MARS EXPLORATION ROVERS

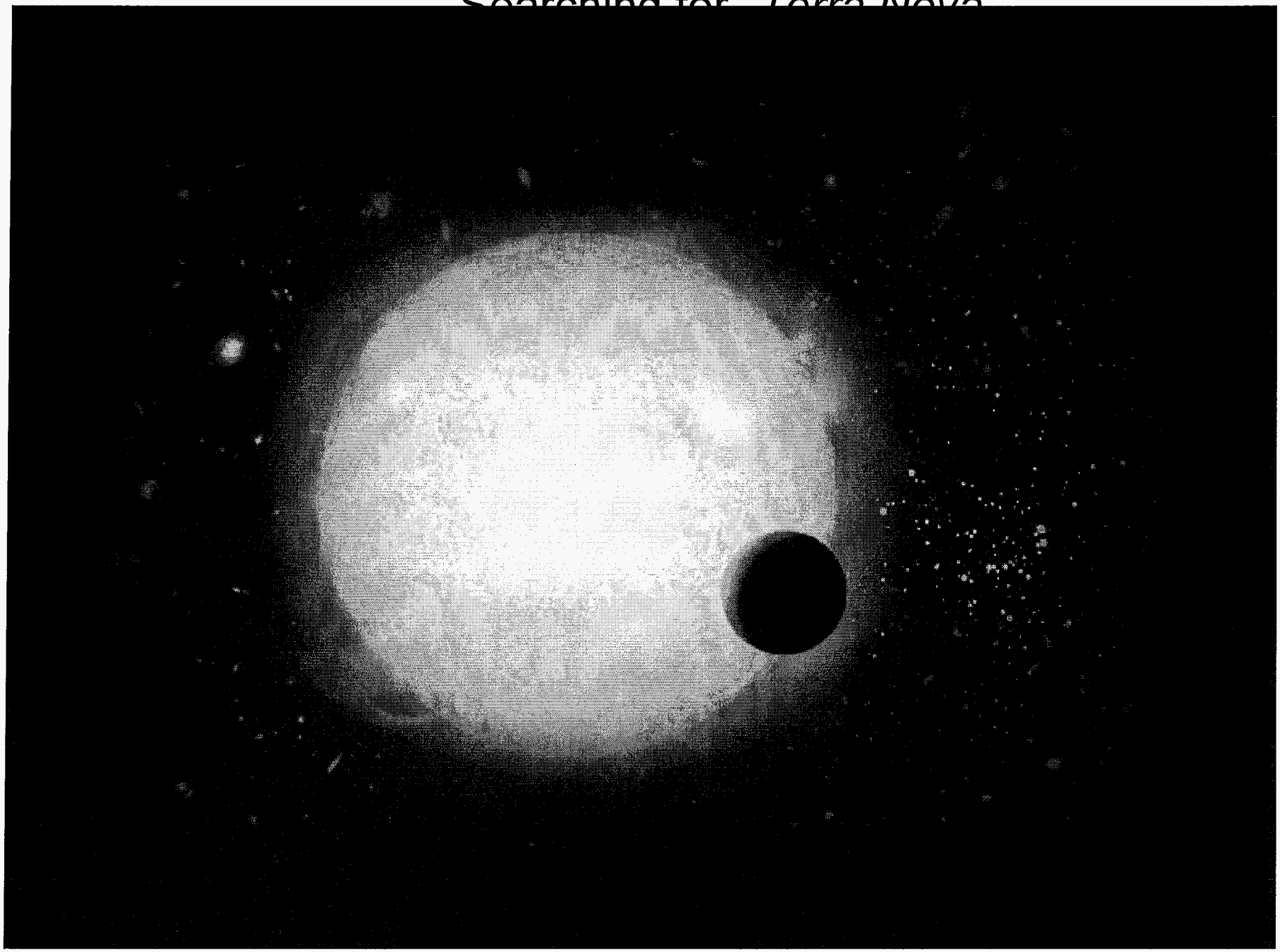
Continuing the Quest

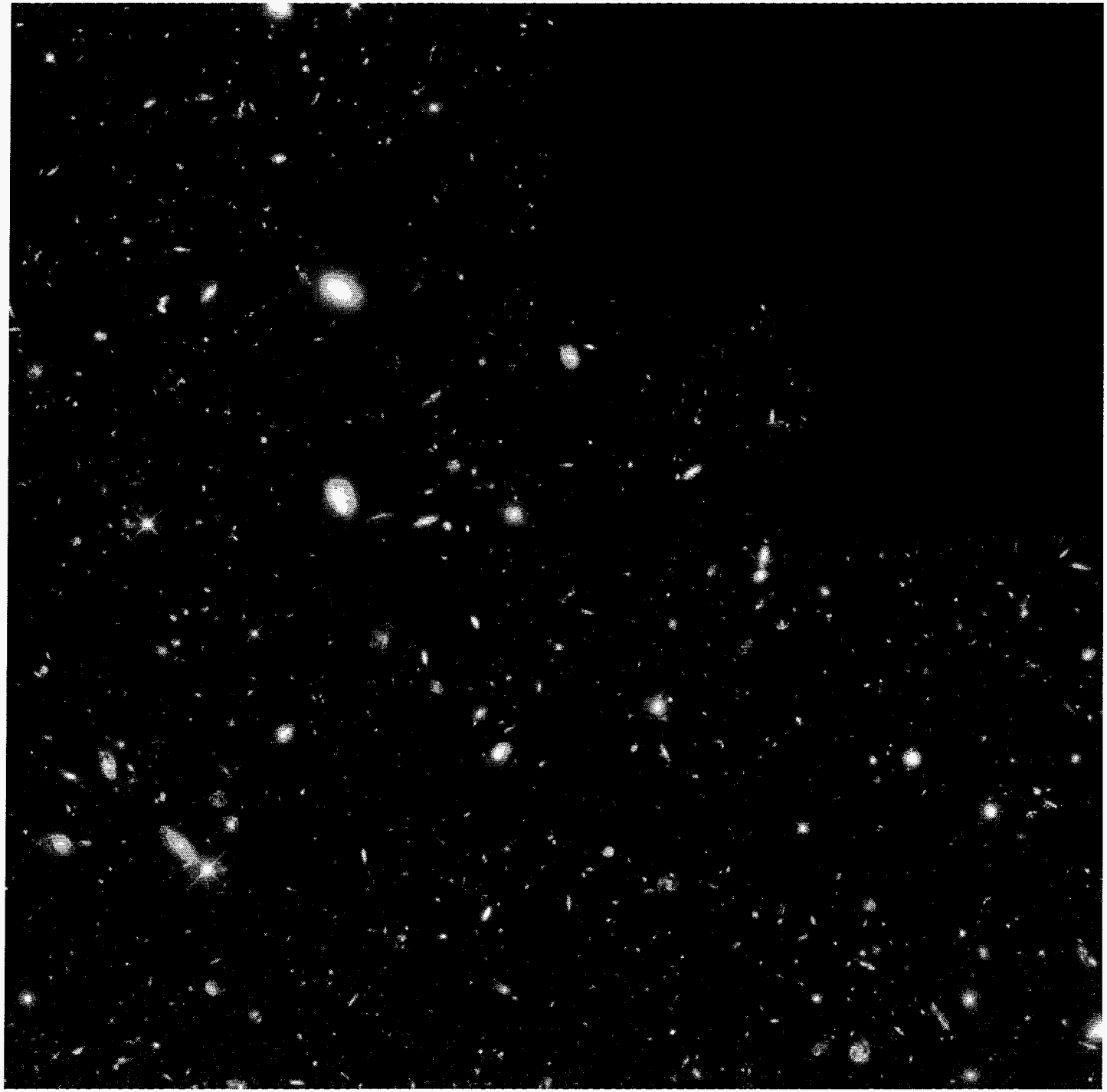
From the old Mars...

...to the new Mars...

...to the future Mars!

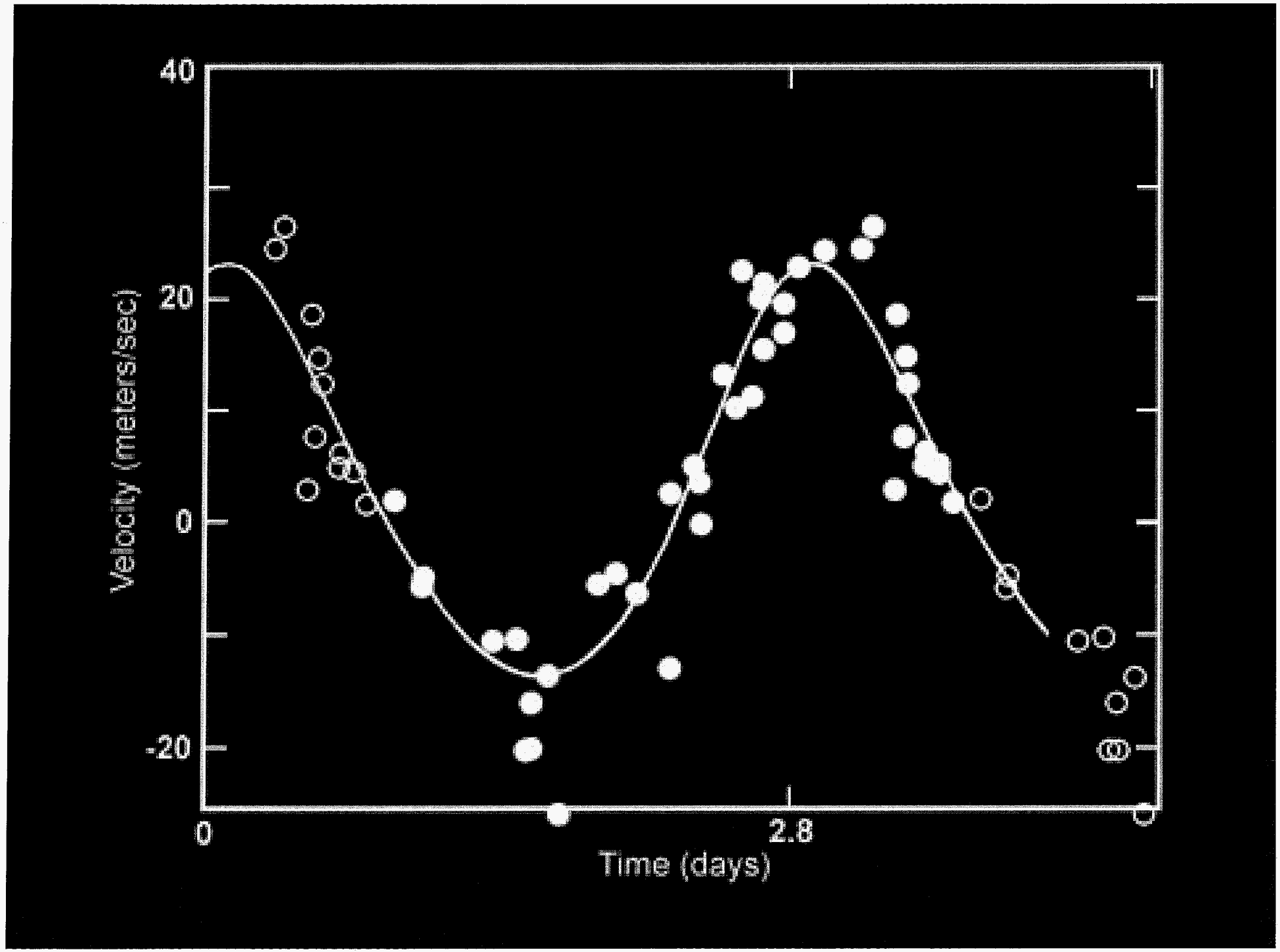
Searching for "Terra Nova"

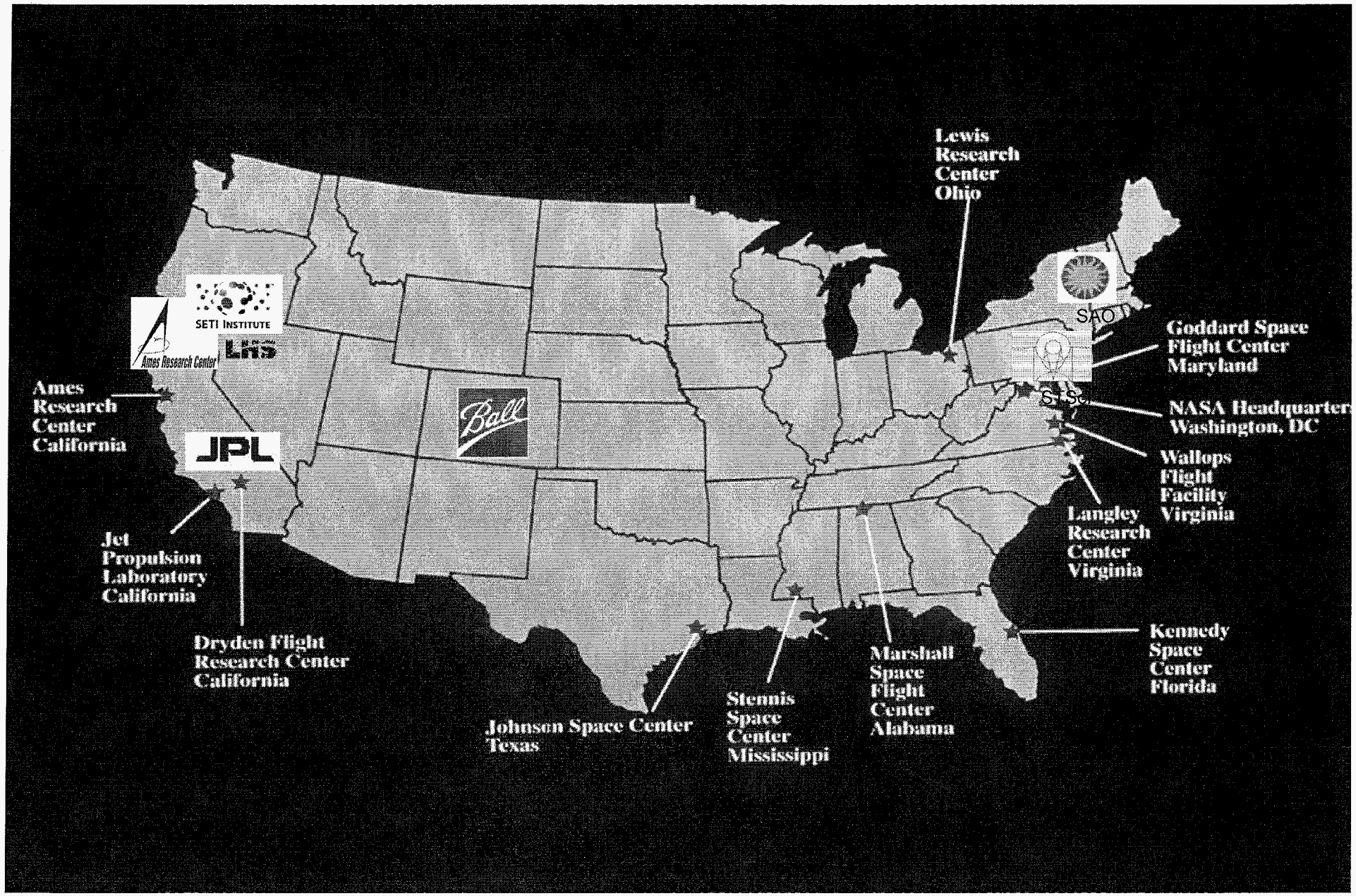




JPL

www.jpl.nasa.gov


40
20
0
-20
Velocity (meters/sec)
0
2.8
Time (days)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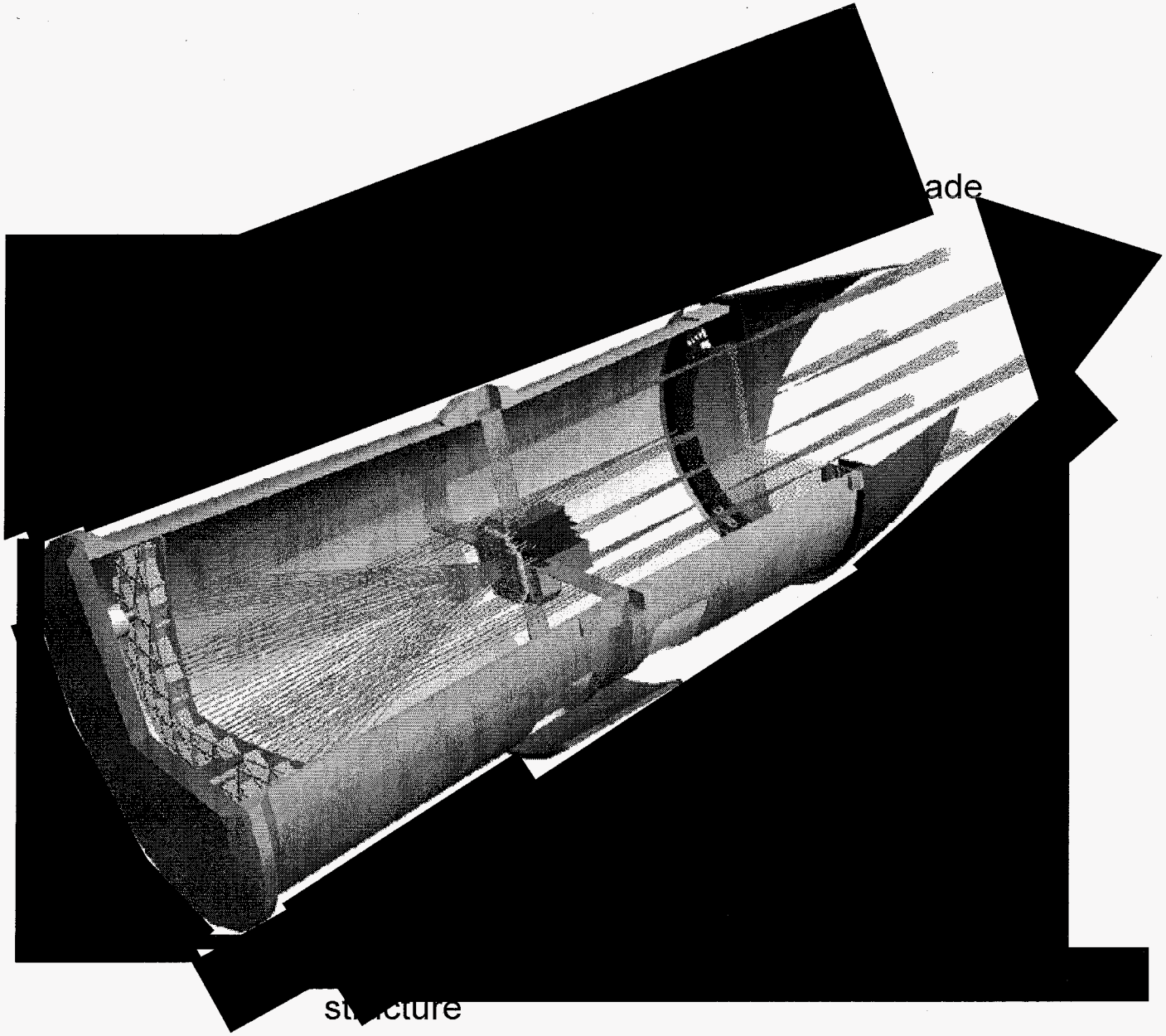
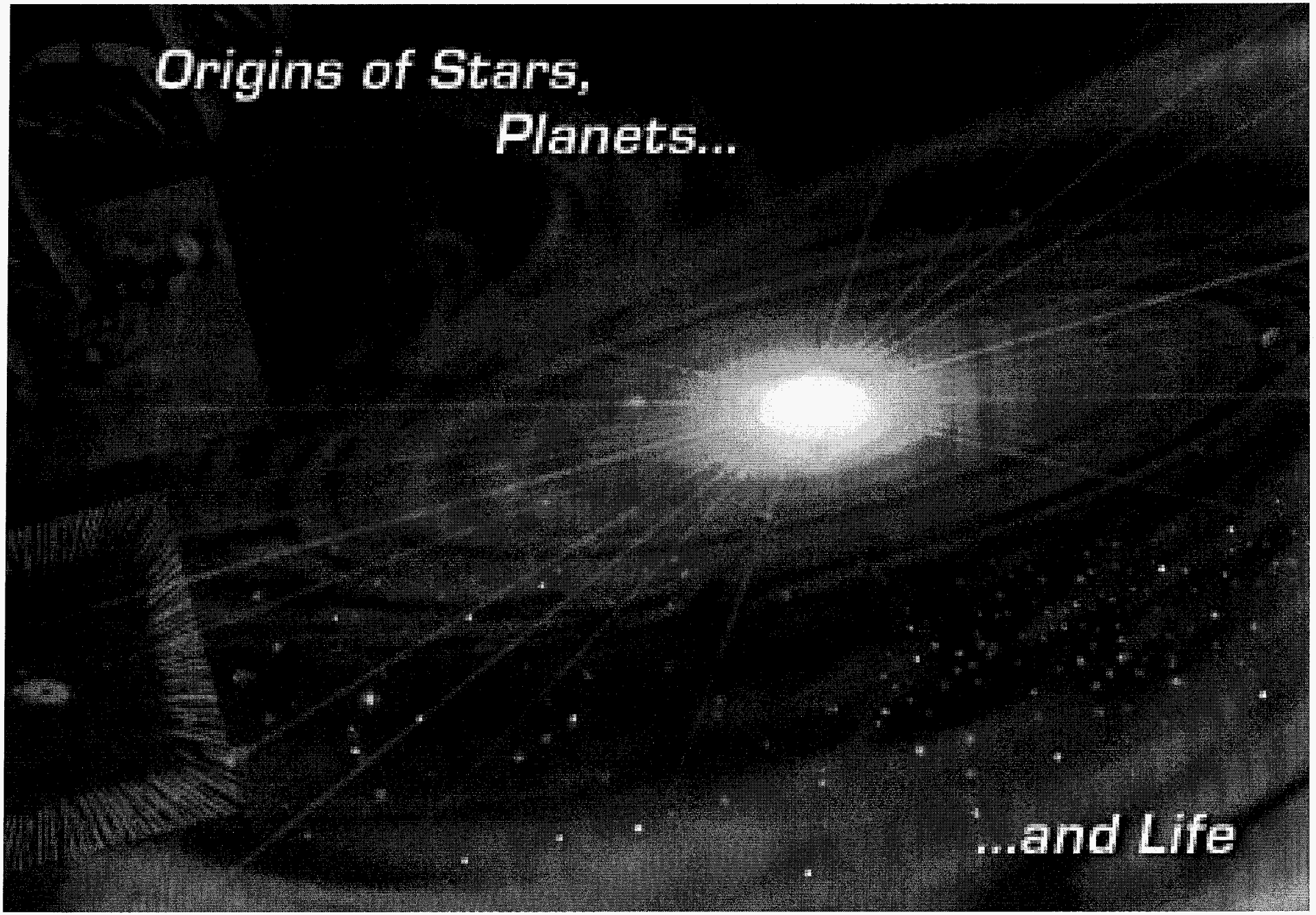
Goddard Space Flight Center Maryland
NASA Headquarters Washington, DC
Wallops Flight Facility Virginia
Langley Research Center Virginia
Kennedy Space Center Florida
Marshall Space Flight Center Alabama
Stennis Space Center Mississippi
Johnson Space Center Texas
Dryden Flight Research Center California
Jet Propulsion Laboratory California
Ames Research Center California
SETI INSTITUTE
Ames Research Center
LHS
JPL
Ball
SAO

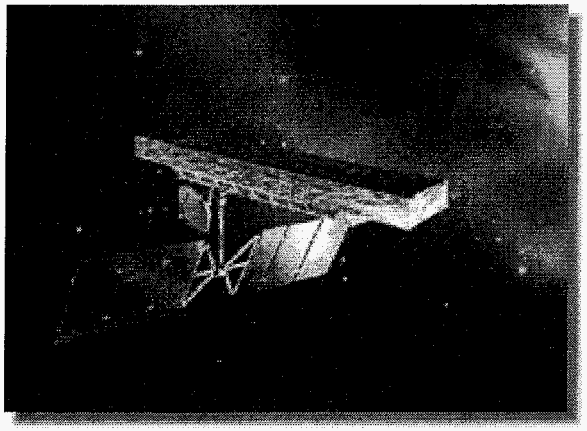


Focus

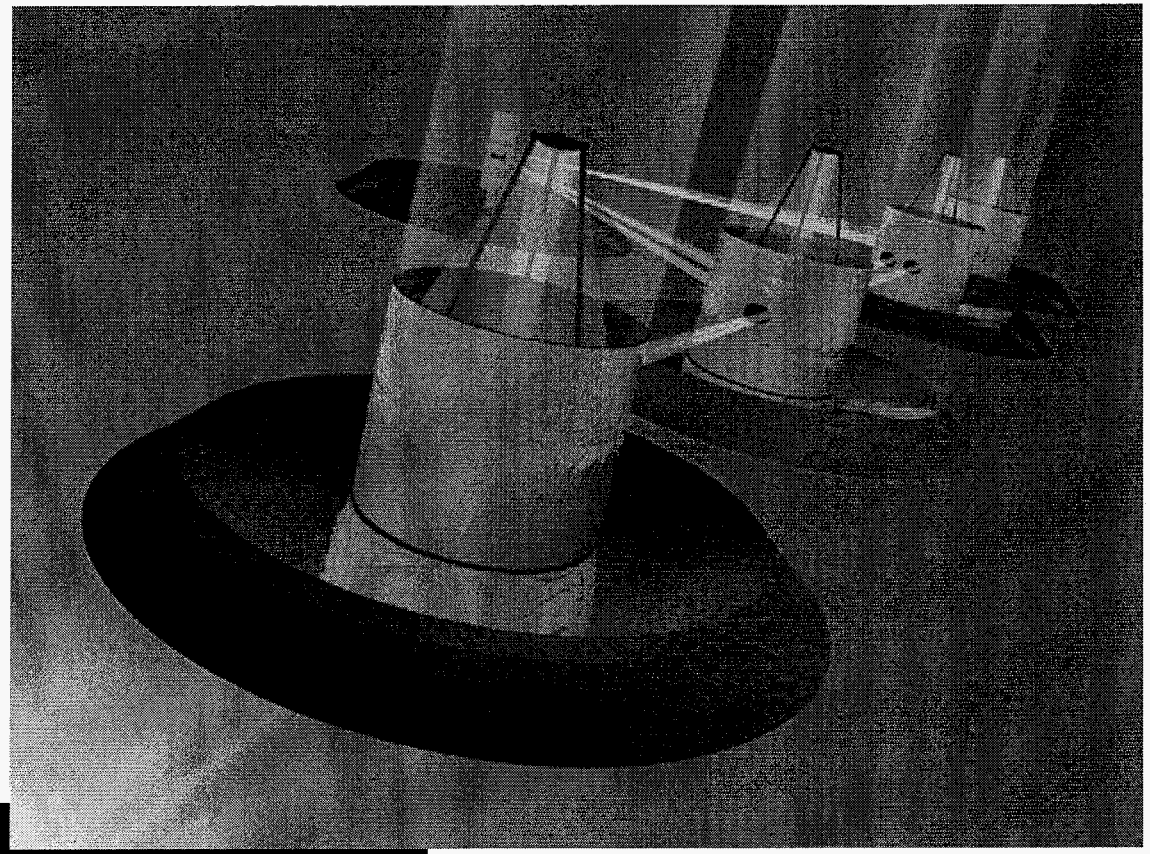
ade

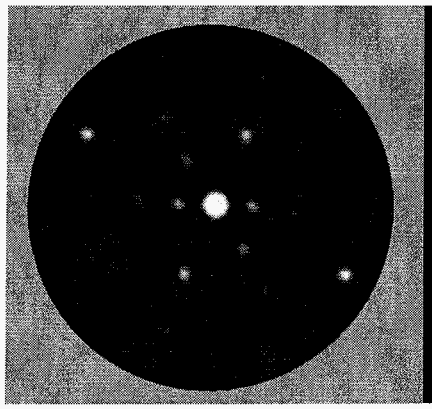
st cture

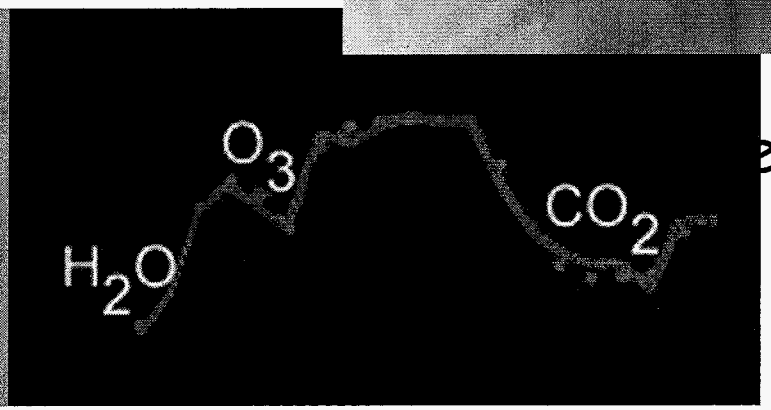

Origins of Stars,
Planets...
...and Life



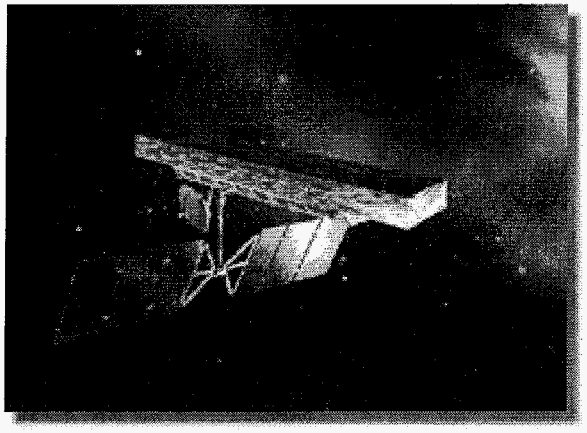
Space Interferometry Mission



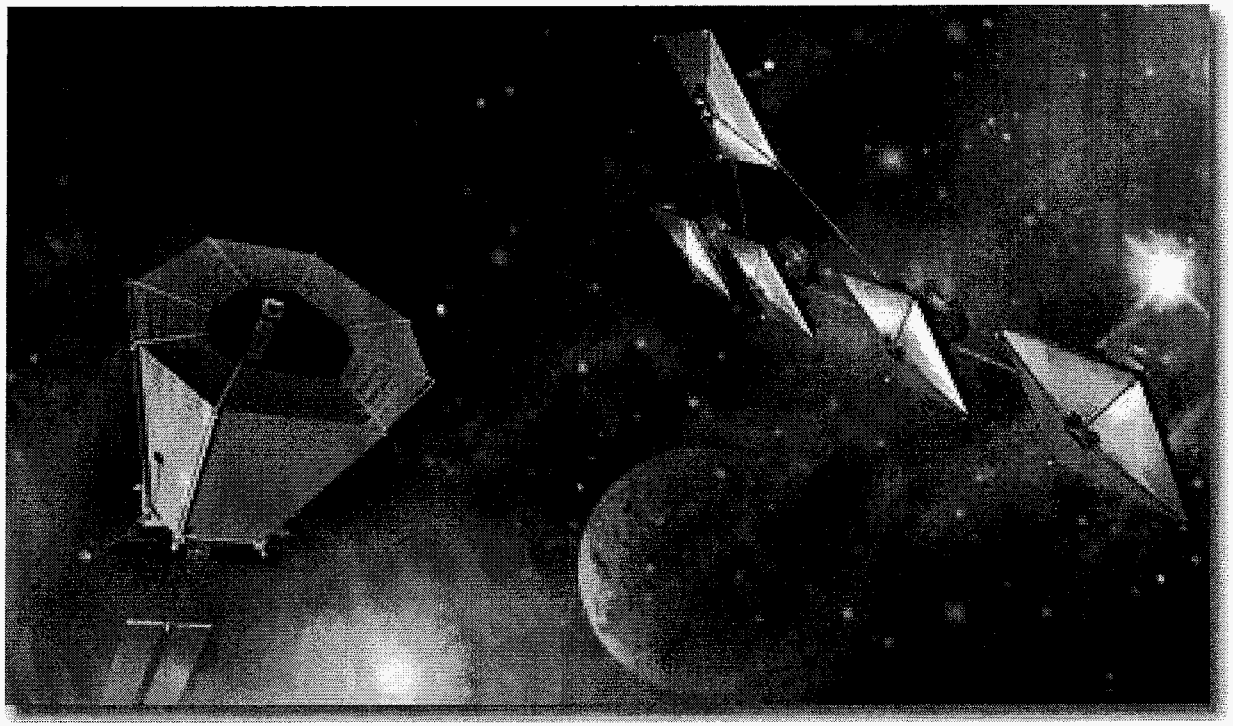


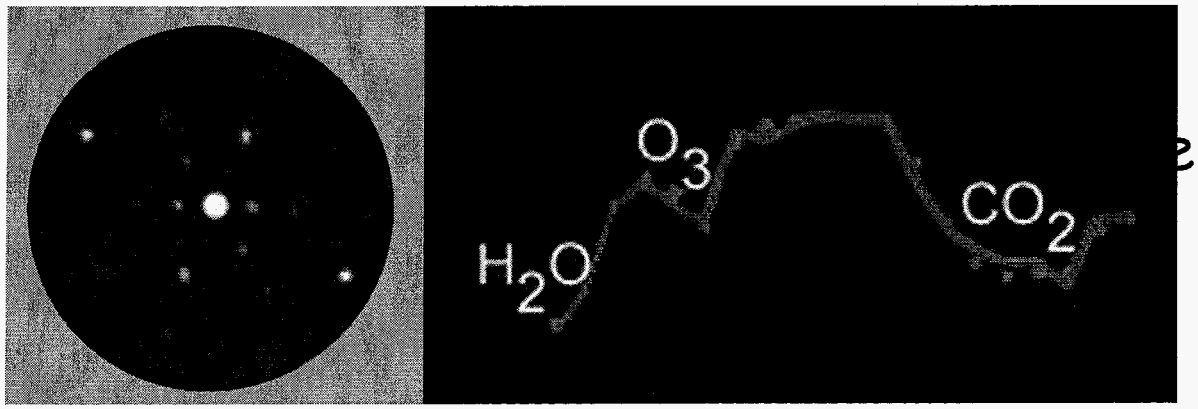


errestrial Planet Finder

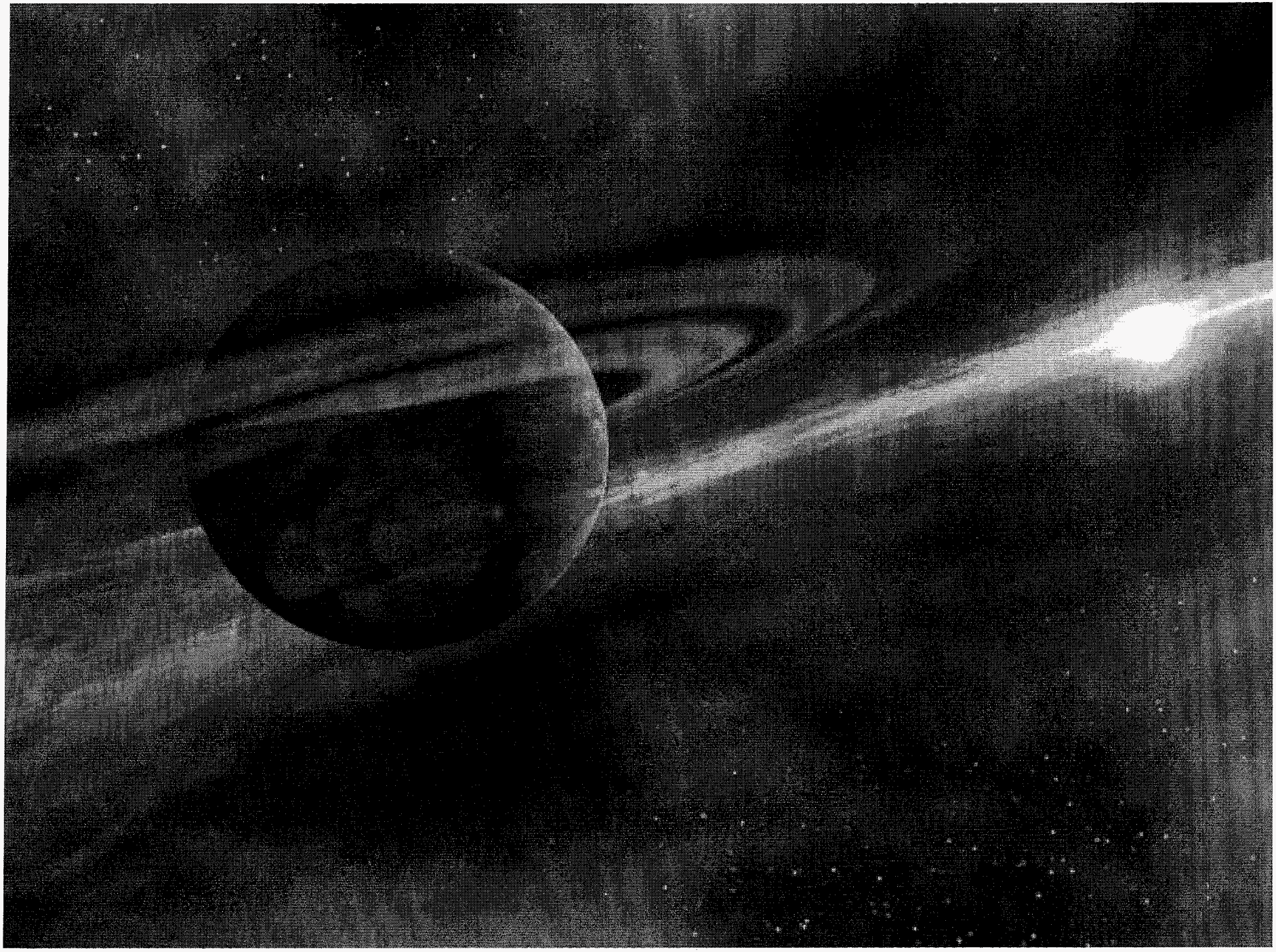


Space Interferometry Mission





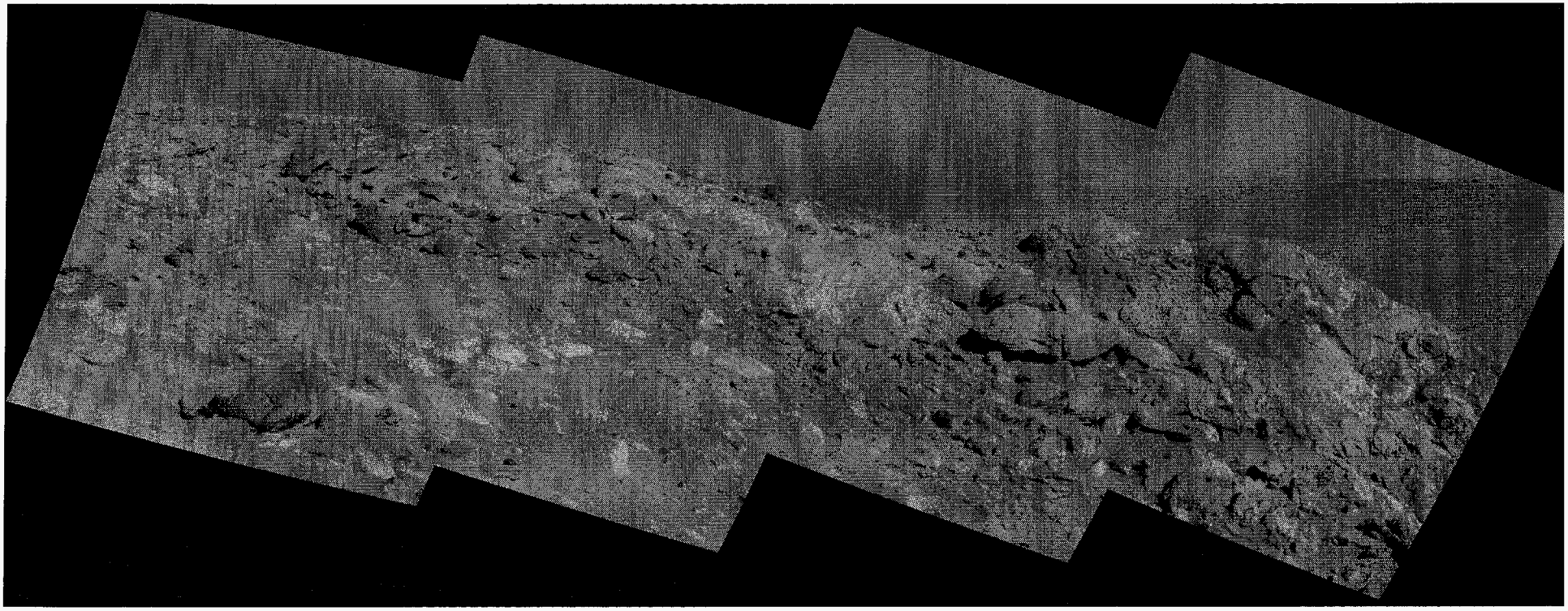
errestrial Planet Finder



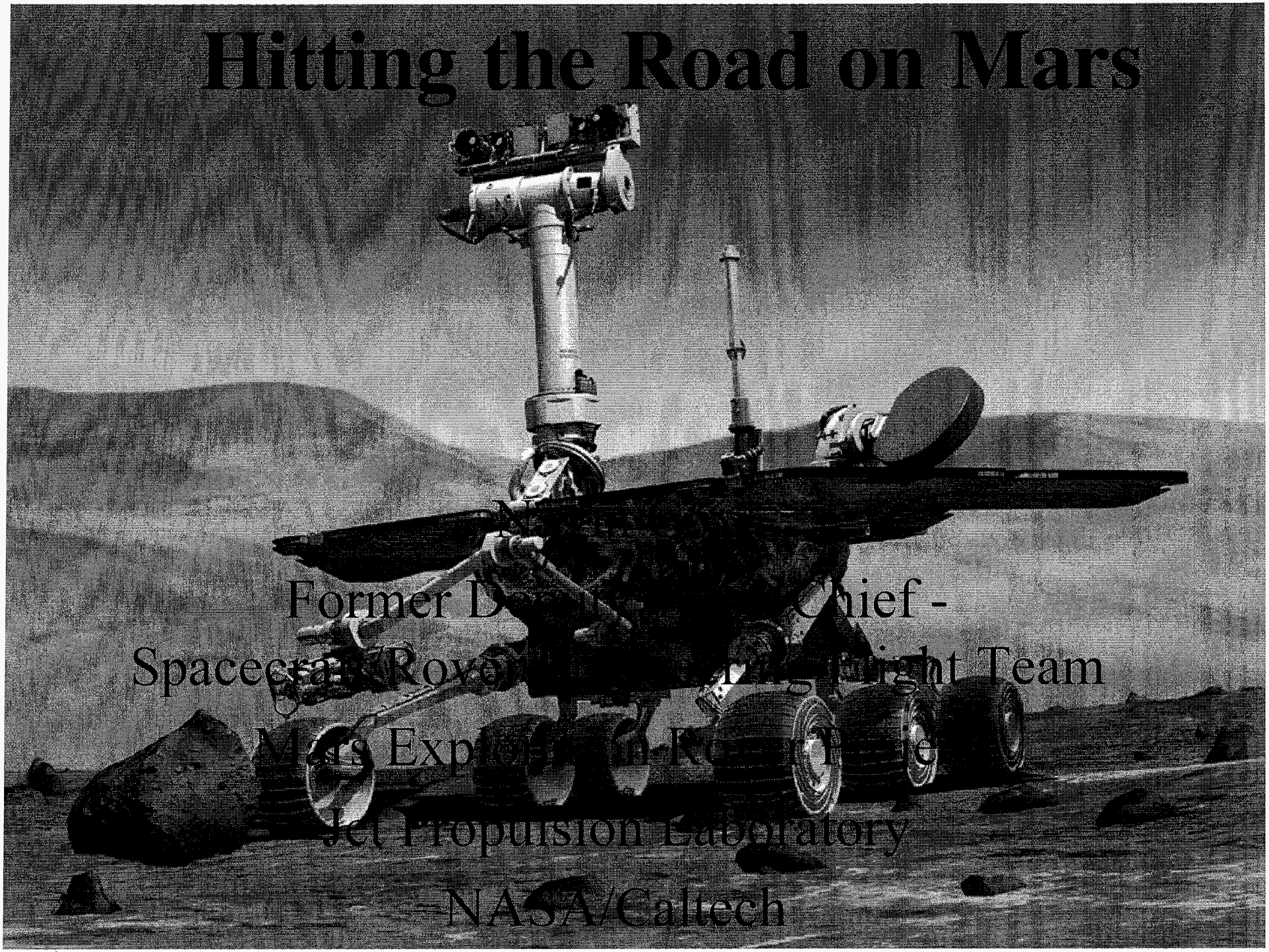
SELECT:
OUR SOLAR SYSTEM
BEYOND
SUN
MERCURY
VENUS
EARTH
MOON
MARS
ASTEROIDS
METEOROIDS
COMETS
JUPITER
SATURN
URANUS
NEPTUNE
PLUTO
KUIPER BELT OBJECTS
Our Solar System

Credit: ESA, Alfred Vidal-Madjar (Institut d'Astrophysique de Paris, CNRS, France)

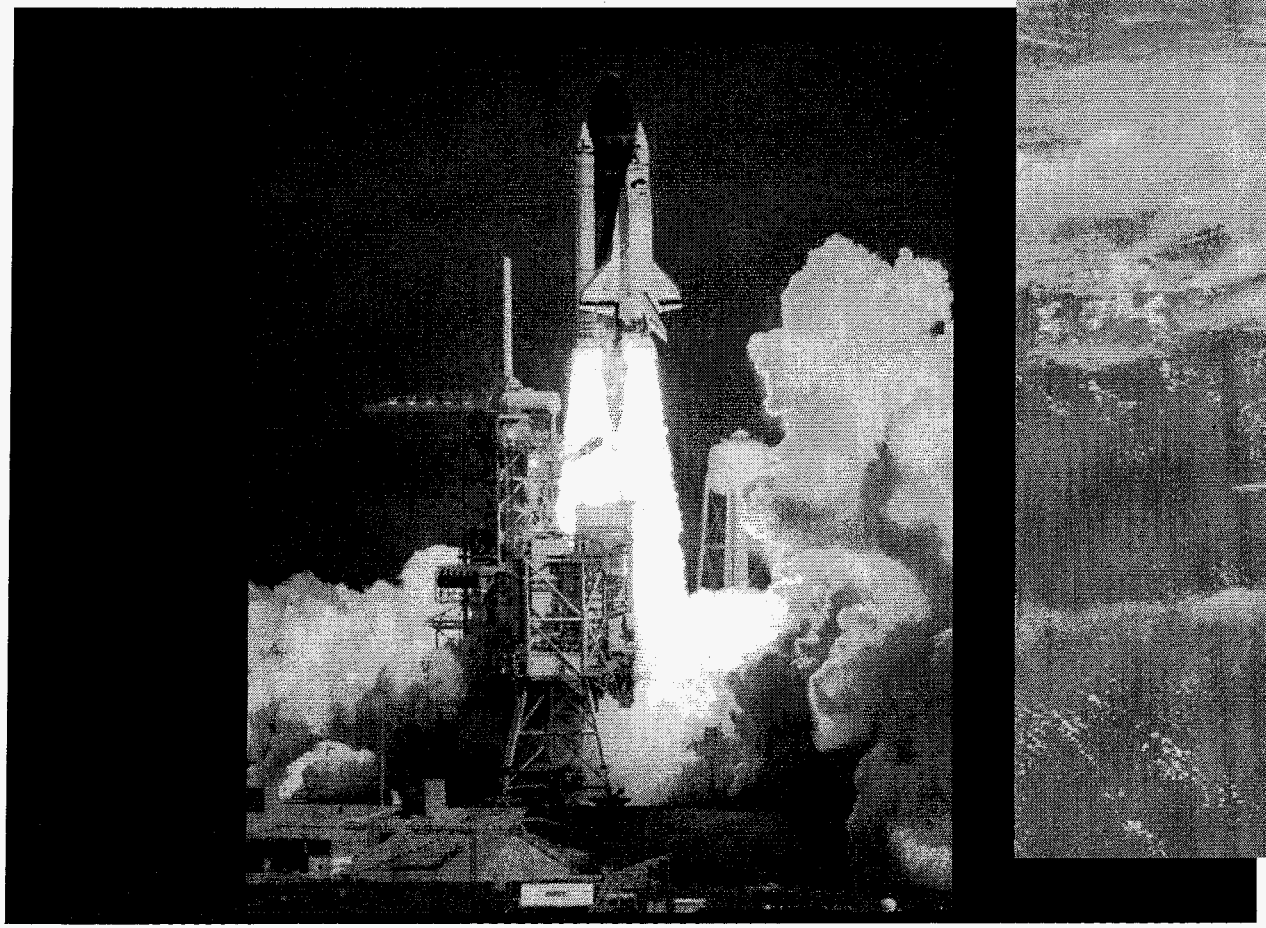
Spirit Landing Site
"Columbia Memorial Station"

