U.S. DEPARTMENT OF THE INTERIOR
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ATLAS OF MARS
1:500,000 GEOLOGIC SERIES
WEST MANGALA VALLES REGION
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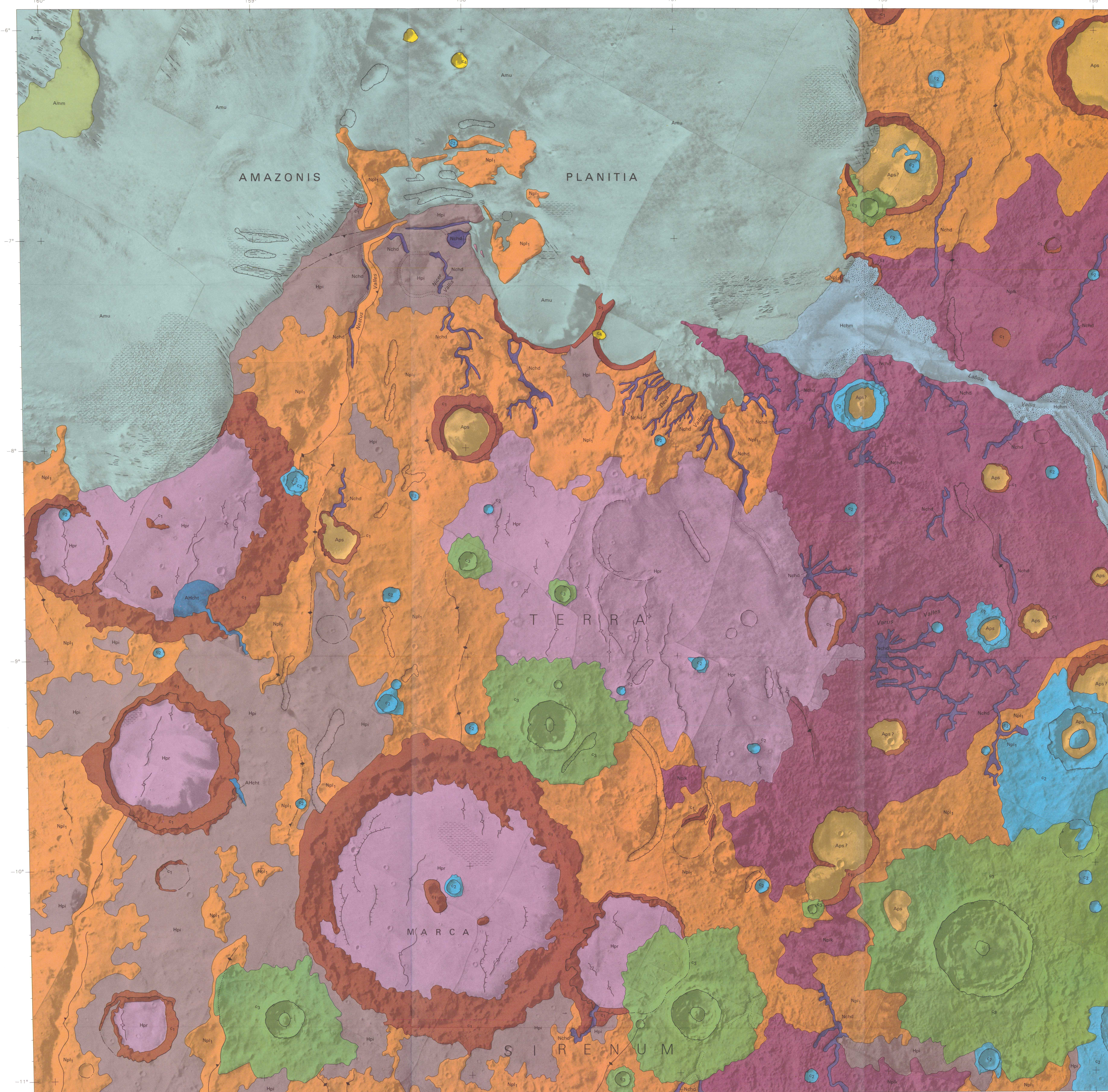
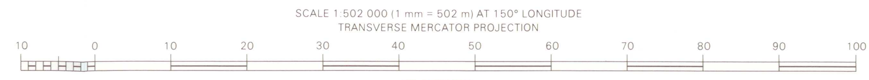
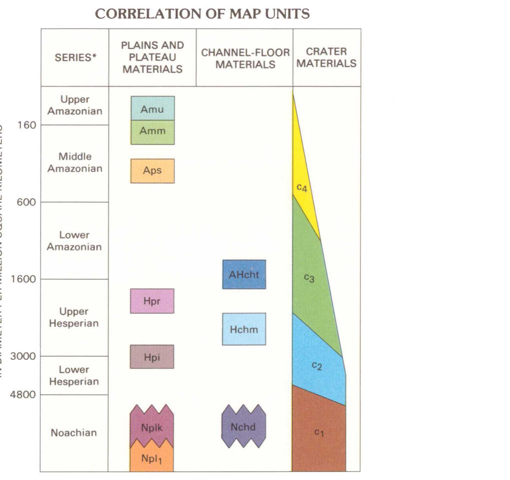




