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Mars Landing Site Catalog

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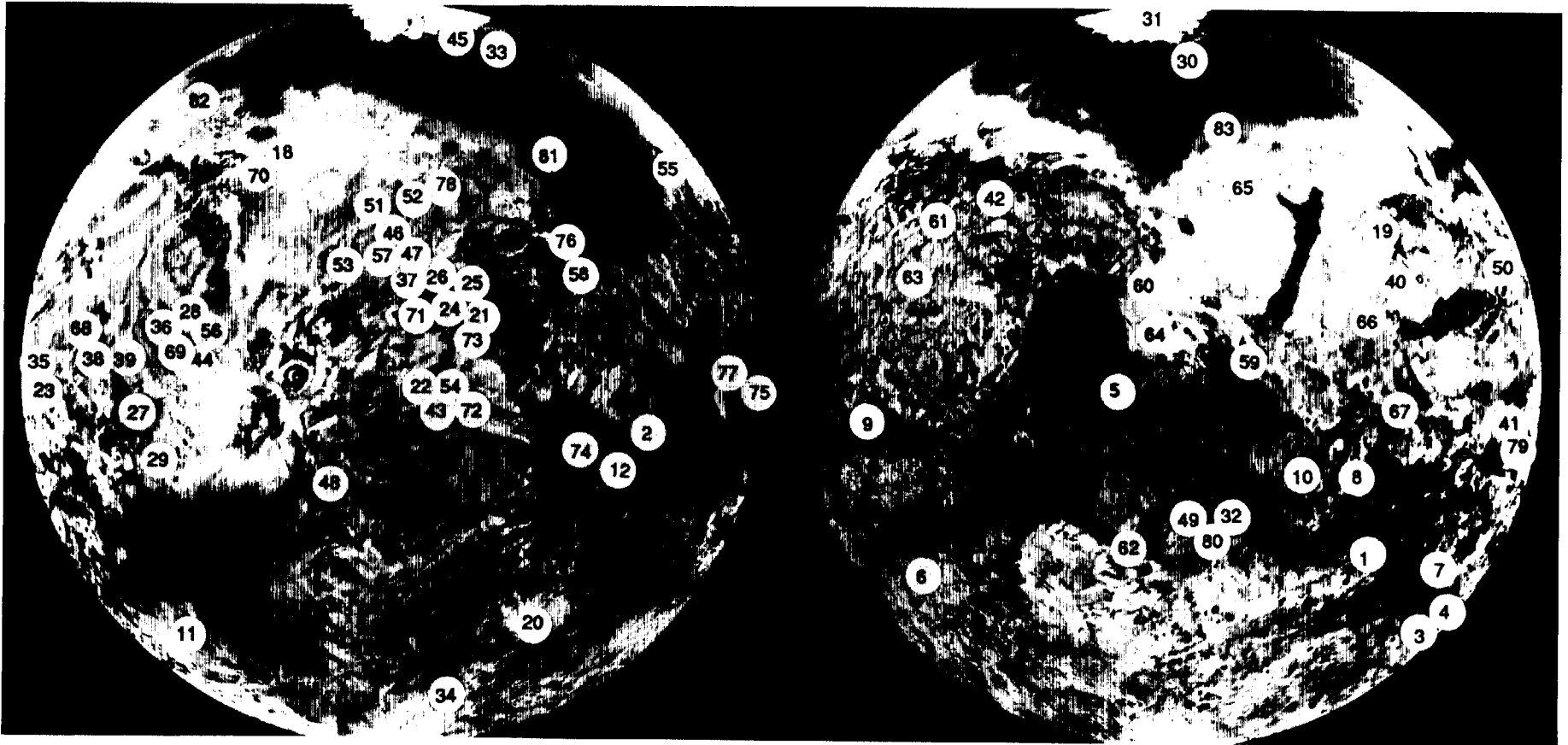
PREFACE

This catalog was compiled from material provided by the planetary community for areas on Mars that are of potential interest for future exploration. The catalog has been edited for consistency insofar as practical. However, the proposed scientific objectives and characteristics for the sites have not been reviewed. It should be noted that this is a "working" catalog that is being revised, updated, and expanded continually.

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R. Greeley
5 December 1989

MARS SITE INDEX



WESTERN HEMISPHERE

EASTERN HEMISPHERE

ORIGINAL PAGE
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Introduction

The late 1980s saw a renewed interest in missions to Mars. Studies have been made and are underway by various United States, Soviet, and European committees to recommend missions ranging from relatively simple unmanned probes to exploration programs involving humans presence on Mars. A key part of most of these programs includes selection of sites on Mars for various purposes, including selection of sampling area for detailed analysis either *in situ* or for return to Earth.

This catalog is established to provide ready access to information on potential landing sites. It is structured to allow expansion of the data base (both in number of sites, and in information on each site) and to be readily accessible either electronically or via hard copy; input to the catalog is also welcomed.

Catalog Access

As well as being available in printed form, the most recent version of the catalog may be purchased on

3-1/2" diskettes in PageMaker 3.01 format, Apple MacIntosh version. The disk version of the catalog includes scanned copies of all maps and photographs.

Hard copy or information on diskette versions of the catalog can be obtained from:

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SPAN address: ASUIPF::GREELEY

NASAMAIL address: RGREELEY

Input to the catalog should be made by completing the form on the following page. Comments on sites in the catalog are also welcomed and will be added.

POTENTIAL MARS LANDING SITE

Name _____ Phone _____

Address _____

Type of landing site: Rover Sample return Penetrator Balloon
 Other (specify) _____

1. Name of area _____ Location _____°lat. _____°long.
 Map sheet (MTM#) _____ Elevation _____ km
 Viking Orbiter images _____

2. Scientific rationale for site _____

3. Specific science objectives (list by priority):

	Objectives	Probability of Success in Meeting Objective
a.	_____	_____
	_____	_____
	_____	_____
b.	_____	_____
	_____	_____
	_____	_____
c.	_____	_____
	_____	_____
	_____	_____
d.	_____	_____
	_____	_____
	_____	_____

4. Targets (keyed to above). Identify by lat. and long. and/or on sketch map. Include xerox of images with frame numbers.

5. Potential problems, mission/spacecraft constraints.

6. Estimated trafficability for roving vehicle _____
 (Scale 1-5, 1 = smooth plain, 5 = fresh lava surface)

7. Estimated traverse distance (round-trip) _____ km

8. Other (back of page, additional sheets; photos, maps, etc.)

Send to: Ronald Greeley, Dept. of Geology, Arizona State University, Tempe, AZ 85287-1404

Table. Landing site parameters (keyed to index map and catalog site number).

No.	Name	Type	Contributor	Quadrangle	Elevation	Latitude (°)	Long. (°W)	Geology
1	Eridania NW	MRSR	S. Squyres	MC-29 NW	3.0 to 4.0	36.00 S	228.00	Ancient cratered highlands.
2	Parana Valles	MRSR	S. Squyres	MC-19 SE	1.0	22.00 S	12.00	Old volcanics and channel deposits.
3	Eridania	MRSR	S. Squyres	MC-29 SE, SW	4.0	58.00 S	212.00	Old volcanic plains.
4	Eridania SE	MRSR	S. Squyres	MC-29 SE	5.0	57.00 S	195.00	Inter. age volcanic plains.
5	Iapygia	MRSR	S. Squyres	MC-21 NE	5.0	9.00 S	279.00	Inter. age to old volcanic plains.
6	Noachis	MRSR	S. Squyres	MC-27 SW	5.0	55.00 S	337.00	Inter. age to old volcanic plains.
7	Terra Cimmeria	MRSR	S. Squyres	MC-29 NC	5.0	42.00 S	211.00	Inter. age to old volcanic plains.
8	Mare Tyrrhenum	MRSR	S. Squyres	MC-22 SE	3.0 to 4.0	23.00 S	231.00	Old volcanic plains.
10	Terra Tyrrhena	MRSR	S. Squyres	MC-22 SW	3.0	25.00 S	266.00	Inter. age to old volcanic plains.
11	Phaethontis SW	MRSR	S. Squyres	MC-24 SW	5.5	51.00 S	153.00	Inter. age to old volcanic plains.
12	Samara Valles	MRSR	S. Squyres	MC-19 SE, SW	2.0	23.00 S	21.00	Old volcanic plains and channel deposits.
13		MRSR	S. Squyres					
14		MRSR	S. Squyres					
15		MRSR	S. Squyres					
16		MRSR	S. Squyres					
17		MRSR	S. Squyres					
18	Alba Patera	MRSR	D. Schneeberger	MC-2 SE	3.0	47.00 N	116.00	Young volcanics.
19	Northern Elysium	MRSR	P. Mouginiis-Mark	MC-7 SC	0.0	33.00 N	212.00	Young volcanics and channel deposits.
20	Argyre Planitia	MRSR	T. Parker	MC-26 SW	1.0	55.00 S	42.00	Ancient crust and layered plains deposits.
21	Maja Valles	MRSR	J. Rice	MC-10 NE	-0.5	18.95 N	53.50	Ancient crust, channel, and lacustrine.
22	Candor Mensa	MRSR	B. Lucchitta	MC-18 NW	1.0	5.50 S	74.50	Young volcanics and sedimentary deposits.
23	Memnonia	MRSR	D. Scott	MC-16 NW	1.0	11.00 S	173.00	Volcanics and channel deposits.
24	Mouth of Maja Valles	MRSR	R. DeHon	MC-10 NE	-0.5	17.90 N	53.80	Channel deposits.
25	Maja Valles Canyon	MRSR	R. DeHon	MC-10 NE	-0.5	17.65 N	54.25	Channel and lacustrine deposits.
26	Upper Maja	MRSR	R. DeHon	MC-10 NE	0.5	18.20 N	57.00	Intermediate-age volcanics and lacustrine deposits.
27	Up. Mangala Valles	MRSR	J. Zimbelman	MC-16 NE	3.0	13.80 S	148.10	Channel deposits.
28	Olympus Mons SE	MRSR	R. Greeley	MC-9 SW	2.8	14.00 N	131.00	Young-to-intermediate-age volcanics.
29	W Daedalia Planum	MRSR	R. Greeley	MC-16 SE	3.0	19.00 S	144.00	Ancient crust and young-to-intermediate-age volcanics.
30	North Polar Cap	MRSR	C. Leovy	MC-1A, B	1.0	80-85 N	—	Polar-layered deposits.
31	North Pole	MRSR	C. Leovy	MC-1A, B	1.0	90.00 N	—	Polar-layered deposits.
32	Hadriaca Patera	MRSR	F. West	MC-28 NE	1.5	32.50 S	266.00	Young-to-intermediate-age volcanics and channel deposits.
33	Chasma Boreale	MRSR	H. Masursky	MC-1A, B	-0.5	80.80 N	44.00	Polar-layered deposits.
34	Planum Australe	MRSR	H. Masursky	MC-30A,B	4.0	82.50 S	60.00	Polar-layered deposits.

Table. Landing site parameters (keyed to index map and catalog site number).

No.	Name	Type	Contributor	Quadrangle	Elevation	Latitude (°)	Long. (°W)	Geology
35	Memnonia Sulci	MRSR	H. Masursky	MC-16 NW	2.0	9.70 S	174.20	Young volcanics.
36	Olympus Rupes SE	MRSR	H. Masursky	MC-9 SW	2.0	13.80 N	131.20	Young volcanics.
37	Kasei Valles	MRSR	H. Masursky	MC-10 SW, NW	1.0	15.10 N	75.80	Young-to-intermediate-age volcanics and channel deposits.
38	Mangala Valles West	MRSR	H. Masursky	MC-16 NW	1.0	7.20 S	158.60	Young-to-intermediate-age volcanics and channel deposits.
39	Mangala Valles East	MRSR	H. Masursky	MC-16 NE	2.5	4.70 S	147.50	Young-to-intermediate-age volcanics and channel deposits.
40	Elysium Mons	MRSR	H. Masursky	MC-15 NW	4.0	24.30 N	214.80	Young volcanic plains.
41	Apollinaris Patera	MRSR	H. Masursky	MC-23 NE	1.0	7.50 S	187.20	Young-to-intermediate-age volcanics.
42	Nilosyrtis Mensae	MRSR	H. Masursky	MC-5 SE	2.5	35.50 N	302.50	Intermediate-age volcanics and ancient cratered uplands.
43	Candor Chasma	MRSR	H. Masursky	MC-18 NW	2.5	10.50 S	74.50	Young volcanic and sedimentary deposits.
44	Tharsis-Olympus	MRSR	D. Scott/K. Tanaka	MC-9 SW	4.0	12.00 N	125.00	Young volcanic plains and aureole deposits.
45	Chasma Boreale	MRSR	D. Scott/K. Tanaka	MC-1 A, B	0.0	82.00 N	57.00	Polar layered deposits and grooved plains.
46	Labeatis North	MRSR	D. Scott/K. Tanaka	MC-3 SE	2.5	31.00 N	83.00	Intermediate-age volcanic plains.
47	Labeatis South	MRSR	D. Scott/K. Tanaka	MC-10 NW	2.0	24.00 N	80.00	Intermediate-age volcanic plains.
48	Solis	MRSR	D. Scott/K. Tanaka	MC-17 SE	9.0	27.00 S	100.00	Ancient crust, intermediate-age volcanics.
49	Hadriaca	MRSR	D. Scott/K. Tanaka	MC-28 NE; MC-22 SW	1.0	29.00 S	269.00	Intermediate-age volcanic plains and ancient crust.
50	Elysium	MRSR	D. Scott/K. Tanaka	MC-15 NE	-0.5	27.00 N	185.00	Young-to-intermediate-age volcanic plains.
51	Mareotis Volcanic	MRSR	H. Moore	MC-3 SE	3.0	36.00 N	88.00	Old-intermediate-age volcanics.
52	Tempe Volcano	MRSR	H. Moore	MC-3 SE	1.8	39.00 N	76.00	Intermediate-age volcanics.
53	Ceraunius Fossae	MRSR	H. Moore	MC-9 NE	5.0	20.00 N	112.00	Young-to-intermediate-age volcanics.
54	Candor	MRSR	E. Robbins	MC-18 NW	2.0	5.50 S	74.50	Sedimentary deposits.
55	No. Cydonia	MRSR	P. Etzler	MC-4 SE	-0.5	40.00 N	10.00	Erosional remnants of plateaus on highland-lowland boundary scarp.
56	Tharsis-Olympus	MRSR	D. Scott	MC-9 SW	3.5	12.50 N	125.50	Young volcanics.
57	Labeatis	MRSR	D. Scott	MC-10 NW	2.5	25.00 N	82.00	Intermediate-age volcanic plains.
58	Chyrse Planitia	MRSR	R. Craddock	MC-10 NE	-2.2	22.52 N	47.97	Intermediate-age volcanic plains.
59	Amenthes SE	Penetrator	US/Soviet Group	MC-14 SE, SW	1.0 to 2.0	4.00 N	247.00	Ancient highlands.
60	Isidis North	Balloon	US/Soviet Group	MC-6 SE, SW; 13 NE; 14 NW	-1.0 to 2.0	16-36 N	267-282	Intermediate-age volcanics, eolian deposits.
61	Arabia	Penetrator	US/Soviet Group	MC-5 SC; 12NE	1.0 to 2.0	30.00 N	327.00	Old volcanics.
62	Hadriaca	Penetrator	US/Soviet Group	MC-28 NE, NW	0.0 to 1.0	36.00 S	271.00	Intermediate volcanics.

Table. Landing site parameters (keyed to index map and catalog site number).

No.	Name	Type	Contributor	Quadrangle	Elevation	Latitude (°)	Long. (°W)	Geology
63	Arabia South	Penetrator	US/Soviet Group	MC-12 SE, NE	1.0 to 2.0	15.00 N	333.00	Ancient highlands.
64	Isidis Planitia	Penetrator	US/Soviet Group	MC-13 SE	-3.0 to -2.0	10.00 N	275.00	Intermediate-age volcanics.
65	Utopia	Penetrator	US/Soviet Group	MC-6 SE	-3.0 to -2.0	45.00 N	251.00	Channel deposits and ground ice.
66	Elysium SW	Penetrator	US/Soviet Group	MC-15 NW; 14NE	-1.0 to 0.0	17.00 N	224.00	Intermediate-age volcanics.
67	Elysium South	Balloon	US/Soviet Group	MC-14 SE; 15SW; 22NE; 23NW	-1.0 to 2.0	4 S-7 N	205-32	Channel deposits and young volcanics.
68	Medusae Fossae	Penetrator	US/Soviet Group	MC-16 NE, NW	1.0 to 2.0	2.00 S	159.00	Young volcanic plains.
69	Olympus South	Penetrator	US/Soviet Group	MC-8 SE; 9SW	1.0 to 2.0	11.00 N	137.00	Young volcanic plains.
70	Alba West	Penetrator	US/Soviet Group	MC-2 SE	1.3	45.00 N	126.00	Intermediate-age volcanics.
71	Kasei South	Penetrator	US/Soviet Group	MC-10 SW	0.0 to 1.0	10.00 N	80.00	Young volcanics.
72	Candor Chasma	Penetrator	US/Soviet Group	MC-18 NW	-1.0 to 0.0	6.00 S	73.00	Sedimentary deposits.
73	Lunae Planum East	Penetrator	US/Soviet Group	MC-10 NE, SE	1.0 to 2.0	16.00 N	63.00	Intermediate-age volcanics.
74	Capri Chasma	Penetrator	US/Soviet Group	MC-18 NE, SE; MC-19 NW, SE	-2.0 to -1.0	14.00 S	46.00	Sedimentary deposits.
75	Meridiani SW	Penetrator	US/Soviet Group	MC-19 NE	1.0 to 2.0	12.00 S	7.00	Ancient highlands.
76	Tempe	Balloon	US/Soviet Group	MC-4 SW; 10NE	0.0 to 1.0	25-52 N	30-60	Ancient plateau and channel deposits.
77	Ares	Balloon	US/Soviet Group	MC-11 SE,SW; 19 NE, NW	-1.0 to 1.0	13 S-10 N	0-25	Ancient highlands and channel deposits.
78	Tempe Fossae	MRSR	C. Madras	MC-3 SE	2.0	40.00 N	76.50	Ancient fractured terrain.
79	Aeolis SE	MRSR	N. Cabrol	MC-23 SE	0.0	15.50 S	188.50	Ancient cratered highlands.
80	Dao Vallis	Balloon	F. West	MC-28 NE	1.5	30.00 S	262.00	Intermediate-age volcanic and sedimentary deposits.
81	Acidalia Planitia	Balloon	J. Runavot	MC-4 NE, NW, SC, SE	-3.0 to -1.0	40-60 N	10-40	Northern lowland plains.
82	Arcadia Planitia	Balloon	J. Runavot	MC-2 NW, SW, SC	-3.0	40-60 N	150-180	Northern lowland plains.
83	Utopia Planitia	Balloon	J. Runavot	MC-6 NE, SE; 7 SW	-3.0 to -1.0	40-60 N	240-270	Northern lowland plains.

Rover/Sample-Return Missions

General Statement

This document outlines the criteria for selecting landing sites on Mars. It is derived from the MRSR work group subcommittee, chaired by M. Drake. Because of the lack of detail concerning the mission(s), it is necessary to state certain premises upon which the criteria are based. Premises include science, lander, and rover issues. The criteria are written in general terms. The criteria will evolve and become more specific as the mission(s) becomes better described. Should any of the premises prove to be incorrect, the criteria may require reconsideration.

Science Issues

Science Premises

Premise 1: There will be a minimum of two sample return missions as part of a Mars program. The second mission will be a backup for a possible failure of the first mission.

Premise 2: At some point the mission will be defined. At present there are several unknowns. It is not known whether there will be one or two landers per mission, nor are the capabilities of the landers or the rovers known. These uncertainties may affect site selection criteria when resolved. It is assumed that the mission will meet the science objectives as defined in subsequent site selection criteria (see section 3.2.2).

Premise 3: Landing site selection criteria will evolve. Apollo experience on the Moon shows that as scientific and engineering data are obtained, the mission goals become more ambitious.

Premise 4: Preferable candidate landing sites selection will occur after Mars Observer (MO) data are available. MO data will enhance the ability to determine if a site meets science and engineering criteria.

Premise 5: Candidate sites will be selected initially using science criteria. Engineering criteria such as accessibility, trafficability, and landability will be used as discriminants among science sites of comparable interest.

Science Objectives

It is important to know the timing and nature of major events on Mars, such as atmospheric outgassing, core formation, crust formation, erosional episodes, depositional episodes, and organic formation. Such knowledge is critical to a comprehensive understanding of the origin and evolution of Mars as a planet and as a possible host for life forms. This chronological and systemic knowledge can be gained from an efficient sampling program.

Studies which will characterize the major geologic units in terms of age, composition, morphology, and origin may be grouped into three categories, each of valid scientific importance.

- *Planetary igneous differentiation and crust formation.* Samples should include unweathered volcanic rocks from the major terrains (ancient cratered plains, northern resurfaced plains, Tharsis plateau) and unweathered plutonic rocks from the ancient cratered uplands for determination of radiometric ages, chemical compositions, and mineralogy.
- *Effects of water and other volatiles on surface chemistry and morphology, and on climate.* Samples should include sediments of fluvial, aeolian, or lacustrine origin and igneous rock altered by weathering. In addition, ground ice and atmospheric gases should be sampled. Samples should be taken from regions where accompanying units provide radiometric age control,

either through stratigraphically interleaved volcanic rocks or through crater-count ages calibrated by radiometric information.

- *Conditions for and evidence of development of life.* Samples should include sediments from sites suspected of harboring water and organic material considered conducive to the development of life and likely to have preserved organic chemicals. These materials should come from sites whose ages and sedimentary nature is understood from sample categories 1 and 2 above.

Criteria Derived From Scientific Considerations

From the preceding scientific objectives the following statements are derived for priority in landing site selection:

- Sites should provide samples of unambiguous provenance(s) and ensure sampling of major geologic units. Landing site complexity does not necessarily equate to ambiguous provenance.
- Sites collectively should address the maximum number of scientific questions. Individual sites should address a reasonable subset of scientific questions (a trade-off is recognized between developing an extremely capable—and expensive—rover and increasing the number of landing sites).

The ideal site would provide ready access to the following:

1. Young Igneous Rocks
2. Intermediate Age Igneous Rocks
3. Old Igneous Rocks
4. Water-laid Sediments
5. Old Impact Breccias
6. Ground Ice
7. Soils - upper level of weathered rock profile
8. "Loess" - windblown dust

Rover Issues

The ability to reconcile the conflicting requirements for site safety, acquisition of variety of sample types, and acquisition of samples of known provenance depends to a major degree on rover mobility. Mobility permits acquisition of rocks even when the landing is on unconsolidated debris; it permits travel from safe, bland, landing sites to sites of geologic interest; and it permits movement from one geologic unit to another in order to acquire samples, thereby insuring a variety of samples of known provenance. The value of mobility is difficult to quantify but the following table indicates qualitatively how range and 'risk' of failure to meet sample objectives are related.

RELATION BETWEEN ROVER RANGE AND SCIENCE RISK		
Radial range from Landing Point	Science Risk	
	No Rock	Only 1 rock type
0.001 km	high	high
0.1 km	moderate	high
1 km	low	high
10 km	low	moderate
100 km	low	low

The risk assessment of acquiring no fresh rocks is based mainly on Viking experience. The two Viking sites are known from thermal inertia data to be more rocky than most of Mars. Yet only a few small rocks were within reach of the landers, and all attempts to pick up and analyze small rocks failed. The 'rocks' analyzed turned out to be clods of unconsolidated debris, not true rocks. Thus, at a typical Mars site there is a high probability that no rocks are within reach of a sampling arm on a lander. In addition, drifts of poorly consolidated material, several meters across, occur throughout the Viking 1 site. Again, because the VL-1 site is atypically blocky, we can expect such drifts to be more extensive at other, more typical sites, and mobility of a few to tens of meters may be required to acquire rock samples. This problem could be exacerbated if the lander had some terminal guidance system to avoid blocks. Therefore, with

mobility of 100 m there is still moderate chance that no rocks will be accessible. (The enormous difference between Mars and the Moon in this respect needs re-emphasis. The loose debris on the Moon is composed largely of rock fragments comminuted by impacts. Most of the rock fragments are chemically and mineralogically unaltered, and so are representative of the geologic unit from which they originated. The loose material on the Moon was therefore very useful in reconstructing the Moon's geologic history. Mars is very different. The loose material on the martian surface is almost certainly highly weathered, and so provides little information on the chemistry and mineralogy of primary rocks. The loose material is also fine-grained and deposited by the wind so it will tend to bury any coarser, unweathered impact debris thrown into the site. In addition, no rock fragments were present in fine-grained and cloddy material at the Viking lander sites, based on their cohesion during surface sampling. The loose material at the martian surface is thus of limited usefulness in reconstructing the geologic history of the planet).

Mobility is also needed to ensure that more than one rock type is sampled at a given site. The mobility required to do this is difficult to quantify. Uncertainties in the location of geologic boundaries are typically a few kilometers. Lava flows are typically several to a few tens of kilometers across. For safety reasons, the landing ellipse will probably be placed entirely within one geologic unit, characterized as 'safe'. Unless there is landmark tracking, the ellipse will likely be several kilometers across, so a several kilometer traverse may be required to go from the 'safe' landing site to a more scientifically interesting site. Thus, different factors suggest that movement of several kilometers from the landing point will be required to ensure that two geologic units can be sampled. Travel of several tens of kilometers appears required for a safe site and in order to sample a diverse set of geologic units and materials.

In order to move tens of kilometers the rover should have the capability of moving relatively rapidly in bland, hazard-free areas. As previously indicated,

the Viking landing sites are probably more blocky than most of Mars. Insofar as blocks impede movement, therefore, more mobility should be possible at a typical site than is suggested by the characteristics of the Viking sites. Movement over extreme terrain (such as talus slopes), fresh lava flows (such as aa), and lee slopes of dunes are not required for science purposes.

Rover Trafficability Premises

Premise 1: There will be some sort of rover.

Criteria Derived From Rover Trafficability Considerations

There are three identifiable classes of trafficability hazards: discrete, statistical, and time variable. Some hazards may fit into more than one class, and are listed in the class in which they are most likely to be detected prior to landing.

Discrete: Includes *hazard separation* (e.g., blocks) $n \times$ turning circle ($n > 2$); and *long linear obstacles*, such as fractures which would require longer rover range.

Statistical: Site does not exceed critical frequency of untrafficable slopes (critical frequency = ?), (untrafficable slopes = ?); site is smooth at critical scale (scale $1/\text{slope}$), (1 m on horizontal surface), and avoid sites with low bearing strength.

Time Variable: Avoid sites of known dust storm generation and avoid sites with temperatures which impair mission operations. For example, if one objective is to use remote sensing instruments to select non-ice samples, then the landing site should not be near polar caps where frost deposition will likely occur.

Sampling Strategy and Validation

Choice of where to sample and what to retain will be made on the basis of the remote sensing instruments on-board the rover, the remote sensing instruments on the orbiter, previously acquired remote sensing data, and on analytical data from

the rover instruments. For acquisition of most rock samples, the spectral and optical instruments will provide the information on which the choice is made. Every effort should be made to acquire samples representative of the spectral and morphological variety that are accessible. In some infrequent cases, acquisition of information in addition to remote sensing data may be needed before a decision is made to acquire a sample. For these cases, it is desirable to have the capability of placing the Alpha Proton X-ray Spectrometer (APXS) against the rocks to be sampled. While it would be ideal to get APXS data on all samples acquired, this is thought to be unwise, because increased complexity and increased time of operations in sample acquisition reduces rover mobility, thereby decreasing the chances of reaching different geologic units, and acquiring a variegated sample set.

Trenching or coring of the unconsolidated materials will be done at only a few locations chosen on the basis of remote sensing information, neutron spectrometer data, and Differential Scanning Calorimeter coupled with an Evolved Gas Analyzer (DSC/EGA) analyses of material at the surface. The decision to take and retain samples from depth will be based largely on the results of the DSC/EGA analyses. These analyses will be made prior to acquisition of samples for retention and return to Earth. No analyses need be performed on the samples acquired for Earth return. Analyses of nearby samples will provide sufficient information on whether or not to retain samples. This policy is invoked to impose simplicity on the sample acquisition process. It implies that “splits” need not be made on acquired samples, with parts being analyzed, and parts being retained pending the results of the analyses.

Once a sample has been acquired for return to Earth and loaded into the sample storage device on the rover, it will be retained, ultimately to be loaded on the Ascent Vehicle for Earth return. In other words, the decision to acquire a sample for Earth return is made at the sample site, not at some subsequent time. This policy is intended to eliminate

the need for complex sample handling capabilities involving temporary storage on the rover and temporary storage at the lander, such that samples are held pending decisions to be retained or rejected. An implication is that the rover should, on any traverse, carry excess sampling holding capability in the event some extraordinary find occurs (the proverbial dinosaur bone). A possible alternative to this policy is that the rover carry multiple modules that fit into the sample cannister on the Ascent Vehicle, and a decision could be made not to load some of the modules for return to Earth.

After each rover traverse, approximately one third of the remaining space in the Sample Cannister on the Ascent Vehicle will be filled. Samples will never be removed from the Ascent Vehicle. The purpose of this policy is twofold. The first is to not risk damaging the sample cannister on the ascent vehicle by repeatedly inserting and removing samples. The second is to ensure that the ascent vehicle always has samples on-board in the event of forced early departure.

A photographic record should be made of the geologic setting of all samples, both before and after sample acquisition, and the locations of all *in situ* analyses. Spectral data should also be acquired on all samples.

Samples collected separately should be separately packaged and labelled.

Remote Sensing on Rover

Remote sensing has two functions. The first is to aid in navigation of the rover. The second is to aid in sample acquisition and characterization of the landing site by identifying chemical and mineralogical differences of materials within view of the sampling vehicle, and by characterizing physical processes that might affect the samples.

Stereo Imaging with Resolution of about 10 cm at 100 m; 0.1 cm at 1m

(These resolutions are approximate and provided as an indication of what might be necessary). The

camera needs to be mounted at least TBD m above the ground for navigation purposes and for far-field viewing. This scientific requirement arises from the need to interpret local geology and recognize sampling and science opportunities.

Multi-spectral Sensing Capability with Wavelength Range of 0.3 to 25 microns

Spatial and spectral resolution, number of wavelength channels, and whether an imaging spectrometer or a point spectrometer are required are all TBD.

This requirement can be accomplished in different ways as follows roughly in decreasing order of desirability. However, how spatial resolution, spectral resolution and imaging capability are traded against each other remains TBD.

Spectral capability with 100+ channels on one of the stereo cameras indicated above, coupled with the capability of changing the number of channels as desired (multi-spectral imaging).

Addition of about 10 spectral channels to one of the stereo cameras indicated above, coupled with a point spectrometer with spatial resolution TBD, but comparable to the camera resolution, and with spectral resolution of at least 20 nm (multi-band imaging plus spectrometer).

No spectral capability on the stereo cameras but independent point spectrometer with spatial resolution comparable to the camera and spectral resolution of at least 20 nm (monochrome imaging plus spectrometer). The multispectral capability is needed to identify mineralogic and chemical variations in the surrounding materials, and to make tentative identification of the cause of the variations, primarily in order to support rover traverse planning and sampling strategy. As previously indicated, the decision to acquire samples will be based largely on the spectral data.

High Resolution (0.005 cm) Imaging

The intent here is to utilize the on-board cameras, by addition of appropriate optics, to provide high

resolution views of nearby materials. If the cameras have multispectral capabilities then the utility of this capability is greatly enhanced. The objective is to characterize accessible materials at the scale of mineral grains (equivalent to a geologist using a hand lens in the field to identify rocks and minerals).

Analytical Instruments on the Rover

The purpose of the analytical instruments is two-fold. The first is to directly support sample selection. Because only a limited mass of material can be returned to Earth, some capability for discriminating between different types of samples is needed in order to ensure that a variegated sample set is collected. With analytical capability on the rover, intelligent choices can be made as to where to go to sample, what to sample, and what to retain in order to maximize variety in the returned set. The second purpose of analytical instruments is to do *in situ* science. A number of measurements, such as those sensitive to local conditions, can be made only on Mars. In addition, first order interpretations can be made concerning the types of materials available at the landing site, and the general geologic context, while the mission is in progress. These interpretations could influence the subsequent course of the mission, affecting traverse planning, sampling strategy and so forth. The following capabilities are desired to support sample selection and to establish the geologic context in which the mission is conducted. Each analytical procedure will have requirements on sample size, sample preparation, and sample manipulation. Until specific instruments are selected, the particular sampling and preparation requirements remain TBD.

General Elemental Analysis

General elemental analysis with the following capability:

- (1) major elements with a sensitivity of 0.1 atom percent and an accuracy of about 3 atom percent,

- (2) primordial radionuclides to a sensitivity of TBD,
- (3) selected minor and trace elements (e.g. C, N, F, P, S, Cl, Ti) to TBD sensitivity.

The preferred instrument is the alpha proton, X-ray spectrometer (APXS) because, of the analytical instruments currently available, it will suffer minimum interference from the effects of the radio-thermal generator. In addition to being able to analyze acquired and prepared samples, it is desirable that it can be manipulated so as to place it against material, such as a rock face, that are difficult to sample.

One purpose of having an analytical capability on the rover is to chemically characterize accessible materials as an aid in sample selection. As previously indicated, this does not imply that all samples acquired need to be analyzed, or that at sample sites numerous analyses be made of local materials in order to decide what should be samples. Many of the decisions on sample acquisition can be made on the basis of data from spectral instruments, coupled with a general knowledge of how the spectral data are related to APXS data. A second function of the on-board chemical analysis capability is to aid in interpretation of the local geology and thereby support planning of rover operations. The on-board analytical capability will also help calibrate the remote spectral observations.

Neutron Spectrometer

Neutron Spectrometer to distinguish between thermal, epithermal and fast neutrons. The main purpose of this instrument is to determine the H content and hence the H₂O content in the materials within 1 meter of the surface. The instrument will give an indication as to where subsurface sampling might unearth materials more water rich than typical.

Differential Scanning Calorimeter Coupled with an Evolved-Gas Analyzer (DSC-EGA)

The DSC should be capable of measuring solid-state transitions characteristic of volatile-bearing minerals including major groups of clay minerals, hydrous salts, and carbonates, and including occurrence of those phases as minor (1-10% abundance) components of bulk samples. The EGA should be able to perform as an independent analyzer of the atmosphere or as analyzer of the DSC gaseous effluent, with the ability to reliably identify and measure at least molecular water, carbon dioxide, carbon monoxide, nitrogen, oxygen, sulfur dioxide, nitrogen (II and IV) oxides, and organics.

The purpose of this instrument is to determine low temperature mineralogy and the composition of volatile components, including organics. Results from the instrument, in conjunction with spectral data, will be used to decide where best to sample for volatile rich materials. The results are particularly applicable to sampling the unconsolidated materials and water-lain sediments. The instrument will also be used to make measurements on Mars of characteristics that are unlikely to be preserved, or difficult to preserve in returned samples.

Other Possibilities

Other possibilities include some device for measuring hard-rock mineralogy (X-ray diffractometer), a stable isotope laser spectrometer (SILS), and some way of measuring the Eh and pH of the soil.

Premise 1: Rover design is predicated on current knowledge of the martian surface.

Premise 2: Rover will have the capability of traversing terrains subject to engineering criteria to be developed.

Lander Issues

Landability Premises

Premise 1: Landing sites will be selected based on landability and trafficability criteria.

Premise 2: Lander design is predicated on current knowledge of Mars.

Premise 3: A safe landing site means that a lander can touch-down intact, a rover can be deployed, and an ascent vehicle can be launched.

Premise 4: Landability criteria must be practical, i.e, data must be available to evaluate candidate sites.

Premise 5: Criteria should permit probability of safe landing superior to Viking post-mission estimates.

Discussion: There is an interaction between landing site selection criteria and the approach taken to lander design to reduce landing hazard. Options include a robust lander, precision landing, and active hazard detection and avoidance. Each has implications for the level of information required about specific landing sites. For example, if a lander is built to survive blocky hazards with a zone of influence of 1 m and to survive slopes of up to 14°, Viking Lander data suggest that the probability

of one successful landing in one attempt is 0.984, for two successful landings in two attempts is 0.97, and for one successful landing in two attempts is 0.9997.

Landing Site Criteria Derived From Landing Safety Considerations

There are three identifiable classes of landability hazards: discrete, statistical, and time variable. Some hazards may fit into more than one class, and are listed in the class in which they are most likely to be detected prior to landing. Dimensions of the hazards remain TBD.

Discrete: Linear features such as crevasses or ridges; high mountains along ground track; and maximum landing site altitude.

Statistical: Big rock; steep slopes; and bearing strength/coefficient of friction must be sufficient to support lander.

Time Variable: Avoid sites of known dust storm generation.

PENETRATOR MISSIONS

The following science criteria, sampling objectives, and engineering constraints were defined at the 25 July 1989 meeting of the joint United States/Soviet Landing Site Working Group, held in Flagstaff, Arizona.

Science Criteria

- Uniform geology
- Potential future sites for lander
- Inaccessibility by other means
- Seismic spacing
- Meteorologic spacing
- Highest possible latitude

Sampling Objectives

- Recent volcanics
- Intermediate-age volcanics
- Ancient highlands
- Ground ice (i.e., high latitude)
- Waterlaid sediments
- Explosive (felsic?) volcanics
- Polar deposits
- Dust and soil and atmosphere (any site)

Engineering Constraints

- $\pm 45^\circ$ latitude
- < 2 km high
- ~ 150 km error radius
- Identical payloads
- 2 m (2-10 m) (?) penetration

Meteorological Considerations for Penetrator Sites

(drafted by C. Leovy)

a) *Site safety considerations:* To satisfy the landing pressure constraint, all sites have been chosen to have elevations below the 2 km. It should be noted that the landing season, late northern summer, is near the seasonal pressure minimum, so the pressure on entry can be expected to be about

10% below the seasonal mean (equivalent to about 1 km).

Wind drift may be a consideration for penetrator entry. Winds are currently very poorly known in general, but may be expected to be much better understood before the mission with the aid of Mars Observer data and improved models. However, some general statements can be made. Regions of low regional slope in the northern hemisphere mid-latitudes should be relatively safe at this season from the point of view of winds. We have specific evidence of very light winds in the lowest scale height at the Viking lander 2 site in Utopia Planitia. Stronger winds are likely in regions of high regional slope in low latitudes. There is evidence of moderately strong slope winds above the boundary layer at Viking lander 1 (~ 20 m/s), and cloud forms in the vicinity of the Tharsis volcanoes and Olympus Mons during the early morning hours suggest strong winds there at those times. There is a possibility of strong winds associated with storminess at southern mid-latitudes at this season, but we have little data bearing on this.

b) *Meteorological science considerations for a 3-4 station network:* Several grouping strategies could accomplish important science goals for meteorology, as follows:

(i) *Low latitude string.* A string of 3-4 pressure measurements, widely separated in longitude, with high precision pressure measurements would allow detailed study of Kelvin waves, thermal tides, normal modes, and if winds are measured, low latitude regional topographic winds (e.g., 068, 072, 069, 064).

(ii) *Southern vs. northern hemisphere winter storms.* *these storms are responsible for considerable dust raising and transport in the north.* The key site in the list for this purpose is 062. It would be highly desirable to have two sites near 45° S, plus one or two sites in the north at about the same latitude.

(iii) *Regional slope pressure variations and winds.* If wind data could be obtained, stations on opposite sides of a regional slope would allow a strategy to determine regional slope winds. For example, 068, 070, 071, and 072, around the Tharsis bulge would form a useful network for this purpose. The potential for deducing regional slope meteorological

effects from pressure and/or temperature data alone is questionable.

(iv) *Constant longitude string.* A string of 3 or 4 stations along a nearly constant longitude stretching from southern to northern mid-latitudes, including at least one in low latitudes could accomplish some of the science of both (i) and (ii) above.

BALLOON MISSIONS

The following considerations were developed at the 25 July 1989 meeting of the joint United States/Soviet Landing Site Working Group meeting, held in Flagstaff, Arizona.

Initial Site:

<-2 km elevation
-45 to +55 latitude (1984)

Drift Mission:

Elevation: <+2 km over range of approximately 1,000 km

Slope: (wind shear limit): <1/100

Winds: (10 m/s = 900 km/Mars day) <4,000 km in 10 days travel; 10 hours/day

Science:

Maximum variety of geology, or unit of great interest, especially at landing site and expected at first (few) descents.

METEOROLOGICAL STATIONS

Meteorological Measurements

At each landing site a long-lived meteorological station should be deployed in such a way that its measurements suffer minimal interference from the lander. The intent is to follow diurnal and seasonal variations in the atmosphere in order to better model atmospheric dynamics, and to characterize atmospheric processes at the site. Atmospheric variations also influence weathering, erosion, migration of volatiles in the soil and exchange of volatiles between the soil and the atmosphere. The station should have a long lifetime (TBD) and make the following measurements over at least one annual cycle with at least 20 averaging intervals per day.

Pressure required to ± 0.01 hPa.

Temperature required at 1 meter above the ground to accuracy and precision of $\pm 2^\circ\text{C}$, and desired also at 10-20 cm above the ground with the same accuracy.

Wind speed to accuracy of $\pm 20\%$, direction to $\pm 30^\circ$.

Frost point temperature to $\pm 2^\circ\text{K}$ for frost points above 180°K .

Two upward-looking broad-band photometers, one in the UV, one in the visible and near IR, both with accuracies of $\pm 10\%$ and precisions of $\pm 5\%$.

Site 001 - Eridania NW

Site 001

Site Name: Eridania NW

Type of Site: Rover/Sample Return

Latitude: 36°S

Longitude: 228°W

Elevation: + 3.0 to + 4.0 km

Maps: MC-29 NW

Viking Orbiter Images: 420S16 through 420S21; resolution is 90 m/pxl.

Date Entered: 31 October 1989

Date Last Revised: 31 October 1989

Contact:

Steve Squyres
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Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are probably flood lavas of intermediate age. Plains materials lap up against the higher cratered terrain at the contact. A number of well-developed ancient valley systems are present in the cratered terrain and debouch at the contact. The valleys apparently predate emplacement of the plains materials. The geometry of the valleys is not clearly confluent, so it is not clear that fluvial sediments underlie the plains materials. Fresh craters up to about 10 km in diameter excavate into the plains materials, and there are a few ancient buried craters whose rims protrude upward through plains materials.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, recent volcanics.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Steve Squyres

⊗ Landing Site: 36° S Latitude, 228° W Longitude

MC-29NW

100 km

230°W



230°W

Site 001 ERIDANIA NORTHWEST

Site 002 - Parana Valles

Site 002

Site Name: Parana Valles

Type of Site: Rover/Sample Return

Latitude: 22°S

Longitude: 12°W

Elevation: + 1.0 km

Maps: MC-19 SE

Viking Orbiter Images: 651A91 through 651A95; resolution is 260 m/pxl.

Date Entered: 31 October 1989

Date Last Revised: 31 October 1989

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Geologic Setting

The site lies at the confluence of a number of valley systems in ancient cratered terrain. The primary feature of the site is a closed topographic depression with many inflow valleys and a single outflow. The depression is not clearly filled with volcanic deposits, and hence may contain waterlain sediments that are near or at the surface. The deposits filling the depression have an unusual hummocky texture of unknown origin.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, waterlain sediments.

Potential Problems

To be determined.

Trafficability

To be determined.

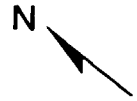
Estimated Traverse Distance

To be determined.

Site 002 PARANA VALLES

10°W

20°S



10°W

20°S

100 km

21

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

ASU - 434

⊗ Landing Site: 22° S Latitude, 12° W Longitude

Steve Squyres

Site 003 - Eridania

Site 003

Site Name: Eridania

Type of Site: Rover/Sample Return

Latitude: 58°S

Longitude: 212°W

Elevation: + 4.0 km

Maps: MC-29 SE

Viking Orbiter Images: 551B27
through 551B32; 373S03; resolution is
70 m/pxl.