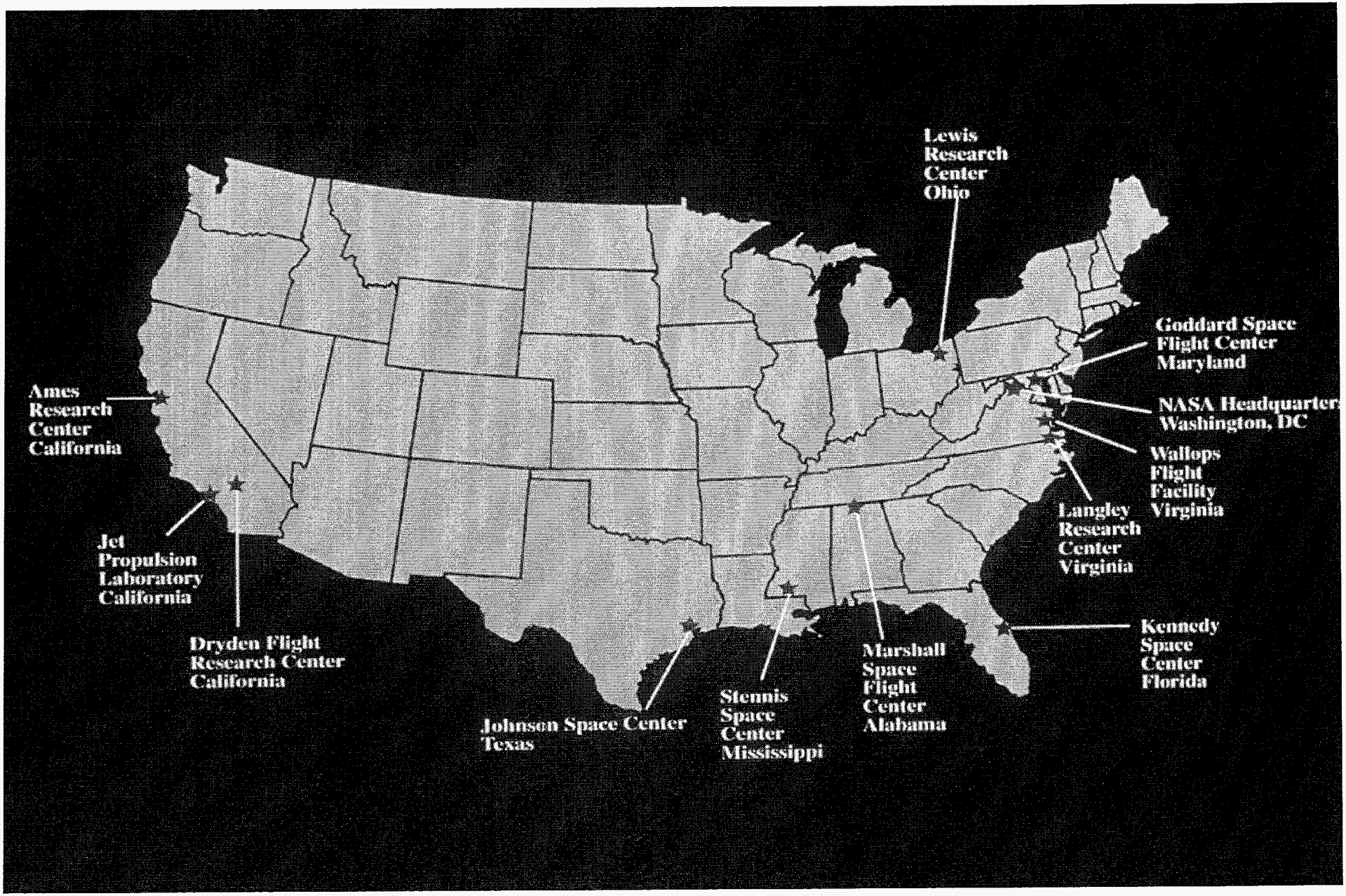


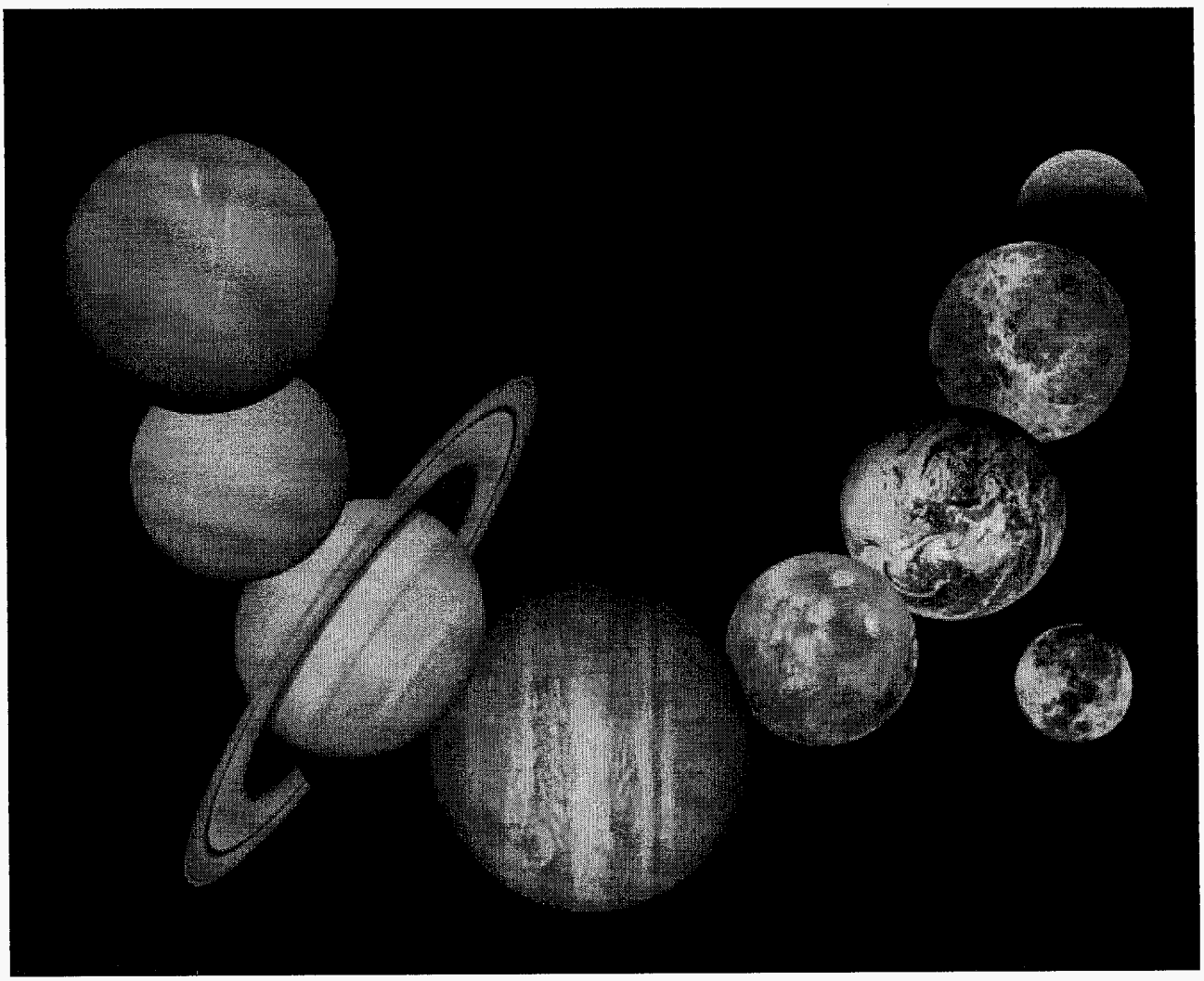
Hitting the Road on Mars

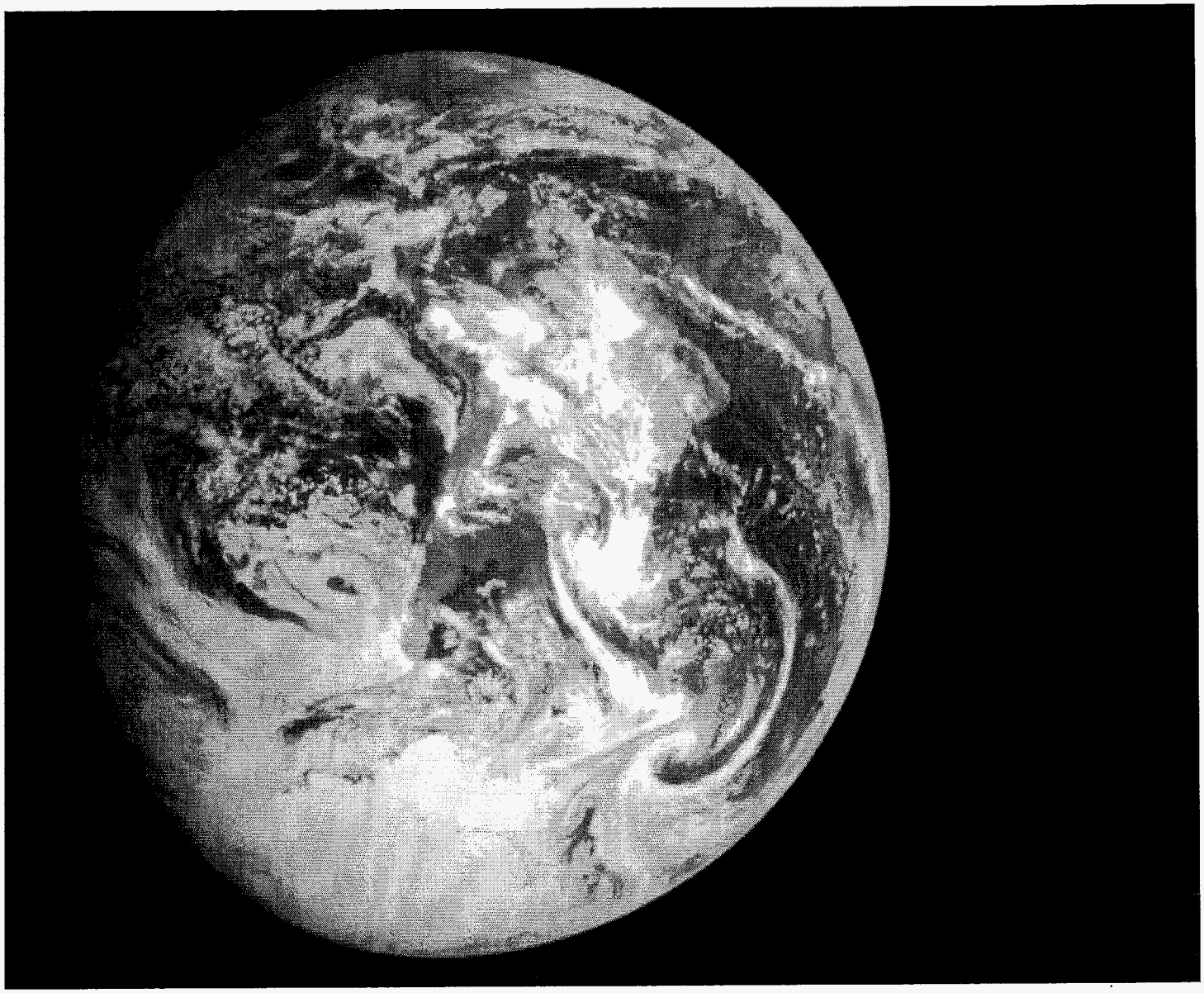


Former D[illegible] Chief -
Spacecraft/Rover [illegible] Flight Team
Mars Exploration Rover Project
Jet Propulsion Laboratory
NASA/Caltech

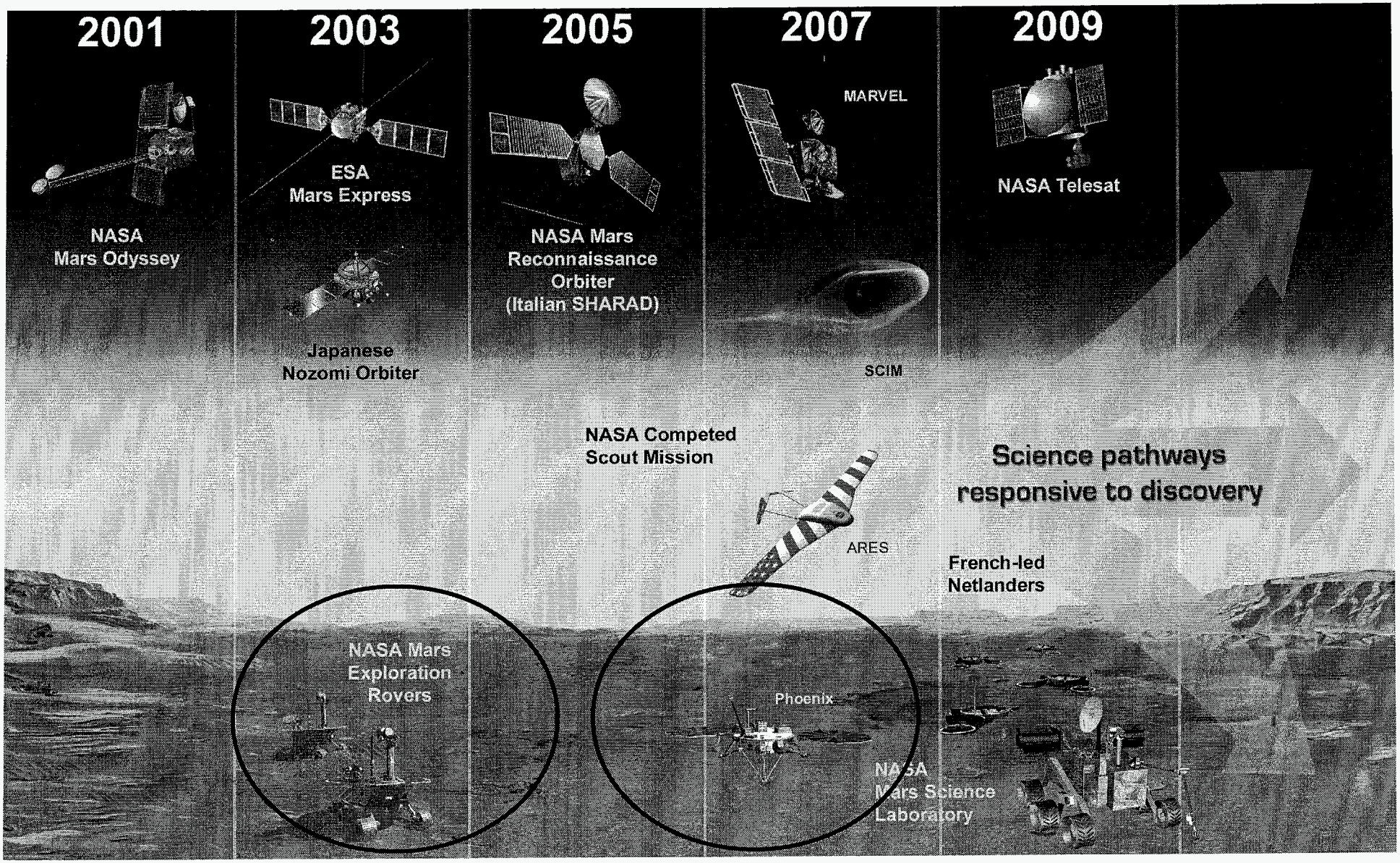



Lewis Research Center Ohio
Goddard Space Flight Center Maryland
NASA Headquarters Washington, DC
Wallops Flight Facility Virginia
Langley Research Center Virginia
Kennedy Space Center Florida
Marshall Space Flight Center Alabama
Stennis Space Center Mississippi
Johnson Space Center Texas
Ames Research Center California
Jet Propulsion Laboratory California
Dryden Flight Research Center California





Mars Missions: 2001-2009



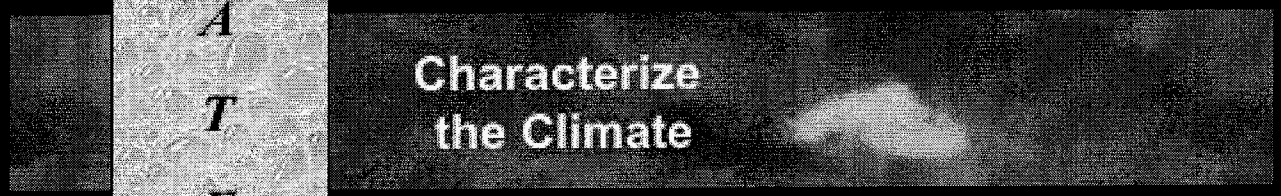
MARS SCIENCE STRATEGY: Follow the Water!

Common Thread

W A T E R

When?
Where?
Form?
Amount?

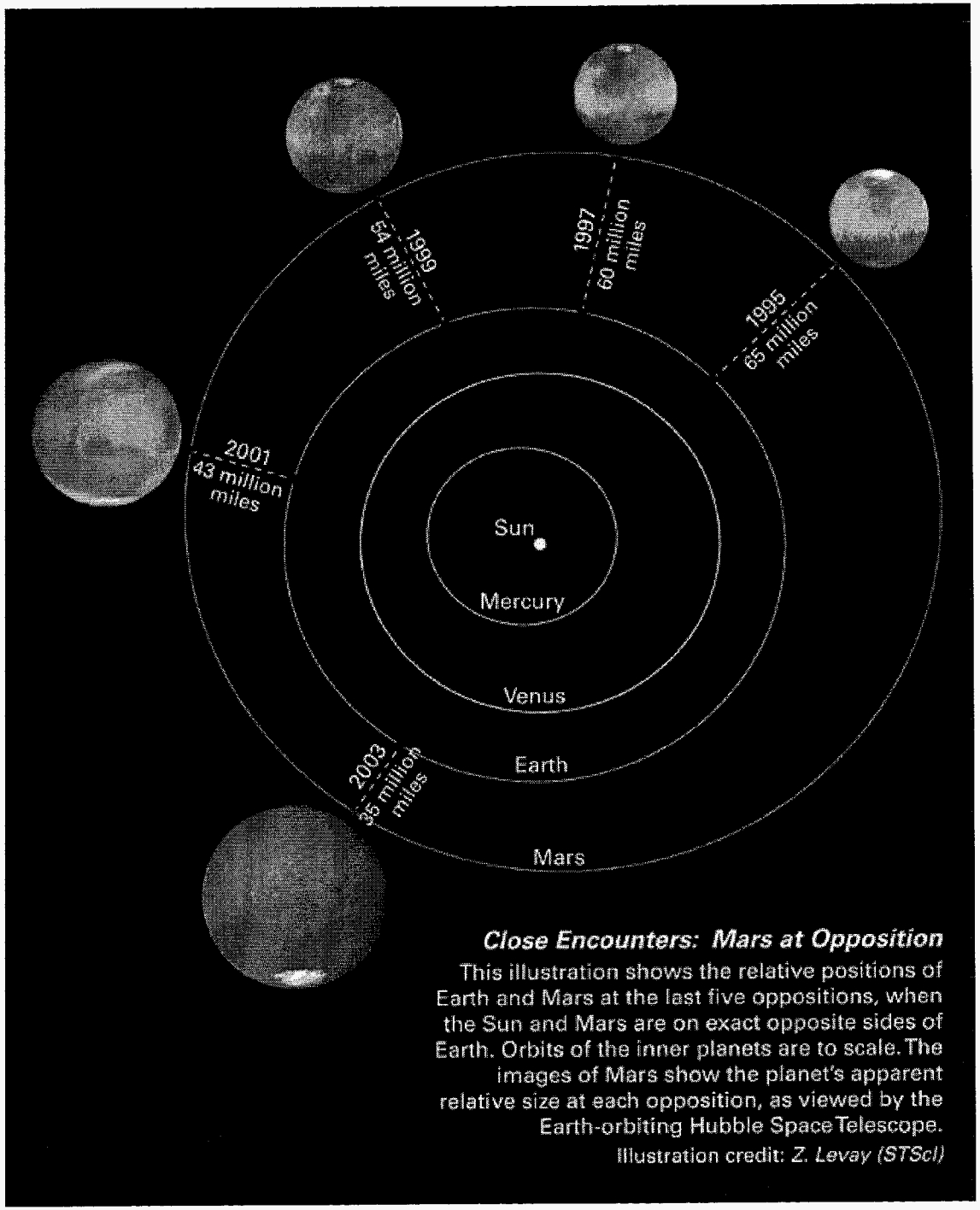
LIFE



CLIMATE

GEOLOGY

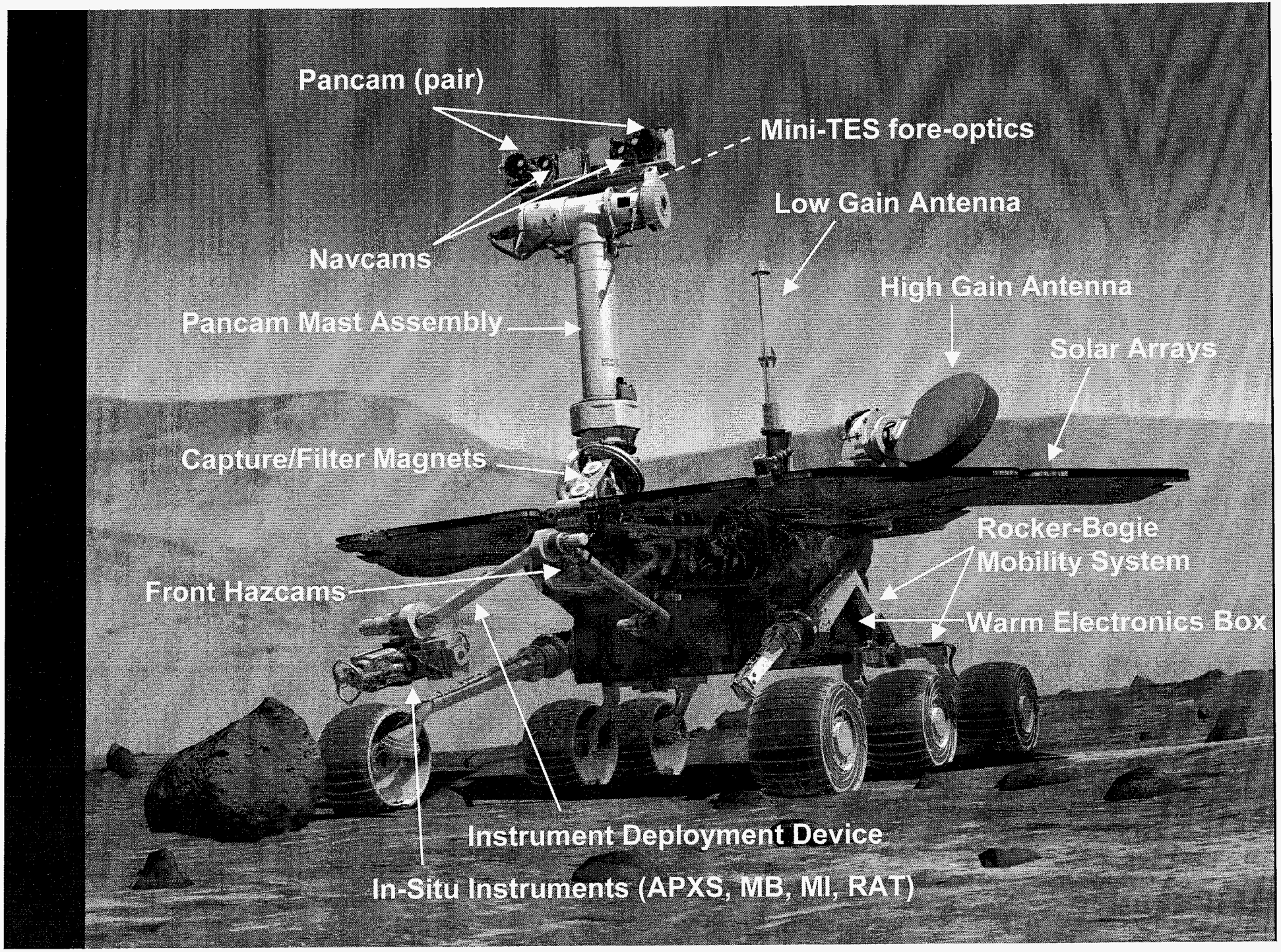
HUMAN



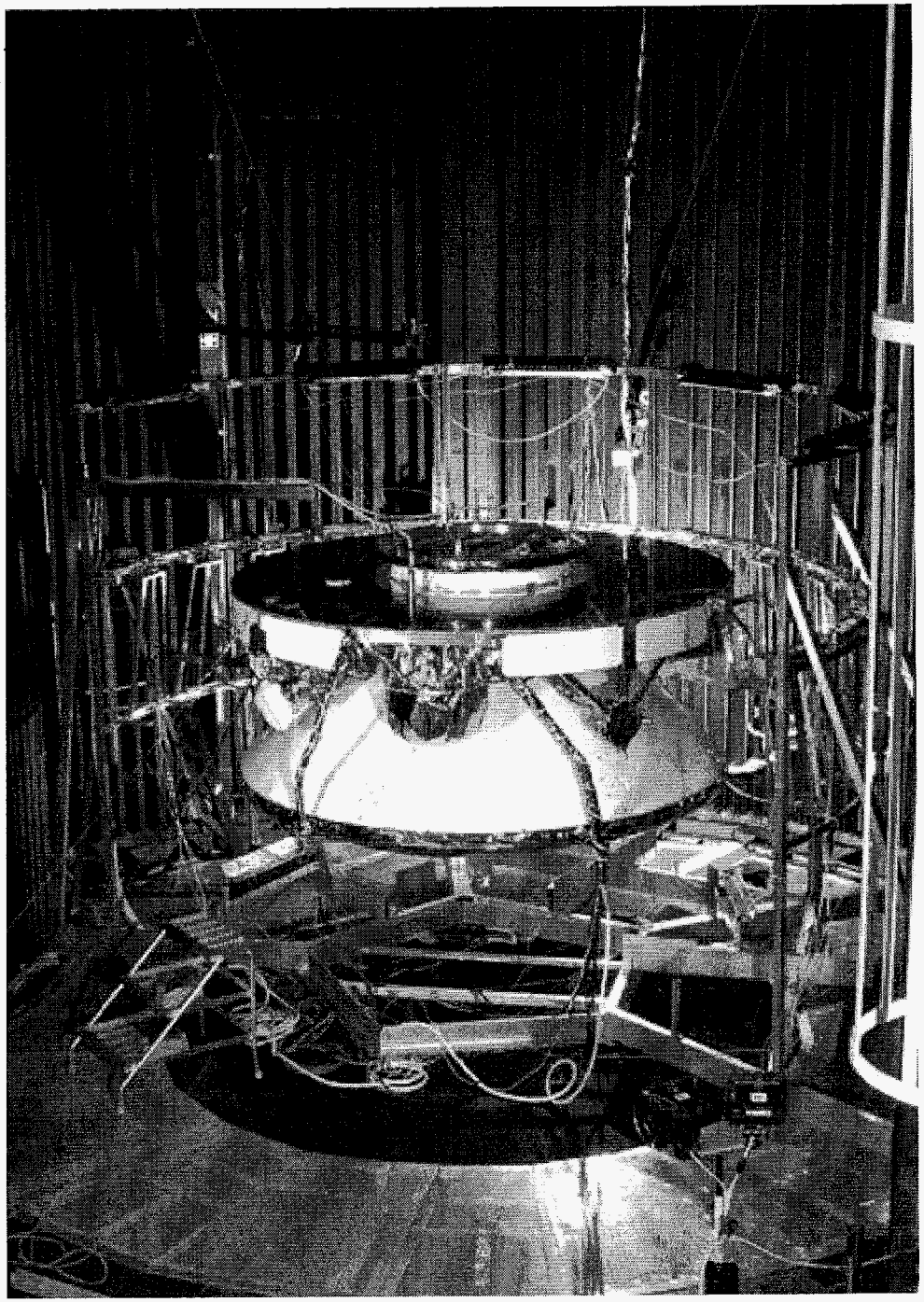
Close Encounters: Mars at Opposition

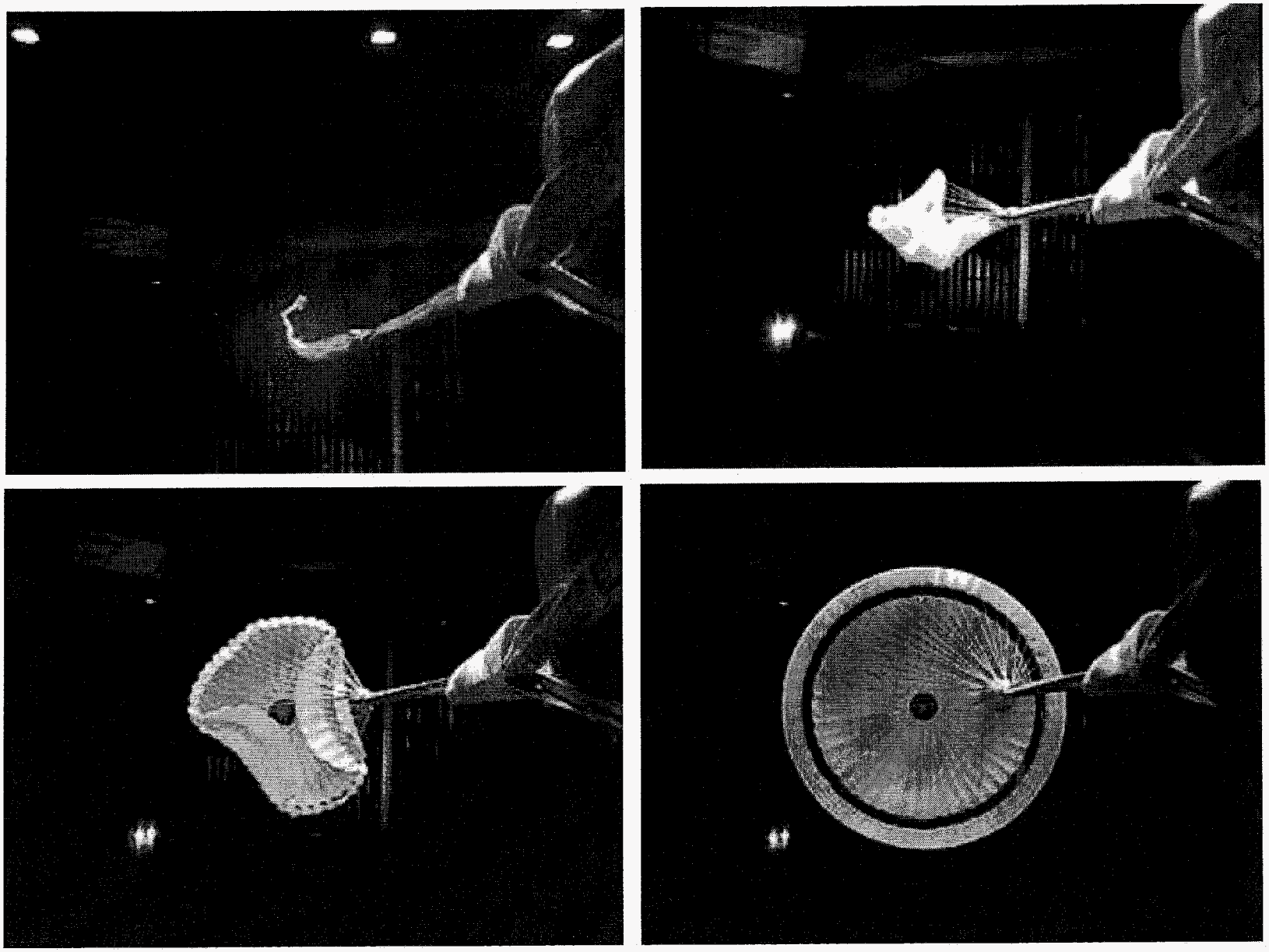
This illustration shows the relative positions of Earth and Mars at the last five oppositions, when the Sun and Mars are on exact opposite sides of Earth. Orbits of the inner planets are to scale. The images of Mars show the planet's apparent relative size at each opposition, as viewed by the Earth-orbiting Hubble Space Telescope.

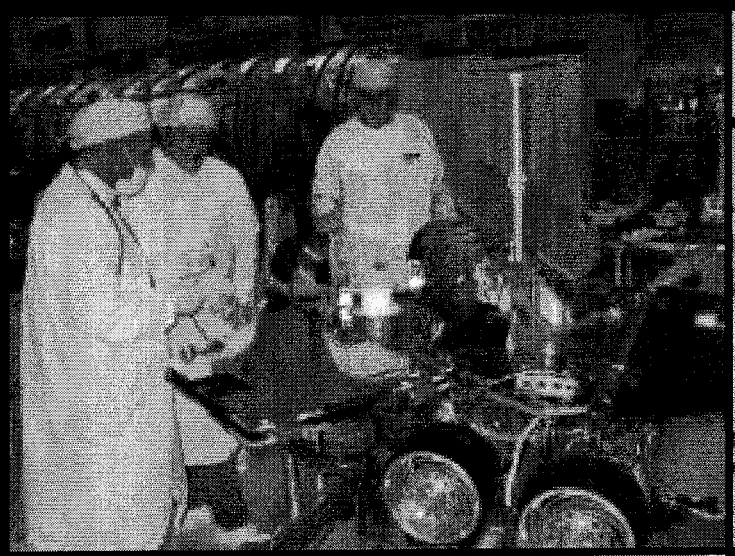
Illustration credit: *Z. Levay (STScI)*

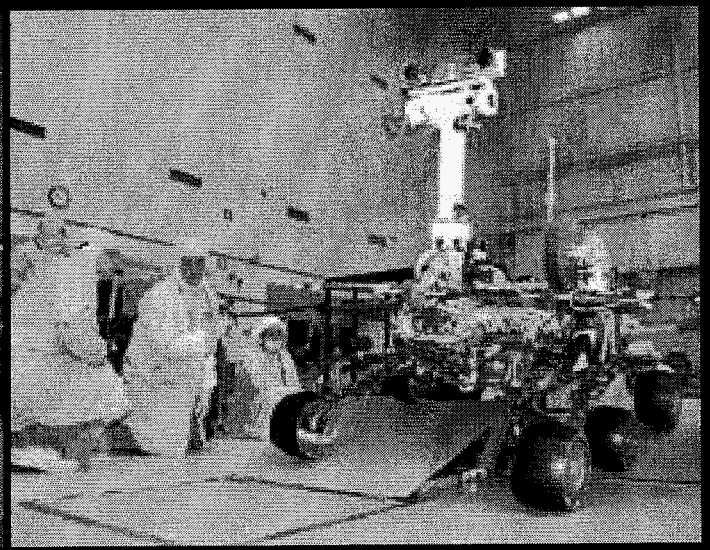

Pancam (pair)
Mini-TES fore-optics
Low Gain Antenna
Navcams
High Gain Antenna
Pancam Mast Assembly
Solar Arrays
Capture/Filter Magnets
Rocker-Bogie
Mobility System
Front Hazcams
Warm Electronics Box
Instrument Deployment Device
In-Situ Instruments (APXS, MB, MI, RAT)

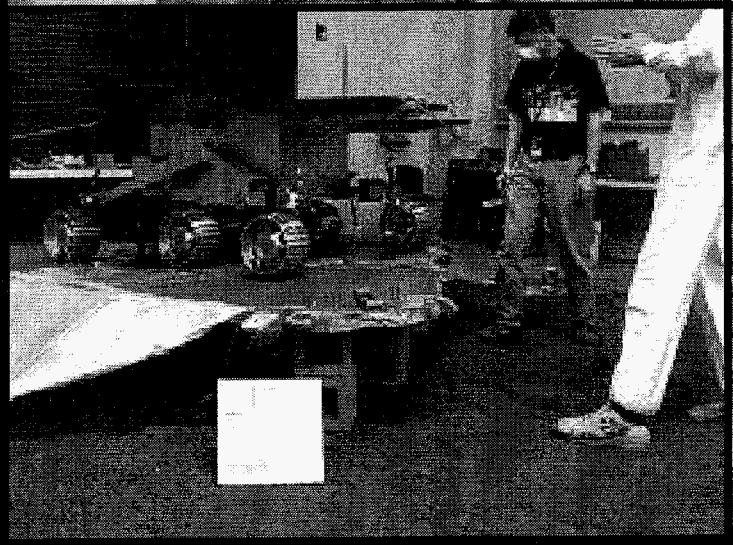
Parachu

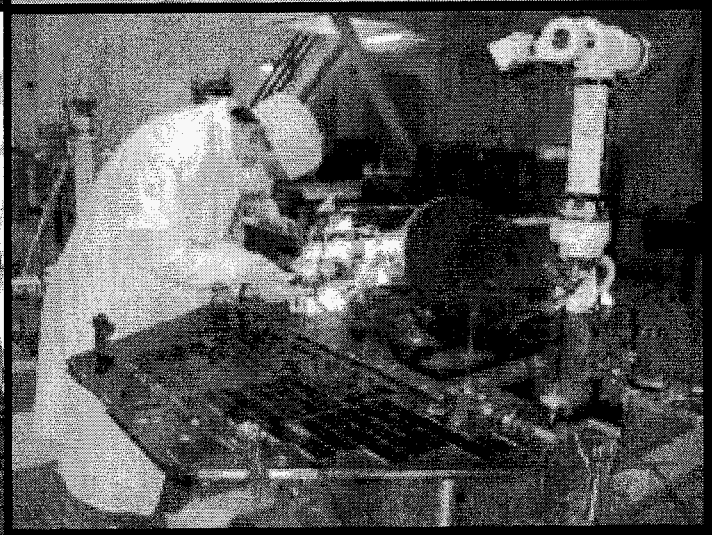




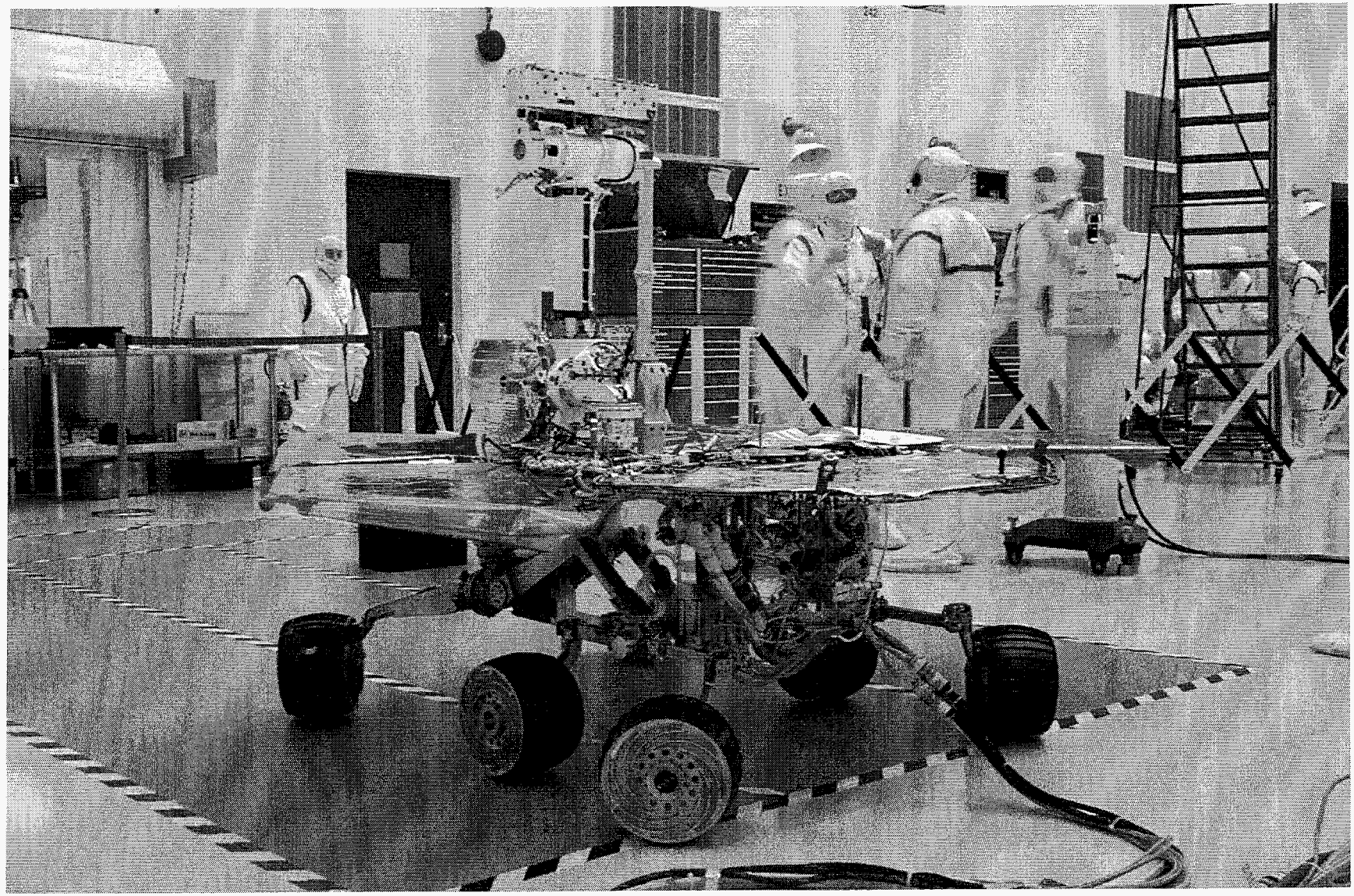






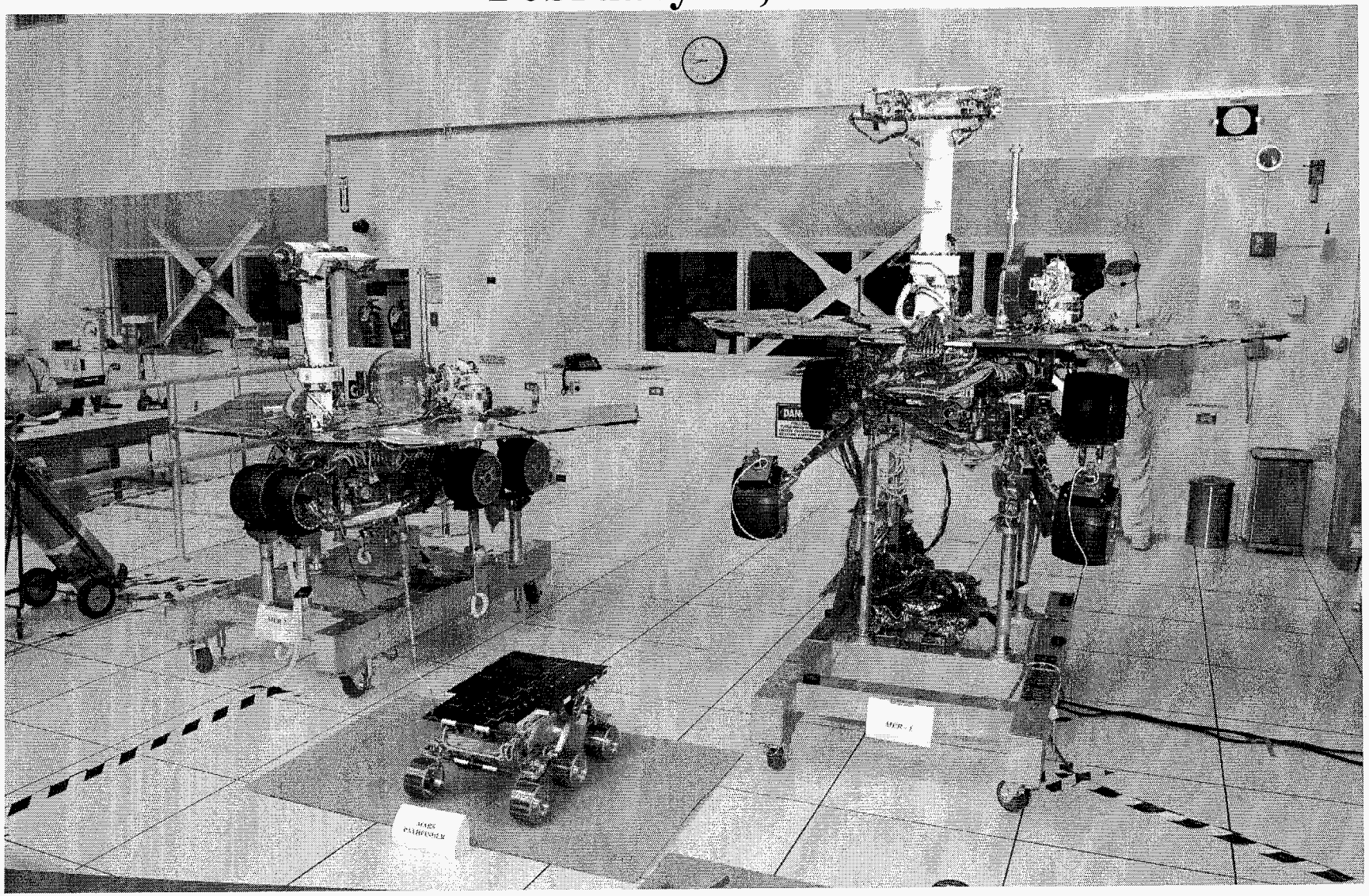


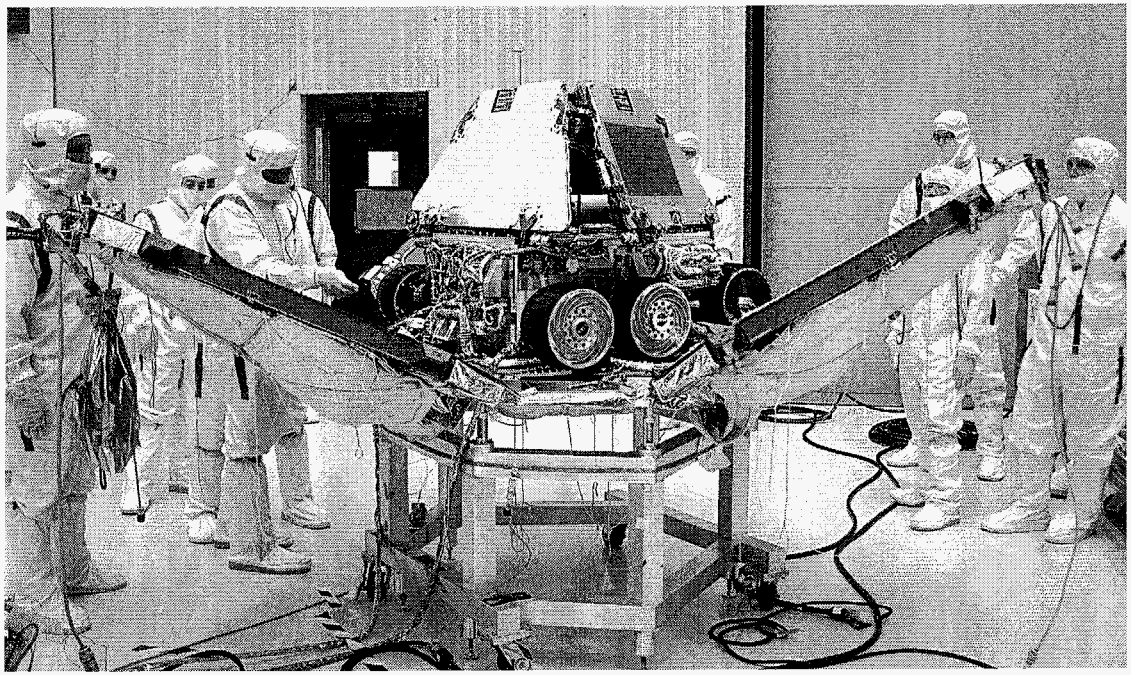
Spirit Driving Testing at KSC

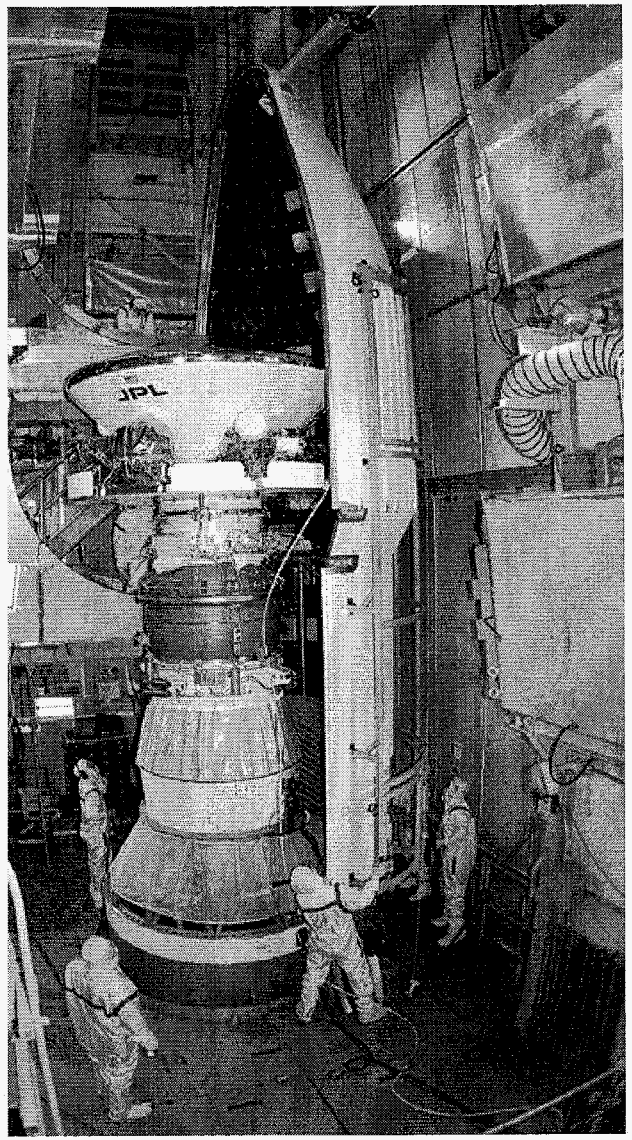


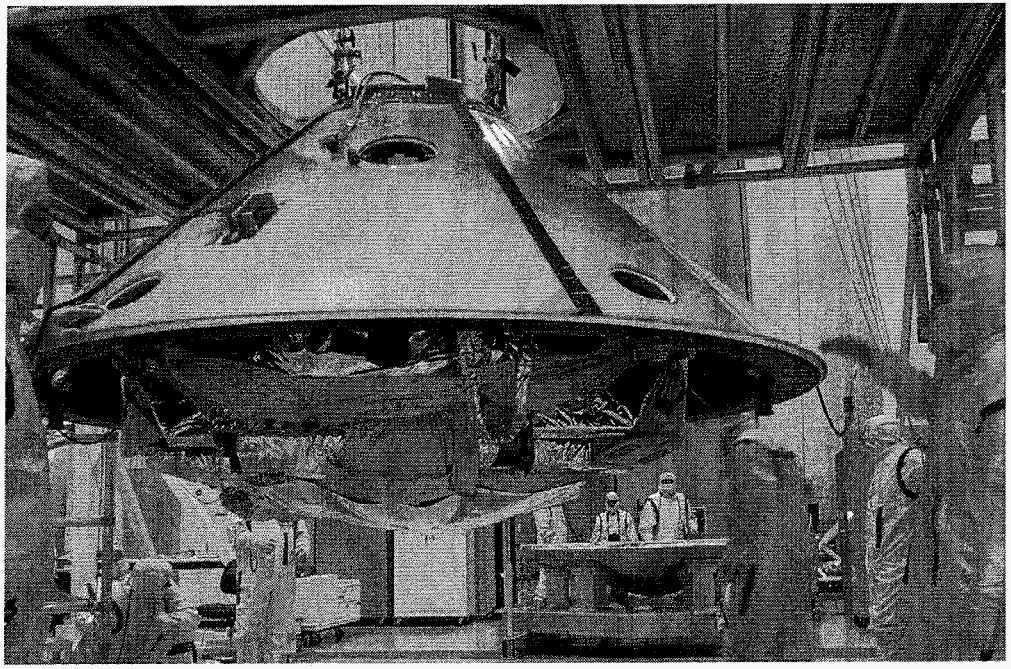
MER #1, MER #2, & Sojourner Spare Rovers