CORRELATION OF MAP UNITS



INTRODUCTION

This map is one in a series of 1:500,000-scale geologic maps initiated by the National Aeronautics and Space Administration to investigate areas of particular scientific interest on Mars. The west Mangala Valles area merits detailed geologic study because it contains several small channels whose ages can be determined relative to geologic units that range in age from early (Noachian) to late (Amazonian) periods of Martian history. Because the small channels are of three ages and channels of each age are of a geomorphic type unique to that age, their study increases our understanding of the continuity of fluvial processes in the evolutionary history of Mars. For these reasons, part of the area is a proposed site for a sample-return mission to Mars.

The map base is a composite of parts of two Viking 1:500,000-scale photomosaics (U.S. Geological Survey, 1985a, b). These photomosaics are based on high-resolution images except in the area that now forms the northwest corner of the composite, for which only lower resolution images are available. Because the latter images were acquired at sun angles opposite these on the high-resolution images, the "mesa" that appears in this area is actually a depression. Some map units correspond or are partly equivalent to units on smaller scale maps (Mutch and Morris, 1979; Scott and Tanaka, 1986). However, in many places interpretations and contacts have been revised to reflect information visible on high-resolution Viking images; geomorphologic details on these images were clarified by spatial filtering (Condit and Chavez, 1979). The depths of channels, thicknesses of geologic units, and heights of scarps were obtained in places by using photoclinometric methods of Davis and Soderblom (1984). The relative ages of geologic units and geomorphic features such as small channels and faults were established by stratigraphic relations and supported by crater counts (fig. 1).

The east Mangala area, which contains another proposed sample-return site, has also been mapped in this series at 1:500,000 scale (Chapman and others, 1989). It lies northeast of the west Mangala map area (at lat 2.5° to 7.5° S., long 145° to 150°; fig. 2). Some plains units common to both areas have slightly different ages, although the units and their channels were dated by the same methods. Each of the two map areas contains channels of three different geomorphic types and ages, of which only two are common to both areas. (The eastern map area contains Lower Amazonian, narrow "ribbon channels" of a type and age not seen in the western area; the degraded channel networks of the western area were not observed in the eastern area.) Thus at least four types of channeling are known to have occurred at different times in the Mangala region.

GEOGRAPHIC SETTING

The map area includes the northern section of Labou Vallis (the westernmost branch of Mangala Valles) and several small channels on Terra Sirenum (fig. 2). Mangala Valles compose a north-trending channel system 850 km long and in places 150 km wide, which appears to originate at one of the east-trending faults of Memnonia Fossae that lies 530 km south of the map area, at about lat 18.5° S., long 149°. Many of the small channels on Terra Sirenum, west of the Mangala branches, also trend north. The highland-lowland boundary scarp that separates Terra Sirenum from Amazonis Planitia is covered or absent throughout the map area.

STRATIGRAPHY OF PLAINS AND PLATEAU MATERIALS

SUMMARY OF HYDROLOGIC HISTORY

... Large volumes of water that eroded Mangala Valles and the Labou branch channel may have come from the melting of interstitial ice in the subsurface by volcanic heating (McCauley and others, 1972; Masursky and others, 1977); specifically, the release of large-scale floods could have been triggered by development of Tharsis volcanism (Greeley and Spudis, 1981). Alternatively, ground water trapped in a confined aquifer beneath a thick permafrost layer could be rapidly released if the pore pressure exceeded the lithostatic pressure (Carr, 1979). However, the recurrent nature of channeling suggests intermittent hydrologic activity on Mars, and the different channel morphologies may further imply that certain processes of channel formation were dominant in or unique to specific periods in the Mangala Valles region.

