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VIKING ROVER STUDIES

by

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PRELIMINARY
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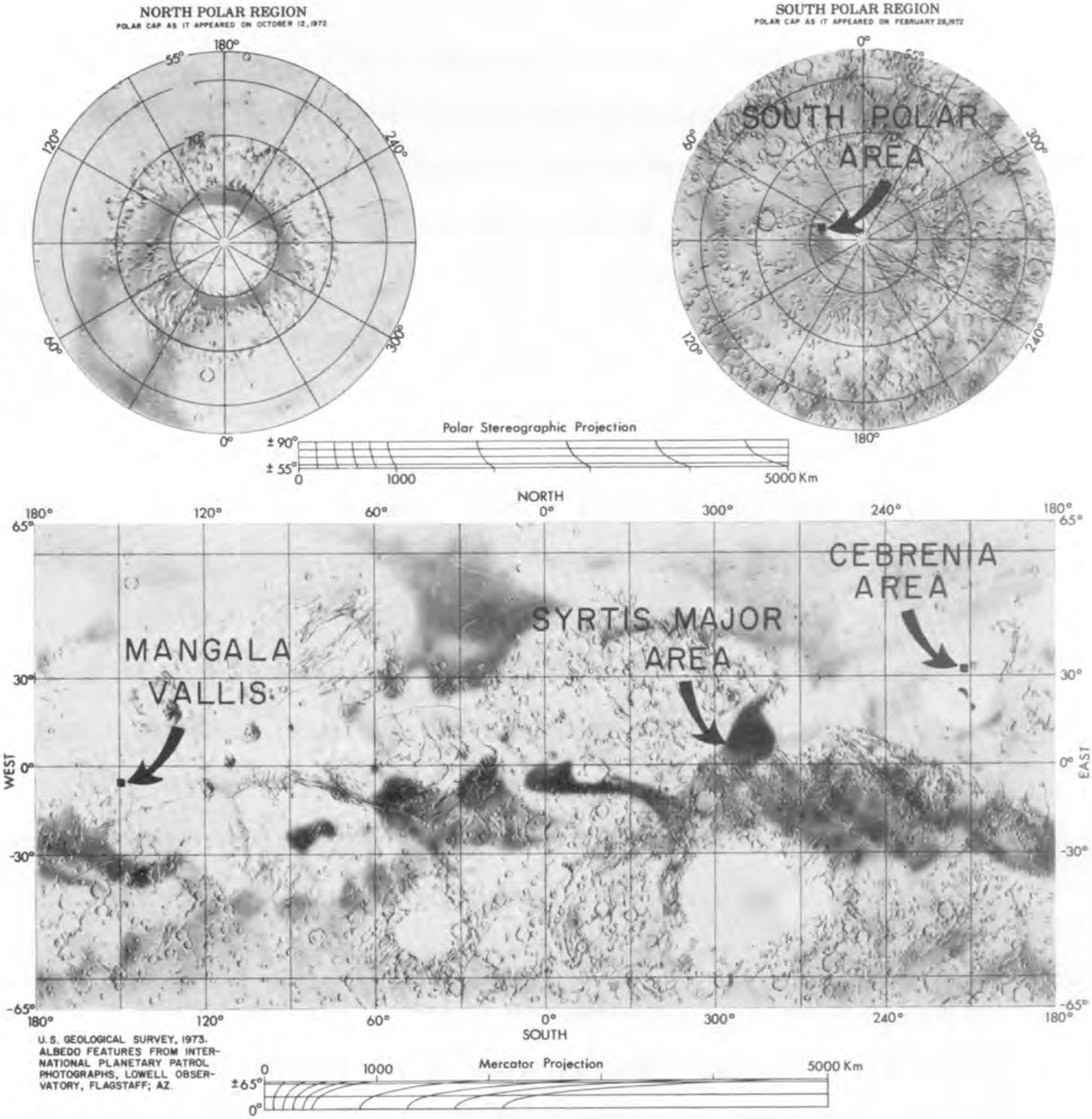
VIKING ROVER STUDIES

Introduction

Intensive study of Mariner 9 data has resulted in an understanding--although far from complete--of the geologic processes affecting the Martian surface and of its history of development. The results are briefly summarized in the following section. The second section consists of geologic studies of four widely separated areas on Mars (figure 1) selected to provide as wide a variety of environments as possible. For each area a detailed geologic map of a high resolution Mariner 9 B-frame was made and several exemplary traverses were plotted to show how the various geologic units might be visited, sampled, and analyzed. In each area 5 to 10 geologic units appear to be accessible. A substantial fraction of each area is covered by loess-like or dune-like units or channel deposits. That is, there are extensive deposits of transported debris that may be strongly sorted by sedimentational processes. However a variety of indigenous rocks are also present in each of the areas selected. Volcanic rocks of several types and impact debris occur locally. These are masked to varying degrees by the transported debris.

Two additional capabilities are necessary beyond those available for Viking '75. The first is a decrease in the size of the landing ellipse so the spacecraft can be put down close to a desirable landing point. The second is a mobility system to allow exploration in the vicinity of the landing point in order to sample the various units locally present more effectively.



VIKING MARS 1979
EXAMPLES OF ROVER MISSIONS

Figure 1

Section 1

The following is a short summary of current ideas on the geologic processes that have operated on the Martian crust and a very brief statement on the evolution of the crust. Intensive study of the Mariner 9 data has led to hypotheses on the development of the Martian crust and surface materials. The two currently planned soft landings on the surface of Mars by the USA in 1976 should provide additional data to test these hypotheses. However, lacking mobility the samples analyzed by the two Viking 75 landers can, at most, be representative of only two geologic units. A single lander with mobility, such as that proposed for the Viking 79 mission, is capable of systematically sampling as many as ten geologic units.

Correlation of ground-based radar elevations from the Haystack and Goldstone observations with Mariner 9 elevation data from occultation studies, the infrared interferometer-spectrometer, ultraviolet spectrometer, and television geodesy and photogrammetry experiments has led to the construction of a planetwide contour map with a one kilometer interval adjusted to a fourth order geoid based on tracking results from the celestial mechanics experiment. The contours are plotted on a new shaded relief base map compiled from more than 1500 television pictures adjusted to the primary and secondary control point network.

The map shows that the planet is pearshaped, the southern hemisphere being high and the northern hemisphere low; the lowest region is at 65 N latitude. The north polar region rises again to the nominal mean level. With regard to the center of mass, the center of figure is displaced more than 3 km toward the south pole

and more than 2 km toward Tharsis Montes at 110°W. Olympus Mons rises more than 29 km above Amazonis Planitia and Pavonis Mons on the Tharsis high rises more than 18 km above the lowland.

Analysis of three classes of information proves that the Martian surface is highly variable: 1) photogeologic interpretation of television images has shown that various distinct geologic units comprise the surface materials, ranging from volcanic materials, fluviatile deposits, eolian deposits, and polar deposits. 2) Topographic data (photogrammetry from television pictures, pressure mapping with the ultraviolet spectrometer and infrared interferometer and infrared radiometer mapping also has shown highly varied terrain with abundant local detail. 3) Further, topographic and physical property mapping with ground-based radar indicates locally highly varied material on the kilometer to meter scale (G.L. Tyler, written communication).

Photointerpretation indicates that the southern highlands are heavily cratered ancient terrain and the northern lowlands are underlain by lava flows. The lavas probably are of basaltic composition. The polar regions are covered by thinly layered deposits, possibly composed of material brought down by the polar snow falls. These deposits are re-eroded and redeposited in two planet-girdling eolian mantles that thin equatorward. The equatorial region between 30°N and S apparently is heavily wind eroded and supplies the material of the polar and temperate eolian mantles.

The lavas of the great volcanoes probably are basaltic in composition based on the gross shield shape and the digitate form

of the flank lava flows. Other volcanic centers resemble ring dike or cone sheet complexes which, on Earth, are characterized by highly variable compositions ranging from mafic to silicic. The Martian volcanic centers range in age from those that are little cratered and eroded to those that are heavily cratered and degraded.

The high plateau east of Tharsis Montes may be underlain by layered volcanic rocks which are exposed in the sides of the great fault valleys and along the northern edge of the plateau.