Date Entered: 31 October 1989

Date Last Revised: 31 October 1989

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Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are apparently flood lavas of intermediate age. The latitude of the site is high enough that ground ice may be present. Lava flows are observed on the plains. These lavas lap up against the higher cratered terrain at the contact. Several well-developed ancient valley systems are present in the cratered terrain and debouch at the contact. The valleys apparently predate emplacement of the plains materials. The geometry of the valleys is not clearly confluent, so it is not clear that fluvial sediments underlie the plains materials. Fresh craters up to about 10 km in diameter excavate into the plains materials. One such crater very close to the site has a well-developed double-lobed fluidized ejecta blanket.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics, ground ice.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 003 ERIDANIA



MC -29SE

⊗ Landing Site: 58° S Latitude, 212° W Longitude

Steve Squyres

Site 004- Eridania SE

Site 004

Site Name: Eridania SE

Type of Site: Rover/Sample Return

Latitude: 57°S

Longitude: 195°W

Elevation: + 5 km

Maps: MC-29 SE

Viking Orbiter Images: 553B09 through 553B16; 373S25

Date Entered: 22 November 1989

Date Last Revised: 22 November 1989

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Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are apparently flood lavas of intermediate age. The latitude of the site is high enough that ground ice may be present. Lava flows are observed on the plains. These lavas lap up against the higher cratered terrain at the contact. Several small ancient valley systems are present in the cratered terrain and debouch at the contact. The valleys apparently predate emplacement of the plains materials. The lavas seem to fill a closed depression into which the valleys drain, so there is a possibility of waterlain sediments being present under the lavas (though this possibility probably is not high enough for this site to be considered as a prime one for sampling such sediments). Fresh craters up

to about 7 km in diameter excavate into the plains materials.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics, ground ice.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 004 ERIDANIA SOUTHEAST



MC -29SE

⊗ Landing Site: 57° S Latitude, 195° W Longitude

Steve Squyres

Site 005- Iapygia

Site 005

Site Name: Iapygia

Type of Site: Rover/Sample Return

Latitude: 9°S

Longitude: 279°W

Elevation: + 5.0 km

Maps: MC-21 NE

Viking Orbiter Images: 754A07 through 754A11

Date Entered: 22 November 1989

Date Last Revised: 22 November 1989

Contact:

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Geologic Setting

The site lies at a contact between ancient cratered terrain and a plains unit that may be volcanic material of intermediate age. Within the ancient terrain very close to the contact, a well-developed valley system debouches into a very degraded 10-km impact crater. The crater appears to be largely filled, and is likely to contain a significant quantity of waterlain sediments. There is no clear evidence for volcanic material in the crater, though this possibility cannot be excluded. There is a fresh 2.5-km crater formed in the crater-filling deposits. A single valley flows out of the 10-km crater and onto the plains.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, waterlain sediments, intermediate volcanics.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 005 IAPYGGIA

280°W
↓



280°W



100 km

MC -21NE

⊗ Landing Site: 9° S Latitude, 279° W Longitude

Steve Squyres

Site 006- Noachis

Site 006

Site Name: Noachis

Type of Site: Rover/Sample Return

Latitude: 55°S

Longitude: 337°W

Elevation: + 5.0 km

Maps: MC-27 SW

Viking Orbiter Images: 575B03 through 575B08

Date Entered: 22 November 1989

Date Last Revised: 22 November 1989

Contact:

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Geologic Setting

The site lies at a contact between ancient cratered terrain and plains materials that are probably flood lavas of intermediate age. The latitude of the site is high enough that ground ice may be present. A very fresh 15-km crater with a well-developed fluidized ejecta blanket lies very near the contact.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics, ground ice.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 006 NOACHIS



MC - 27SW

⊗ Landing Site: 55° S Latitude, 337° W Longitude

Steve Squyres

Site 007-Terra Cimmeria

Site 007

Site Name: Eridania NC
Type of Site: Rover/Sample Return

Latitude: 42°S
Longitude: 211°W
Elevation: + 5 km

Maps: MC-29 NC

Viking Orbiter Images: 370S50;
resolution is 230 m/pxl.

Date Entered: 7 November 1989
Date Last Revised: 7 November 1989

Contact:

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Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are apparently flood lavas of intermediate age. These lavas lap up against the higher cratered terrain at the contact. Many well-developed ancient valley systems are present in the cratered terrain and debouch at the contact. The valleys apparently predate emplacement of the plains materials. The lavas seem to fill a closed depression into which the valleys drain, so there is a possibility of waterlain sediments being present under the lavas (though this possibility probably is not high enough for this site to be considered as a prime one for sampling such sediments). Fresh craters up to about 12 km in diameter excavate into the plains materials.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics.

Potential Problems

To be determined.

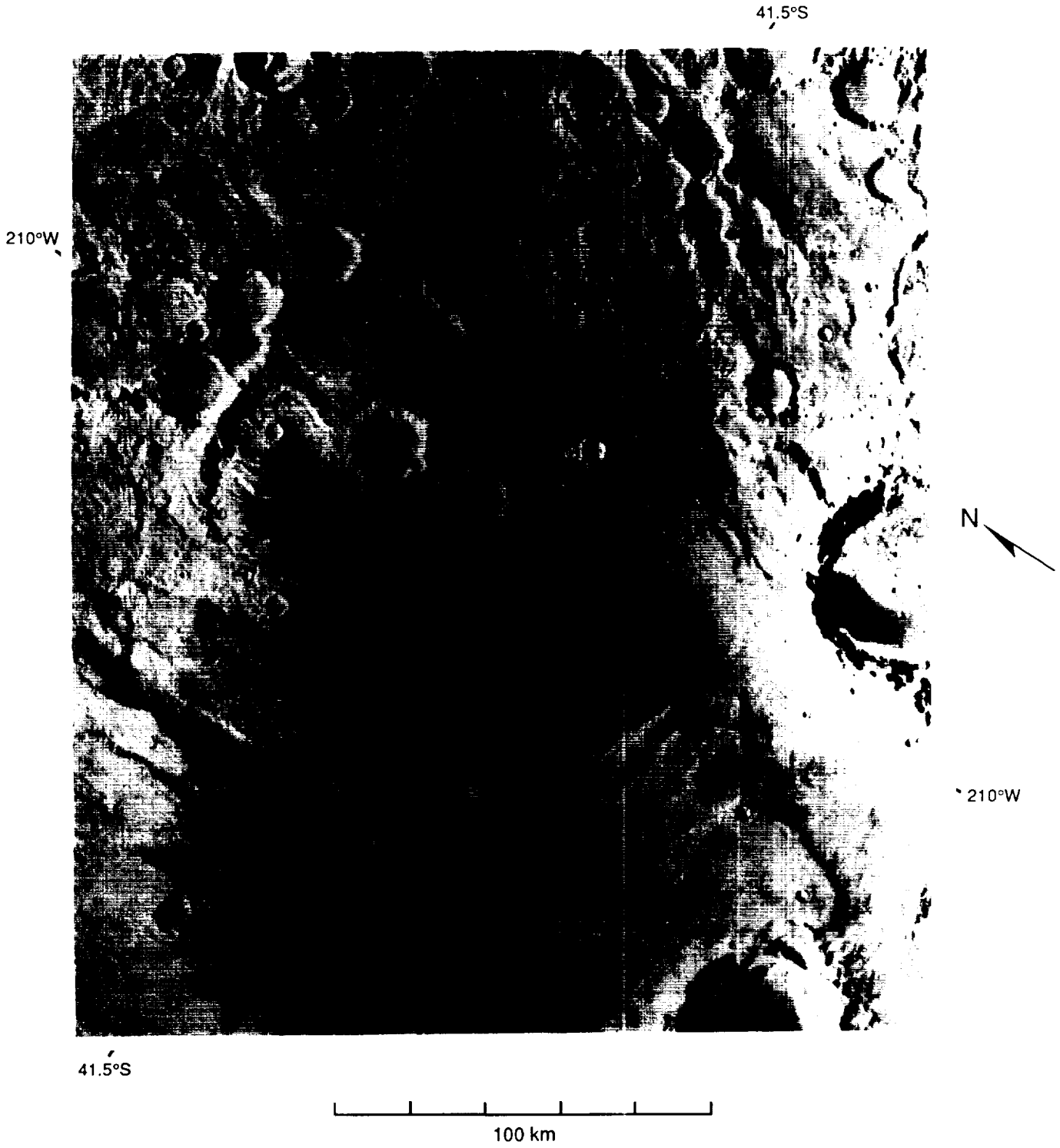
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 007 TERRA CIMMERIA



V.O. 370S50

⊗ Landing Site: 42° S Latitude, 211° W Longitude

Steve Squyres

Site 008 - Mare Tyrrhenum

Site 008

Site Name: Mare Tyrrhenum
Type of Site: Rover/Sample Return

Latitude: 23°S
Longitude: 231°W
Elevation: + 3.0 to + 4.0 km

Maps: MC-22 SE

Viking Orbiter Images: 629A10,
629A27; resolution is 250 m/pxl.

Date Entered: 7 November 1989
Date Last Revised: 7 November 1989

Contact:

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Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are apparently flood lavas of intermediate age. These lavas lap up against the higher cratered terrain at the contact. Many well-developed ancient valley systems are present in the cratered terrain and debouch at the contact. The valleys apparently predate emplacement of the plains materials. The lavas seem to fill a closed depression into which the valleys drain, so there is a possibility of waterlain sediments being present under the lavas (though this possibility probably is not high enough for this site to be considered as a prime one for sampling such sediments). Fresh craters up to about 6 km in diameter excavate into the plains materials.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics.

Potential Problems

To be determined.

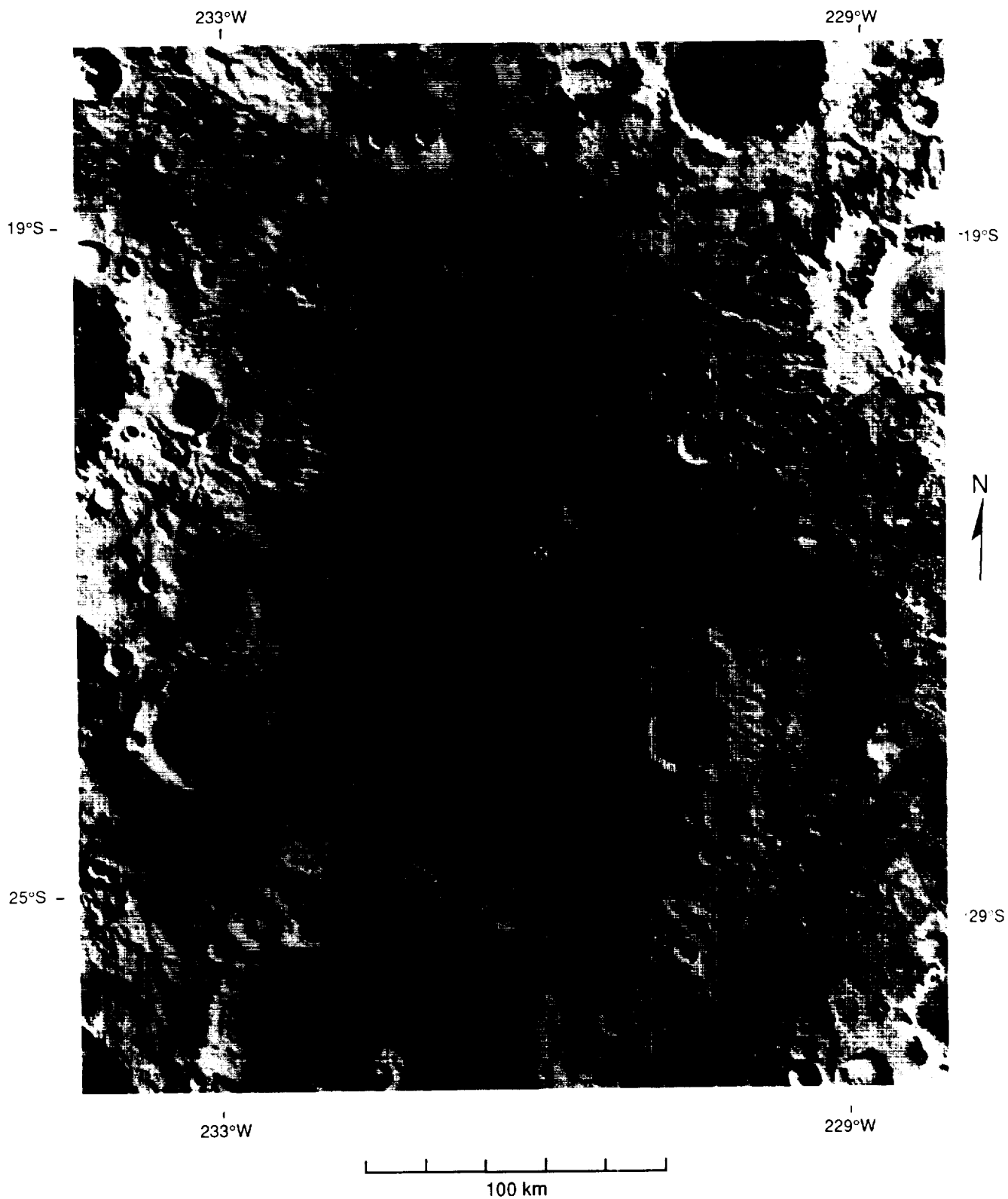
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 008 MARE TYRRHENUM



MC -22SE

⊗ Landing Site: 23° S Latitude, 231° W Longitude

Steve Squyres

Site 009 - Sinus Sabaeus

Site 009

Site Name: Sinus Sabaeus

Type of Site: Rover/Sample Return

Latitude: 6.5°S

Longitude: 335.5°W

Elevation: + 4.0 km

Maps: MC-20 NE

Viking Orbiter Images: 618A09 through 618A11; resolution is 230 m/pxl.

Date Entered: 7 November 1989

Date Last Revised: 7 November 1989

Contact:

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Geologic Setting

The site lies in a 25-km impact crater in ancient cratered terrain. One well-developed valley system and several smaller valleys drain into the crater, so it probably was a site of ancient aqueous sedimentation. No clear evidence for subsequent volcanic filling of the crater is seen, but the resolution of the existing image probably is insufficient for detection of many possible volcanic landforms. The site lies less than 100 km from "White Rock," an unusual high-albedo crater floor deposit that has been guessed by some to be a possible carbonate or evaporite deposit. This is potentially quite an interesting site, but a major improvement in data quality is required before it could be considered seriously.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, possible waterlain sediments.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 009 SINUS SABAEUS



MC -20NE

⊗ Landing Site: 6.5° S Latitude, 335.5° W Longitude Steve Squyres

Site 010- Terra Tyrrhena

Site 010

Site Name: Terra Tyrrhena
Type of Site: Rover/Sample Return

Latitude: 25°S
Longitude: 266°W
Elevation: + 3.0 km

Maps: MC-22 SW

Viking Orbiter Images: 625A31

Date Entered: 28 November 1989
Date Last Revised: 28 November 1989

Contact:

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Geologic Setting

The site lies at a contact between ancient cratered terrain and plains materials that may be flood lavas. However, the resolution is too low to confirm the origin of these plains. Many well-developed valley systems are present in the cratered terrain and debouch with a confluent geometry at the contact, so a sedimentary origin cannot be ruled out. If the plains are volcanic, they are likely to be underlain in some locations by waterlain sediments. A fresh 35 km crater with a broad ejecta blanket excavates into the plains material near the contact.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics and/or waterlain sediments.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

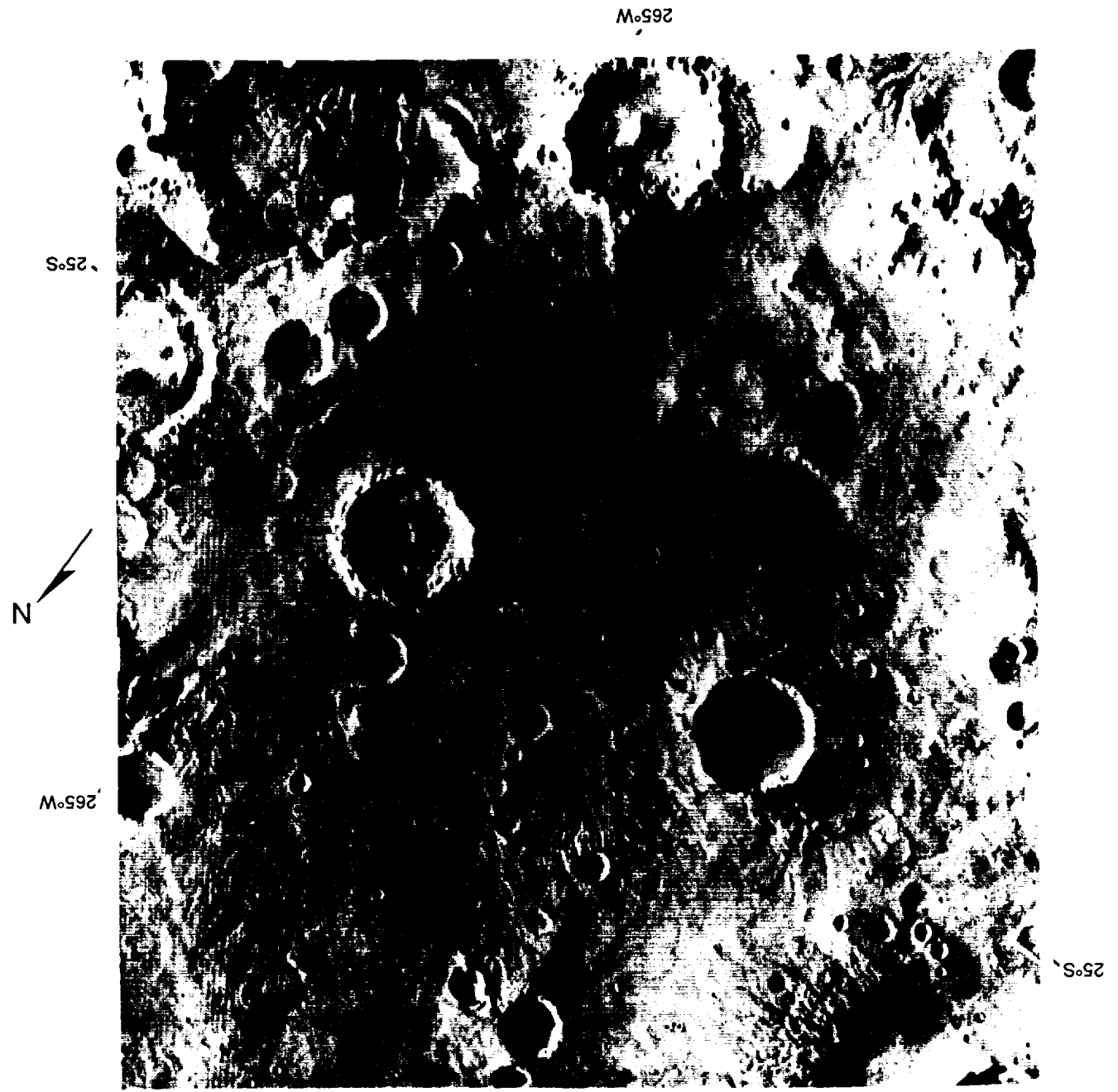
To be determined.

Steve Squyres

⊗ Landing Site: 25° S Latitude, 266° W Longitude

V.O. 625A31

100 km



Site 010 TERRA TYRRHENA

Site 011 - Phaethontis SW

Site 011

Site Name: Phaethontis SW
Type of Site: Rover/Sample Return

Latitude: 51°S
Longitude: 153°W
Elevation: + 5.5 km

Maps: MC-24 SW

Viking Orbiter Images: 526A50 through 526A52

Date Entered: 28 November 1989
Date Last Revised: 28 November 1989

Contact:

Steve Squyres
Dept. of Astronomy
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Cornell University
Ithaca, NY 14853
(607) 255-3508

Geologic Setting

The site lies at a contact between ancient cratered terrain and ridged plains materials that are apparently flood lavas of intermediate age. The latitude of the site is high enough that ground ice may be present. Several well-developed ancient valley systems are present in the cratered terrain and debouch at the contact. However, the geometry of the valleys is not clearly confluent, and they do not clearly flow into a closed depression, so the presence of waterlain sediments, even beneath the lavas of the plains, is uncertain at best. The largest craters excavating into the plains materials near the contact are smaller than 5 km in diameter.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, intermediate volcanics, ground ice.

Potential Problems

To be determined.

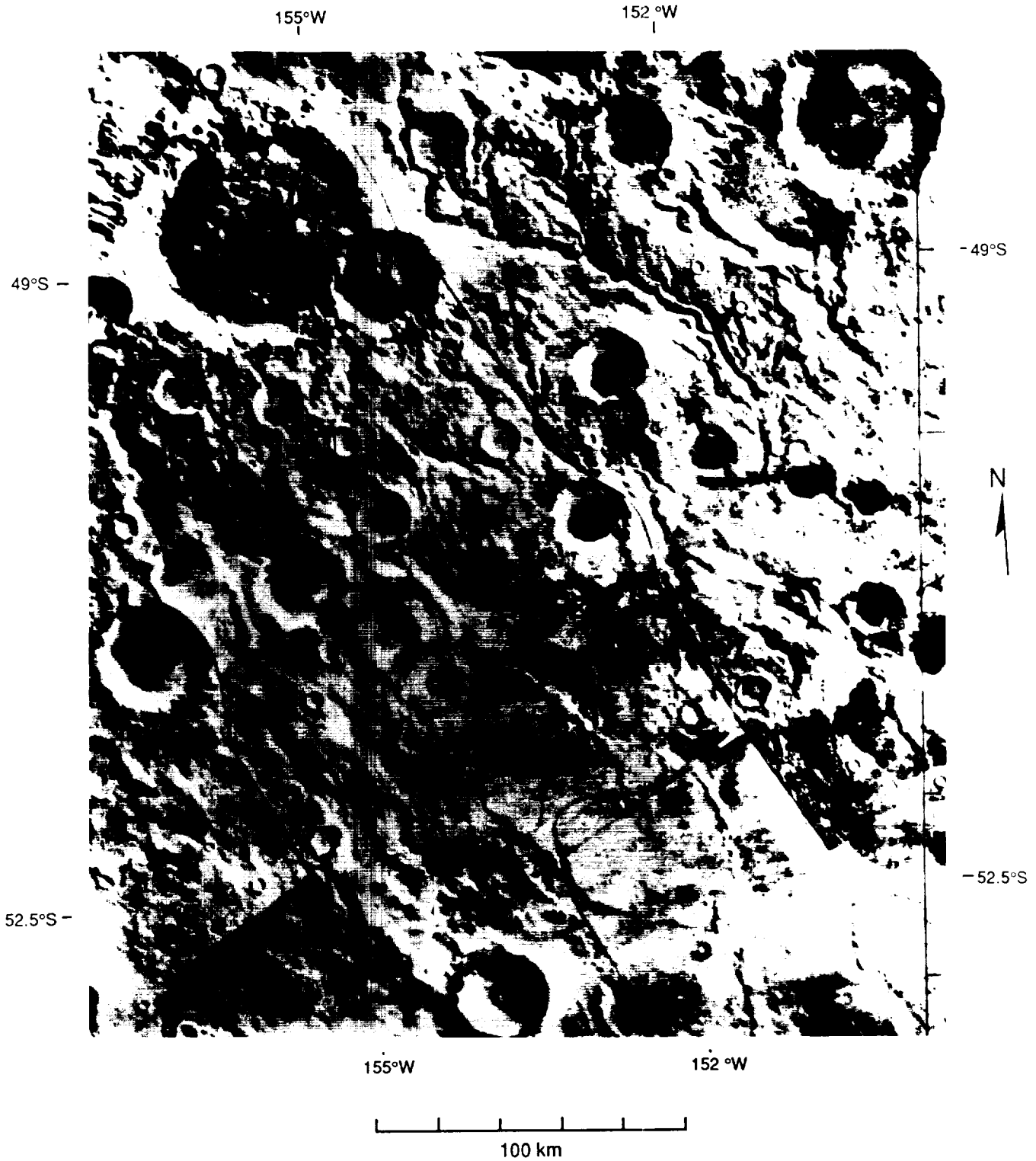
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 011 PHAETHONTIS SOUTHWEST



MC -24SW

⊗ Landing Site: 51° S Latitude, 153° W Longitude

Steve Squyres

Site 012- Samara Valles

Site 012

Site Name: Samara Valles

Type of Site: Rover/Sample Return

Latitude: 23°S

Longitude: 21°W

Elevation: + 2.0 km

Maps: MC-19 SE, SW

Viking Orbiter Images: 615A41 through 615A43

Date Entered: 28 November 1989

Date Last Revised: 28 November 1989

Contact:

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Geologic Setting

The site lies in the vicinity of two large impact craters in ancient cratered terrain. One is about 100 km in diameter, and the other is about 35 km. Many well-developed valley systems drain into the larger crater, and at least one well-developed one drains into the smaller one. Both probably were sites of ancient aqueous sedimentation. No clear evidence for subsequent volcanic filling of either crater is seen, though the resolution of the existing images is insufficient for detection of many possible volcanic landforms. For the larger crater, subdued valley remnants are visible over much of the crater floor, making deep volcanic burial there appear unlikely. This is potentially quite an interesting site, but a major improvement in

data quality is required before it could be considered seriously.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain, waterlain sediments.

Potential Problems

To be determined.

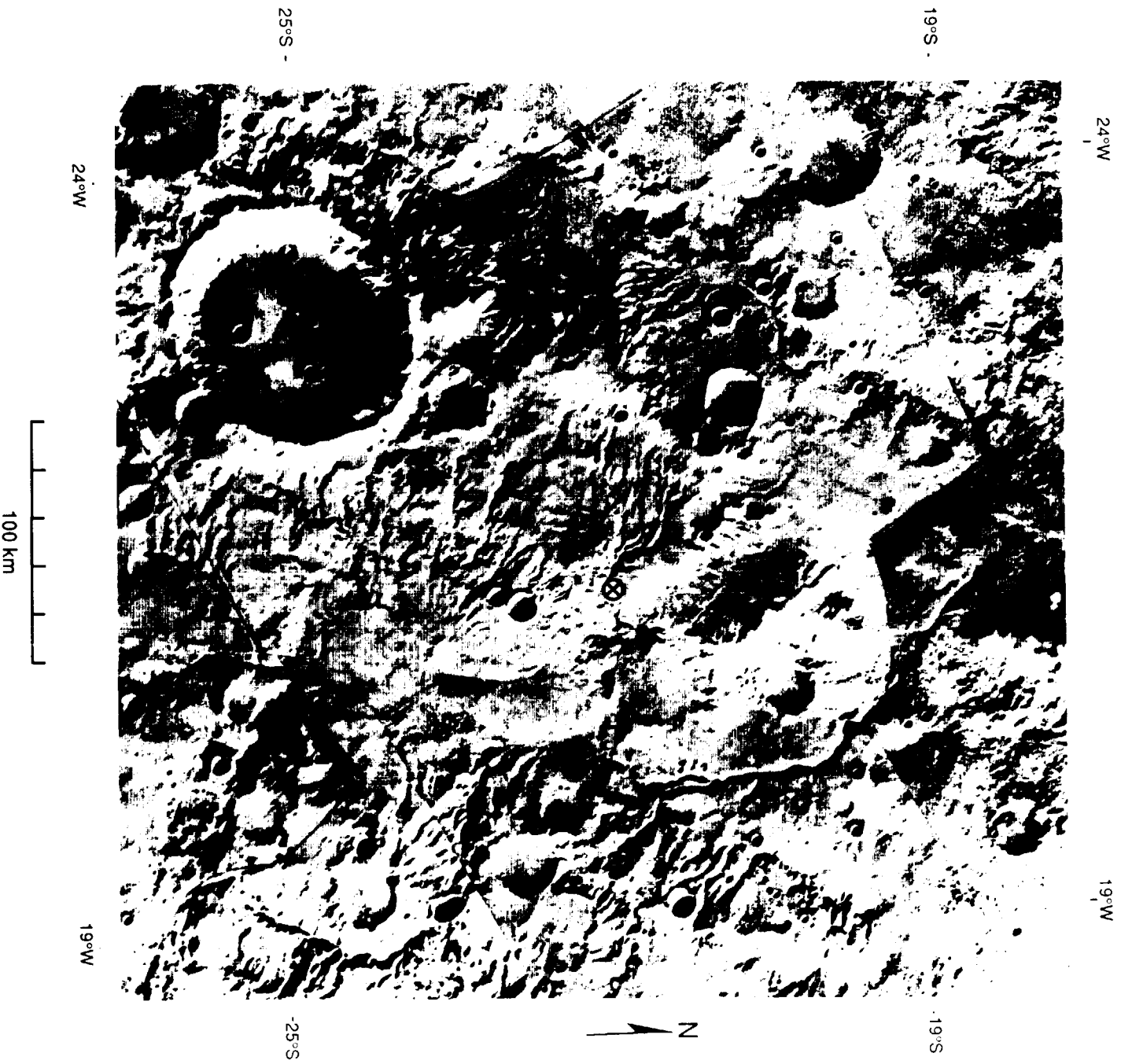
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 012 SAMARA VALLES



MC - 19SE and SW

⊗ Landing Site: 23° S Latitude, 21° W Longitude

Steve Squyres

Sites 013-017- DELETED

Site 000

Site Name:

Type of Site:

Latitude:

Longitude:

Elevation:

Maps:

Viking Orbiter Images:

Date Entered:

Date Last Revised:

Contact:



Site 018 - Alba Patera

Site 018

Site Name: Alba Patera

Type of Site: Rover/Sample Return

Maps: MTM#45117; MC-2 SE

Viking Orbiter Images: 252S32, 252S34

Date Entered: 18 October 1988

Date Last Revised: 18 October 1988

Latitude: 47°N

Longitude: 116°W

Elevation: + 3 km

Contact:

Dale Schneeberger
Jet Propulsion Laboratory
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Pasadena, CA 91109
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Geologic Setting

Alba Patera, a unique volcanic feature, is the largest central volcano in the solar system. At the center lies a 100 km wide caldera. Extending from the central caldera for hundreds of miles are channel-fed flows, sheet lavas, and complex tube-fed lavas. The landing site lies in Alba Fossae, a set of fractures which postdate flows on the Northwest summit region of Alba Patera.

Scientific Rationale

The site provides accessibility to lava flows that appear to exhibit a range in rheology as demonstrated by the various flow morphologies. Crater numbers suggest that three of the units here are not significantly different in age from each other. The site also offers an opportunity to sample volcanic materials thought to be pyroclastics.

Objectives

- a) Tabular flow sample; collection of sample may be hindered by steepness of slope of flow lobes (success 70-90%)

- b) possible pyroclastic materials or deeply weathered material; potential access problem (success 50-70%);
- c) possible older "basal" sheet flows associated with early Alba activity; uncertainty of stratigraphic nature (success 50-70%);
- d) tube-fed flow sample; traverse to sample location may pose a problem to sample acquisition (success 40-60%).

Potential Problems

A potential problem associated with the proposed sample collecting site lies with the uncertainty of the surface roughness. The surface appears relatively smooth in the 60-80 m/pxl images. However, very high resolution images (9-10 m/pxl) south and east of the sample site show surfaces marked by numerous small pits or craters to about 30 meters in diameter (limit of resolution). Yet, all exhibit a similar surface appearance in images of comparable resolution. Therefore, the surface of the proposed sample site may have a potential roughness characteristic of the very high resolution images. Thus, surface roughness will have an impact on sample acquisition. The degree of impact will de-

pend on the capability of the rover vehicle, or whatever sample means are used. If, for example, surface conditions are too rough, a traverse of more than a few kilometers may be impossible. Other problems such as steep topographic gradients, like that found near a tabular flow front, or irregular (etched) topography associated with the hypothesized

pyroclastic terrain, may make sample acquisition difficult.

Trafficability

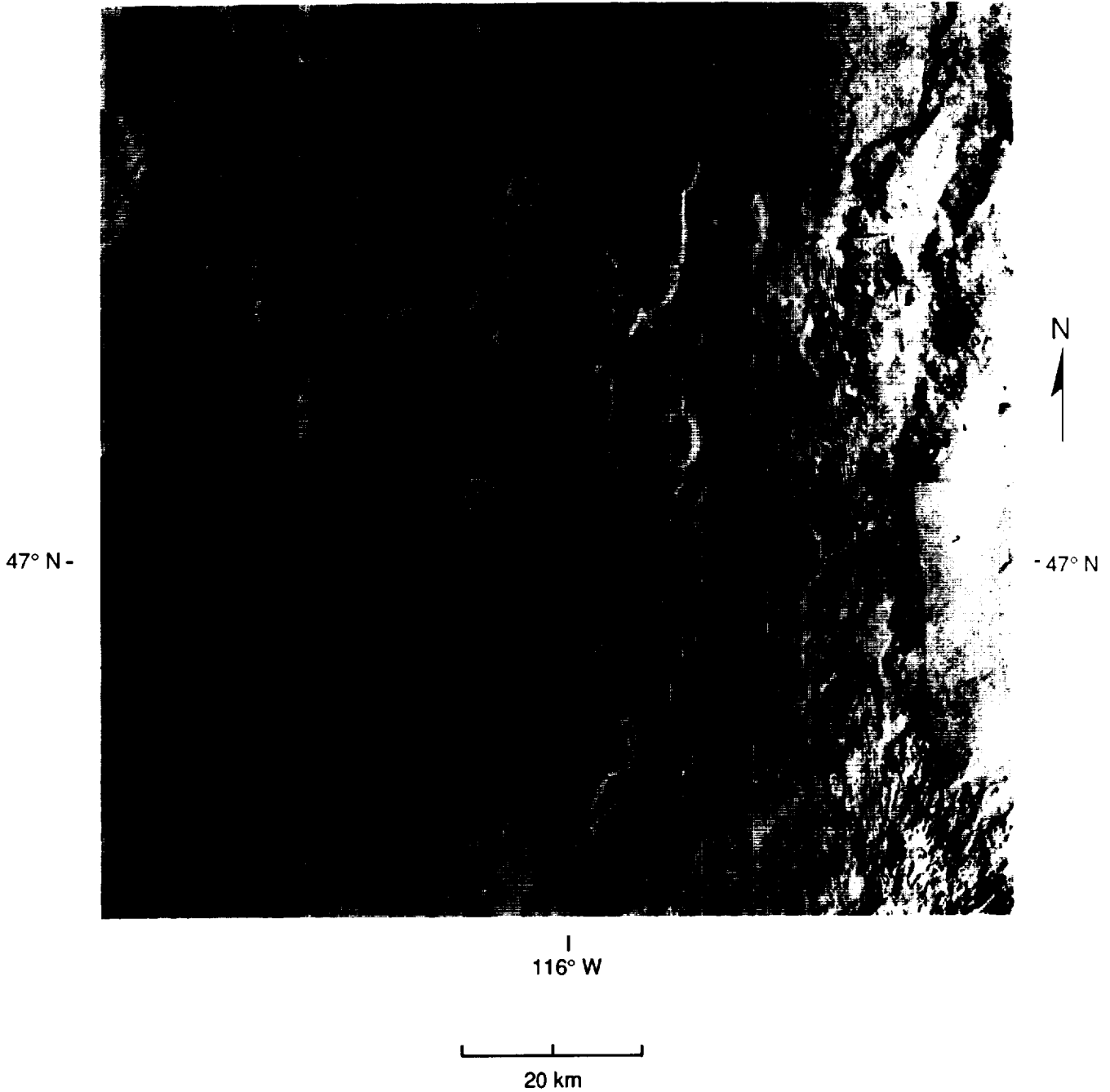
To be determined.

Estimated Traverse Distance

To be determined.

Site 018 ALBA PATERA

116° W



MTM 45117

⊗ Landing Site: 47° N Latitude, 116° W Longitude

D. Schneeberger

Site 019 - Northern Elysium

Site 019

Site Name: Northern Elysium
Type of Site: Rover/Sample Return

Latitude: 33°N
Longitude: 212°W
Elevation: 0 km

Maps: MTM#35212; ML-75L

Viking Orbiter Images: 86A35 through 86A40

Date Entered: 22 September 1988
Date Last Revised: 22 September 1988

Contact:

Peter Mouginis-Mark
Planetary Sciences Division
Hawaii Institute Geophysics
2525 Correa Road
Honolulu, HI 96822
(808) 948-6488

Geologic Setting

The landing site is located on the northwest flank of Hecatus Tholus. Hecatus Tholus, one of the three Elysium volcanoes, is 180 km wide, 6 km high, and topped by a complex caldera from which several lines of depressions and grabens radiate. Small, fluvial-like channels of controversial origin arise close to the landing site.

Scientific Rationale

Age date for lower Amazonian lavas—calibrate crater chronology; investigate origin of materials on flank of Hecates Tholus (explosive?); study possible volcano/ground ice interactions to constrain martian volatile history.

Objectives

- Sample and return lava flow on plains north of Elysium Mons; calibrate size/frequency crater curves (success high: but lander-scale topography may make landing interesting);
- resolve stratigraphy of flanks of Hecates Tholus—old or young channels? (success medium: I'm not sure rover cameras will pick up correct morphology);

- identify physical properties of flanks of Hecates Tholus (success high: providing rover has sampling arm/trench);
- investigate stratigraphy of lowlands/highlands scarp (success medium: rover imaging may not have resolution. Canyon floor topography unknown).

Landing Site: Sample and return selected materials from plains that underlie lobate flows from Elysium Mons.

Interpretation: Undifferentiated lava flows from Elysium Mons.

Goal: Age date flows.

Station 1: Sample and return material from distal end of lobate flow from Elysium Mons.

Interpretation: Relatively young lava flow from Elysium Mons (Lower Amazonian; Greeley and Guest, 1987).

Goal: Age date lava flow. Resolve issue of why lava flows on Mars travel up to ^500 km from source (chemistry vs. effusion rate?).

Station 2: Sample and return material from edge of subdued flow lobe.

Interpretation: Mud flow produced by volcano/ground ice interactions in northern Elysium.

Goals: Identify mode of formation of flow lobe. Age date event.

boundary between northern plains and Elysium lavas.

Station 3: Resolve stratigraphy of deposits associated with channels from Hecates Tholus.

Goals: Answer questions of whether channels pre-date or post-date plains materials and whether channels were water carved or formed by debris flows.

Station 4: Investigate physical properties of flanks of Hecates Tholus.

Goals: Determine if flanks comprise ash fall deposits, pyroclastic flows, or hydrothermally-altered lava flows. This is of key importance in our attempts to determine if early martian volcanism was explosive in nature and the possible paleoclimatic effects explosive eruptions may have had early in martian history.

Station 5: Investigate physical properties of isolated massifs and knobby materials on the plains north of Hecates Tholus.

Goals: Determine if there are morphologic or compositional differences between massifs (assumed to be remnants of earlier, partially-buried surface) and northern plains.

Station 6: Investigate physical properties of eroded scarp along boundary of northern plains and Elysium Mons lava flows.

Goal: Search for evidence of stratigraphy in scarp wall and for evidence of paleo ground-ice.

Sites 3-5 Traverse: Conduct gravity and active seismic experiments to determine sub-surface structure to northwest of Hecates Tholus.

Goals: 1) Determine basal diameter of Hecates Tholus, 2) determine thickness of Elysium Mons lavas, and 3) determine

Potential Problems

Landing site may be rough at scale of spacecraft; long traverse (~170 km)—could rover live required time?; physical properties of flanks of Hecates Tholus unknown—could be too soft for rover (or too steep?).

REQUIRED ROVER CAPABILITIES:

- 1) sample return capability (at least 3 selected rocks).
- 2) trafficability - ^200 km range.
- 3) Rover-to-Earth communications.
- 4) Science experiments:
 - a) cameras (video and multispectral).
 - b) gravimeter.
 - c) trenching ability (^20 cm depth).
 - d) active seismic experiment.

LANDING SITE CONSTRAINTS:

- 1) “hazard-free” landing ellipse (no impact craters in 10 km diameter target detectable on 50 m/pxl images).
- 2) low elevation (< 2 km above 6.1 mb datum).

TARGET AREA: ~50 km west of Hecates Tholus at 33°N, 213°W.

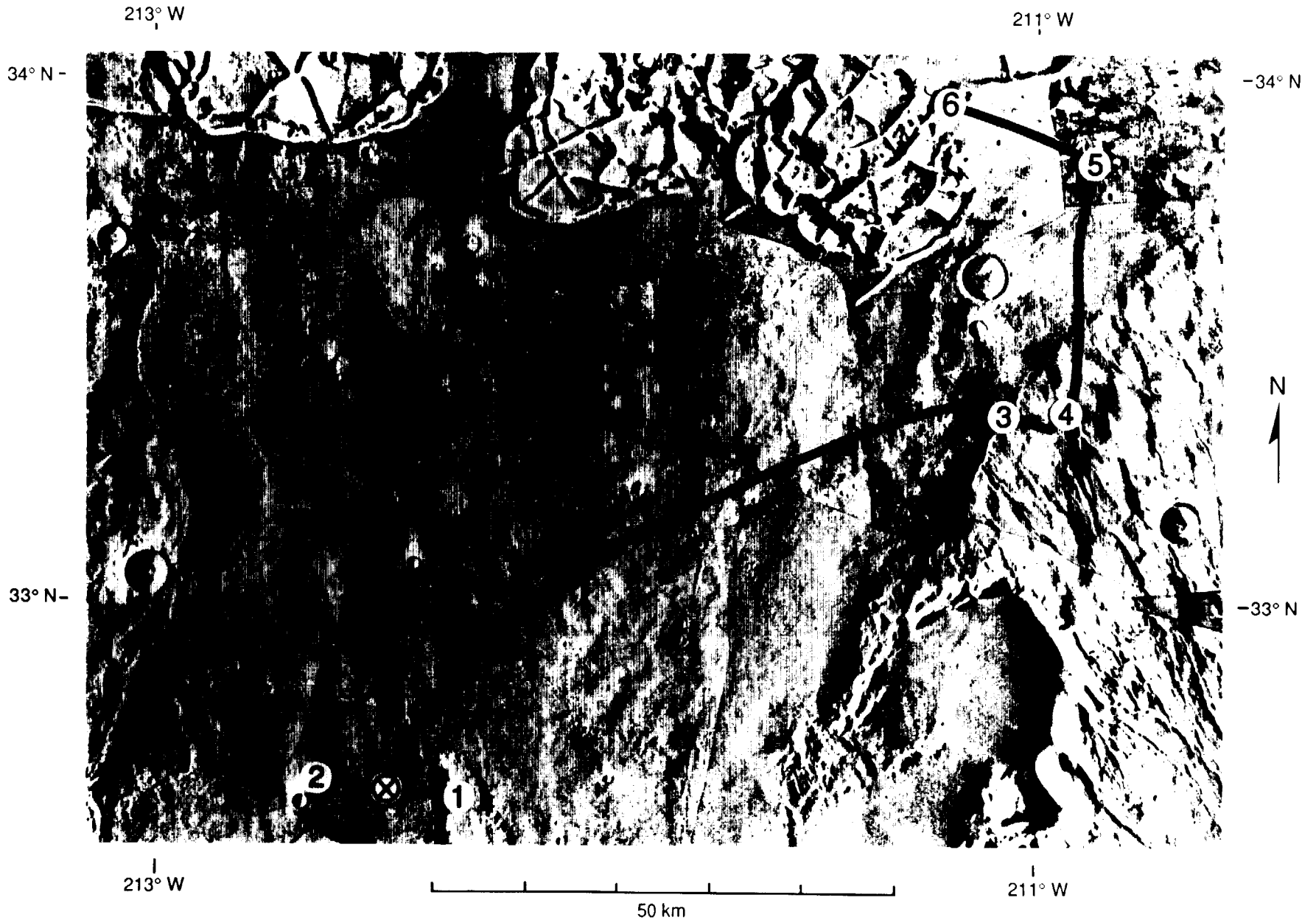
Trafficability

To be determined.

Estimated Traverse Distance

Required Travel Distances	
Landing site to station 1: roundtrip	15 km
Landing site to station 2: roundtrip	13 km
Landing site to station 3:	81 km
Station 3 to station 4: (up-slope)	11 km
Station 4 to station 5: (down-slope)	26 km
Station 5 to station 6:	18 km
TOTAL	164 km

Site 019 NORTHERN ELYSIUM



ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

MTM 35212

⊗ Landing Site: 32.5° N Latitude, 212.5° W Longitude

Pete Mougins-Mark

Site 020 - Argyre Planitia

Site 020

Site Name: Argyre Planitia

Type of Site: Rover/Sample Return

Maps: MTM# -55044; MC-26 SW

Viking Orbiter Images: 567B53

Date Entered: 22 September 1988

Date Last Revised: 22 September 1988

Latitude: 55°S

Longitude: 42°W

Elevation: + 1 km

Contact:

Timothy Parker
Jet Propulsion Laboratory
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Geologic Setting

The landing site lies in Argyre Planitia, one of the largest and best preserved ancient impact basins. Surrounded by rugged massifs which form vague, concentric and radial patterns around the basin. The original basin floor is buried and no inner rings are visible.

Scientific Rationale

Sample layered basin-fill material of possible lacustrine origin (search for fossil organic material), unusual sinuous ridges, and possible deep crustal material in basin rim massifs.

Objectives

- a) Layered plains material (success high: landing site on plains; distance to deflated exposures may be small);
- b) sinuous ridge material (success high: landing site near prominent ridge; traverse to massif crosses ridge);

- c) massifs (2): possible deep crustal material (success moderate: depends on steepness of approach to "fresh" rock at base of each massif).

Potential Problems

Site is at a moderately high southern latitude, placing delta vee and communication link constraints on all component vehicles. Southern approach for lander and ascent vehicles may require consideration of avoidance of high south basin rim mountains.