STRUCTURE

South of the map area, east-trending faults of Memnonia Fossae cut both Hesperian intercrater plains and Noachian materials. These faults became active in the Early Hesperian and were reactivated in Late Hesperian to Early Amazonian time (Plescia and Saunders, 1982; Tanaka, 1986). Water that eroded Mangala Valles and their Labou Vallis branch appears to have emanated from the faults as did Hesperian basaltic lava flows east of the map area (Chapman and others, 1989).

In the map area, large, north-trending, widely spaced ridges occur on Noachian cratered plateau material; they are as long as 40 km and as wide as 5 km. South of the map area, these ridges are truncated by faults of Memnonia Fossae. The Noachian ridges are transitional with scarps of roughly the same size. One of the scarps seen on the photomosaic base (composed of orthographic images) has a false depression or graben on its west side that is not seen on filtered rectilinear images (fig. 3*E*) or on the 1:2,000,000-scale photomosaic of the area (U.S. Geological Survey, 1979). The pervasive, parallel, northward trends of the ridges and local scarps indicate that they are tectonic features. Noting that many Noachian ridges have steep scarps, Scott and Tanaka (1986) have interpreted the ridges to have formed mostly by normal faulting.

North-trending wrinkle ridges are prominent features on the ridged plains material. They differ from the large Noachian ridges in that they are much smaller and are asymmetrical. These features are common on the Moon, Mars, and Mercury, and interpretations of their origin differ (Colton and others, 1972; Howard and Muehlberger, 1973; Scott, 1973; Lucchitta, 1976; Plescia and Golombek, 1986). In studies of the Tharsis plateau ridge systems, Watters and Maxwell (1986) stated that the ridges are best explained as compressional features that formed during a period of isostatic uplift. They probably formed in conjunction with volcanic deposits of ridged plains material. The wrinkle ridges parallel older Noachian ridges and scarps; either the features are volcanic and formed by lava following earlier fractures, or they are tectonic, resulting from thrusting and compression along zones of structural weakness.

The northeast-trending boundary scarp, which separates the Terra Sirenum highland from the Amazonis Planitia lowland to the north, cannot be observed in the map area; it may be covered by the Medusae Fossae Formation. Geologic mapping east of this area suggests that the scarp formed during the Late Hesperian (Chapman and others, 1989). Two small, east-trending scarps at about lat 7° S., long 158.5° may also be of Late Hesperian age, because they cut the intercrater plains unit and are overlain by the Medusae Fossae Formation; the scarps appear to be those of normal faults bounding a small graben.

GEOLOGIC HISTORY

In the west Mangala area, the Noachian cratered plateau unit consists of heavily bombarded material. The Noachian terrain was locally eroded by water derived from ground-water seepage or melted ground ice, leaving small, degraded channels and the pitted surface texture of knobby plateau material. North-trending, normal faulting also formed large ridges that are locally transitional to scarps. The Noachian units were then partly covered by a mantle of Hesperian intercrater plains material that probably consists of reworked Noachian debris. During the Early Hesperian, east-trending faults produced Memnonia Fossae to the south. The fossae were then the source of catastrophic floods that formed Mangala and Labou Valles. During the Late Hesperian, basaltic flows of the ridged plains unit filled low areas and large craters. This unit in the western part of the map area is covered in one place by a fan deposit from the mouth of a theater-headed channel. The channel was produced by sapping or composite processes and probably formed during Late Hesperian to Early Amazonian time. Amazonis Planitia was then surfaced by poorly indurated material of Amazonian age, the Medusae Fossae Formation, which may consist of ignimbrite deposits.

A CANDIDATE LANDING SITE

ROVER TRAVERSES AND SAMPLE STATIONS

Candidate landing sites must contain a diversity of geologic units, spanning a wide age range, that are in close enough proximity to be sampled by a vehicle of limited mobility. If a site also has unique geologic features, its potential value is greater. The west Mangala Valles area includes several such sites; the most promising is shown in figures 5 and 6.