Several different classes of channels are present: broad channels that originate in chaotic terrain; sinuous channels with tributaries and whose braided floors have numerous streamlined islands; finely textured networks of branching channels that are very abundant in the equatorial region; and reticulate, intersecting valleys along the north edge of the plateau. The formation of all classes of channels may have involved the flow of water on or very near the surface. They range in age from those that have been moderately cratered and modified in form to those that have not been noticeably cratered and have retained their original crisp form. The final type of channel originates in craters and becomes narrower downstream rather than wider as do the other types. Closely resembling terrestrial and lunar lava channels, this type probably involves the channelized flow of lava.

The sequence of events in the formation of the Martian crust may be as follows: accretion, planetwide differentiation into rocks having different densities and ratios of alumina/silica as in the

case for the Moon; continued intense bombardment of the upland crust with the formation of the major impact basins such as Hellas and Argyre; mantle convection which stripped the crust from much of the northern hemisphere and caused it to accumulate in the southern hemisphere; lava flooding of the depressed, stripped areas, continued volcanism of the ring dike type in the continental areas; continued basaltic volcanism in the lowlands and along the continental margins, as, for example, along the Tharsis ridge; episodic warming and formation of channels by water, alternating with cooler periods and the formation of extensive ice caps composed of both water and carbon dioxide ice; episodic accumulation of layered deposits at the poles, erosion of these deposits and their redistribution to form eolian debris mantles.

The two proposed landings at 40° and 20° north by the Viking Mars 75 spacecraft will permit sampling two of the geologic units and examining the evidence for the processes. The northernmost USA site at Cydonia (40°N), which lies in the area with highest water content outside of the poles, presumably will provide samples of lowland basaltic rock and of the eolian mantle. The southern site (Chryse) may sample cahnnel material from the central plateau. It may be possible to determine whether the debris is water worn.

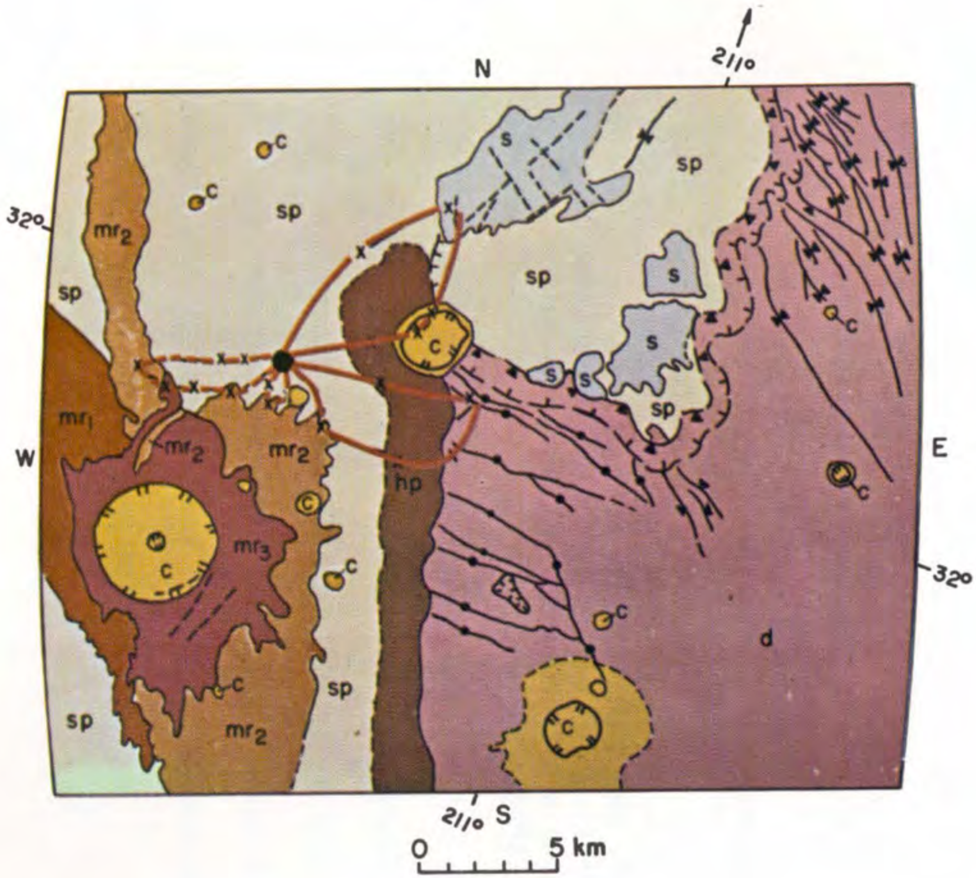
As a result of the landings, we may therefore examine ancient crustal breccias or channel deposits, lowland basalts, or eolian debris and consequently may retain or discard the hypotheses based solely on orbital observations.

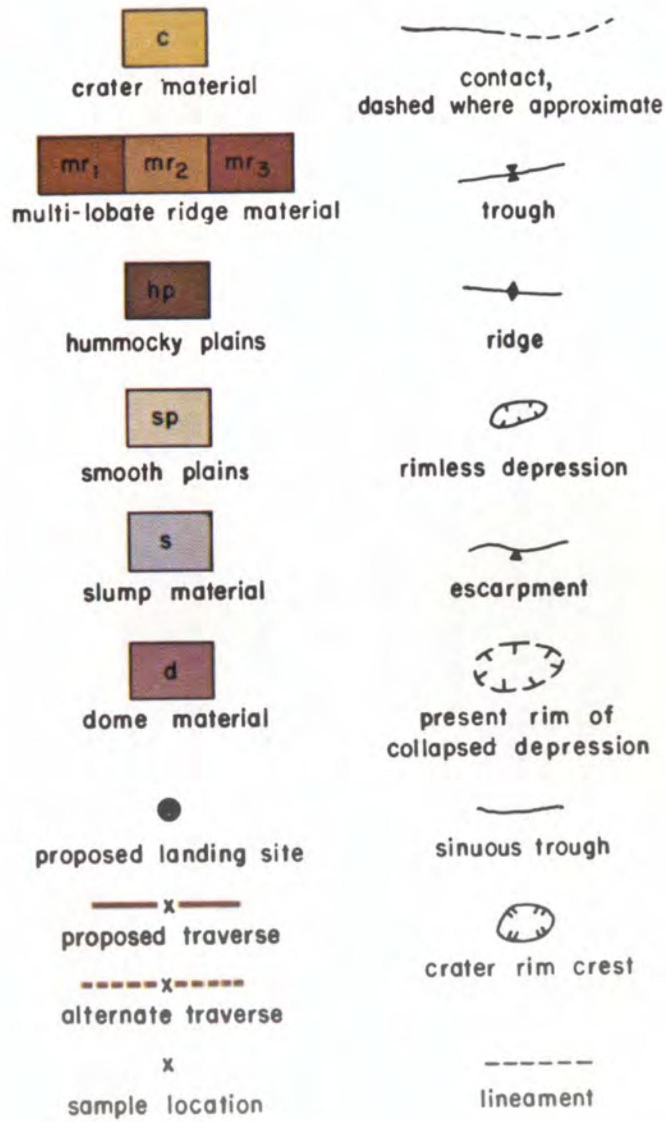
Section 2

Four high resolution television pictures (100 to 300 meter resolution) of widely separated areas have been mapped geologically and analyzed an exemplary traverses have been shown. The traverses are arranged so as to sample the geologic units along a total of about 50 kilometers of traverse distance. In all cases both bedrock and surficial units are considered. Included are an area adjacent to the south polar layered terrain, a volcanic flow and dome, a channeled area, and an area with abundant eolian deposited dunes and streaks.

There are several traverses in each area with a number of stops indicated. At each stop, we plan to take photographs and use the *in situ* geochemical analyzer. At a selected subset indicated a sample would be collected for return to the lander where the full array of analytical devices would be used. Five to ten geologic units occur in each area. Each unit would be sampled several times and at least one sample would be returned to the lander.