Trafficability

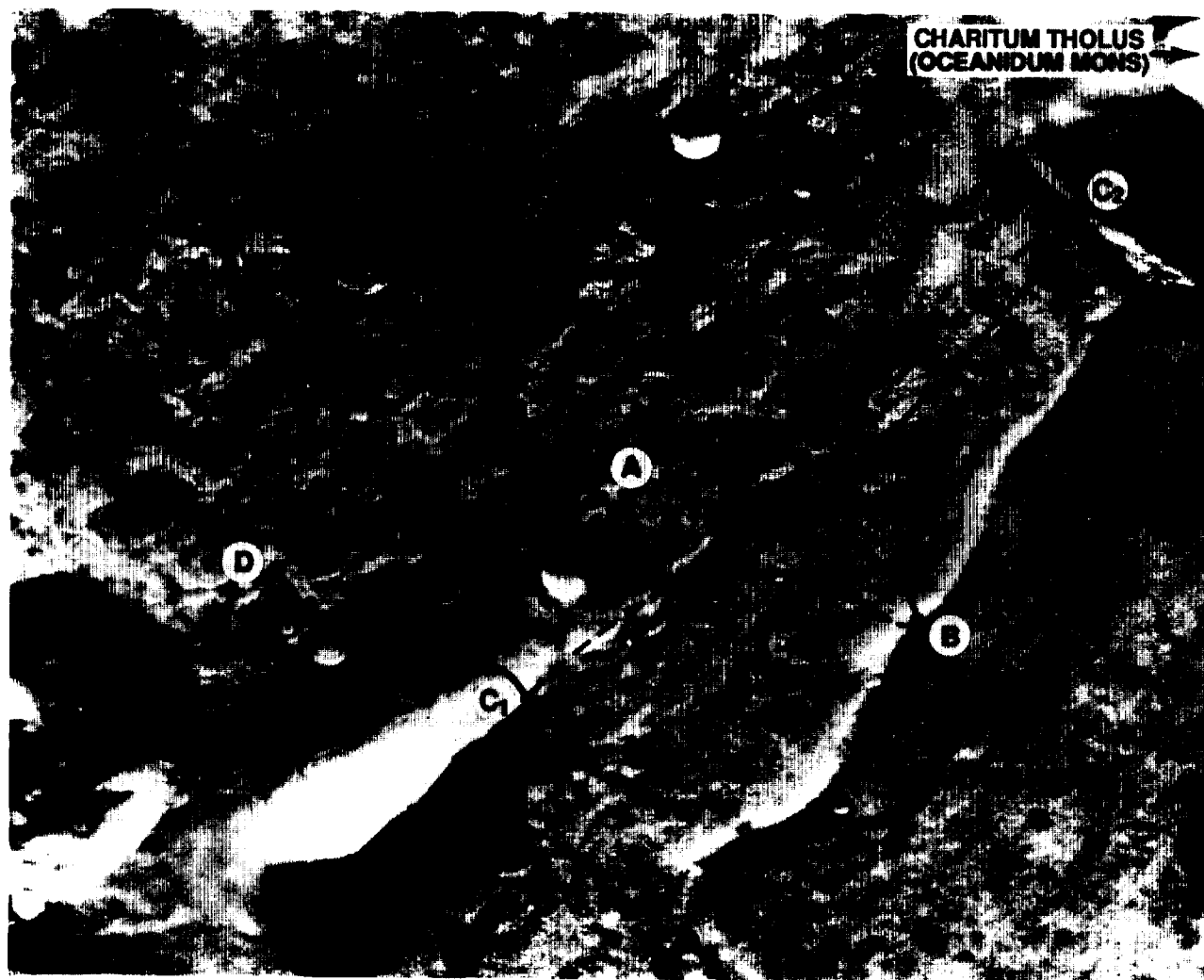
To be determined.

Estimated Traverse Distance

To be determined.

Site 020 ARGYRE PLANITIA

42° W



CHARITUM THOLUS
(OCEANDUM MONS)

55.5° S



55.5° S

42° W

20 km

50 ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Site 021 - Maja Valles

Site 021

Site Name: Maja Valles

Type of Site: Rover/Sample Return

Latitude: 18.95°N

Longitude: 53.50°W

Elevation: - 0.5 km

Maps: MTM#20052; MC-10 NE

Viking Orbiter Images: 825A25,
825A27, 825A46, 825A48

Date Entered: 22 September 1988

Date Last Revised: 22 September 1988

Contact:

Jim Rice

Department of Geology

Arizona State University

Tempe, Arizona 85287-1404

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Geologic Setting

Maja Valles are northeast-trending outflow channels deeply incised into old cratered terrain between Lunae Planum and Chryse Planitia. To the south of Maja Valles is Valles Marineris.

Scientific Rationale

To obtain data/samples on channel morphology, outflow dynamics, stratigraphy of fan-delta complexes at the mouths of Maja, Maumee, and Vedra Valles. Also of interest: origin of streamlined islands and wrinkle ridges; oldest mappable rock unit (Nb) on Mars and the extensive ridged plains unit (Hr) are also contained in this site.

Objectives

- a) Gravels/sediment from channels (success excellent); fan-delta sediments (success excellent); lake deposits (success average);
- b) ancient crustal material (Nb) (success above average); modified basal unit of Hesperian System (Hr) (success excellent); *in situ* wrinkle ridge and island (success excellent);

- c) crater ejecta (small craters) (success excellent); exposed strata along channel walls (success average); atmospheric sample (success excellent);
- d) exobiology (extinct) (success below average); exobiology (extant) (success remote); ground ice (success remote).

Potential Problems

Obvious malfunction of mechanical components, accuracy of landing ellipse, patches of very rough terrain, rover traverse distance, and curation of samples containing volatiles and any exobiology if present.

Trafficability

To be determined.

Estimated Traverse Distance

SOLID TRAVERSE is for separate rover/sample return vehicles which requires rover to return to sample return orbital module (traverse distance = 100 km).

DASHED TRAVERSE is for a combined rover/sample return vehicle which allows

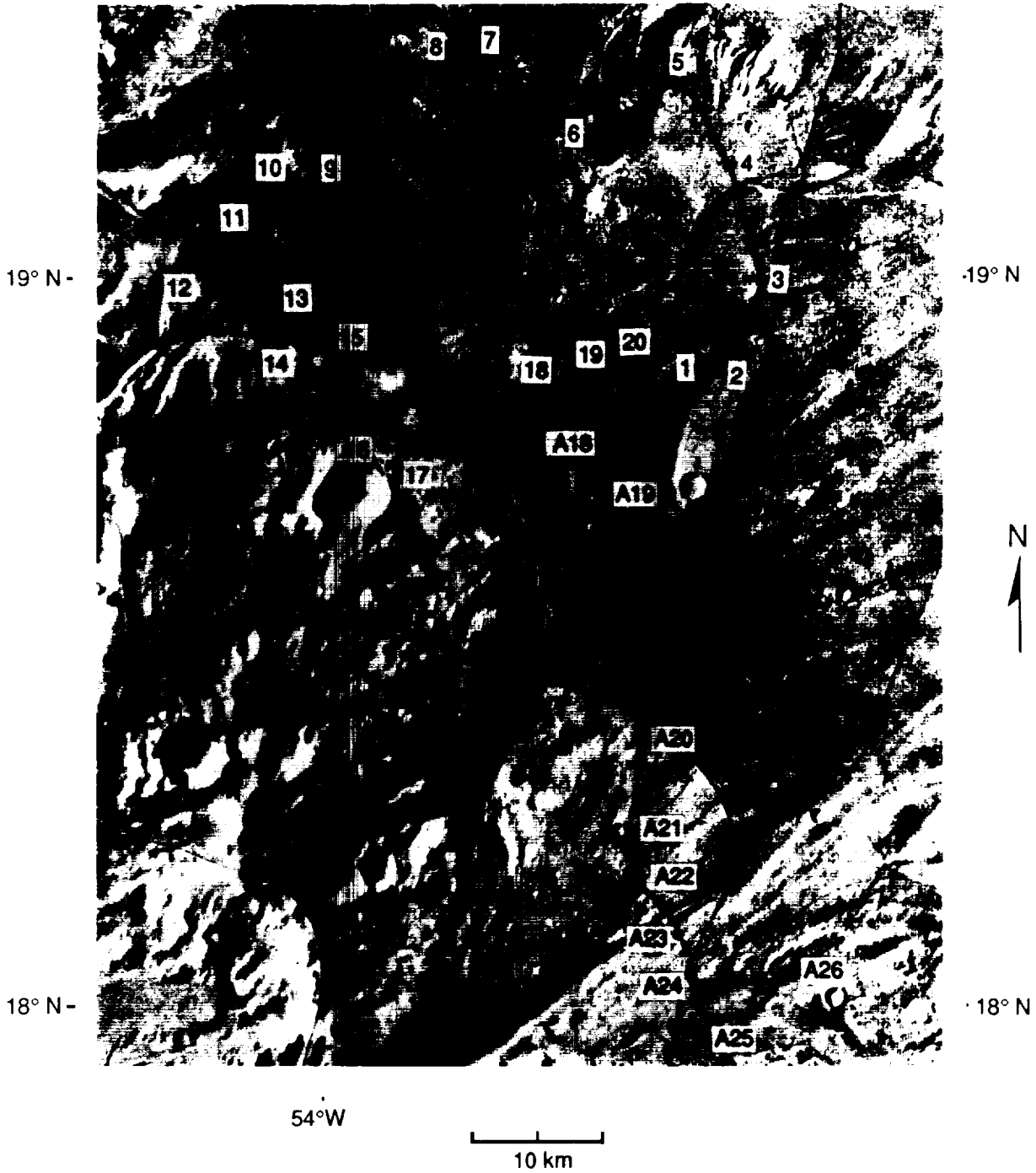
more terrain to be covered and does not require returning to landing site (traverse distance = 100 km; with touchdown point at station 9 on solid).

MAJA VALLES SITE: POSSIBLE SAMPLES
(Keyed to map of site)

<u>STATION NUMBER</u>	<u>DESCRIPTION</u>	<u>STATION NUMBER</u>	<u>DESCRIPTION</u>
1	Lake deposits and or Maja Valles fan delta sediments	17	Nb material and ejecta from large crater
2	Streamlined island material near tail	18	Wrinkle ridge material that may be buried crater rim crest
3	Wrinkle ridge material	19	Wrinkle ridge material from buried crater rim
4	Maja fan delta sediments and modified Hr material	20	Lake deposits and/or crater infill material
5	Streamlined island material	A18	Channel sediments and/or lake deposits
6	Margin of Maja and Vedra fan delta deposits	A19	Streamlined island material near prow and small crater ejecta at lower left of island
7	Vedra fan delta sediments and outflow channel deposits	A20	Major outflow material from Maja
8	Outflow channel deposits and possible lake sediments	A21	Crater ejecta
9	Margin of Vedra and Maumee fan delta deposits	A22	Plunge pool material possibly scoured bedrock
10	Maumee fan delta deposits	A23	Crater ejecta and channel material
11	Crater ejecta from small impact and Vedra sediments	A24	Maja fan delta sediment and channel margin material
12	Ancient crustal material (Nb) and crater lake outflow sediments	A25	Subsequent secondary channel material
13	Margin of Maja and Maumee fan delta deposits	A26	Streamlined island material (immature) and channel plains material
14	Nb Material		
15	Crater ejecta of small impact		
16	Nb material and ejecta from large crater		

Site 021 MAJA VALLES

54° W



MTM 20052

⊗ Landing Site: 18.95° N Latitude, 53.50° W Longitude Jim Rice

Site 022 - Candor Mensa

Site 022

Site Name: Candor Mensa
Type of Site: Rover/Sample Return

Latitude: 5.5°S
Longitude: 74.5°W
Elevation: + 1 km

Maps: MTM# -5072

Viking Orbiter Images: 915A12

Date Entered: 6 September 1988
Date Last Revised: 6 September 1988

Contact:

Baerbel Lucchitta
U.S. Geological Survey
2255 N. Gemini Dr.
Flagstaff, AZ 86001
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Geologic Setting

The landing site is located on Candor Mensa, a mesa in Candor Chasma, which is an east-west trending trough associated with Valles Marineris. Valles Marineris, known as canyonlands, is made up of grabens, canyons, pit craters and channels. The canyon walls exhibit horizontal layering.

Scientific Rationale

Nearby rocks have range of ages and compositions, from very old to very young. Potential to find lake beds (carbonates?) in layered interior deposits. Potential to find very young volcanic deposits. Exciting site for human exploration.

Objectives

- Nature of crustal composition up to 6 km below surface; ancient rocks (success good; reworked in landslide; outcrop of more difficult access);
- nature of layered deposits; volcanic? sedimentary? fossils? (success good; rocks in place; accessible);
- young rocks (post-landsliding); volcanic? ashflow tuffs? felsic? (success good; rocks in place; accessible);

- cap rock of Lunae Planum Plateau; basaltic? sedimentary? (success marginal; reworked in landslide);
- landslide processes: dry? contained water or ice? important for wall-rock composition (success marginal).

VALLES MARINERIS, MARS: AN OPTIMUM SCIENCE-SAMPLE SITE

B.K. Lucchitta, U.S. Geological Survey,
Flagstaff, Ariz. 86001

The Valles Marineris troughs offer a unique sampling opportunity because they expose a thickness of upper crustal rocks as great as 7 km. Also, because of their long and varied history, the troughs give insights into a number of processes that are critical to deciphering the history of Mars.

Ideal sample sites on Mars would yield information on rocks in close proximity having a range of ages and compositions. The Valles Marineris fulfill these requirements. Very old units of Noachian age (Scott and Tanaka, in press) are exposed in the lower walls that would give us data on compositions and ages of rocks that are deep below the surface at most other places. The

most commonly accepted hypothesis is that these rocks are lunar highlands-type breccia (Carr, 1979). The landslides of the Valles Marineris, also, furnish excellent sites to sample these ancient rocks, because the slides fell from trough walls and thus incorporated wall rock. Additionally, most landslide materials contain some cap rock of the plateau, thus offering an opportunity to sample material of intermediate age (Early Hesperian) (1). The cap rock is commonly interpreted as flood basalts (Scott and Carr, 1978), but other compositions cannot be excluded. Younger intermediate-age rocks (Later Hesperian) (Scott and Tanaka, in press) form part of the layered interior deposits. Their origin is uncertain; they have been considered to be volcanic flows, fluvial deposits (Lucchitta, 1982), or wind drifts trapped in ice-covered lakes (Nedell et al., 1987). Samples of these rocks would illuminate an important segment of martian mid-history and shed light not only on the composition of these materials but also on the processes that operated at that time.

A second suite of interior deposits occurs on the Valles Marineris floors, resting unconformably on all other units and reaching thicknesses of as much as 3,000 m in western Candor Chasma (Lucchitta, 1985). These rocks are young, of Late Amazonian age, and are most likely of volcanic origin. They are locally composed of very dark materials that are easily reworked by the wind and may have come from young volcanic vents (Lucchitta, 1987). Elsewhere these deposits are of varied albedo and rugged, and they may be composed of volcanic rock of unknown composition. Sampling these rocks and obtaining their precise compositions and ages would be an important contribution to unraveling the thermal evolution of Mars.

Samples from the Valles Marineris would also give insights into a number of martian processes. The effects of tectonism could be assessed by sampling materials on both sides of the young faults that cut the trough floors.

Mass-wasting processes resulted in talus slopes and landslides. Whether the landslides were wet or dry is not entirely resolved; this question could be addressed by sampling the matrix of landslide deposits. Furthermore, a large channel appears to have emerged from one of the slides and caused a catastrophic flood (Lucchitta, in press); sampling of the channel-floor material might confirm this origin. The composition of the channel material may also establish whether ice was involved in the flooding. Water or ice in the channel must have come from the trough walls, and the discovery that either was present would confirm the existence of the hypothetical ground-ice reservoir on Mars.

Wind deposits are abundant on the channel floors. Dark barchan dunes consist of reworked dark material that appears to have come from volcanic vents in the troughs; samples of this material would give compositions and ages, and thus they might confirm the existence of such vents. Establishing grain sizes of the dune material would also shed light on the mechanism of emplacement and, by analogy, on the origin of many similar dunes elsewhere on Mars, particularly those trapped inside craters. Light-colored, reddish dust from atmospheric fallout is also abundant in the troughs and might be sampled to obtain its composition, thus resolving the controversy of whether dust-storm material is composed of smectite clay (Clark, 1978) or palagonite (Singer, 1982).

Overall, the Valles Marineris offer an opportunity to sample rocks that reflect various ages and compositions, giving insight into important processes on Mars. Most of the samples would be located within reasonable proximity and could be easily reached by rovers or balloons. Although landing a spacecraft on the floor of the Valles Marineris may be too dangerous for the first sample-return mission to Mars, the scientific rewards would be so great that such a landing should be considered for later flights.

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Potential Problems

Steep cliffs to north and east; sampled rocks cannot be tied to cratering chronology.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 022 CANDOR MENSA



MTM -05072

⊗ Landing Site: 5.5° S Latitude, 74.5° W Longitude

Baerbel Lucchitta

Site 023 - Memnonia

Site 023

Site Name: Memnonia

Type of Site: Rover/Sample Return

Maps: MTM# -10172; MC-16 NW
(I-1188)

Viking Orbiter Images: 599A95,
599A97, 440S05

Date Entered: 6 September 1988

Date Last Revised: 6 September 1988

Latitude: 11°S

Longitude: 173°W

Elevation: + 1 km

Contact:

David Scott

U.S. Geological Survey

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Flagstaff, AZ 86001

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Geologic Setting

The Memnonia site is in a valley between the northern lowland plains and southern highlands. The landing area is on ridged plains lava flows, a globally extensive rock unit of intermediate (Hesperian) age. The ridged plains are overlain to the north by very young (Amazonian) rocks postulated to be ash-flow tuffs (Scott and Tanaka, 1982, 1986) or paleopolar deposits (Schultz and Lutz, 1988). On the south side of the valley the ridged plains embay ancient (Noachian) cratered highlands. A small young channel of unknown origin is close (6 km) to the landing site. Viking images (~50 m/pxl) indicate the area is relatively smooth and free of obstacles.

Scientific Rationale

In situ rock outcrops of young (Amazonian), intermediate (Hesperian), and ancient (Noachian) ages occur within about 0-15 km from the landing site. Young stream channel deposits and layered material in the channel gorge could also be sampled. Ridged plains lava flows of Hesperian age are considered to be the most important rock units for deter-

mining the absolute age of the bend in the martian cratering rate curve where the rapidly decaying early flux changes to a nearly constant rate (Neukum, 1987). Together with Amazonian and Noachian rock samples they would provide data on the composition and radiometric ages for major rock units on Mars.

Objectives

Primary sample locations (fig. 1) are numbered in table 1; targets of opportunity that might be sampled enroute are indicated by letters. The landing and ascent sites are assumed to be the same or close together.

Summary of objectives:

- a) Rocks of intermediate age (Hesperian) at landing site (success excellent);
- b) possible pyroclastic rocks of very young age (Amazonian) near (~15 km) landing site (success very good);
- c) ancient rocks (Noachian) near (5-15 km) landing site (success very good);
- d) fluvial materials and young outflow channel near (6 km) landing site (success excellent).

Potential Problems

Stream channel and floodplain deposits including large rocks may be more extensive than presently apparent—need much higher resolution images than 40 m/pxl.

Trafficability

Appears good at image resolution.

Estimated Traverse Distance

- 1) 35 km
- 2) 40 km
- Total 75 km

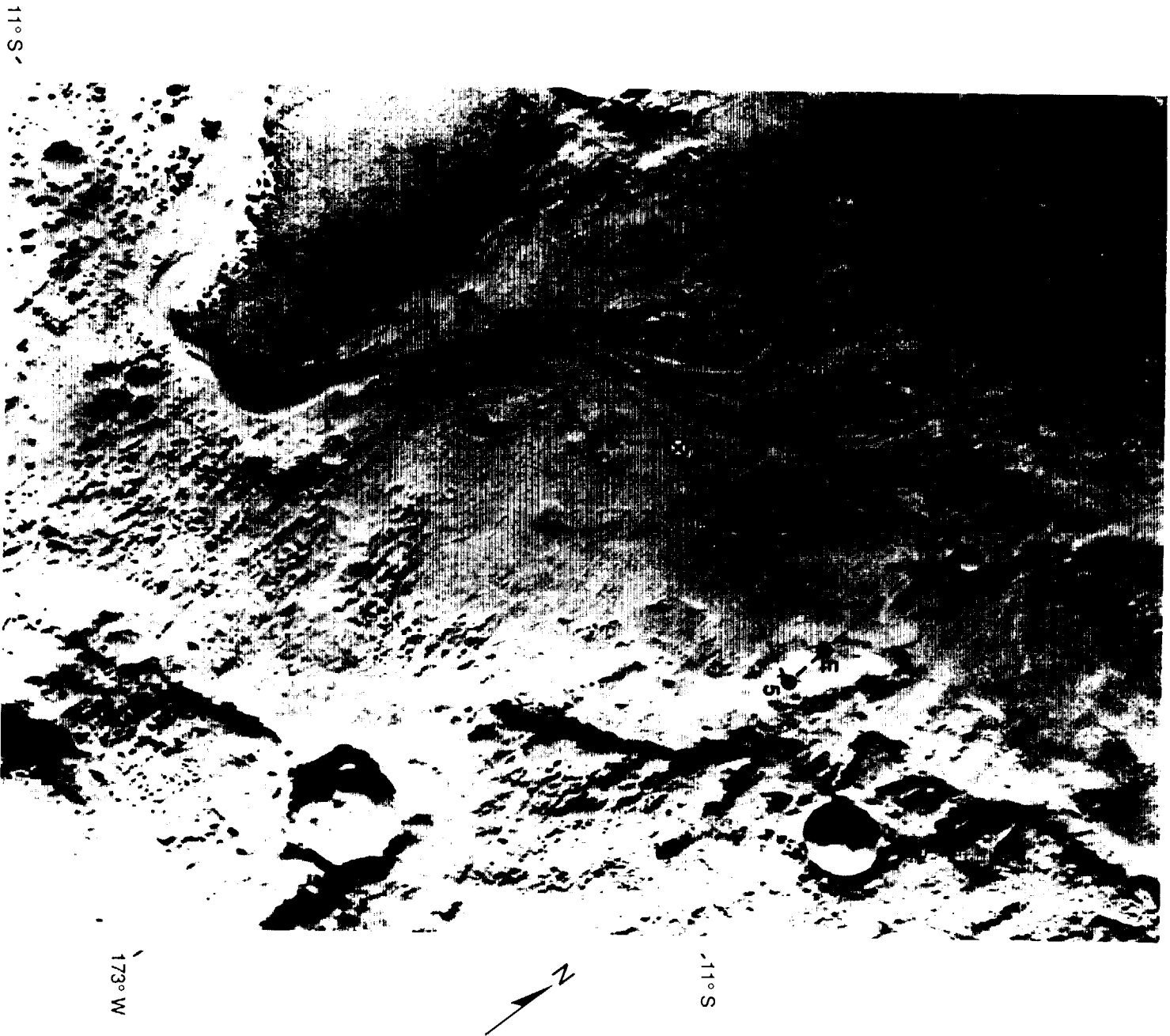
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Table 1. Materials to be sampled on proposed landing site traverses at primary sample stations (numbers) and secondary targets of opportunity (letters). Landing site (LS) and traverses shown in the site figure.

Station/Target	Estimated minimum traverse distance from LS (km)	Sample description and geologic significance
1 (LS)	0	Basalt flows of intermediate age (unit Hr); widespread occurrences; globally correlative geologically and by crater counts.
A	6	Channel material (unit Ach) in bar or island remnant; TV scan for layering, sorting, size distribution.
B	13	Knobby material (unit Nk).
2	16	Member 2 (unit Am ₂) of Medusae Fossae Formation (young ash flow?); TV scan to determine nature of contact with adjacent basalt flows (unit Hr) and knobby material (unit Nk).
3	21	Channel gorge cutting possible layered basalt flows (unit Hr) and older rocks.
C	26	Samples and TV scan along channel from station 3 to C to observe possible layering of basalt flows in channel wall.
4	32	Ejecta and rim material around 500-m-diameter crater in ridged plains unit.
1 (LS)	35	Completion of first traverse.
D	5	Ejecta and rim material around 600-m-diameter crater in ridged plains unit.
5	14	Rim of Noachian (c ₁) crater.
E	16	Ridged plains/c ₁ contact from station 5 to E.
6	23	Wrinkle ridge in ridged plains unit; TV observation of ridge structure.
7	25	Ejecta and rim material from young crater (1,500 m in diameter) in ridged plains unit.
8	29	Fresh crater (300 m in diameter) superposed on channel material and on basalt of ridged plains unit.
F	31	Channel material.
1 (LS)	40	Completion of second traverse.
	75 km	Total distance of two traverses.

Site 023 MEMNONIA
173° W



Viking Orbiter
440S05

⊗ Landing Site: 10° S Latitude, 173° W Longitude

David Scott

25 km

60

APR 1976
BLACK AND WHITE PHOTOGRAPH

Site 024 - Mouth of Maja Valles

Site 024

Site Name: Mouth of Maja Valles
Type of Site: Rover/Sample Return

Latitude: 17.9°N
Longitude: 53.8°W
Elevation: - 0.5 km

Maps: MTM#20052; MC-10 NE

Viking Orbiter Images: 825A27,
825A29, 825A46, 825A48

Date Entered: 6 September 1988
Date Last Revised: 6 September 1988

Contact:

Rene DeHon
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Northeast Louisiana University
Monroe, LA 71203
(318) 342-2188

Geologic Setting

The surface characteristics vary from smooth to rough at meter scale. The material at landing site consists of alluvial materials with possible eolian cover. Landing site is on the head of an alluvial fan at mouth of a gorge. The basement material is Noachian material of the Xanthe Terra highlands and ridged plains of Chryse Planitia. Once a site of pronounced erosion, the site was later subjected to deposition by waning flood waters. The local relief is probably dominated by late stage gullying in alluvial materials; hence, it may be both a bouldery and channelled surface. It may be blanketed with later eolian material. Ridged plains materials are probably not exposed in the immediate vicinity.

Scientific Rationale

To be determined.

Objectives

1 km traverse: Would allow sampling materials of the fan. If an eolian cover is not present, a traverse would be able to examine

the local vicinity for fan dissection. The possibility exists that this region is a wind gap of higher wind velocity and that the area is swept clear of eolian debris. Bedding in the fan could reveal part of the flow history in Maja. Sampling of fan sediments would provide materials for analysis from the canyon section of Maja. It is doubtful that material from beyond Xanthe Terra would be present.

5 km traverse: Would place a rover at the nearest edge of the gorge with the possibility of sampling the oldest rocks (Noachian basement materials) either in place or as colluvial material not far removed from its source.

10 km traverse: To the west would allow inspection of the north wall of the gorge and dissected Noachian materials. A traverse to the southern wall would allow inspection of the tributary/distributary gorge on the south wall.

25 km traverse: Up the canyon (west) would allow inspection of the wall of the canyon (Noachian materials), sediments in smooth deposits of the floor, and possible bedrock

materials in hummocky floor material. Alternately, the traverse could proceed eastward onto the fan proper.

50 km traverse: Covering a larger area would offer little new. If the rover moved westward, it would essentially be trapped within the canyon and not be able to explore the plains on either side. If the rover moved eastward, the most common terrain would be materials of the alluvial fan/delta.

Comments: Ambitious in terms of safety, with all the good and bad points of working

a fan/delta type deposit. An on-board seismic experiment could investigate the Xanthe Terra/Chryse Planitia boundary and/or the fan configuration.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

1-50 km

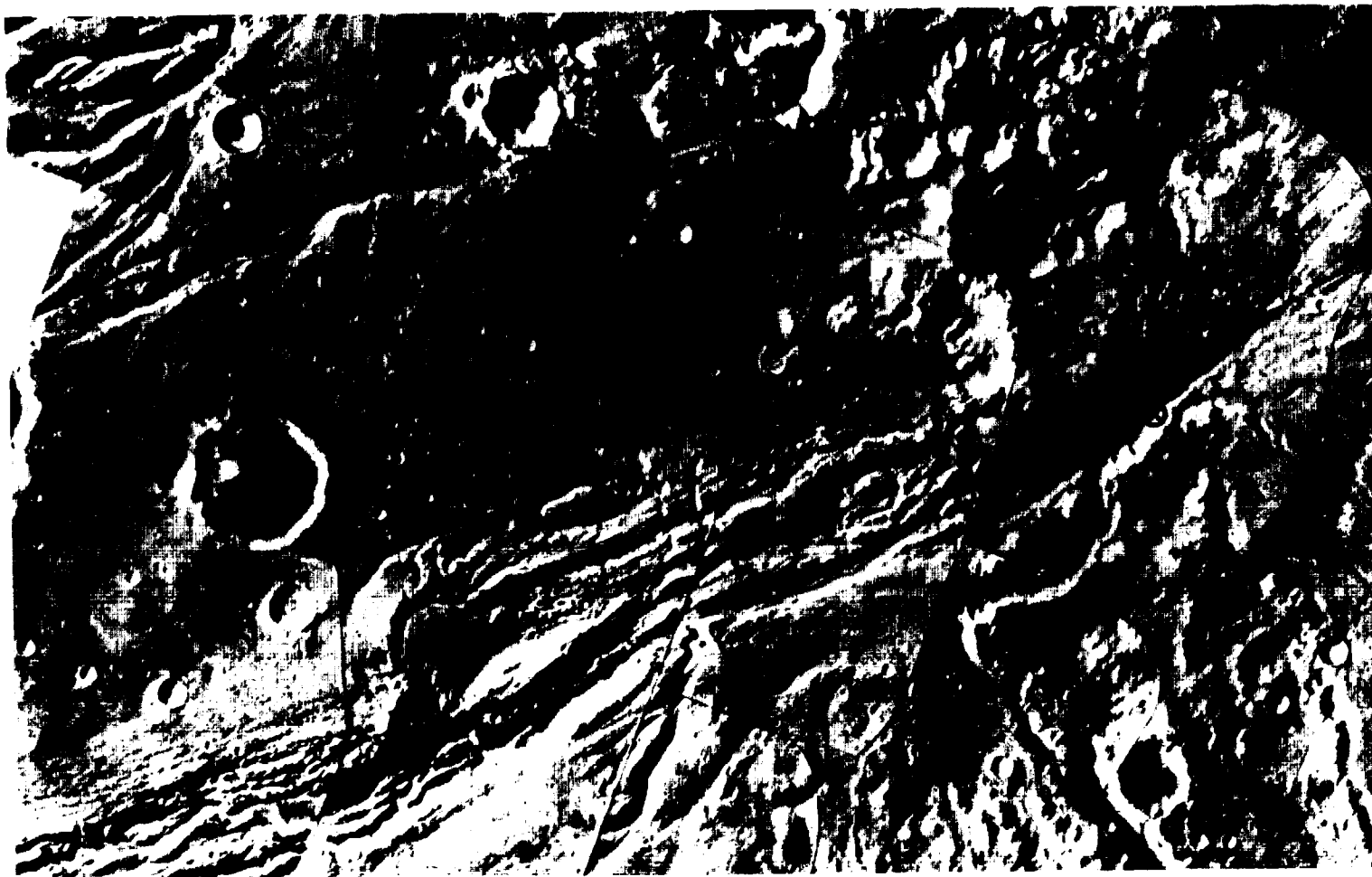
Site 024 MOUTH OF MAJA VALLES

55° W

53.5° W

18.5° N -

-18.5° N



63

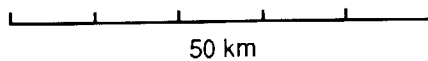


17.5° N -

-17.5° N

55° W

53.5° W



ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

MTM -20052

⊗ Landing Site: 17.9° N Latitude, 53.8° W Longitude

Rene De Hon

Site 025-Maja Valles Canyon Flood Plain

Site 025

Site Name: Maja Valles Canyon Flood Plain

Type of Site: Rover/Sample Return

Maps: MTM#20052; MC-10 NE

Viking Orbiter Images: 825A25, 825A27, 825A46, 825A48

Date Entered: 6 September 1988

Date Last Revised: 6 September 1988

Latitude: 17.65°N

Longitude: 54.2 - 54.3°W

Elevation: - 0.5 km

Contact:

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Geologic Setting

Lacustrine materials (possible eolian cover). Relatively flat plain on the south side of Maja Valles. The site was a region of deposition during ponding of Maja waters prior to cutting through the highland barrier.

Scientific Rationale

This site offers a potentially safer landing site, but traverses would have to be a greater distance to areas of interest.

Objectives

The primary traverse would be eastward to the secondary channel that leads into the Maja proper. The sampling route would traverse probable lake sediments, crater ejecta, colluvium from the walls of the secondary

valley, materials on the floor of Maja proper, and colluvium from the high wall on the northern side of Maja.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

For minimum potential the rover would have to be capable of at least a 10 km traverse, and a 30-50 km capability would be most desirable. Safer than the primary site (site .024), the alternate site requires more stringent mobility requirements.

Site 025 MAJA VALLES CANYON FLOOD PLAIN

55° W

53.5° W

18° N -

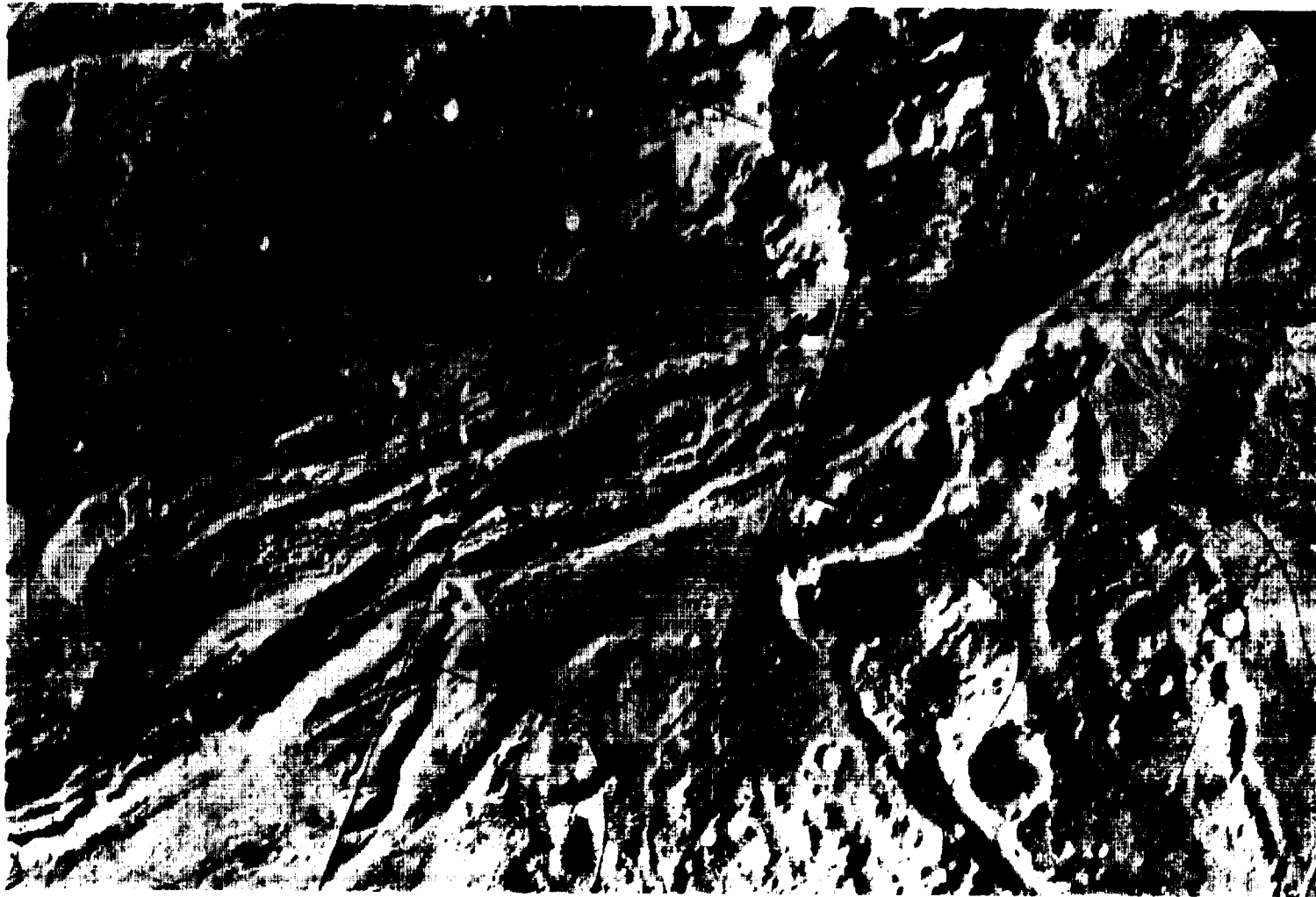
-18° N

65



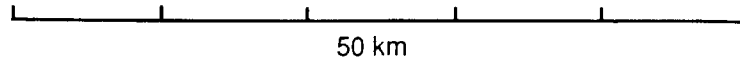
17.5° N -

-17.5° N



55° W

53.5° W



50 km

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MTM 20052

⊗ Landing Site: 17.65° N Latitude, 54.25° W Longitude

Rene De Hon

Site 026 - Upper Maja

Site 026

Site Name: Upper Maja
Type of Site: Rover/Sample Return

Latitude: 18.2°N
Longitude: 57°W
Elevation: + 0.5 km

Maps: MTM# 20057; MC-10 NE

Viking Orbiter Images: 825A26

Date Entered: 6 September 1988
Date Last Revised: 6 September 1988

Contact:

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Geologic Setting

Surface of Lunae Planum. This area was awash by the Maja outflow and probably held ponded waters. The area of the landing site is an undetermined thickness (but probably a thin cover) of alluvial and lacustrine sediment overlying ridged plains materials.

Scientific Rationale

Smooth plain, high density of small pits; smooth to moderately rough at meter scale; sampling of possible eolian cover; probable lacustrine sediments; basalts exposed as ejecta from small craters in the area.

Objectives

1-10 km traverse: A short traverse from a safe landing site will not provide much more than sampling of the plains materials and underlying Hesperian volcanics exposed as crater ejecta. Below the eolian cover, the sediments are derived from the full 1000 km reach of the upper Maja Valles section.

20-50 km traverse: Longer traverses allow the possibility of a greater diversity of materials. Traverses could reach fresh crater

ejecta to sample materials beneath the ridged plains materials; the Lunae Planum—Xanthe Terra boundary to sample Noachian cratered plateau material and/or Noachian basement materials; and the head of a channel entering Xanthe Terra to inspect channel materials and channel walls.

Comment: I would rate this as one of the safer landing sites—but not particularly interesting. Probability of eolian cover is high. A seismic experiment could investigate the thickness of eolian/lacustrine sediments and the thickness of ridged plains materials. With maximum range, and on-board seismics, the rover could enter one of the canyons and investigate the Lunae Planum/Xanthe Terra boundary structure.

Potential Problems

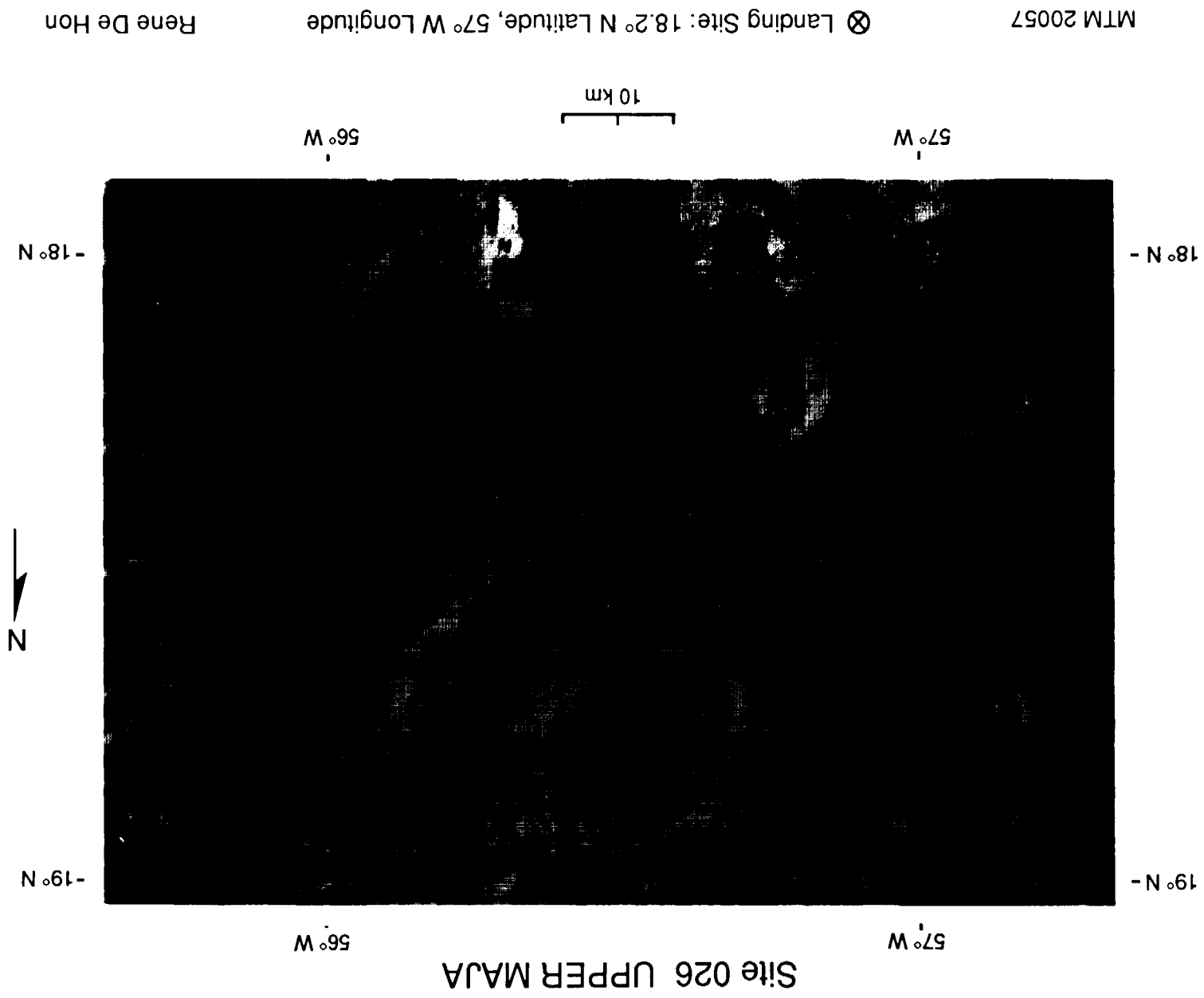
To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.



Site 027 - Upper Mangala Valles

Site 027

Site Name: Upper Mangala Valles
Type of Site: Rover/Sample Return

Latitude: 13.8°S; alternate 13.7°S
Longitude: 148.1°W; alternate 148.7°W
Elevation: + 3 km

Maps: MTM# - 15147; MC-16 NE
(I-1185)

Viking Orbiter Images: 639A12,
447S35

Date Entered: 6 September 1988
Date Last Revised: 3 July 1989

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Geologic Setting

Mangala Valles is an outflow channel which originates in a graben associated with Memnonia Fossae just south of the landing site. Landing site 027 is located west of the Tharsis Mountains and south of the highland-lowland border.

Scientific Rationale

Sample an extensive plains unit intimately related to flooding events in Mangala Valles, while providing access to other major geologic materials along relatively short traverses. The suite of samples could span much of the geologic history of the planet. Note: An extended roving mission could traverse down Mangala Valles.

Objectives

- a) Sample Hesperian-age plains that were either emplaced by floods in Mangala Valles, or modified by the floods (success very high. Target site is on this plains unit. 447S35 frame shows large areas that are featureless at 45 m/pxl (safe?);

- b) Noachian-age materials exposed along scarp at west base of prominent ridge (oldest material exposed in landing area) (success high. Location is ~18 km from landing site; trafficability should be good);
- c) Noachian-age cratered plains exposed northwest of landing site. Note: plains are superposed on Target 2 materials (north of site) (success high. Location is ~26 km from landing site; trafficability should be good);
- d) fresh-appearing crater ejecta. Target 4 is a rampart at distal edge of ejecta (related to volatiles?); Target 4' is lunar-like crater (success moderate. Crater ejecta may be very blocky, making travel difficult. However, the rampart may be very important for volatile-related questions).

Potential Problems

Lack of high resolution Viking images of proposed site (639A12 has 244 m/pxl resolution). 45 m/pxl images are available for adjacent areas (e.g. 447S35) so that an alternative site could be selected within the coverage of these images; unfortunately, a site

further west would lengthen the traverse distance to the Noachian materials (to ~50 km one way). Note: Good Earth-based radar data are available at latitude 14.46°S.

Trafficability

Good to excellent around landing site, moderate on Noachian materials, moderate to poor on crater ejecta.