Twenty-four sample stations are located within 38 km of the landing site (fig. 5). (The landing and ascent sites are assumed to be the same or close together.) Traverse routes to the stations are provisionally laid out from the landing site, where contingency samples would be obtained (table 1); the routes appear to be relatively smooth and free of obstacles at image resolution (50 m/pixel). However, much higher resolution images, possibly obtained from a Mars Observer or other missions, are considered necessary for the final selection of an optimum landing site and of rover traverses to the stations recommended for sampling. (The mostly craterless surface of intercrater plains material in parts of the traverse area may be due to a thin mantle of young eolian dust that may be eroding off the Medusae Fossae Formation.)

Like the candidate landing sites in this map area and the east Mangala area (Chapman and others, 1989; fig. 2), the other sites in the planned science study areas (fig. 7) maximize the probability of selecting samples that will answer the widest diversity of fundamental questions within reasonable mission constraints.

REFERENCES CITED

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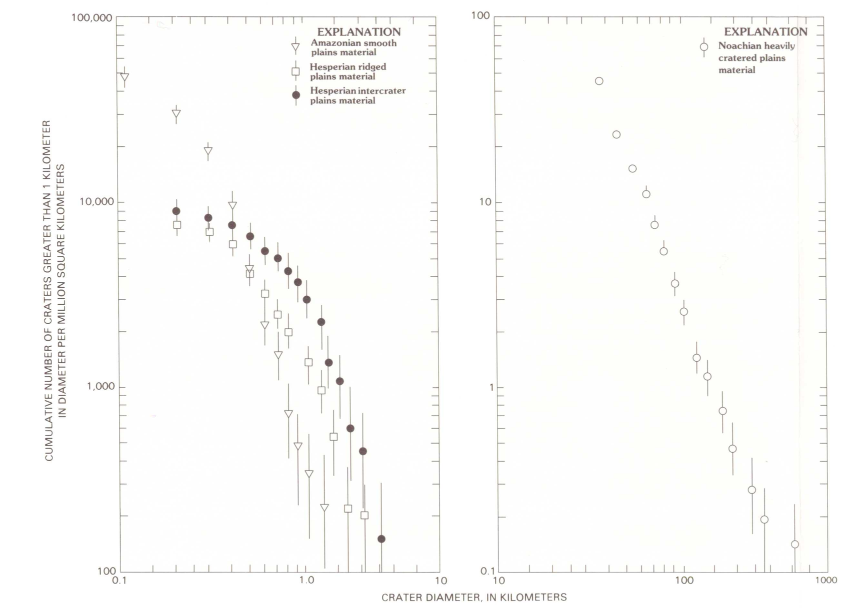