The sites are shown and traverses plotted in the following illustrations:





CANDIDATE VIKING ROVER LANDING SITE

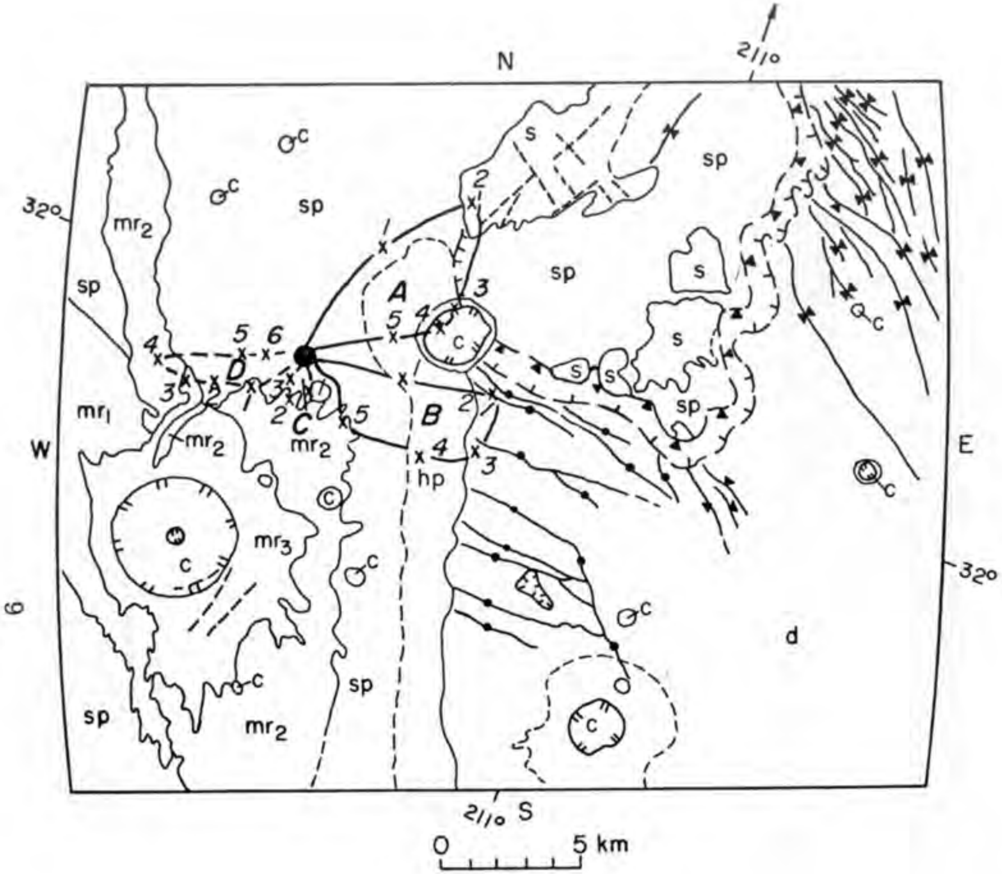
CEBRENIA AREA

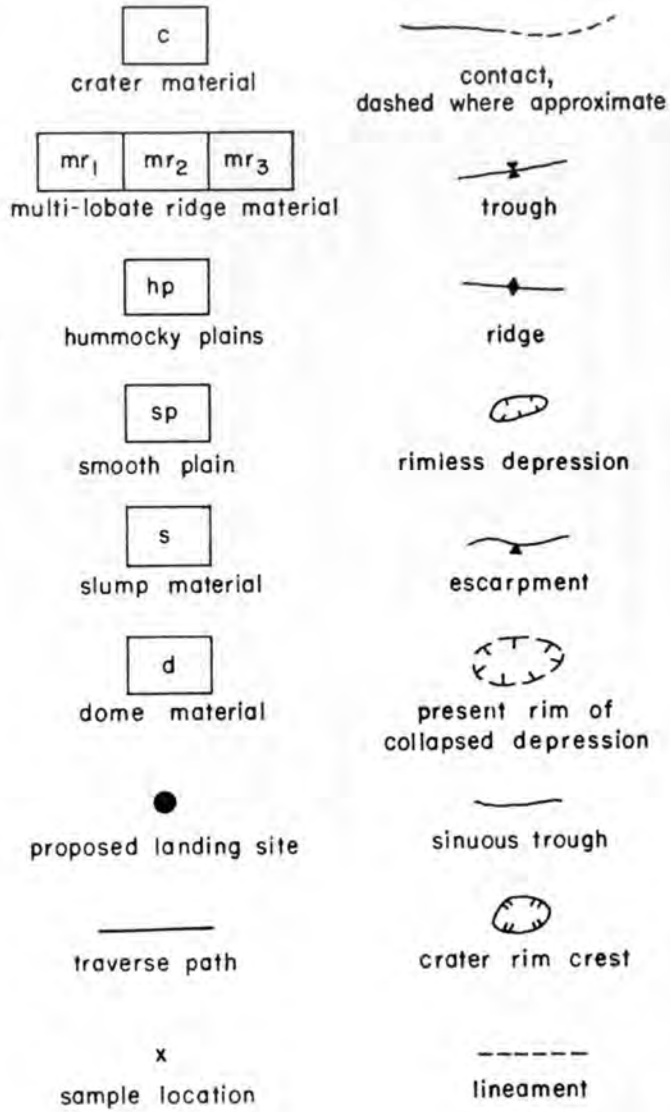
(32° N, 211° W)

by

J. M. Boyce and Harold Masursky

MARCH 1974





CANDIDATE VIKING ROVER LANDING SITE
CEBRENIA AREA
(32° N, 211° W)
by
J. M. Boyce and Harold Masursky
MARCH 1974

CANDIDATE VIKING ROVER LANDING SITE

CEBRENIA AREA (211.5, 32.0 N)

J. M. Boyce and Harold Masursky

c

Crater material

Characteristics
Material in and around craters

Interpretation
Relatively young impact craters; some craters may be volcanic in origin

Mr_1	Mr_2	Mr_3

Multi-lobate ridge material

Characteristics
Rough textured deposits which form lobate terminations and irregular scarps. Mr_1 is the stratigraphically lowest unit

Interpretation
Lava flows; may be basaltic in composition; the morphology indicates low viscosity, alternately these units may be mud flows

hp

Hummocky plains

Characteristics
Rougher and more textured than unit sp

Interpretation
Volcanic material of intermediate age

sp

Smooth plains

Characteristics
Very gently rolling smooth plains with a few widely dispersed small craters. This unit embays and is younger than unit d

Interpretation
Eoliean deposits or lava flows

s

Slump material

Characteristics
Hilly material near the base of the steep escarpment around unit d

Intepretation
Slump and slide material from unit d

d

Dome material

Characteristics
Rough, hummocky material that forms the large dome. Irregular shaped craters, depressions and trough are superposed

Intepretation
Volcanic material, or possibly a large pingo

Cebrenia Site

Traverse A.

Station 1: Unit [sp] Very gently rolling smooth plain at B-frame resolution except for a few widely dispersed small craters. Eolian deposits or flood lavas. In situ chemical analysis, sample return to lander. photographic coverage.

Station 2: Unit [s] Hill forming material near the base of the step escarpment around unit d. Slump and slide material from unit d. In situ chemical analysis, sample return to lander, photographic coverage.

Station 3: Unit [c] Material in and around craters. Relatively young impact craters. In situ chemical analysis; photographic coverage.

Station 4: Unit [hp] Rougher and more textured than unit sp. Volcanic material of intermediate age. In situ chemical analysis, photographic coverage.

Traverse B.

Station 1: Unit [hp] same as station A-5.

Station 2: Unit [d] Rough hummocky surfaced dome forming material Irregular shaped craters, depressions and trough superposed. Dome forming volcanic material, or as some authors have suggested, a large pingo. In situ chemical analysis, sample return to lander, photographic coverage.

Station 3: Unit [d] same as station B-2.

Station 4: Unit [hp] same as station A-5 except sample return.

Cebrenia Site (continued)

Traverse B.

Station 5: Unit [mr_2] Rough textured deposits that form lobate and irregular scarps at their terminations. Stratigraphically an intermediate subunit of mr. Lava flow material. expected to be basaltic composition because its morphology indicates low viscosity or other authors have suggested these units could be mud flows. In situ chemical analysis, sample return to lander, photographic coverage.

Traverse C.

Station 1: Unit [c] Same as station A-3.

Station 2: Unit [mr_2] Same as station B-5.