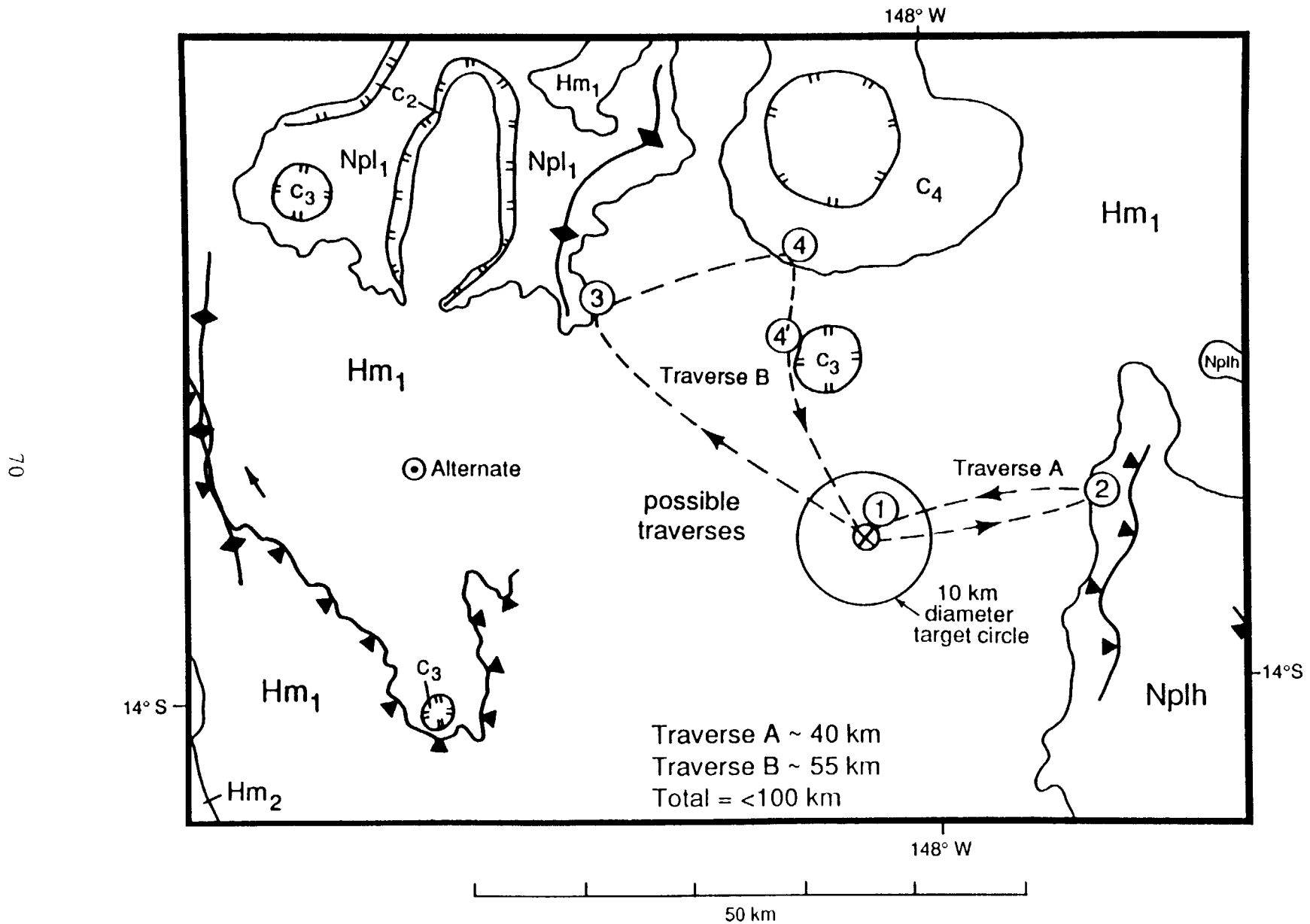
Estimated Traverse Distance

Prime site: <100 km total, two separate traverses (see figure).

Alternate site: ~100 km for all but Target 2 (Noachian) materials.

~160 km for all target sites in one long traverse.

Site 027 UPPER MANGALA VALLES



MTM -15147

⊗ Landing Site: 13.8° S Latitude, 148.1° W Longitude
 ⊙ Alternate Landing Site: 13.7° S Latitude, 148.7° W Longitude

James Zimbelman

Site 028 - Olympus Mons Southeast

Site 028

Site Name: Olympus Mons Southeast

Type of Site: Rover/Sample Return

Latitude: 14°N; alternate 13°N

Longitude: 131°W; alternate 125°W

Elevation: + 2.8 km

- Maps: a) MC-9 SW (I-1259)
and MC-9 NW (I-1261)
b) Controlled photomosaic of the
Olympus Mons region of Mars
(I-1379)
c) Geologic Maps: MC-9 SW
(I-1268) and MC-9 NW
(I-1266)

Contact:

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Viking Orbiter Images:

- 044B27 (resolution: 147 m/pxl)
045B61-68 (resolution: 146 m/pxl)
046B34-40 (resolution: 135 m/pxl)
890A34 (resolution: 162 m/pxl)

Date Entered: March 1989

Date Last Revised: March 1989

Geologic Setting

This site lies on young lava (basaltic?) plains on the southeastern margin of the shield volcano, Olympus Mons. It includes a variety of geologic units such as old fractured terrain, aureole deposits, and lava flows originating from Olympus Mons as well as flows from possible local fissures and vents.

Scientific Rationale

Principal sampling objective(s): Intermediate and young volcanic units, aureole deposits of Olympus Mons, terra material (fractured rough and smooth terrain), aeolian deposits.

Sampling rationale:

- a) *Plains material* (unit Aop): Young lava

flows (Amazonian age) possibly derived from fissures east of Olympus Mons. Youngest lava flows in region (and perhaps on Mars). Age determinations will provide calibration for young magmatic activity on Mars. Some flows exhibit mare ridges. There is controversy over the origin and age of these features (younger or same age as flows). Long-range transect crosses one set of mare ridges and possible source area.

Crater calibration: Total area of contiguous unit=420,000 km²; although it is composed of multiple flows probably erupted from multiple vents, it is a homogeneous unit at regional scale.

- b) *Olympus Mons post-scarp flows* (unit Aom₂): Youngest lava flows that were derived from flanks of Olympus Mons after formation of basal scarp. Age determinations will provide data for some of

the most recent volcanic activity on Mars. *Crater calibration:* Total surface area of the shield represented by this sample site=376,000 km².

- c) *Aureole deposits* (units AHoa₁ and AHoa₂): Highly fractured and dissected hilly terrain that is embayed by plains (lava?) material. Very extensive to north and west of Olympus Mons. Two units of apparently different ages mapped in area. Origins controversial, but may be derived from gravity spreading from older, “precursor” volcano to Olympus Mons, or from ash-flow deposits. Compositional determinations from samples will help to assign origin to these extensive units.

Crater calibration: AHoa₁=144,000 km², AHoa₂=62,000 km²; may be very difficult to obtain meaningful crater statistics for these units because they are highly fractured.

- d) *Terramaterial* (HNht): Mapped as single unit, but two units evident in area. Unit (a) consists of fractured and slumped blocks along eastern scarp of Olympus Mons; probably represents early shield-building materials. Unit (b) consists of extensive fissured and fractured plains material. Compositional data and age determinations will provide information on origins of these two units. In particular, determination of the age, origin, and composition of these units and comparison with the various aureole deposits may enable the controversy of the aureole material to be resolved.

Crater calibration: HNht=159,000 km²; also occurs as extensive unit to the east near Valles Marineris.

- e) *Surficial materials, including debris flows on marginal escarpment, and wind streaks on plains material:* Samples from these materials will provide important infor-

mation on contemporary geologic processes on Mars.

Potential Problems

Hazard Assessment

Principal hazards: Possible lava flow lobes on the plains; blocks and rubble downslope from or at the base of areas of high relief (e.g., aureole outcrops, the Olympus Mons scarp); fractures on the smooth lava flow surface; ridges on smooth lava flow surface.

The site is on a lava flow surface which appears to be generally flat and of intermediate-to-young age. Lavas are inferred to have erupted from vents on ESE base of Olympus Mons scarp (Scott and Tanaka, 1986) and flowed from there northward and southward around the base of the Olympus scarp to embay surrounding aureole deposits and to truncate flows from the Olympus summit which have flowed over the scarp. Flow features are found near the inferred vent area (ESE side), and include ridges and apparent tensional fractures, possible collapsed tubes or fractures, flow lobes, and possible glassy remnants of gaseous lavas (e.g. cavernous, “shelly” pahoehoe). Aeolian mantling is evident in many areas.

Objectives

Landing Sites

Option A: Short range (Lander and Rover at same site) 100 km traverse.

Location: 14° 10' N; 131° 50' W.

Geologic units:

Olympus Plains material (Aop): overlapping smooth lava flows.

Olympus Mons post-scarp flows (Aom₂): multiple lava flows of Olympus Mons shield volcano.

Presumed terra material (early-stage shield-building material exposed in scarps): Unit a, slumped blocks from marginal escarpment of Olympus Mons (HNht_a).

Sequence of operations:

1. Lander (L) and Rover (R) land on plains close to base of Olympus Mons scarp. Obtain samples of “fresh” younger lava flows with source away from Olympus Mons (sample S-1) for radiometric age determinations and correlation with crater count ages; also sample weathered flow surfaces (S-2); and soil (S-3) at lander site. Excellent probability of sampling success.
2. Traverse A: Deploy Rover to obtain samples of fresh (sample S-4) and weathered (sample S-5) basalts from lava flows that originate on Olympus Mons shield and flow across marginal escarpment. Good probability of sampling success at flow margins. Rover returns samples to Lander.
3. Traverse B: Deploy Rover to obtain samples of *in situ* material (sample S-6) and talus material (sample S-7) from scarp zone on southeast margin of shield; will provide samples of older terra material. Good probability of sampling terra material. As in other localities along the scarp zone, it may be difficult to assign a context to talus material, which could have been derived from the Olympus Mons shield, the terra material of the scarp zone, or post-scarp flows or plains material at the base of the scarp. Rover returns samples to Lander.
4. Traverse C: Deploy Rover to obtain samples of lava flows on plains adjacent to shield (sample S-8). Additional samples of plains unit for comparison

with younger flows. Good probability of sampling success. Rover returns samples to Lander.

Option B: Long Range: Traverse by Rover from Lander (L) to Ascent vehicle (A). Approximate traverse length is 500 km.

Geologic Units:

- Aureole members 1 and 2 (AHoa_{1,2}): dissected material of uncertain origins. Possible landslide material or ash flow tuff.
- Plains material (Aop): overlapping smooth lava flows.
- Shield member (Aos): multiple lava flows of Olympus Mons shield volcano. Includes pre-scarp flows (Aom₁) and post-scarp flows (Aom₂).
- Older fractured material: embayed and fractured materials (HNht_{a,b}).
- Aeolian material (bright streaks).

Sequence of operations:

1. Ascent vehicle (A) lands on plains close to margin of Olympus Mons shield. Obtains sample of fresh (sample L-1) and weathered basalt (sample L-2) at landing site for radiometric age determinations and correlation with crater count ages of plains member (Aop). High probability of sampling success.
2. Rover (R) lands 450 km to east-southeast on plains material (Aop) close to contact with terra material. Rover is deployed and collects sample of fresh and weathered plains material (samples L-3,4). High probability of sampling success.
3. Rover moves northeast across plains unit to terra material. Samples this unit (sample L-5). Samples required for radiometric age determinations and correlation with crater count ages. As

- this material is old and heavily cratered, it may have a thick regolith; thus, obtaining a fresh sample may be difficult. The probability of obtaining a good sample will be enhanced by sampling a graben wall.
4. Rover turns to move west-northwest, recrosses plains material to aureole material. Crosses low albedo zone where aeolian or weathered material may be absent. Samples plains material (sample L-6). The probability of successfully sampling this material is enhanced by the probable absence of surficial materials. Collects samples of aureole material (AHoa₁) from outliers of aureole deposits (sample L-7) for compositional and possible radiometric age determinations. It may be difficult to obtain a fresh sample of aureole materials. These materials may be weathered, and their dissected nature suggests that talus may be abundant. If the aureole materials are ash flows, then obtaining radiometric ages may be difficult.
 5. Rover proceeds northwest across plains unit. Samples fresh and weathered plains member at three locations (samples L-8,11) to determine compositional and possible age differences between basalt flows of plains member. High probability of successfully sampling plains material. Samples L-9,10 from fractured area; flow lobes are visible. Possible local sources of lavas of plains member. Near-vent location may give rise to occurrence of shelly pahoehoe, with attendant trafficability hazards. In addition, lavas extruded may be glassy in texture, leading to problems with age and compositional determinations.
 6. Rover proceeds to sample outliers of aureole unit (AHoa₂) (sample L-14). Information from these samples will facilitate age and compositional comparisons between geographically separated outcrops of the aureole unit. However, it may be difficult to obtain a fresh sample of aureole materials. These materials may be weathered, and their dissected nature suggests that talus may be abundant. If the aureole materials are ash flows, then obtaining radiometric ages may be difficult. Adjacent to aureole deposits, Rover samples the bright aeolian material to south of outcrops (samples L-12,13). If high albedo materials on Mars are dust, then there is an excellent opportunity to sample windblown material at this location.
 7. Rover travels southwest across plains material (sample L-15) to base of scarp of Olympus Mons shield. Good probability of sampling success from plains material. Rover obtains sample of lobate unit at base of scarp. This unit is a possible post-scarp lava flow (sample L-16). Good possibility of sampling success at flow margin. Rover then obtains samples of *in situ* material (sample L-17) and talus (sample L-18) from fractured terra material (HNht₁) exposed in scarp on southeast margin of shield. However, the presence of post-scarp lava flows in this area may prevent access to *in situ* terra material. Also samples lobate material that may be debris cone or post-scarp lava flow (sample L-19). Good probability of sampling this unit, the origin of which is uncertain. As in other localities along the scarp, it may be difficult to assign a context to talus material, which could have been derived from the Olympus Mons shield, the terra material of the scarp zone, or post-scarp flows or plains material at the base of the scarp.
 8. Rover continues south along base of scarp on lava plains. Rover samples *in situ* material (sample L-20) and talus

(sample L-21) from fractured terra material (HNht₁) exposed in scarp on southeast margin of shield. Good probability of sampling terra material. As in other localities along the scarp, it may be difficult to assign a context to talus material, which could have been derived from the Olympus Mons shield, the terra material of the scarp zone, or post-scarp flows or plains material at the base of the scarp.

9. Rover diverges to southeast across lava plains. Additional sample obtained of this unit (sample L-22). Good probability of sampling success. Rover reaches ridge that may be fissure vent and collects sample from end of ridge (sample L-23). It may be very difficult to obtain a good sample of the ridge material, as talus mantling the end of the ridge may restrict access to fresh samples.
10. Rover continues southwest along base of scarp. Collects samples of talus (sample L-24), and resamples fractured material at southwest end of exposure (samples L-25,26). Good probability of sampling terra material. As in other localities along the scarp zone, it may be difficult to assign a context to talus material, which could have been derived from the Olympus Mons shield, the terra material of the scarp zone, or post-scarp flows or plains material at the base of the scarp.
11. Rover reaches site of ascent vehicle (L) and unloads samples collected.
12. Rover proceeds on loop traverse to obtain samples of fresh (sample L-27) and weathered (L-28) basalts from lava flows that originate on Olympus Mons shield and flow across scarp (post-scarp

flows, Aom₂). Excellent probability of sampling success at flow margins. Rover returns samples to ascent vehicle.

13. Ascent vehicle returns samples to Earth.

DESCRIPTION OF UNITS ON ACCOMPANYING GEOLOGIC MAP

Aop Olympus Plains Flows - Embays basal scarp of Olympus Mons and overlaps post-scarp flows, mottled albedo.

Interpretation: Lava flows from most recent fissure eruptions southeast of Olympus Mons.

Aom₂ Olympus Mons Post-scarp Flows - Lava flows form complex, finely textured, interfingering tongues and lobes, mottled albedo.

Interpretation: Lava flows from crest and flanks of Olympus Mons, after formation of basal scarp.

AHoa₂ Olympus Mons Aureole, Unit 2 - Islands of hilly material embayed with Aop.

Interpretation: formed by gravity spreading of materials from an earlier, larger Olympus Mons; alternatively, ash or lava flows.

AHoa₁ Olympus Mons Aureole, Unit 1 - Hilly material with corrugated surface cut by numerous faults and fractures. Embayed with Aop.

Interpretation: Similar to AHoa₂, but formed at an earlier time.

HNht₁ Terra Material, Undivided - both rough and smooth; fractured, faulted, and cratered material, numerous blocks and slump features along base of Olympus Mons.

Interpretation: Gravity slides along base of Olympus Mons.

Appendix: Science Rationale for study of aureole deposits

Among the more enigmatic features observed on the surface of Mars are the aureole deposits concentrated around the base of Olympus Mons. These features consist of large patches of rough, irregular terrain, presenting in many cases a lobate boundary. The terrain is characterized by numerous mounds of material, dissected in radial and circumferential patterns by narrow ridges and grooves. The origin(s) of these features are not known, although numerous theories and models have been proposed. These theories can be broadly categorized into two groups, magmatic and tectonic/mass-wasting. We first review the magmatic models.

King and Riehle (1974) envision a period of pyroclastic volcanism at Olympus Mons, during which ash deposits are carried long distances from the shield and emplaced as *nuees ardentes*. This friable ash is eroded by wind and compacted. The aureoles are the erosional remnants of these deposits. Samples of aureole material formed by this mechanism would be composed of tuff and compacted ash.

A similar model of aureoles resulting directly from volcanic emplacement is presented by Morris (1979, 1982). Volcanic vents around the shield are presumed to have erupted pyroclastic materials which were deposited in huge sheets away from the shield. These were then eroded by wind. The aureoles represent the weathered remnant of the ash sheets. Ignimbrites, tuffs, and other pyroclastic materials would be the expected samples in this case.

The existence of a large volcanic construct which pre-dates Olympus Mons is proposed by both McCauley et al. (1972) and Carr (1973). After its formation, a long period of weathering and erosion occurred, followed by the growth of the Olympus Mons shield. The outskirts of this large structure exceeded the size of Olympus Mons, and the

remnants are the present day aureoles. According to this model, one would expect to sample shield volcano material such as basalts which would be old compared to Olympus Mons. It also may be possible to sample the ancient shield at the base of the scarp of Olympus Mons.

Blasius (1976) suggested that plutonic activity related to the formation of Olympus Mons may have been responsible for the formation of the aureoles. Shallow plutons would have been unroofed and eroded, again by wind. The erosional remnants of this process represents the aureoles. Samples in this case would be various plutonic rocks.

A very different type of model has been proposed by Hodges and Moore (1979). They envision a thick ice layer under which Olympus Mons erupted and eventually reached the surface, analogous to an Icelandic table mountain. Continuing eruptions then formed the shield. Around Olympus Mons, basaltic magma erupted from vents and intruded the ice layer, similar to the mode of formation of Icelandic mobergs. The aureoles are the surface expressions of this intruded basalt, and would be composed of palagotonized tuffs, breccias, and pillow lavas.

Williams (1988) proposed that the area was covered with aeolian deposits prior to magmatic activity. Sills intruding below these deposits caused them to be uplifted and fractured, and were subsequently eroded by wind. The aureoles represent the vestiges of these aeolian deposits. Samples therefore would be expected to consist of ancient aeolian material.

The second type of model of aureole formation invokes tectonic and mass wasting processes rather than magmatic activity. Harris (1977) proposed that Olympus Mons was formed on top of a thick sequence of frozen bedded volcanic and aeolian sediments. The weight of Olympus Mons squeezed these beds out, in the form of gravity-assisted thrust sheets. The aureoles repre-

sent the distal edges of these sheets, which have ridden over one another. Sample 5 in this case would be taken from old bedded ash and lava flows.

A similar model is envisioned by Francis and Wadge (1983) in which thrust sheets originally spread under gravity from an ancestral Olympus Mons structure. Again, the aureoles would be the edges of the thrust sheets and would be composed of lavas and pyroclastic and erosional deposits.

Thrusting of a thin ductile layer overlain by a thicker brittle layer is modeled by Tanaka (1985). Interstitial ice comprising 10% of the volume of the layers is proposed to allow the thrusting to extend to the large distances observed. The aureoles are fractured erosional remnants of the thick brittle layer, consisting of aeolian deposits of lava flows. Presumably the lower layer may be exposed as well, allowing ancient materials such as pyroclastics and impact breccias to be sampled in addition to the surface lava and aeolian material.

Lopes et al. (1980, 1982) envision large scale landslides on the scarps of Olympus Mons. These landslides deposit material around Olympus Mons, as well as forcing thrust sheets to develop further out from the base of the shield. The aureoles are the result of these landslides and thrust sheets. For this case samples would be ancient crustal material, possibly remnants of a shield pre-dating Olympus Mons.

Careful study of material gathered on a sample-return mission could distinguish between many of these models. Some, such as those of Hodges and Moore (1979), and Blasius (1976), could be determined uniquely based on the data. Possible uncertainties may exist distinguishing between certain of the other models based on the samples alone, but combining this data with high resolution spacecraft pictures and rover images should enable a distinction to be made between any of these models.

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Estimated Traverse Distance

Table 1: Summary of sample locations at Olympus Mons Southeast site.

Option A: Traverse by Rover from Lander

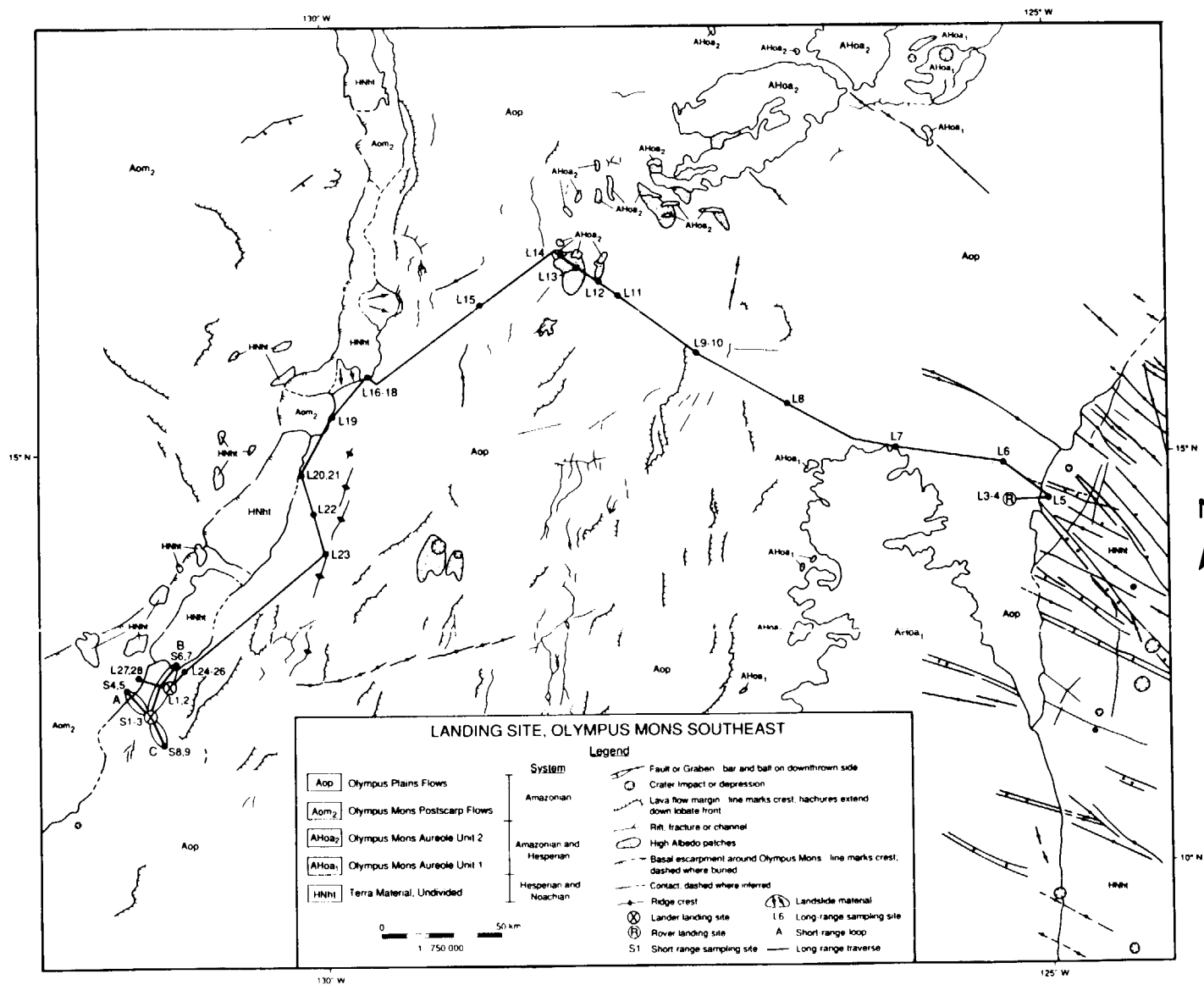
<i>Station</i>	<i>Loop Distance (km)</i>	<i>Cumulative Distance (km)</i>	<i>Prime Objective</i>
S-1,3	0.0	0.0	Plains material
Traverse A S-4,5	27.0	27.0	Post-scarp flow
Traverse B S-6,7	51.0	78.0	Fractured terra material
Traverse C S-8	22.0	100.0	Plains material

Option B: Long range traverse

<i>Station</i>	<i>Distance from last station (km)</i>	<i>Cumulative Distance (km)*</i>	<i>Prime Objective</i>
L-3,4	0.00	0.00	Plains material
L-5	15.00	15.00	Terra material
L-6	22.50	37.50	Plains material
L-7	42.75	80.25	Aureole deposits
L-8	45.75	126.00	Plains material
L-9,10	40.50	166.50	Plains material (near source)
L-11	37.50	204.00	Plains material
L-12	9.00	213.00	Bright streak
L-13	11.25	224.25	Bright streak
L-14	7.50	231.75	Aureole deposits
L-15	36.75	268.50	Plains material
L-16,18	57.00	325.50	Possible post-scarp flow, fractured terra material
L-19	21.75	347.25	Lobate debris flow or post-scarp flow
L-20,21	26.25	373.50	Fractured terra material
L-22	16.50	390.00	Plains material
L-23	17.25	407.25	Ridge in plains material
L-24,26	72.00	479.25	Fractured terra material
L-1,2	8.25	487.50	Plains material
L-27,28	27.00	514.50	Post-scarp flow

* from Rover landing site

Site 028 OLYMPUS MONS SOUTHEAST



ASU 465

⊗ Landing Site: 14° N Latitude, 131° W Longitude
 ⊕ Landing Site: 13° N Latitude, 125° W Longitude

Ronald Greeley

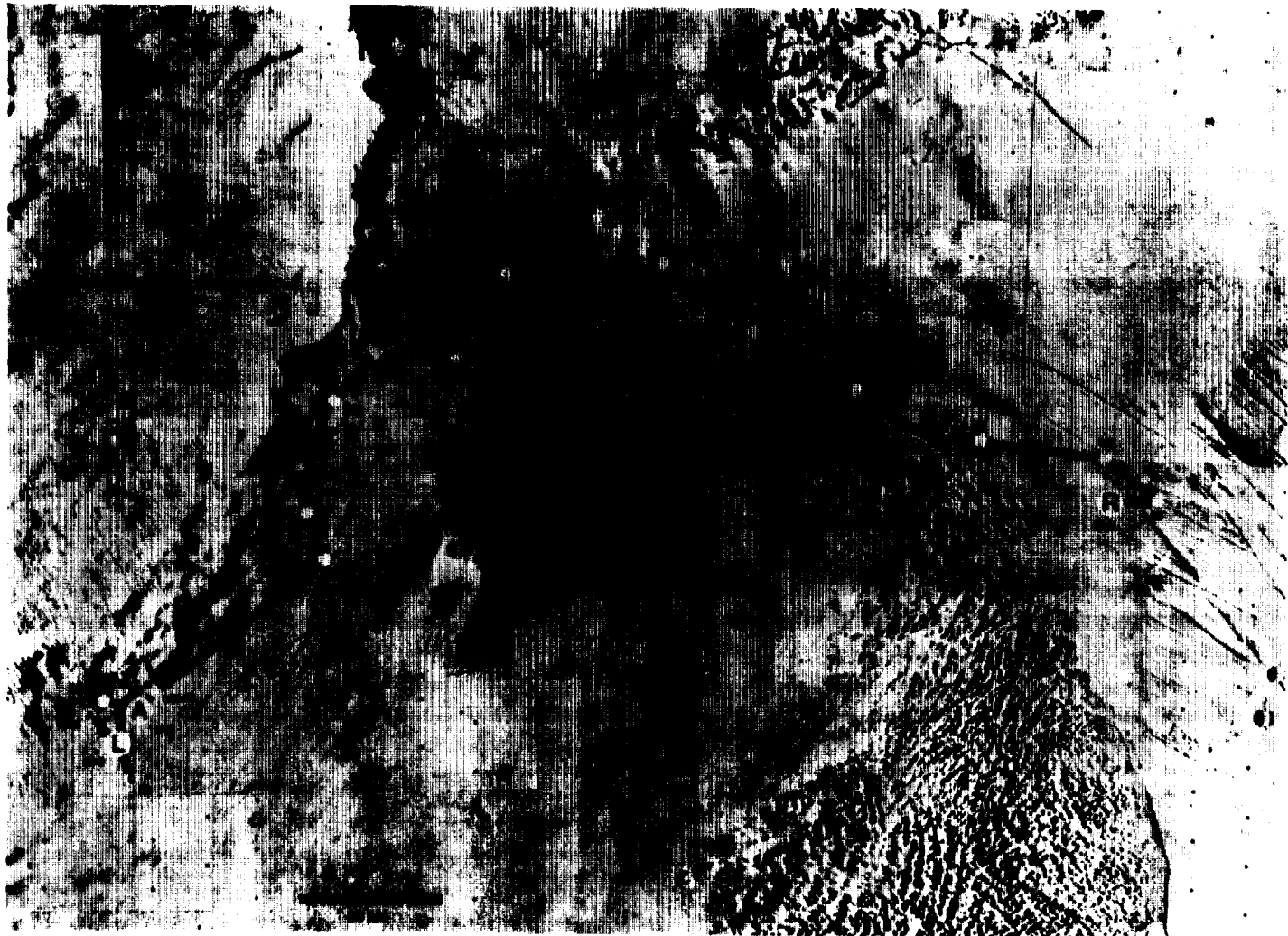
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Site 028 OLYMPUS MONS SOUTHEAST

130° W

125° W



15° N



13° N

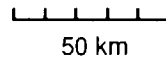
80

15° N -

13° N -

130° W

125° W



50 km

ASU 465

(L) Landing Site: 14° N Latitude, 131° W Longitude

(R) Landing Site: 13° N Latitude, 125° W Longitude

Ronald Greeley

ORIGINAL FROM
BLACK AND WHITE PHOTOGRAPH

Site 029 - Western Daedalia Planum

Site 029

Site Name: Western Daedalia Planum
Type of Site: Rover/Sample Return

Latitude: 19°S; alternate 18.5°S
Longitude: 144°W; alternate 147°W
Elevation: + 3 km

Maps: MC-16 SE

Viking Orbiter Images: 637A 81, 83
(resolution 130-300 m/pxl);
639A 11-14, 16, 35, 37

Date Entered: February 1989

Date Last Revised: February 1989

Contact:

Ronald Greeley
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Arizona State University
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Geologic Setting

This site is in western Daedalia Planum where lava flows of the Tharsis province embay cratered terrain of the martian highlands. The specific site is located on lava flows which lap against the base of the central peak for a large (120 km diameter) nearly-buried impact crater. The regional structure is dominated by fractures which trend east-northeast and are related to the Tharsis Rise.

Scientific Rationale

- a. *Young volcanics:* Amazonian-age lava flows derived from Tharsis (probably Arsia Mons); provides samples of late-stage igneous activity and allows crater-count calibration (represents unit(s) of 603,000 km²). High probability of sampling success.
- b. *Intermediate-age volcanics:* Landing site on a unit mapped as Amazonian-Hesperian age (Scott and Tanaka, 1986). May be younger (Greeley and Craddock, 1988) and from a local eruptive source; provides potential for sampling from a different igneous province and crater-count calibration than young

volcanics (represents unit(s) of 724,000 km²). High probability of sampling success.

- c. *Central peak material:* Landing site adjacent to central peak for a 120 km impact crater. Lavas "flood" the central peak and provide access to either outcrop or to debris shed from the peak. Peak material probably derived from a depth of 10 km or more and would enable sampling of deep crust and/or upper mantle. Good probability of sampling success; samples may be weathered.

Additional Consideration:

The central peak rises about 3 km above the surrounding lava plains. The slope on the eastern flank of the peak is estimated to be ~7.6°. If the rover were capable of negotiating this slope and the inferred blocky surface, there may be the opportunity to sample a relatively undisturbed cross section of the crust.

It must be noted that the impact occurred in an area surfaced with early-stage volcanics. Consequently, there is

a possibility that the central peak is “veneered” with lavas. In addition, the western side of the central peak may be veneered with ejecta from a younger crater superposed on the primary crater.

A critical measurement via Mars Observer would be remote sensing for compositional information on the central peak.

- d. *Surficial materials:* Wind streaks in western Daedalia indicate the presence of aeolian material. Moderate probability of sampling windblown material.

Gullies on the eastern side of the central peak suggest erosion by fluvial processes. Cannot determine if similar gullies are accessible from landing site for “fluvial” sample.

- e. *Crater rim material:* Ancient crustal rocks exposed in rim of the 120 km impact crater; would represent less-deep crust than the central peak. Weathered and possibly fresh rocks available, either as outcrop or as slope debris.

- f. *Ancient cratered uplands:* Exposed 135 km due west of the landing site; mapped as the oldest and most widespread crustal material on Mars (Scott and Tanaka, 1986); would provide compositional data on this key unit and opportunity to obtain radiometric dates for crater-count calibration (represents unit of 315,000 km²). The unit does not appear to have been excessively modified by fluvial or aeolian materials, increasing the probability of obtaining valid samples for the unit.

Objectives

Intermediate age and young volcanic rocks, ancient cratered terrain, central peak material from a 120 km crater (to obtain a deep crustal sample).

OPTION A:

Site Within Lava-flooded Impact Crater (19°S, 144°W) Short-range (Lander, Rover same site) Traverse (100 km)

Geologic units:

“young” lava flow (AHlp₂, basalt)

Tharsis lava flow (At, basalt)

central peak (Nplcp, deep crustal material)

large crater rim material (Nplcr, crustal material)

small crater ejecta (basalt or excavated crust)

weathered material/alluvium (basalts or crust)

Stations:

1. Lander (X) and rover (R) land on “young” lava flow within floor of large flooded crater near Tharsis lava flow lobe; obtain samples of “fresh” basalt (sample S1-1), weathered basalt (sample S1-2), and soil (sample S1-3) at landing site for radiometric age determination of “fresh” basaltic surface and correlation with crater-counting ages.

2. Deploy rover to obtain samples of fresh (sample S2-1) and weathered (sample S2-2) basalts and soils (sample S2-3) from Tharsis lava flow lobe (10 km, traverse A) for studies of basalts of different age and perhaps composition. Rover returns samples to lander.

3. Deploy rover to obtain: fresh central peak (sample S3-1) sample for compositional analysis of deep crustal material; weathered material from central peak for evaluation of weathering processes (sample S3-2); ejecta from small crater (sample S3-3) adjacent to central peak for analysis of less weathered subsurface basalt and/or shocked materials (30 km, traverse B). Rover returns samples to lander.

4. Deploy rover to obtain sample of: fresh large crater rim (sample S4-1) for analysis of

“fresh” crustal highland material; weathered talus from large crater rim for evaluation of weathering processes and effects (sample S4-2); ejecta from small crater (sample S4-3) for sampling of subsurface material (“fresh” basalts, underlying crust?); possible bright-streak material from small crater (sample S4-4) for analysis of aeolian dust and/or sand (60 km, traverse C). Rover returns samples to lander.

OPTION B: Long-range (Lander, Rover separate sites) Traverse (500 km)

Geologic units:

- dark-streak material (AHlp₂, unmantled basalt?)
- large crater rim material (Nplcr, crustal material)
- crustal material (NPl₁)
- “young” lava flow (AHlp₂ basalt)
- Tharsis lava flow (At)
- central peak (Nplcp, deep crustal material)
- crater rim material (Nplcr, crustal material)
- small crater ejecta
- weathered material/alluvium

Stations:

1. Lander (X) lands (19°S, 144°W) on “young” lava flow within floor of large flooded crater; obtain samples of fresh (sample L1-1) and weathered basalt (sample L1-2), and soil (sample L1-3) at landing site for radiometric age determination of “young” basaltic surface and correlation with crater-counting ages.
2. Rover (R) lands ~300 km (18.5°S, 147°W) to westnorthwest of the lander, within dark streak of small crater located on “young” lava flow surface; obtains sample of unmantled lava flow (sample L2-1, “fresh” basalt?) at landing site.

3. Rover moves to southwest to obtain samples of crater ejecta (sample L3-1), mantled “young” lava flow surface (sample L3-2) and soil (sample L3-3).

4. Rover moves to southwest to obtain fresh sample of large crater rim material (sample L4-1) and weathered material (alluvial? fluvial?) at/near base of slope (sample L4-2, 12 km traverse).

5. Rover turnseastsoutheast to obtain sample of crustal highland material at promontory (sample L5-1), weathered crustal material (sample L5-2) and soil (sample L5-3, 83 km traverse).

6. Rover traverses plain to crater, obtaining samples of crater ejecta (sample L6-1, basaltic material from different depths, possibly shocked materials), soils (sample L6-2), and bright streak (aeolian dust and/or sand) material (sample L6-3, 70 km traverse).

7. Rover continues east to sample fresh (sample L7-1) and weathered (sample L7-2) crustal material of large crater rim, and soil (sample L7-3, 45 km traverse). Rover returns to lander, deposits samples (50 km traverse).

8. Rover moves north to obtain samples of: fresh (sample L8-1) and weathered (sample L8-2) basalt from Tharsis lava flow lobe (8 km traverse); fresh (sample L9-1) and weathered (sample L9-2) deep crustal material of central peak (28 km traverse); small crater ejecta (sample L10-1) and soil (sample L10-2, 10 km traverse); returns to Lander.

Potential Problems

The site is on lava flow surfaces inferred to be relatively flat and of intermediate-to-young age. Flows are inferred to be of “flood” style, i.e., very fluid, spread as flat sheets; do not appear to have local flow features such as

channels or collapsed lava tubes which would pose hazards and obstacles. May be thinly mantled with aeolian deposits which would reduce local relief. Principal hazards are possible blocks weathered free from the tops of lava flows and possible local flow scarps.

Blocks shed from the central peak and crater rim may prevent travel on slopes of those features. Such blocks would provide alternatives to samples obtained from outcrops of the central peak and crater rim.

Estimated Traverse Distance

Mars Landing Site: Western Daedalia Planum

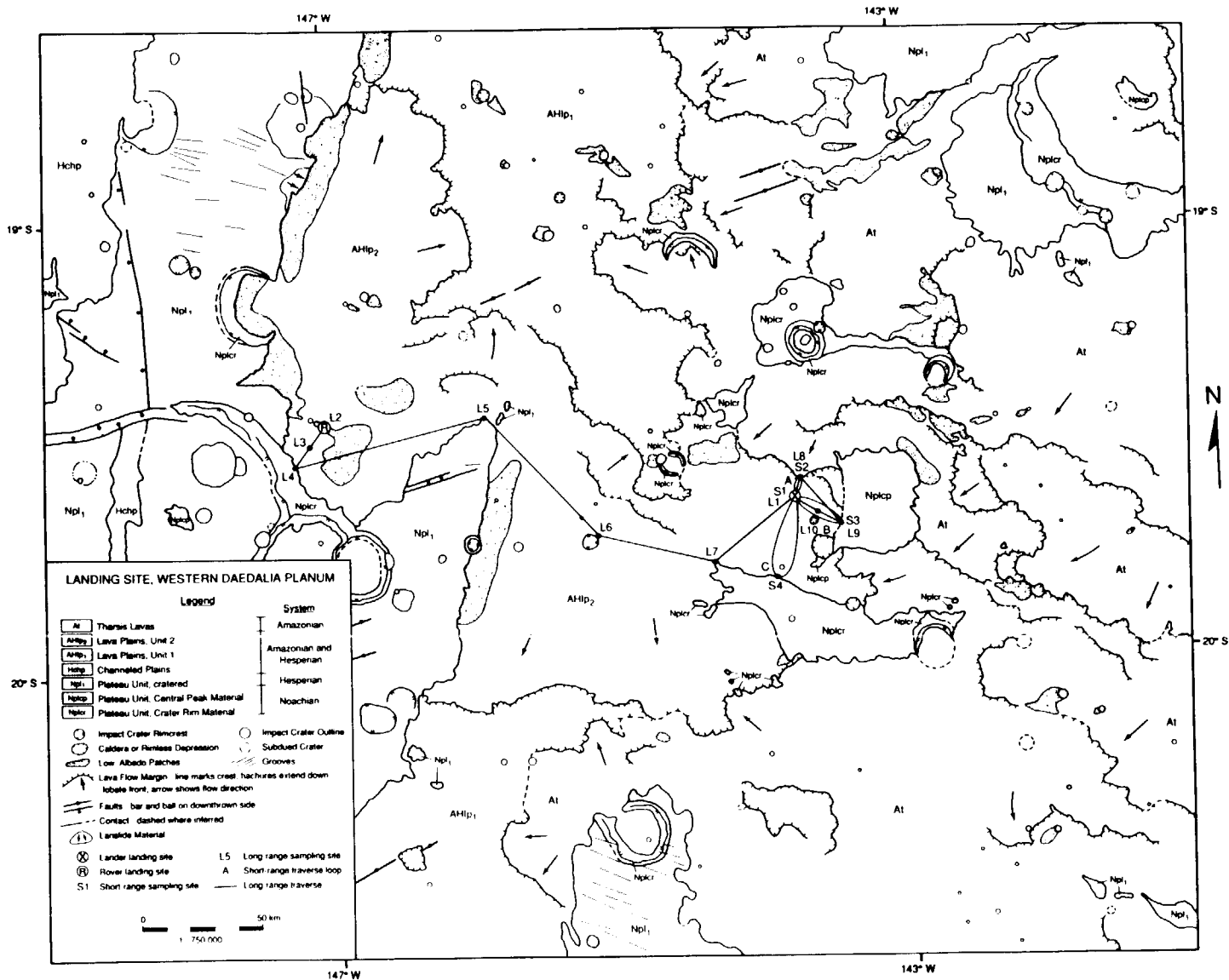
Option A: Short-range Traverse

Station Objective	Loop Distance (km)	Cumulative Distance (km)	Prime Sampling
S1-1,2,3	0	0	Tharsis lava; soil
S2-1,2,3	10	10	Tharsis lava; soil
S3-1,2,3	30	40	Central peak material; small crater ejecta
S4-1,2,3,4	60	100	Crater rim material; small crater ejecta; high albedo patch

Option B: Long-range Traverse

Station	Distance from Last Station (km)	Cumulative Distance (km)	Prime Sampling Objective
L2-1	0	0	Unmantled lava flow
L3-1,2,3	10	10	Crater ejecta; young lava flow; soil
L4-1,2	12	22	Crater rim material
L5-1,2,3	83	105	Plateau unit; soil
L6-1,2,3	70	175	Crater ejecta, soil, high albedo material

Site 029 WESTERN DAEDALIA PLANUM



85

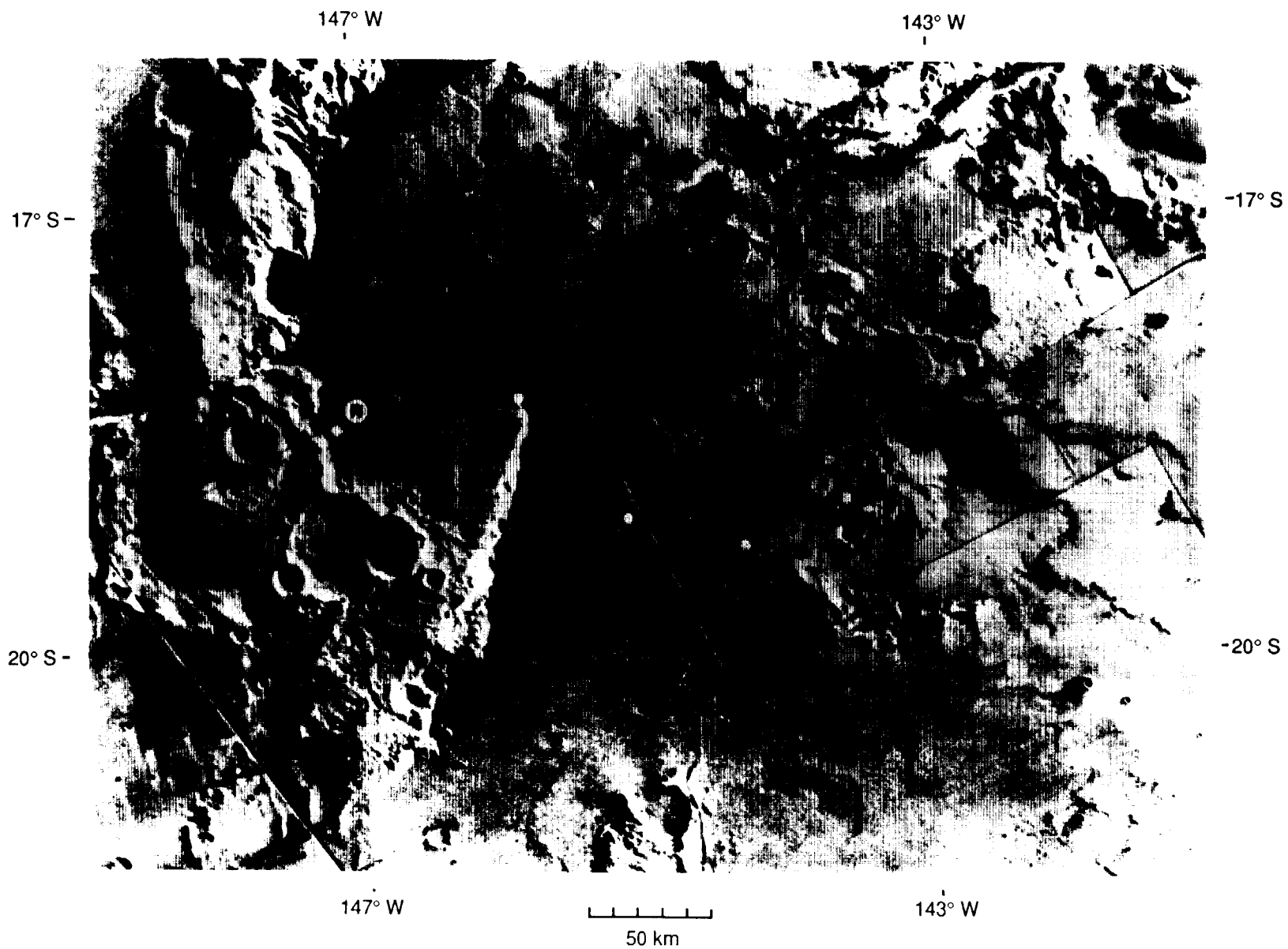
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ASU 3381-H

⊗ Landing Site: 19° S Latitude, 144° W Longitude
Ⓡ Landing Site: 18.5° S Latitude, 147° W Longitude

Ronald Greeley

Site 029 WESTERN DAEDALIA PLANUM



86 ORIGINAL PAGE BLACK AND WHITE PHOTOGRAPH

ASU 3381-H

- Ⓐ Landing Site: 19° S Latitude, 144° W Longitude
- Ⓡ Landing Site: 18.5° S Latitude, 147° W Longitude

Ronald Greeley

Site 030 - North Polar Cap

Site 030

Site Name: North Polar Cap
Type of Site: Rover/Sample Return

Latitude: 80 - 85°N
Longitude: Any
Elevation: + 1 to - 2 km

Maps: MC-1, A and B

Viking Orbiter Images: 816A41-42,
840A12, 768A05, 765A26+28,
714A07, 750A25, 801A42, 798A42

Date Entered: March, 1989
Date Last Revised:

Contact:

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Geologic Setting

Polar ice and polar layered deposits composed of water-ice and dust surround the North Pole.