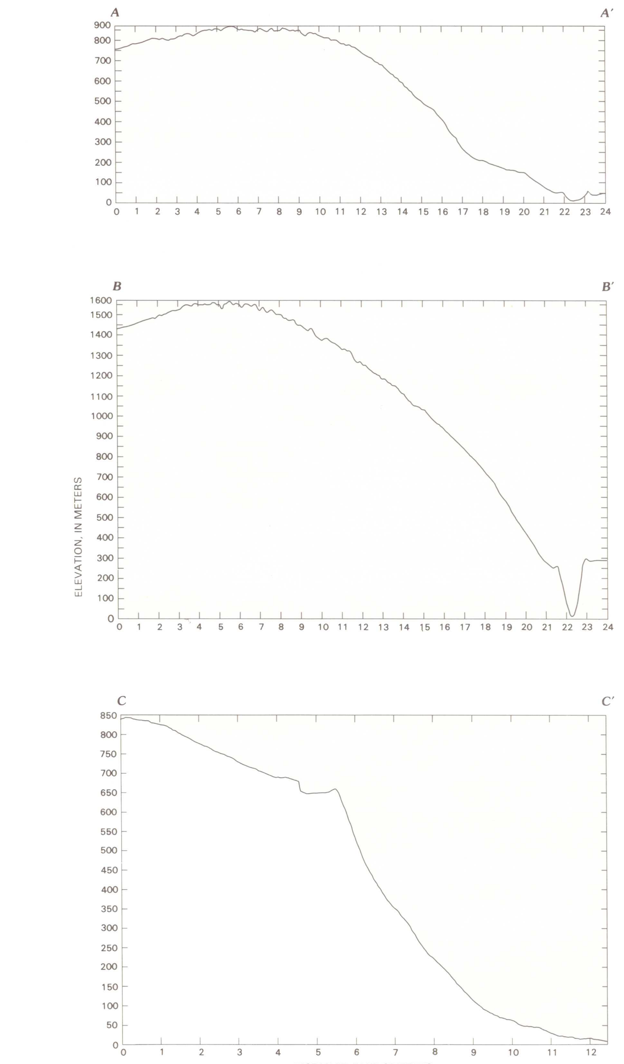

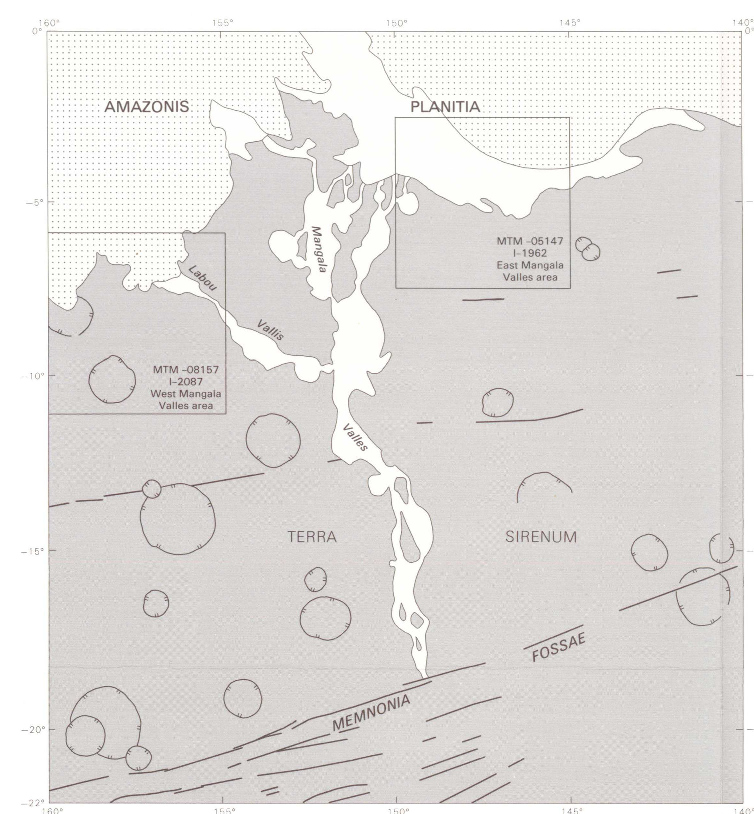

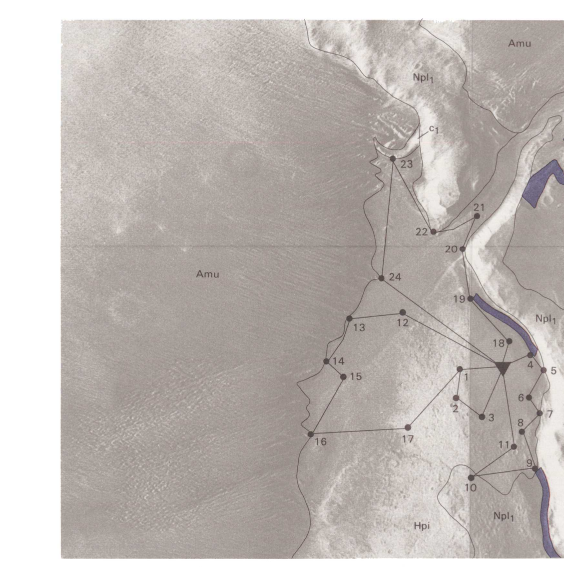

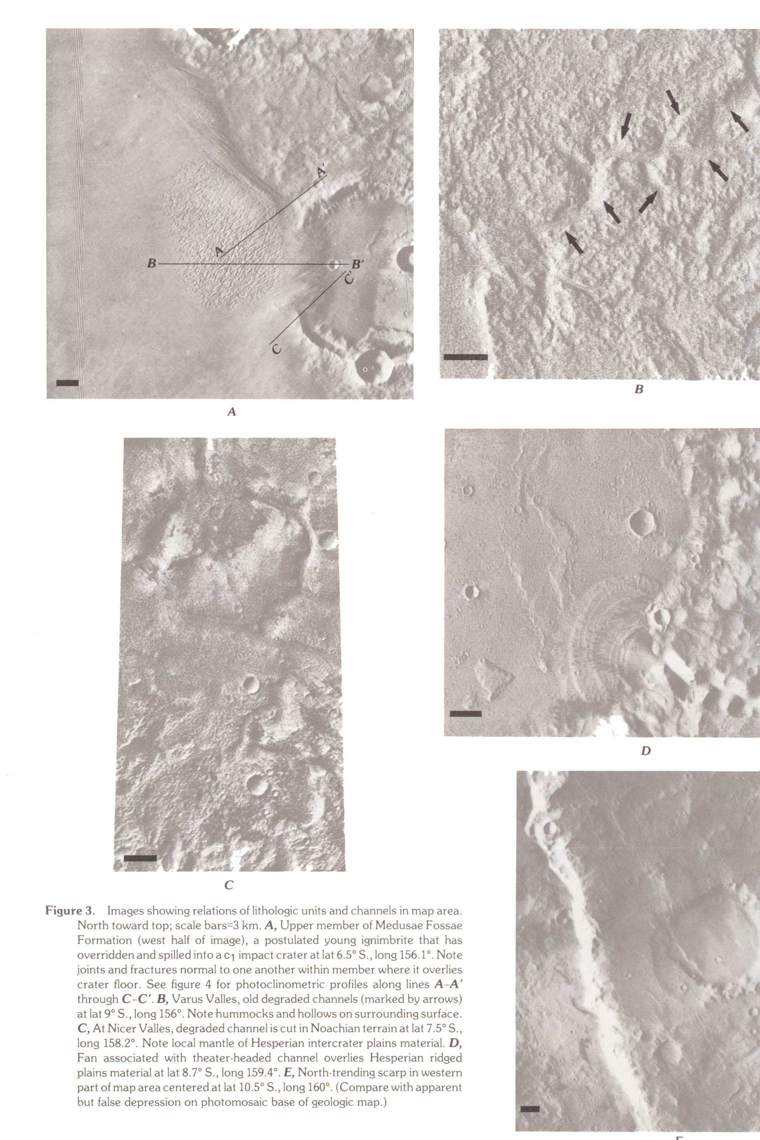

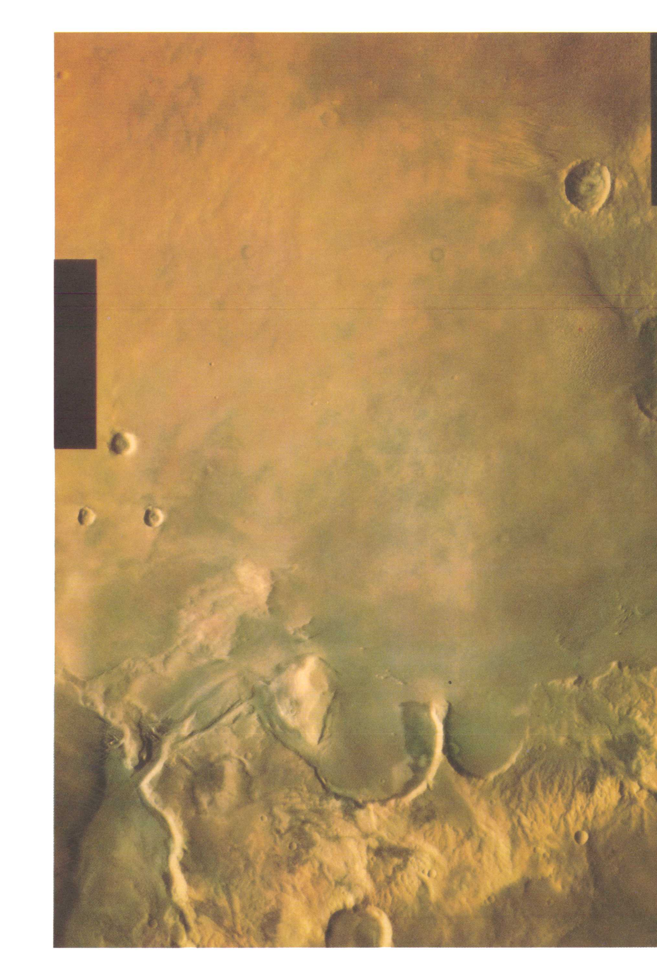

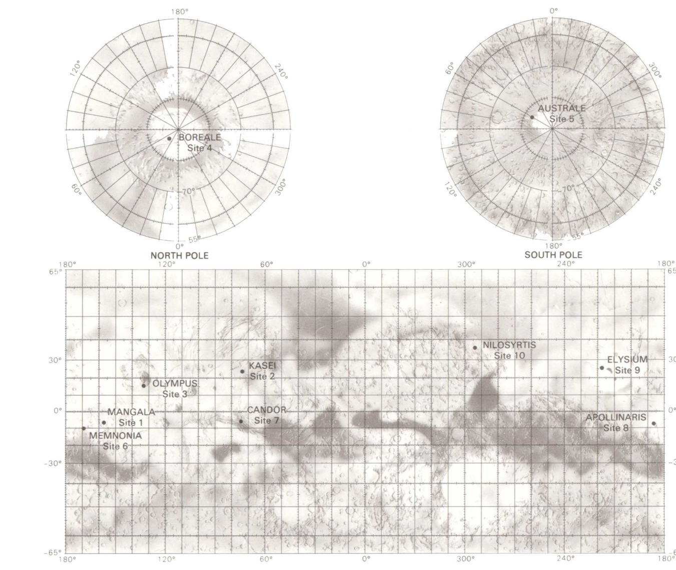

Table 1. *Materials to be sampled at stations (numbers) of proposed landing-site (LS) traverses (fig. 5).*

Station number	Estimated minimum traverse distance from LS (km)	Sample description and geologic significance	Station number	Estimated minimum traverse distance from LS (km)	Sample description and geologic significance
LS	0	Eolian and possible fluvial material of intercrater plains unit (Hpi); probable volcaniclastic composition	13	15	Possible young ignimbrite deposit (upper member of Medusae Fossae Formation, Amu); TV scan for evidence of layering, sorting, or vapor cavities
1	4	Intercrater plains material having slightly rougher surface and higher albedo than at LS; core sample	14	20	Possible young ignimbrite deposit (Amu); TV scan