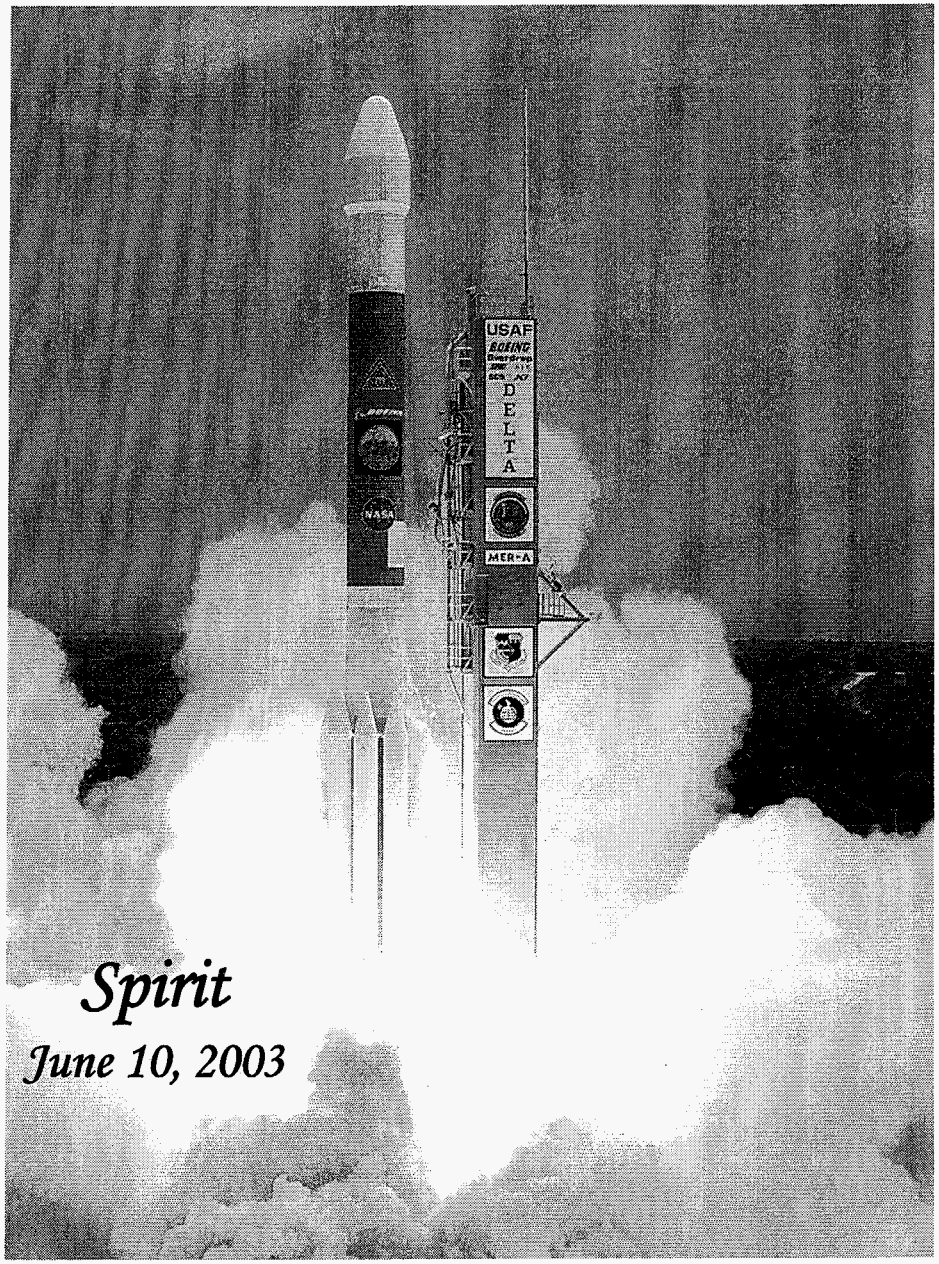
February 10, 2003





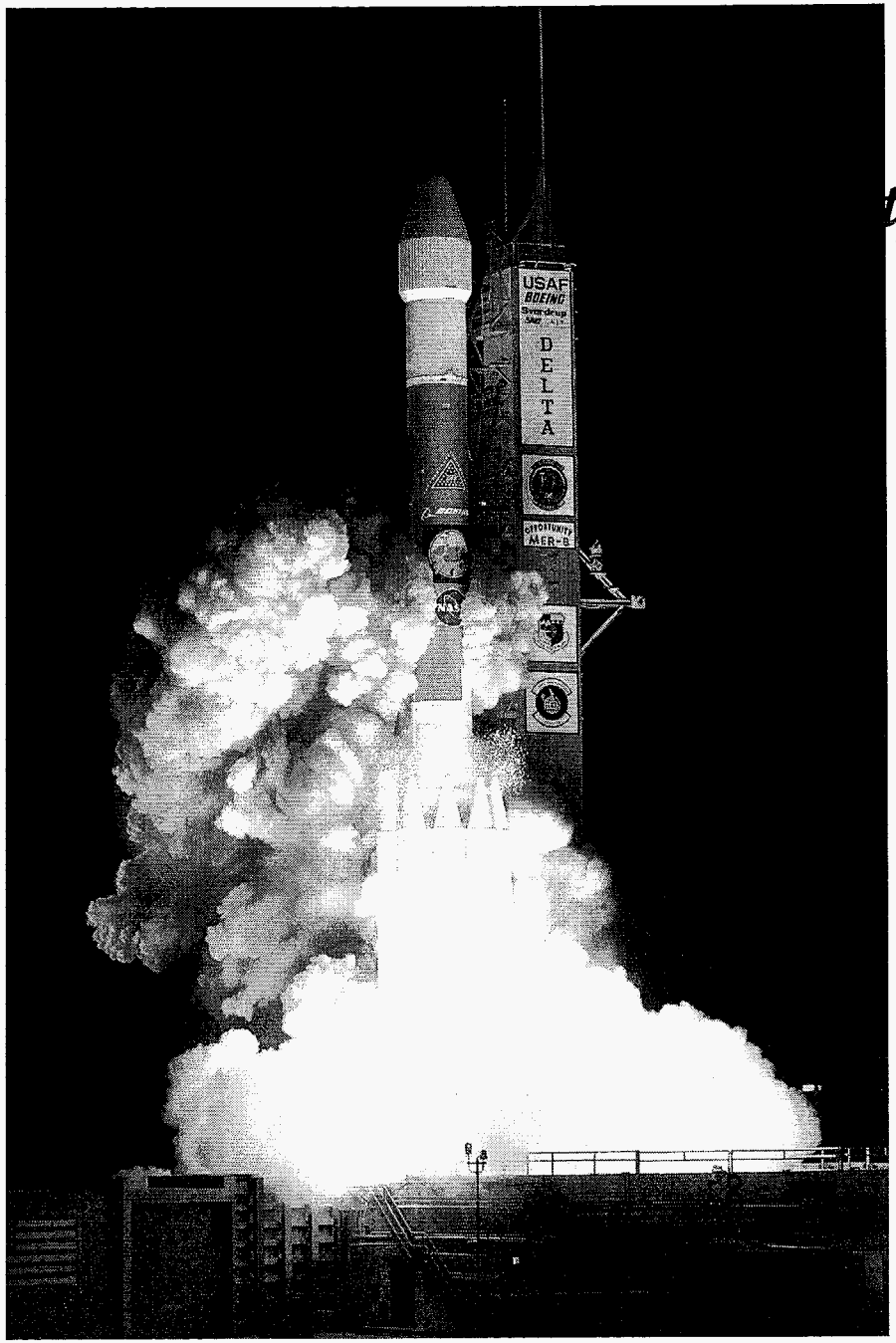

JPL





Spirit

June 10, 2003



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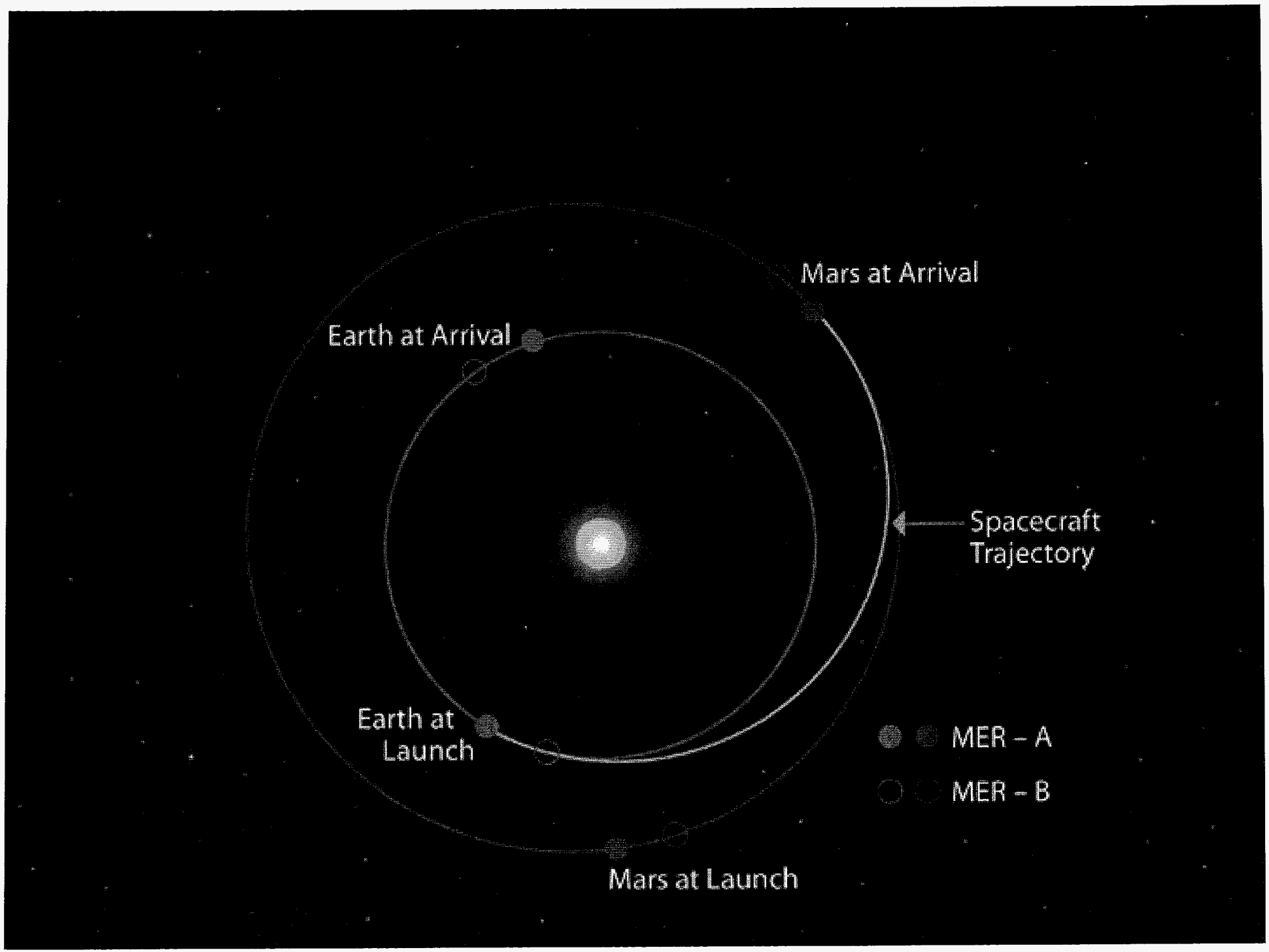
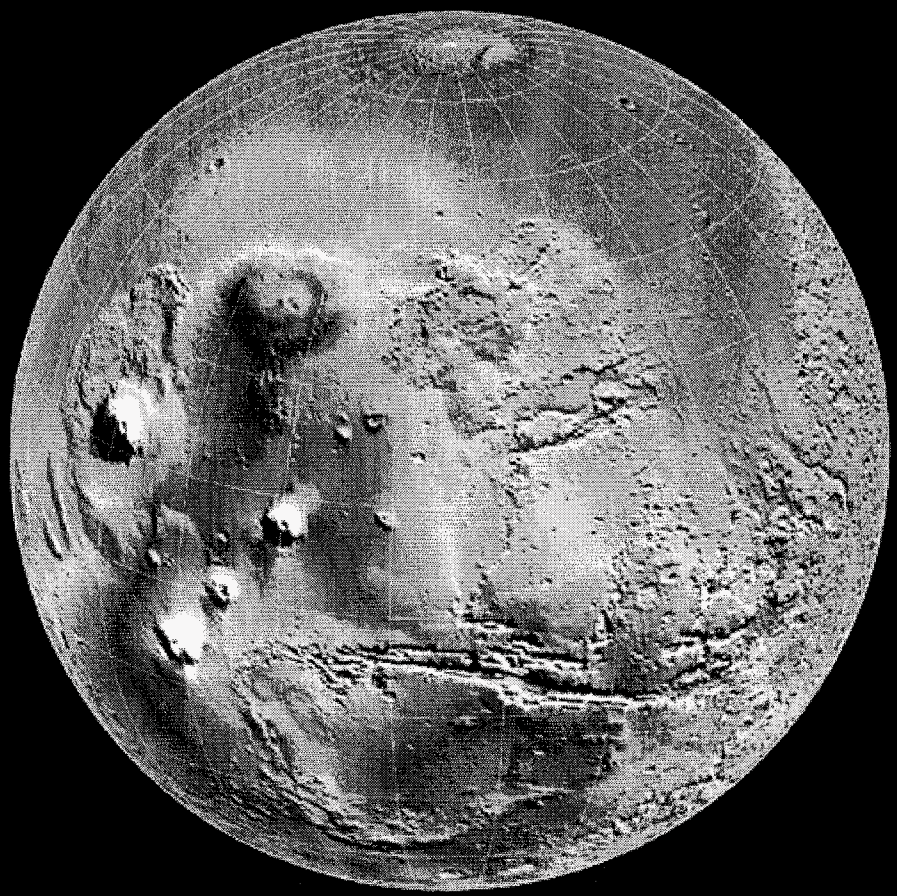
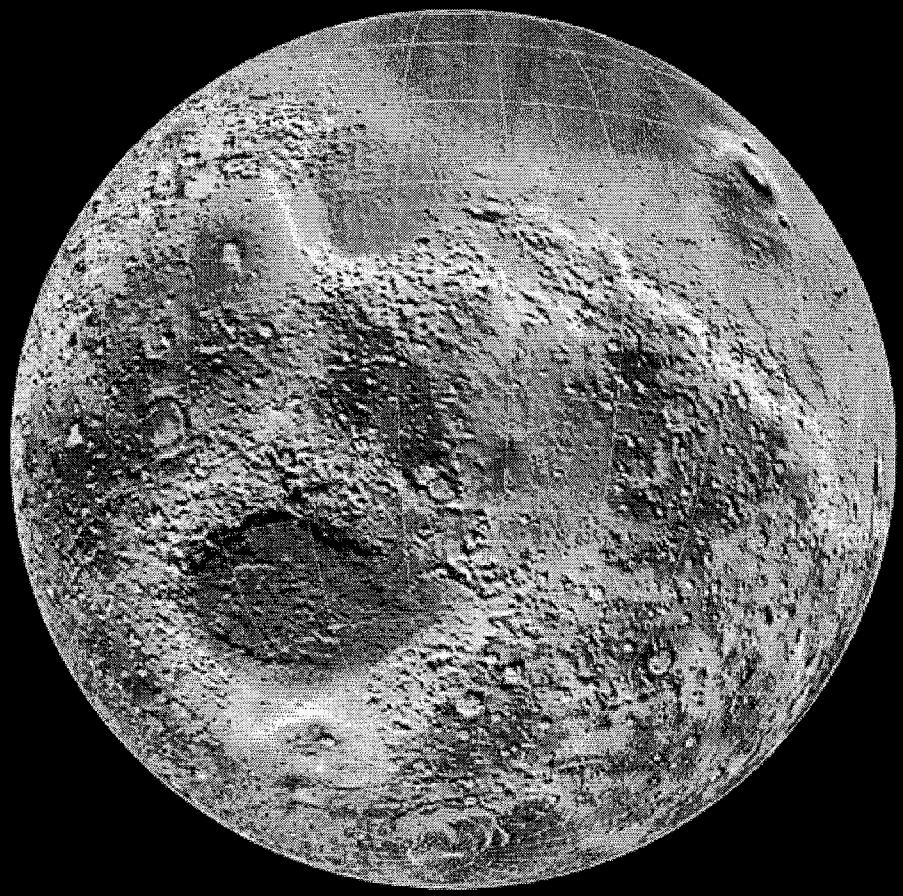
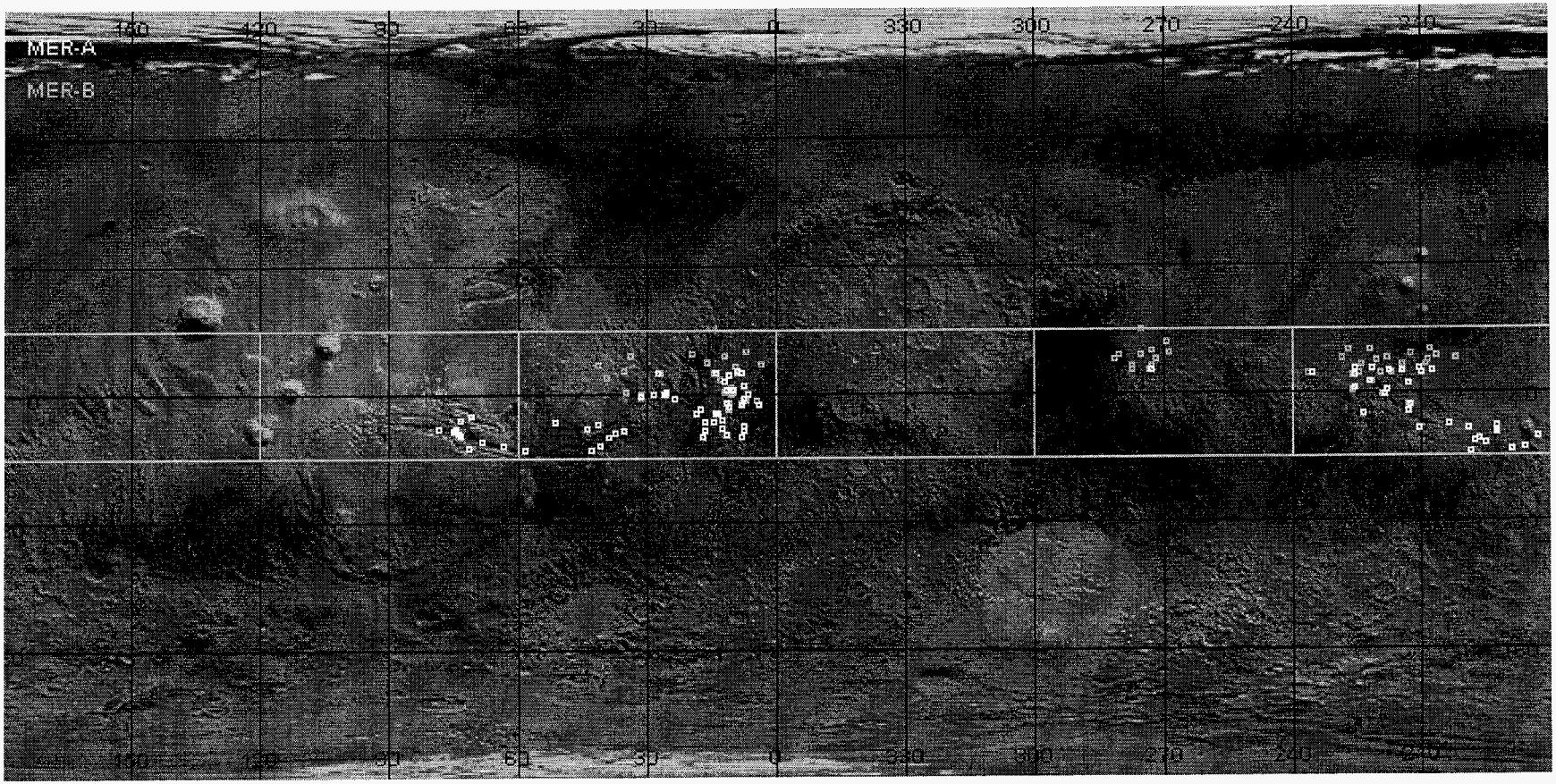
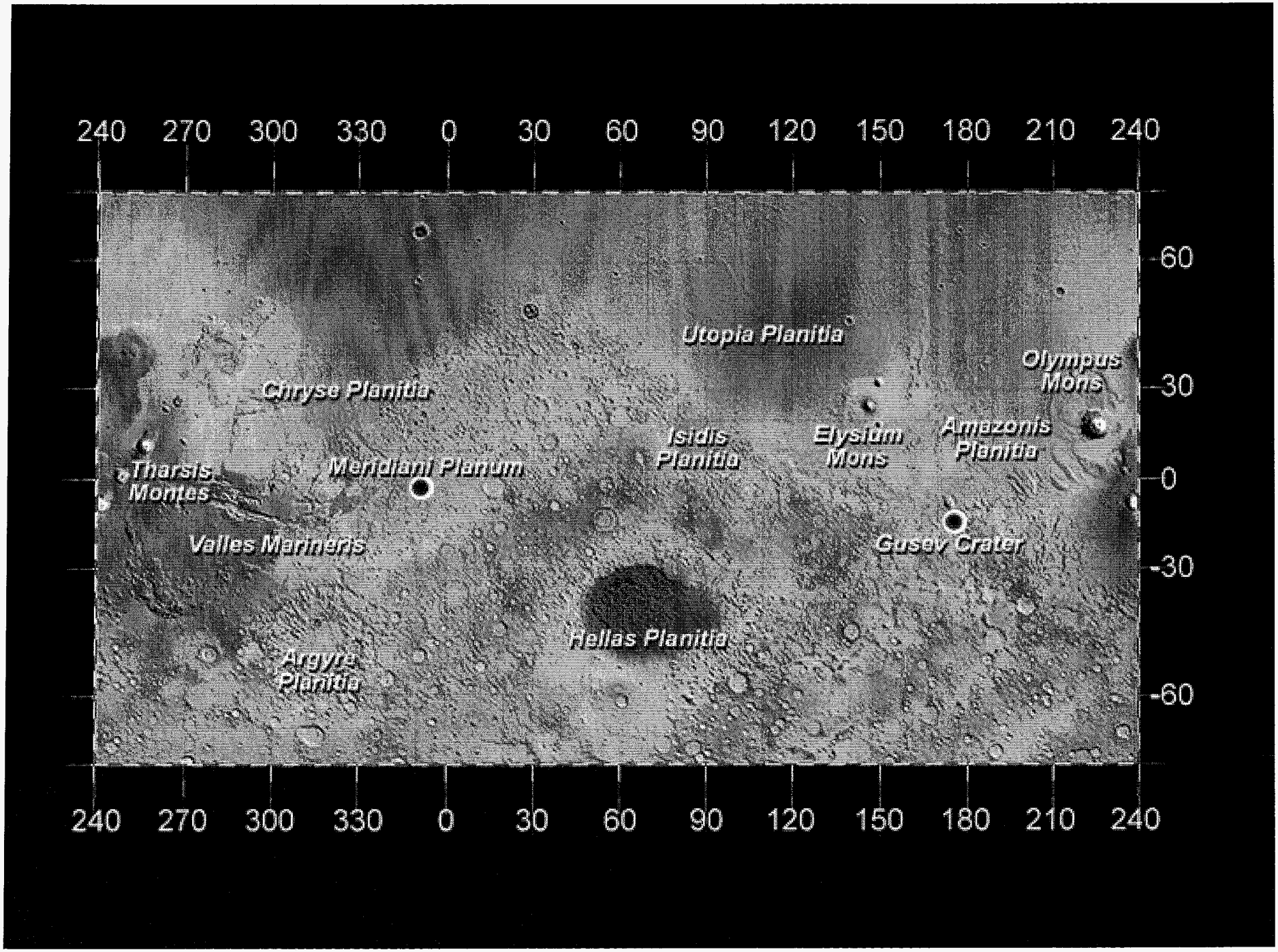
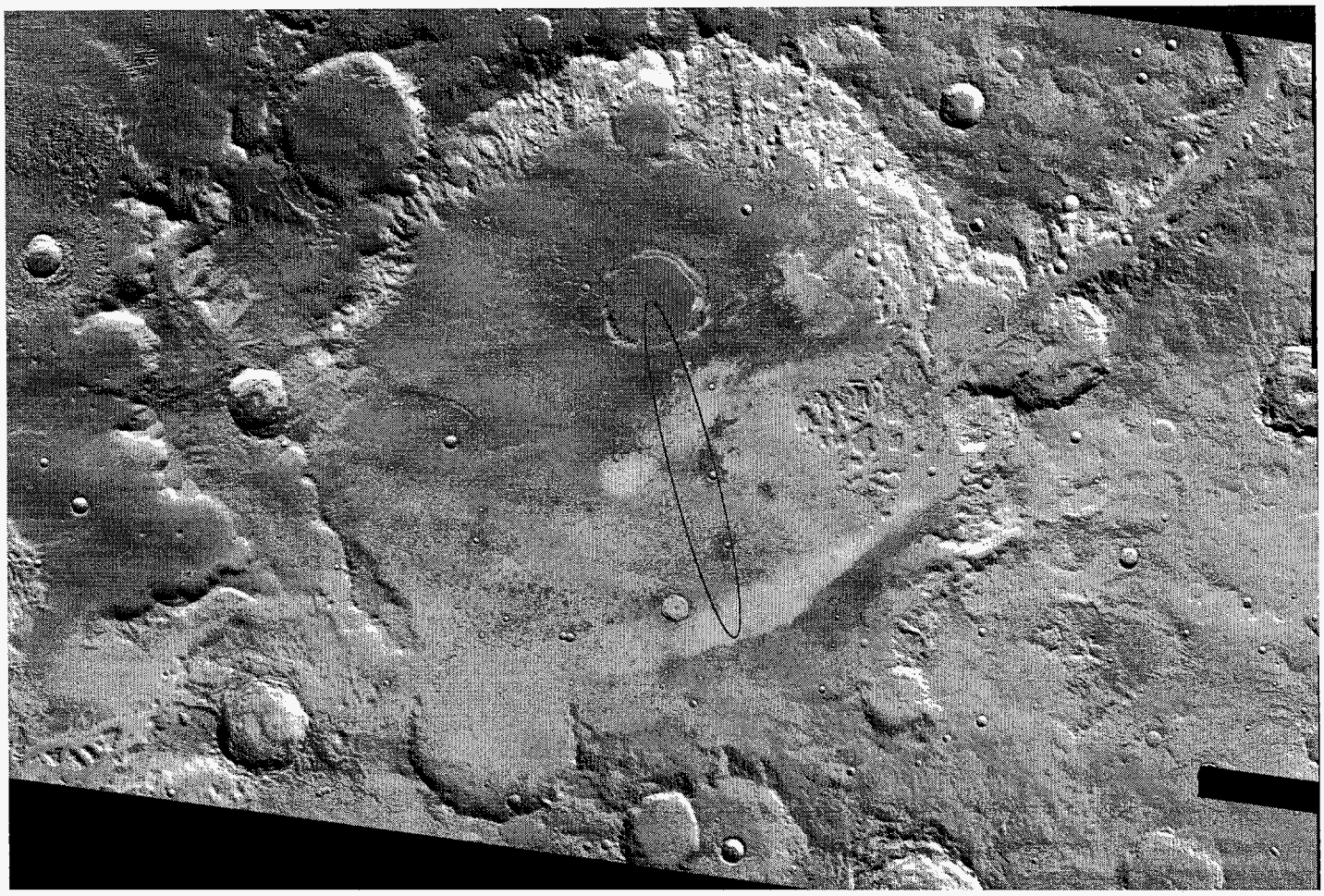

Mars at Arrival
Earth at Arrival
Spacecraft Trajectory
Earth at Launch
MER – A
MER – B
Mars at Launch

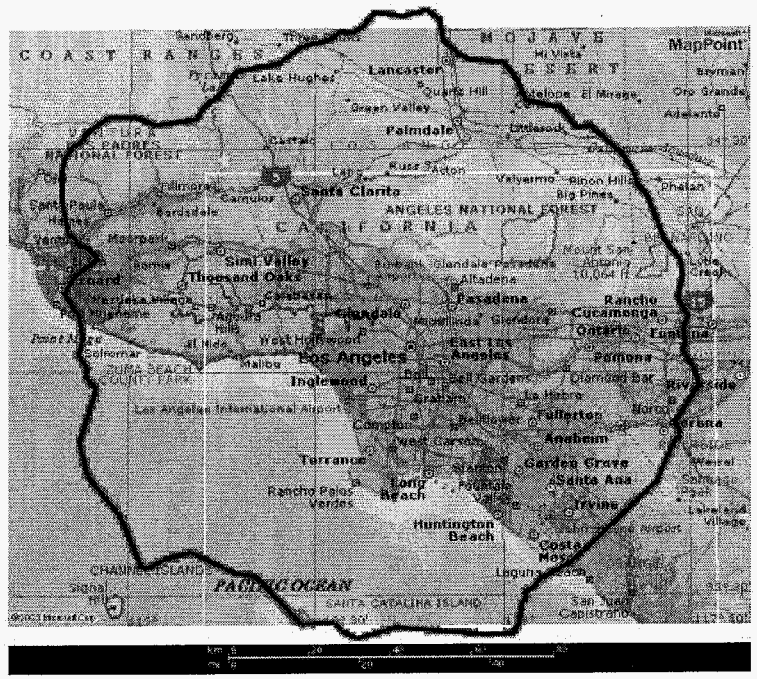


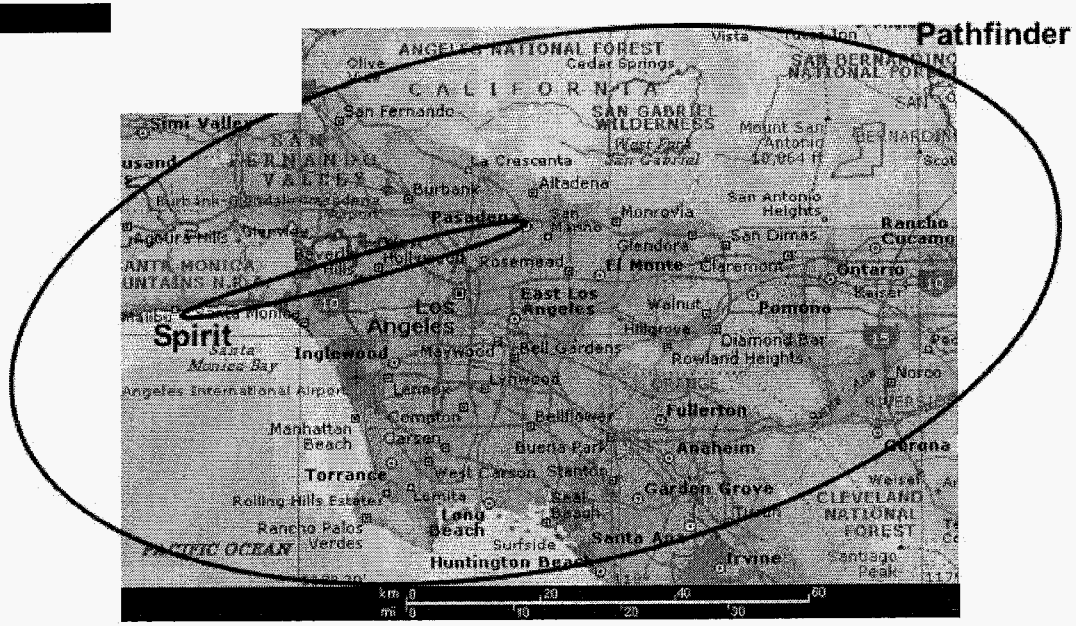


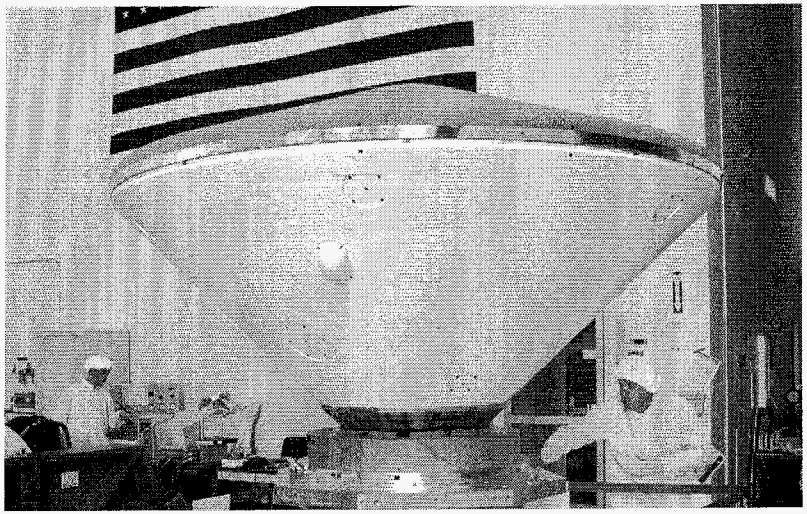

MER-A
MER-B
150
120
90
60
30
0
330
300
270
240
210

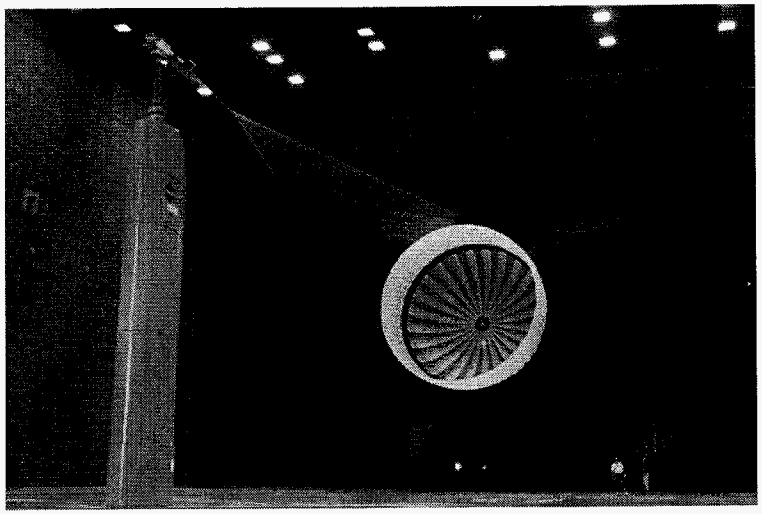

240 270 300 330 0 30 60 90 120 150 180 210 240
60
30
0
-30
-60
Utopia Planitia
Olympus Mons
Chryse Planitia
Isidis Planitia
Elysium Mons
Amazonis Planitia
Tharsis Montes
Meridiani Planum
Valles Marineris
Gusev Crater
Hellas Planitia
Argyre Planitia

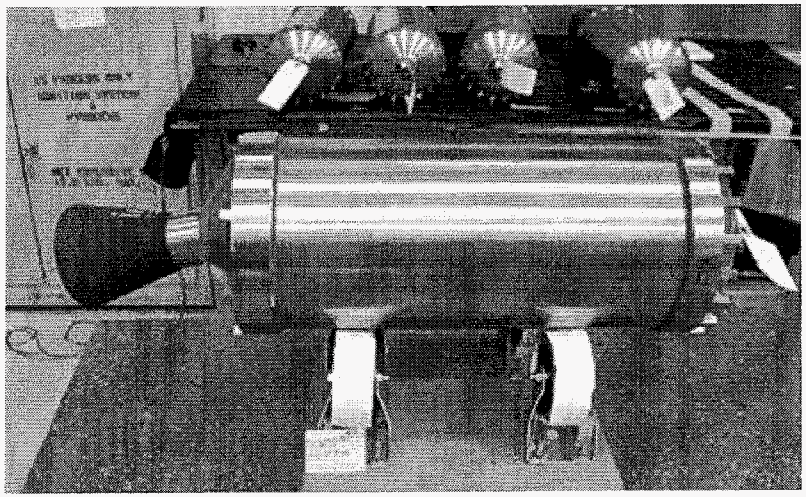


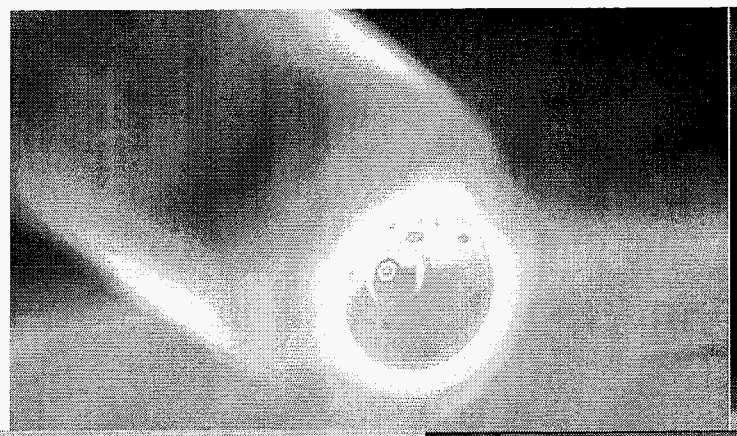
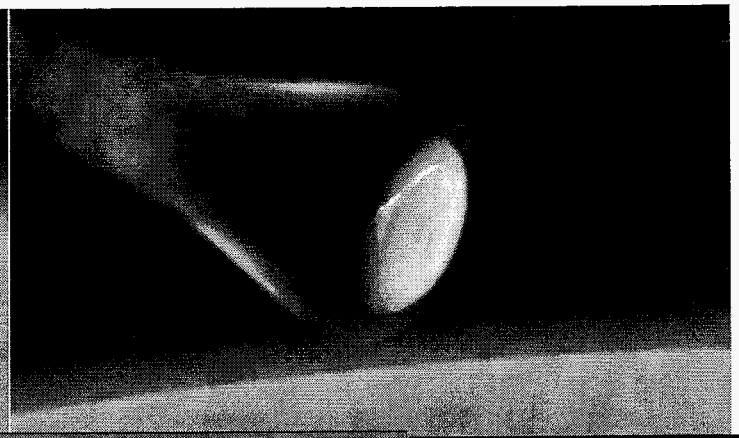
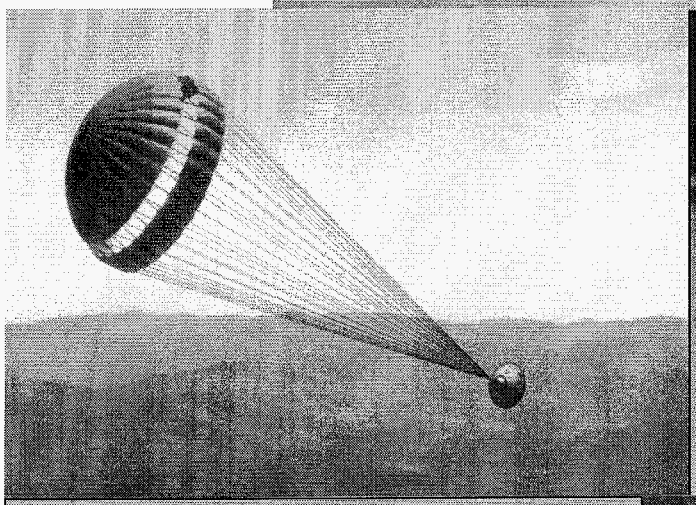
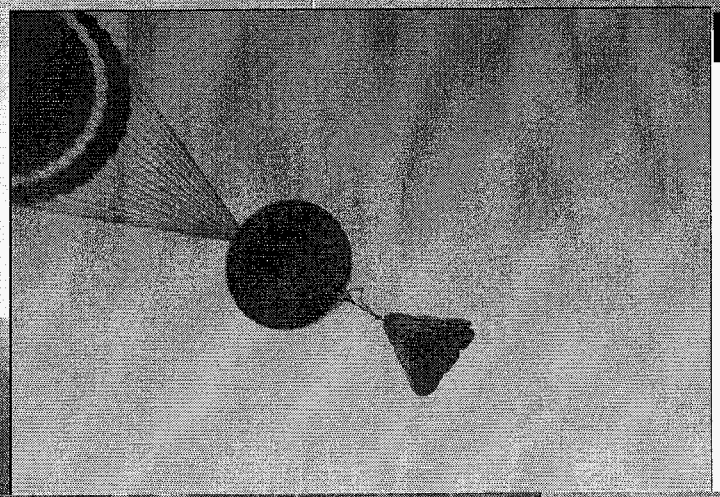
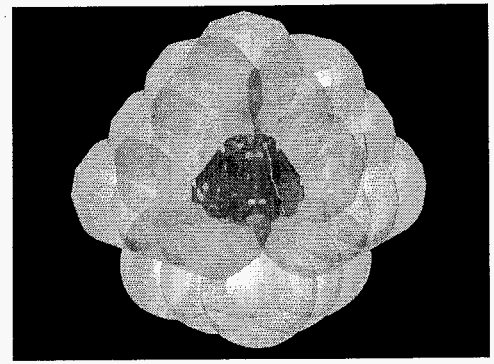
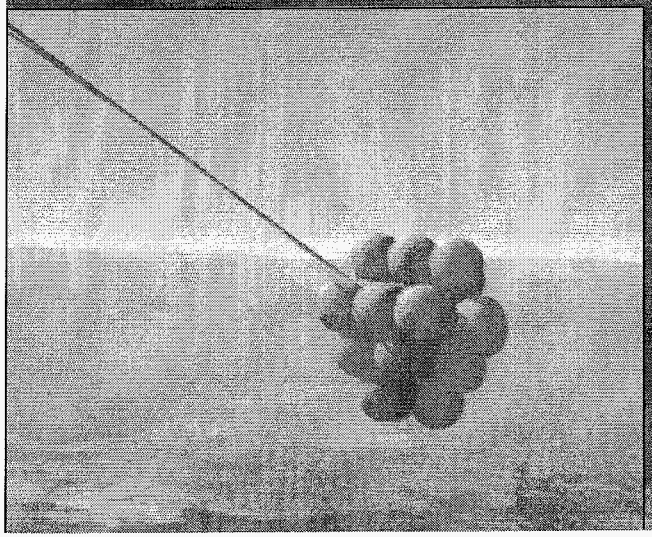
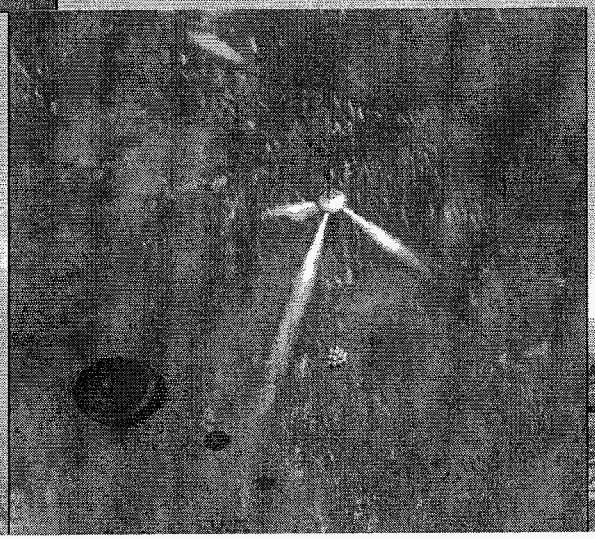
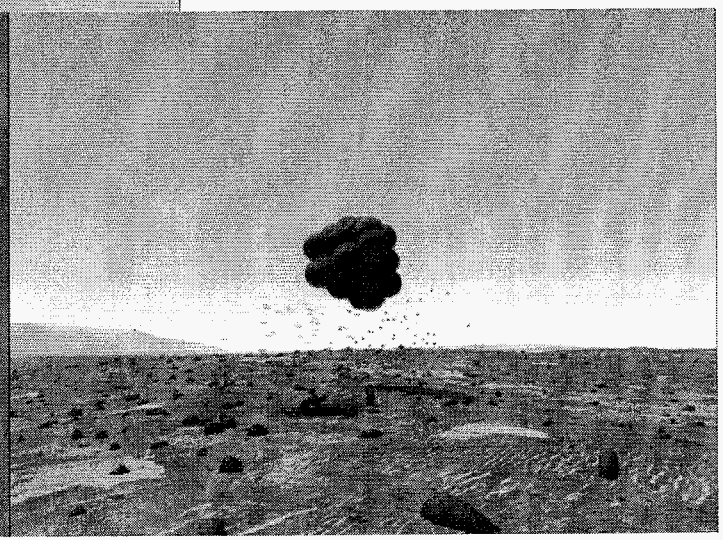