Station 3: Unit [mr_3] Same as station B-5 except no sample return.

Traverse D. (alternate traverse)

Station 1: Unit [mr_2] Same as station C-2 except no sample return.

Station 2: Unit [sp] Same as station C-3.

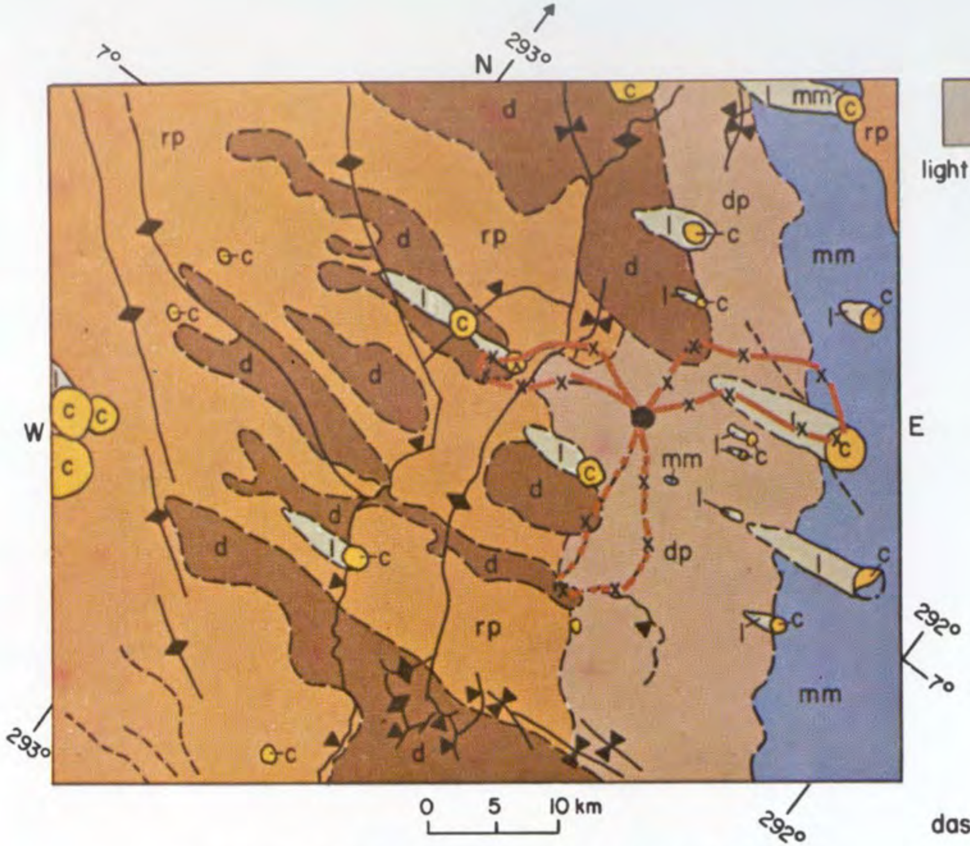
Station 3: Unit [mr_3] Same as station B-5 except this unit is the highest mr subunit stratigraphically and no sample return.

Station 4: Unit [mr_2] Same as station D-1.

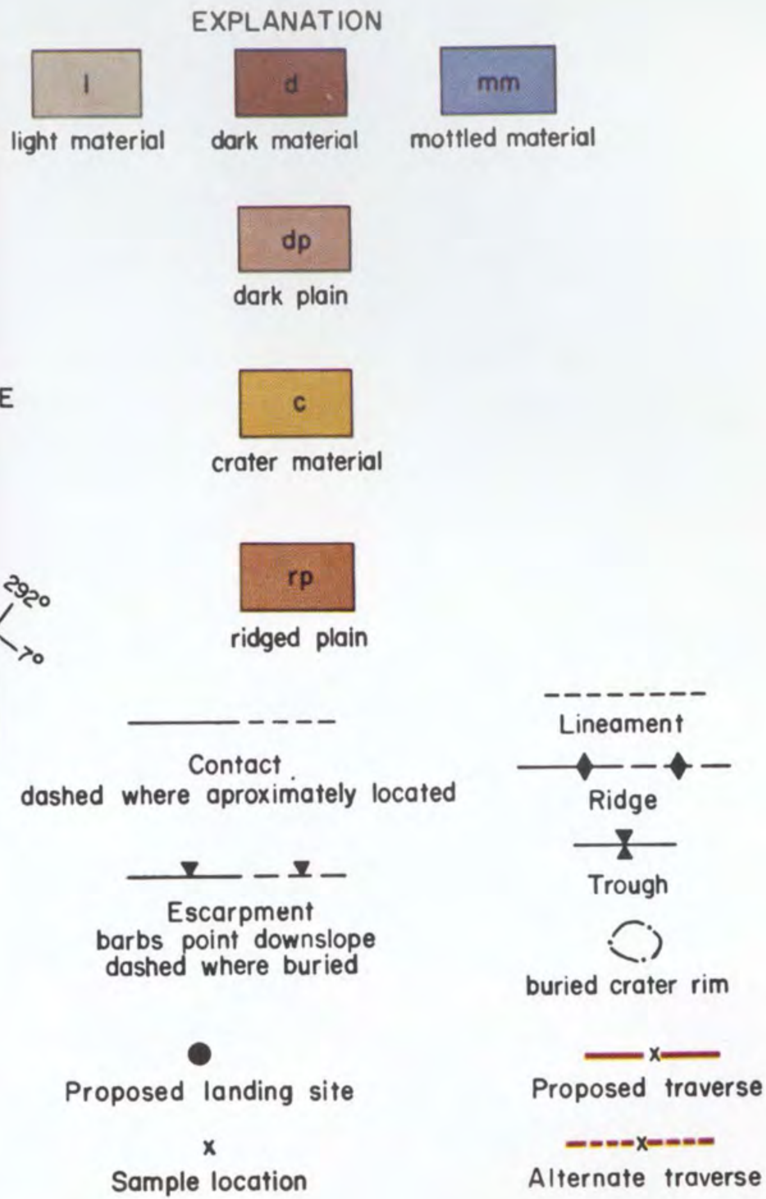
Station 5: Unit [sp] Same as station C-3.

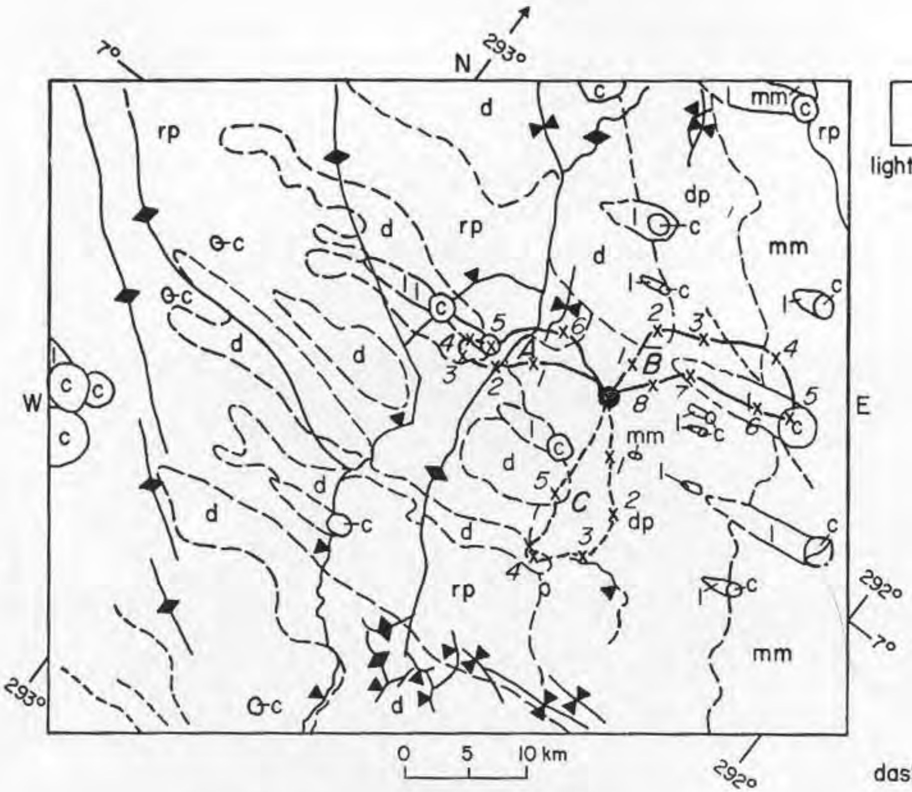
Station 6: Unit [sp] Same as station C-3.