Scientific Rationale

Polar layered deposits have most complete record of modern climatic evolution. They may also control cycling of volatiles and dust.

Objectives

- a) Compositions of ice/dust in polar deposits: questions include relative amount of ice/dust, grain size of dust, weathering of dust, dust aggregates (success depends upon how sampling is conducted - requires a strategy different from other areas of Mars, e.g. coring, melting, etc.);

- b) controls on layering: do variations in ice/dust content control layering? Is there layering at a scale of millimeters to centimeters? (success: if conditions permit roving, prospects are excellent);
- c) surface processes on ice: ablation, dust-ice deposits, wind action. Micro-relief features (success excellent).

Potential Problems

High latitude: landing, temperatures, seasonal winds, uncertain surface roughness. Sampling: Core sample desirable. What is the hardness of the ice-dust mixture?

Trafficability

To be determined.

Estimated Traverse Distance

(round trip) 10-20 km

Site 031 - North Pole

Site 031

Site Name: North Pole

Type of Site: Rover/Sample Return

Latitude: 90°N

Longitude:

Elevation: + 1 km

Maps: MC-1, A and B

Viking Orbiter Images: 765A26,
768A05, 768A06

Date Entered: March 1989

Date Last Revised: March 1989

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Geologic Setting

Polar ice and polar layered deposits composed of water-ice and dust surround the North Pole.

Scientific Rationale

Center of a unique repository of volatiles. Opportunity to investigate properties of seasonally varying cap materials - key to current climate. History of volatile deposition over precessional cycle. Dust storm history.

Objectives

- a) Seasonal composition of volatile deposits (success very high);
- b) drill to obtain 2 meter core for precessional cycle composition variations; dust vs. water, etc. (success moderate);

- c) EM sounding for depth and layer structure of polar caps (success high);
- d) seasonal and interannual variations controlling condensation regime (success high).

Potential Problems

Communications and orbit transfer problems require study. Maintenance through cold and dark season requires study. Effects of CO₂ ice deposition on spacecraft require study.

Trafficability

To be determined.

Estimated Traverse Distance

(round trip) (a):0, (b) 1000 km; (a) No traverse needed for primary mission, (b) Long traverse capability would allow determination of spatial deposition history across the cap.

Site 032 - Hadriaca Patera

Site 032

Site Name: Hadriaca Patera

Type of Site: Rover/Sample Return

Latitude: 32.5°S

Longitude: 266°W

Elevation: + 1.5 km

Maps: MC-28 NE

Viking Orbiter Images: 62S18-20,
32A529

Date Entered: 6 September 1989

Date Last Revised: 6 September 1989

Contact:

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Geologic Setting

Mid-Hesperian central vent volcano, Hadriaca Patera (AHh), and the older channel material of Harmakhis Vallis (Hch) leading down into Hellas Planitia's modified eolian, fluvial, and lava flow material (Hh₃).

Scientific Rationale

Investigation of the slopes of Hadriaca Patera and nearby volcanoes and ancient cratered terrain. Investigation of a channel, Harmakhis Vallis and possible investigation of the junction area of Harmakhis Vallis with Hellas Planitia. This may give the opportunity to investigate some of the floor of Hellas Planitia, possible investigation of frosts, clouds, and dust storms in Hellas Planitia.

Objectives

Land on the south slope of Hadriaca Patera. From there the vehicle is to move south, going into the graben-like start of Harmakhis Vallis. From there the vehicle is to move through the Harmakhis Vallis, taking pictures and making measurements. If range permits, the vehicle should follow Harmakhis Vallis into Hellas Planitia.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 032 HADRIACA PATERA - DAO VALLES

270°W

265°W

35°S -

-35°S



270°W

265°W



50 km

ASU -713

⊗ Landing Site: 33° S Latitude, 266° W Longitude

Frederick R. West

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Site 033 - Chasma Boreale

Site 033

Site Name: Chasma Boreale

Type of Site: Rover/Sample Return

Latitude: 80.8°N

Longitude: 44.0°W

Elevation: - 0.5 km

Maps: MC-1, A and B

Viking Orbiter Images: 058B34,
4261B22

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

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Geologic Setting

Chasma Boreale is a large swirl pattern trough originating in Planum Boreum. Planum Boreum is composed of polar ice and polar layered deposits surrounded by thick, smooth to hummocky eolian deposits.

Scientific Rationale

To be determined.

Objectives

Rocks available: water ice cap, layered deposits, northern plains material.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 034 - Planum Australe

Site 034

Site Name: Planum Australe

Type of Site: Rover/Sample Return

Latitude: 82.5°S

Longitude: 60.0°W

Elevation: + 4 km

Maps: MC-30, A and B

Viking Orbiter Images: 319B52

Date Entered: March 1989

Date Last Revised: March 1989

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Geologic Setting

Planum Australe consists of polar ice deposits covered by CO₂ frost (because of colder temperatures relative to the North Pole), and polar layered deposits. These are adjacent to Dorsa Argenta polar plains materials.

Scientific Rationale

To be determined.

Objectives

Rocks available: carbon dioxide ice cap, layered deposits, southern plains material.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 034 PLANUM AUSTRALE



MTM -85080

⊗ Landing Site: 82.5° S Latitude, 60° W Longitude

Harold Masursky

Site 035 - Memnonia Sulci

Site 035

Site Name: Memnonia Sulci
Type of Site: Rover/Sample Return

Latitude: 9.7°S
Longitude: 174.2°W
Elevation: + 2 km

Maps: MC-16 NW (I-1186)

Viking Orbiter Images: 599A55

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

Harold Masursky
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff, AZ 86001
(602) 527-7003

Geologic Setting

Memnonia Sulci is southwest of the Tharsis Bulge and just north of the highland-lowland boundary scarp. The Medusae Fossae Formation consists of smooth to rolling hills, and in places is ridged and deeply eroded.

Scientific Rationale

To be determined.

Objectives

Ancient cratered deposits (possible norites), intercrater plains, basaltic lava flows, rhyolitic volcanoclastic deposits.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 035 MEMNONIA SULCI

174° W

8° S

172° W

10° S

8° S



174° W

10° S

172° W



50 km

Viking Orbiter
599A55

⊗ Landing Site: 9.7° S Latitude, 174.2° W Longitude

Harold Masursky

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ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Site 036 - Olympus Rupes (Southeast)

Site 036

Site Name: Olympus Rupes (Southeast)

Type of Site: Rover/Sample Return

Latitude: 13.8°N

Longitude: 131.2°W

Elevation: + 2 km

Maps: MC-9 SW

Viking Orbiter Images: 045B44

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

Harold Masursky
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(602) 527-7003

Geologic Setting

Olympus Rupes is the scarp on the southeast flank of Olympus Mons. The plains and shield members of the Olympus Mons Formation consist of smooth lava flows. Highly deformed terrain materials occur along the scarp.

Scientific Rationale

To be determined.

Objectives

Basaltic lava flows of three ages.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 036 OLYMPUS RUPES

131° W



-14° N

14° N -

131° W



50 km

Viking Orbiter 045B44

⊗ Landing Site: 13.8° N Latitude, 131.2° W Longitude

Harold Masursky

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BLACK AND WHITE PHOTOGRAPH

Site 037 - Kasei Valles

Site 037

Site Name: Kasei Valles

Type of Site: Rover/Sample Return

Latitude: 15.1°N

Longitude: 75.8°W

Elevation: + 1 km

Maps: MC-10 SW and MC-10 NW;
MTM# 15077

Viking Orbiter Images: 858A34

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

Harold Masursky

U.S. Geological Survey

2255 N. Gemini Drive

Flagstaff, AZ 86001

(602) 527-7003

Geologic Setting

Kasei Valles originates in the Tharsis Montes Formation lava flows which are of two different ages; an earlier flow has been dissected and partially covered by a younger flow.

Scientific Rationale

To be determined.

Objectives

Intermediate age basalt flows into which channels are incised, and young flows that overlie channels.

Potential Problems

To be determined.

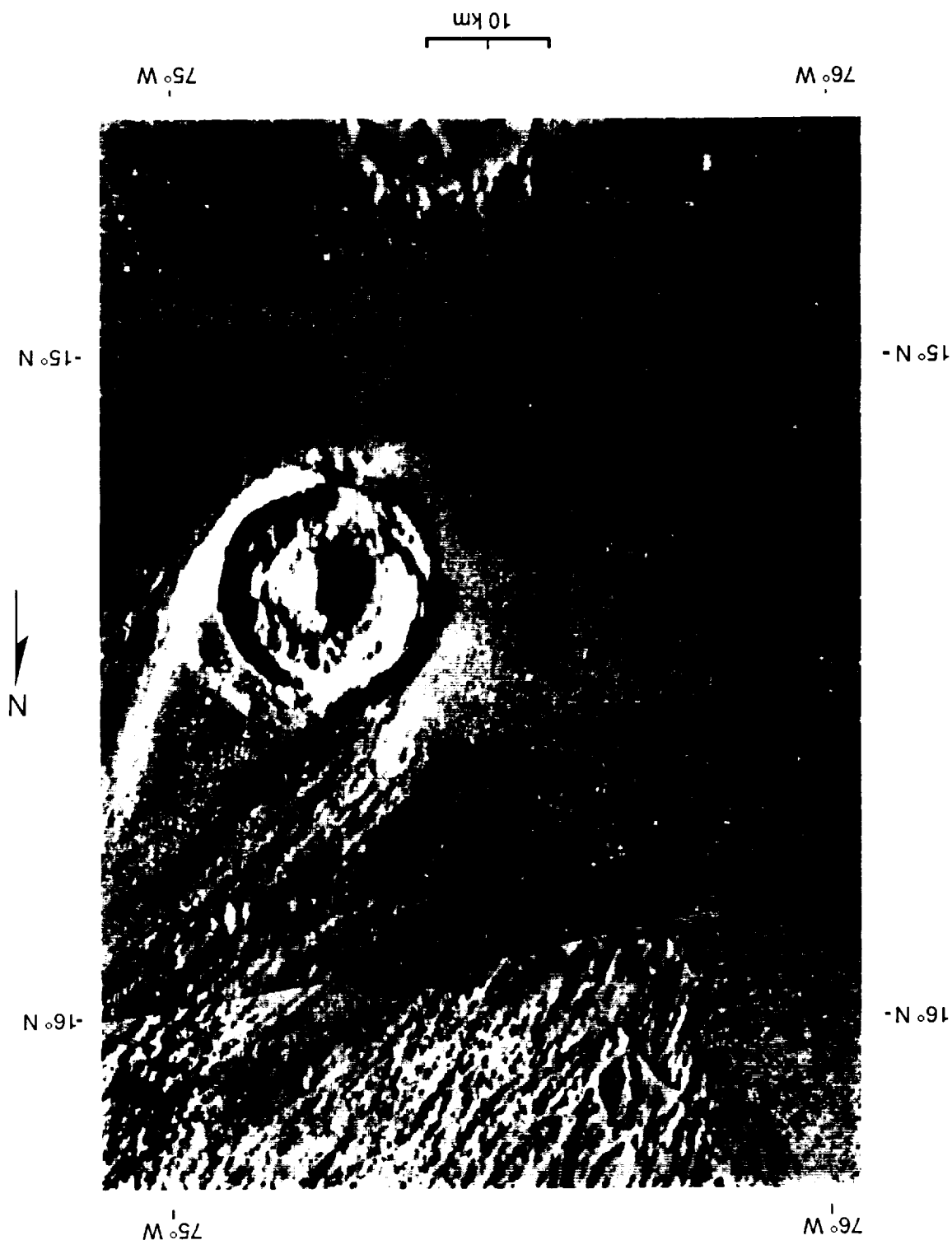
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

MTM 15077 ⊗ Landing Site: 15.1° N Latitude, 75.8° W Longitude Harold Masursky



Site 037 KASEI VALLES

Site 038 - Mangala Valles West

Site 038

Site Name: Mangala Valles West
Type of Site: Rover/Sample Return

Latitude: 7.2°S
Longitude: 158.6°W
Elevation: + 1 km

Maps: MC-16 NW (I-1186);
MTM# 05157

Viking Orbiter Images: 637A75

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

Harold Masursky
U.S. Geological Survey
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(602) 527-7003

Geologic Setting

Mangala Valles is west of Tharsis Montes. Mangala Valles West is the western distributary channel which cuts through Noachian cratered unit of the Plateau Sequence. The Medusa Fossae Formation north of the landing site consists of smooth lava flows of different ages.

Scientific Rationale

To be determined.

Objectives

Ancient cratered terrain (possible norites, anorthosites), intermediate-age and interme-

diate-composition lava flows, young basaltic flows, and younger rhyolitic volcanoclastic rocks.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 038 MANGALA VALLES

159° W

158° W

6.5° S -

- 6.5° S



7.5° S -

- 7.5° S

159° W

158° W

10 km

MTM 05157

⊗ Landing Site: 7.2° S Latitude, 158.6° W Longitude

Harold Masursky

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

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Site 039 - Mangala Valles East

Site 039

Site Name: Mangala Valles East
Type of Site: Rover/Sample Return

Latitude: 4.7°S
Longitude: 147.5°W
Elevation: + 2.5 km

Maps: MC-16 NE (I-1185); MTM# 05147

Viking Orbiter Images: 639A29+31

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

Harold Masursky
U.S. Geological Survey
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(602) 527-7003

Geologic Setting

Mangala Valles is west of the Tharsis Montes and cuts through the Noachian cratered unit of the Plateau Sequence. The Medusae Fossae and Tharsis Montes lava flows are near the landing site.

diate-composition lava flows, young basaltic flows, and younger rhyolitic volcanoclastic rocks.

Scientific Rationale

To be determined.

Potential Problems

To be determined.

Objectives

Ancient cratered terrain (possible norites, anorthosites) intermediate-age and interme-

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 039 MANGALA VALLES EAST

148° W

147° W

4° S -

-4° S

103



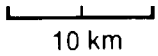
ORIGINAL FILE
BLACK AND WHITE PHOTOGRAPH



5° S -

-5° S

148° W



147° W

MTM 05147

⊗ Landing Site: 4.7° S Latitude, 147.5° W Longitude

Harold Masursky

Site 040 - Elysium Mons

Site 040

Site Name: Elysium Mons
Type of Site: Rover/Sample Return

Latitude: 24.3°N
Longitude: 214.8°W
Elevation: + 4 km

Maps: MC-15 NW; MTM# 25212

Viking Orbiter Images: 541A44

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

Harold Masursky
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Flagstaff, AZ 86001

Geologic Setting

The site lies on the western flank of Elysium Mons. The main edifice of Elysium Mons consists of rilled lobate deposits. Radiating away from the edifice are lobate plains deposits that overlie and embay neighboring volcanoes Albor Tholus and Hecates Tholus.

Scientific Rationale

To be determined.

Objectives

Two ages of basaltic flows.

Potential Problems

To be determined.

Trafficability

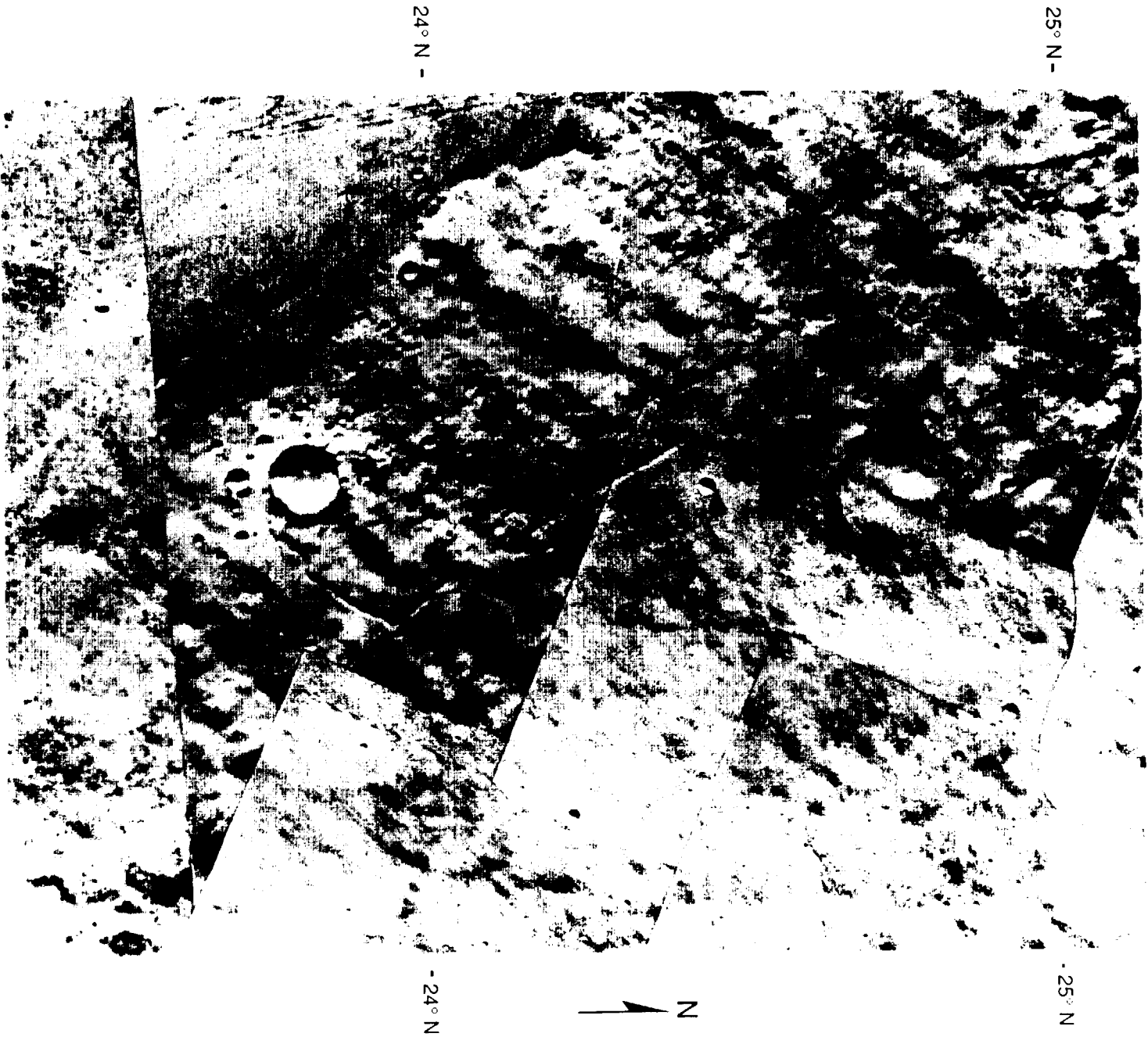
To be determined.

Estimated Traverse Distance

To be determined.

Site 040 ELYSIUM MONS

215° W



215° W

10 km

MTM 25212

⊗ Landing Site: 24.3° N Latitude, 214.8° W Longitude Harold Masursky

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ORIGINAL PHOTOGRAPH
BLACK AND WHITE PHOTOGRAPH

Site 041 - Apollinaris Patera

Site 041

Site Name: Apollinaris Patera
Type of Site: Rover/Sample Return

Latitude: 7.5°S
Longitude: 187.2°W
Elevation: + 1 km

Maps: MC-23 NE

Viking Orbiter Images: 635A55+57,
596A36

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

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Geologic Setting

Apollinaris Patera is a shield volcano located just north of the highland-lowland border, and southeast of Elysium Mons. Apollinaris Patera consists of several members including deposits dissected by channels.

Scientific Rationale

To be determined.

Objectives

Two ages of basaltic flows.

Potential Problems

To be determined.

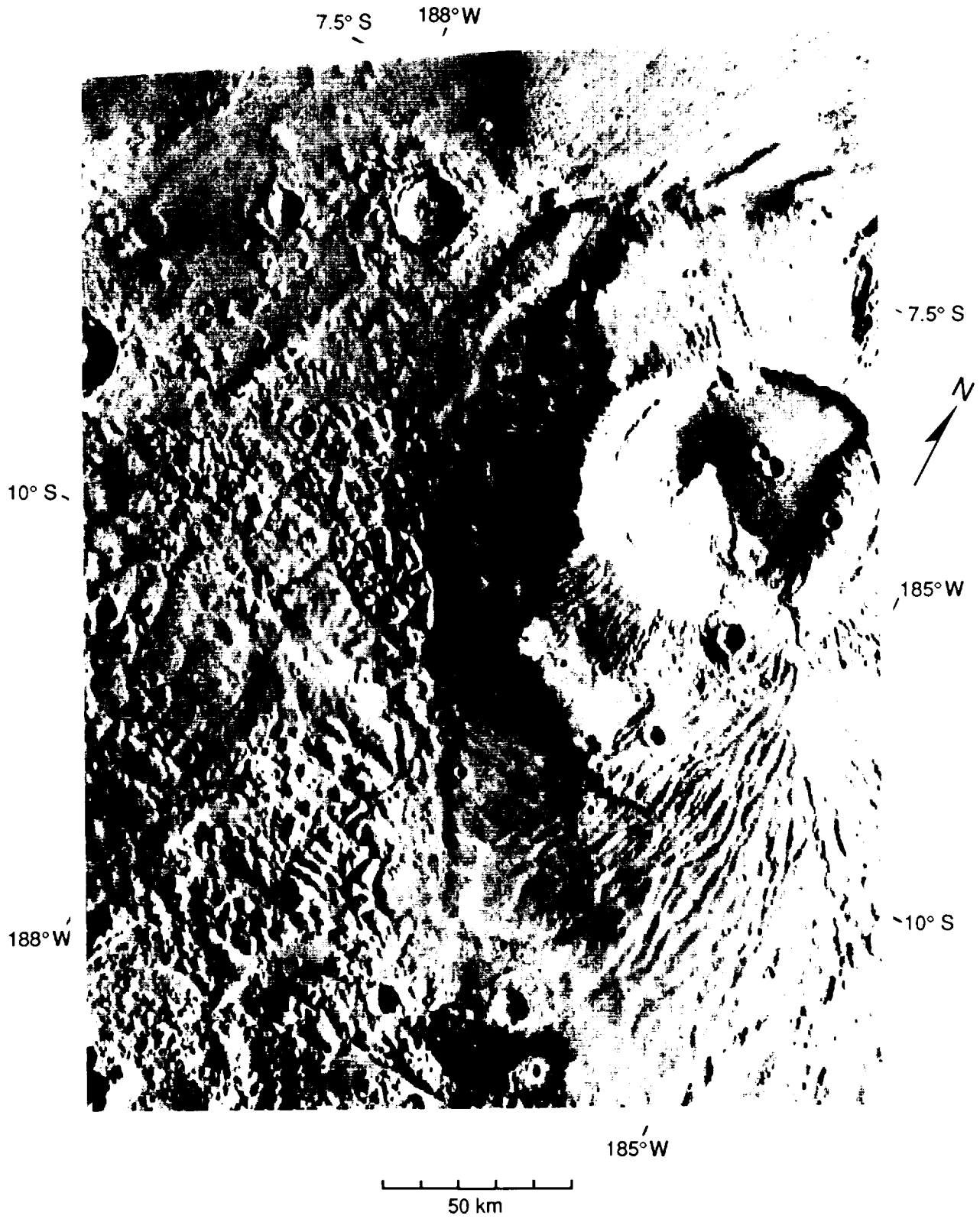
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 041 APOLLINARIS PATERA



Viking Orbiter
635A57

⊗ Landing Site: 7.5° S Latitude, 187.2° W Longitude

Harold Masursky

Site 042 - Nilosyrtris Mensae

Site 042

Site Name: Nilosyrtris Mensae
Type of Site: Rover/Sample Return

Latitude: 35.5°N
Longitude: 302.5°W
Elevation: + 2.5 km

Maps: MC-5 SE

Viking Orbiter Images: 569A20

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

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Geologic Setting

The Nilosyrtris Mensae area is situated on the highland-lowland border. The ridged unit and undivided unit of the Plateau Sequence are extensive in this area.

Scientific Rationale

To be determined.

Objectives

Basaltic intermediate age plains, and ancient heavily cratered uplands.

Potential Problems

To be determined.

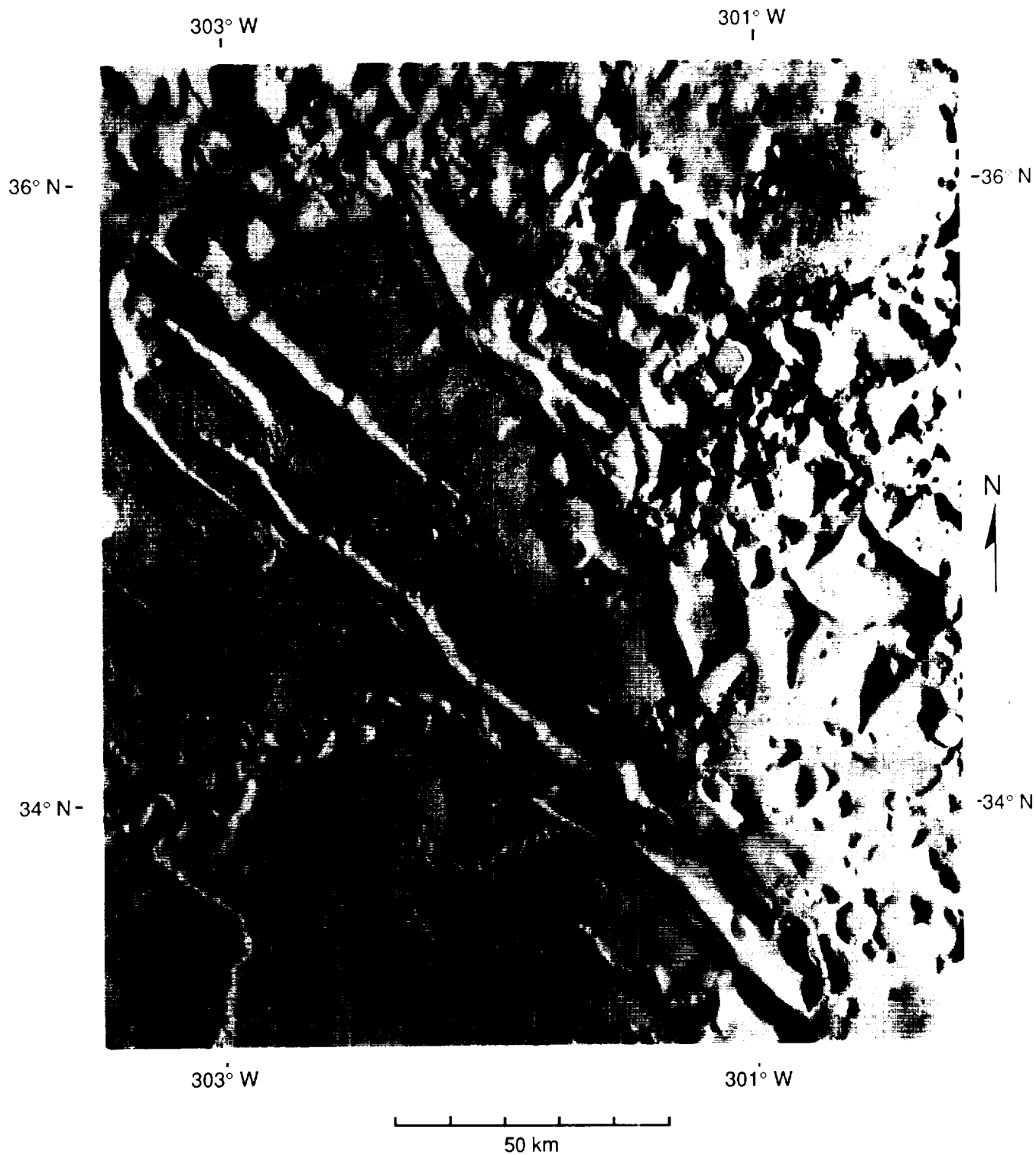
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 042 NILOSYRTIS MENSÆ



Viking Orbiter
569A20

⊗ Landing Site: 35.5° N Latitude, 302.5° W Longitude

Harold Masursky

Site 043 - Candor Chasma I

Site 043

Site Name: Candor Chasma I

Type of Site: Rover/Sample Return

Latitude: 10.5°S

Longitude: 74.5°W

Elevation: + 2.5 km

Maps: MC-18 NW

Viking Orbiter Images: 608A70+72

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

Harold Masursky
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Geologic Setting

Candor Chasma and Melas Chasma are east-west trending troughs associated with Valles Marineris. Valles Marineris, known as canyonlands, is made up of grabens, canyons, pit craters and channels. The canyon walls exhibit horizontal layering.

Scientific Rationale

To be determined.

Objectives

Layered rocks in canyon.

Potential Problems

To be determined.

Trafficability

To be determined.

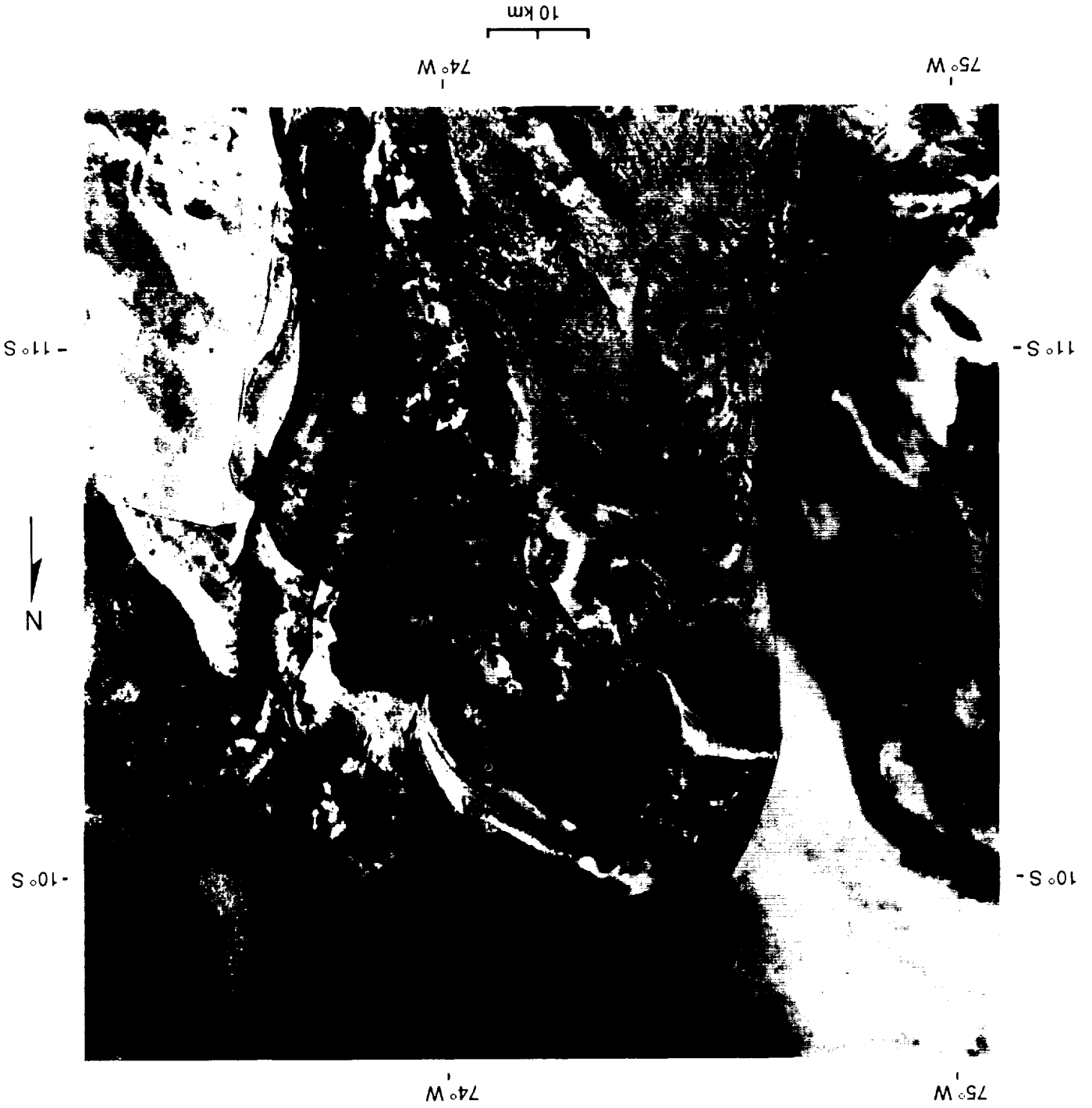
Estimated Traverse Distance

To be determined.

Harold Masursky

⊗ Landing Site: 10.5° S Latitude, 74.5° W Longitude

MTM-10072



Site 043 CANDOR CHASMA I

Site 044 - Tharsis-Olympus

Site 044

Site Name: Tharsis-Olympus
Type of Site: Rover/Sample Return

Latitude: 12°N
Longitude: 125°W
Elevation: + 4 km

Maps: MC-9 SW

Viking Orbiter Images: 045B68

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

D.H. Scott and K.L. Tanaka
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Geologic Setting

The site lies between Tharsis Montes and Olympus Mons. Smooth lava flows of the Olympus Mons plains member intersect the older Olympus Mons aureole deposit which is smooth and degraded by wind. The younger fractured material of the highly deformed terrain material (Ulysses Fossae) forms relatively smooth raised surfaces of moderate relief with fractures, grabens, and collapse depressions.

Scientific Rationale

To be determined.

Objectives

Aop, flows of Olympus plains (Aoa₁), lowermost aureole of Olympus Mons (Hf), fractured flows of Ulysses Fossae.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 044 THARSIS-OLYMPUS



Viking Orbiter
045B68

⊗ Landing Site: 12° N Latitude, 125° W Longitude

D. Scott and K.L. Tanaka

Site 045 - Chasma Boreale

Site 045

Site Name: Chasma Boreale
Type of Site: Rover/Sample Return

Latitude: 82°N
Longitude: 57°W
Elevation: 0 km

Maps: MC-1, A and B; MTM# 80050

Viking Orbiter Images: 790A25

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

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Geologic Setting

Chasma Boreale is a large swirl pattern trough originating in Planum Boreum. Planum Boreum is composed of polar ice and polar layered deposits surrounded by thick, smooth to hummocky eolian deposits. The grooved member of the Vastitas Borealis Formation subpolar plains deposits exhibits a polygonal pattern in the mouth of Chasma Boreale.

Scientific Rationale

To be determined.

Objectives

Polar layered material (Apl); grooved plains material (Hvg); crater material (c).

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 045 CHASMA BOREALE



MTM -80050

⊗ Landing Site: 82° N Latitude, 57° W Longitude

D.H. Scott and K.L. Tanaka

Site 046 - Labeatis North

Site 046

Site Name: Labeatis North
Type of Site: Rover/Sample Return

Latitude: 31°N
Longitude: 83°W
Elevation: + 2.5 km

Maps: MC-3 SE

Viking Orbiter Images: 858A03

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

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Geologic Setting

The site is northeast of the Tharsis Montes near Tempe Fossae. Faults trending northeast, which are part of the system of faults radiating from Tharsis Montes, run through this area. Three formations, Tharsis Montes formation, ridged plains material, and highly deformed material, are near the landing site.

Scientific Rationale

To be determined.

Objectives

Member 2 of Tharsis Montes Fm (Ht₂); ridged plains material (Hr); highly deformed (faulted) material (Nf).

Potential Problems

To be determined.

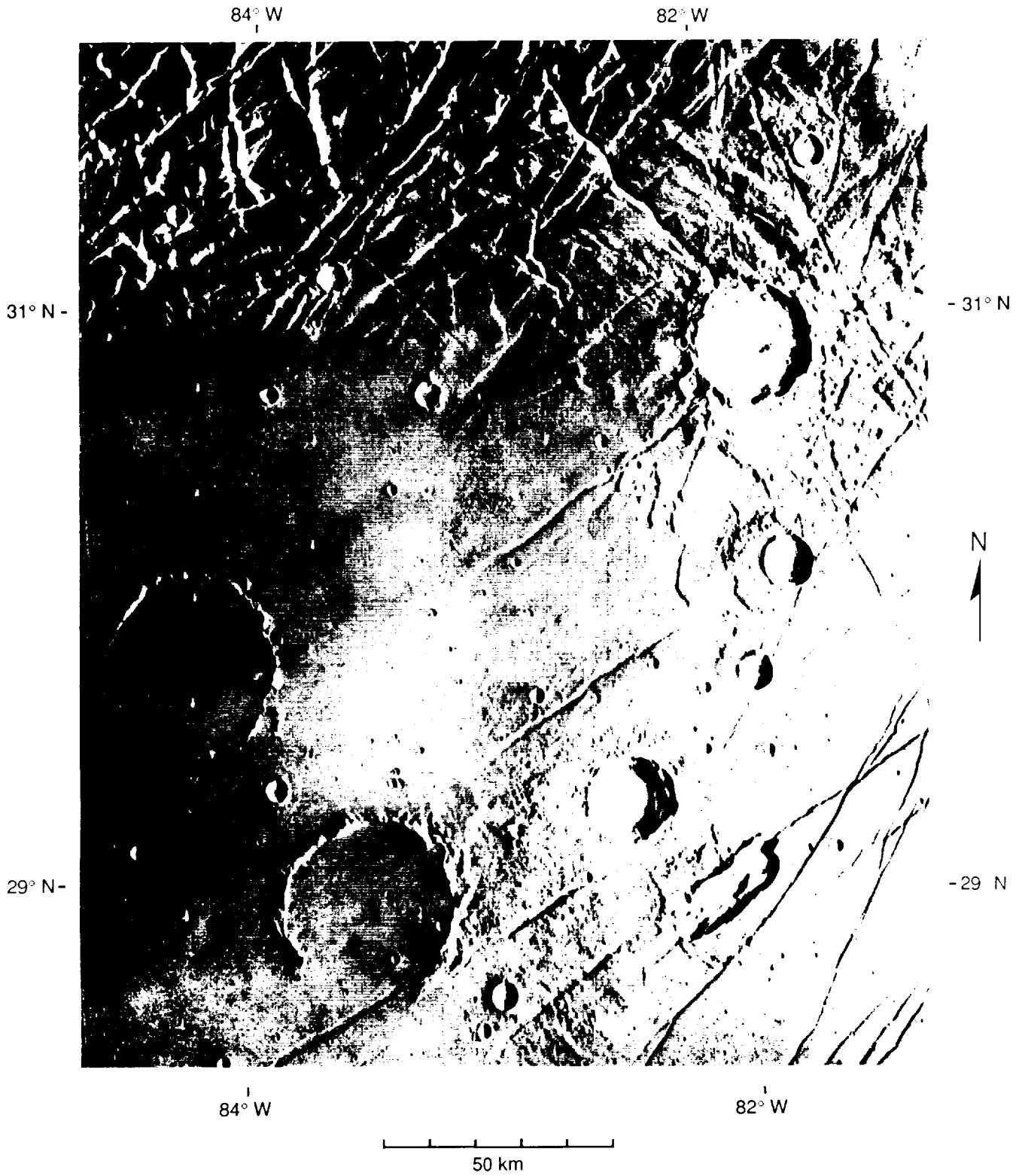
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 046 LABEATIS NORTH



Viking Orbiter
858A03

⊗ Landing Site: 31° N Latitude, 83° W Longitude

D.H. Scott and K.L. Tanaka

Site 047 - Labeatis South

Site 047

Site Name: Labeatis South
Type of Site: Rover/Sample Return

Latitude: 24°N
Longitude: 80°W
Elevation: + 2.0 km

Maps: MC-10 NW; MTM# 25077

Viking Orbiter Images: 555A26

Date Entered: March 1989
Date Last Revised: March 1989

Contact:

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Geologic Setting

The site is northeast of Tharsis Montes near Tempe Fossae. Three formations are close to the landing site: smooth flows of member 2 of Tharsis Montes Formation, light flows with dark wind streaks of member 4 of Tharsis Montes Formation, and ridged plains materials.

Scientific Rationale

To be determined.

Objectives

Member 4 of Tharsis Montes Fm (At₄); member 2 of Tharsis Montes Fm (Ht₂); ridged plains material (Hr).

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

24° N -



- 24° N



Site 047 LABEATIS SOUTH

80° W

80° W

50 km



⊗ Landing Site: 24° N Latitude, 80° W Longitude

D.H. Scott and K.L. Tanaka

MTM 25077

Site 048 - Solis

Site 048

Site Name: Solis

Type of Site: Rover/Sample Return

Latitude: 27°S

Longitude: 100°W

Elevation: + 9.0 km

Maps: MC-17 SE (I-1190)

Viking Orbiter Images: 606A14

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

D.H. Scott and K.L. Tanaka

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Geologic Setting

Solis Planum, a highly cratered and faulted plain, lies to the east of the landing site and Claritas Fossae runs through the site. Claritas Fossae is an intense fracture zone south of Tharsis, part of the extensive array of roughly radiant fractures surrounding the Tharsis Bulge. These formations intersect at the landing site: highly cratered and faulted plains of the lower member of the Syria Planum Formation, a highly deformed terrain material, and younger fractured material.

Scientific Rationale

To be determined.

Objectives

Lower member of Syria Planum Fm (Hsl); older fractured flows (Hf); basement material (Nb).

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 048 SOLIS

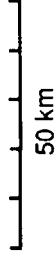
100° W



27° S

-27° S

100° W



Viking Orbiter
606A14

⊗ Landing Site: 27° S Latitude, 100 ° W Longitude

D.H. Scott and K.L. Tanaka

Site 049 - Hadriaca

Site 049

Site Name: Hadriaca

Type of Site: Rover/Sample Return

Latitude: 29°S

Longitude: 269°W

Elevation: + 1 km

Maps: MC-28 NE, MC-22 SW,
MC-28 NE

Viking Orbiter Images: 629A13,
629A16, 629A18, 106A08

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

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Flagstaff, AZ 86001
(602) 527-7188

Geologic Setting

Hadriaca Patera is a central vent volcano northeast of Hellas Planitia, with radial ridges, a low profile, and a smooth floored caldera in the center. The landing site lies on the northwestern flank of Hadriaca Patera and intersects with four formations listed below.

Scientific Rationale

To be determined.

Objectives

Shield material of Hadriaca Patera (Hhp); smooth unit of plateau sequence (Hpl); ridged

plains material (Hr); mountains of Hellas rim material (Nm).

Potential Problems

To be determined.