MapPoint
COAST RANGES
MOJAVE DESERT
Lancaster
Palmdale
Santa Clarita
ANGELES NATIONAL FOREST
CALIFORNIA
Simi Valley
Thousand Oaks
Pasadena
Rancho Cucamonga
Ontario
Los Angeles
Inglewood
Pomona
Riverside
Anaheim
Garden Grove
Santa Ana
Torrance
Long Beach
Irvine
Huntington Beach
PACIFIC OCEAN

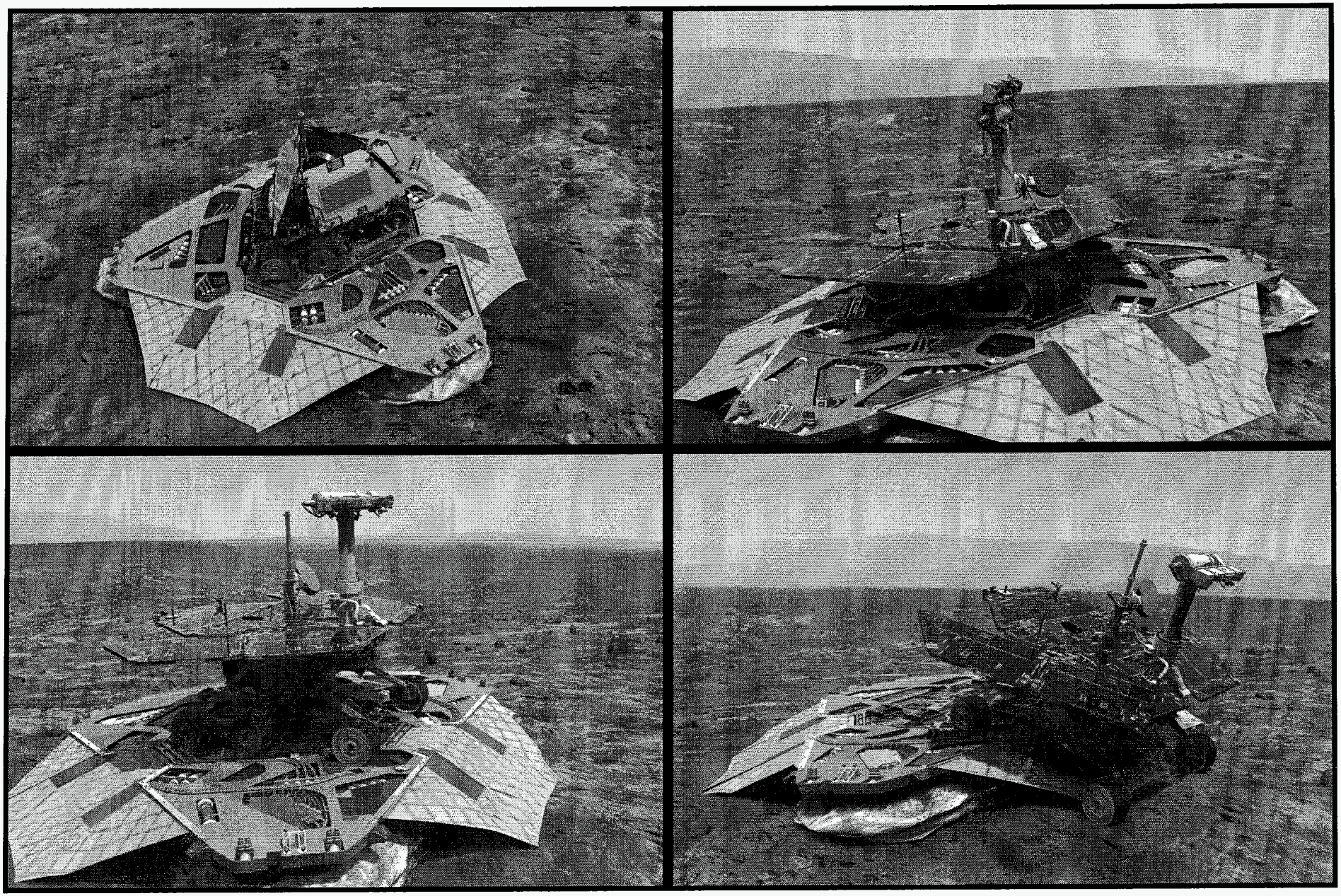

Pathfinder
Spirit
ANGELES NATIONAL FOREST
CALIFORNIA
SAN GABRIEL WILDERNESS
Simi Valley
SAN FERNANDO VALLEY
Burbank
Pasadena
Altadena
Monrovia
Glendora
El Monte
Ontario
Pomona
Los Angeles
East Los Angeles
Inglewood
Bell Gardens
Fullerton
Anaheim
Torrance
Long Beach
Garden Grove
Santa Ana
Irvine
Huntington Beach
PACIFIC OCEAN
CLEVELAND NATIONAL FOREST

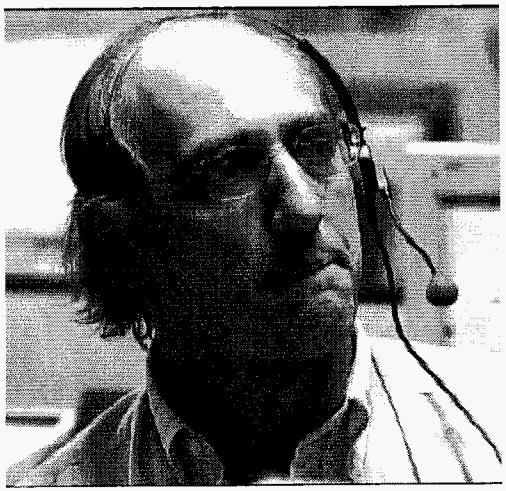










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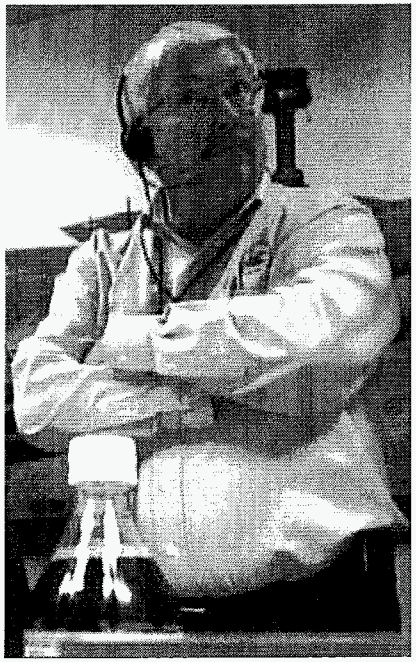
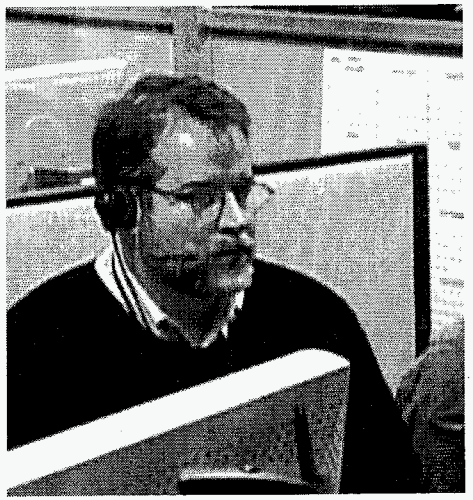
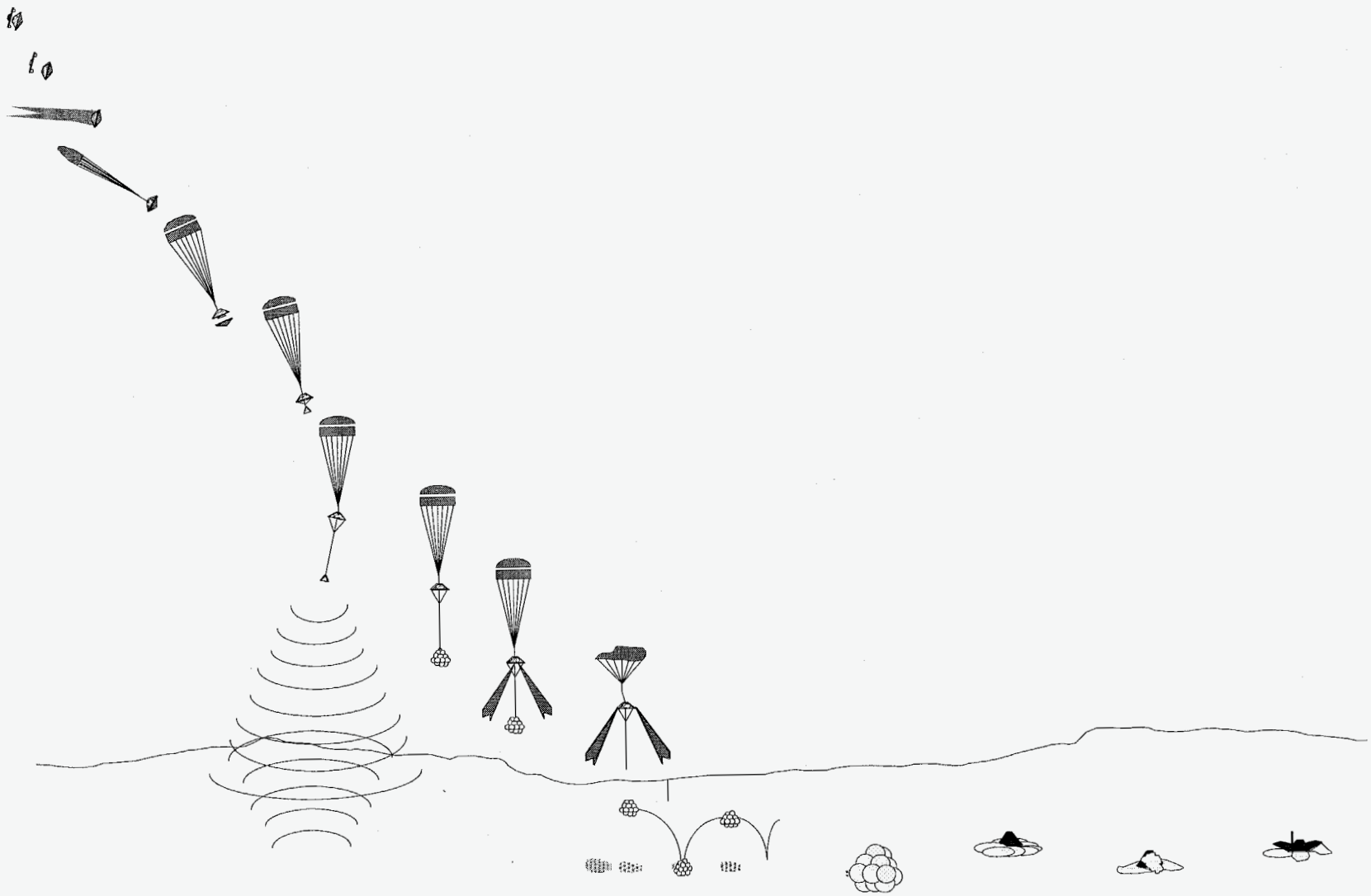
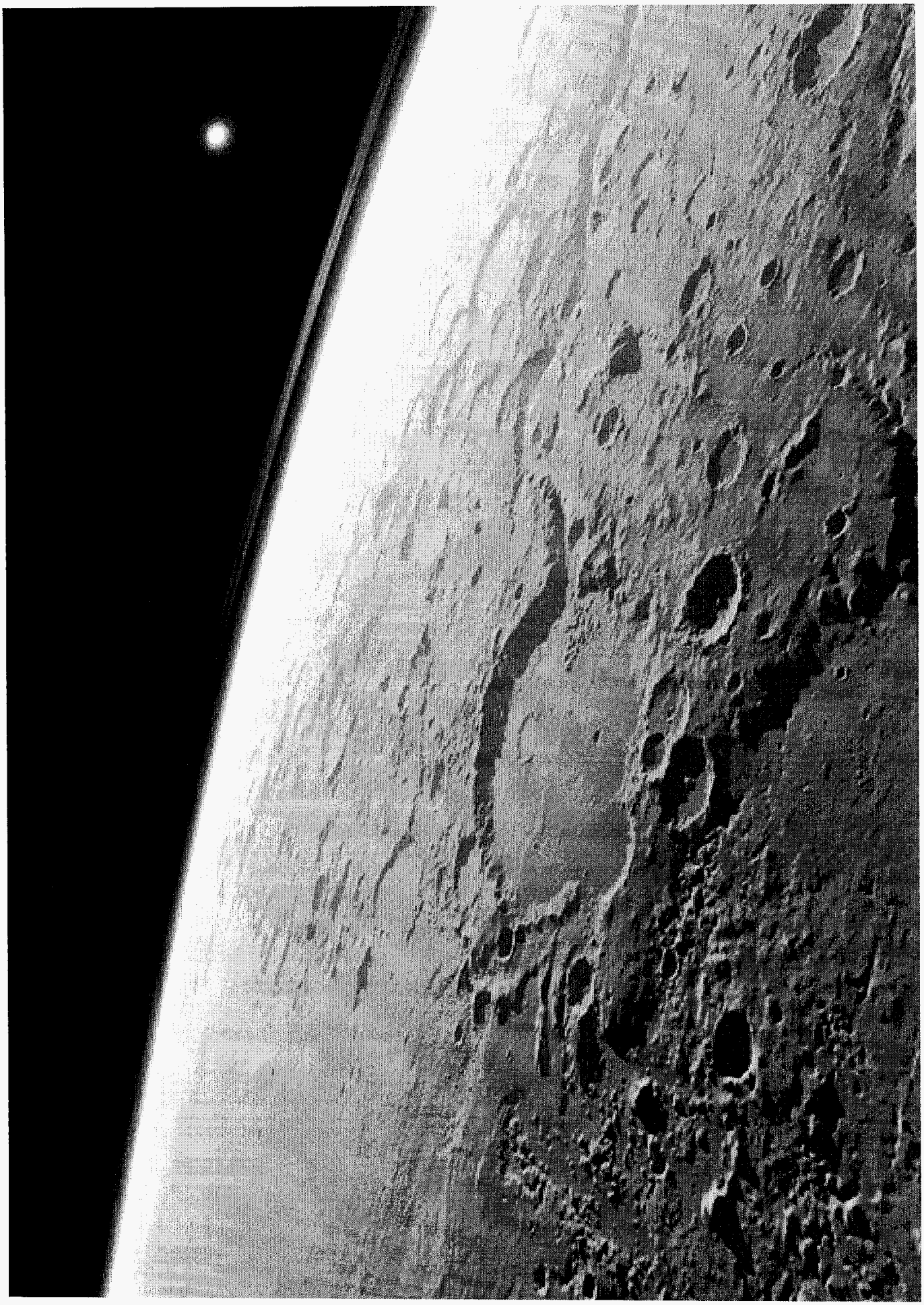
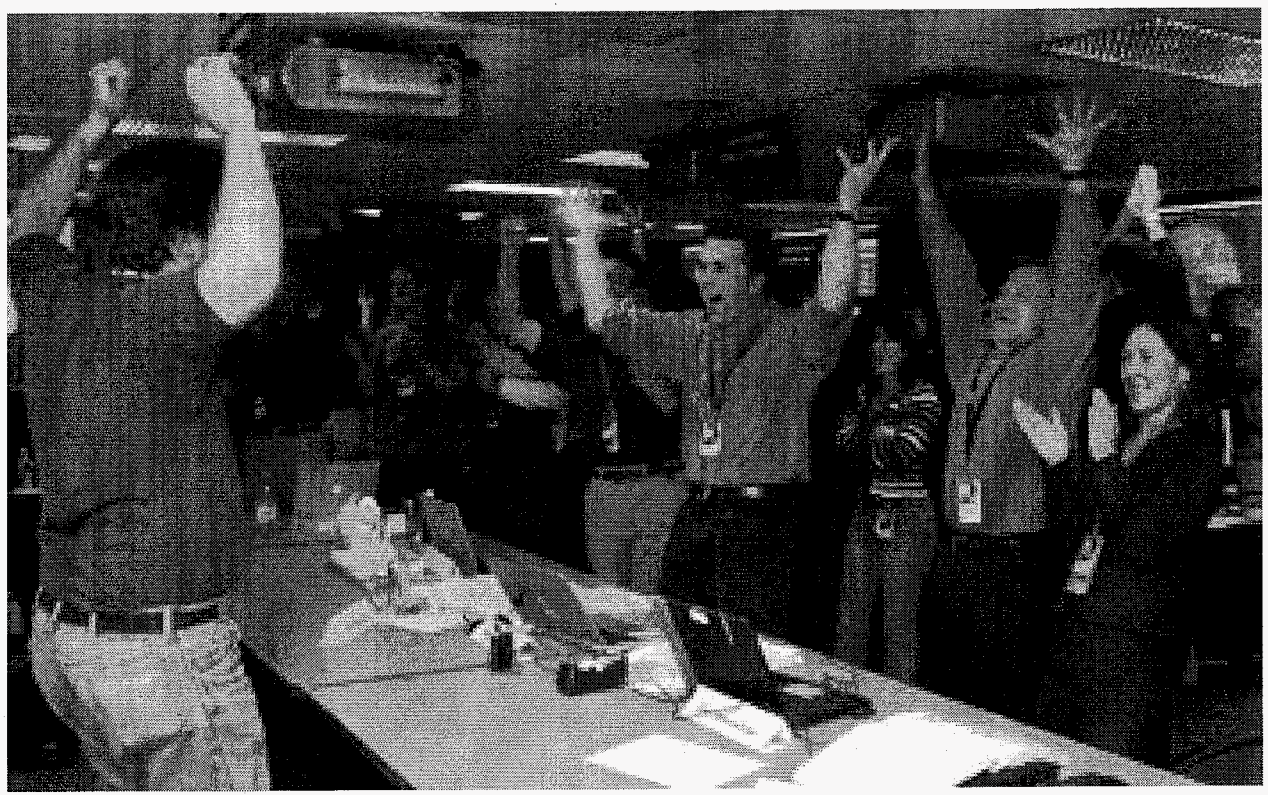


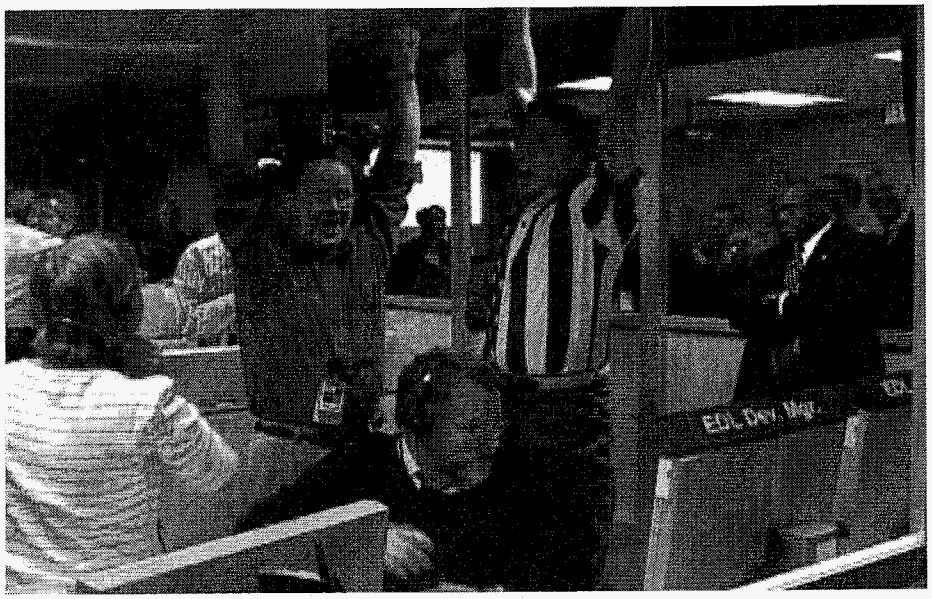


Entry, Descent & Landing Timeline





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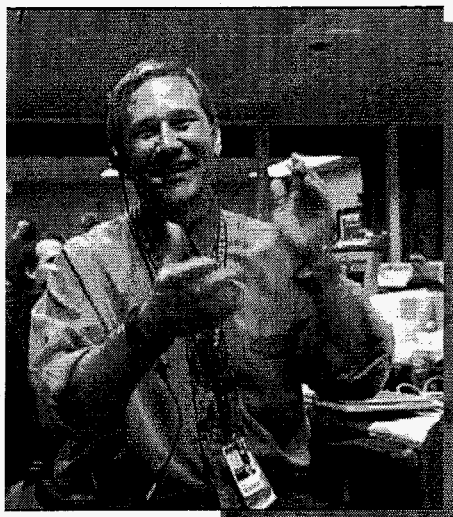
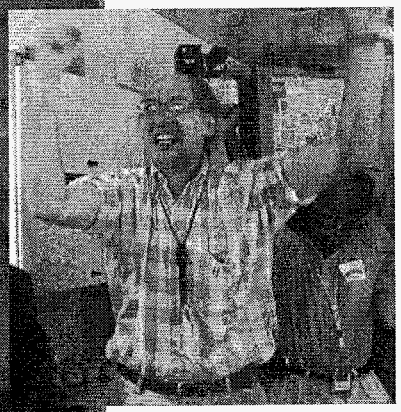
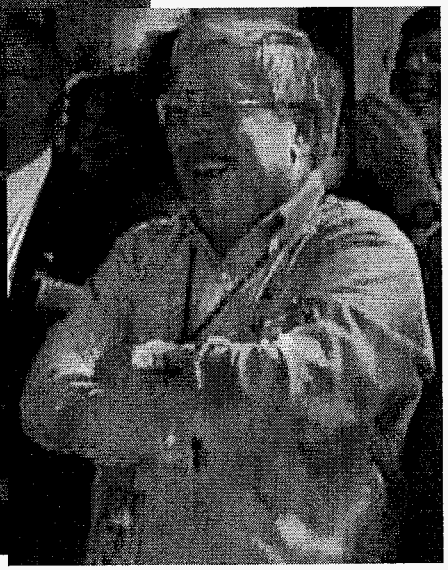
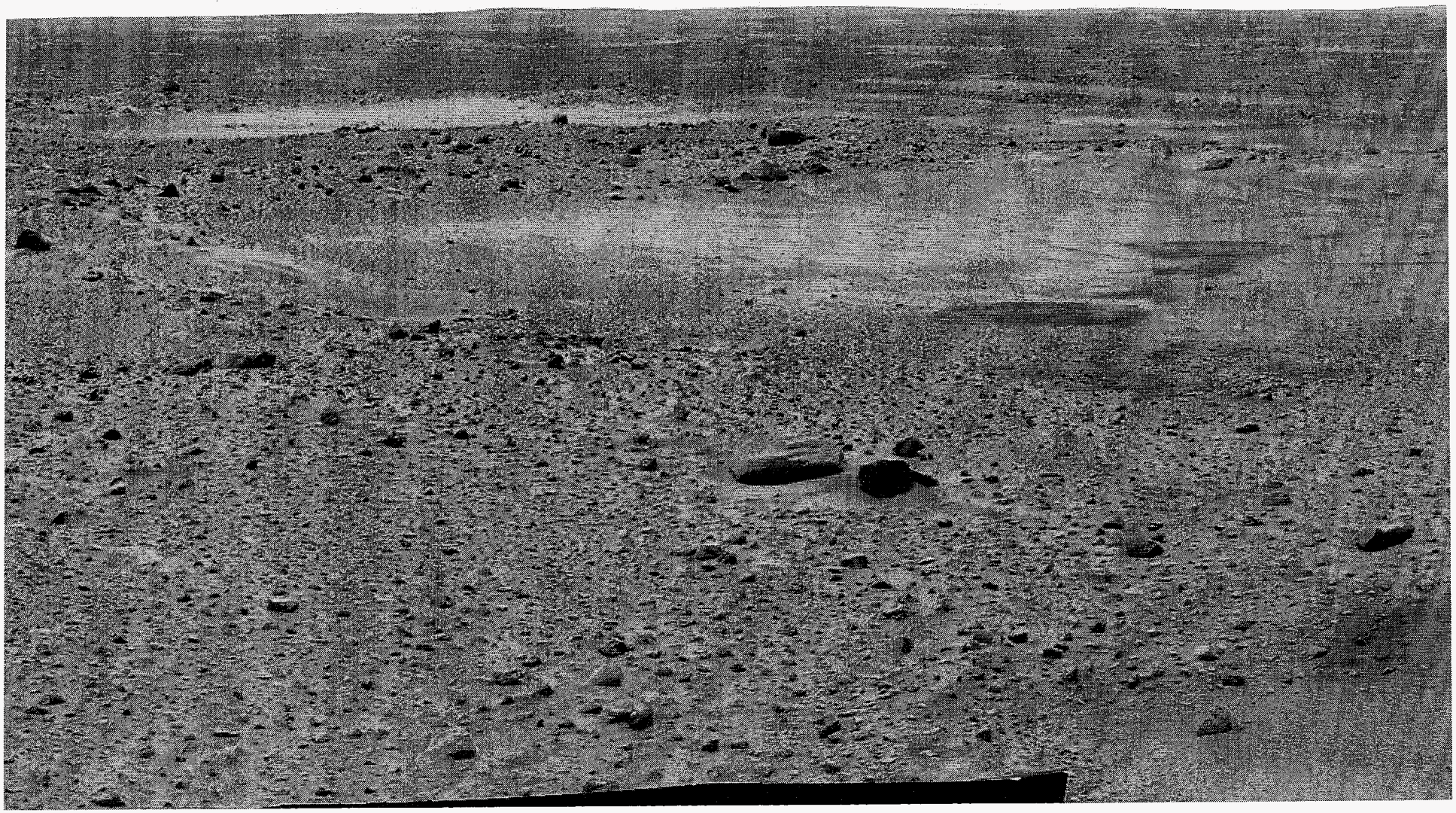
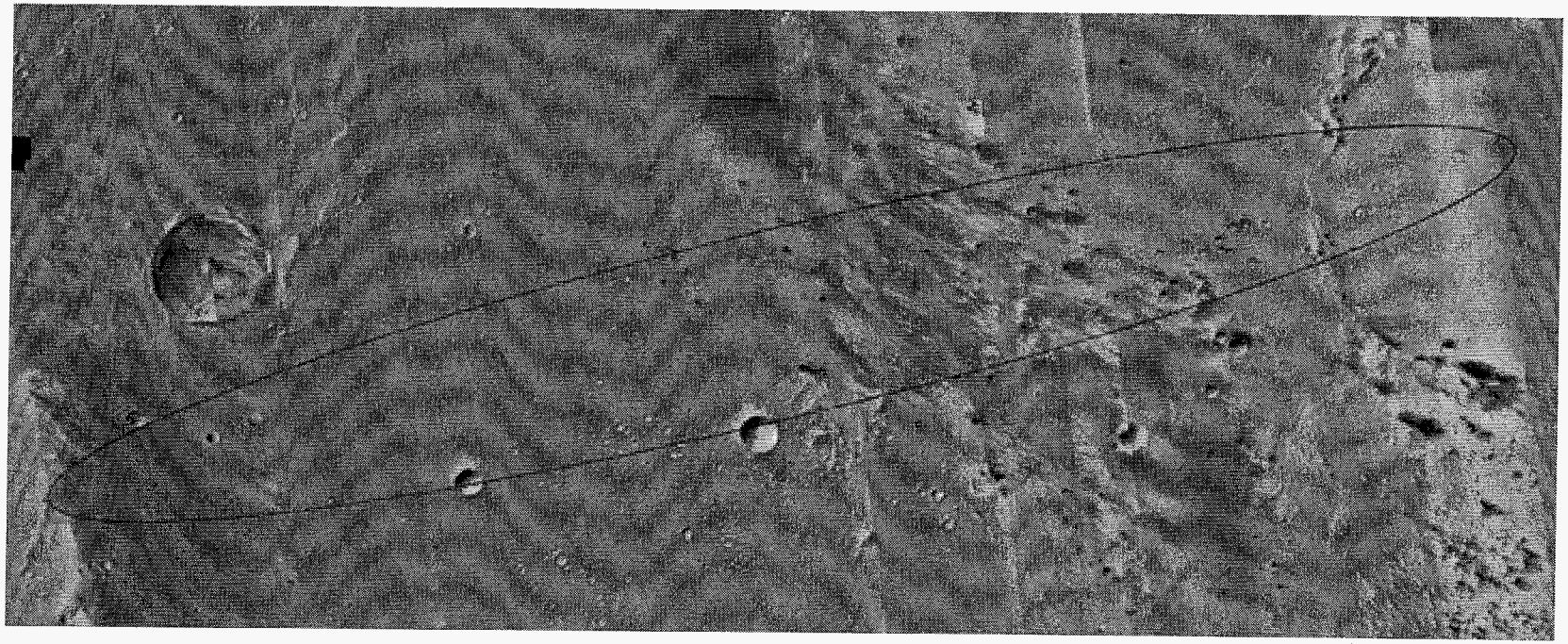


