volcanic. Whatever their origin, it is clear that they are the result of modification of a primitive impact-dominated surface like the lunar terrae. Formation of the trough-and-furrow material followed. This originated from intense fracturing and gentle upwarping of terrain that may be correlative with the cratered plateau material. Later flood basalts similar to those of the lunar maria erupted. These occur in the central part of the quadrangle and northward into Lunae Planum. Their thickness must be of the order of several kilometers to obliterate almost all traces of the subjacent cratered plateau and trough-and-furrow materials. The cratered plains are next in the sequence and are inferred to consist of a complex succession of superposed flows probably related to the onset of volcanism in the Tharsis region to the west and covered by eolian materials.

Some time after these major regional units were formed, thermokarst activity began in the Valles Marineris area. A series of closed depressions formed along zones of parallel graben like those still seen north of Tithonium Chasma. Individual larger graben may have been present in ...



QUADRANGLE LOCATION

ALBEDO MARKINGS AND CONTOURS



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GEOLOGIC MAP OF THE COPRATES QUADRANGLE OF MARS

By
J.F. McCauley
1978