Significance: Composition and textures in volcanic rocks should be determinable and compared from station to station to see if compositional changes are apparent between the dome and flows. The crater ejecta may include material from underlying units and the affect of the impact process on composition can be checked. The variation in composition will give a guide to the igneous processes on Mars.



CANDIDATE VIKING ROVER LANDING SITE
SYRTIS MAJOR AREA
6°54'N 292°48'W
by
J.M. Boyce and Harold Masursky
MARCH 1974





CANDIDATE VIKING ROVER LANDING SITE

SYRTIS MAJOR AREA

6°54'N 292°48'W

by

J.M. Boyce and Harold Masursky

MARCH 1974

EXPLANATION

l — light material

d — dark material

mm — mottled material

dp — dark plain

c — crater material

rp — ridged plain

Contact — dashed where aproximately located

Lineament

Ridge

Trough

Escarpment — barbs point downslope, dashed where buried

buried crater rim

Proposed landing site

Proposed traverse

x — Sample location

Alternate traverse

CANDIDATE VIKING ROVER LANDING SITE

SYRTIS MAJOR AREA (6°54'N, 292°48')

J. M. Boyce and Harold Masursky

1

Light material

Characteristics
Plumose streaks adjacent to small craters

Interpretation
Windblown deposits downwind of crater

d

Dark material

Characteristics
Irregular patches of low albedo; no intrinsic relief

Interpretation
Surficial windblown material or course material left after removal of fines

mm

Mottled material

Characteristics
Mottled and streaky patterns of relatively low and high albedo

Interpretation
Windblown dune deposits

dp

Dark plain

Characteristics
Nearly flat plain with uniform and relatively low albedo

Interpretation
Unit rp blanketed by variable thickness of dark material; it may be similar to unit d and unit mm

Syrtis Major Area

c

Crater material

Characteristics
Material in and around small craters

Interpretation
Relatively young impact craters

rp

Ridged plain

Characteristics
Flat moderately cratered plain with low, elongate, generally northwest trending ridges, troughs, scarps, and lineaments

Interpretation
Volcanic flow material with eroded scarps and wrinkle ridges. Plain may be covered by eolian material of variable thickness

Syrtis Major site

Traverse A.

Station 1: Unit [dp] nearly flat plain with uniform and relatively low albedo. Ridged plain blanketed by a thin and possibly variably thick layer of dark eolian material. In situ chemical analysis and photographic coverage.

Station 2: Unit [rp] at the base of a northwest trending ridge on the flat moderately crateral plain with low, elongate, generally northwest trending ridges, troughs, scarps and lineaments. Volcanic flow material with eroded wrinkle ridges and scarps. Plain possibly covered by eolian material of variable thickness. In situ chemical analysis, sample return, and photographic coverage.

Station 3: Unit [d] irregular patch of low albedo. Surficial windblown material or coarse material left after removal of fines. In situ chemical analysis, photographic coverage, and sample return.

Station 4: Unit [1] plumose streak occurring to leeward of small crater. Windblown deposit. In situ chemical analysis, sample return, and photographic coverage.

Station 5: Unit [c] material in and around the small crater. Material from small impact crater superimposed on the ridged plain. In situ chemical analysis, sample, return, and photographic coverage.

Station 6: Unit [rp] flat moderatly cratered plain with low elongate, generally northwest trending ridges, troughs, scarps, and lineaments. Volcanic flow material with eroded scarps and wrinkle ridges. Plain possibly covered by eolian material of variable thickness. In situ chemical analysis and photographic coverage.

Syrtis Major site

Traverse B.

Station 1: Unit [dp] same as station A-1.

Station 2: Unit [d] same as station A-3 except no sample return.

Station 3: Unit [dp] same as Station A-1.

Station 4: Unit [mm] mottled and streaky patterns of relatively low and high albedo. Windblown dunes deposit. In situ chemical anLYysis, sample return, and photographic coverage.

S-ation 5: Unit [c] same as Station A-5.

Station 6: Unit [l] same as Station A-4.

S ation 7: Unit [l] same as station B-6 (or A-4) except no sample return.

Station 8: Unit [dp] same as station B-1.

Traverse C (alternate traverse)

Station 1: Unit [dp] same as A-1.

Station 2: Unit [dp] same as A-1.

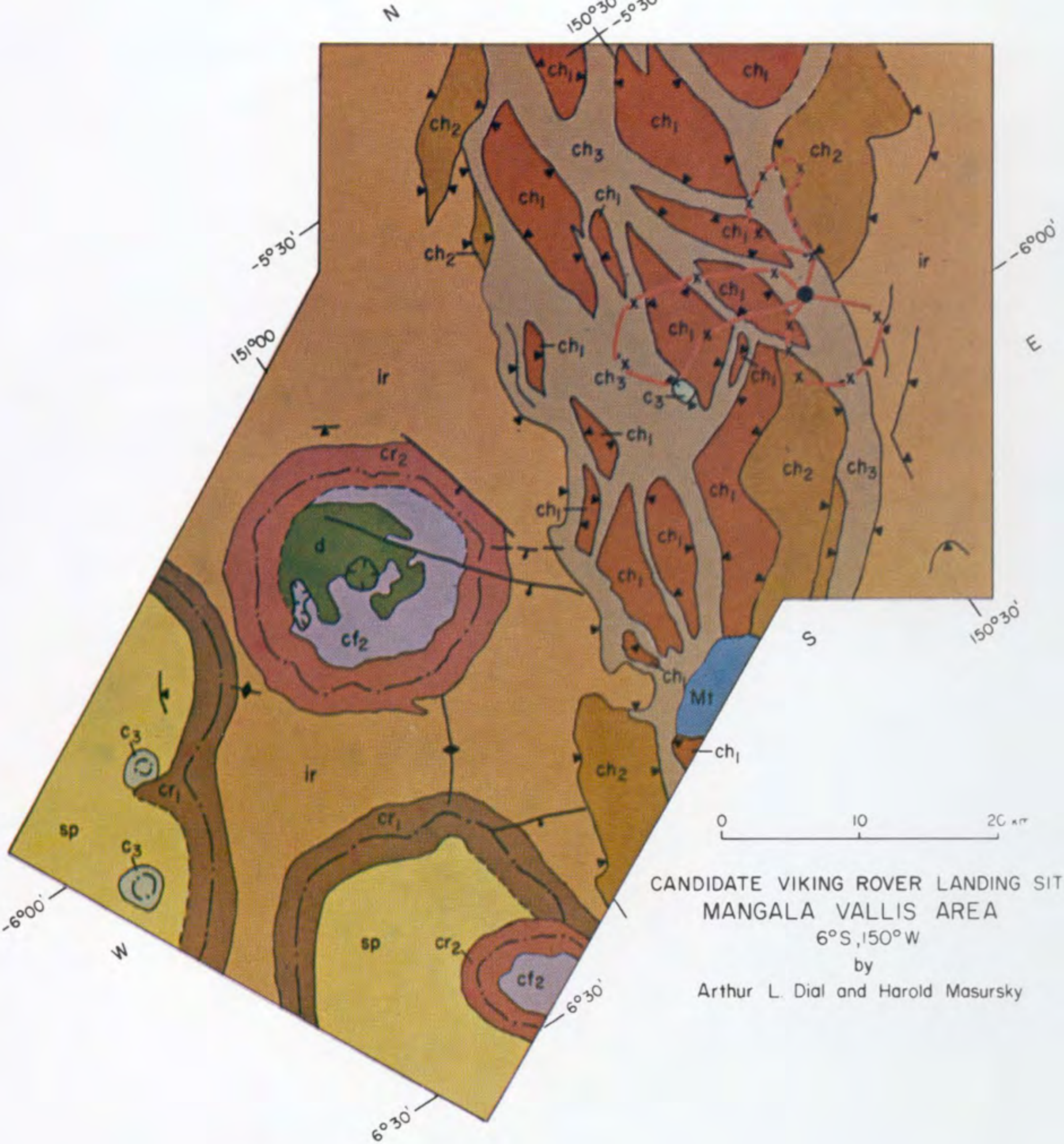
Station 3: Unit [dp] same as A-1 except sample return.