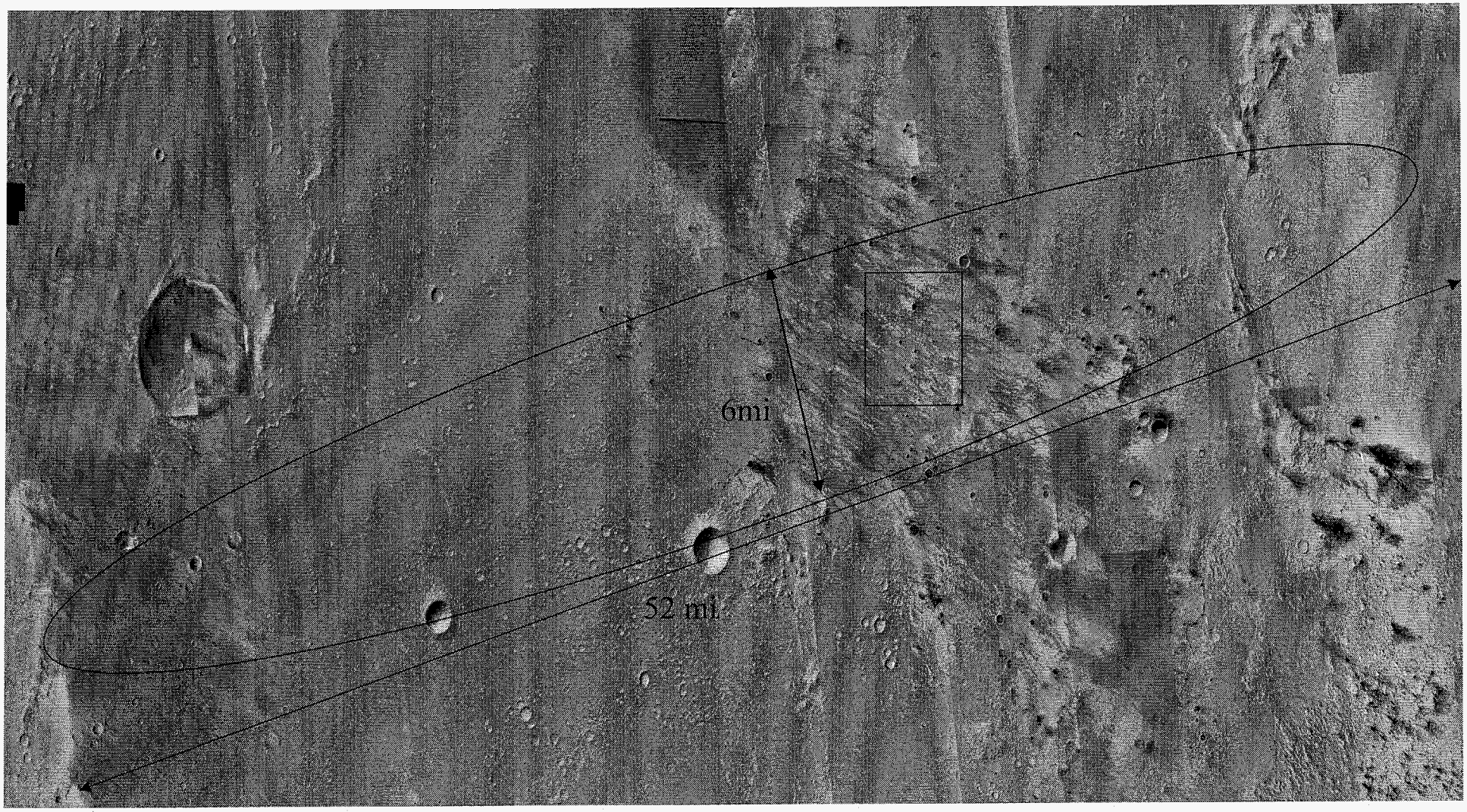


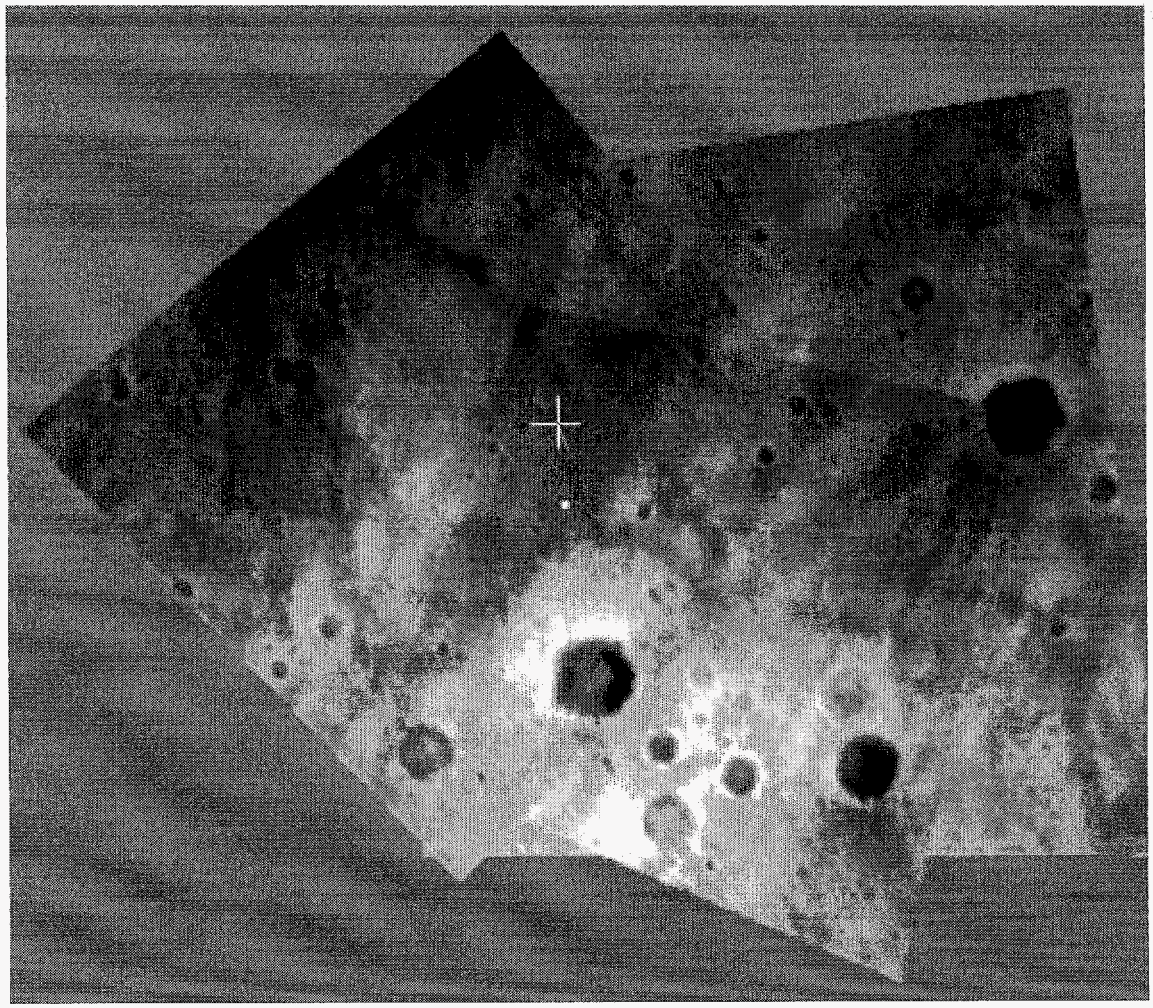




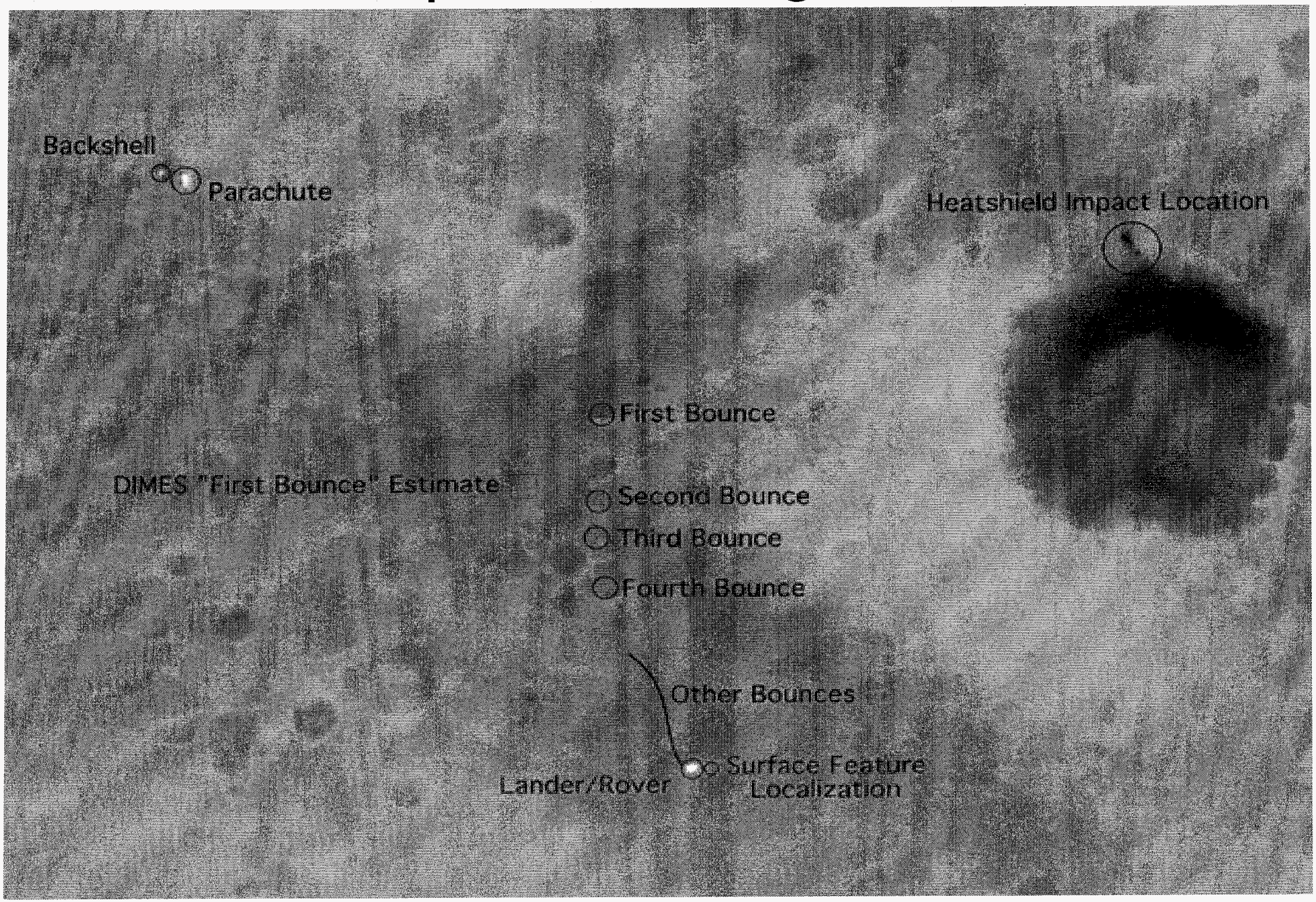


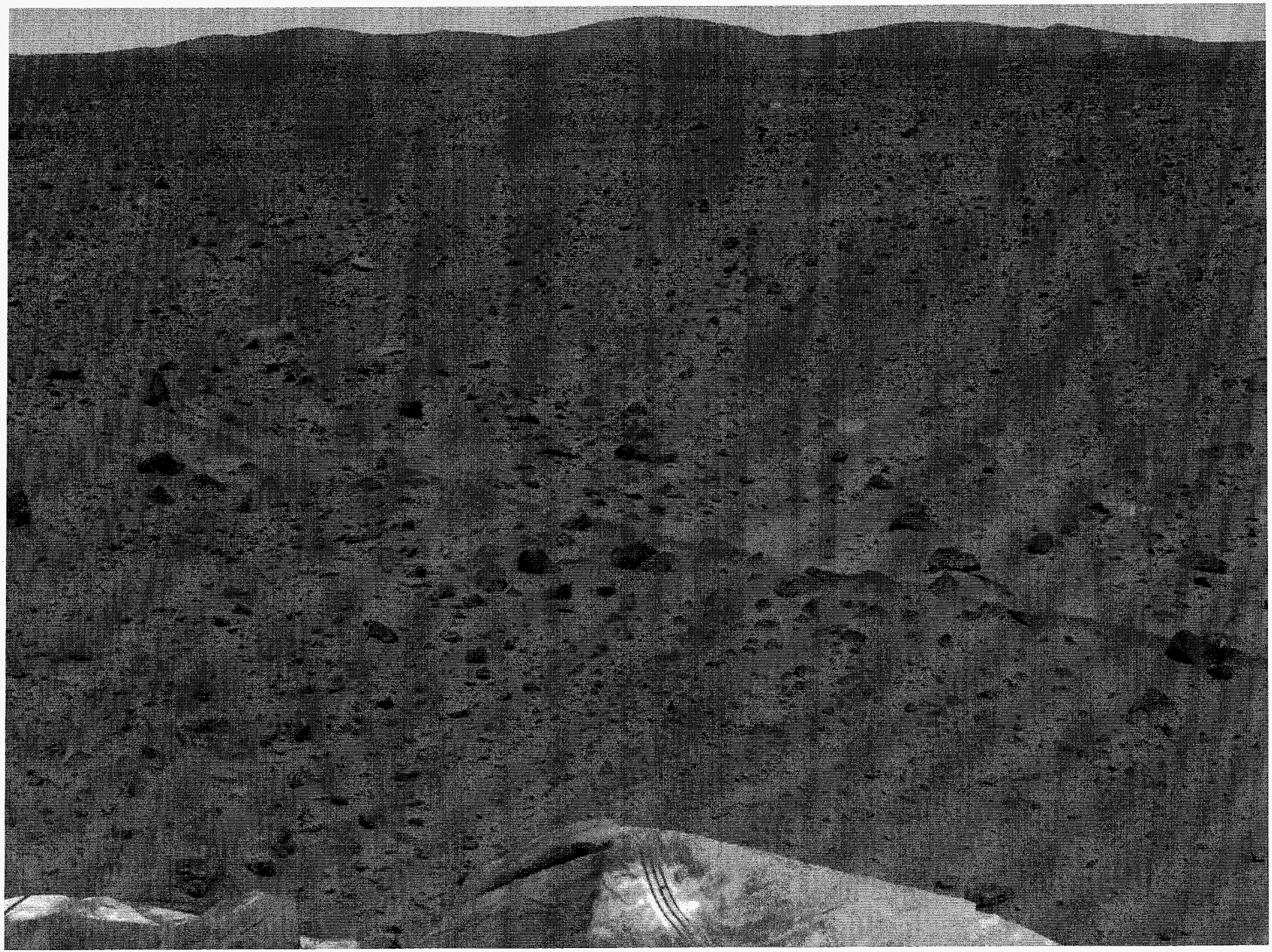
Gusev Landing Ellipse

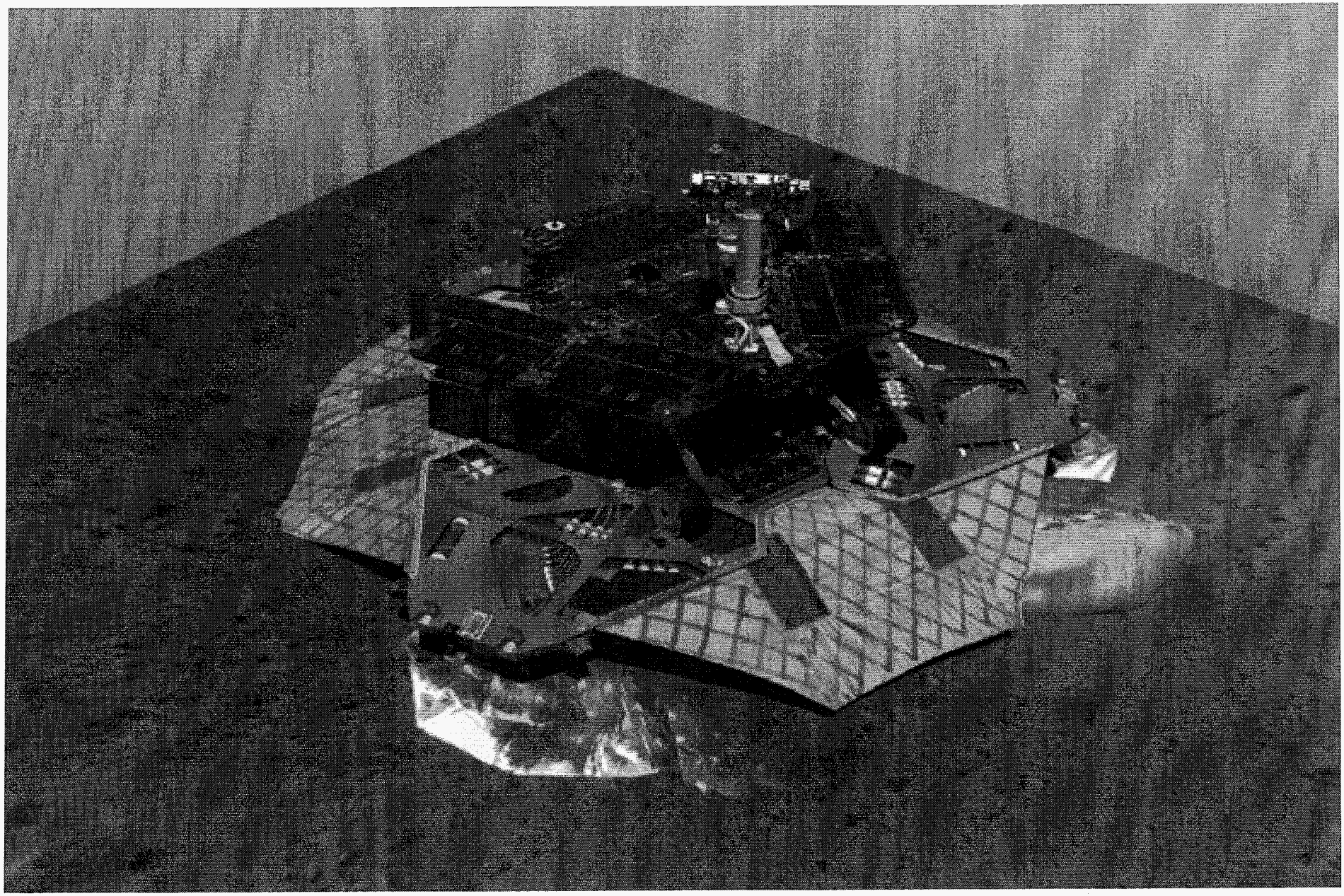


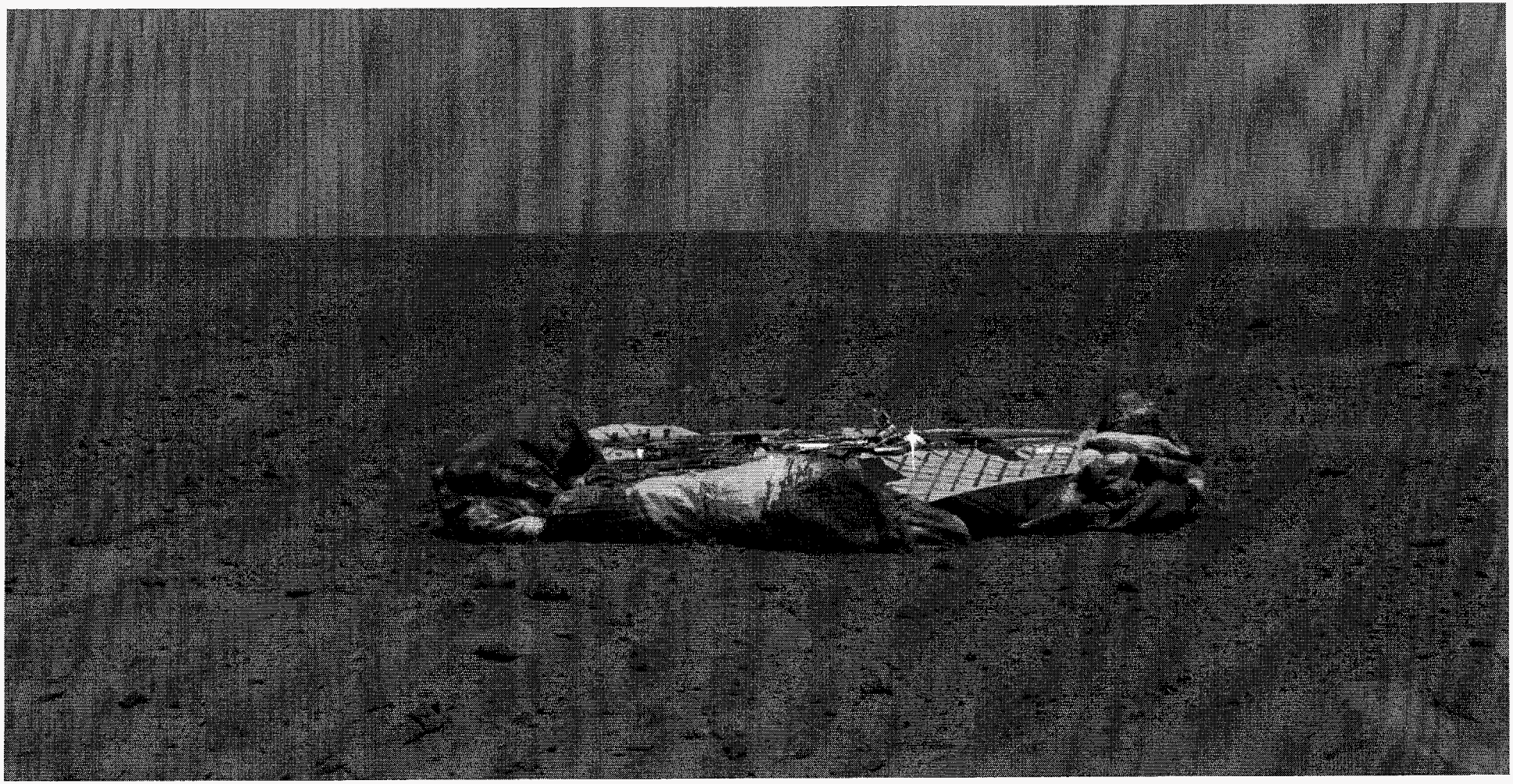


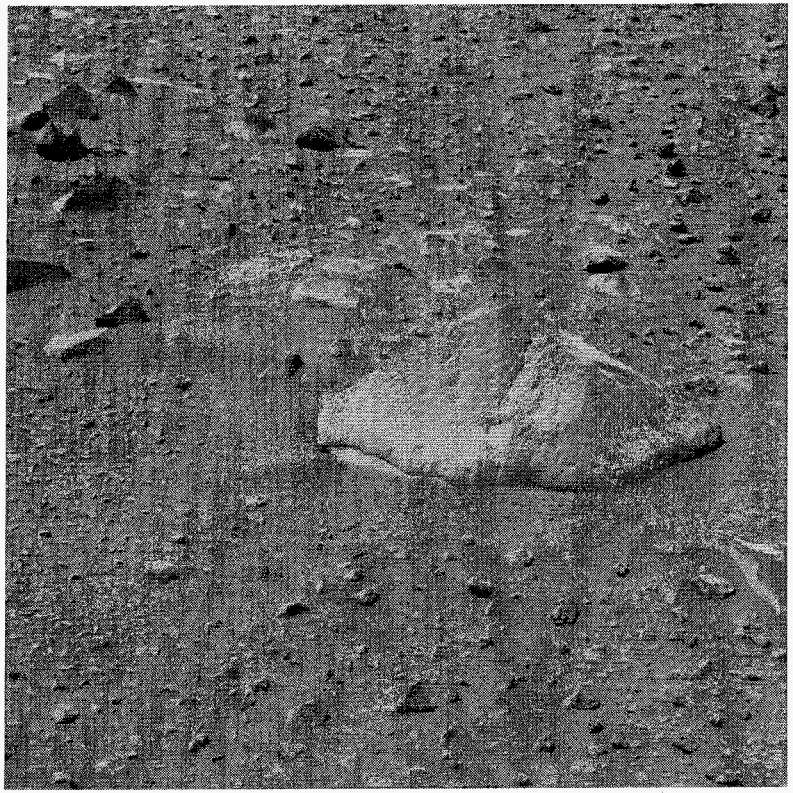
Spirit Landing Site

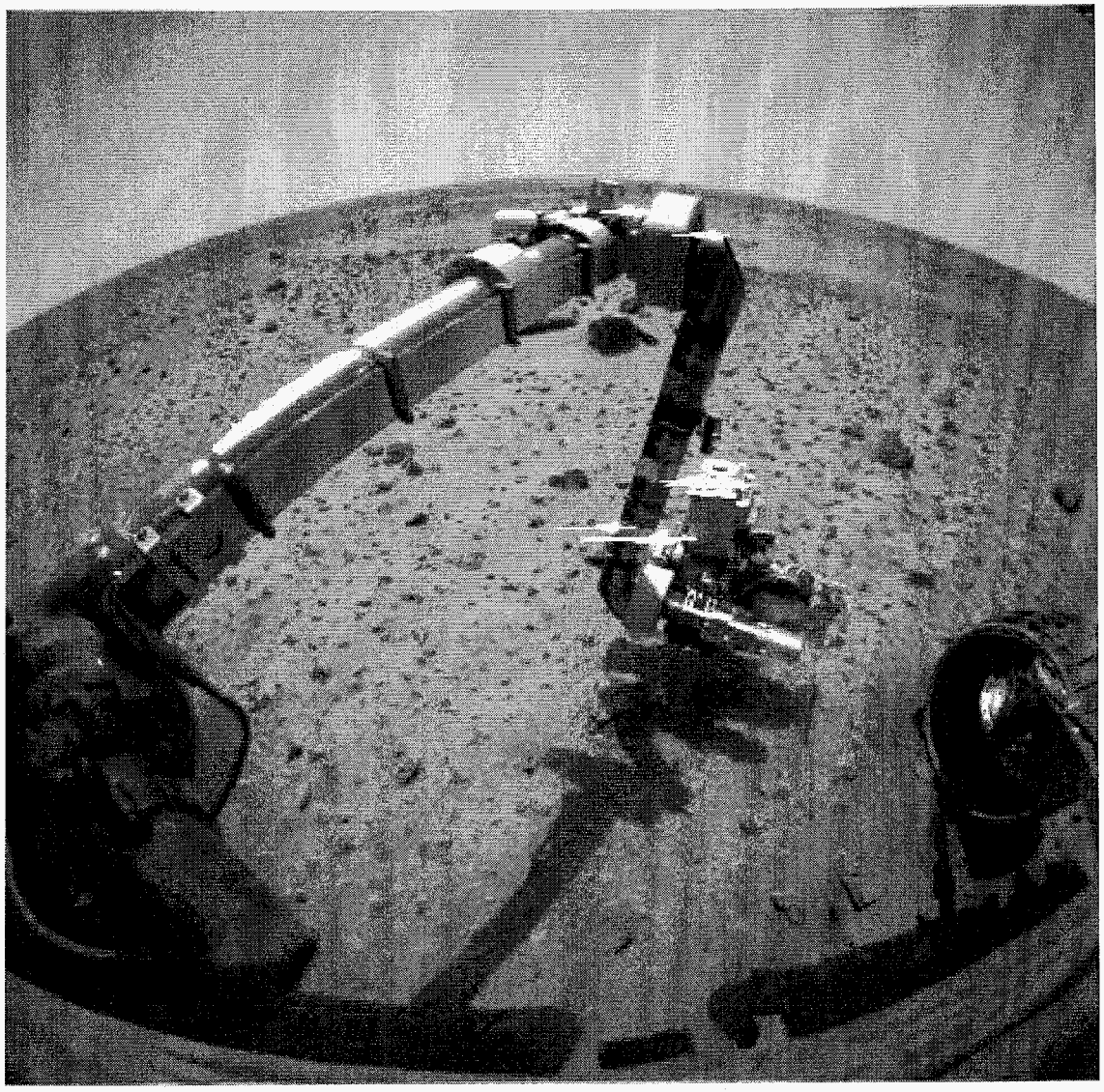


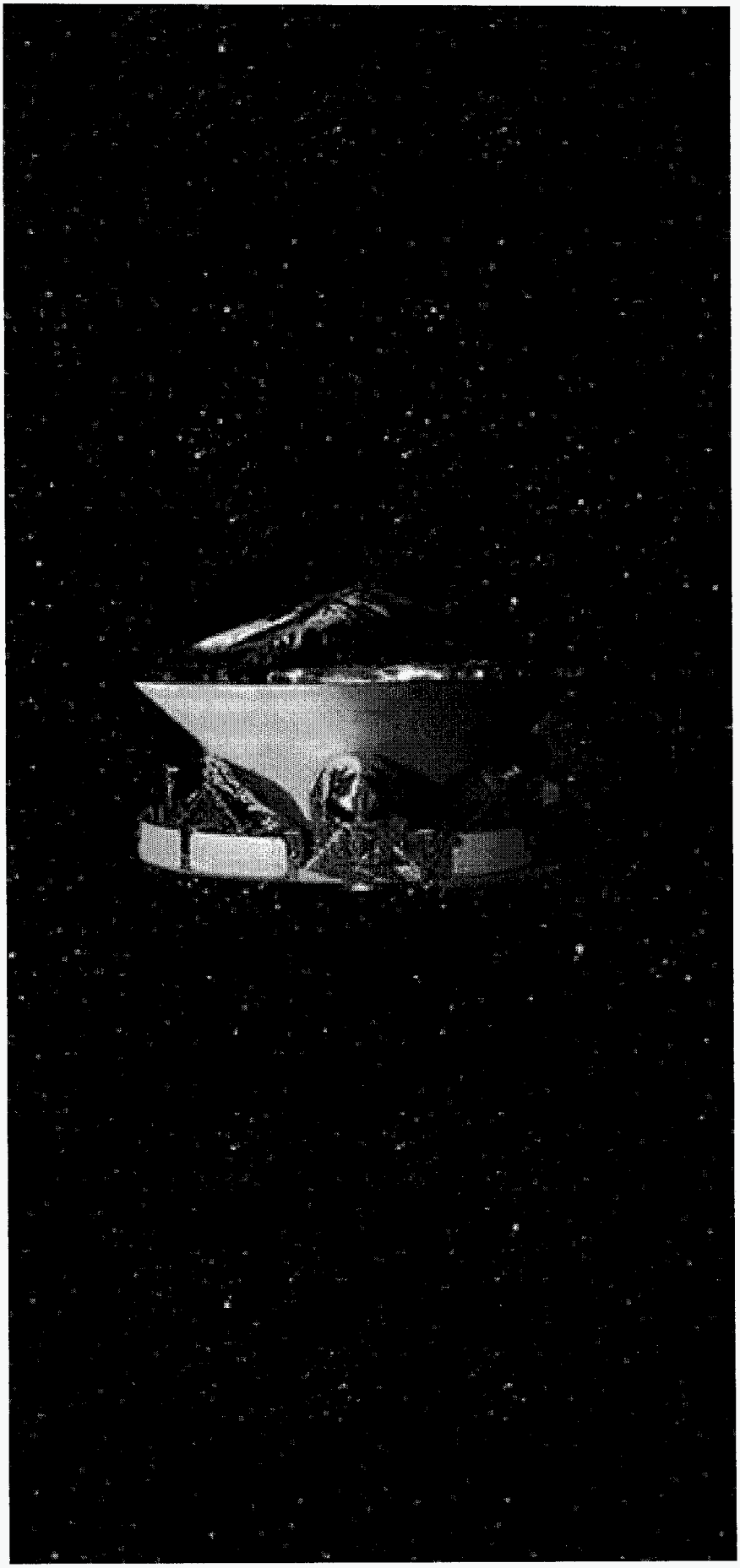












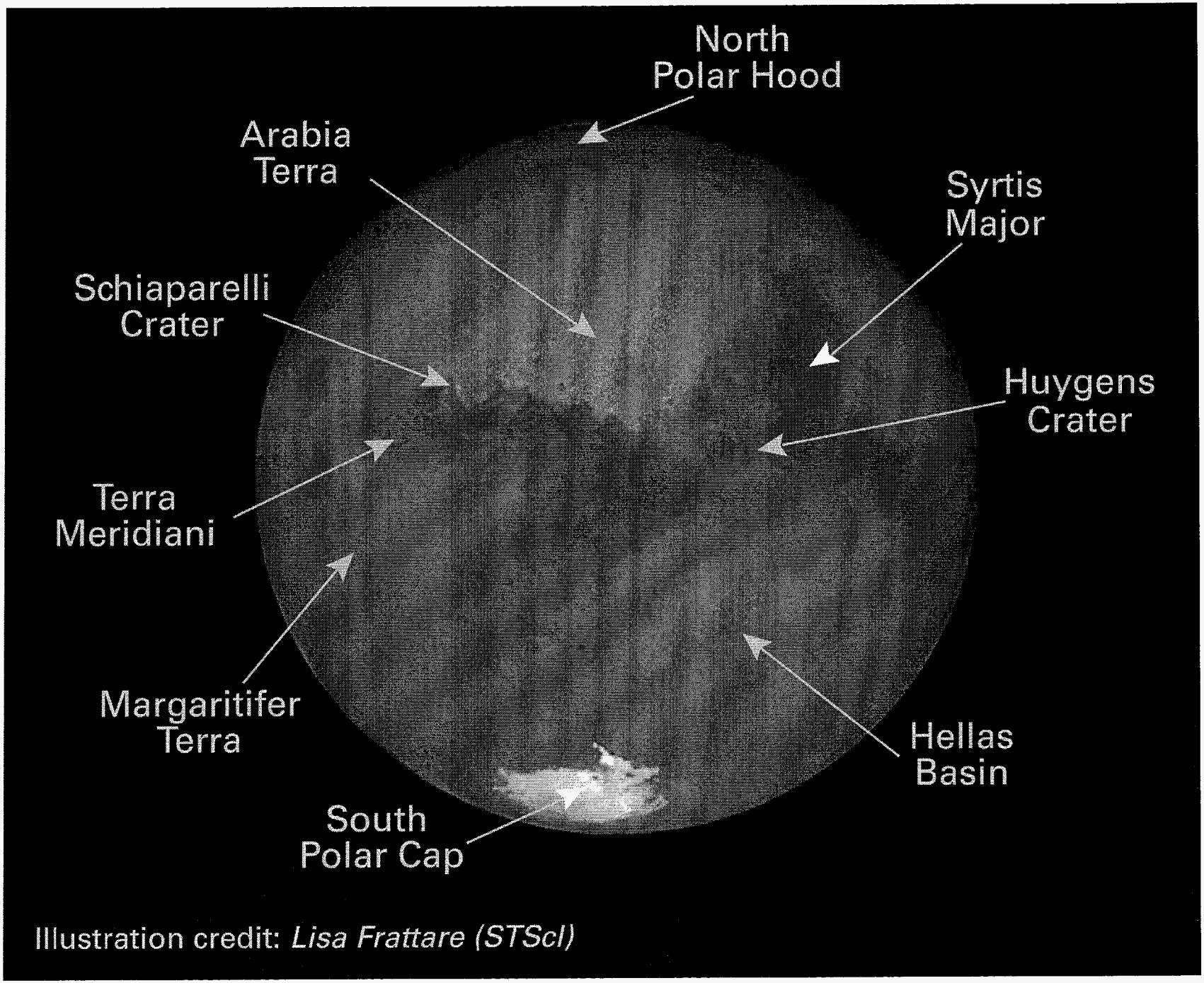
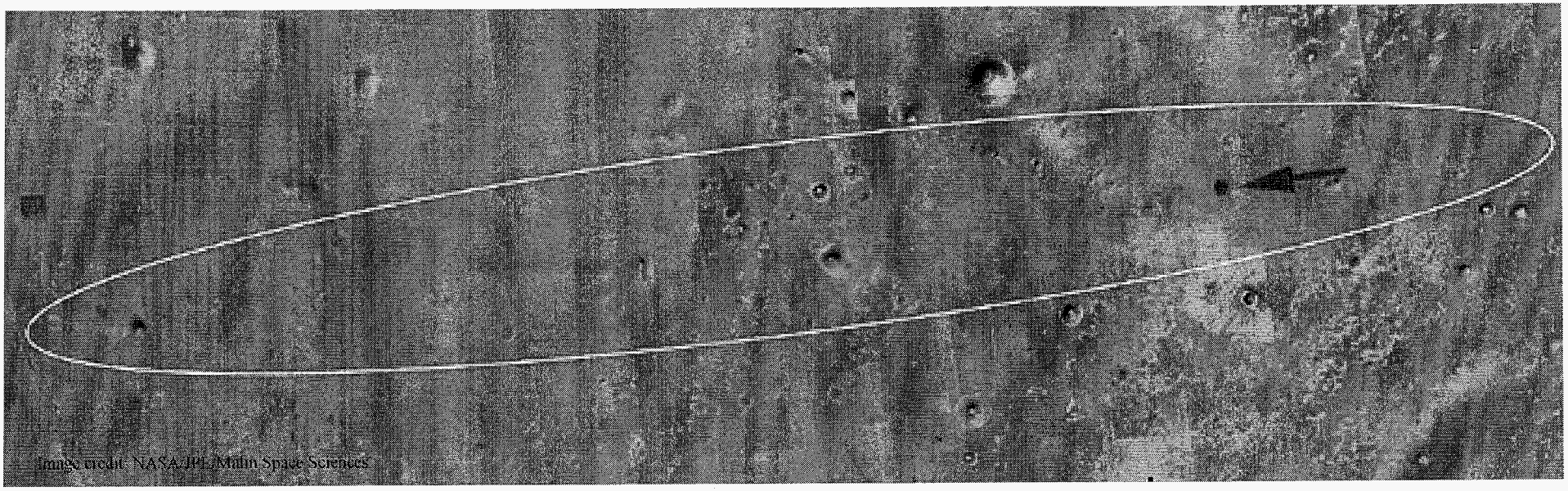


Illustration credit: *Lisa Frattare (STScI)*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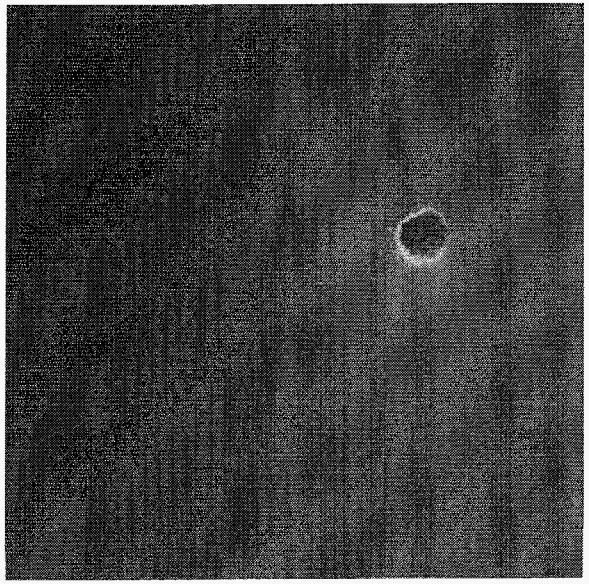

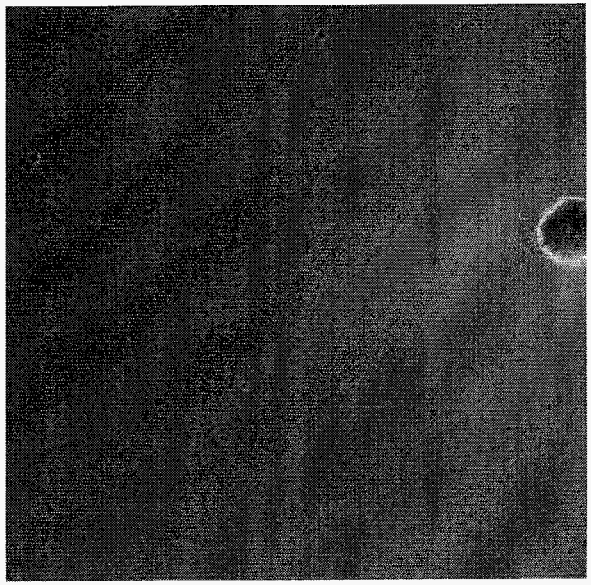

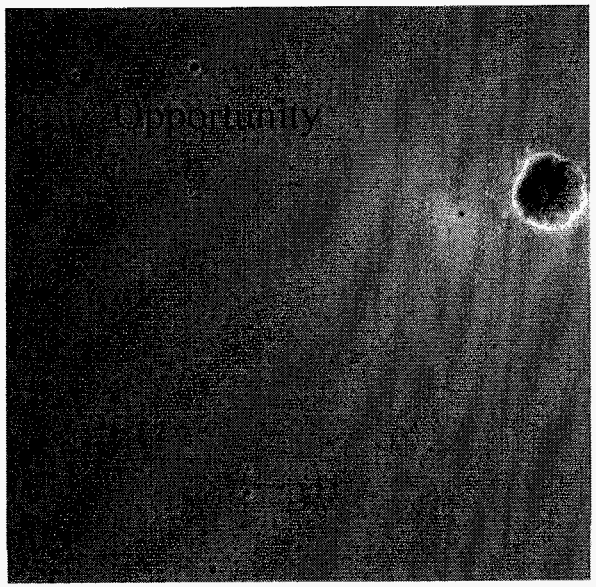
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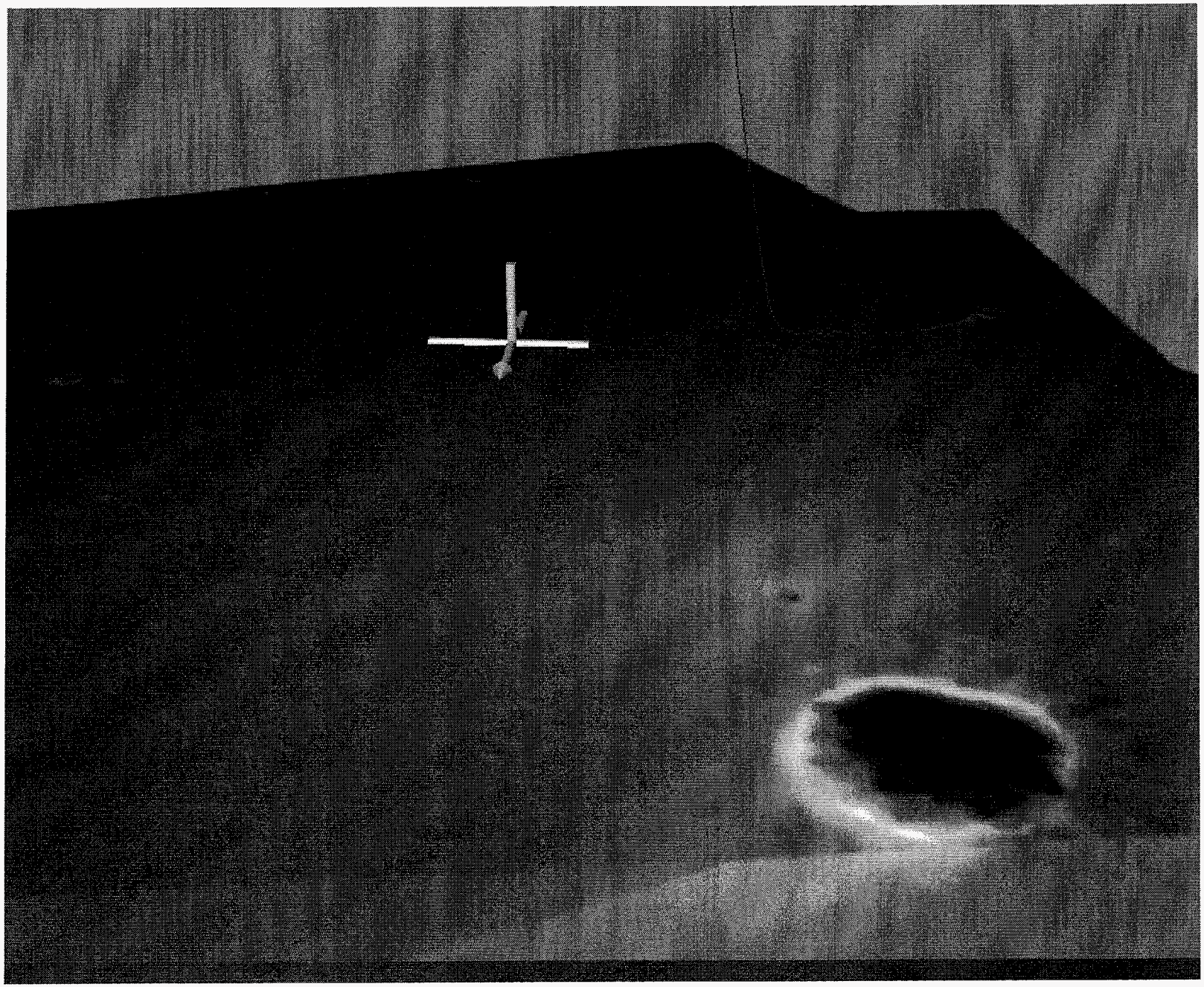
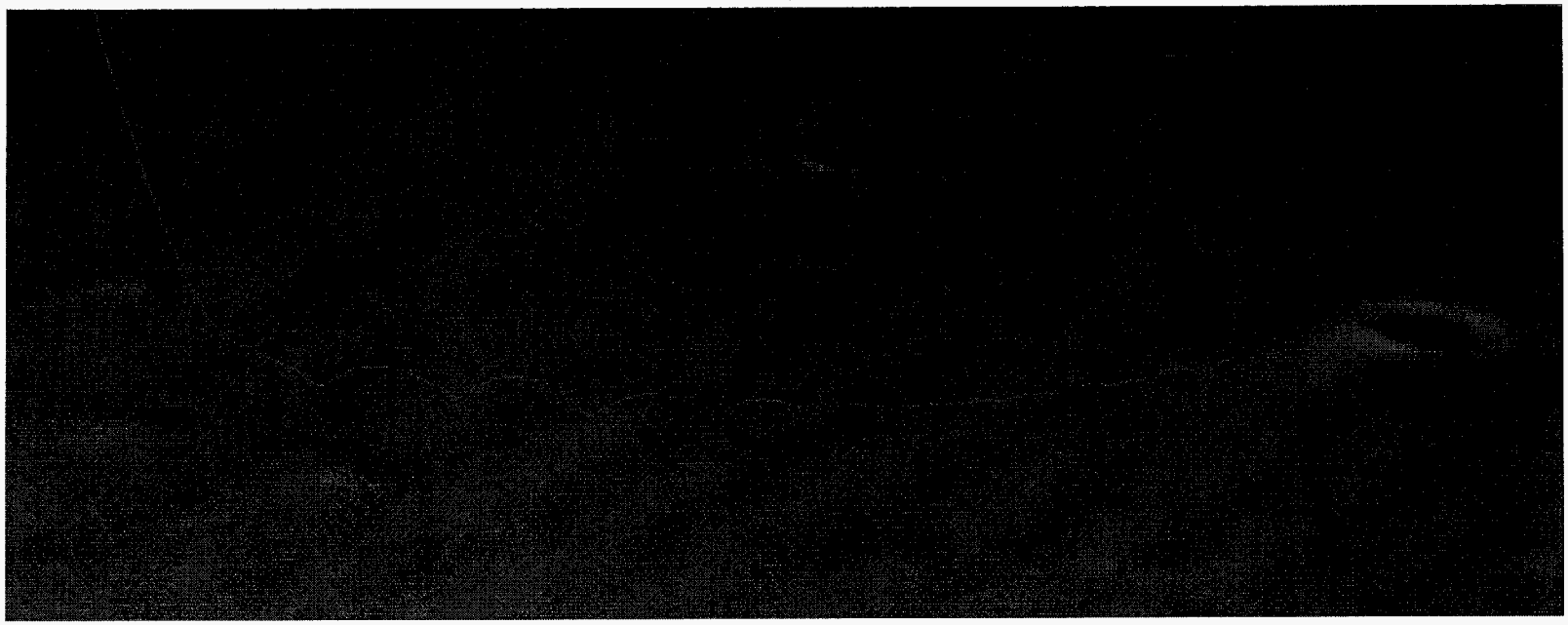
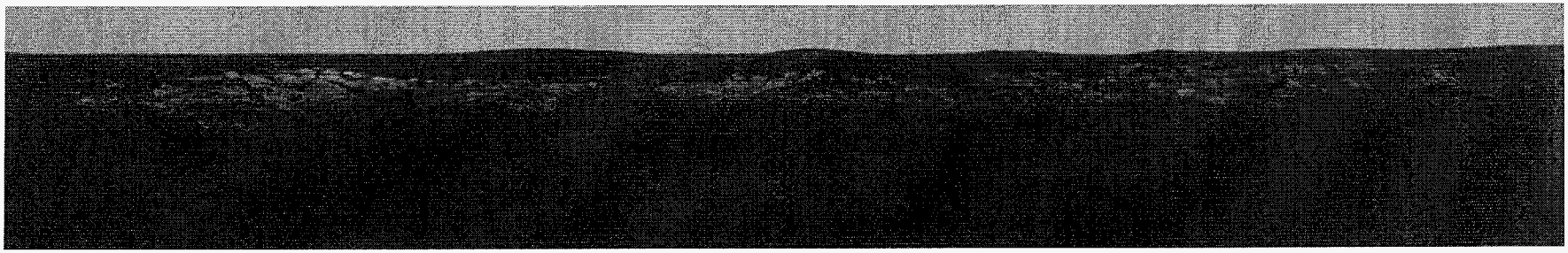
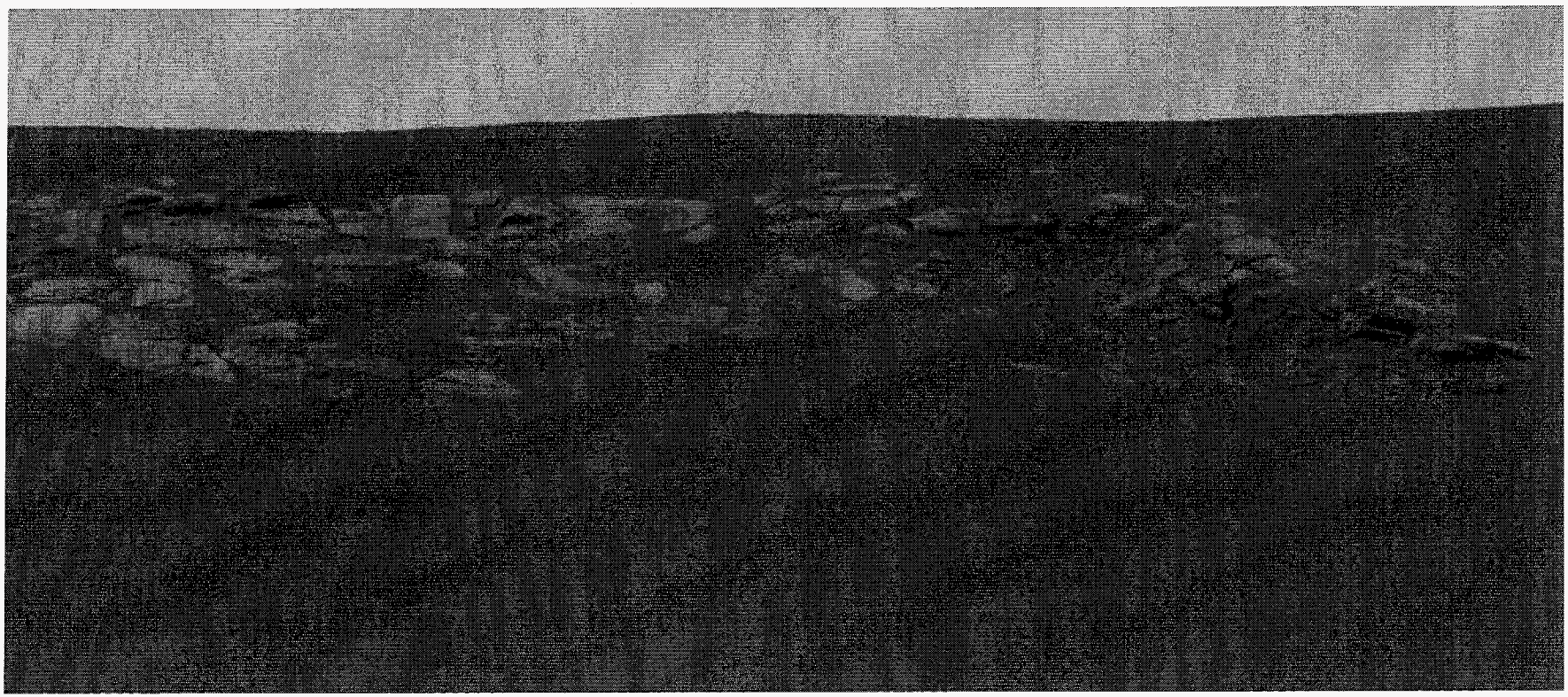
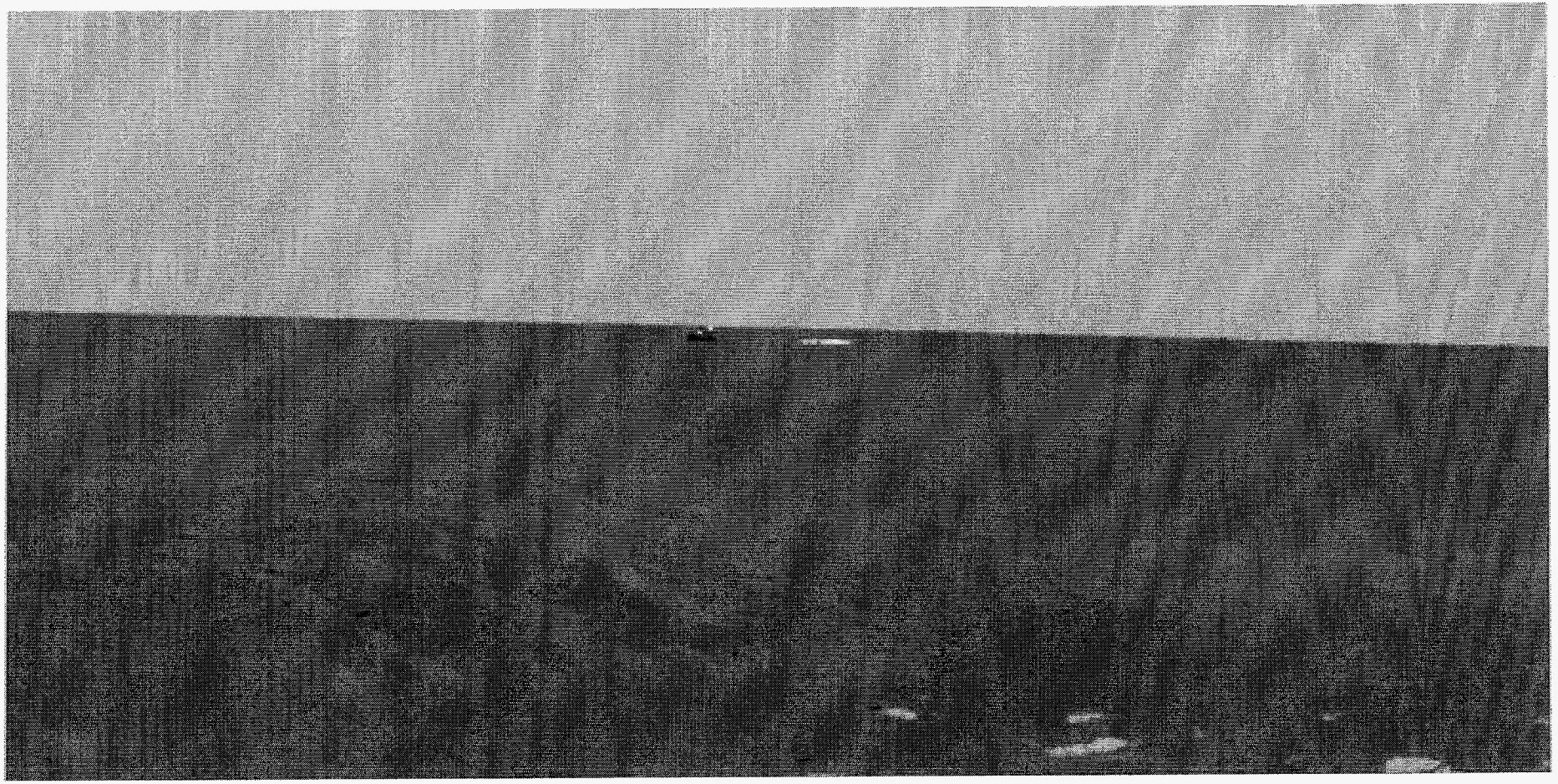
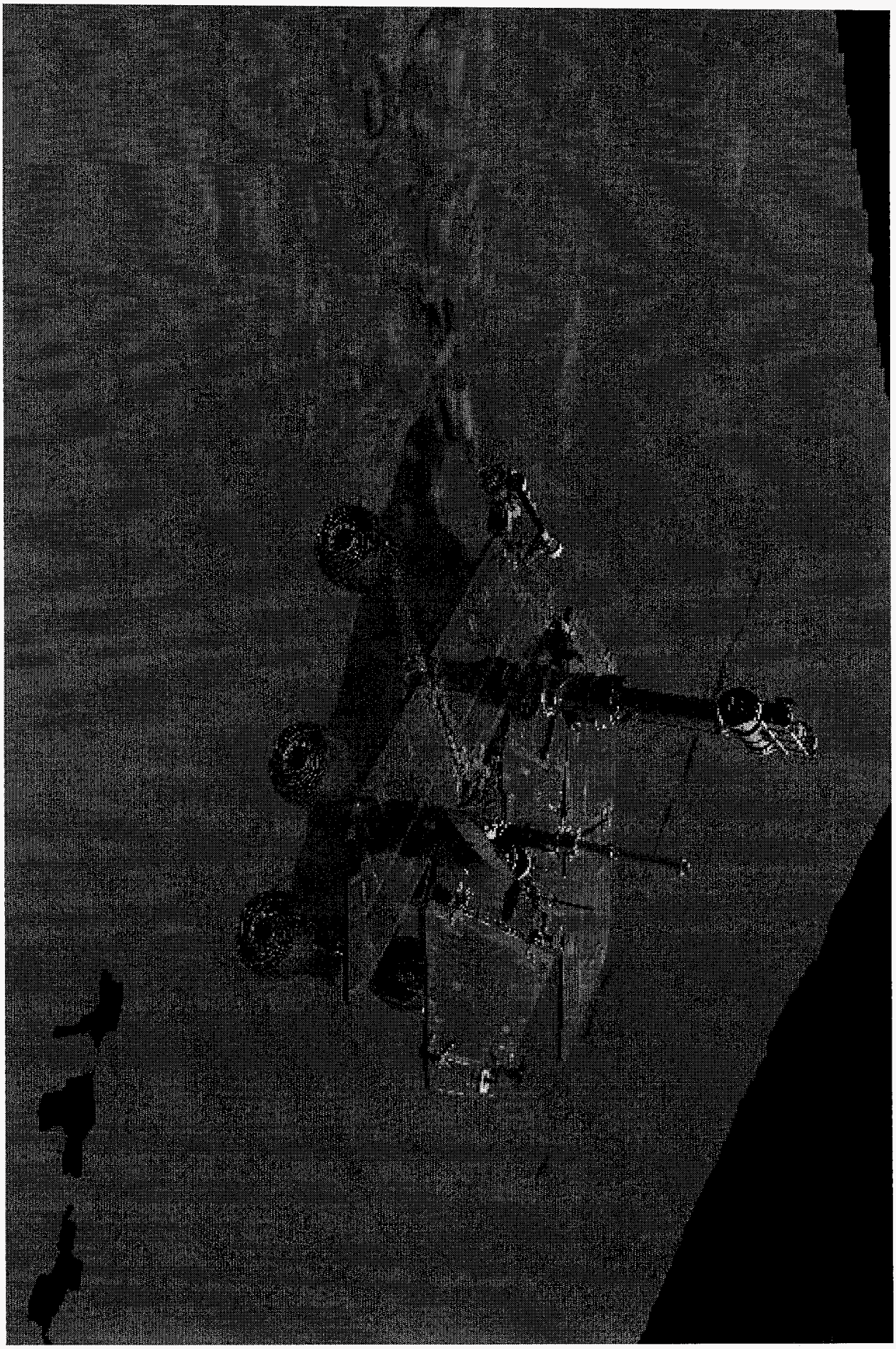