Trafficability

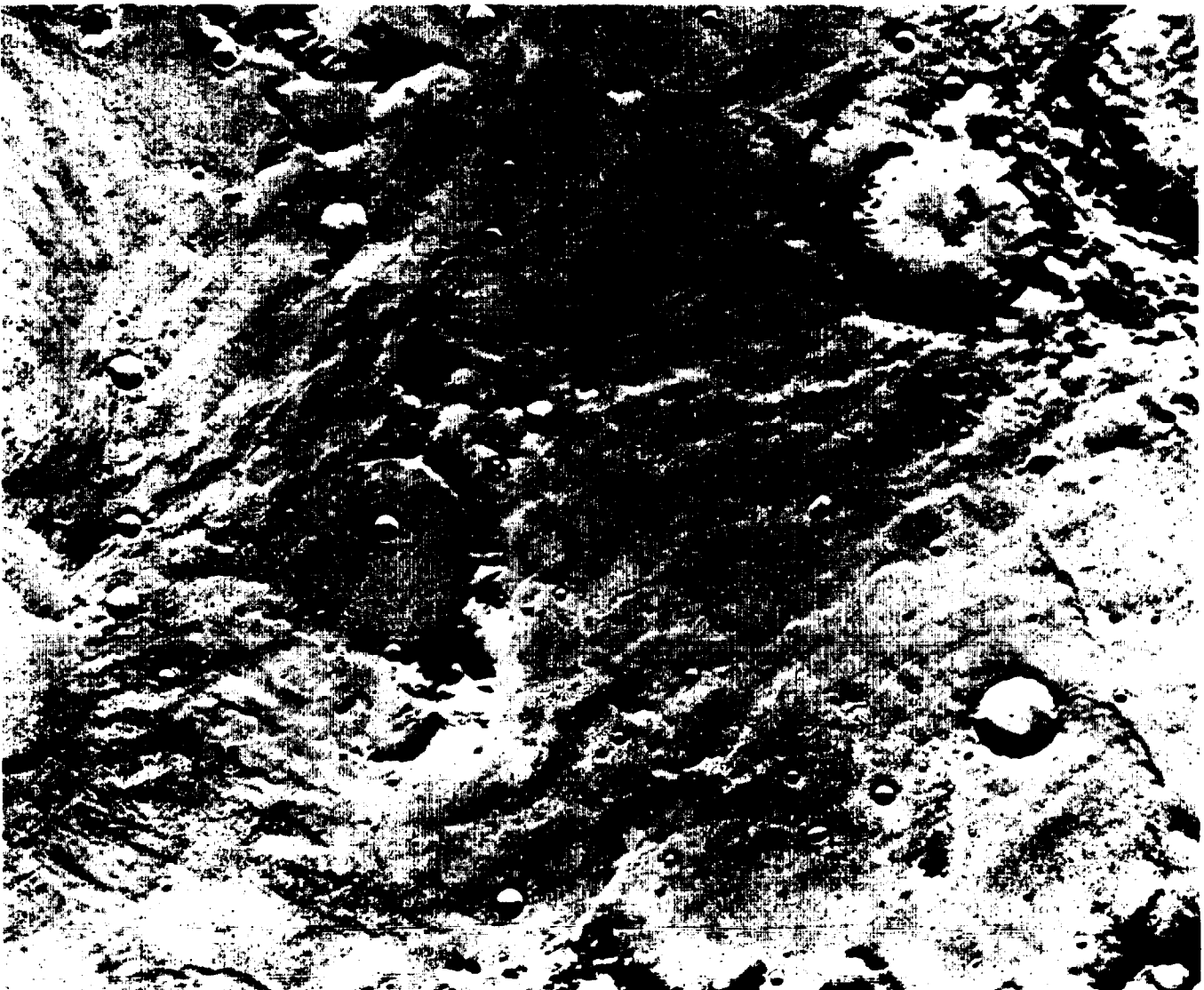
To be determined.

Estimated Traverse Distance

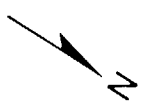
To be determined.

Site 049 HADRIACA

269° W

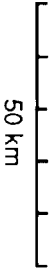


29° S



29° S

269° W



Viking Orbiter
106A08

⊗ Landing Site: 29° S Latitude, 269° W Longitude

D.H. Scott and K.L. Tanaka

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ORIGINAL PAGE

BLACK AND WHITE PHOTOGRAPH

Site 050 - Elysium

Site 050

Site Name: Elysium

Type of Site: Rover/Sample Return

Latitude: 27°N

Longitude: 185°W

Elevation: - 0.5 km

Maps: MC-15 NE

Viking Orbiter Images: 545A08, 545A29

Date Entered: March 1989

Date Last Revised: March 1989

Contact:

D.H. Scott and K.L. Tanaka

U.S. Geological Survey

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Flagstaff, AZ 86001

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Geologic Setting

The main edifice of Elysium Mons consists of rilled lobate deposits. Radiating away from the edifice are lobate plains deposits. The site is located on the far eastern flank of Elysium Mons amid plains, flows, ridged plains material and knobby remnants of plateau material.

Scientific Rationale

To be determined.

Objectives

Plains flows of Elysium Mons (Ael₁); ridged plains material (Hr); knobby remnants of plateau materials (HNu).

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 050 ELYSIUM

186° W

185° W

28° N-

-28° N



186° W

185° W

50 km

MC - 15NE

⊗ Landing Site: 27° N Latitude, 185° W Longitude

D.H. Scott and K.L. Tanaka

Site 051- Mareotis Volcanic Field

Site 051

Site Name: Mareotis Volcanic Field
Type of Site: Rover/Sample Return

Latitude: 36°N
Longitude: 88°W
Elevation: + 3 km

Maps: MTM# 35087: MC-3 SE

Viking Orbiter Images: 627A45, 857A27

Date Entered: 3 April 1989
Date Last Revised: 3 April 1989

Contact:

Henry J. Moore
U.S. Geological Survey
Branch of Astrogeology MS 946
345 Middlefield Road
Menlo Park, CA 94025
(415) 329-5175

Geologic Setting

Mareotis volcanic field, part of Mareotis Fossae, is northeast of the Tharsis Bulge. The Tharsis fractures trend northeast through the volcanic field. The site is in Mareotis Fossae and is among rough hilly material and smooth, light-colored, partly mottled material.

- c) not yet evaluated;
- d) not yet evaluated.

Potential Problems

Unknown at this time.

Scientific Rationale

Establish relations between volcanism, tectonism, and fractured terrain.

Trafficability

To be determined.

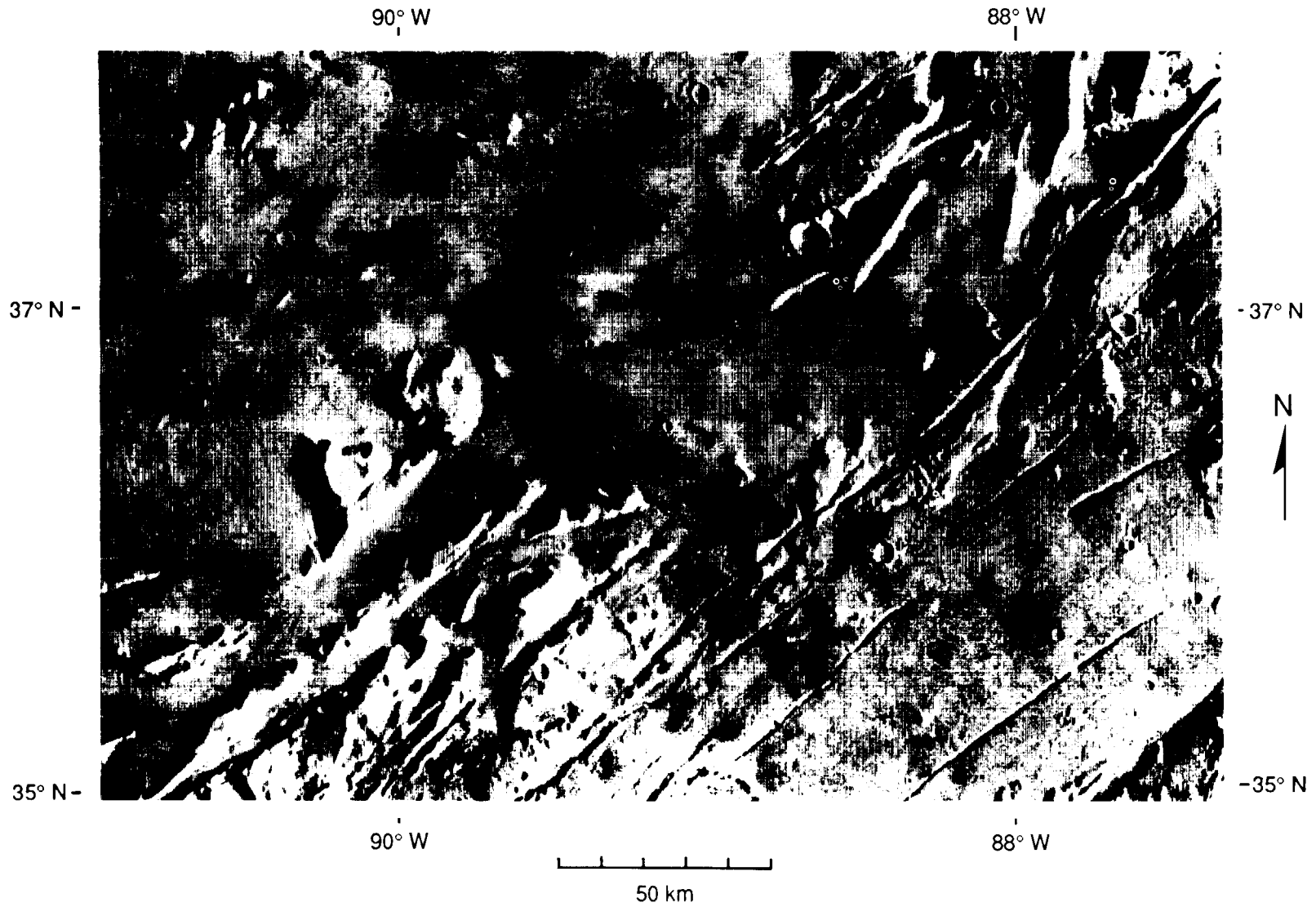
Objectives

- a) Sample volcanic materials;
- b) sample old fractured terrain materials;

Estimated Traverse Distance

To be determined.

Site 051 MAREOTIS VOLCANIC FIELD



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ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Viking Orbiter 857A27

⊗ Landing Site: 36° N Latitude, 88° W Longitude

Henry J. Moore

Site 052- Tempe Volcano

Site 052

Site Name: Tempe Volcano

Type of Site: Rover/Sample Return

Latitude: 39°N

Longitude: 76°W

Elevation: + 1.8 km

Maps: MTM# 40077: MC-3 SE

Viking Orbiter Images: 704B52

Date Entered: 3 April 1989

Date Last Revised: 3 April 1989

Contact:

Henry J. Moore
U.S. Geological Survey
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345 Middlefield Road
Menlo Park, CA 94025
(415) 329-5175

Geologic Setting

The Tempe volcano is in Tempe Fossae, northeast of Tharsis Montes. The landing site lies in highly deformed material with complexly oriented faults, fractures, and collapse depressions.

- b) sample volcanic flow materials (0.98 success rate);
- c) not yet evaluated;
- d) not yet evaluated.

Scientific Rationale

Establish relations between volcanism, tectonism, and fractured terrain.

Potential Problems

Unknown at this time.

Objectives

- a) Sample old fractured terrain material (0.99 success rate);

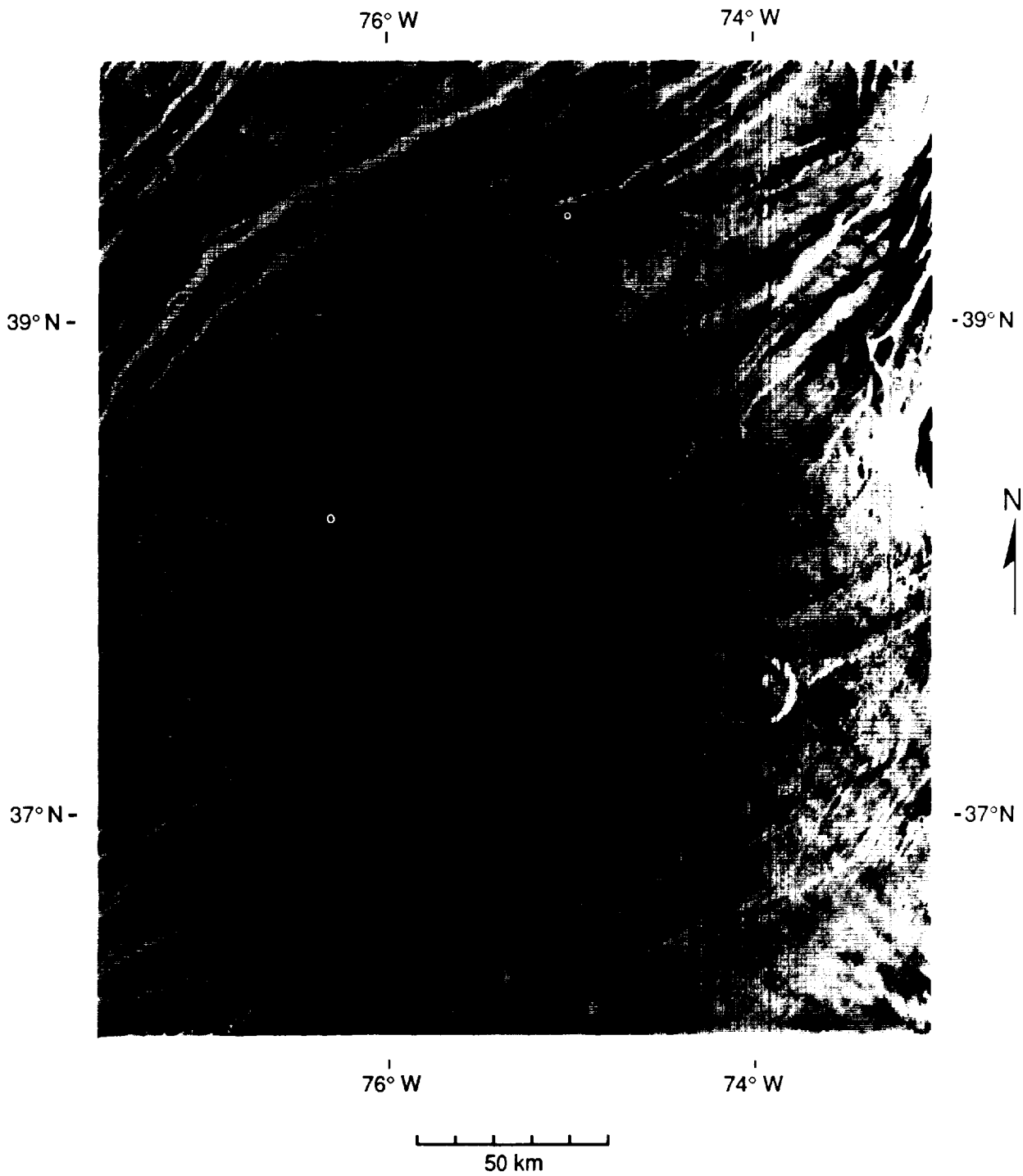
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 052 TEMPE VOLCANO



Viking Orbiter
704B52

⊗ Landing Site: 39° N Latitude, 76 ° W Longitude

Henry J. Moore

Site 053- Ceraunius Fossae Volcanic Field

Site 053

Site Name: Ceraunius Fossae Volcanic Field

Type of Site: Rover/Sample Return

Maps: MTM# 20112: MC-9 NE

Viking Orbiter Images: 516A34

Date Entered: 3 April 1989

Date Last Revised: 3 April 1989

Latitude: 20°N

Longitude: 112°W

Elevation: + 5 km

Contact:

Henry J. Moore
U.S. Geological Survey
Branch of Astrogeology MS 946
345 Middlefield Road
Menlo Park, CA 94025
(415) 329-5175

Geologic Setting

Ceraunius Fossae Volcanic Field, south of Alba Patera, consists of a series of overlapping flows whose surfaces are relatively smooth and even-toned to mottled and streaked. Ceraunius Fossae, highly deformed terrain material, lies east of the landing site.

Scientific Rationale

Establish relations between volcanism, tectonism, and fractured terrain.

Objectives

- a) Sample volcanic materials (0.99 success rate);

- b) sample old fractured terrain materials (0.98 success rate);
c) not yet evaluated;
d) not yet evaluated.

Potential Problems

Unknown at this time.

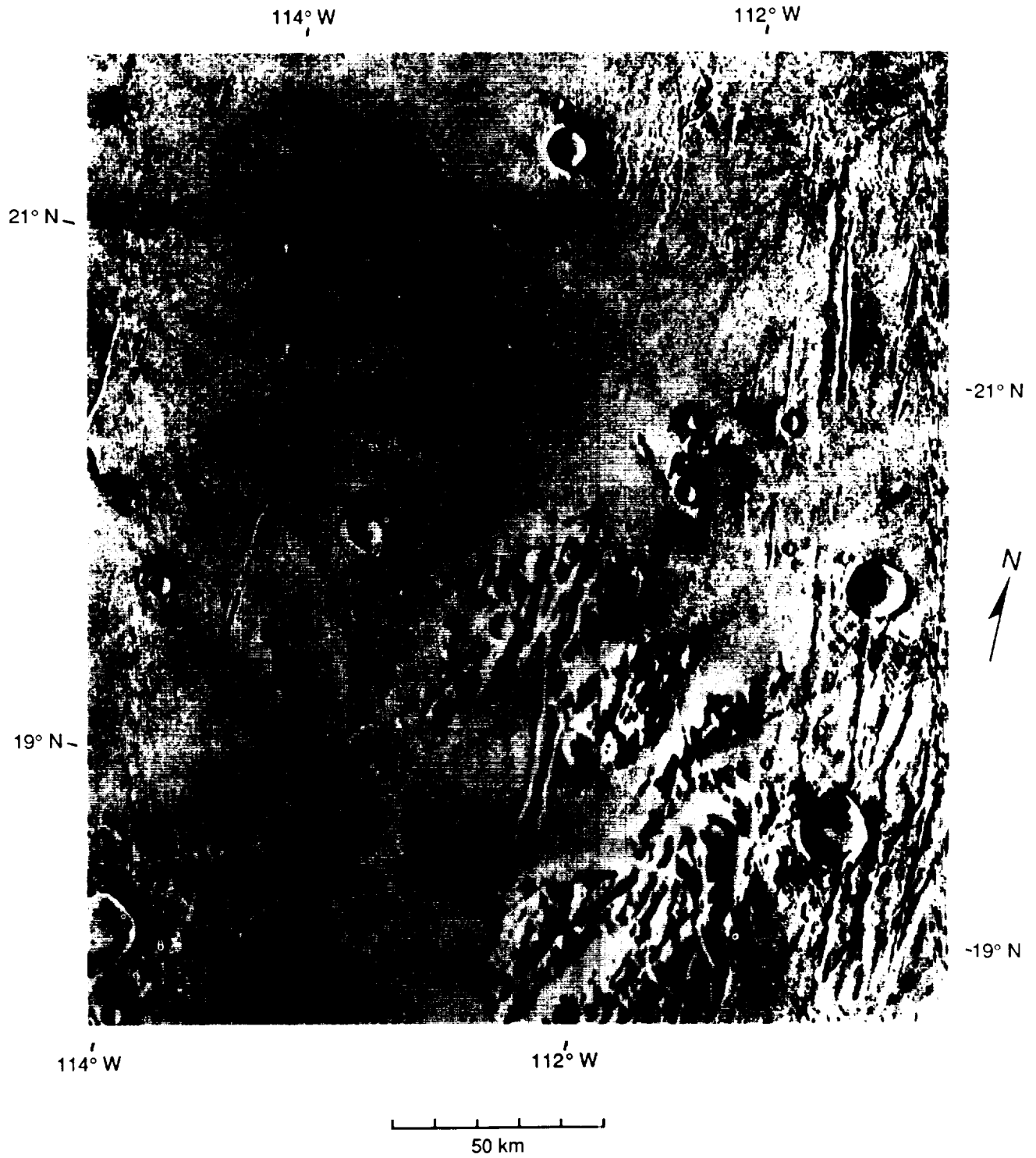
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 053 CERAUNIUS FOSSAE VOLCANIC FIELD



Viking Orbiter 516A34

⊗ Landing Site: 20° N Longitude, 112° W Latitude

Henry J. Moore

Site 054- Candor

Site 054

Site Name: Candor

Type of Site: Rover/Sample Return

Latitude: 5.5°S

Longitude: 74.5°W

Elevation: + 2 km

Maps: MTM# 05072; MC-18 NW

Viking Orbiter Images: 561A26, 561A27

Date Entered: May, 1989

Date Last Revised: May, 1989

Contact:

Eleanora I. Robbins
U.S. Geological Survey
927 National Center MS 956
Reston, VA 22092
(703) 648-6527

Geologic Setting

Candor Chasma is an east-west trending trough associated with Valles Marineris. Valles Marineris, known as Canyonlands, is made up of grabens, canyons, pit craters and channels. The canyon walls exhibit horizontal layering.

Scientific Rationale

If site was locus of ground water discharge in the past, then microbial minerals precipitated by ancient iron bacteria might be concentrated at heads of channels, at sapping sites, and along base of valley wall scarps.

Objectives

To collect weakly indurated iron ore at red and black patches to scan with microscope

for morphologically distinct Fe and Mn oxide minerals that might have been precipitated by ancient iron bacteria. (Success is unknown regarding presence of bacteria. Location easily reached.)

Potential Problems

Landing inside Valles Marineris troughs.

Trafficability

1 to 2.

Estimated Traverse Distance

50 km.

Site 054 CANDOR

75° W

74° W

5° S -

- 5° S

133



6° S -

- 6° S

75° W

74° W



50 km

⊗ Landing Site: 5.5° S Latitude, 74.5° W Longitude

Eleanora I. Robbins

MTM 05072

ORIGINAL PAGE
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Site 055- Northern Cydonia/SE Acidalia

Site 055

Site Name: Northern Cydonia/SE
Acidalia

Type of Site: Rover/Sample Return

Maps: MC-4 SE

Viking Orbiter Images: 561A07,
561A24, 561A26, 637B54, 637B56

Date Entered: May, 1989

Date Last Revised: May, 1989

Latitude: 40°N

Longitude: 10°W

Elevation: - 0.5 km

Contact:

Paul Etzler
Geospectra Corp.
P.O. Box 1387
Ann Arbor, MI 48106
(313) 994-3450

Geologic Setting

The site is on the southeast margin of Acidalia Planitia and on the northern edge of the highland-lowland boundary. Nearby materials include the Vastitas Borealis grooved member, hummocky undivided material, Plateau Sequence cratered unit, and Arcadia Formation flows with lobate margins.

Scientific Rationale

Contact between northern plains and southern cratered highlands.

Objectives

Sample northern plains, fractured terrain, base of cratered highland remnants (may measure time sequence of debris aprons), volcanic constructs, and pseudocraters.

Potential Problems

Sampling area consists of smooth plains. Debris from erosional remnants may cause some problems. Fractured terrain may be difficult to traverse, but need only be sampled at edges. Erosional remnants may cause some problems when landing, but should be avoidable. Sampling operations should be simple.

Trafficability

mostly 1; maybe some 5.

Estimated Traverse Distance

100 km.

Site 055 NORTHERN CYDONIA/SOUTHEAST ACIDALIA



MC - 4SE

⊗ Landing Site: 40° N Latitude, 10° W Longitude

Paul Etzler

Site 056- Tharsis-Olympus

Site 056

Site Name: Tharsis-Olympus
Type of Site: Rover/Sample Return

Latitude: 12.5°N
Longitude: 125.5°W
Elevation: + 3.5 km

Maps: MC-9 SW

Viking Orbiter Images: 890A41, 045B68

Date Entered: July, 1989
Date Last Revised: July, 1989

Contact:

David Scott
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff, AZ 86001
(602) 527-7188

Geologic Setting

Landing site lies between Olympus Mons, an enormous shield volcano, and Tharsis Montes, the three large shield volcanoes of the Tharsis bulge. The site is on the edge of an aureole lobe southeast of Olympus Mons, one of several lobes of ridged terrain that extend several hundred kilometers out from the base of Olympus Mons.

- b) Highly deformed terrain materials (unit Hf) consisting of fractured crustal rocks (success excellent; appear to be accessible within about 15 km from landing site);
- c) Aureole deposits, lower member (unit Aoa₁) of Olympus Mons (success excellent; within 15 km or less range from landing site).

Scientific Rationale

To obtain samples of very young (Upper Amazonian) lava flows and intermediate age (Hesperian) rocks together with materials forming aureole deposits of Olympus Mons.

Potential Problems

Lack of high-resolution (<50 m/pxl) images to better assess smoothness of landing area and mobility of rover to other location objectives.

Objectives

- a) Lava flows of upper member (unit Aop₁) of Olympus Mons Formation (success excellent; landing site smooth-appearing plains);

Trafficability

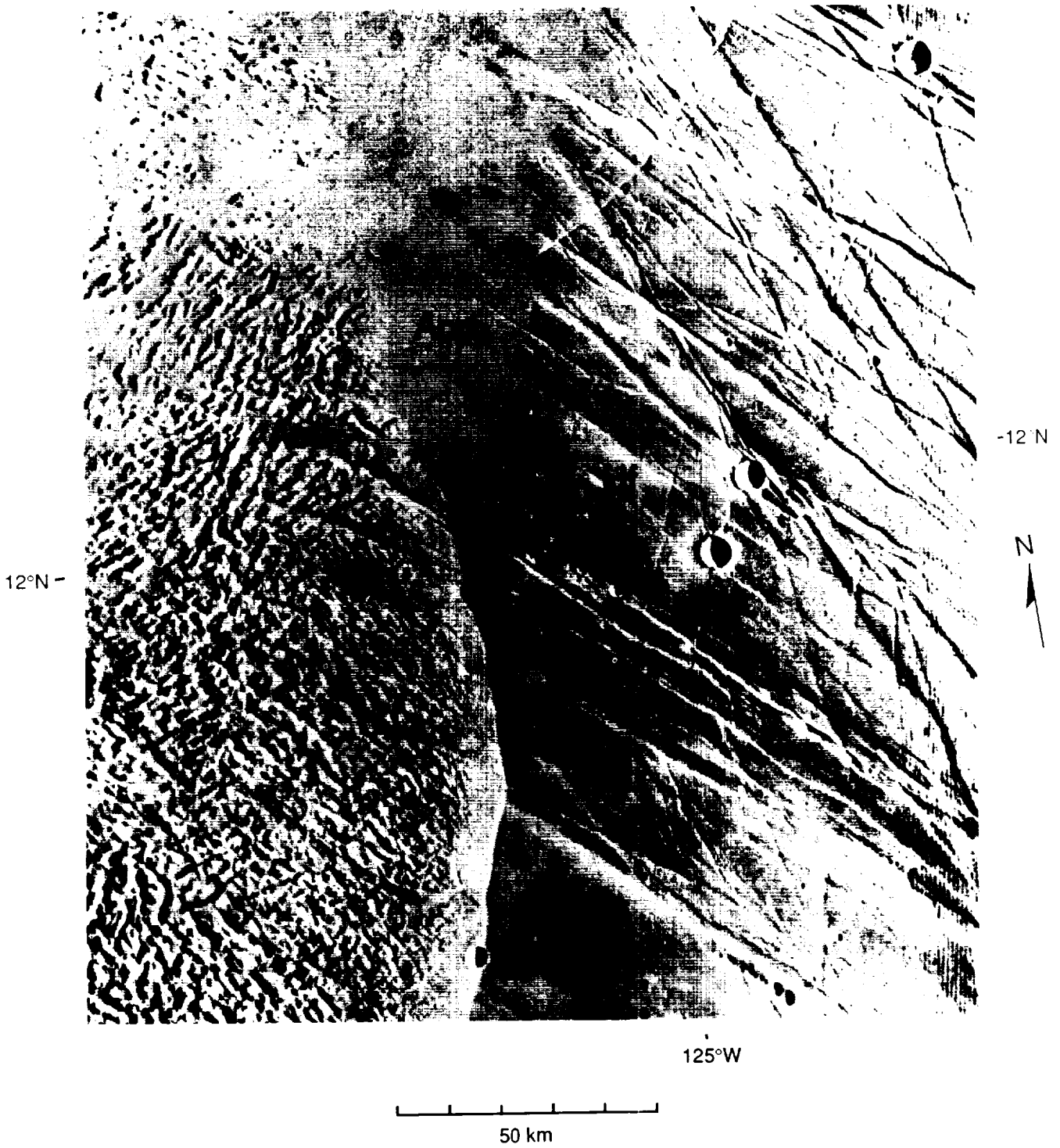
2.

Estimated Traverse Distance

30± km.

Site 056 THARSIS OLYMPUS

125°W



Viking Orbiter
890A41

⊗ Landing Site: 12.5° N Latitude, 125° W Longitude

David Scott

Site 057- Labeatis

Site 057

Site Name: Labeatis

Type of Site: Rover/Sample Return

Latitude: 25-30°N

Longitude: 81-83°W

Elevation: + 2.5 km

Maps: MC-10 NW

Viking Orbiter Images: 858A05,
858A03, 555A28

Date Entered: July, 1989

Date Last Revised: July, 1989

Contact:

David Scott
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff, AZ 86001
(602) 527-7188

Geologic Setting

Landing site consists of several possible sites along the linear contact between flows from Tharsis and flows from Lunae Planum. The area is cut by faults radiating outward from the Tharsis bulge.

Scientific Rationale

Nearly linear contact extending for 300+ km between young Hesperian (unit H₂) lava flows from Tharsis (probably Ascraeus Mons) and early Hesperian lava flows (unit Hr) of Lunae Planum.

Objectives

- a) Lava flows (unit H₂) from Tharsis Montes; these flows overlap (unconformably) the ridged plains (unit Hr) flows of Lunae

Planum (success excellent; terrain appears featureless and flat);

- b) Lava flows (unit Hr) of Lunae Planum; most widespread plains type of lava flows on Mars. Age very important for Mars chronology (success excellent; same as above with more faulting and small crater density).

Potential Problems

None envisioned, but high resolution images not available.

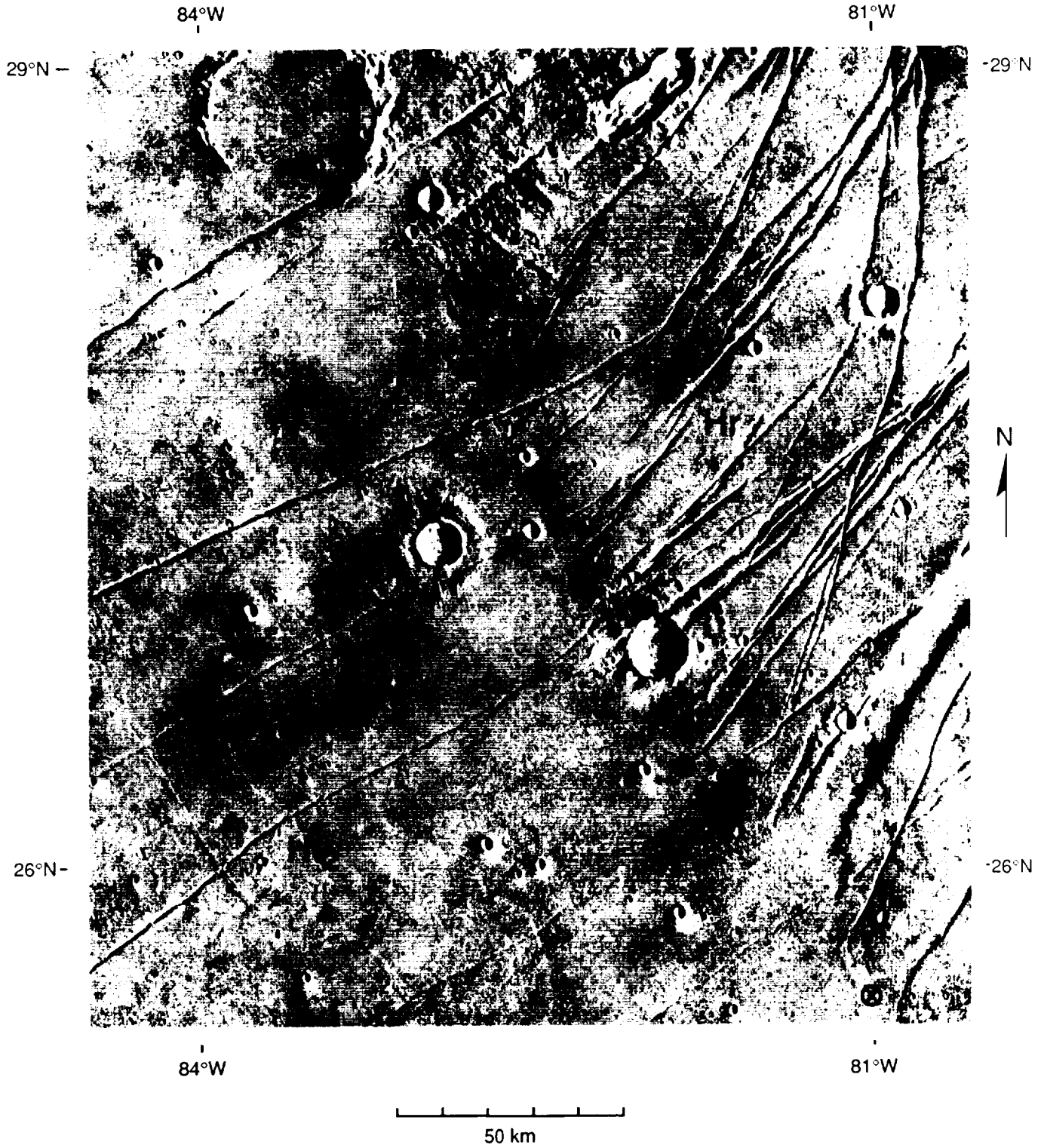
Trafficability

2.

Estimated Traverse Distance

<30 km.

Site 057 LABEATIS



Viking Orbiter
858A05

⊗ Landing Site: 25°- 30° N Latitude, 81°- 83° W Longitude

David Scott

Site 058- Chryse Planitia/Viking 1

Site 058

Site Name: Chryse Planitia/Viking 1

Type of Site: Rover/Sample Return

Latitude: 22.52°N

Longitude: 47.97°W

Elevation: - 2.2 km

Maps: MTM# 20047, 25047

Viking Orbiter Images: 20A44 through 20A53; 20A66 through 20A75; 452B10, 452B11

Date Entered: July, 1989

Date Last Revised: July, 1989

Contact:

Robert A. Craddock

CEPS/NASM 3101

Smithsonian Institution

Washington, D.C. 20560

(202) 357-1457

Geologic Setting

This site is dominated by Hesperian ridged plains material with wrinkle ridges (Xanthe Dorsa) that trend north-south. The Hesperian ridged plains are one of the most extensive units mapped on Mars.

Scientific Rationale

Obtain sample of Hesperian ridged plains, one of the most extensive units on the martian surface, and to conduct further scientific investigations in the vicinity of the Viking 1 lander. Design of the spacecraft is aided by "ground truth" observations made by the Viking lander, elevation of landing site, and latitude (i.e., line-of-site communication).

Objectives

a) Target A; land 2 km north of the Viking 1 landing site at 22.52°, 47.97°. Obtain contingency sample of Hesperian-age ridged plains, which compose one of the most extensive geologic units on Mars. Geologic mapping indicates that the age of the ridged plains represents the end of the period of heavy bombardment on Mars, so that an absolute age of these

materials will influence the age of all other martian geologic units (success: very high; depends on successful landing of rover and return vehicle, which is aided by surface photographs obtained by Viking 1);

- b) target B; obtain ejecta sample from crater formed by jettisoned Viking aeroshell located approximately 1 km south of the proposed landing site (or approximately 1 km north of the Viking 1 landing site). Collected samples would represent material to a depth of about 2 m, eliminating the need for a drill aboard the rover (success: high; depends on targeting ability before and after landing);
- c) target C; obtain sample of the Viking 1 lander (e.g., sampler shroud) to determine weathering rates on Mars, obtain soil/rock samples from Viking landing site, conduct range of complementary science experiments in the vicinity of the lander, photograph the lander, and send radio commands to turn lander antennae back towards Earth (success: high; depends on ability to direct rover to Viking 1 position. Trafficability will be poor based on Viking photographs, but rover

will probably be designed to cope with this type of terrain). Return to landing site (target A) before beginning the second phase of the mission;

- d) target D; obtain samples of Xanthe Dorsa ridge from proposed landing site to San Juan crater. Photographs of the ridge in various places may aid in the understanding of ridge formation. Ejecta material from San Juan would represent material to a depth of approximately 50 m (success: high; depends on the performance of the roving vehicle in rocky terrain. Navigation should be aided by the presence of the wrinkle ridge);
- e) target E; obtain ejecta samples from the rampart crater, Yorktown, to determine possible ejecta flow mechanism (e.g.,

volatiles in target material). Observe distribution of coarse/fine material during traverse to determine possible Chryse channel-forming mechanism(s) (success: high to moderate; depends on durability of rover). Return to landing site (target A) to complete second phase of the mission.

Potential Problems

To be determined.

Trafficability

3.

Estimated Traverse Distance

100 km.

Site 058 CHRYSE PLANITIA/VIKING 1

48° W

23° N -

- 23° N

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ORIGINAL PAGE
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22° N -

- 22° N



48° W



30 km

MTM 20047 and MTM 25047

⊗ Landing Site 22.52° N Latitude, 47.97° W Longitude

Robert A. Craddock

Site 059- Amenthes Southeast

Site 059

Site Name: Amenthes Southeast

Type of Site: Penetrator

Maps: MC-14 SE, SW

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 4°N

Longitude: 247°W

Elevation: + 1 to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Heavily cratered terrain southwest of Nepenthes Mensae with old degraded craters and rough intercrater surface resulting from eolian and fluvial erosion. Old highland material with fluvial and eolian material inside the craters.

Scientific Rationale

Ancient highlands.

Objectives

Obtain composition of ancient highlands material, local seismic information (possibly

global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 059 AMENTHES SOUTHEAST

250° W

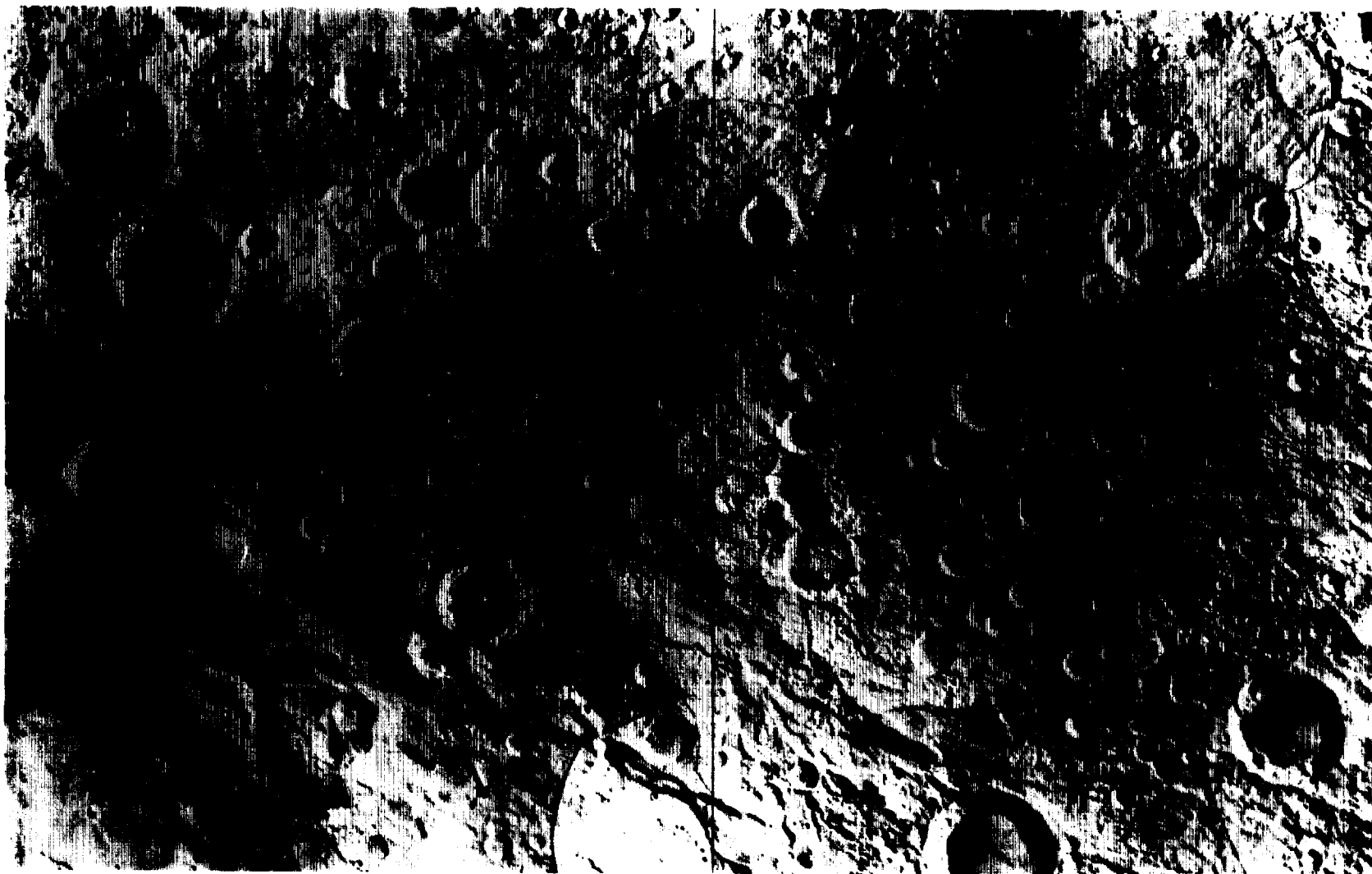
245° W

5°N -

-5°N

144

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BLACK AND WHITE PHOTOGRAPH



250° W

245° W

100 km

MC - 14 SE and SW

⊗ Landing Site: 4° N Latitude, 247° W Longitude

U.S./Soviet Group

Site 060- Isidis North

Site 060

Site Name: Isidis North

Type of Site: Balloon

Maps: MC-6 SE, SW; MC-13 NE;
MC-14 NW; 1:15M (I-1321)

Viking Orbiter Images: Numerous
images

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 36°N to 16°N

Longitude: 282°W to 267°W

Elevation: - 1 km to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

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Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The area is located northeast of Syrtis Major, a low relief volcano. The area is cut by graben (Nili Fossae) which trend southwest-northeast. To the southeast is Isidis Planitia, an ancient impact basin.

Scientific Rationale

Geologic and meteorologic assessment of the Isidis basin.

Objectives

Obtain composition of ancient plateau sequence, knobby plains (volcanic?), smooth

plains, grooved member of Vastitas Borealis Formation (lava flows, alluvium which have undergone compaction or periglacial processes).

Potential Problems

To be determined.

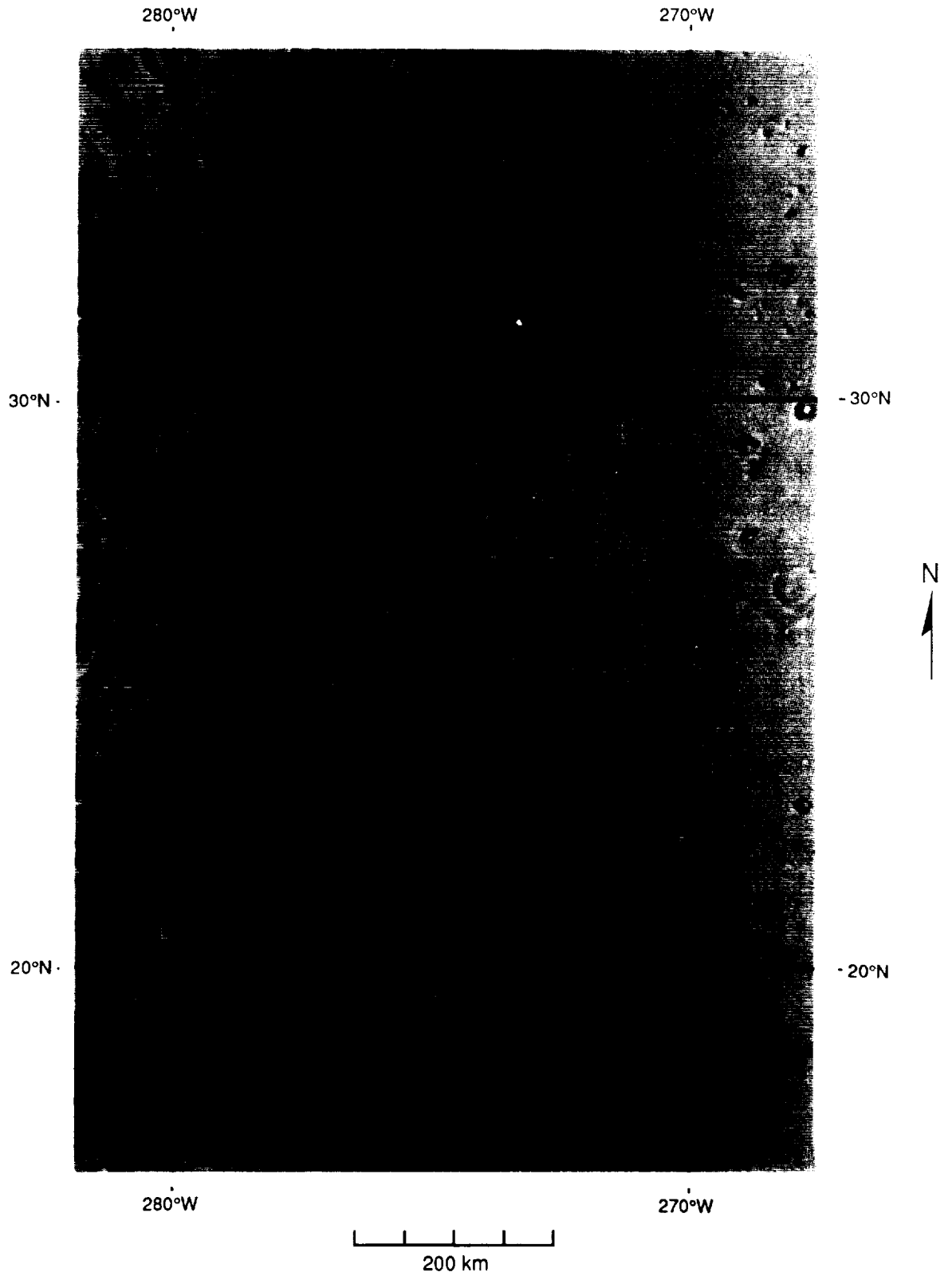
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 060 ISIDIS NORTH



1:15 M USGS I-1321

Site: 16°N-36°N Latitude, 267°W-282° W Longitude

U.S./Soviet Group

Site 061- Arabia

Site 061

Site Name: Arabia

Type of Site: Penetrator

Maps: MC-5 SC, MC-12 NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 30°N

Longitude: 327°W

Elevation: + 1 to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

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Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Site lies on ancient ridged plains, just north of the large crater Cassini. Ridged plains material is interpreted to be of volcanic origin. Impact crater density is high and implies Noachian age. If the volcanic interpretation is correct, these are some of the oldest volcanic materials on the planet. Because of the substantial age of the region, geologic modification may have been quite significant; in particular, crater-filling sediments and crater ejecta deposits excavated from below the ridged plains material may be common.