Station 4: Unit [d] same as A-3.

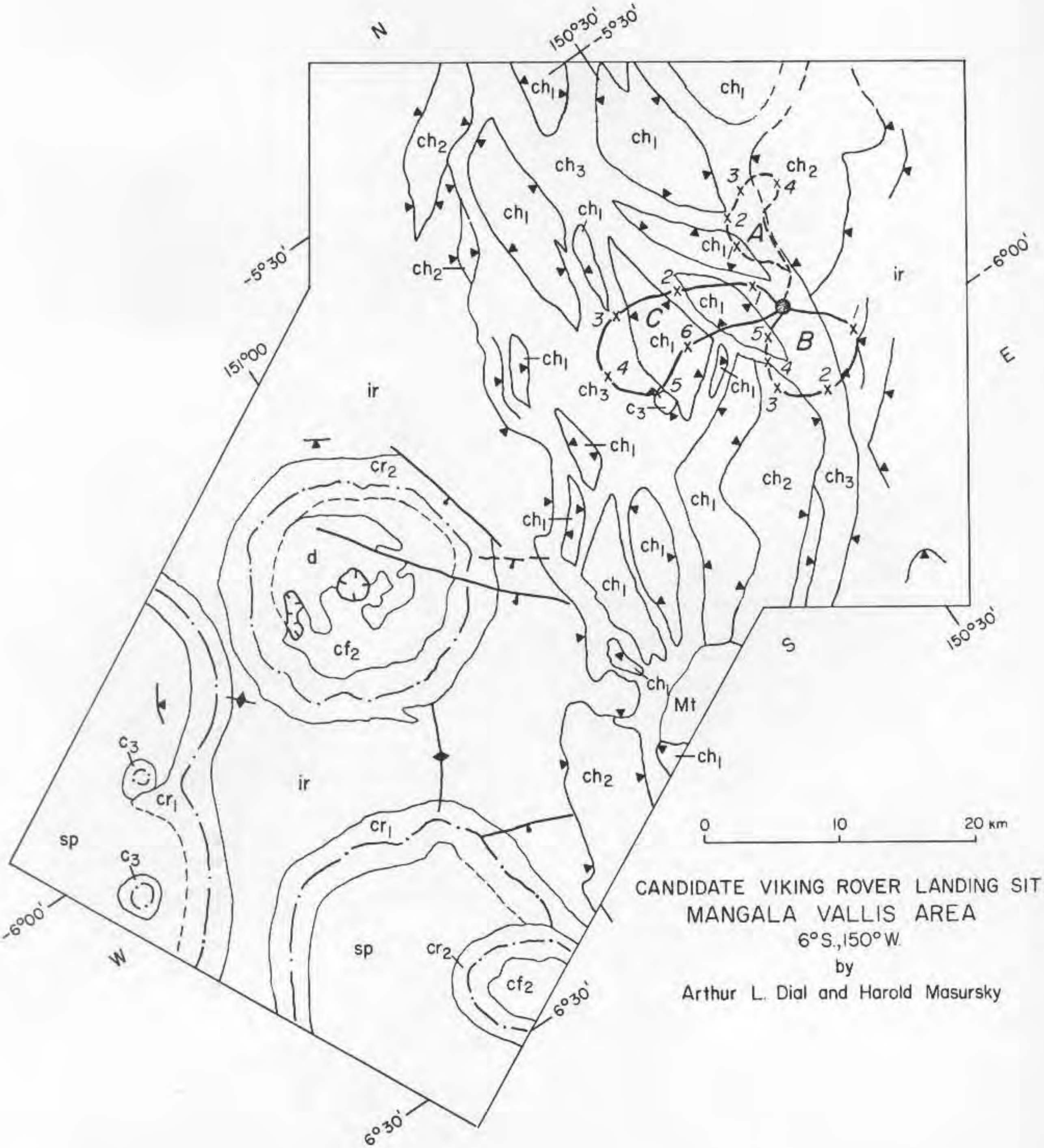
Sttiion 5: Unit [d) l same as A-3.

Significance:

The materials to be analyzed and sampled include volcanic flows, possibly basaltic composition, impact crater ejecta and bright and dark eolian debris. It should be possible to determine whether there is a variation in composition of the volcanic flows in different parts of the area. Sampling the impact ejecta will show if buried units are brought up and exposed. The lag gravels (dark eolian material) and bright eolian debris will show how effective the Martian Wind is in chemically segregating materials.



CANDIDATE VIKING ROVER LANDING SITE
MANGALA VALLIS AREA
6°S, 150°W
by
Arthur L. Dial and Harold Masursky



CANDIDATE VIKING ROVER LANDING SITE

MANGALA VALLIS AREA

6° S., 150° W.

by

Arthur L. Dial and Harold Masursky

EXPLANATION

- mt — mottled terrain
- d — dark material
- sp — smooth plain
- ir — irregular material

crater material

- c3
- cr2 | cf2
- Cr1

channel deposits

- ch3
- ch2
- ch1

Contact
dashed where uncertain

Scarp
barb points downslope

Ridge

prominent rim crest of crater

trough

Fault
dashed where uncertain
bar and ball on downthrown side

enclosed basin
surrounded by escarpment

Proposed landing site

x
Sample location

Proposed traverse

Alternate traverse

CANDIDATE VIKING ROVER LANDING SITE

MANGALA VALLIS (6°S, 150°W)

by

Arthur L. Dial, Jr.
and
Harold Masursky

Sp

Smooth Plains

Characteristics
Flat, featureless material lying on the floors of the most degraded craters.

Interpretation
Eolian or volcanic deposits

ir

Irregular Material

Characteristics
Plains with hummocky irregular surface.

Interpretation
Older surface modified by erosional processes.

C_3

Crater Material

Characteristics
Small craters (<05 km) with sharp rims.

Interpretation
Impact craters, relatively young

c - crater material undivided
cr - crater rim material; smooth to very rough
cf - crater floor material; mapped where surface roughness is detectable.

Cr_2	Cf_2

Crater Material

Characteristics
Medium to large craters (10 to 20 km) with rough to smooth floors with rim and floor material.

Interpretation
Impact craters of intermediate age

Cr_1

Crater Material

Characteristics
Large craters (>20 km) with smooth flat floors and subdued rims

Interpretation
Degraded imapct craters; probably of greatest age

Mt

Mottled Terrain

Characteristics
Irregular clusters of small mounds and ridges

Interpretation
Eolian dunes

D

Dark Material

Characteristics
Irregular patch of material having low albedo found on the floor of the large C_2 crater.

Interpretation

May be volcanic deposits or materials exposed by wind erosion

Ch_3

Channel Deposit

Characteristics
Material occupying the lowest elevation in the channel system relatively smooth

Interpretation
Youngest channel deposit

Ch_2

Channel Deposit

Characteristics
Material occupying the intermediate elevations in the channel system

Interpretation
Intermediate aged channel deposits

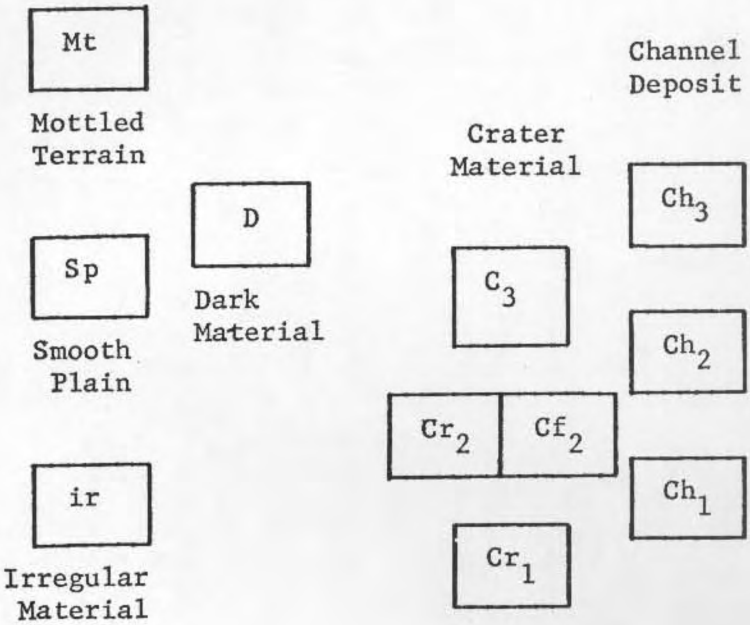
Ch_1

Channel Deposit

Characteristics
Material occupying the highest elevation in the channel system

Interpretation
Oldest channel deposits

EXPLANATION
Age Relationship



LIST OF STATIONS
ALONG TRAVERSES
OF
MANGALA VALLIS AREA

TRAVERSE A

Station A_1: Unit (Ch_1) Material occupying the highest elevations in channel system. Oldest channel deposit. In situ analyses with returned sample analyses.