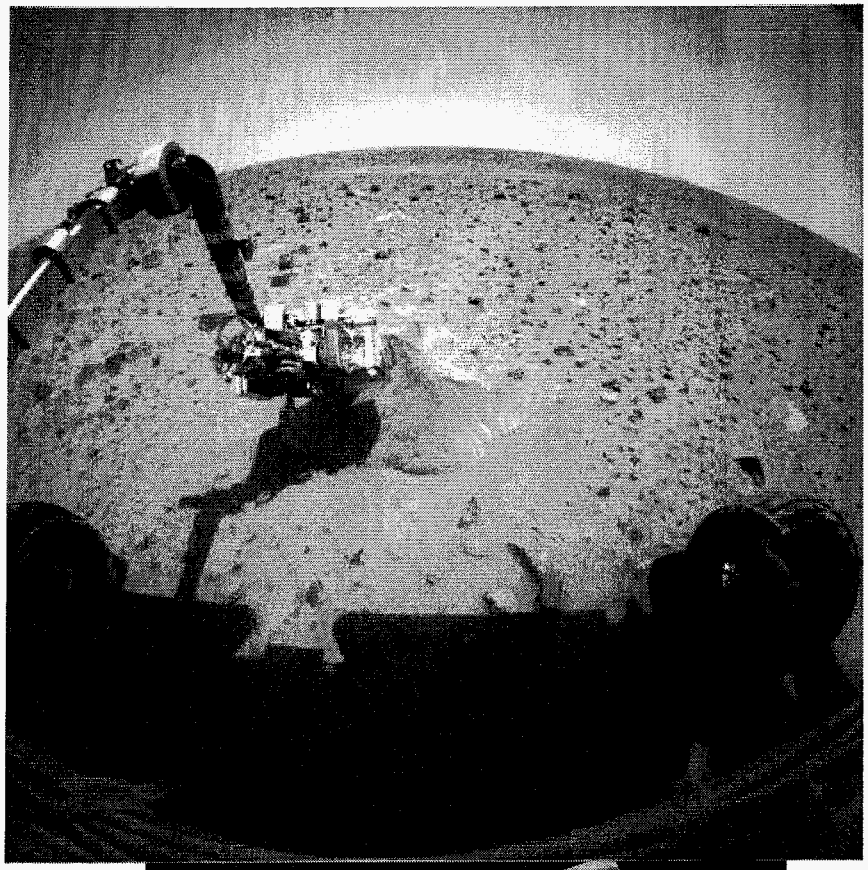


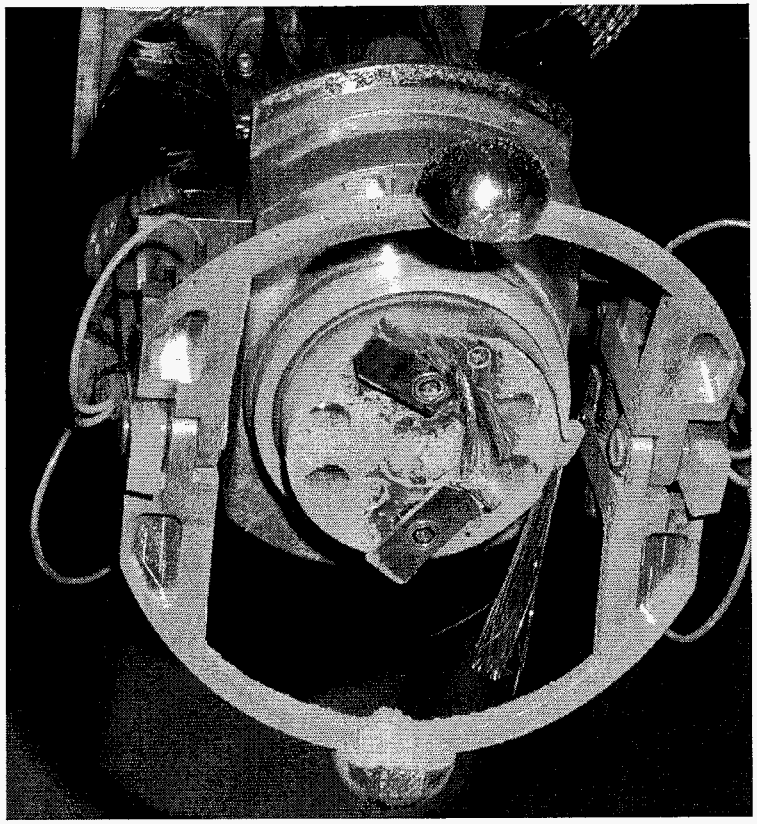


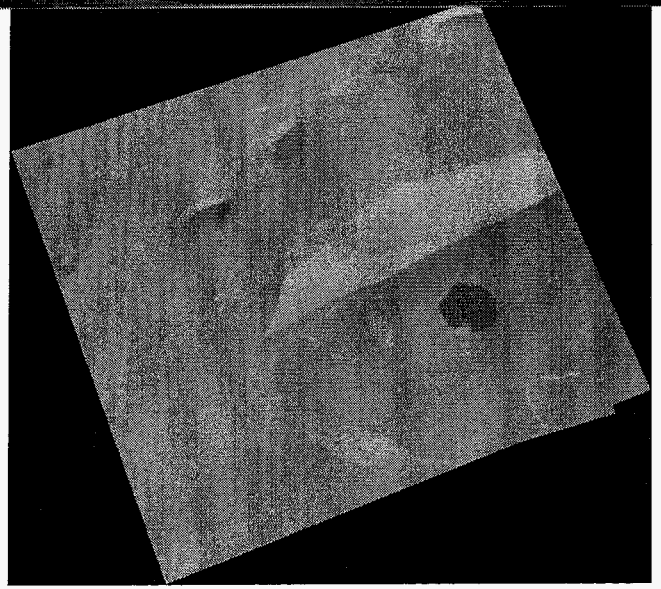


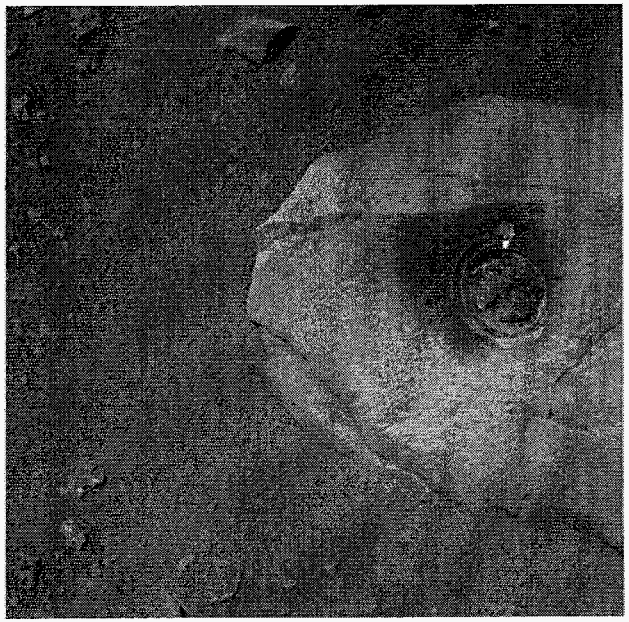




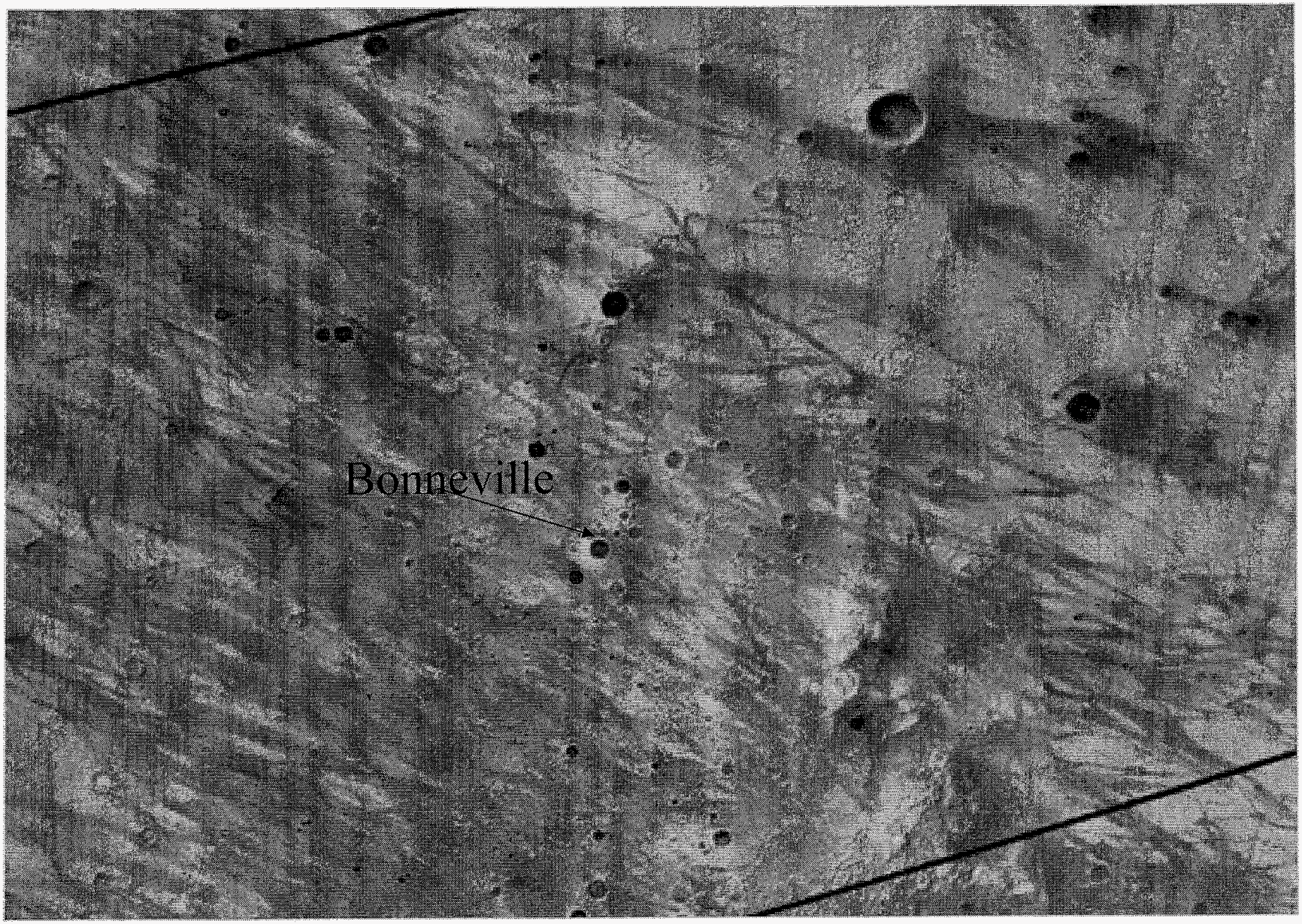


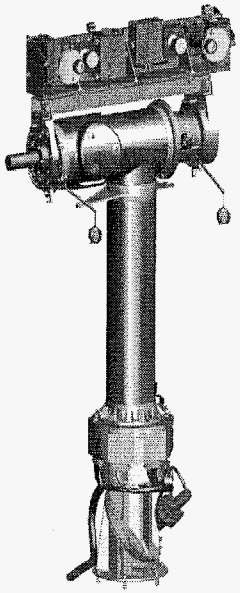


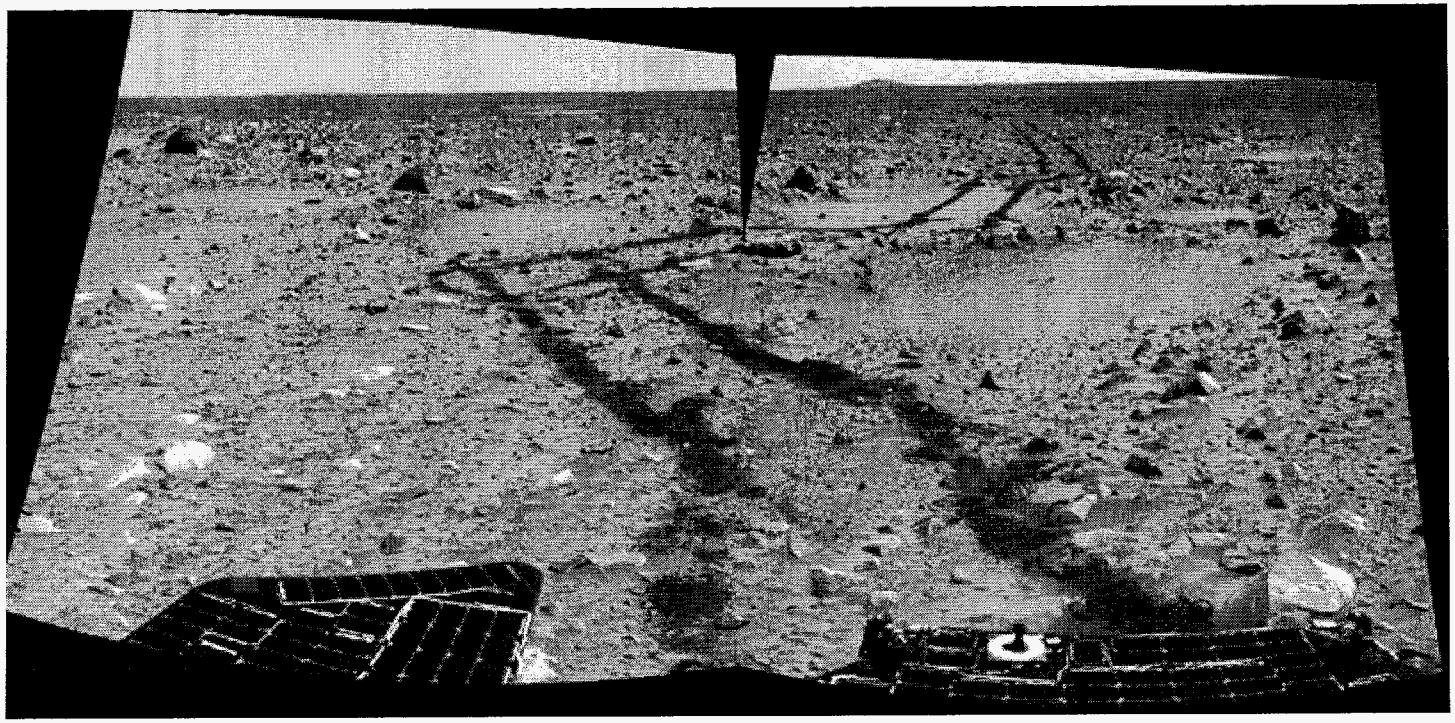


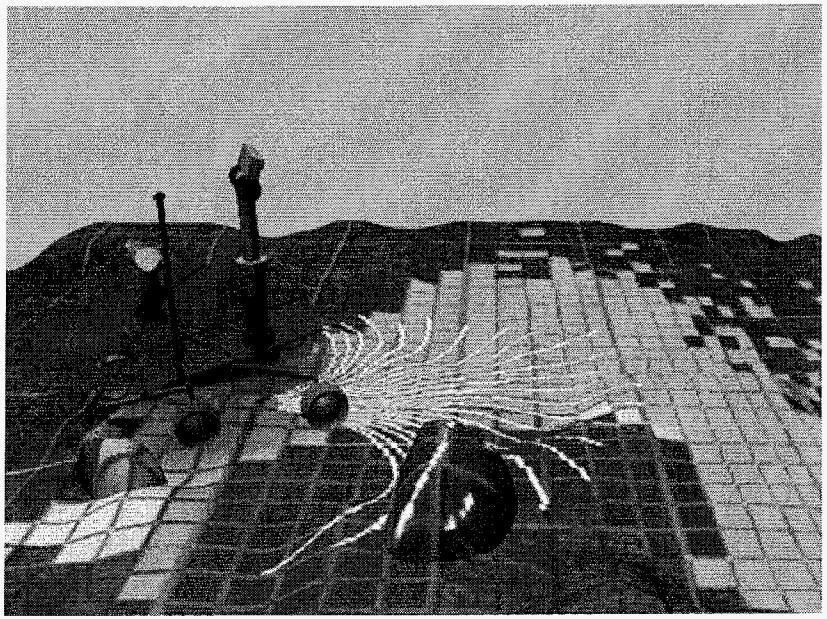


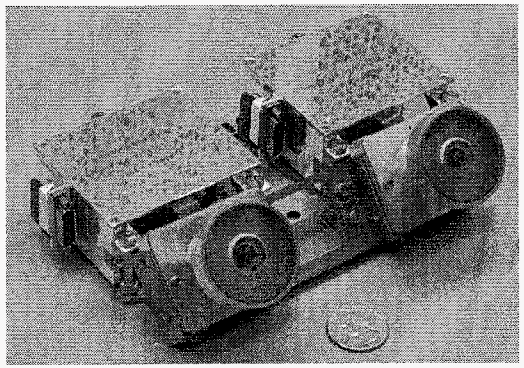
Adirondack
Sols 15-35


Bonneville

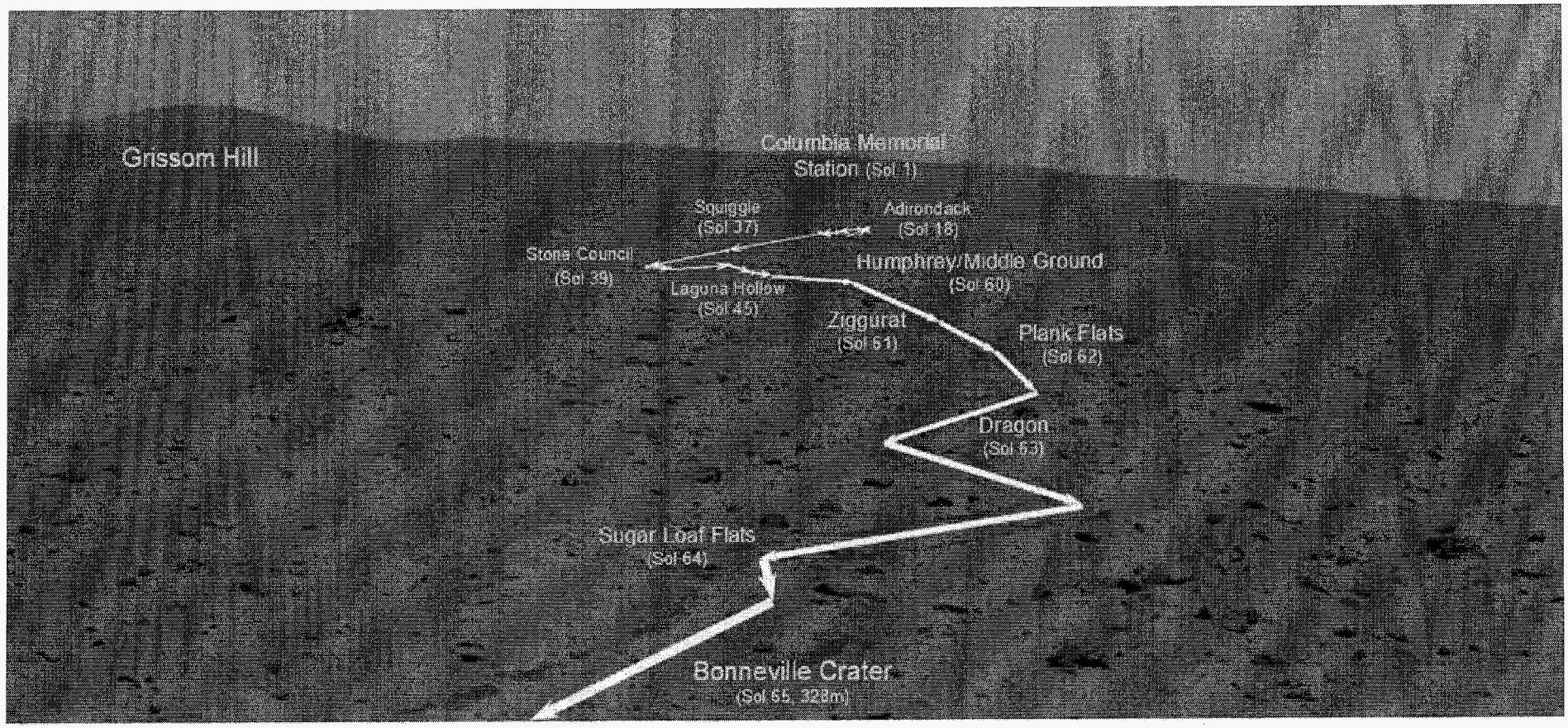




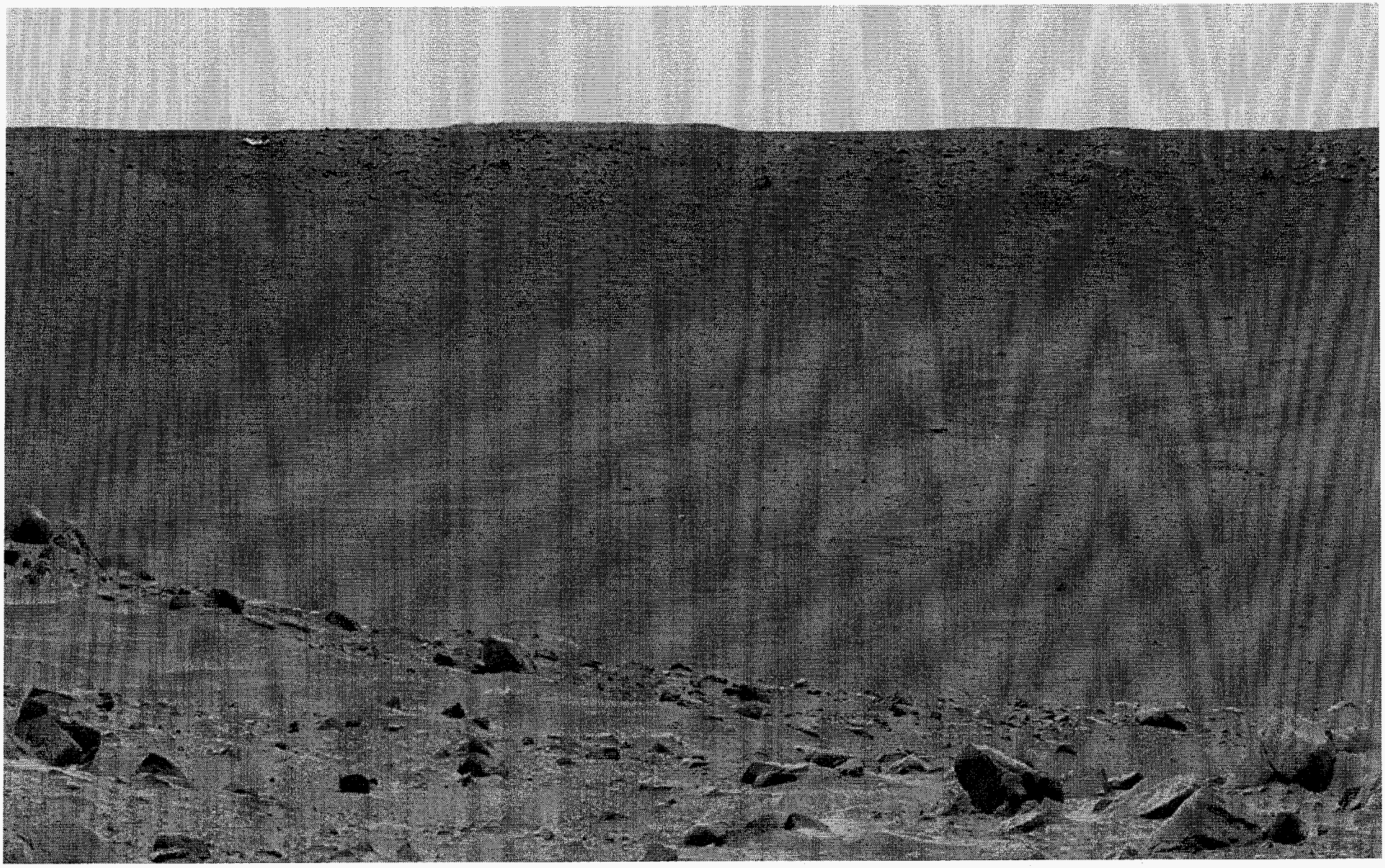


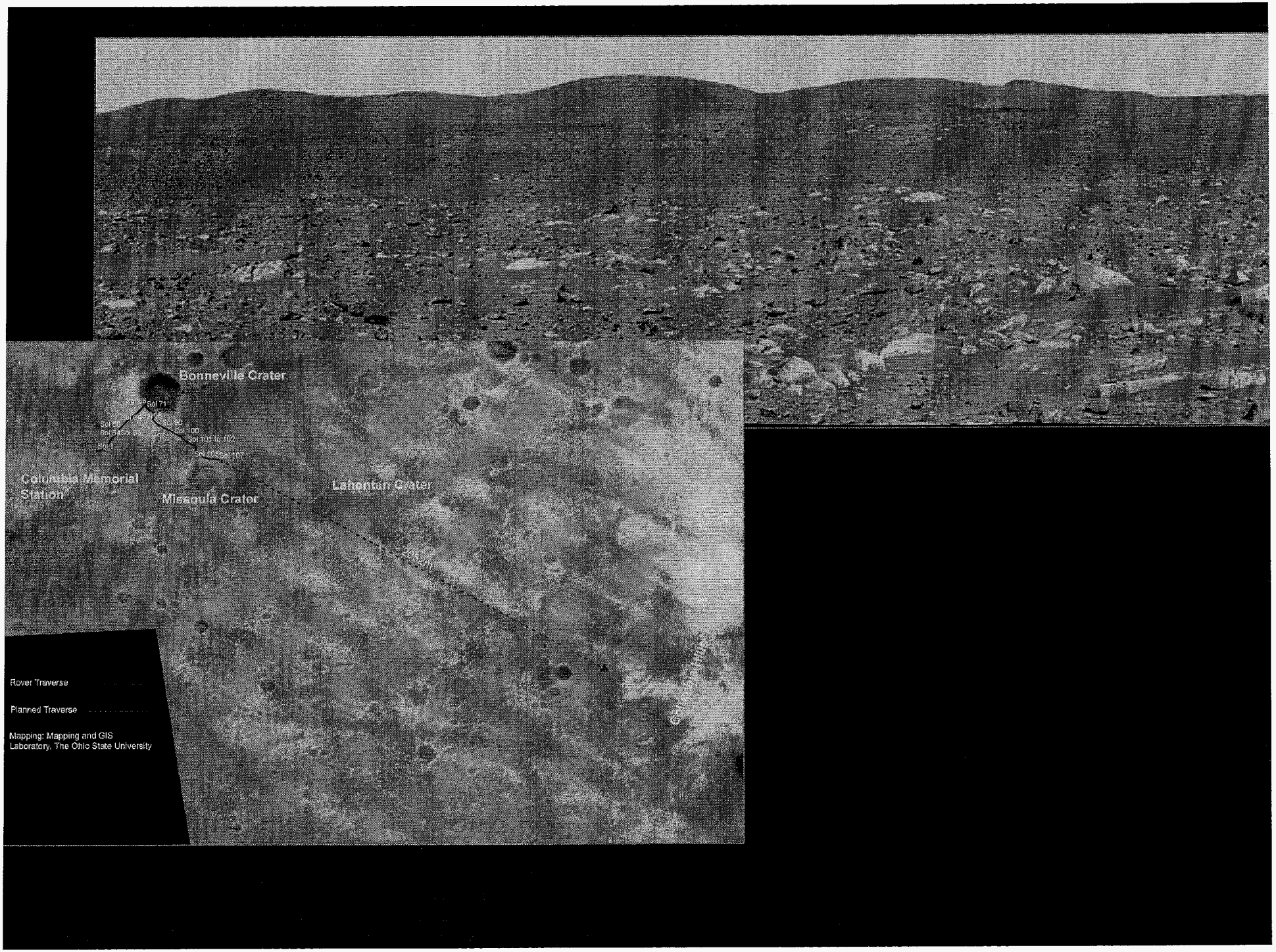


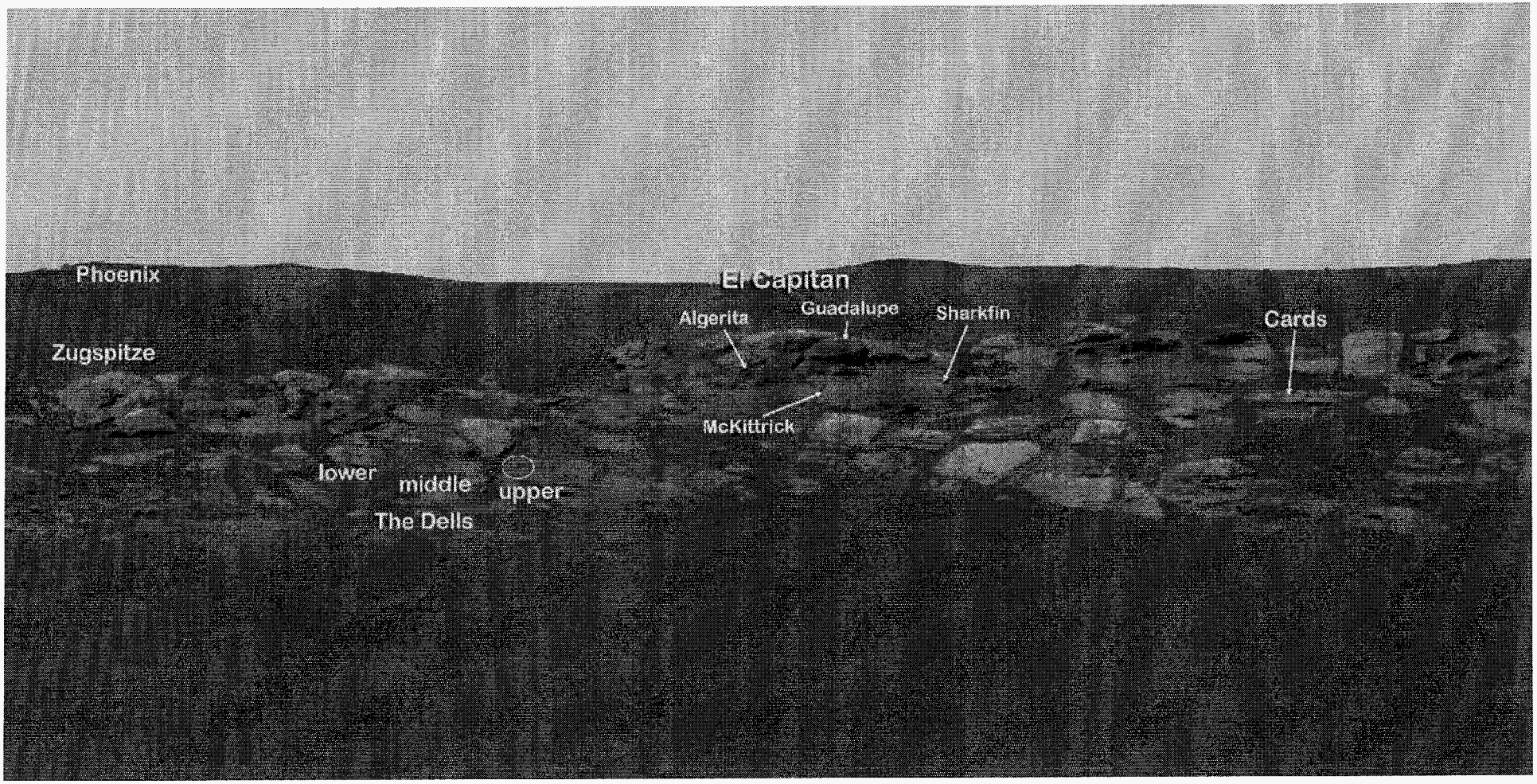
Spirit Rover Traverse – Bonneville Crater (Sol 65)

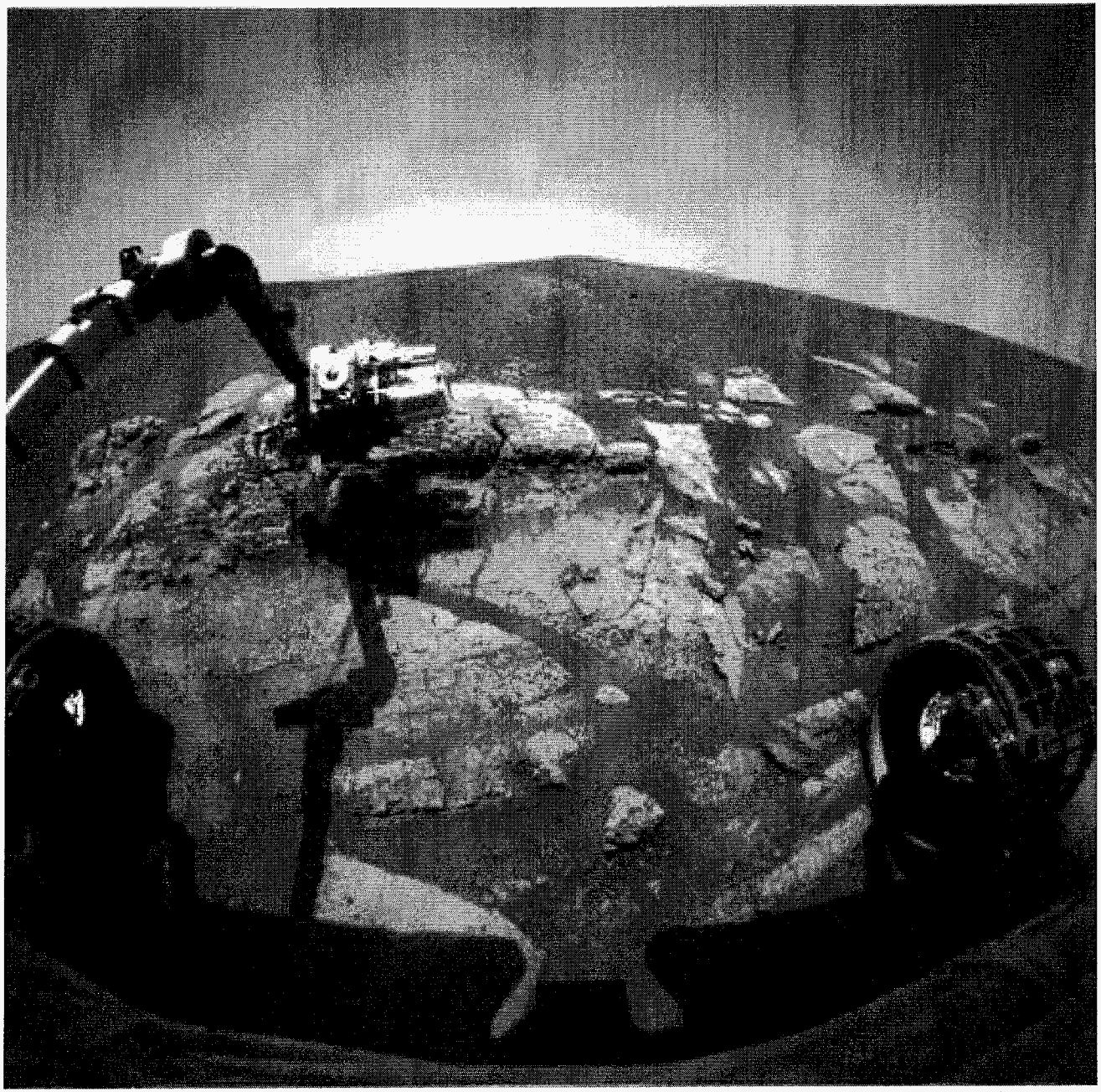


Mapping and GIS Laboratory, OSU



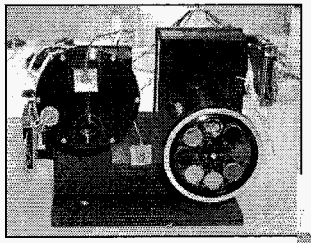

Bonneville Crater
Sol 71
Sol 100
Sol 101 to 102
Sol 103 Sol 107
Columbia Memorial Station
Missoula Crater
Lahontan Crater
Rover Traverse
Planned Traverse
Mapping: Mapping and GIS Laboratory, The Ohio State University

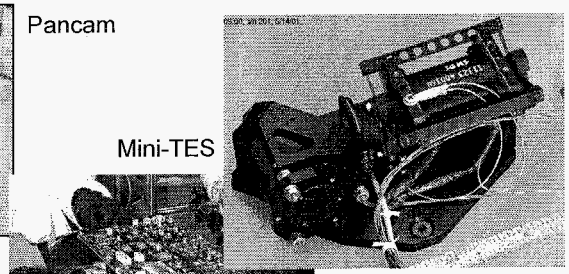

Phoenix
El Capitan
Algerita
Guadalupe
Sharkfin
Cards
Zugspitze
McKittrick
lower
middle
upper
The Dells

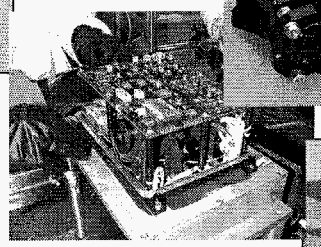


Athena Science Payload

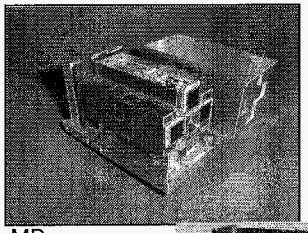
- **Pancam** – high-resolution (16°x16°) color panchromatic stereo cameras
- **Mini-TES** – a mid-infrared point spectrometer
- **Microscopic Imager** – close-up imaging of rock and "soil"
- **Mössbauer Spec trometer** – analysis of iron in rocks
- **Alpha Particle X-Ray Spectrometer** – detects elements in rocks and "soils"
- **Rock Abrasion Tool** – used to remove outer surface of rocks for analysis of non-weathered rock material
- **Magnets and calibration targets** – To collect iron containing dust and for comparison to known sources
- **Engineering cameras**
  - Navcam – wide-angle stereo cameras (45°x 45°) used for traverse planning
  - Hazcam – very-wide-angle (120°x120°) stereo cameras used for identifying potential hazards to rover driving and arm movement


Pancam


Mini-TES



MI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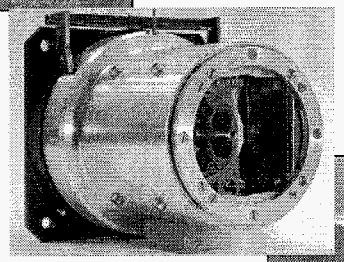
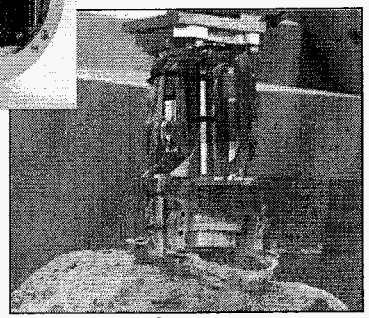
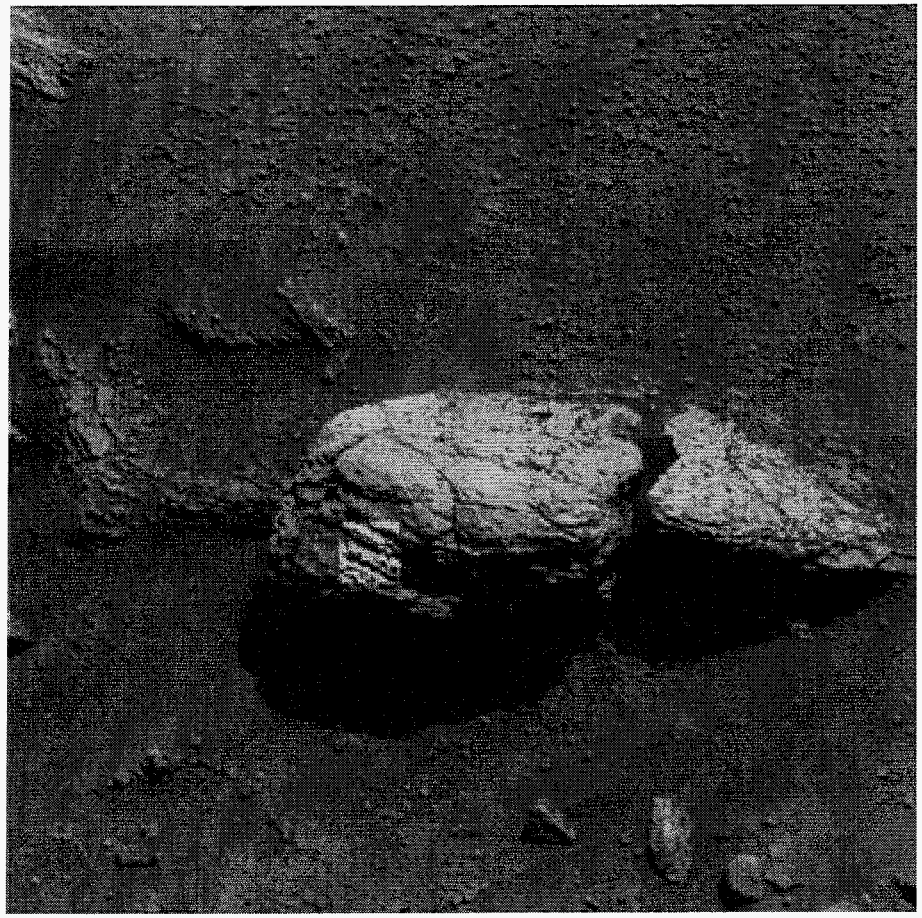
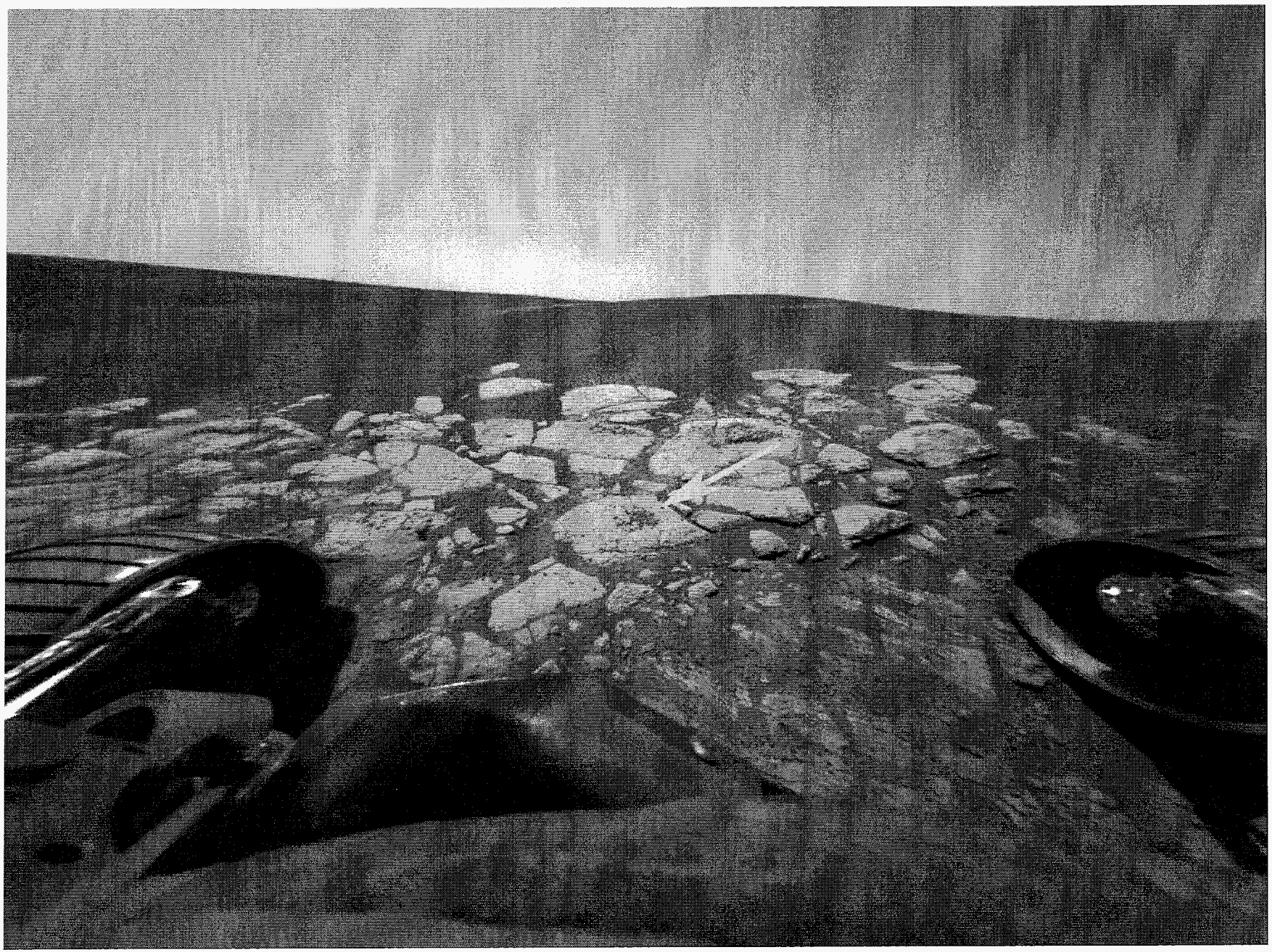
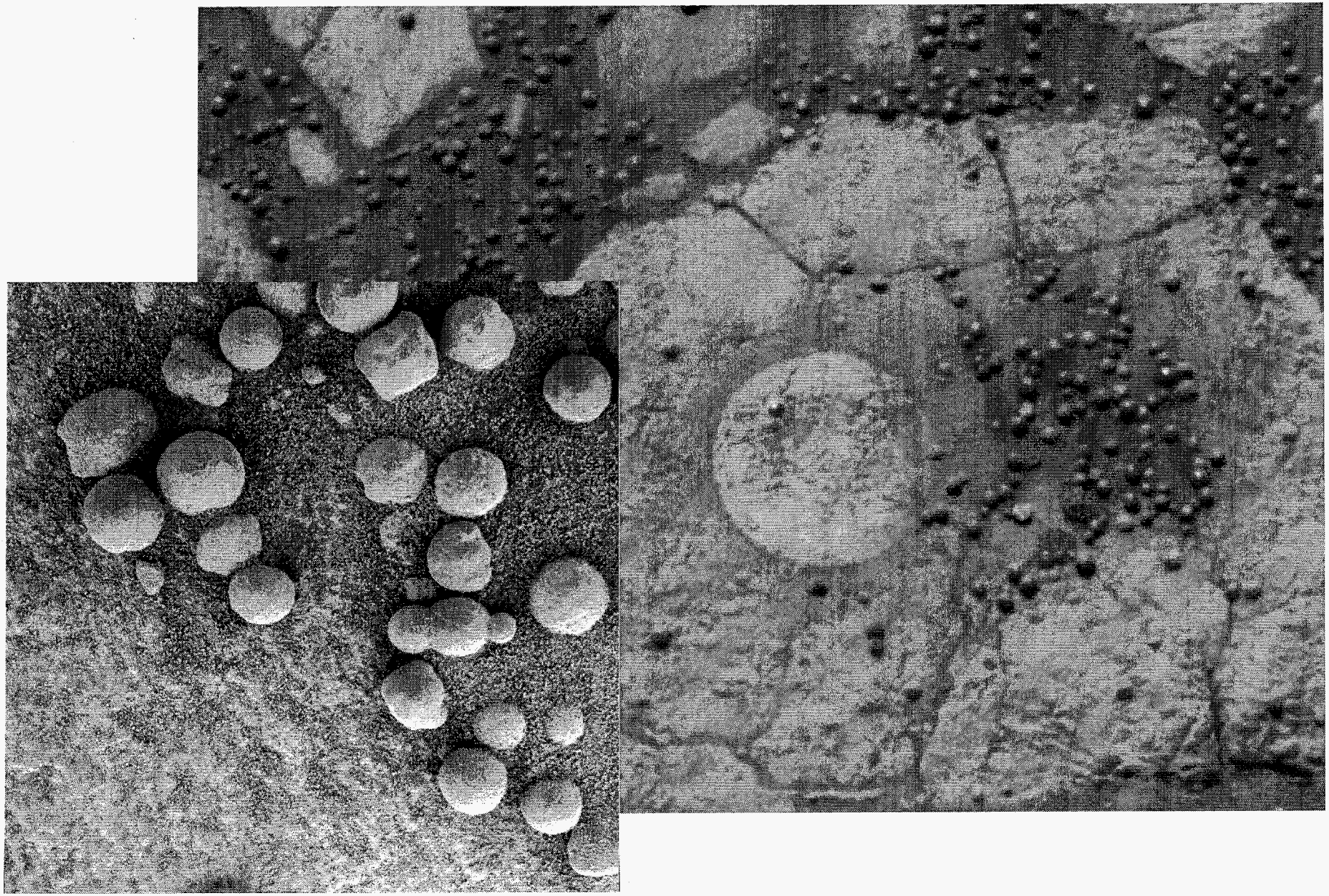
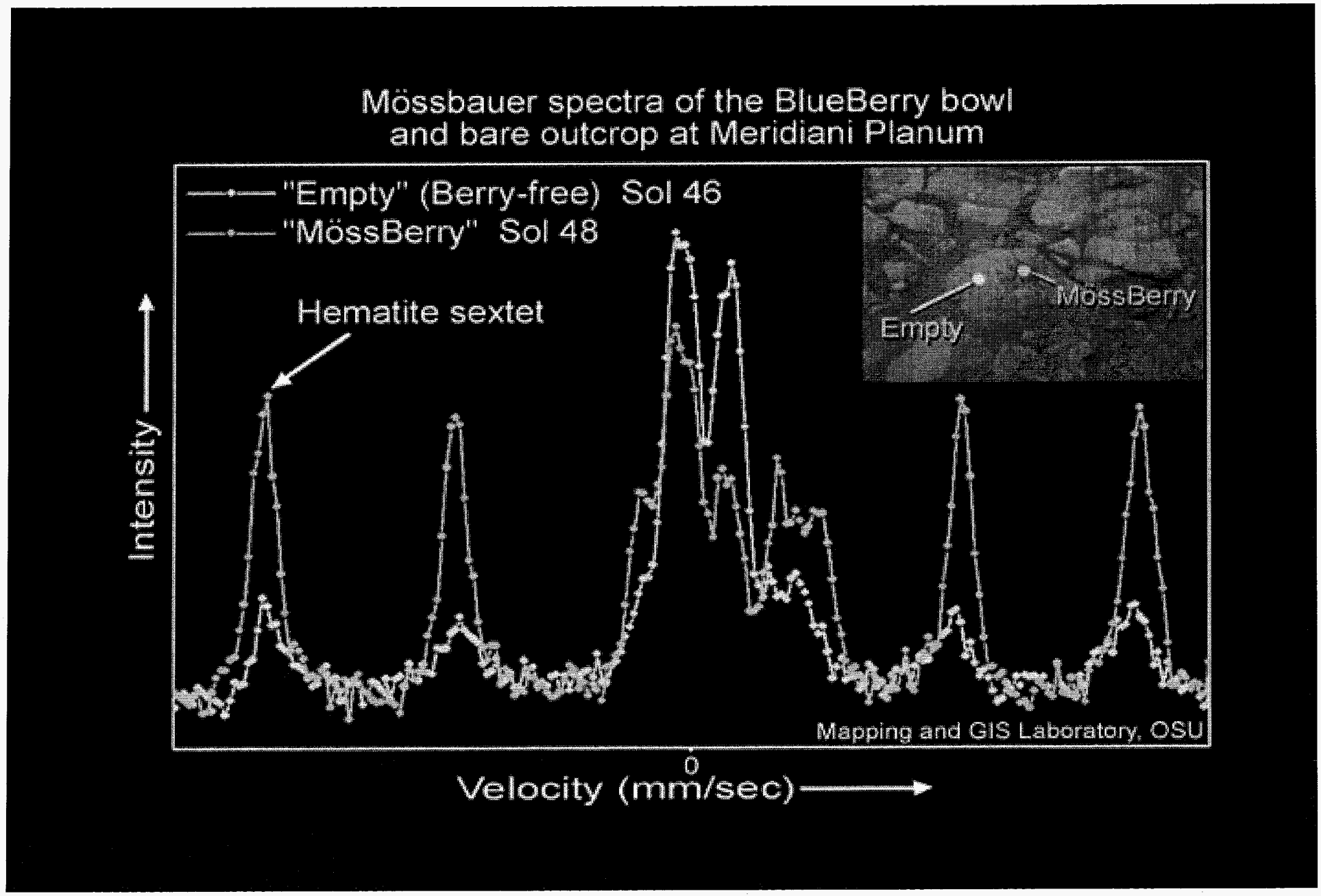