2	6.5	Ejecta and rim material around <500-m-diameter crater	15	22	Intercrater plains material having very smooth surface; core sample
3	10	Eolian and possible fluvial material of intercrater plains unit	16	28	Possible young ignimbrite deposit (Amu); TV scan
LS	15	Completion of first traverse	17	37	Intercrater plains material having a slightly rougher surface and higher albedo than at other stations; core sample
4	3	Channel material (Nchd); core sample	LS	48	Completion of third traverse
5	5	Heavily cratered plateau material (Npl_1) in talus of scarp; TV scan of scarp for evidence of layering	18	2.5	Intercrater plains material (Hpi) having darker albedo than at other stations
6	8	Local low albedo on intercrater plains material	19	7.5	Channel material (Nchd)
7	10	Heavily cratered plateau material	20	12	Heavily cratered plateau material exposed in talus of scarp; TV scan of scarp for layering
8	12.5	Thin mantle of eolian and possible fluvial material of intercrater plains unit (Hpi) blanketing rough, heavily cratered plateau unit; core sample	21	15.5	Ejecta and rim material of crater 500 m in diameter
9	16.5	Channel material (Nchd); core sample	22	20	Heavily cratered plateau material
10	23	Heavily cratered plateau material	23	27.5	Rim material of c_1 crater
11	28	Thin mantle of intercrater plains material over heavily cratered plateau unit; core sample	24	38.5	Possible young ignimbrite deposit (Amu); TV scan for evidence of layering, sorting, or vapor cavities
LS	35	Completion of second traverse	LS	52	Completion of fourth traverse
12	10	Intercrater plains material; very smooth surface due to thin mantle of young eolian dust; core sample		150	Total distance of four traverses

GEOLOGIC MAP OF SCIENCE STUDY AREA 1B, WEST MANGALA VALLES REGION OF MARS

(SPECIAL MTM –08157 QUADRANGLE)

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