Station A_2: Unit (Ch_3) Material occupying the lowest elevation in the channel system relătively smooth. Youngest channel deposit. In situ analyses with returned sample analyses.

Station A_3: Unit (Ch_3) same as Station A_2

Station A_4: Unit (Ch_2) Material occupying the intermediate elevations in the channel system. Intermediate age channel deposit. In situ analyses with returned sample analyses.

TRAVERSE B

Station B_1: Unit (ir) Plains with hummocky irregular surface. Older surface modified by erosional processes. In situ analyses with returned sample analyses.

Station B_2: Unit (Ch_3) same as Station A_2

Station B_3: Unit (Ch_1) same as Station A_1

Station B_4: Unit (Ch_3) same as Station A_2

Station B_5: Unit (Ch_1) same as Station A_1

TRAVERSE C

Station C_1: Unit (Ch_3) same as Station A_2

Station C_2: Unit (Ch_3) same as Station A_2

Station C_3: Unit (Ch_3) same as Station A_2

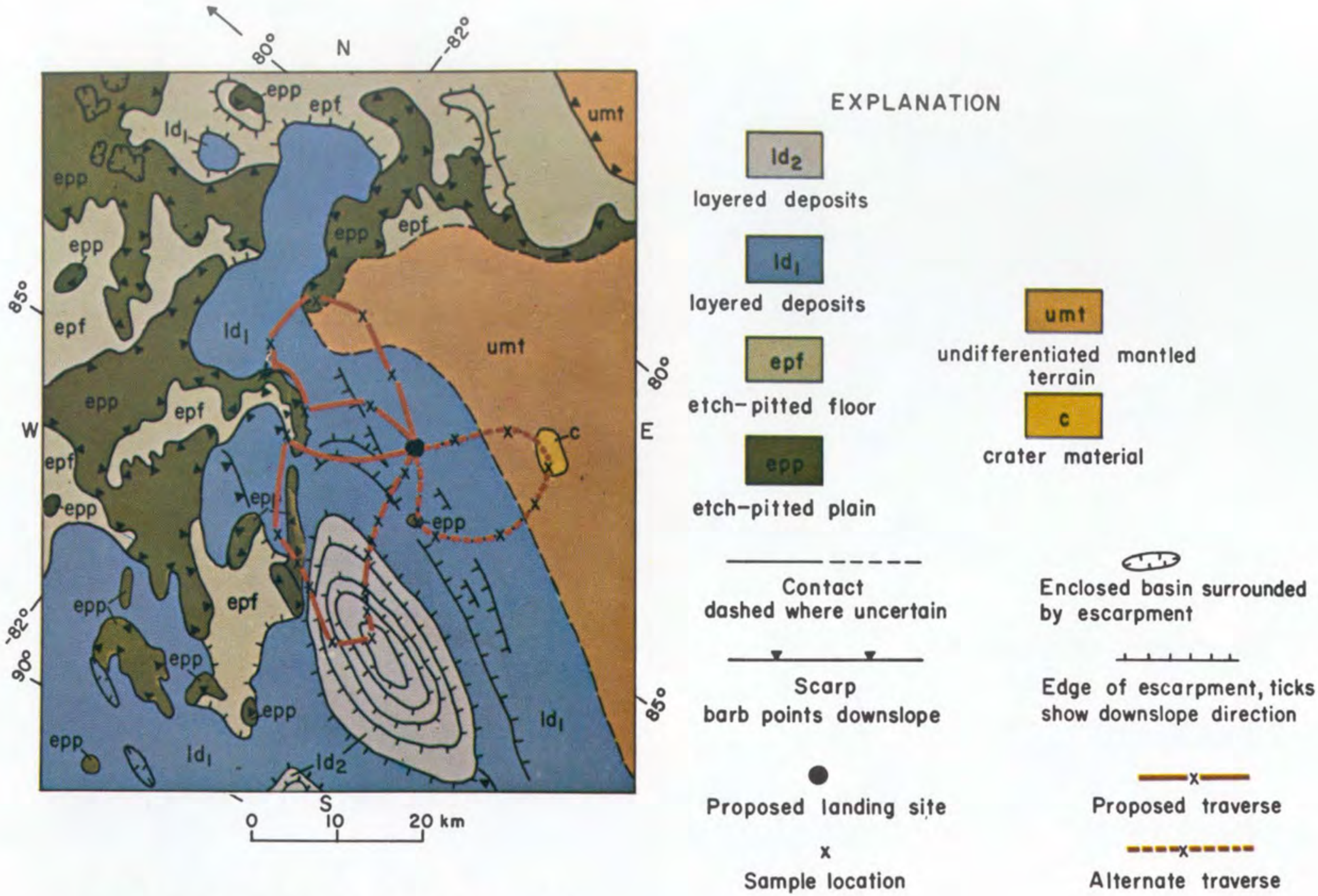
Station C_4: Unit (Ch_3) same as Station A_2

Station C_5: Unit (C) Small craters (<5 km) with sharp rims. Impact craters, relatively young. In situ analyses with returned sample.

Station C_6: Unit (Ch_1) same as Station A_1

Significance:

The most interesting unit in the area is the sequence of channel deposits that occur at three levels and may be of three ages. Variation in composition, grain size or texture might indicate origin in different areas. Appearance of fragments should indicate whether they are water worn or not. This question, that is, the flow of water on the surface is one of the most significant ones on Mars. Study of the different terrace levels may indicate the length of time necessary to erode the channels. Impact crater ejecta may expose deeper seated materials and may show differences in composition due to the impact process. The irregular material may reveal by composition and texture its mode of origin.