APXS

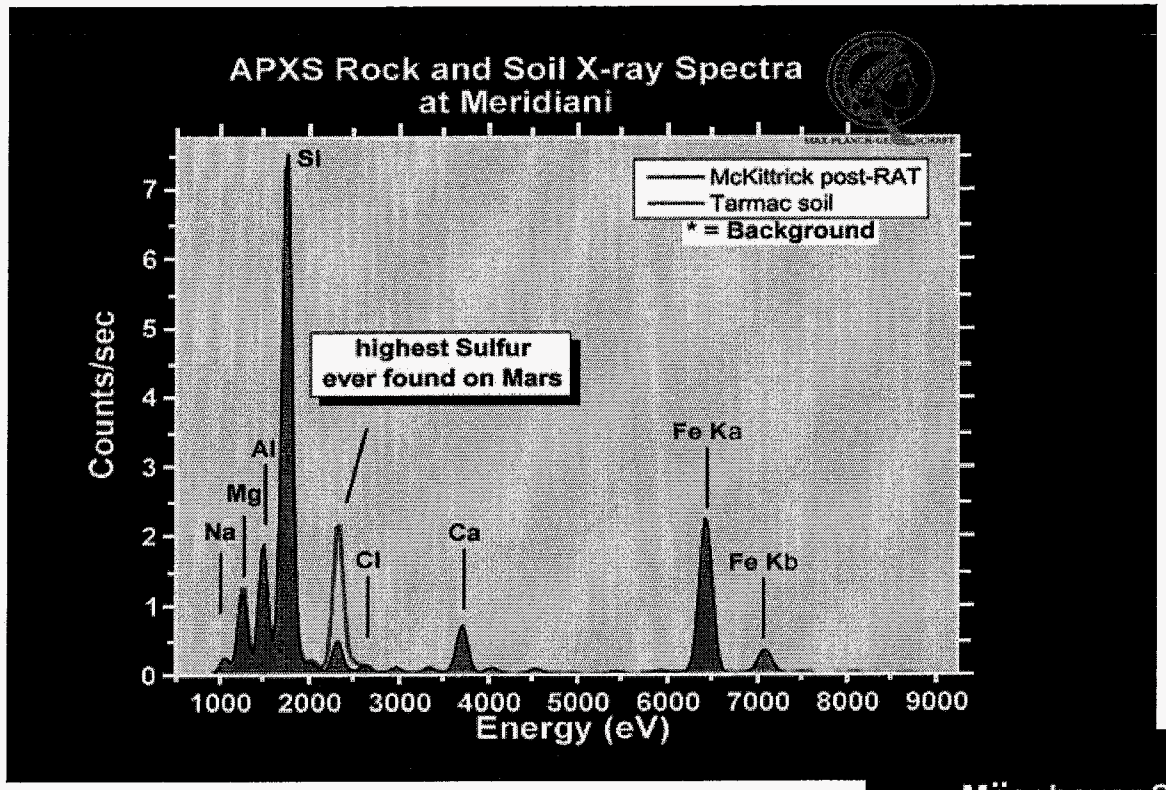

RAT

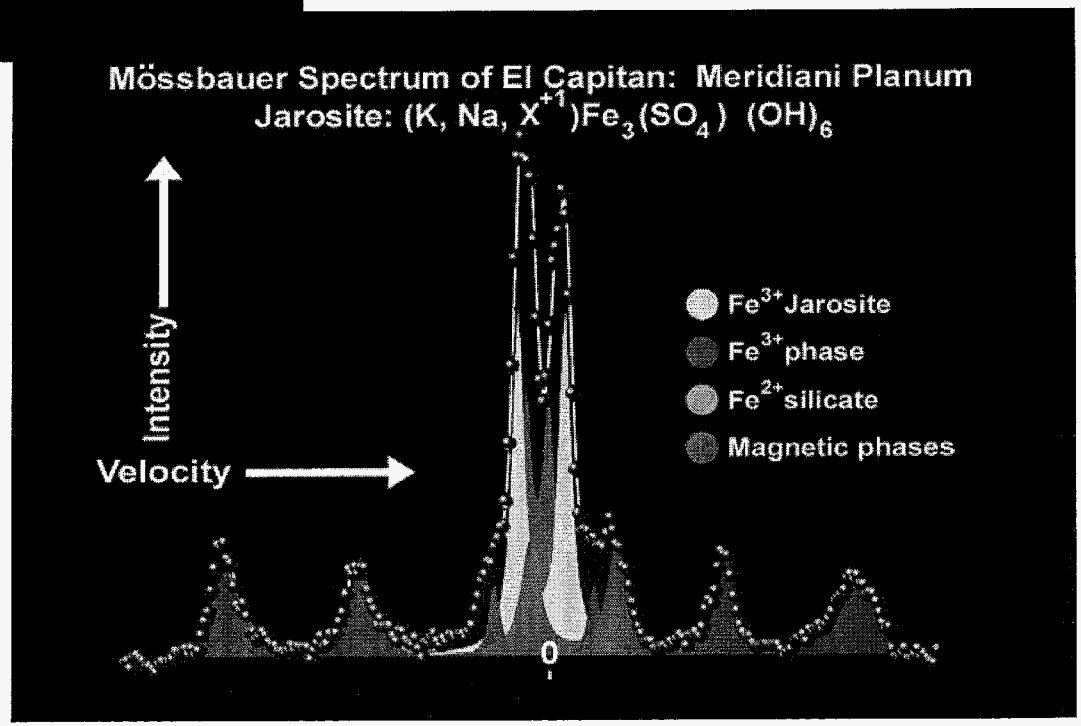


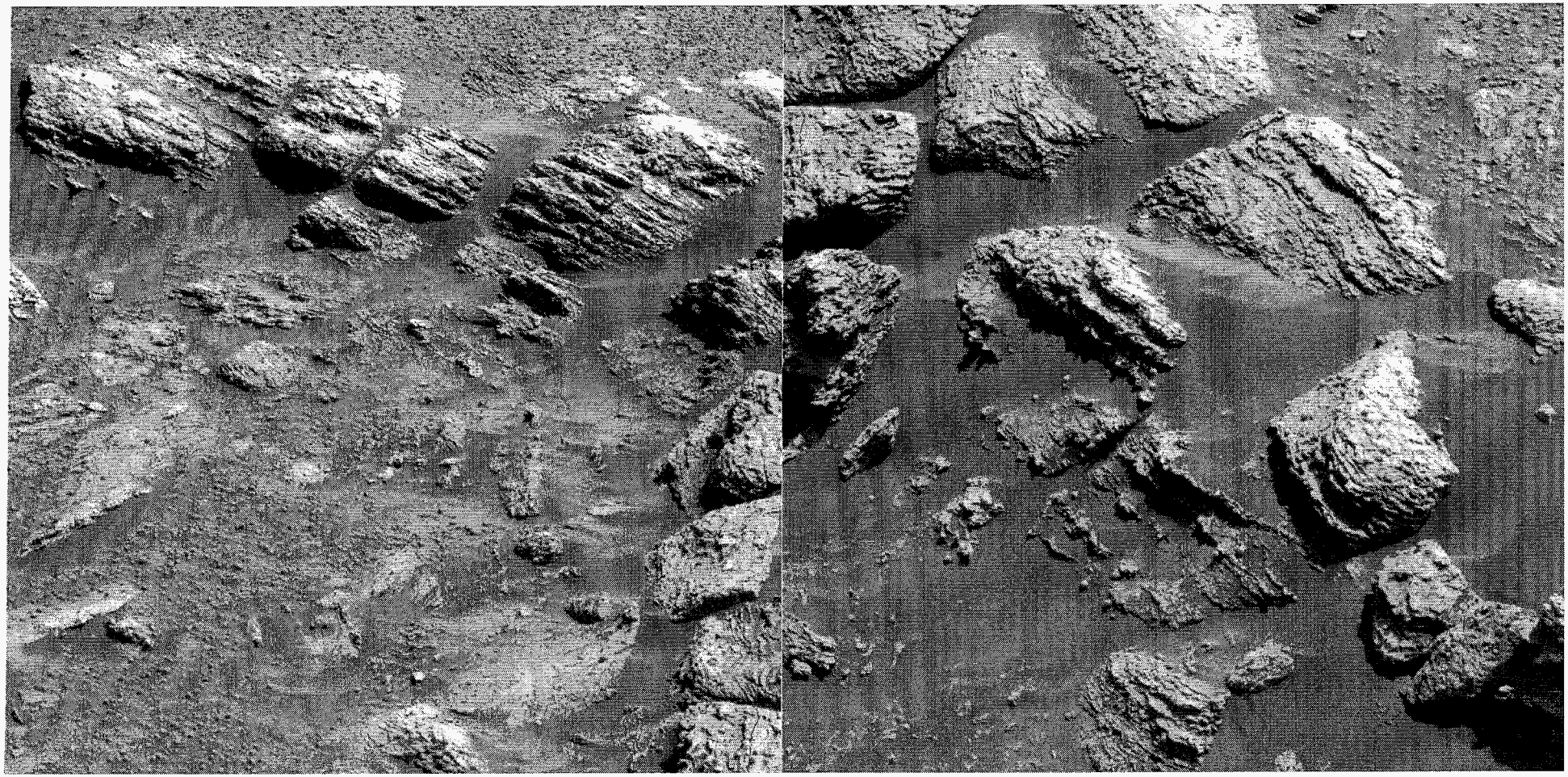




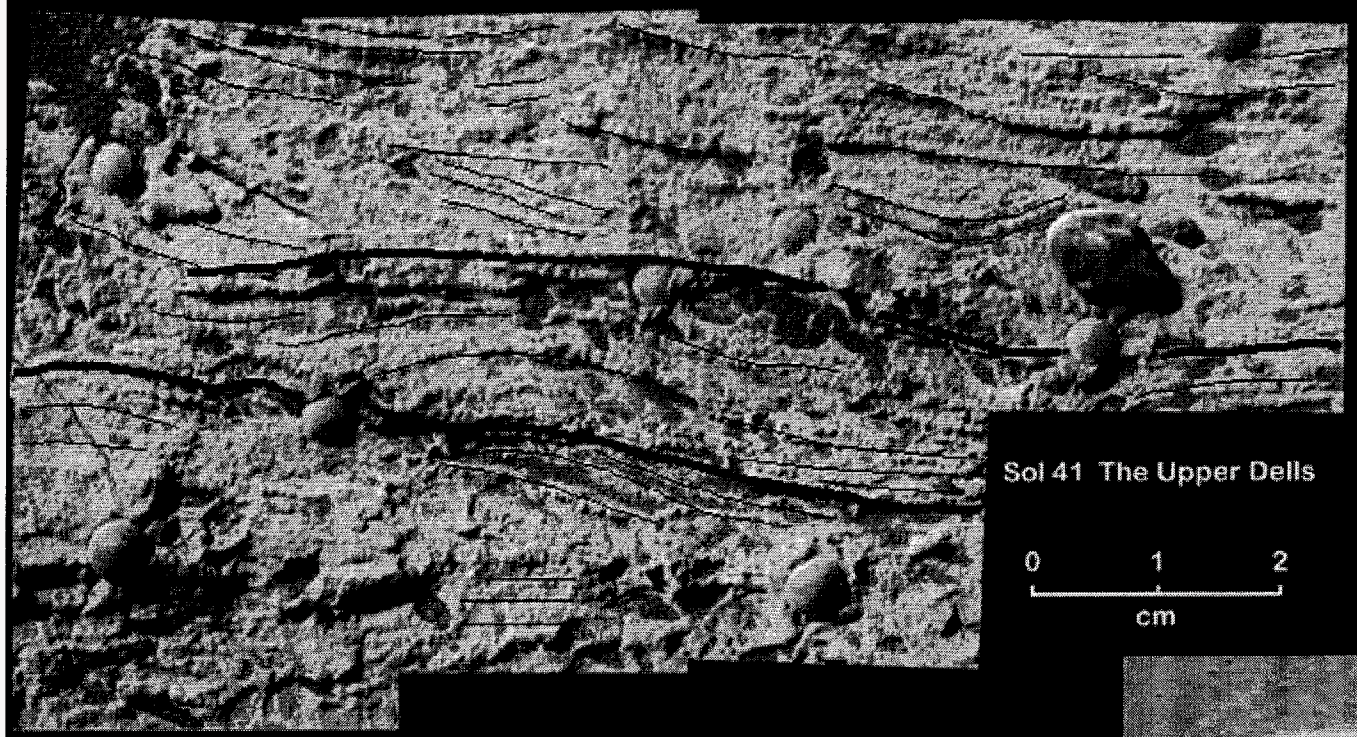

Mössbauer spectra of the BlueBerry bowl
and bare outcrop at Meridiani Planum
"Empty" (Berry-free) Sol 46
"MössBerry" Sol 48
Hematite sextet
Empty
MössBerry
Intensity
Velocity (mm/sec)
0
Mapping and GIS Laboratory, OSU

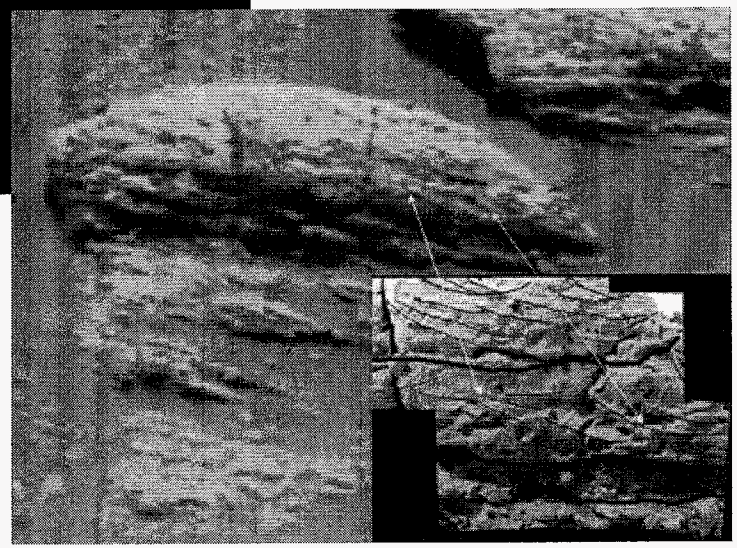

APXS Rock and Soil X-ray Spectra
at Meridiani
McKittrick post-RAT
Tarmac soil
* = Background
highest Sulfur
ever found on Mars
Si
Al
Mg
Na
Cl
Ca
Fe Ka
Fe Kb
Counts/sec
Energy (eV)
0
1
2
3
4
5
6
7
1000
2000
3000
4000
5000
6000
7000
8000
9000

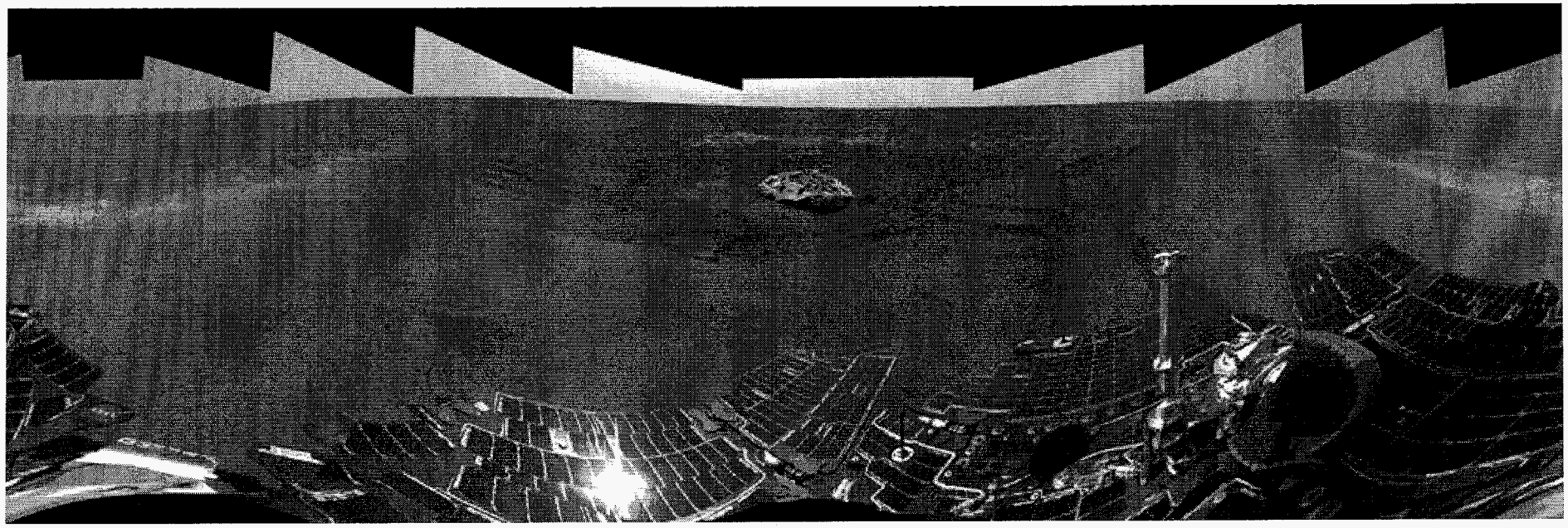

Mössbauer Spectrum of El Capitan: Meridiani Planum
Jarosite: (K, Na, X+1)Fe3(SO4) (OH)6
Intensity
Velocity
0
Fe3+Jarosite
Fe3+phase
Fe2+silicate
Magnetic phases

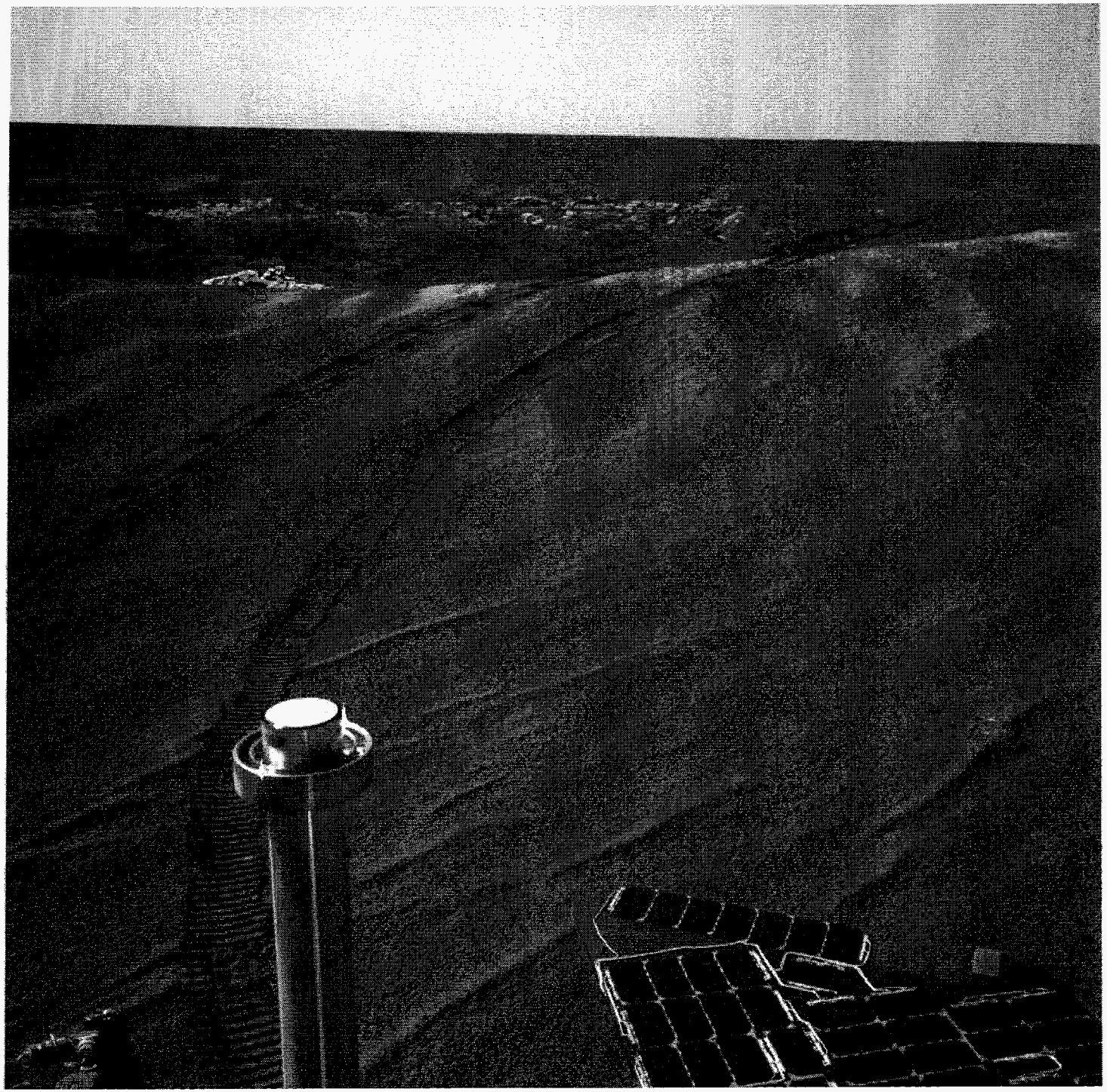


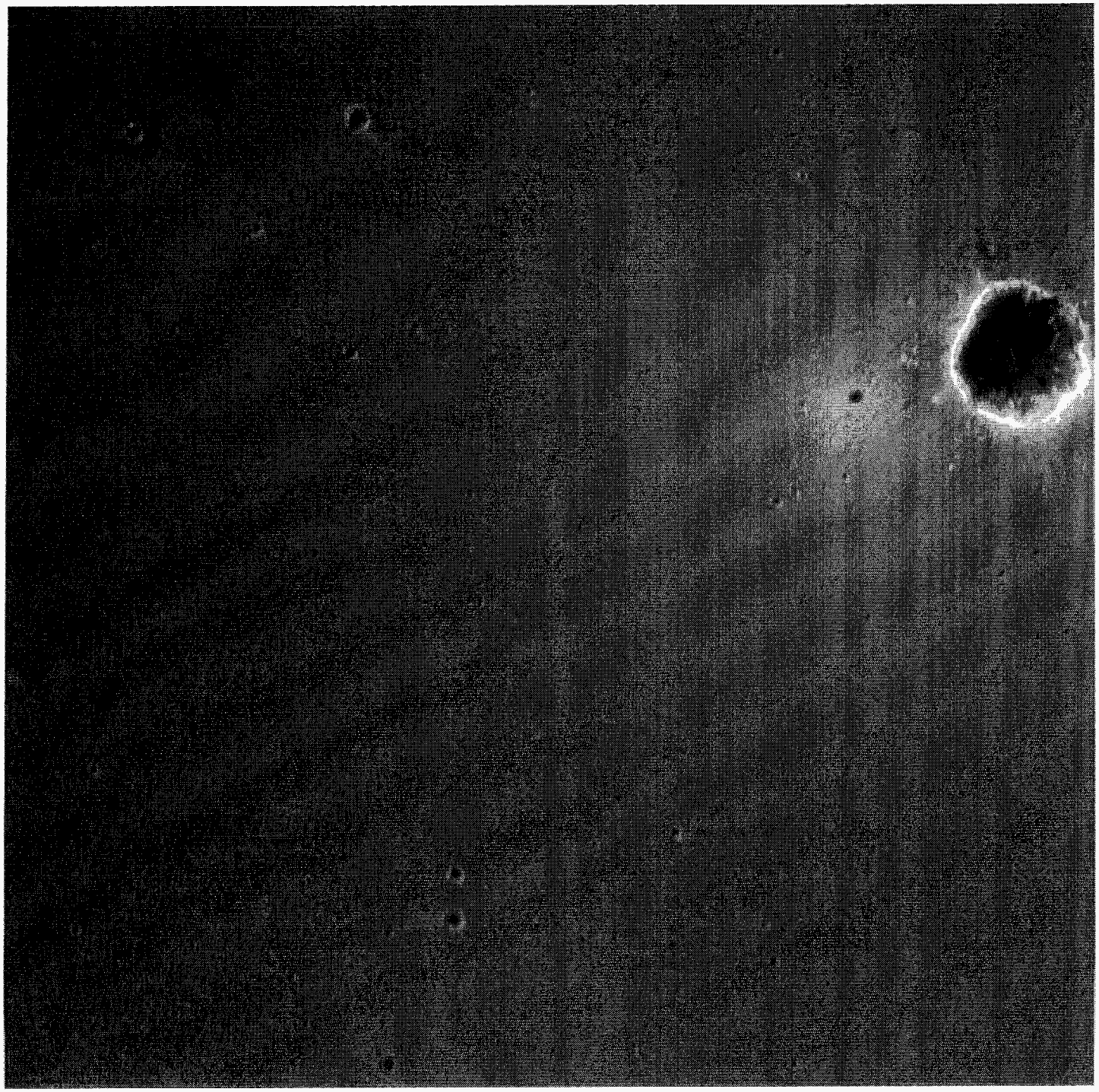
Upper Dells MI Mosaic

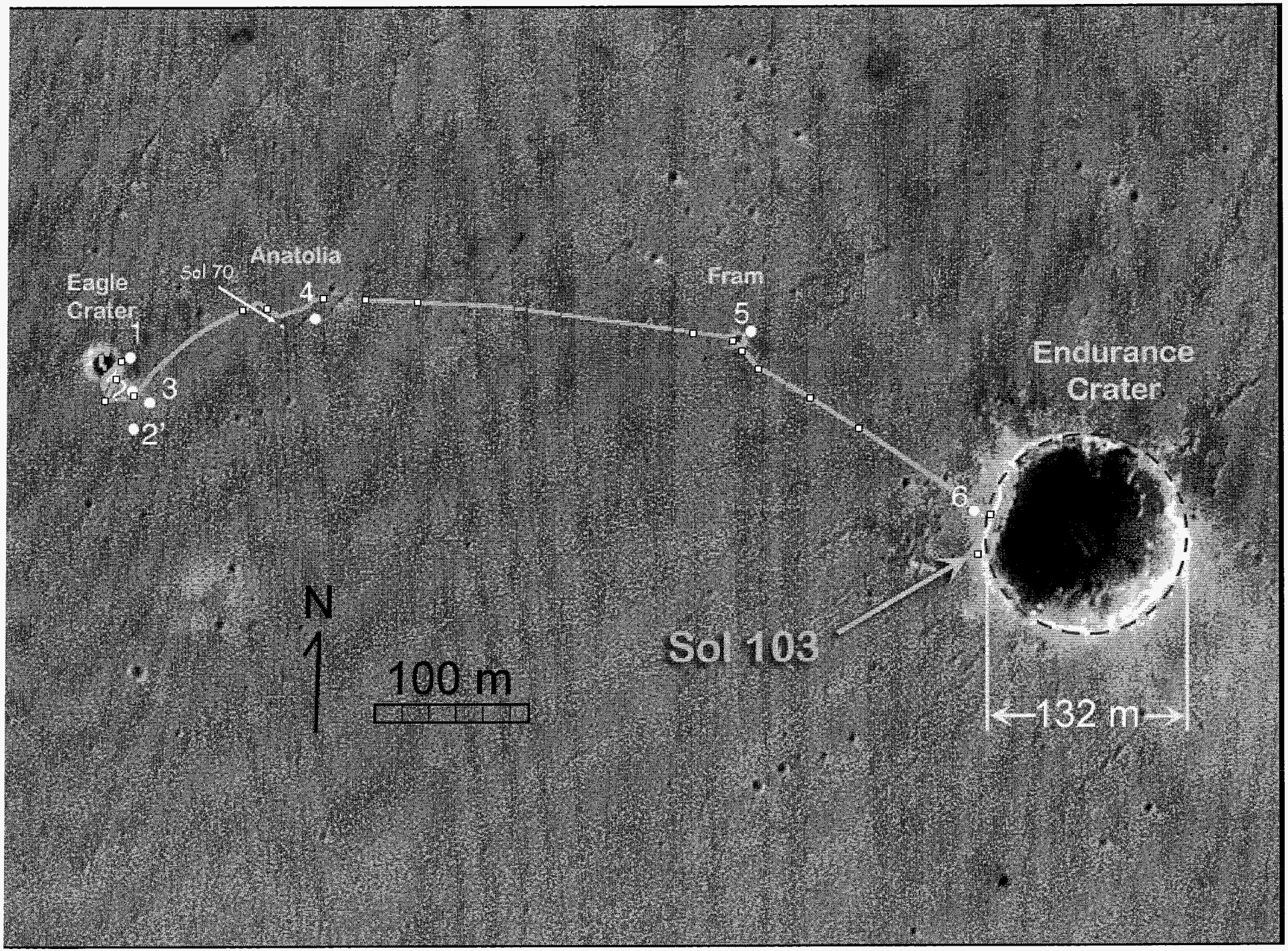




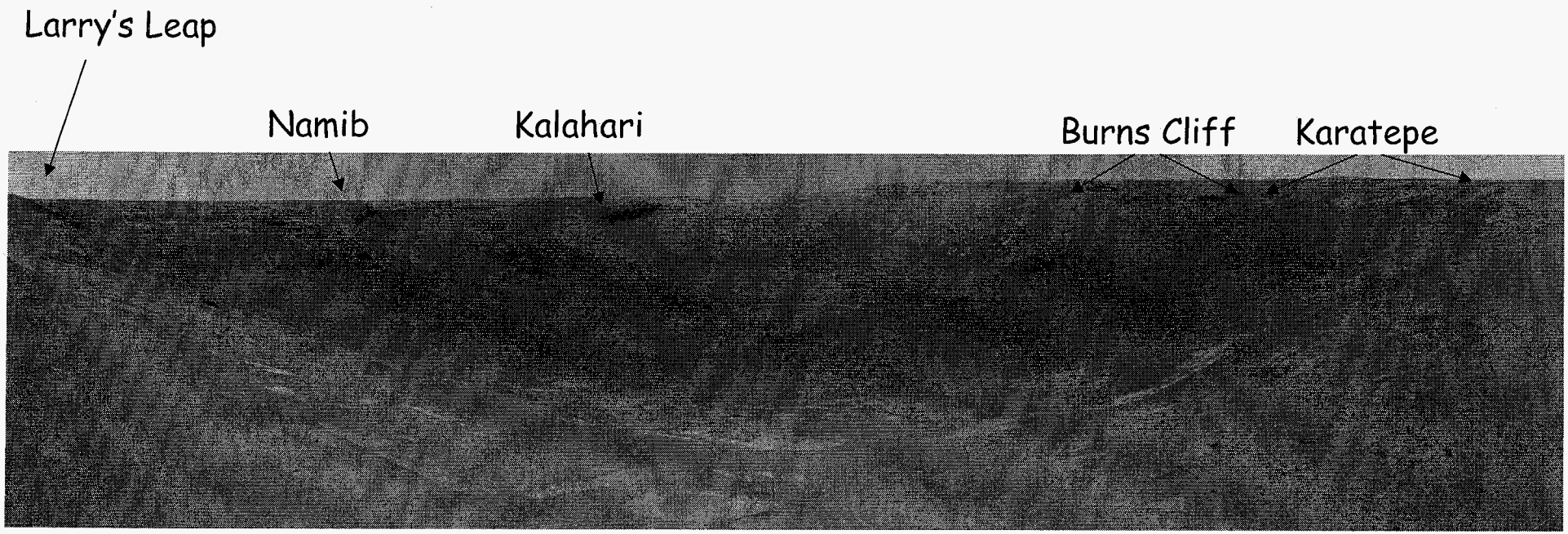




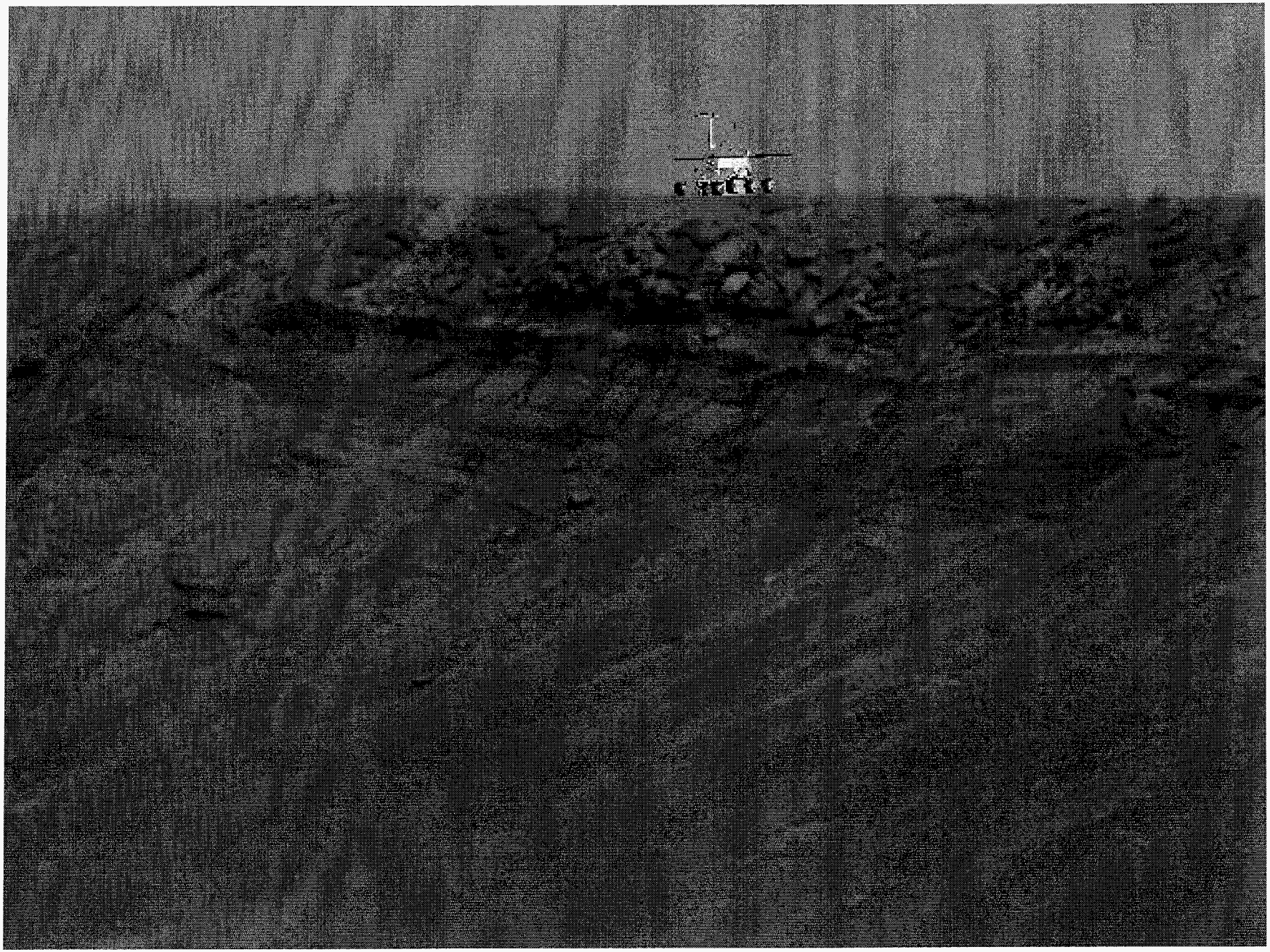


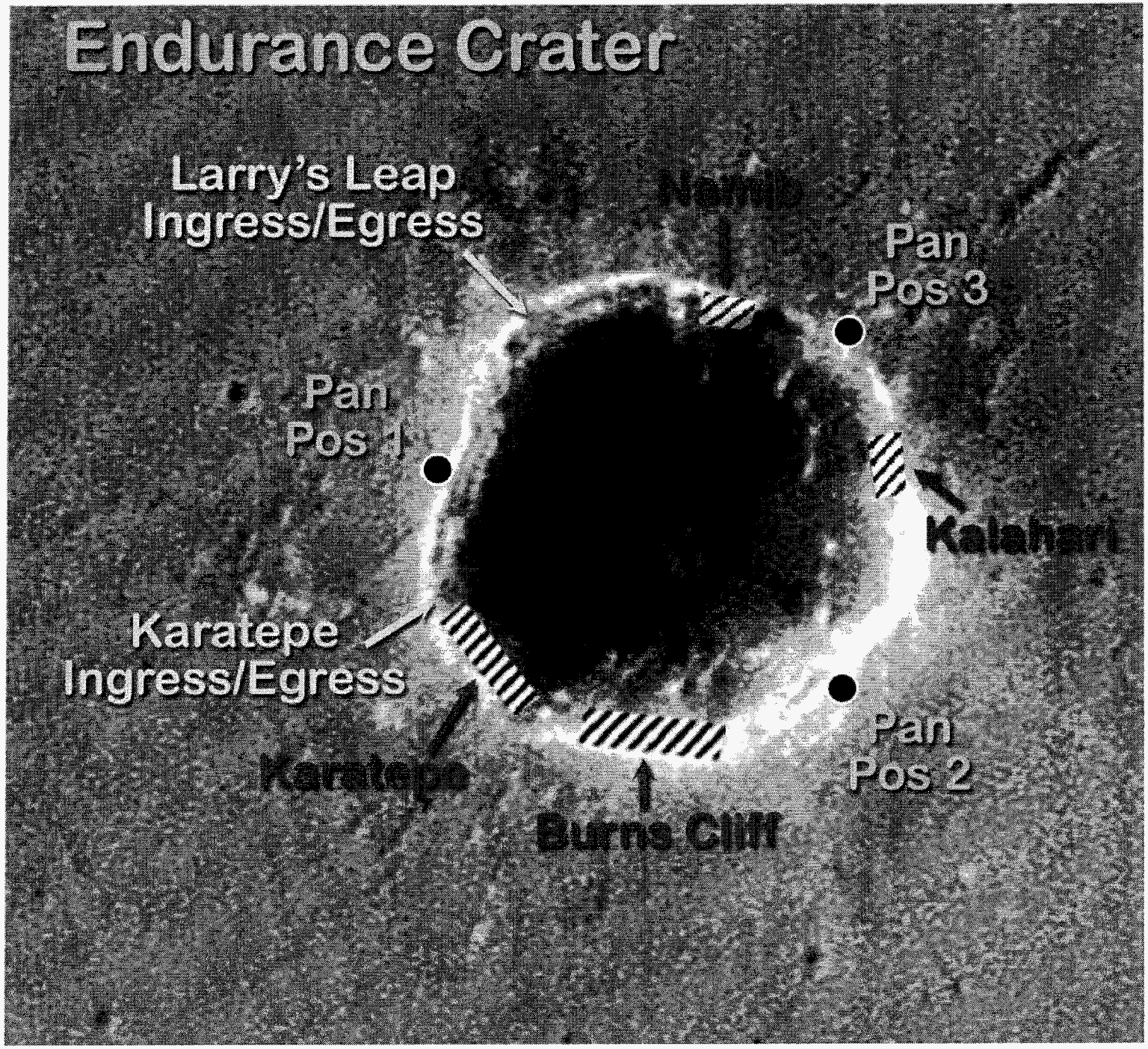

Eagle
Crater
1
2
3
2'
Sol 70
Anatolia
4
Fram
5
6
Endurance
Crater
Sol 103
N
100 m
132 m

Endurance Crater

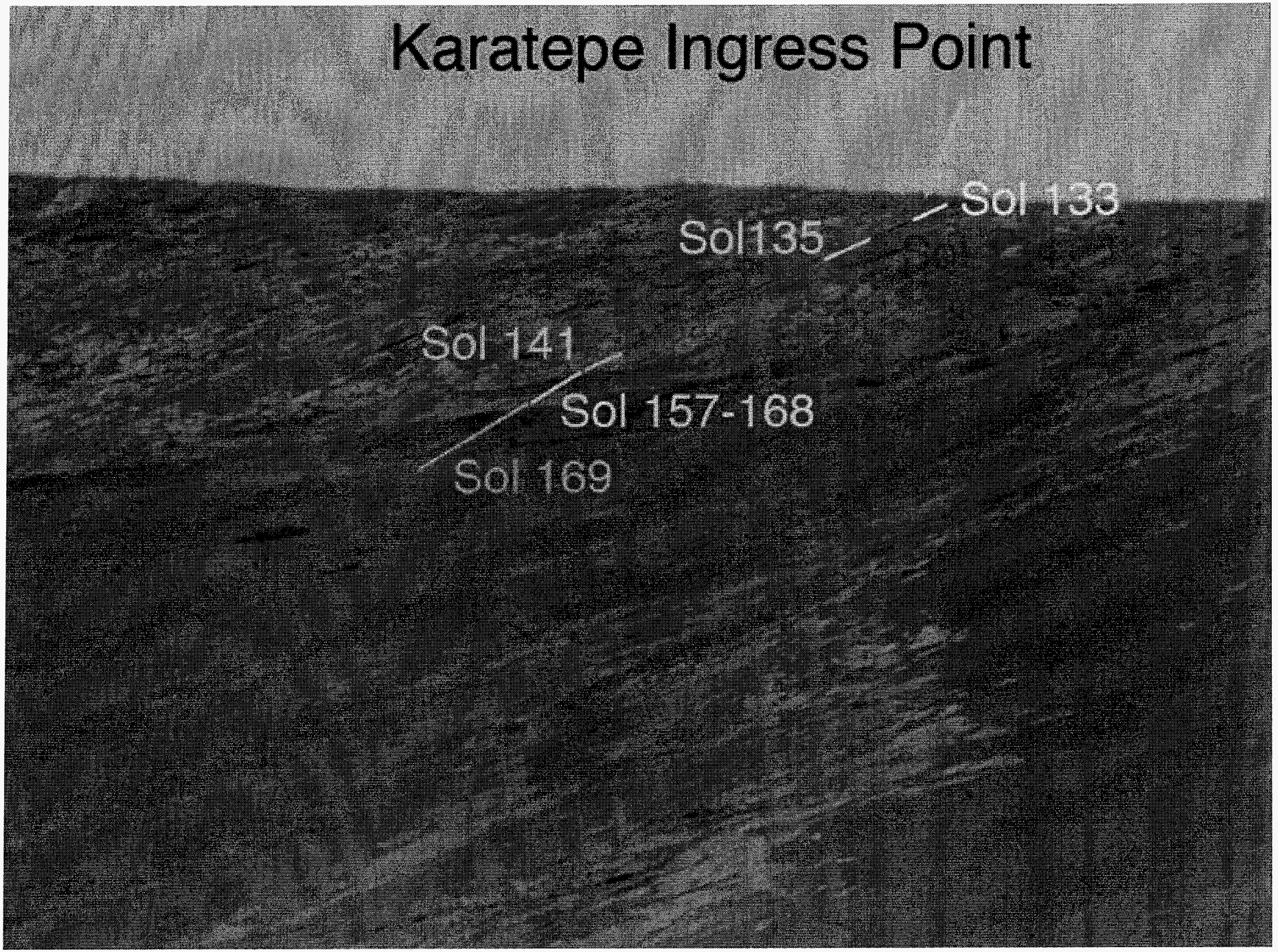


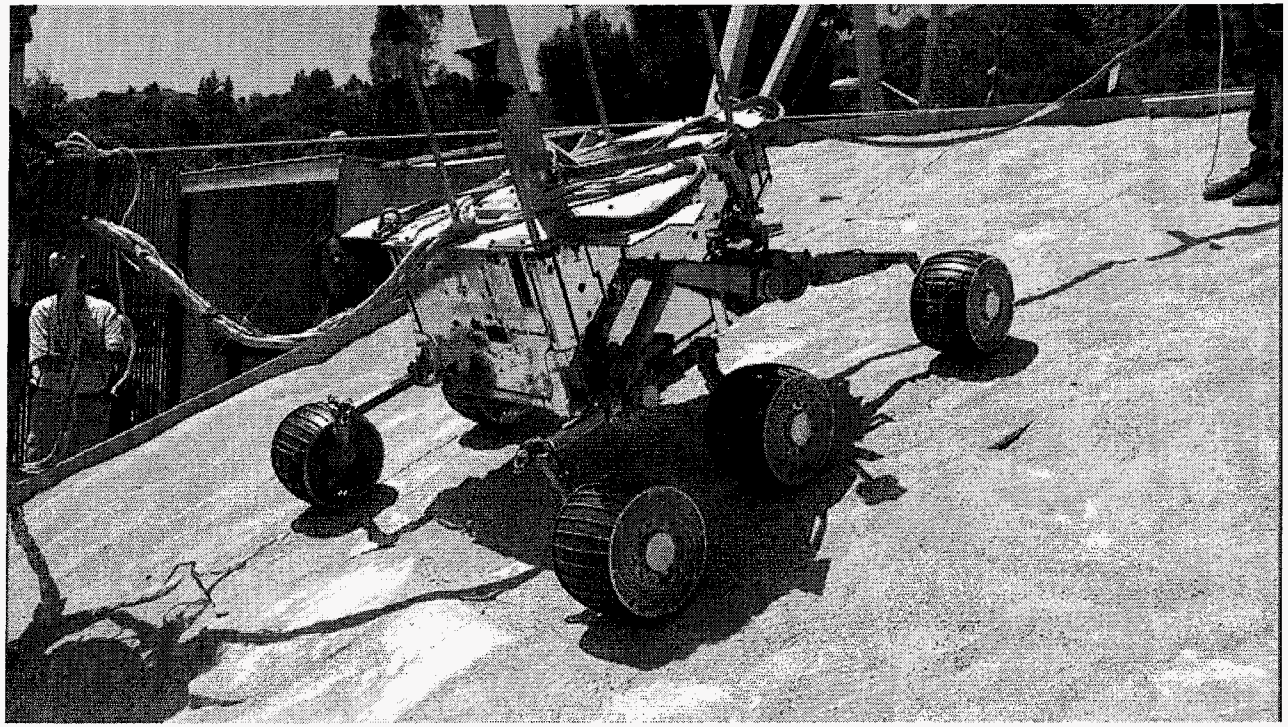
Pancam West Rim -(Sol 101)

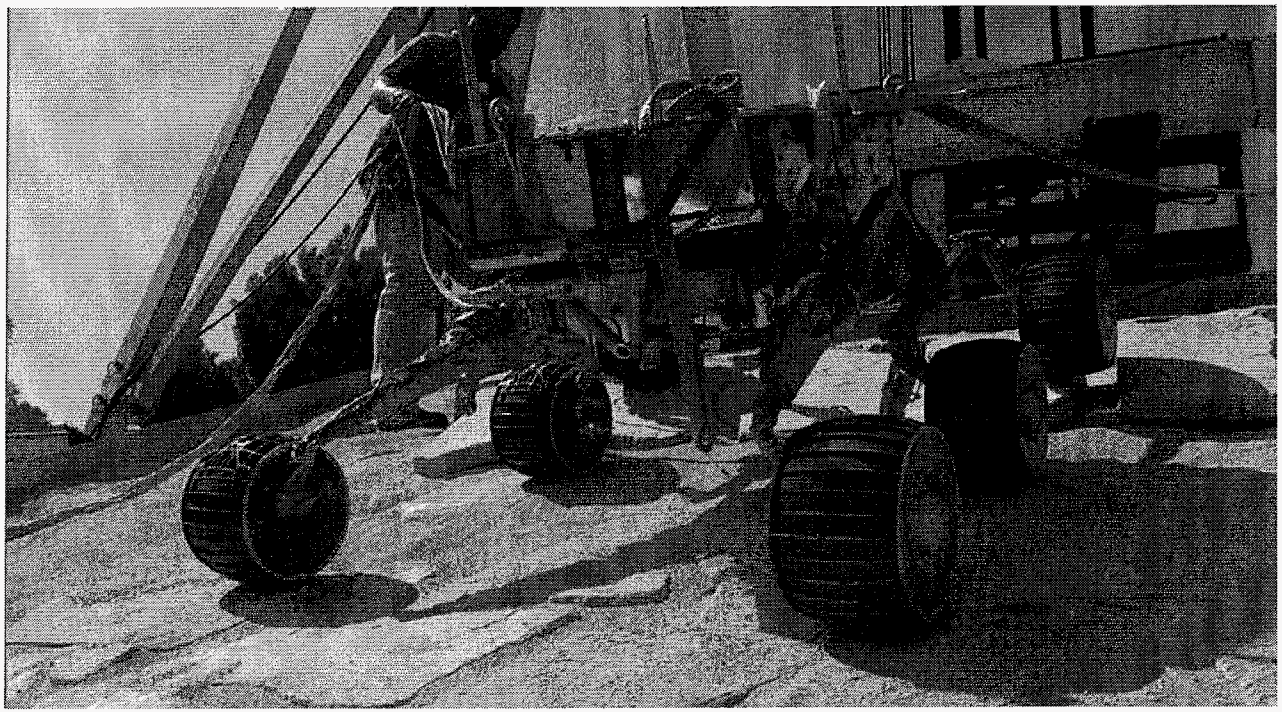


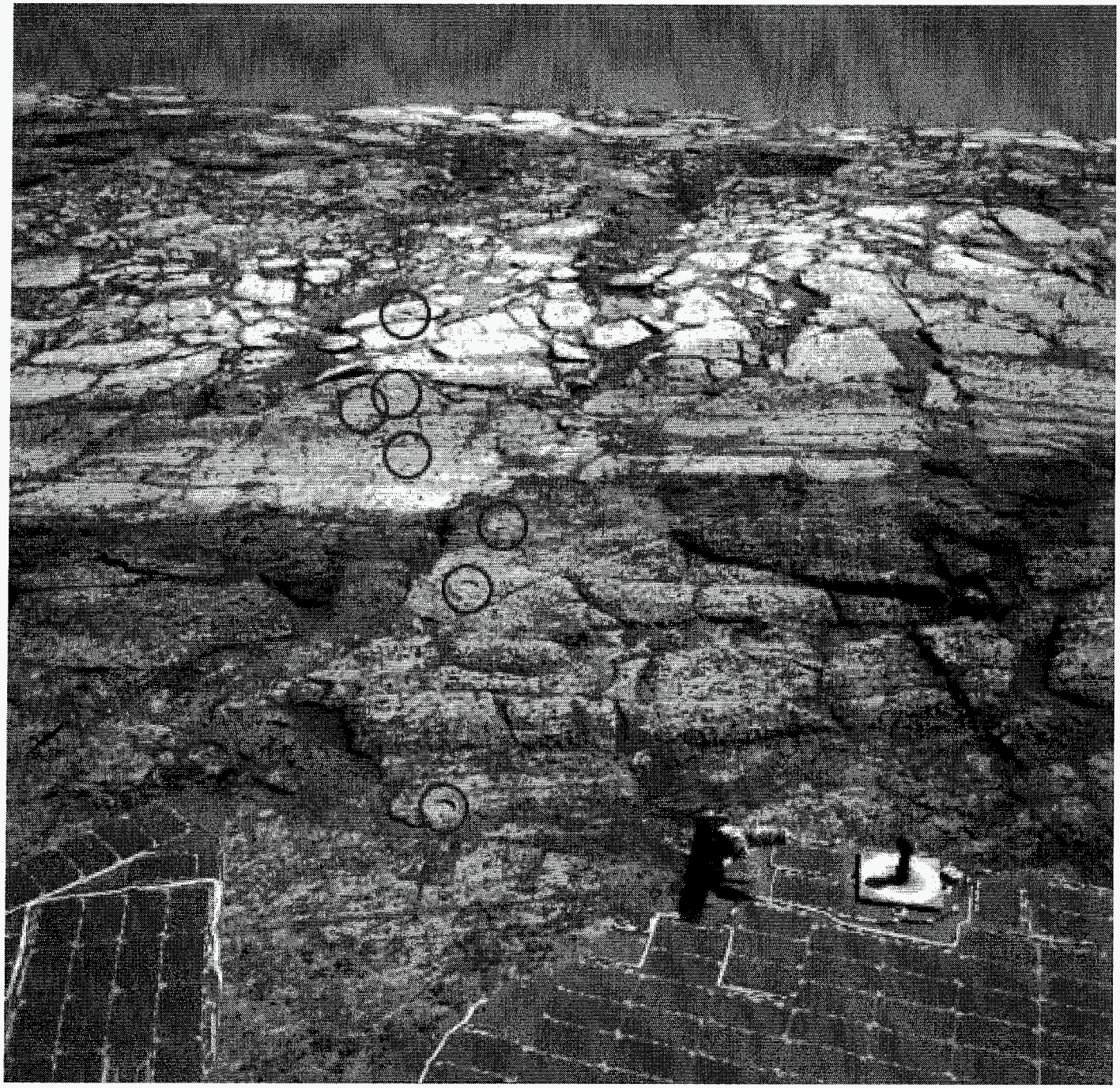

Endurance Crater
Larry's Leap
Ingress/Egress
Pan
Pos 3
Pan
Pos 1
Kalahari
Karatepe
Ingress/Egress
Pan
Pos 2
Burns Cliff