Scientific Rationale

Ancient volcanics, ridged plains.

Objectives

Obtain composition of ancient volcanics, ridged plains, local seismic information

(possibly global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 061 ARABIA



MC -12NE and 5SC

⊗ Landing Site: 30° N Latitude, 327° W Longitude

U.S./Soviet Group

Site 062- Hadriaca

Site 062

Site Name: Hadriaca

Type of Site: Penetrator

Maps: MC-28 NW, NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 36°S

Longitude: 271°W

Elevation: 0 to + 1 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

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Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Northeast margin of Hellas basin composed of volcanics of Hadriaca Patera. The smoothed plain-like surface tilted to southeast is complicated by southwest-northeast grooves. At southeast the plain is dissected by Dao Vallis, at northwest the relic of highly cratered terrain. Volcanic material (possibly pyroclastic) of intermediate age, material of cratered highland, lahar deposits.

Scientific Rationale

Intermediate volcanics.

Objectives

Obtain composition of intermediate volcanics, local seismic information (possibly global

in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 062 HADRIACA

272.5° W

267.5° W

32.5° S -

- 32.5° S

150

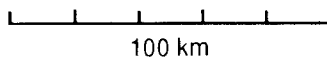
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37.5° S -

- 37.5° S

272.5° W

267.5° W



100 km



ASU - IPF 710

⊗ Landing Site: 36° S Latitude, 271° W Longitude

U.S./Soviet Group

Site 063- Arabia South

Site 063

Site Name: Arabia South

Type of Site: Penetrator

Maps: MC-12 SE, NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 15°N

Longitude: 333°W

Elevation: + 1 to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The site is located within the ancient cratered highlands. This is one of the few areas of the cratered highlands that lies below the +2 km contour. The area is dissected by numerous finely branching river valleys and the area between the large craters is gently rolling, thereby indicating that younger intercraters plains are largely absent, and that the old highland surface is exposed.

Scientific Rationale

Ancient highlands.

Objectives

Obtain composition of ancient highland material, local seismic information (possibly

global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

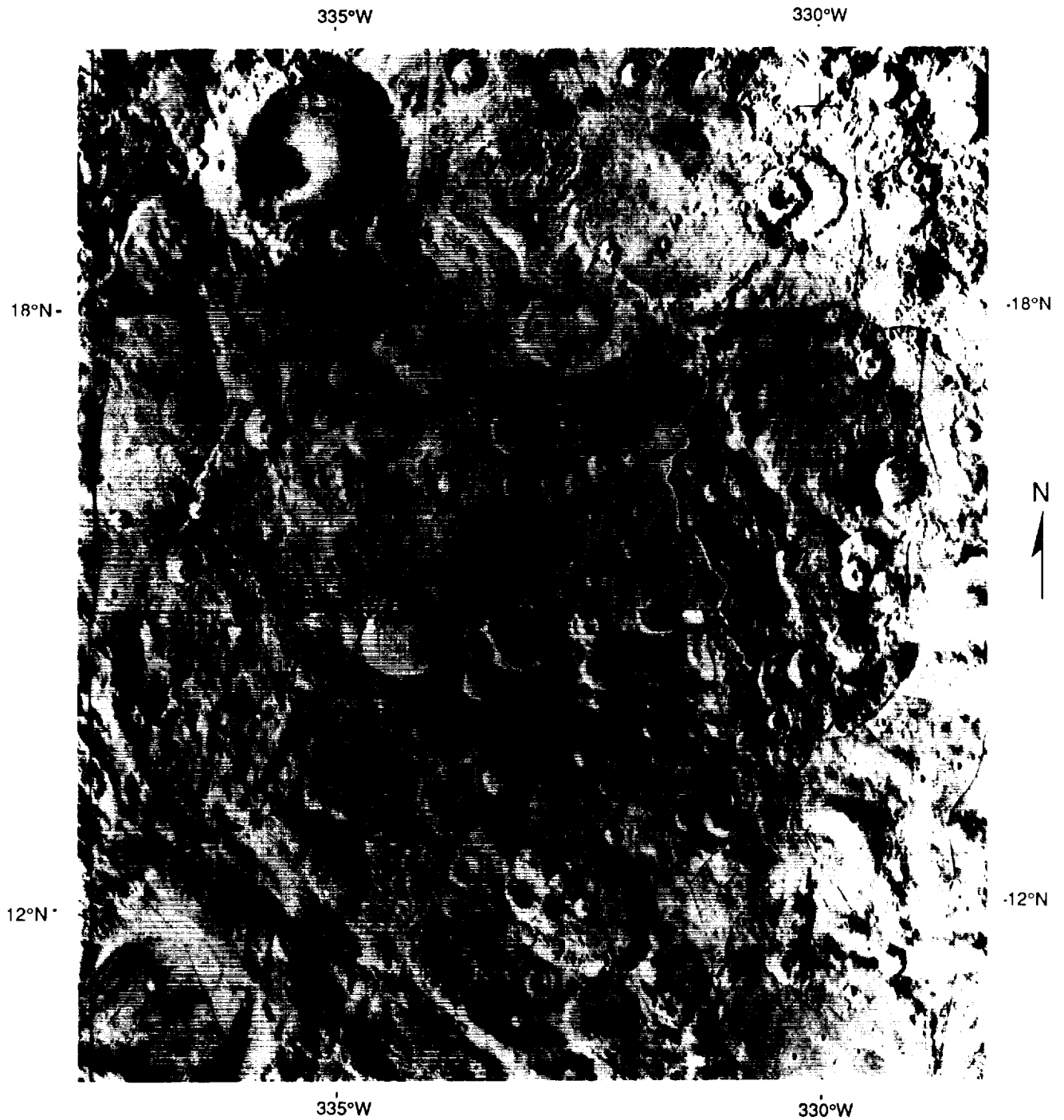
Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 063 ARABIA SOUTH



MC -12NE and SE

⊗ Landing Site: 15° N Latitude, 333° W Longitude

Steve Squyres

Site 064- Isidis Planitia

Site 064

Site Name: Isidis Planitia

Type of Site: Penetrator

Latitude: 10°N

Longitude: 275°W

Elevation: - 2 to - 3 km

Maps: MC-13 SE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Site lies on the floor of the Isidis basin on volcanic plains of intermediate age. Distinct lava flows are not observed. The area is dominated by numerous small cones, presumed to be volcanic in origin, aligned in chains as if above curvilinear fissure vents. Cones frequently have elongate pits at their summits. Post-volcanic mantling in this region appears minor.

conjunction with other penetrators), meteorology, and photogeology.

Scientific Rationale

Small volcanic cones.

Potential Problems

To be determined.

Objectives

Obtain composition of volcanic materials, local seismic information (possibly global in

Trafficability

Not applicable.

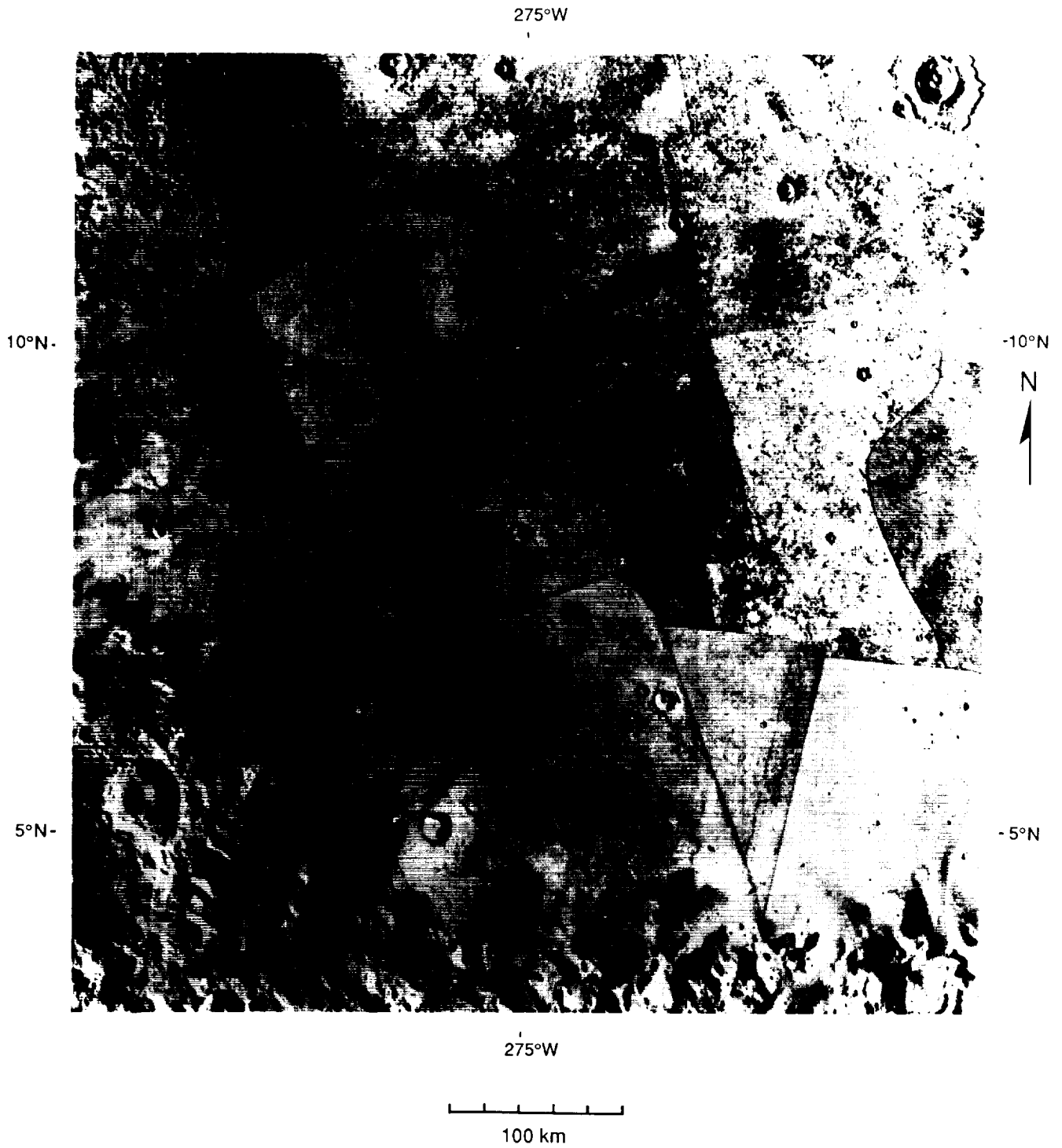
Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 064 ISIDIS PLANITIA



MC -13SE

⊗ Landing Site: 10° N Latitude, 275° W Longitude

U.S./Soviet Group

Site 065- Utopia

Site 065

Site Name: Utopia

Type of Site: Penetrator

Maps: MC-6 SE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 45°N

Longitude: 251°W

Elevation: - 2 to - 3 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Site lies at a low elevation on Utopia Planitia. This region is believed to be the primary site of deposition for water and mud flows that were produced by volcano-ground ice interactions in the Elysium region to the southeast. Waterlain sediments may be the dominant materials at the site. In addition, the high latitude of the site substantially improves the possibility that ground ice could be preserved. Post-fluvial modification of the area of various sorts has probably taken place, and volcanic and eolian materials may also be present along with aqueous sediments.

Scientific Rationale

Sediments, ground ice, lahars(?) from Elysium.

Objectives

Obtain composition of sediments (aqueous, volcanic, aeolian?), determine if ground ice is present, local seismic information (possibly global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

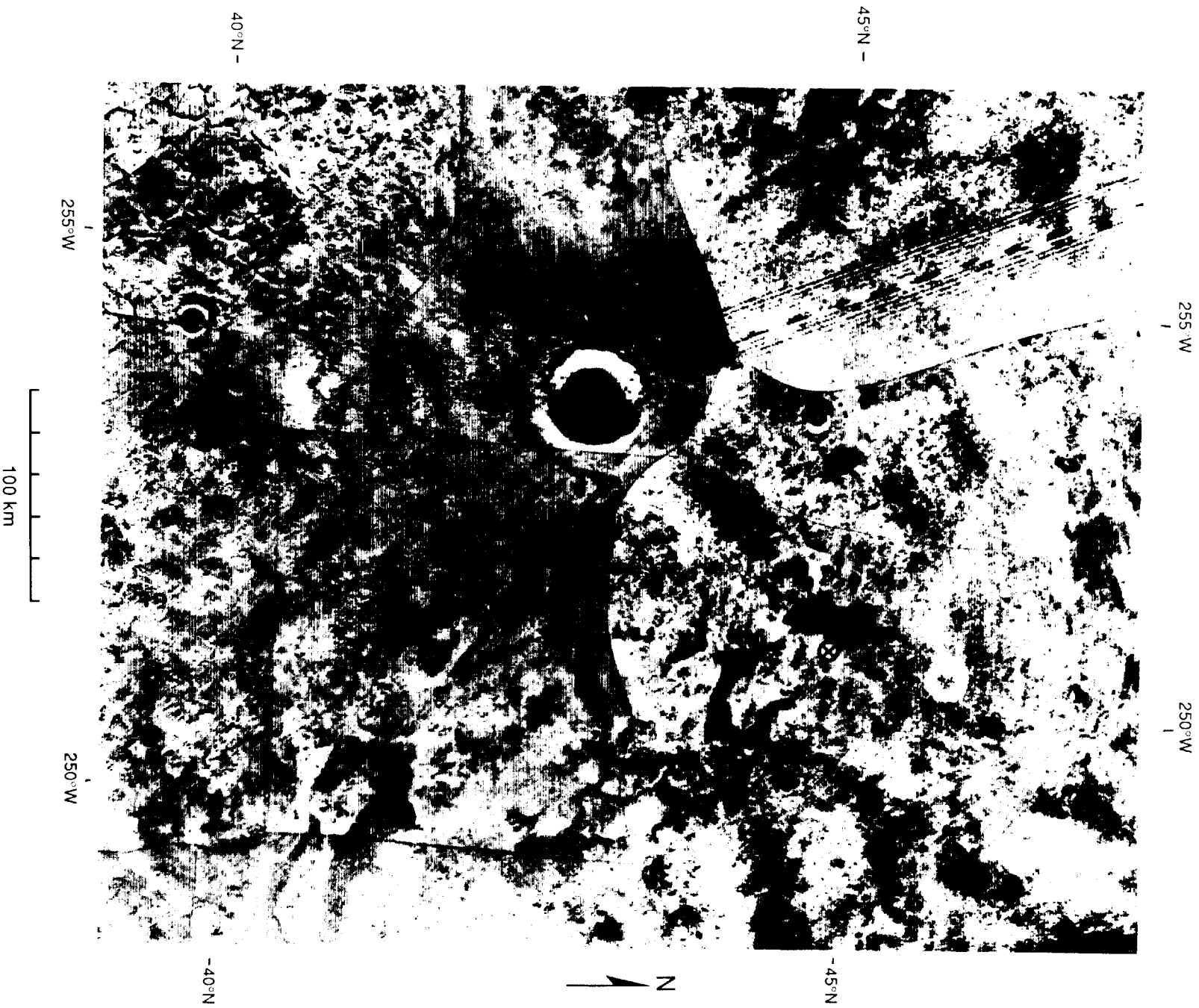
Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 065 UTOPIA



MC-6SE

⊗ Landing Site: 45° N Latitude, 251° W Longitude

U.S./Soviet Group

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ORIGINAL PHOTOGRAPH
BLACK AND WHITE PHOTOGRAPH

Site 066- Elysium Southwest

Site 066

Site Name: Elysium Southwest
Type of Site: Penetrator

Maps: MC-15 NW, MC-14 NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 17°N

Longitude: 224°W

Elevation: - 1 to 0 km

Contact:

US/Soviet Landing Site Working Grp.
Michael Carr
U.S. Geological Survey, MS 946
Branch of Astrogeological Studies
345 Middlefield Road
Menlo Park, CA 94025
(415) 323-8111

Geologic Setting

700 km southwest of summit of Elysium Mons on Member 1 (oldest unit) of the Elysium Formation. Consists of lobate, plains-forming deposits that overlie and embay units from Albor Tholus and Hecates Tholus. Ellipse includes relatively fresh impact craters, some as large as 50 km. Wind streaks indicate presence of aeolian material. Bright streaks show winds predominantly from the east.

Scientific Rationale

Flows, intermediate volcanic.

Objectives

Obtain composition of intermediate volcanic materials, local seismic information (possi-

bly global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

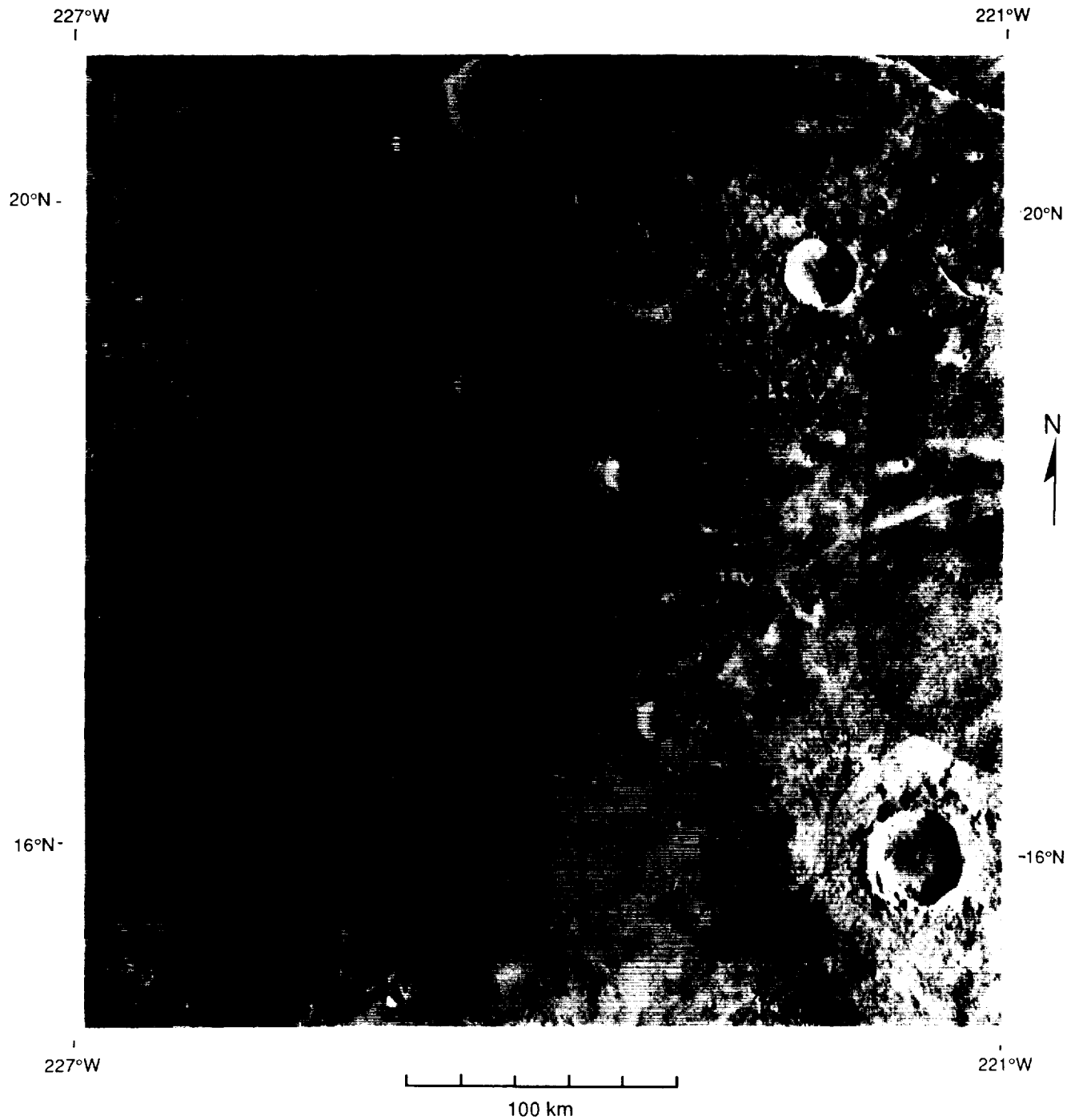
Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 066 ELYSIUM SOUTHWEST



MC -14NE and 15NW

⊗ Landing Site: 17° N Latitude, 224° W Longitude

U.S./Soviet Group

Site 067- Elysium South

Site 067

Site Name: Elysium South

Type of Site: Balloon

Maps: MC-14 SE, MC-15 SW,
MC-22 NE, MC-23 NW; 1:15M (I-1321)

Viking Orbiter Images: Numerous
images

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 7°N to 4°S

Longitude: 232°W to 205°W

Elevation: - 1 km to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The area is located southwest of Elysium Mons, a large shield volcano. The area is predominantly smooth plains with young channels and flood plains located to the east.

Scientific Rationale

Geologic and meteorologic assessment of northern plains and its boundary with the southern cratered uplands.

Objectives

Obtain composition of smooth plains, ancient plateau sequence possible lava flows

and pyroclastics, and fluvial deposits, meteorology, and photogeology.

Potential Problems

To be determined.

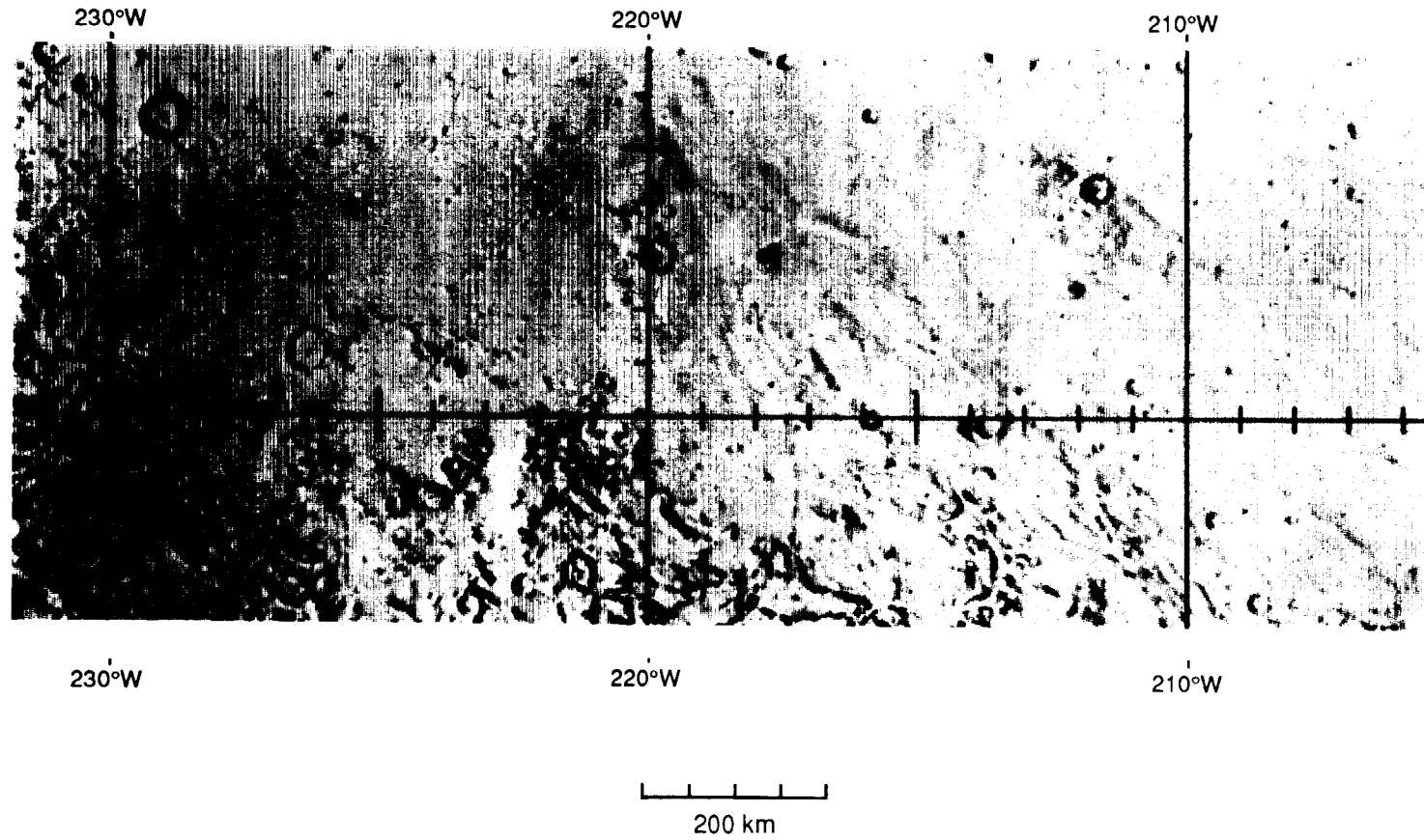
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 067 ELYSIUM SOUTH



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1:15 M USGS I-1321

Site: 4°S-7°N Latitude, 205°W-232° W Longitude

U.S./Soviet Group

Site 068- Medusae Fossae

Site 068

Site Name: Medusae Fossae

Type of Site: Penetrator

Maps: MC-16 NW, NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 2°S

Longitude: 159°W

Elevation: + 1 to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The site is located entirely within a thick, easily erodible sedimentary deposit that overlies volcanic plains and highlands in the area. The origin of these deposits is controversial. One possibility is that the deposits are thick sequences of pyroclastic deposits of ignimbrites. Another hypothesis is that they are analogous to the present polar layered terrain and formed when one of the poles was at this location. If ignimbrites, the deposits may have formed as a result of more silicic volcanism than the lava plains.

Scientific Rationale

Volcanics (silicic?).

Objectives

Obtain composition of volcanics (silicic?) and composition of sediments (polar layered

terrain?), local seismic information (possibly global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

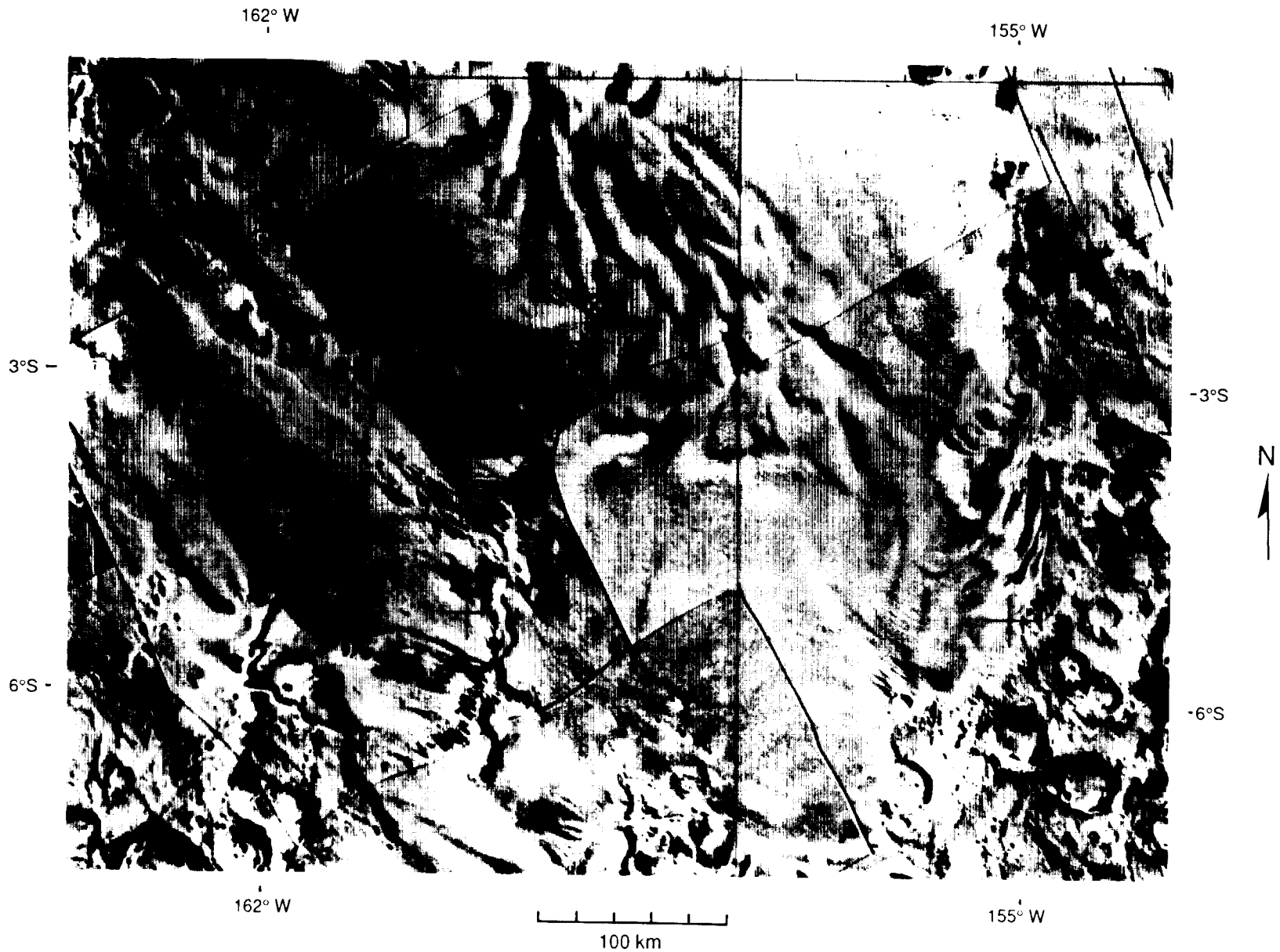
Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 068 MEDUSAE FOSSAE



ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

MC - 16NE and NW

⊗ Landing Site: 2° S Latitude, 159° W Longitude

U.S./Soviet Group

Site 069- Olympus South

Site 069

Site Name: Olympus South
Type of Site: Penetrator

Latitude: 11°N
Longitude: 137°W
Elevation: + 1 to + 2 km

Maps: MC-8 SE, MC-9 SW

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.
Michael Carr
U.S. Geological Survey, MS 946
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Menlo Park, CA 94025
(415) 323-8111

Geologic Setting

300 km south-southwest of Olympus Mons scarp. Consists of young volcanic plains member of the Olympus Mons Formation; includes lobate to smooth lava flows possibly erupted from fissure vents. Bright wind streaks indicate presence of windblown material and winds predominantly from the east. Relatively few superposed impact craters.

conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Scientific Rationale

Young volcanics.

Estimated Traverse Distance

Not applicable.

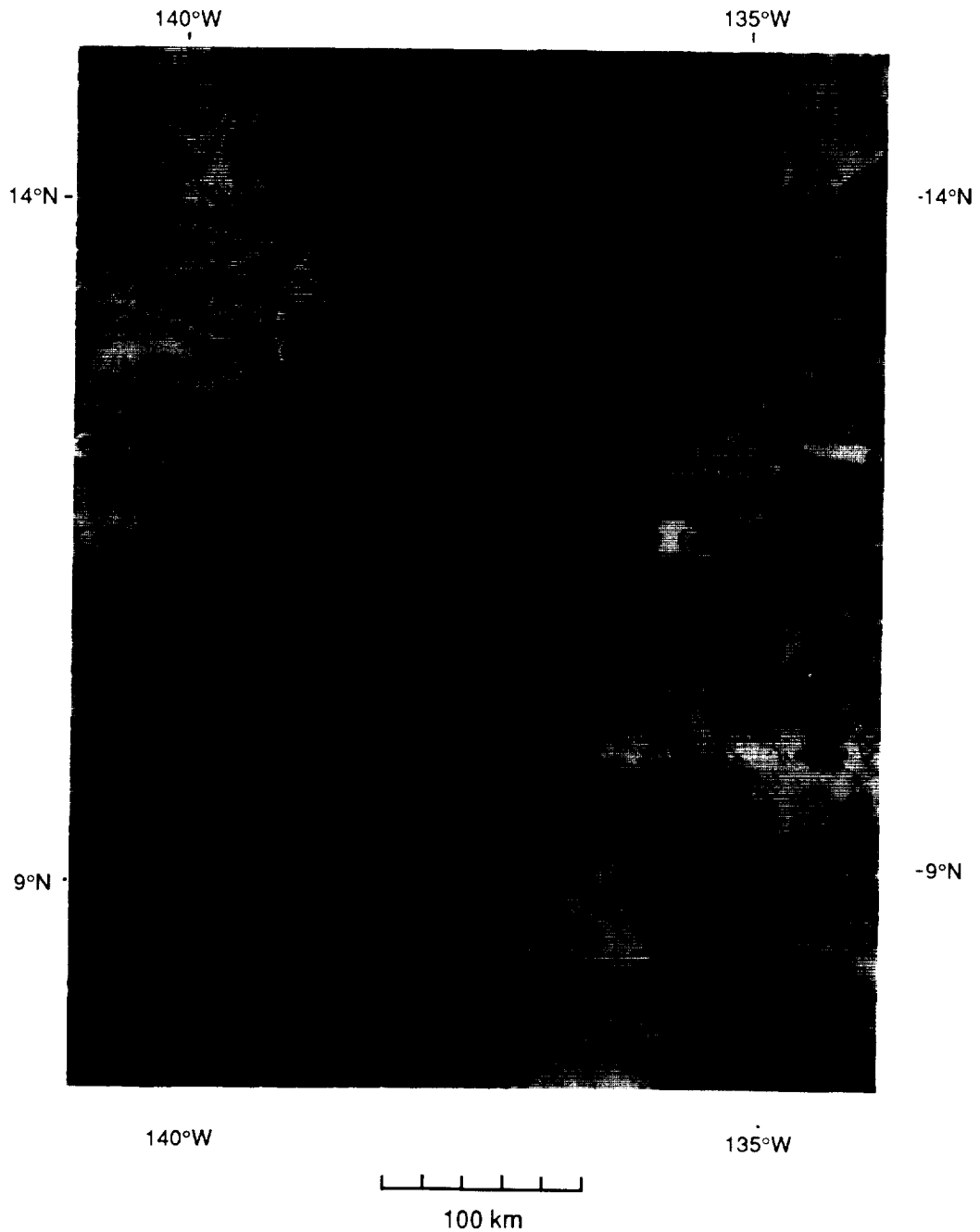
Objectives

Obtain composition of volcanic materials, local seismic information (possibly global in

Other

Landing circle size is 150 km radius.

Site 069 OLYMPUS SOUTH



MC - 8SE and 9SW

⊗ Landing Site: 11° N Latitude, 137° W Longitude

U.S./Soviet Group

Site 070- Alba West

Site 070

Site Name: Alba West
Type of Site: Penetrator

Latitude: 45°N
Longitude: 126°W
Elevation: + 1 km

Maps: MC-2 SE

Viking Orbiter Images:

Date Entered: 25 July 1989
Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.
Michael Carr
U.S. Geological Survey, MS 946
Branch of Astrogeological Studies
345 Middlefield Road
Menlo Park, CA 94025
(415)323-8111

Geologic Setting

Site lies on volcanic plains of intermediate age, west of Alba Patera. Volcanic flow fronts are observed, but are less distinct than on younger Alba volcanic materials. Low ridges may indicate that flows were tube-fed. Some eolian mantling of the flows is likely, and the high latitude suggests that ground ice could be present.

information (possibly global in conjunction with other penetrators), meteorology, and photogeology.

Scientific Rationale

Intermediate volcanics.

Potential Problems

To be determined.

Objectives

Obtain composition of volcanic material, detect ground ice if present, local seismic

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 070 ALBA WEST

125° W



166

ORIGINAL SOURCE:
BLACK AND WHITE PHOTOGRAPH

MC - 2SE

⊗ Landing Site: 45° N Latitude, 126° W Longitude

U.S./Soviet Group

Site 071- Kasei South (Euchus Chasma)

Site 071

Site Name: Kasei South (Euchus Chasma)

Type of Site: Penetrator

Maps: MC-10 SW

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 10°N

Longitude: 80°W

Elevation: + 1 km to 0 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

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345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Young volcanic plains of Tharsis; consists of Member At5 of the Tharsis Montes Formation; smooth to lobate flows from the west (some of the youngest of the Tharsis area). Bright wind streaks suggest aeolian deposits and winds predominantly from the west-southwest. Eastern third of landing ellipse is in the channel of Euchus Chasma.

Scientific Rationale

Young volcanics.

Objectives

Obtain composition of volcanic material and possibly fluvial sediments, local seismic in-

formation (possibly global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 071 KASEI SOUTH (EUCHUS CHASMA)



MC -10SW

⊗ Landing Site: 10° N Latitude, 80° W Longitude

U.S./Soviet Group

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ORIGINALLY
BLACK AND WHITE PHOTOGRAPH

Site 072- Candor Chasma II

Site 072

Site Name: Candor Chasma II
Type of Site: Penetrator

Maps: MC-18 NW

Viking Orbiter Images:

Date Entered: 25 July 1989
Date Last Revised: 25 July 1989

Latitude: 6°S
Longitude: 73°W
Elevation: 0 km to - 1 km

Contact:
US/Soviet Landing Site Working Grp.
Michael Carr
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Branch of Astrogeological Studies
345 Middlefield Road
Menlo Park, CA 94025
(415) 323-8111

Geologic Setting

The site straddles both Ophir and Candor Chasmas. The areas covered have several kilometers of relief from the floors of the canyons to the volcanic plateau in which the canyons are cut. Within the canyons is a thick sequence of sediments that is believed to be waterlain. The main interest of the site is the waterlain sediments of intermediate age.

Scientific Rationale

Sediments, igneous rocks(?).

Objectives

Obtain composition of sediments (aqueous?), local seismic information (possibly global in

conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 072 CANDOR CHASMA II



MC -18NW

⊗ Landing Site: 6° S Latitude, 73° W Longitude

U.S./Soviet Group

Site 073- Lunae Planum East

Site 073

Site Name: Lunae Planum East
Type of Site: Penetrator

Latitude: 16°N
Longitude: 63°W
Elevation: + 1 km to + 2 km

Maps: MC-10 SE, NE

Viking Orbiter Images:

Date Entered: 25 July 1989
Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.
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(415) 323-8111

Geologic Setting

Site is 450 km west-southwest of boundary with Chryse Planitia. Ridged plains of presumed volcanic origin (lunar mare-type; flood lavas?). Ridges trend north-south; fresh impact craters to 30 km in diameter occur within the ellipse.

Scientific Rationale

Ridge plains, intermediate volcanics.

Objectives

Obtain composition of ridged plains, volcanic material, local seismic information (possibly global in conjunction with other

penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 073 LUNAE PLANUM EAST



100 km

MC -10NE and SE

⊗ Landing Site: 16° N Latitude, 63° W Longitude

U.S./Soviet Group

Site 074- Capri Chasma

Site 074

Site Name: Capri Chasma
Type of Site: Penetrator

Latitude: 14°S
Longitude: 46°W
Elevation: - 1 km to - 2 km

Maps: MC-18 NE, SE; MC-19 NW, SE

Viking Orbiter Images:

Date Entered: 25 July 1989
Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.
Michael Carr
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345 Middlefield Road
Menlo Park, CA 94025
(415) 323-8111

Geologic Setting

The site lies almost wholly within Capri Chasma at the eastern end of Valles Marineris. Waterlain sediments and erosional remnants of the pre-canyon surface covers most of the site. The main interest of the site is the sediments, which could give an indication of whether the canyon did at one time contain standing water. A secondary objective at the site is to sample the ancient volcanoes and highland into which the canyons are cut.

Scientific Rationale

Sediments, igneous rocks(?).

Objectives

Obtain composition of sediments (aqueous?), and ancient volcanics, local seismic informa-

tion (possibly global in conjunction with other penetrators), meteorology, and photo-geology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 074 CAPRI CHASMA

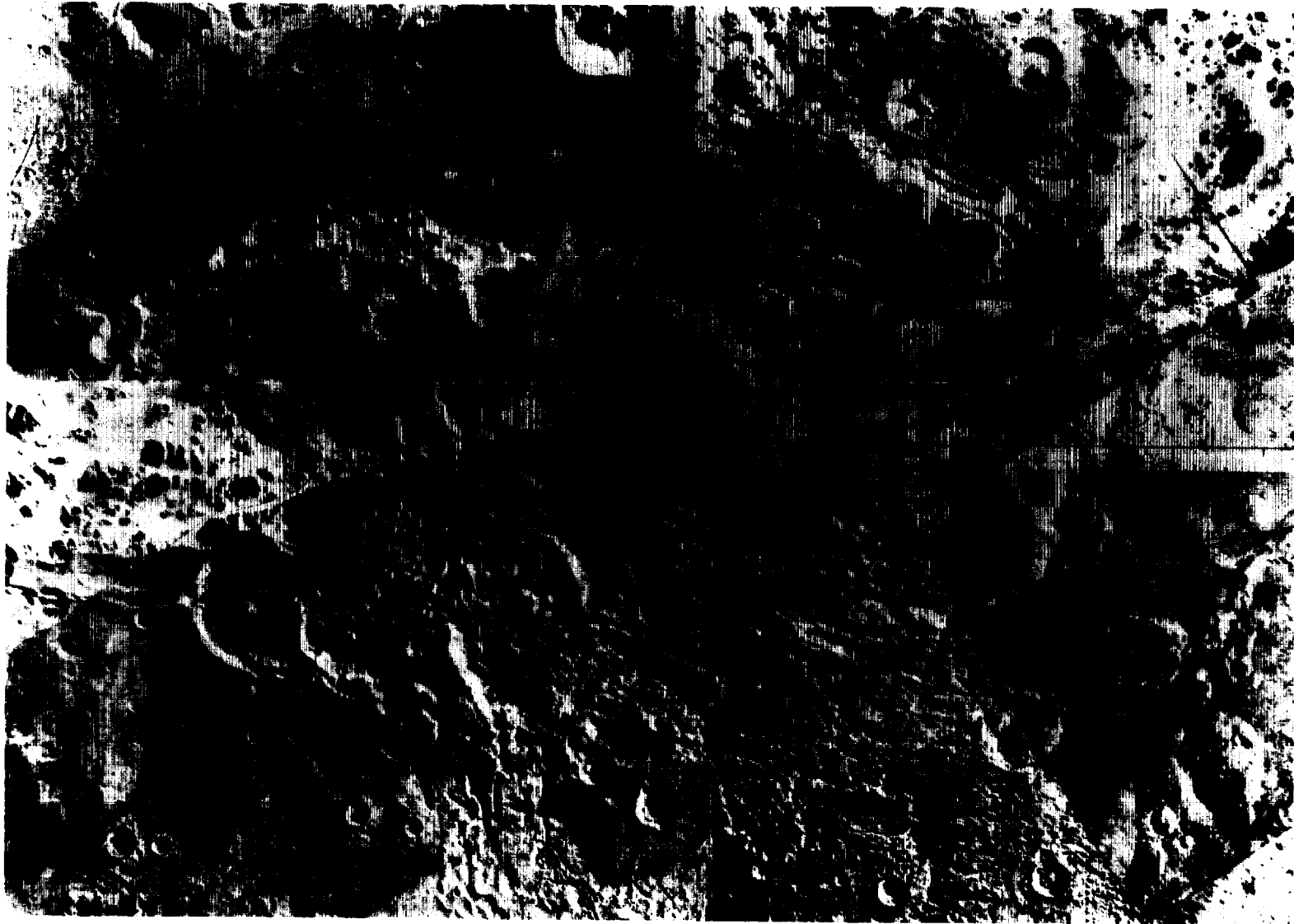
50°W

40°W

11°S -

-11°S

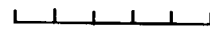
174



19°S -

-19°S

50°W



100 km

40°W

MC - 18NE, SE; 19NW, SW

⊗ Landing Site: 14° S Latitude, 46° W Longitude

U.S./Soviet Group

GENERAL PLAN
BLACK AND WHITE PHOTOGRAPH

Site 075- Meridiani Southwest (Margaritifer Terra)

Site 075

Site Name: Meridiani Southwest (Margaritifer Terra)

Type of Site: Penetrator

Maps: MC-19 NE

Viking Orbiter Images:

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 12°S

Longitude: 7°W

Elevation: + 1 km to + 2 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

Ancient heavily cratered terrain carved by fluvial and eolian processes. Ancient highland material and remnants of sedimentary mantle.