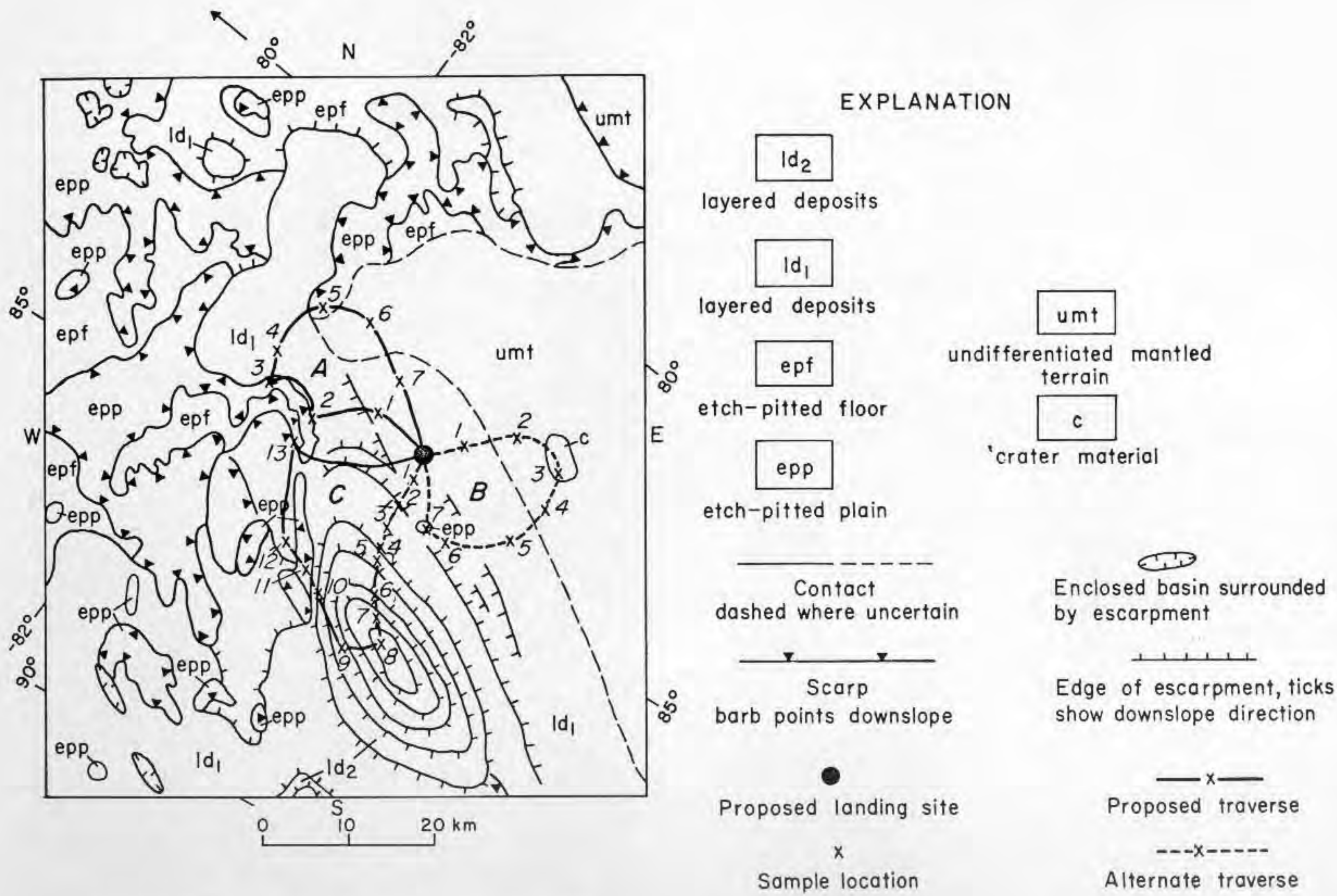


CANDIDATE VIKING ROVER LANDING SITE
SOUTH POLAR AREA
(82°S,83°W)

by

Arthur L. Dial and Harold Masursky

March 1974



CANDIDATE VIKING ROVER LANDING SITE
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LANDING SITE

SOUTH POLAR AREA (82°S, 83°W)

by

Arthur L. Dial, Jr.
and
Harold Masursky

Ld_2

Layered Deposits

Characteristics
Moderately smooth material with continuous and prominent ledges; light and dark layers visible in scarp faces.

Interpretation
Youngest eolian sedimentary layered deposit with fine particulate debris; may include CO_2 and H_2O.

Ld_1

Layered Deposits

Characteristics
Moderately smooth material with sinuous beveled slopes contoured by alternating light and dark layers.

Interpretation
Oldest eolian sedimentary layered deposits containing basically the same material as Ld_2

umt

Undifferentiated
Mantle Terrain

Characteristics
Smooth rolling plains with broadly undulating surface.

Interpretation
Probably represents thin blanket of eolian material

Epf

Etch-pitted floor

Characteristics
Smooth featureless floors of basins in the Etch-pitted plains.

Interpretation
Represents the last stages of erosion involving the Epp material

Epp

Etch-pitted plains

Characteristics
Surface is generally smooth, flat; indented by irregular pits.

Interpretation
Eolian debris blanket; eroded by wind. Melting of subsurface ice may be involved.

C

Crater Material

Characteristics

Crater material undivided.

Interpretation

Impact crater which has been covered by UMt material

AGE RELATIONSHIP

Ld_2

Layered Deposits

Ld_1

Umt — Undifferentiated Mantle Terrain

Epf — Etch-pitted floor

C — Crater Material

Epp — Etch-pitted plain

LIST OF STATIONS

ALONG TRAVERSE

OF

SOUTH POLAR AREA

TRAVERSE A

Station A_1: Unit (Ld_1) moderately smooth material with sinuous beveled slopes, contoured by alternating light and dark layers. Eolian sedimentary layered deposits with fine particulate debris. may include CO_2 and H_2O. In situ analyses and returned sample analyses at lander.

Station A_2: Unit (Epp). Surface is generally smooth, flat; indented by irregular pits. Eolian debris blanket; eroded by wind. Melting of subsurface ice may be involved. In situ analyses and returned sample analyses at lander.

Station A_3: Unit (Epp) same as Station A_2

Station A_4: Unit (Ld_1) same as Station A_1

Station A_5: Unit (Epp) same as Station A_2

Station A_6: Unit (UMt) Smooth rolling plains with broadly undulating surface. Probably represents thin blanket of eolian material. In situ analyses and returned sample analyses at lander.

Station A_7: Unit (Ld_1) same as Station A_1

TRAVERSE B

Station B_1: Unit (Ld_1) same as Station A_1

Station B_2: Unit (UMt) same as Station A_1

Station B_3: Unit (C) crater material undivided. Impact crater which has been covered by UMt material. In situ analyses and returned sample analyses at lander.

Station B_4: Unit (UMt) same as Station A_6

Station B_5: Unit (Ld_1) same as Station A_1

Station B_6: Unit (Ld_1) same as Station A_1

Station B_7: Unit (Epp) same as Station A_2

TRAVERSE C

<u>Station</u> 1: Unit (Ld_1) same as Station A_1

<u>Station</u> 2: Unit (Ld_1) same as Station A_1

<u>Station</u> 3: Unit (Ld_1) same as Station A_1

<u>Station</u> 4: Unit (Ld_1) same as Station A_1

<u>Station</u> 5: Unit (Ld_2) Moderately smooth material ledges; light and dark layers visible in scrap faces. Young eolian sedimentary layered deposit with fine particulate debris; may include CO_2 and H_2O. In situ analyses with returned sample analyses.

<u>Station</u> 6: Unit (Ld_2) same as Station C_5

<u>Station</u> 7: Unit (Ld_2) same as Station C_5

<u>Station</u> 8: Unit (Ld_2) same as Station C_5

<u>Station</u> 9: Unit (Ld_2) same as Station C_5

<u>Station</u> 10: Unit (Ld_2) same as Station C_5

<u>Station</u> 11: Unit (Epp) same as Station A_2

<u>Station</u> 12: Unit (Ld_1) same as Station A_1

<u>Station</u> 13: Unit (Ld_1) same as Station A_1

Significance: A-1 Layered eolian debris; will be good to compare its composition with the original volcanic rock composition and equatorial wind worked debris to see if the polar deposits are different. Upper, middle, and lower parts of the unit should be compared to see if there was a change in composition during the deposition of the unit that might record climate changes.

Significance: A-2 Older eolian debris that overlies the cratered terrain. It is being stripped by the wind resulting in the formation of closed depressions. The composition of this unit needs to be compared with the layered deposits. It may be quite different and record different climatic conditions during its deposition.

Significance: A-6 The composition should be compared with the other eolian units to see if they are different and whether different source areas might be involved or different climatic conditions.

Significance: B-3 Impact debris should be compared with the basic unit to see if underlying units are exposed and whether changes have occurred in the impact process.

Summary Arguments

The rover plus new science allows us to explore around the landing site, to sample the heterogenous geologic units, and possibly collect sample for biologic analysis from more favorable environments. As much of the Mars surface seems to be covered by loess-like or sand dune deposits, which may be highly biased chemically, it may be essential to be able to travel over the surface to collect representative samples. If the rover mission is a precursor to sample return, it would make sense to sample the surface materials to establish the variability before returning a sample at large cost. From the current understanding of variability it would seem advisable to collect the samples with a rover and return a suite of samples rather than a single one at the landing point. Even without sample return, an understanding of the local variability is essential to understanding Mars. New instruments are desirable on the orbiter, also: a gamma ray spectrometer, magnetometer, gravity meter, and radar altimeter along with a pair of advanced cameras with low and high resolution telescopes; may want to include an infrared interferometer spectrometer.

The cost of this mission may be prohibitive; scientifically it seems to be optimal.

It would be highly desirable to fly the orbiter for a Martian year, that is, two earth years to observe the full change in Martian seasons.