Scientific Rationale

Ancient highlands.

Objectives

Obtain composition of ancient highland material and sedimentary mantle (aeolian, fluvial?), local seismic information (possibly

global in conjunction with other penetrators), meteorology, and photogeology.

Potential Problems

To be determined.

Trafficability

Not applicable.

Estimated Traverse Distance

Not applicable.

Other

Landing circle size is 150 km radius.

Site 075 MERIDIANI SOUTHWEST
(MARGARITIFER TERRA)



MC -19NE

⊗ Landing Site: 12° S Latitude, 7° W Longitude

U.S./Soviet Group

Site 076- Tempe

Site 076

Site Name: Tempe

Type of Site: Balloon

Maps: MC-4 SW, MC-10 NE; 1:15M (I-1320)

Viking Orbiter Images: Numerous images

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Latitude: 17°N to 40°N

Longitude: 60°W to 61°W

Elevation: 0 km to + 1 km

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

U.S. Geological Survey, MS 946

Branch of Astrogeological Studies

345 Middlefield Road

Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The area is located northeast of the Tharsis Bulge and north of Kasei Vallis, a major outflow channel.

Scientific Rationale

Geologic and meteorologic assessment of Tempe Terra Plateau.

Objectives

Obtain composition of ancient plateau sequence subsequently eroded by decay of

ground ice, fluvial processes, ridged plains, and channel material.

Potential Problems

To be determined.

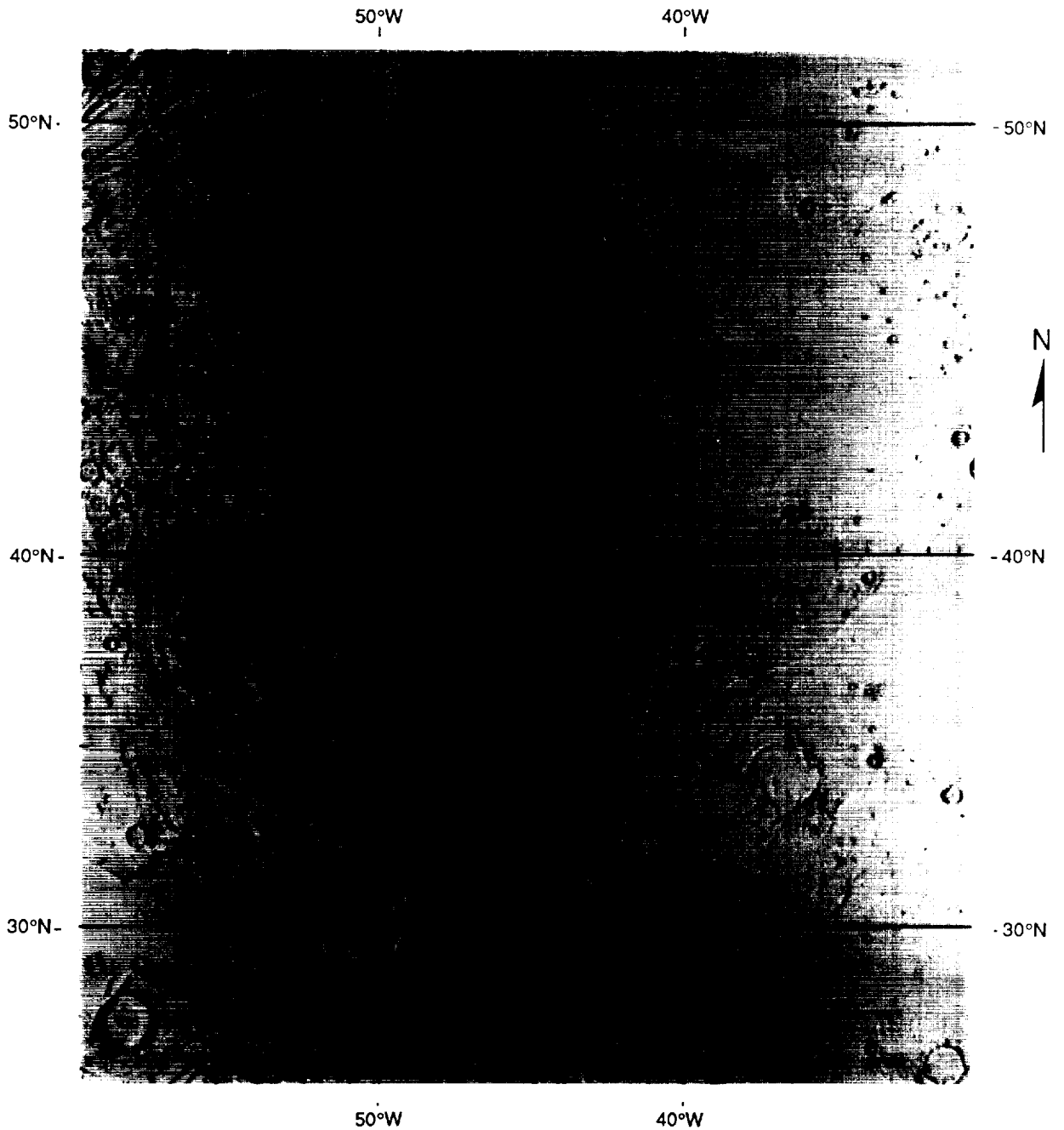
Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

Site 076 TEMPE



1:15 M USGS I-1320

Site: 25°N-52°N Latitude, 30°W-60° W Longitude

U.S./Soviet Group

Site 077- Ares

Site 077

Site Name: Ares

Type of Site: Balloon

Latitude: 10°N to 13°S

Longitude: 0°W to 25°W

Elevation: - 1 km to + 1 km

Maps: MC-11 SE, SW; MC-19 NE, NW;
1:15M (I-1320)

Viking Orbiter Images: Numerous
images

Date Entered: 25 July 1989

Date Last Revised: 25 July 1989

Contact:

US/Soviet Landing Site Working Grp.

Michael Carr

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Menlo Park, CA 94025

(415) 323-8111

Geologic Setting

The area is located near Ares Valles, a major outflow channel with its source area (chaotic terrain) amidst ancient highlands.

terrain. There are also some local patches of ridged plains material.

Scientific Rationale

Geologic and meteorologic assessment of the Ares Valles outflow channel region.

Potential Problems

To be determined.

Objectives

Obtain composition of ancient highland assemblages, channel material, and chaotic

Trafficability

To be determined.

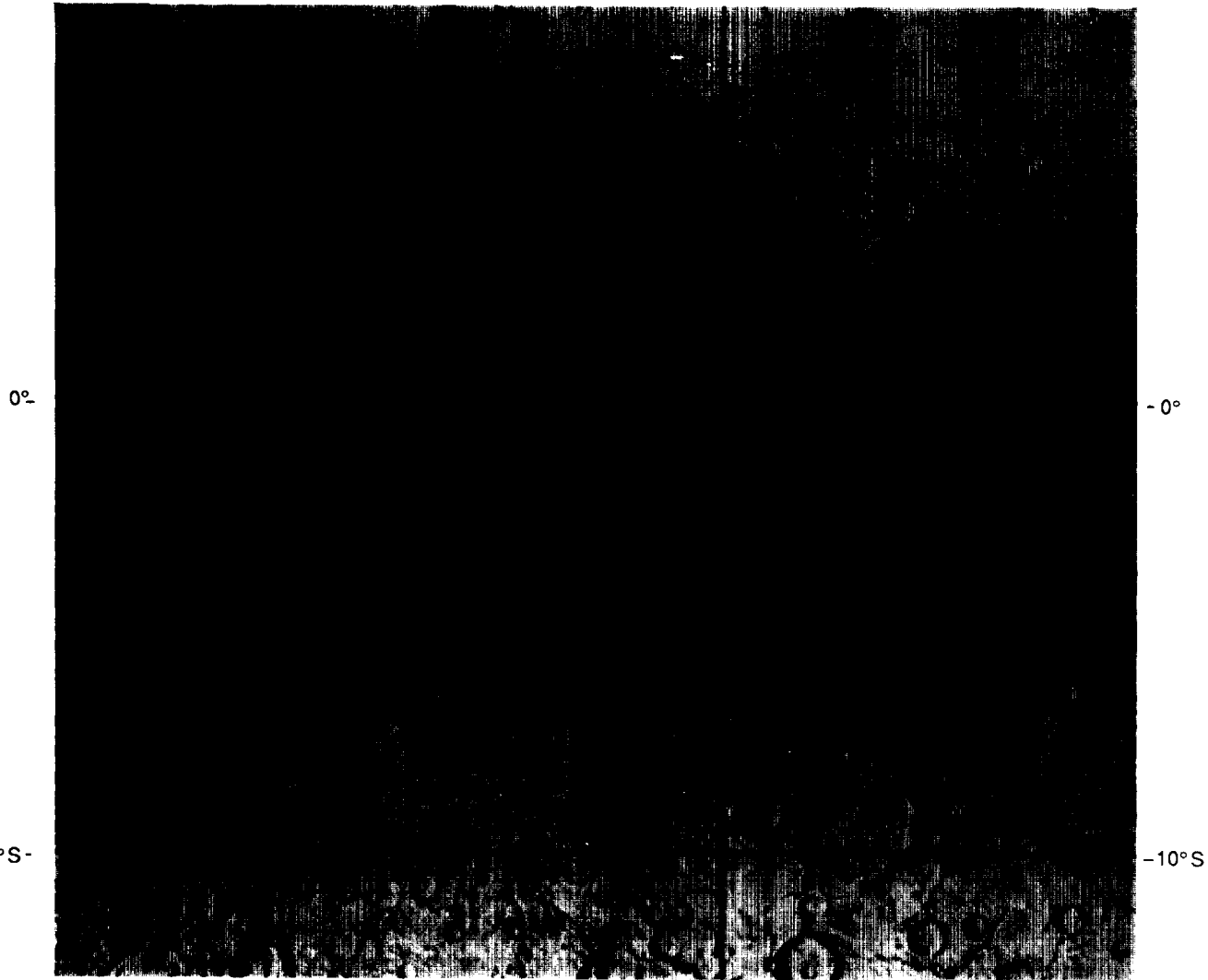
Estimated Traverse Distance

To be determined.

Site 077 ARES

20°W

10°W



0°

-0°

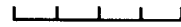


10°S-

-10°S

20°W

10°W



200 km

180

BLACK AND WHITE PHOTOGRAPH

Site 078- Tempe Fossae

Site 078

Site Name: Tempe Fossae

Type of Site: Rover/Sample Return

Latitude: 40°N

Longitude: 76.5°W

Elevation: + 2 km

Maps: MC-3 SE

Viking Orbiter Images: 704B49 through 704B54; 857A29 through 857A31

Date Entered: August 1989

Date Last Revised: August 1989

Contact:

Claudine Madras
c/o Richard P. Binzel
M.I.T., Bldg. 54-418
Cambridge, MA 02139
(617) 253-6486

Geologic Setting

Noachian and Hesperian age uplands north-east of the Tharsis volcanic province; consists predominantly of volcanic materials that have been fractured by Tharsis-related tectonism.

Scientific Rationale

Investigation of subsurface water for potential use by manned landing mission.

Objectives

- a) Measure the characteristics of the permafrost layer: composition depth and local variability (success high);

- b) Utilization experiments: ability to harvest by a potential manned mission (success high);
- c) Study the surface chemistry as a follow-up to the Viking experiments (success high);
- d) Search for evidence of life (success medium).

Potential Problems

Constraints include range of the rover.

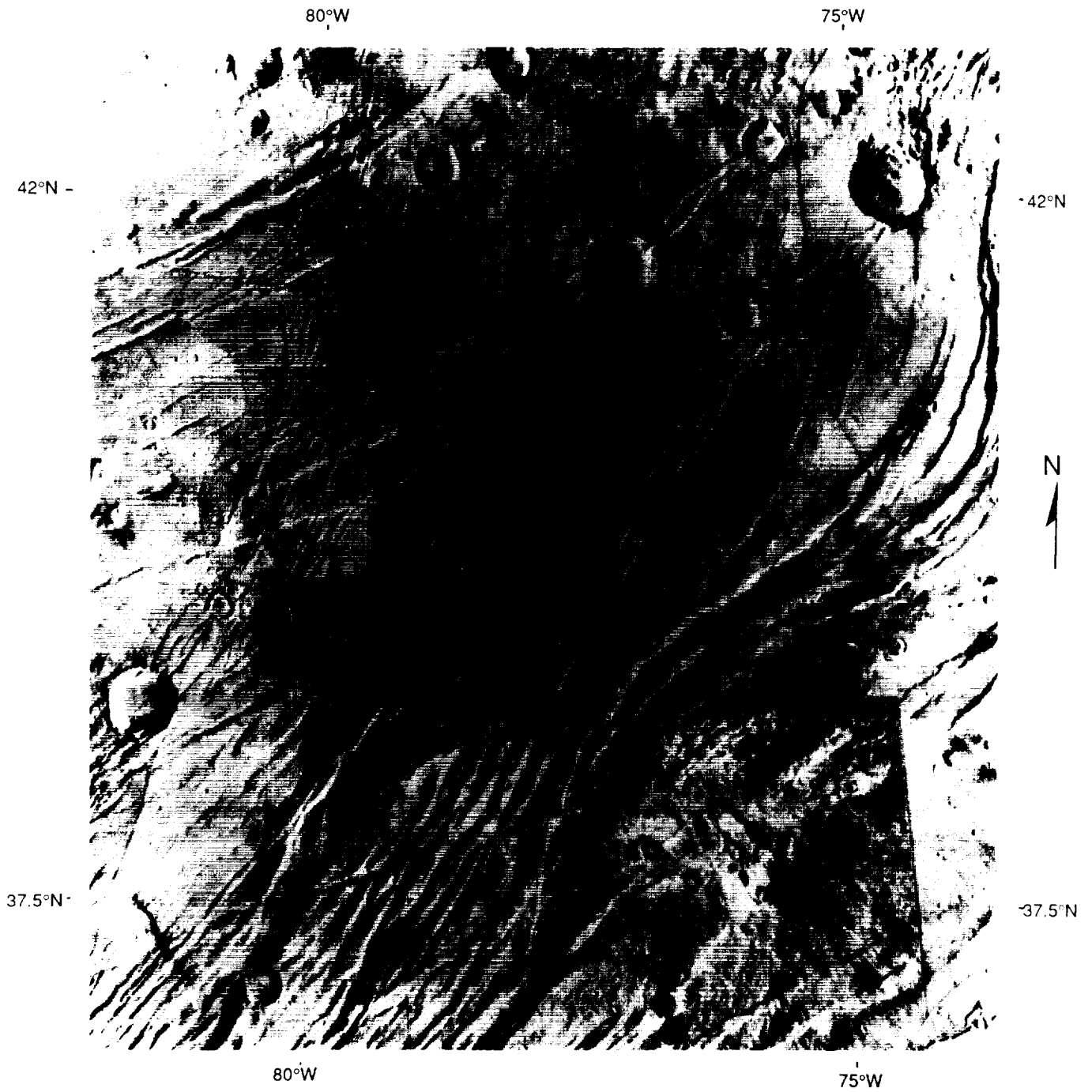
Trafficability

5

Estimated Traverse Distance

50 km.

Site 078 TEMPE FOSSAE



MC -3SE

⊗ Landing Site: 40° N Latitude, 76.5° W Longitude

C. Madras

Site 079- Aeolis Southeast

Site 079

Site Name: Aeolis Southeast

Type of Site: Rover/Sample Return

Latitude: 15.5°S

Longitude: 188.5°W

Elevation: 0 km

Maps: MC-23 SE

Viking Orbiter Images: 596A53 through 596A56, 88A68, 211-5760

Date Entered: 1 November 1989

Date Last Revised: 1 December 1989

Contact:

N.A. Cabrol

Ministere De L'Education Nationale

Observatoire de Paris

Section d'Astrophysique

5.Plac Jules Janssen

92195 - Meudon Principal Cedex

Tel.: (1) 45.07.75.30

Telex: 270912 OBSASTR -

201571 LAM

Geologic Setting

The landing site includes a wide impact basin (150 km diam.) in the Elysium Planitia, and a large valley between Al' Qahira and Ma'adim Valles. The landing site is southwest of Apollinaris Patera, at 15.5°S, 190°W. The average slope does not exceed 1.5%. The terrain is open and allows a good margin for landing operations. Few obstacles are visible according to available data. The site shows few major impact craters or linear hazards.

Scientific Rationale

Non-ambiguous geological diversity including volcanic material, possible tectonic activity, impact crater material, plain material, eolian deposits, plateau material, and channel material.

Objectives

- a) Definition of martian volcanism system by lava sampling.
- b) Definition of atmospheric model by eolian deposit samples.
- c) Contribution to martian water hypothesis by channel investigations.

- d) Contribution to the geological layers by rock sampling.
- e) Opportunity for biological experiments in a past water-rich terrain.

Landing site and point **a**: Collection of lava samples in the Elysium volcanic region. Erection of seismic stations. Collection of eolian deposits. Erection of meteorological stations to analyse possible cathabatic winds at the plateau/plain margin.

Traverse 1 and point **b**: At valley-plain margin, collection of eolian deposits, channel material, lava, plateau material (down the valley slopes) on a small area. Proceed with corings at shallow depth to characterize different levels of deposits. Possible evidence of water transport. Core may reveal a succession of eolian and channel deposits. Possible wind deflated lava coming from the upper plateau and some gravity accumulations of plateau materials down the slopes.

Traverse 2 and point **c**: Collection of sediment samples upstream of point **b**. Comparison with point **b** samples may indicate the transport capacity of a supposed

martian runoff. Images of slopes to document possible existence of terraces in order to understand the flow variations.

Traverse 3 and point d: Collection of slope accumulation samples along traverse. Collection of crater ejecta material at point d.

Traverse 4 and return to lander: Preparation of samples for Earth return mission.

Potential Problems

To be determined.

Trafficability

The average slope does not exceed 1.5%.
The terrain is open and allows a good margin

for landing operations. Few obstacles are visible according to available data. The selected landing site shows few major impact basins or linear hazards.

Estimated Traverse Distance

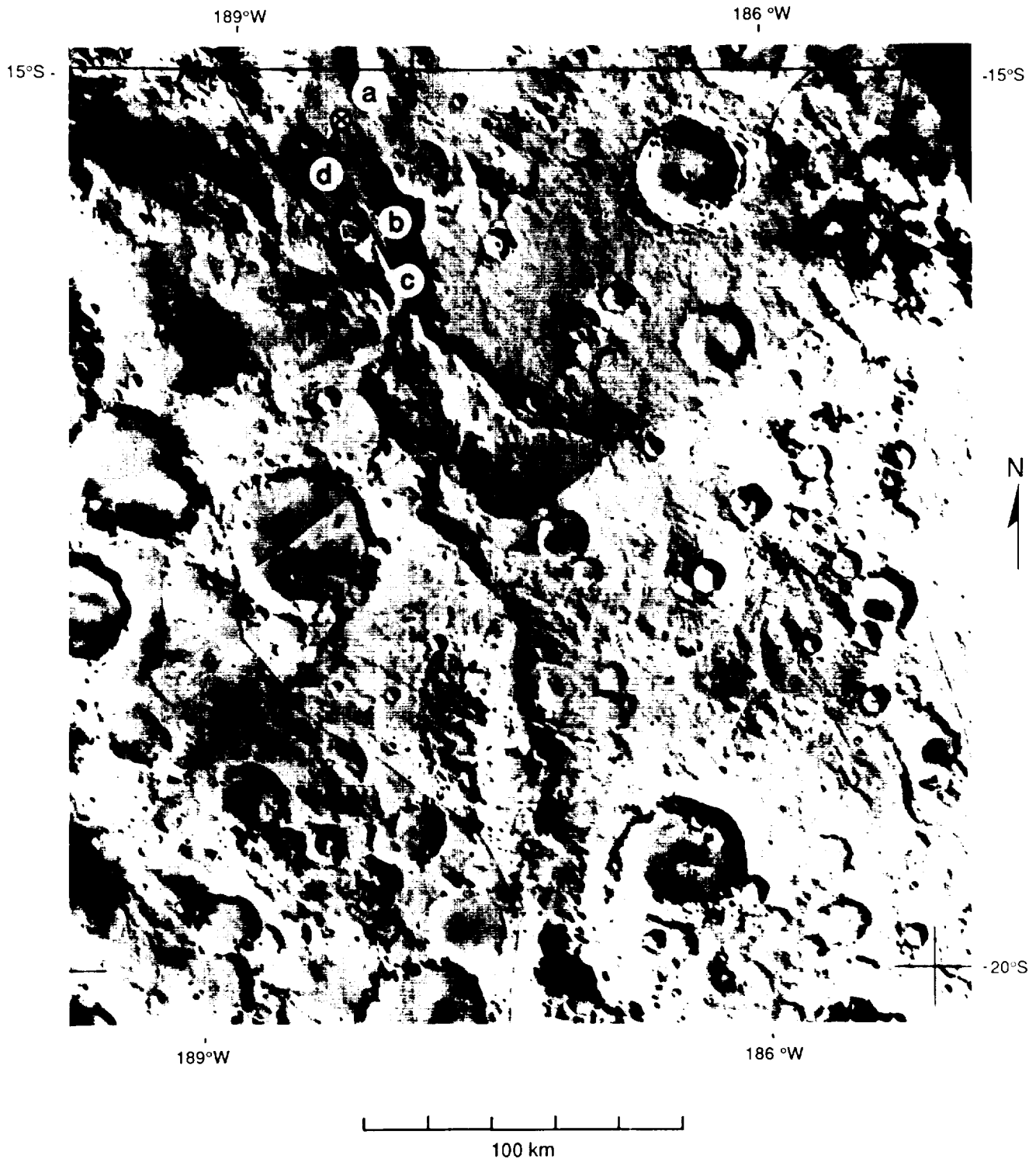
Total traverse distance 105 km.

TRAVERSE:

1. Rover traverse from site a to b 30 km
2. Rover traverse from site b to c 15 km
3. Rover traverse from site c to d 45 km
4. Rover traverse from site d to a 18 km

5 month mission time.

Site 079 AEOLIS SOUTHEAST



MC -23SE

⊗ Landing Site: 15.5° S Latitude, 188.5° W Longitude

N. Cabrol

Site 080- Dao Vallis

Site 080

Site Name: Dao Vallis

Type of Site: Balloon

Latitude: 30°S

Longitude: 262°W

Elevation: + 1.5 km

Maps: MC-28 NE

Viking Orbiter Images: 625A18,
625A20, 329S29, ASU IPF-710

Date Entered: 6 September 1989

Date Last Revised: 1 October 1989

Contact:

Frederick R. West
519 Monroe Circle
Glen Burnie, MD 21061

Geologic Setting

The landing site lies on the upper end of the spatulate depression where Dao Vallis originates on the slope of Hadriaca Patera. Hadriaca is a Mid-Hesperian central vent volcano northeast of Hellas Planitia, with radial ridges, a low profile and a smooth floored caldera at its center. Dao Vallis, an apparent outflow channel, drops 5 km in elevation as it descends across the southwestern flank of Hadriaca to its terminus in Hellas Planitia. At least 6 different types of terrain units are found either in Dao Vallis or within several hundred kilometers of it.

Scientific Rationale

Area contains six types of terrain units, volcanics, channel material, basin material, mountainous terrain, plains material. Potential to detect water vapor. Possible frosts, clouds, and dust storms in Hellas Planitia.

Objectives

An overall survey (incl. closeup images and infrared mapping) of Noachian mountainous terrain, Hadriaca Patera caldera and slope,

Hesperian Plains, Dao Vallis, and Hellas Planitia. Detection of water vapor.

Terrain Units:

- AHh - Hadriaca Patera Formation: Floor material of central caldera and of surrounding volcanic eruption material.
- Ah5 - Channeled Plains Rim Unit: On east rim of Hellas Planitia basin.
- Hch - Older Channel Material: Floors of Dao and Harmakhis Valles.
- Hpl3 - Smooth Hesperian Plains: Flat, relatively featureless plains in southern material.
- Nh1 - Basin-Rim Unit: Material of Hellas Planitia basin rim.
- Nm - Noachian Mountainous Material: Large, very rugged, isolated blocks scattered around Hellas Planitia Basin.

TENTATIVE TRAVERSE ROUTE:

1. The aerial traverse should start at the region of Noachian mountainous terrain at about 30°S, 262°W.
2. After surveying this formation the balloon should then proceed nearly due west

at a height of 5 km across the Hesperian plains and the Hadriaca Patera formation to the Hadriaca caldera at 30.8°S, 267°W. At a height of 5km, the radius of the sector of visible martian surface is 183 km.

3. After surveying the caldera the balloon should proceed at azimuth 100° to a position above the Hesperian plains terrain about 31.5°S, 263°W which is about 30 km north of the apparent start of the southern branch of Dao Vallis.
4. The balloon should then proceed due south until it is directly above the start of this branch of Dao Vallis, and then proceed above it at azimuth 220°, which should keep this branch of Dao Vallis within view of the imaging system.
5. When the balloon reaches 33.5°S latitude, it should then turn in a westerly direction until it is over the Hesperian plains material which separates the two branches of Dao Vallis.
6. At 33.6°S, 266.5°W, proceed at azimuth 223°. This flight path will roughly follow the course of Dao Vallis almost to its terminus in Hellas Planitia. Then the balloon should be able to keep both branches of Dao Vallis under observation if it can maintain an elevation of 5 km above the Martian surface. The flight path should take the balloon nearly over the junction of the two branches of Dao Vallis at 37°S, 270°W.
7. From there, the balloon will follow the lower Dao Vallis to its large bend at 40°S, 273.8°W not far from its terminus in Hellas Planitia. The balloon should then continue its aerial survey of Dao Vallis to its terminus, and then continue its aerial

survey as far into Hellas Planitia as possible.

Departures from this traverse route can and should be made for a closer investigation of interesting features as they are spotted on the images produced by this proposed aerial survey and traverse.

In addition to a television imaging system, the balloon payload should at least contain infrared mapping spectrometer for the detection of water vapor and a radar or laser altimeter to determine height above the martian surface.

Potential Problems

To be determined.

Trafficability

To be determined.

Estimated Traverse Distance

To be determined.

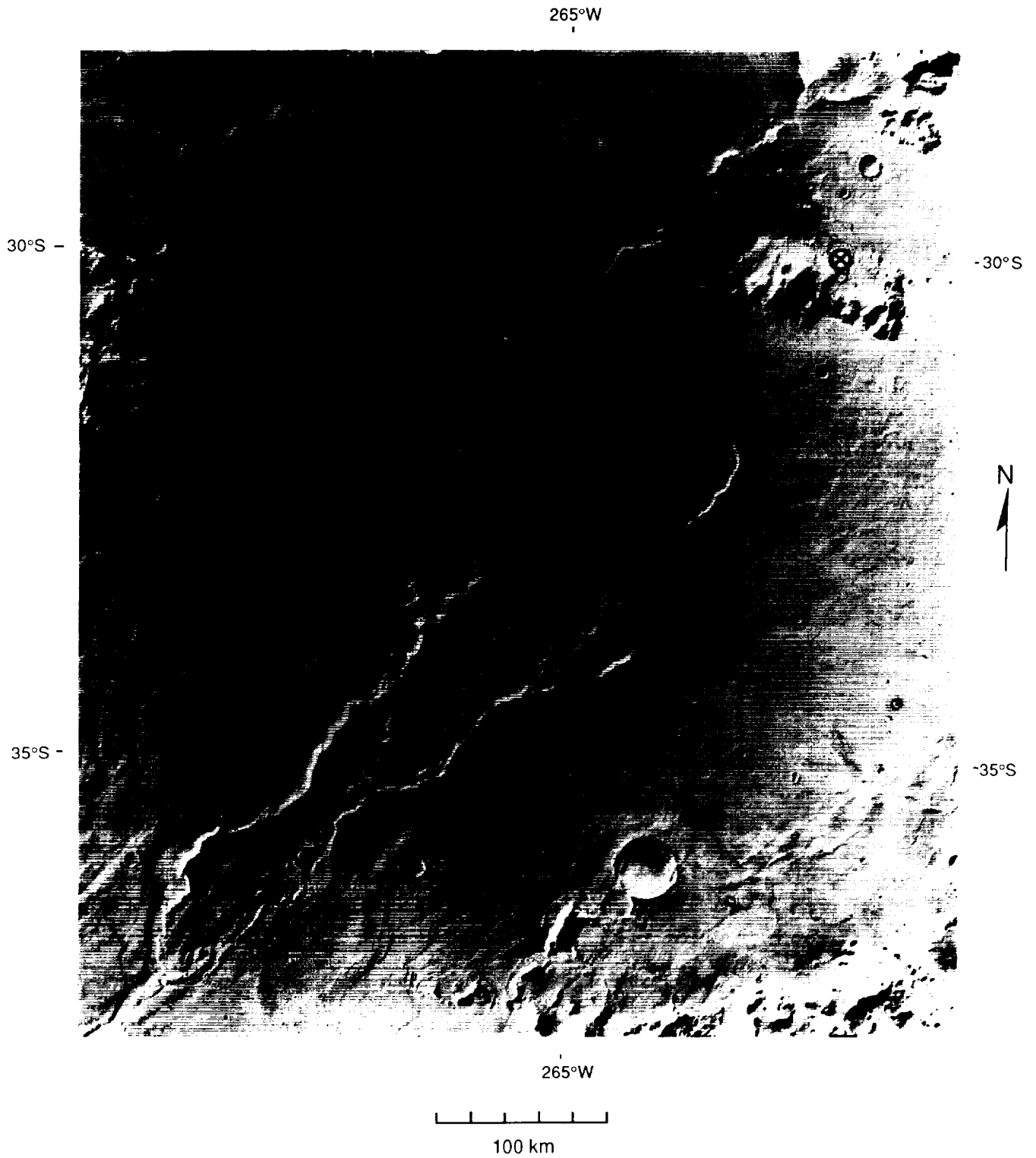
Other

Some desired characteristics of the balloon are:

- a) It is powered so that it can follow a pre-planned route above the Martian surface;
- b) it can fly at altitudes of a few meters to five kilometers or higher; and
- c) it can land payloads (preferably mobile) at interesting sites it picks out on the Martian surface.

The balloon might operate (at least partially) in a joint traverse with a more advanced Mars Rover/Sample Return mission on the surface.

Site 080 DAO VALLIS



ASU - IPF 710

⊗ Landing Site: 30° S Latitude, 262° W Longitude

F. West

Site 081- Acidalia Planitia

Site 081

Site Name: Acidalia Planitia

Type of Site: Balloon

Maps: MC-4 NE, NW, SE, SC; 1:15M (I-1320)

Viking Orbiter Images: Numerous images

Date Entered: 22 November 1989 (by R. Greeley)

Date Last Revised: 22 November 1989

Latitude: 40° to 60°N

Longitude: 10° to 40°W

Elevation: - 1 km to - 3 km

Contact:

Josette Runavot, Chair

Internl. Mars Environ. Working Grp

Centre National D'Etudes Spatiales

Centre Spatiales de Toulouse

18, Ave. Edouard-Belin

31055 Toulouse Cedex FRANCE

Phone: 61.27.37.49

Telex: CNES 531 081 F

Fax: 61.28.14.08

Geologic Setting

Northern lowland plains; plains of volcanic and/or sedimentary origin; have been extensively modified by aeolian and periglacial processes.

Scientific Rationale

Site selected to meet engineering constraints.

Objectives

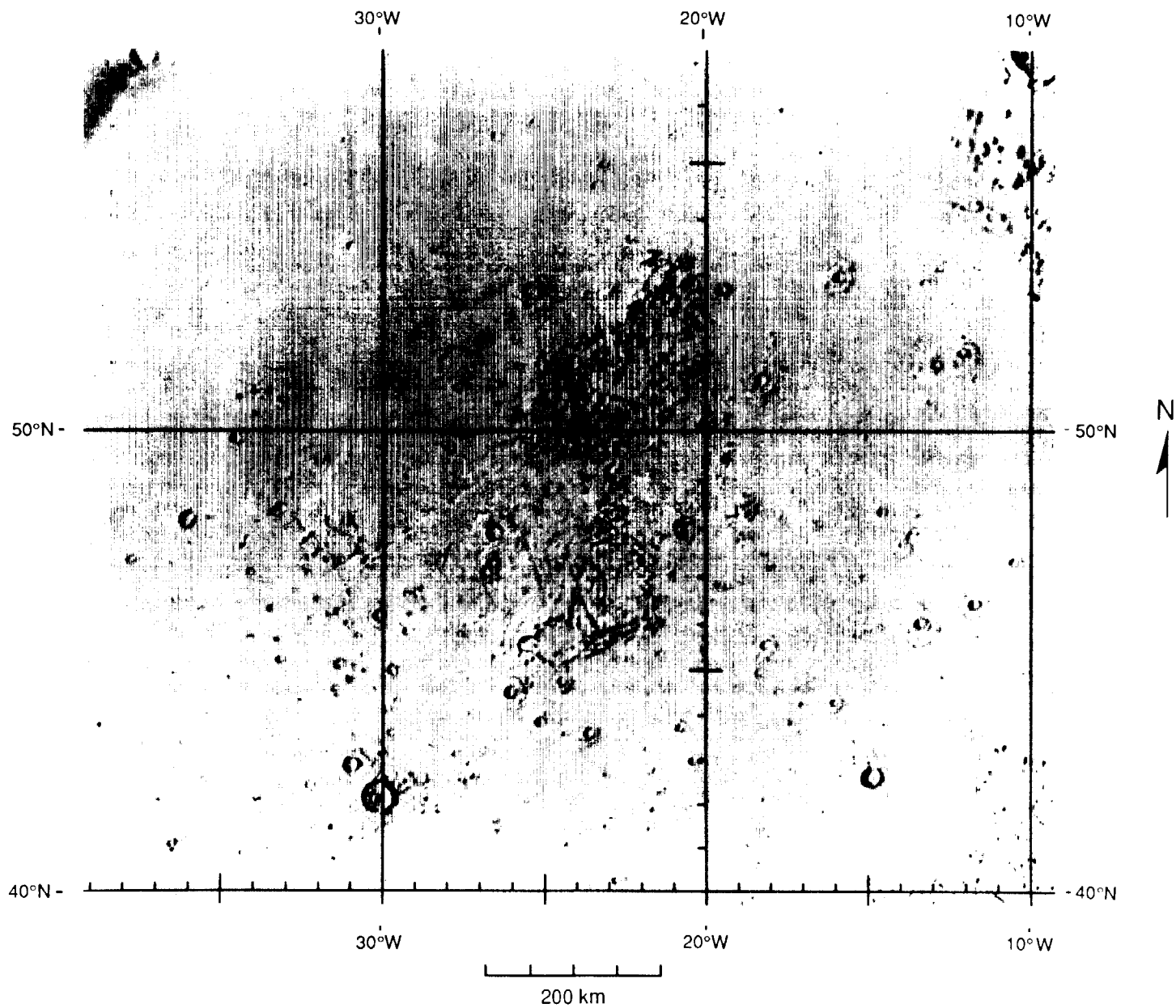
Obtain composition of Vastitas Borealis Formation (mottled, grooved, and knobby

members), fresh lava flows of Arcadia Formation and some isolated patches of ancient highland material.

Assumptions

First balloon would be injected October, 1995 at L, 170° to 175°; second balloon would be injected 2 to 4 weeks later.

Site 081 ACIDALIA PLANITIA



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ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Site 082- Arcadia Planitia

Site 082

Site Name: Arcadia Planitia

Type of Site: Balloon

Maps: MC-2 NW, SW, SC; 1:15M
(I-1320)

Viking Orbiter Images: Numerous
images

Date Entered: 22 November 1989 (by R.
Greeley)

Date Last Revised: 22 November 1989

Latitude: 40° to 60°N

Longitude: 150° to 180°W

Elevation: - 3 km

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Geologic Setting

Northern lowland plains; covers principally the Amazonian-age Arcadia Formation (lava flows, small cinder cones; terrain modified by aeolian periglacial processes). Toward the east merges with volcanics from Alba Patera.

Scientific Rationale

Site selected to meet engineering constraints.

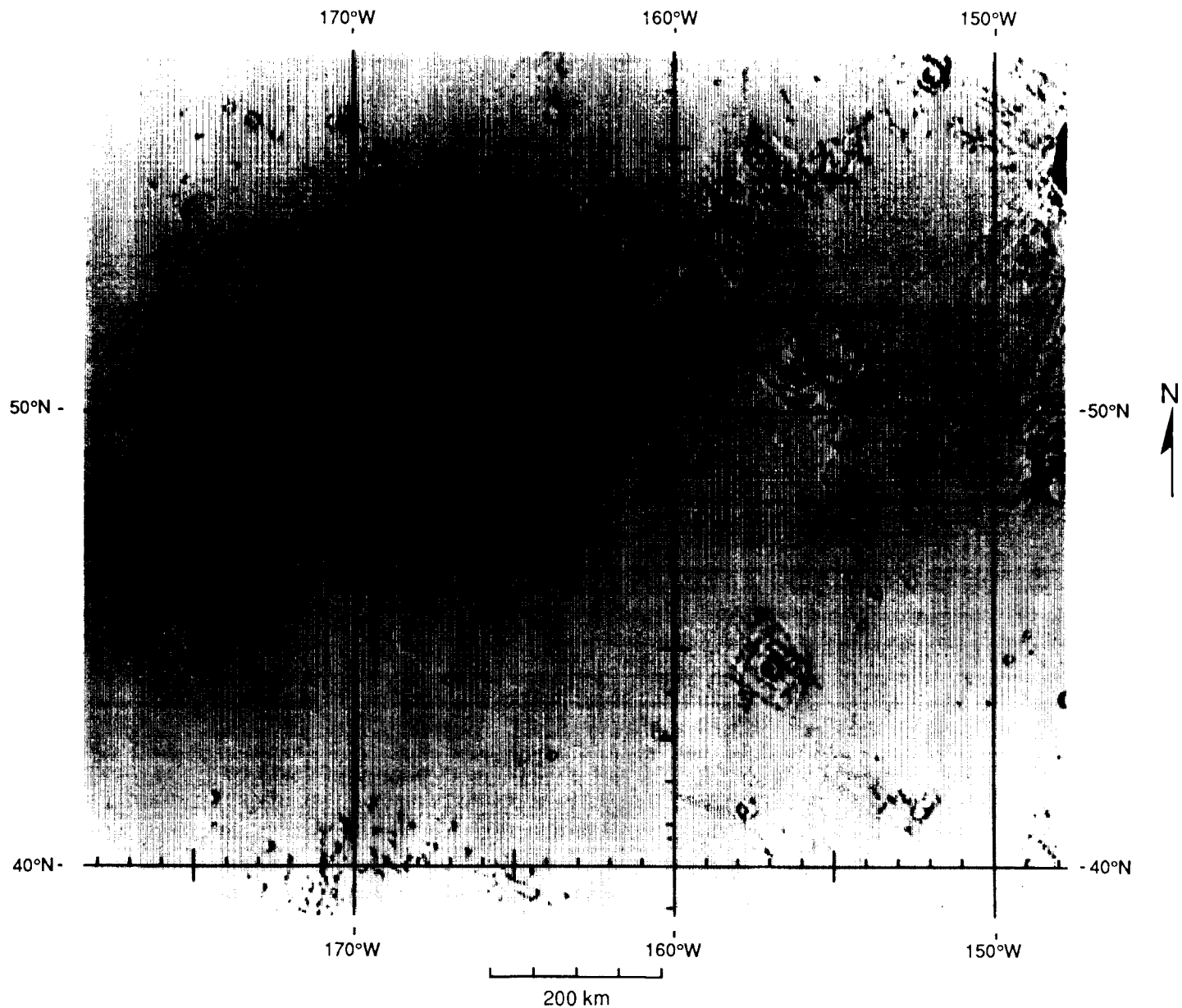
Objectives

Obtain composition of grooved, knobby, and mottled members of Vastitas Borealis Formation, and volcanic materials of Arcadia Formation.

Assumptions

First balloon would be injected October, 1995 at L₁ 170° to 175°; second balloon would be injected 2 to 4 weeks later.

Site 082 ARCADIA PLANITIA



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CHRONICLE OF
BLACK AND WHITE PHOTOGRAPHY

Site 083- Utopia Planitia

Site 083

Site Name: Utopia Planitia

Type of Site: Balloon

Maps: MC-6 SE, NE; MC-7 SW; 1:15M (I-1321)

Viking Orbiter Images: Numerous images

Date Entered: 22 November 1989 (by R. Greeley)

Date Last Revised: 22 November 1989

Latitude: 40° to 60°N

Longitude: 240° to 270°W

Elevation: - 1 km to - 3 km

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Geologic Setting

Northern lowland plains; includes subpolar plains of Vastitas Borealis, plus mottled terrain interpreted to be wind-deflated, and grooved terrain (periglacially modified?) of Hesperian age; also includes part of the Elysium formation (lava flows and/or lahars from the Elysium volcanics).

Scientific Rationale

Site selected to meet engineering constraints.

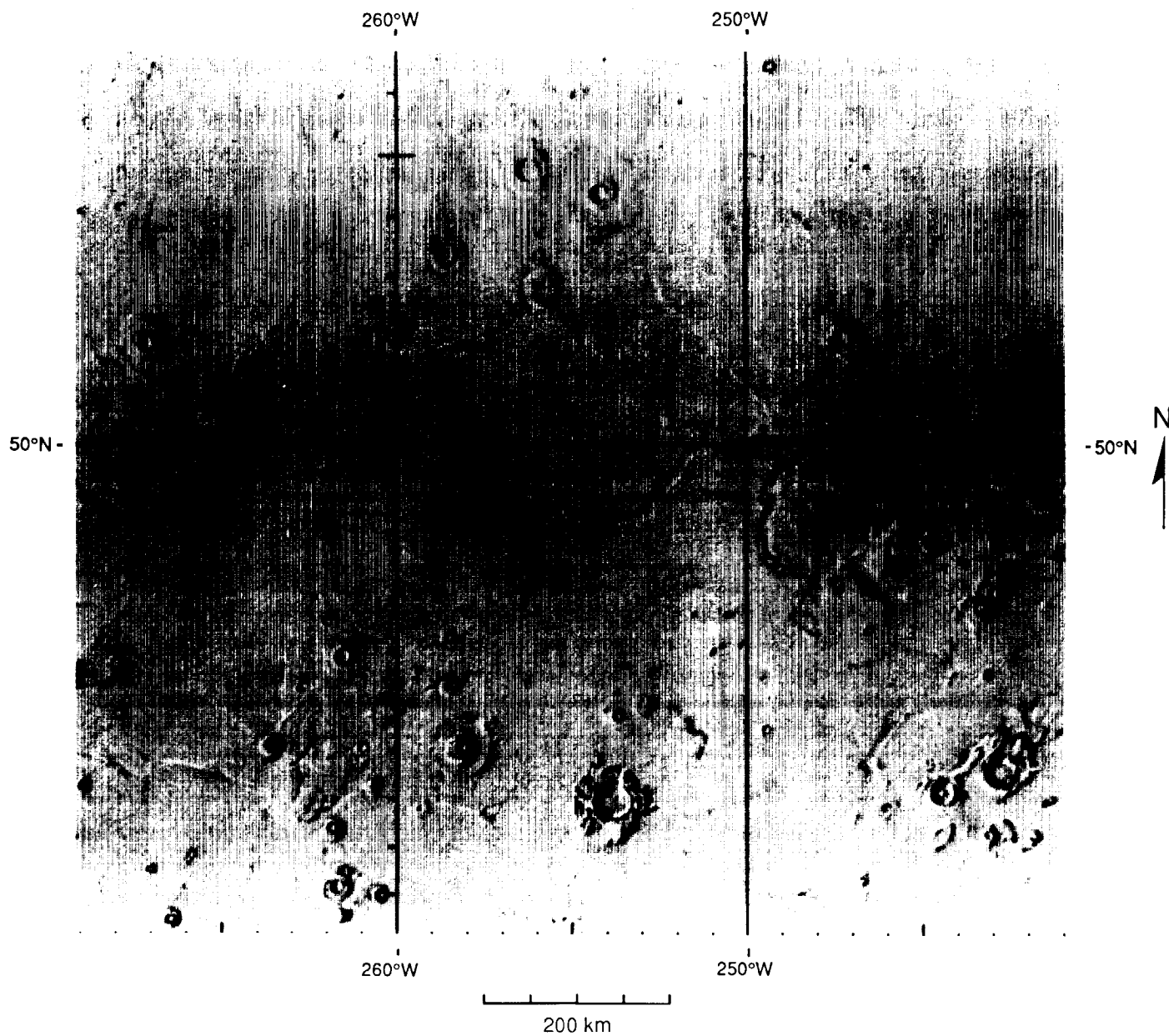
Objectives

Obtain composition of Vastitas Borealis Formation (mottled, grooved, and knobby members), channel material, and volcanic plains modified by fluvial, periglacial, and or aeolian processes.

Assumptions

First balloon would be injected October, 1995 at L_s 170° to 175°; second balloon would be injected 2 to 4 weeks later.

Site 083 UTOPIA PLANITIA



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CHANDLER PROJ
BLACK AND WHITE PHOTOGRAPH



Report Documentation Page

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