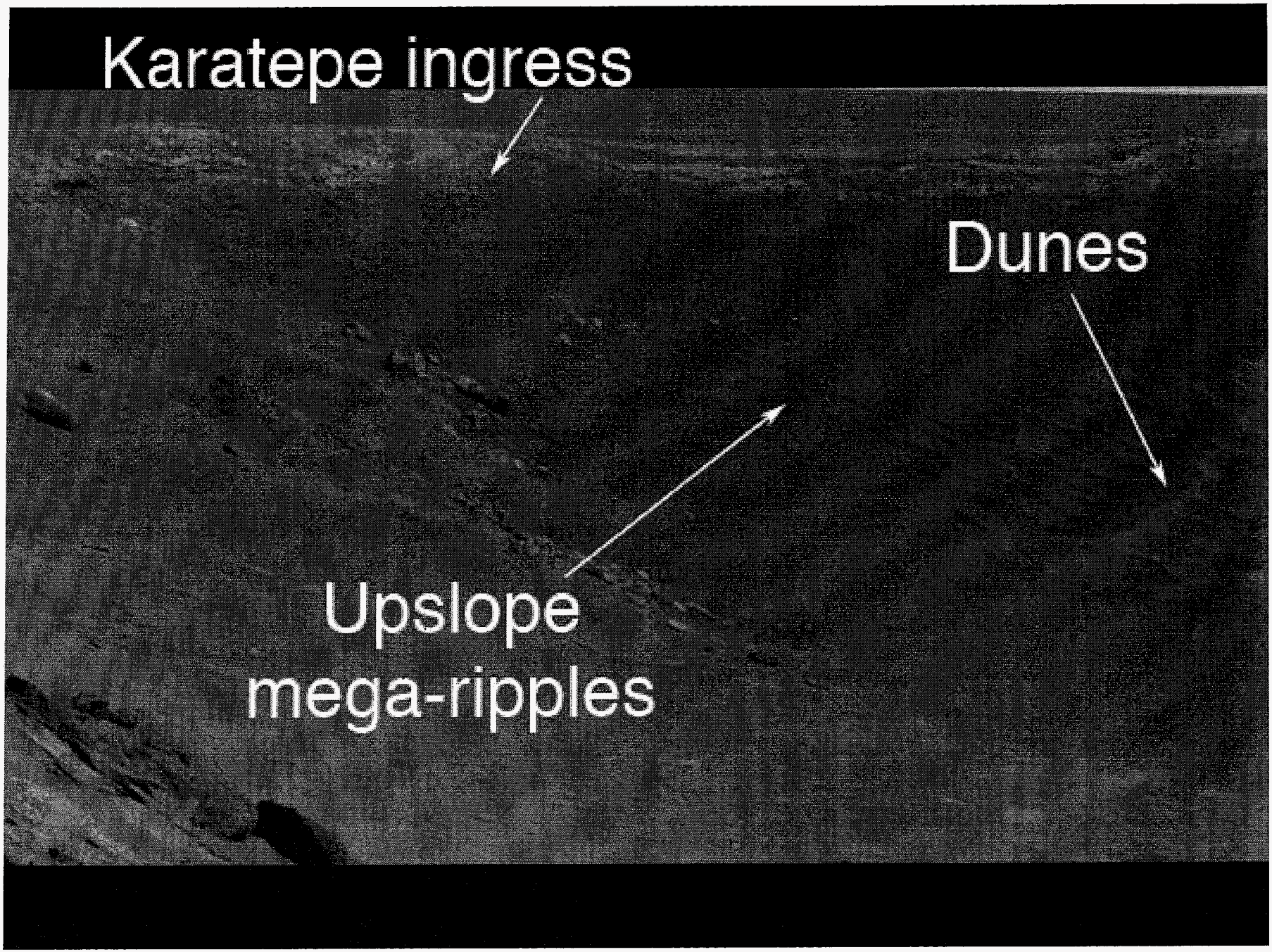
Karatepe Ingress Point

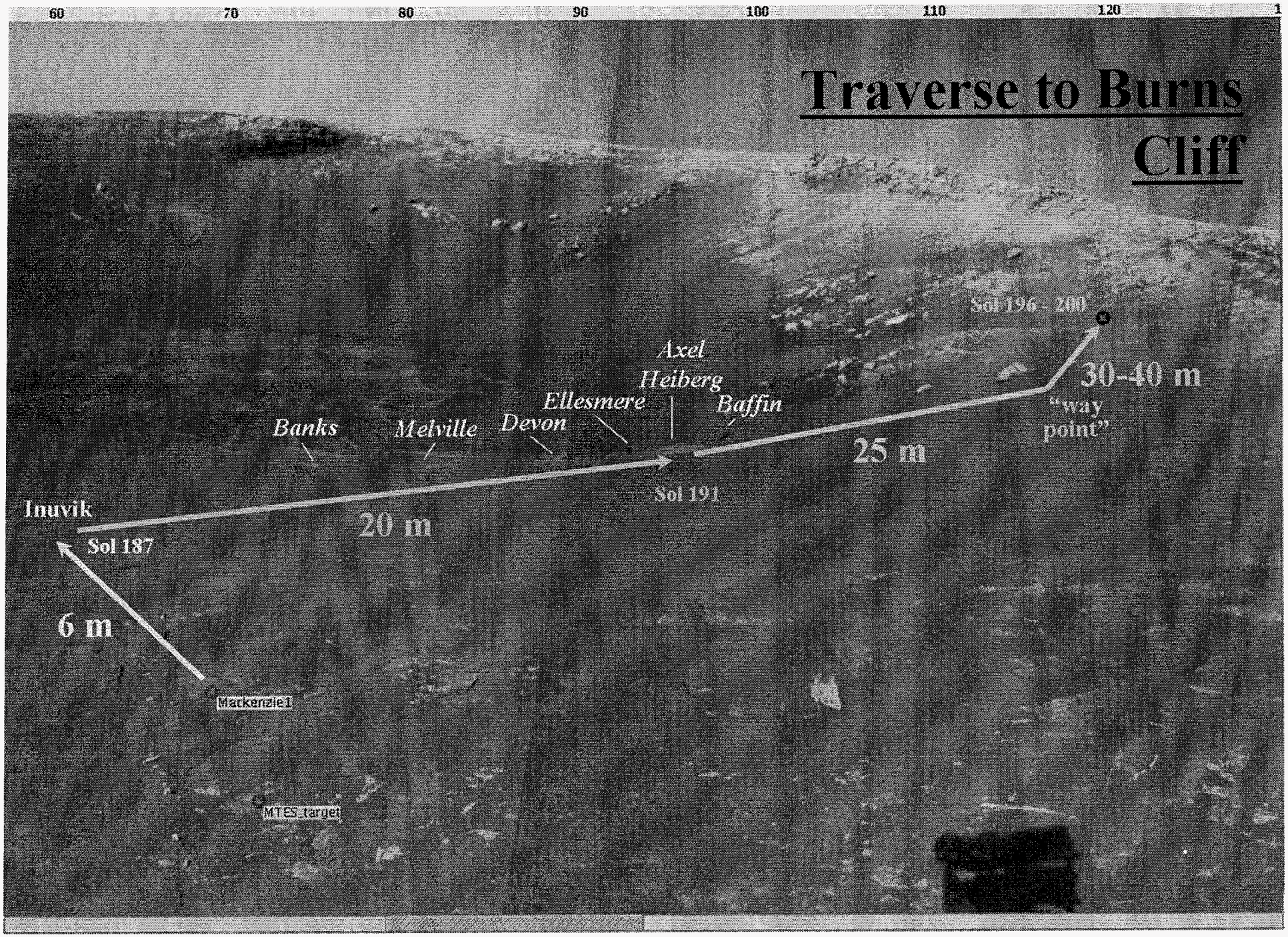


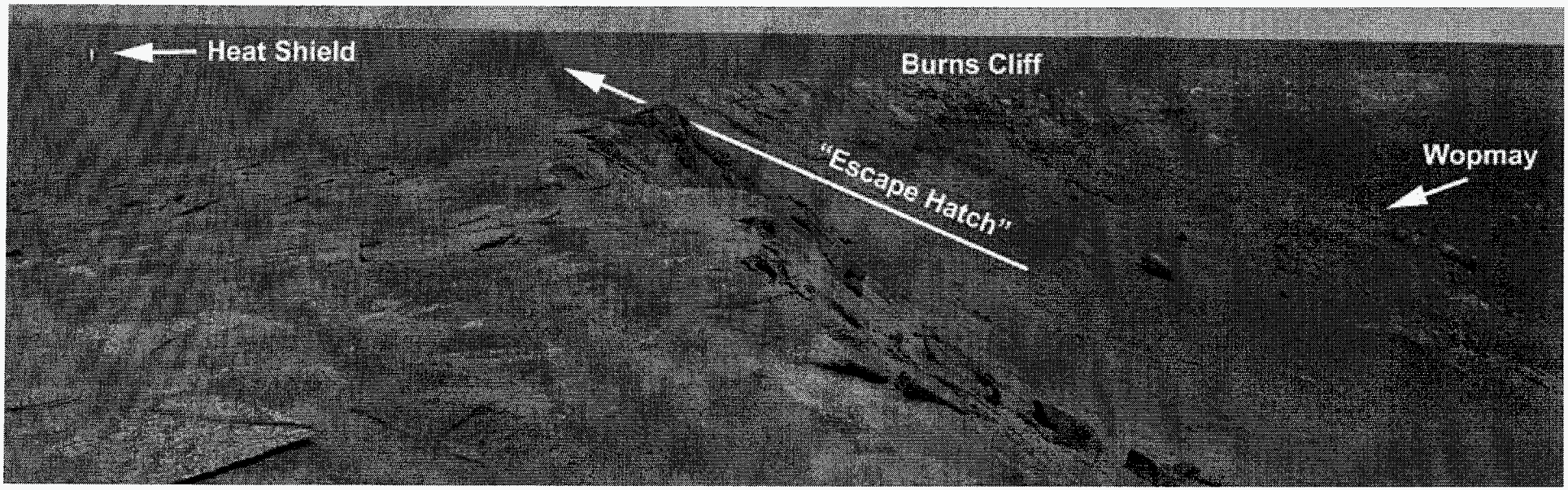


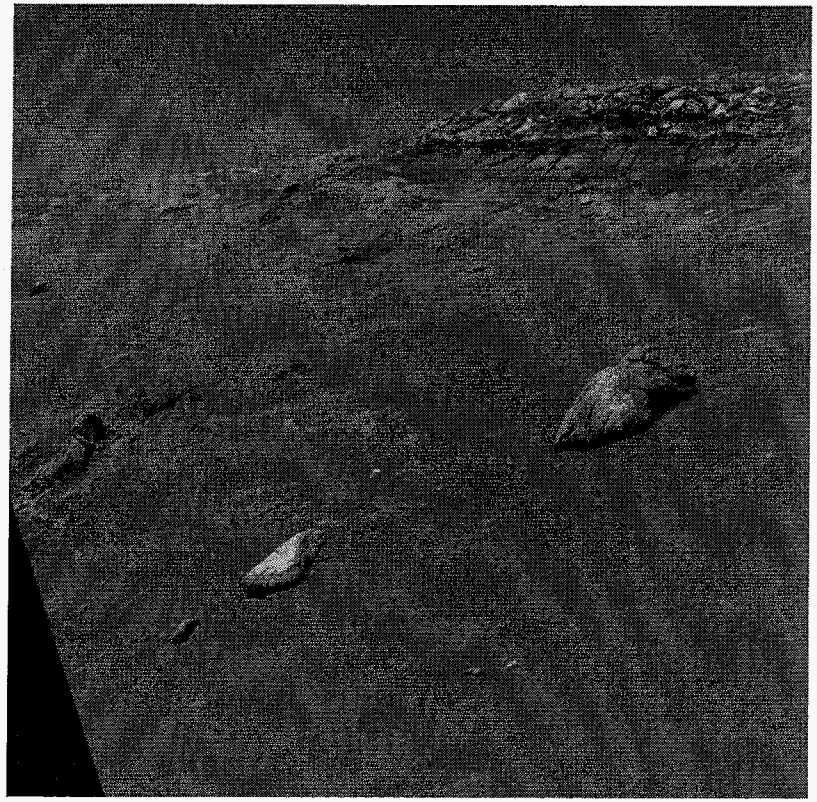


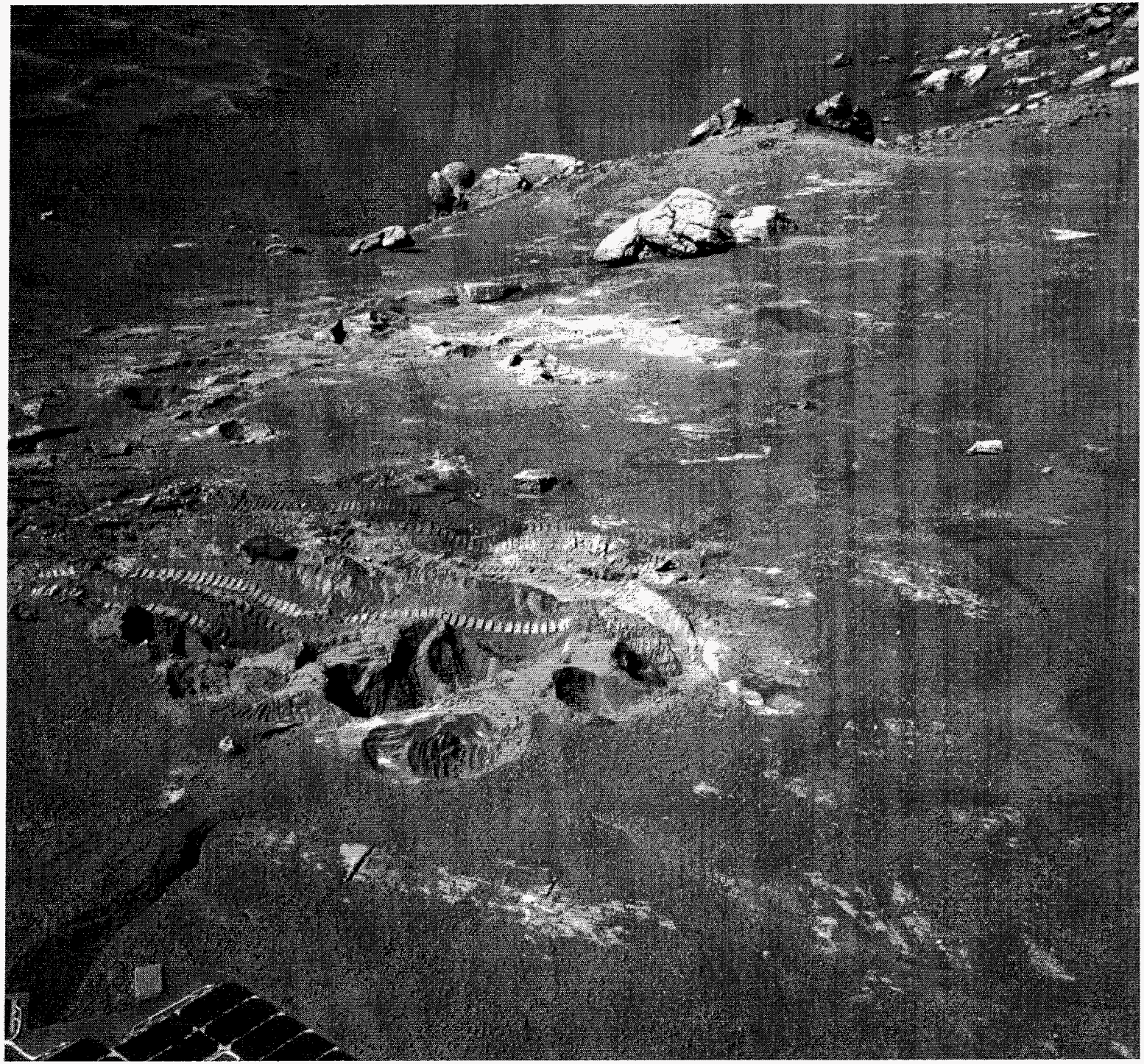


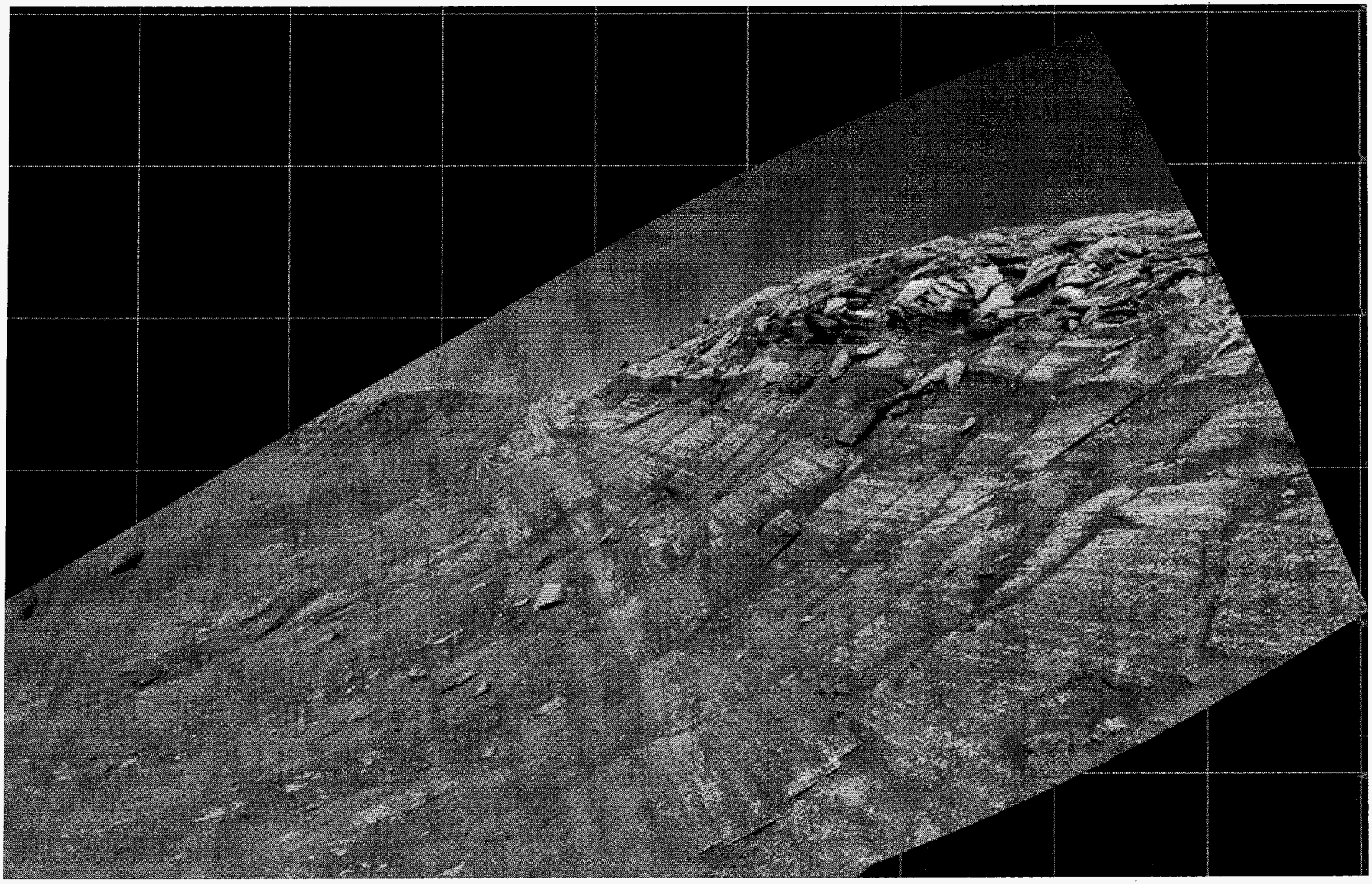

Karatepe ingress
Dunes
Upslope
mega-ripples


Traverse to Burns Cliff
60
70
80
90
100
110
120
Sol 196 - 200
Axel Heiberg
Ellesmere
Baffin
Banks
Melville
Devon
30-40 m
"way point"
25 m
Sol 191
Inuvik
20 m
Sol 187
6 m
Mackenzie1
MTES_target


Heat Shield
Burns Cliff
"Escape Hatch"
Wopmay

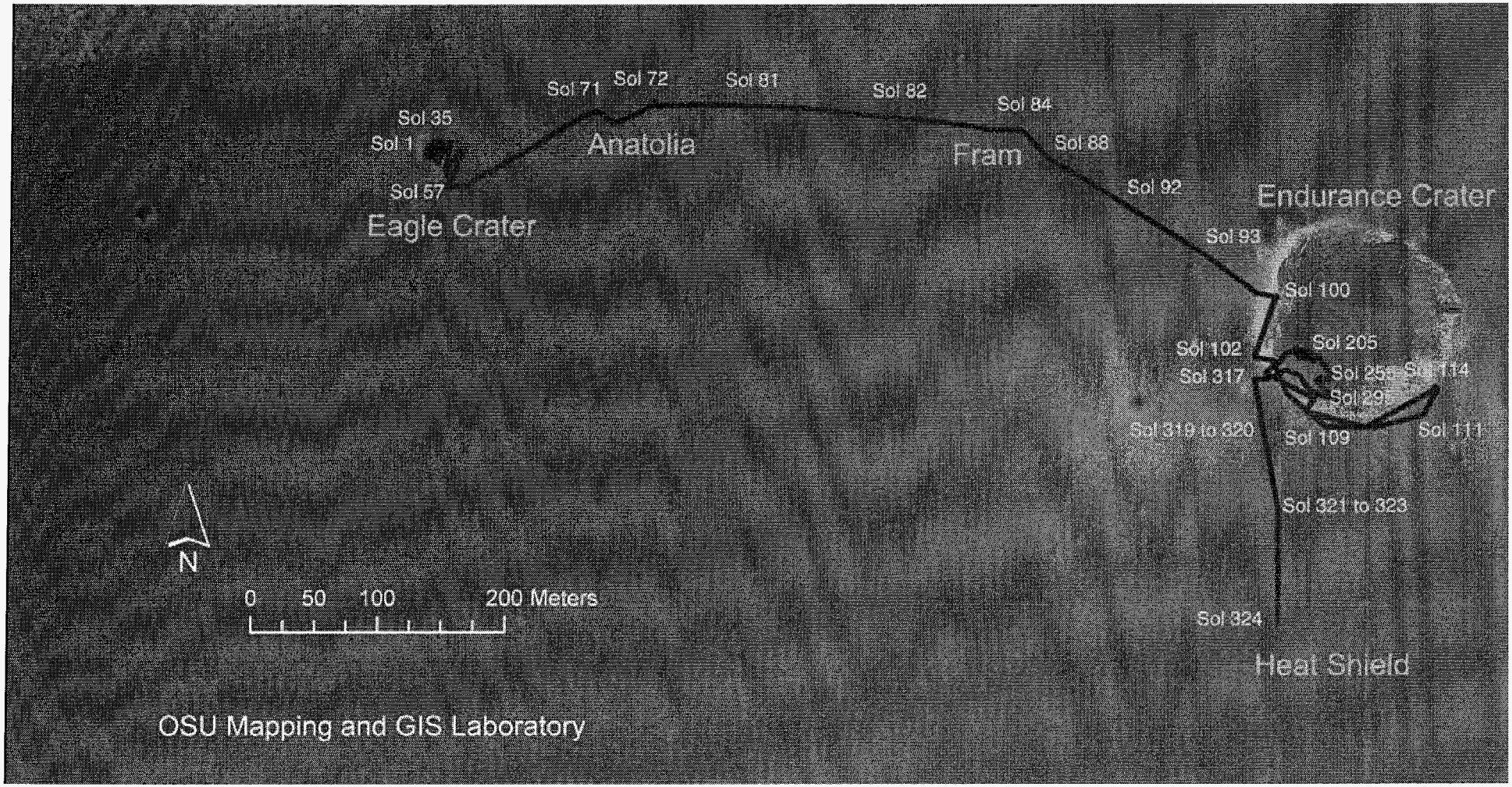


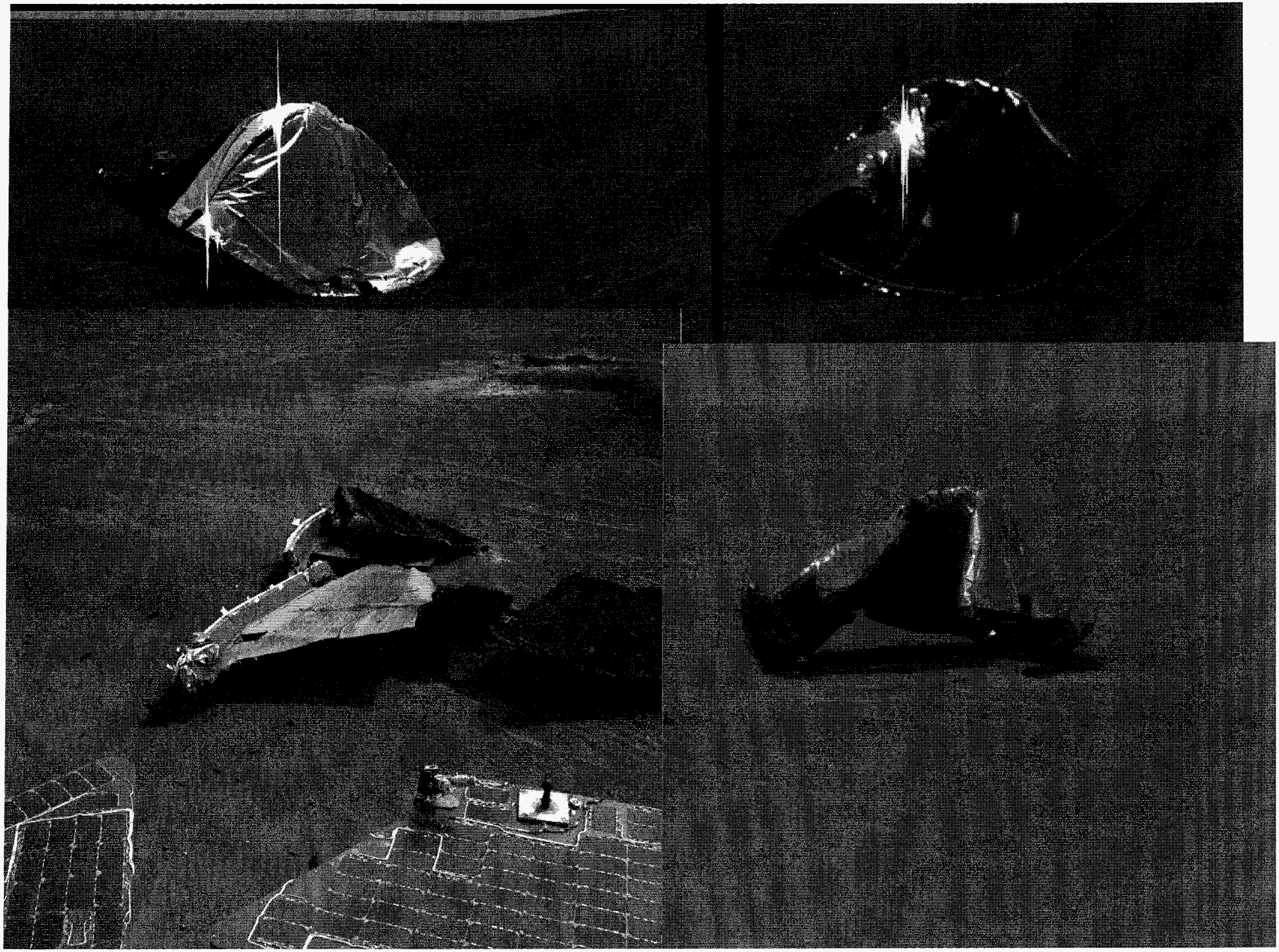




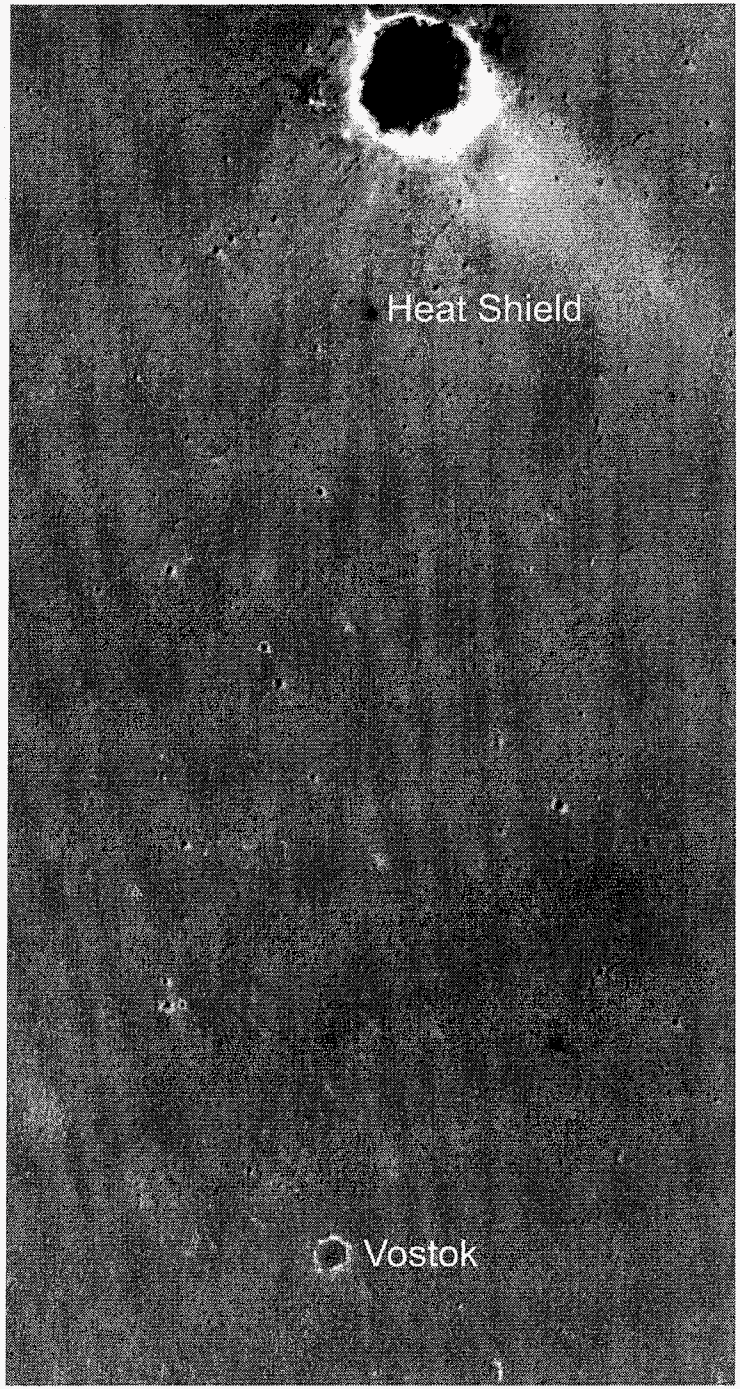
Spirit Landing Site
"Columbia Memorial Station"

Opportunity Rover Traverse Map (Sol 324)

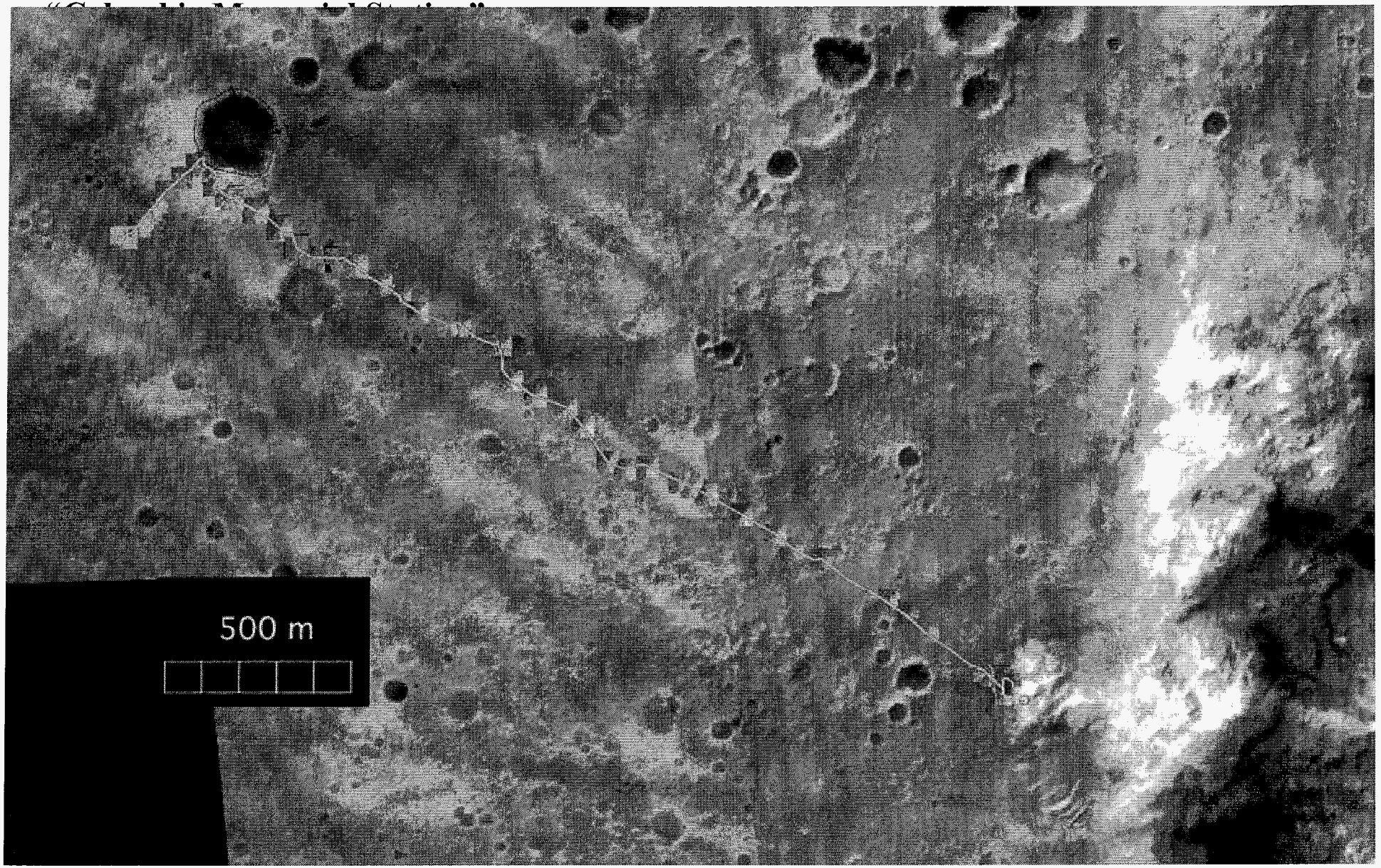


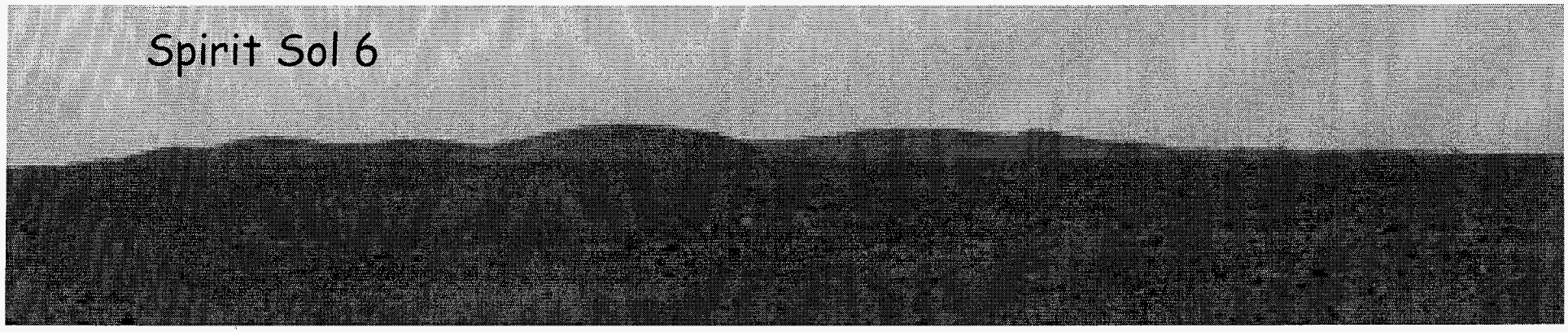


Spirit Landing Site
"Columbia Memorial Station"

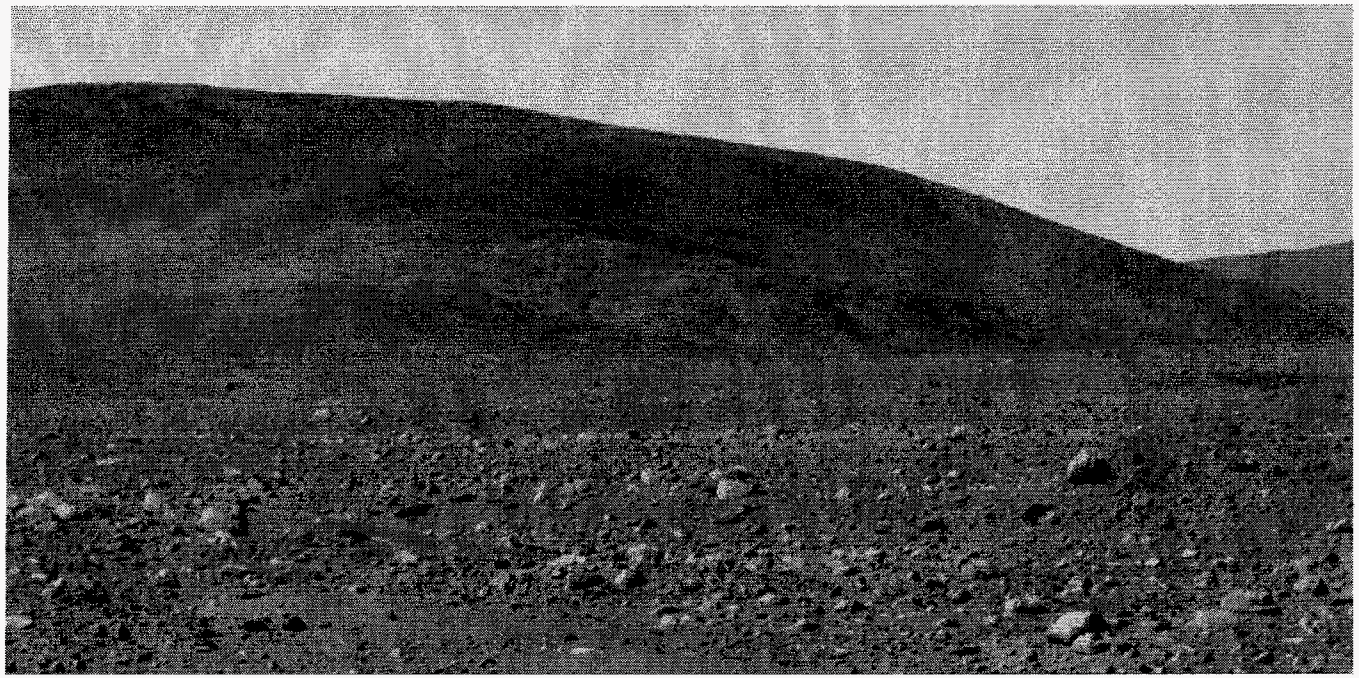


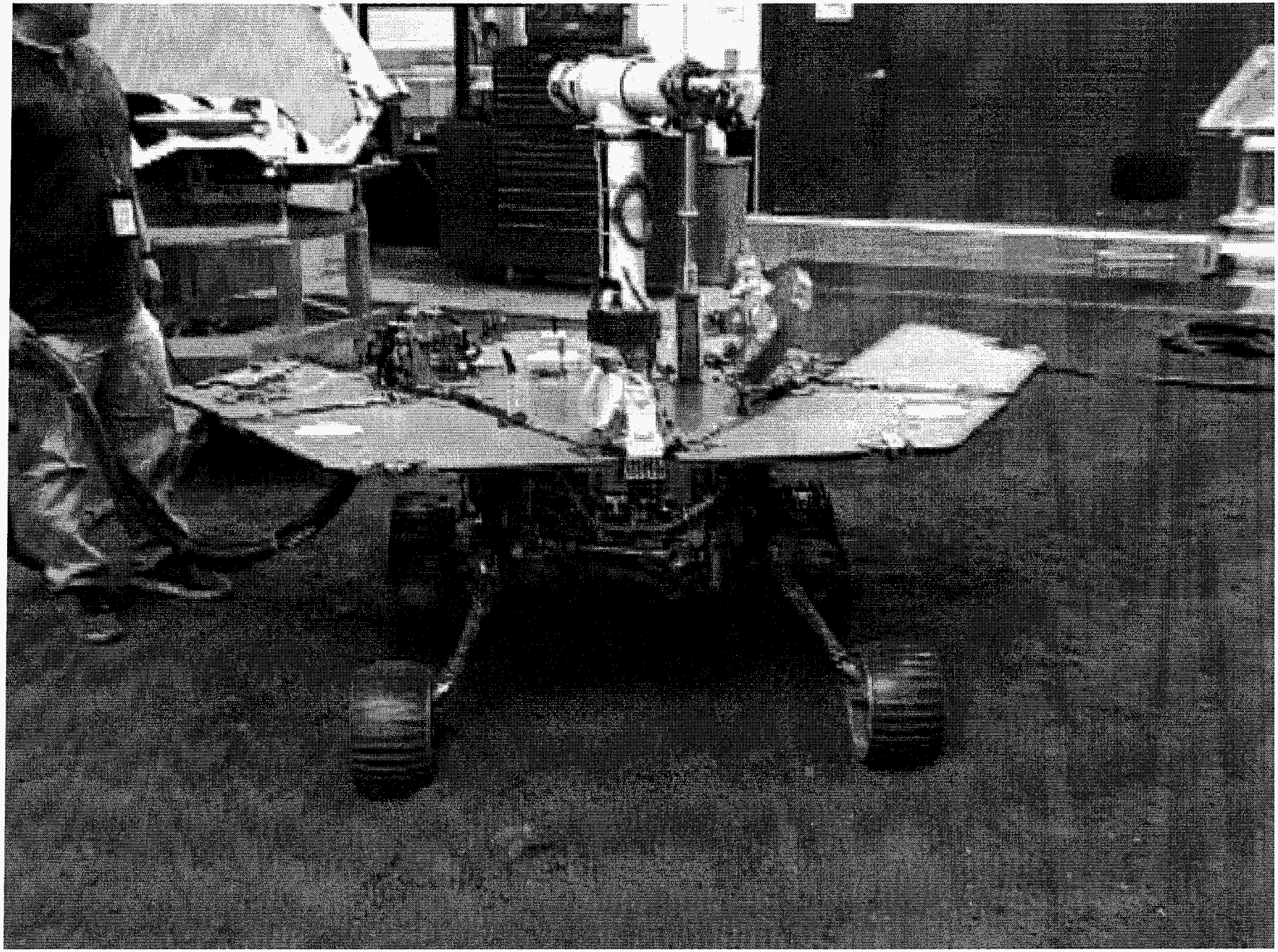
Spirit Landing Site

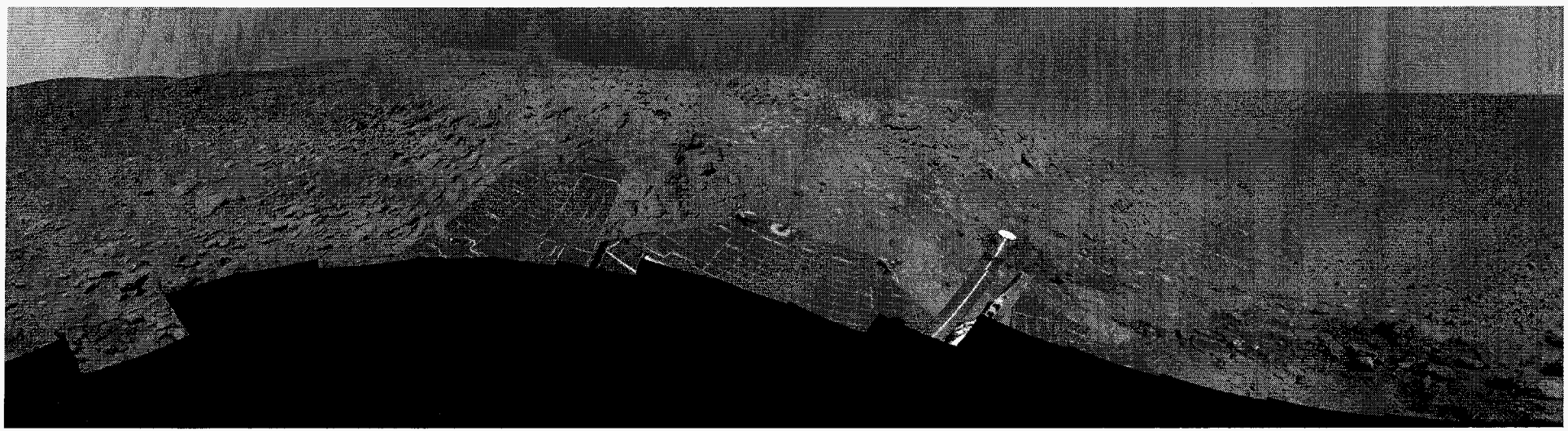




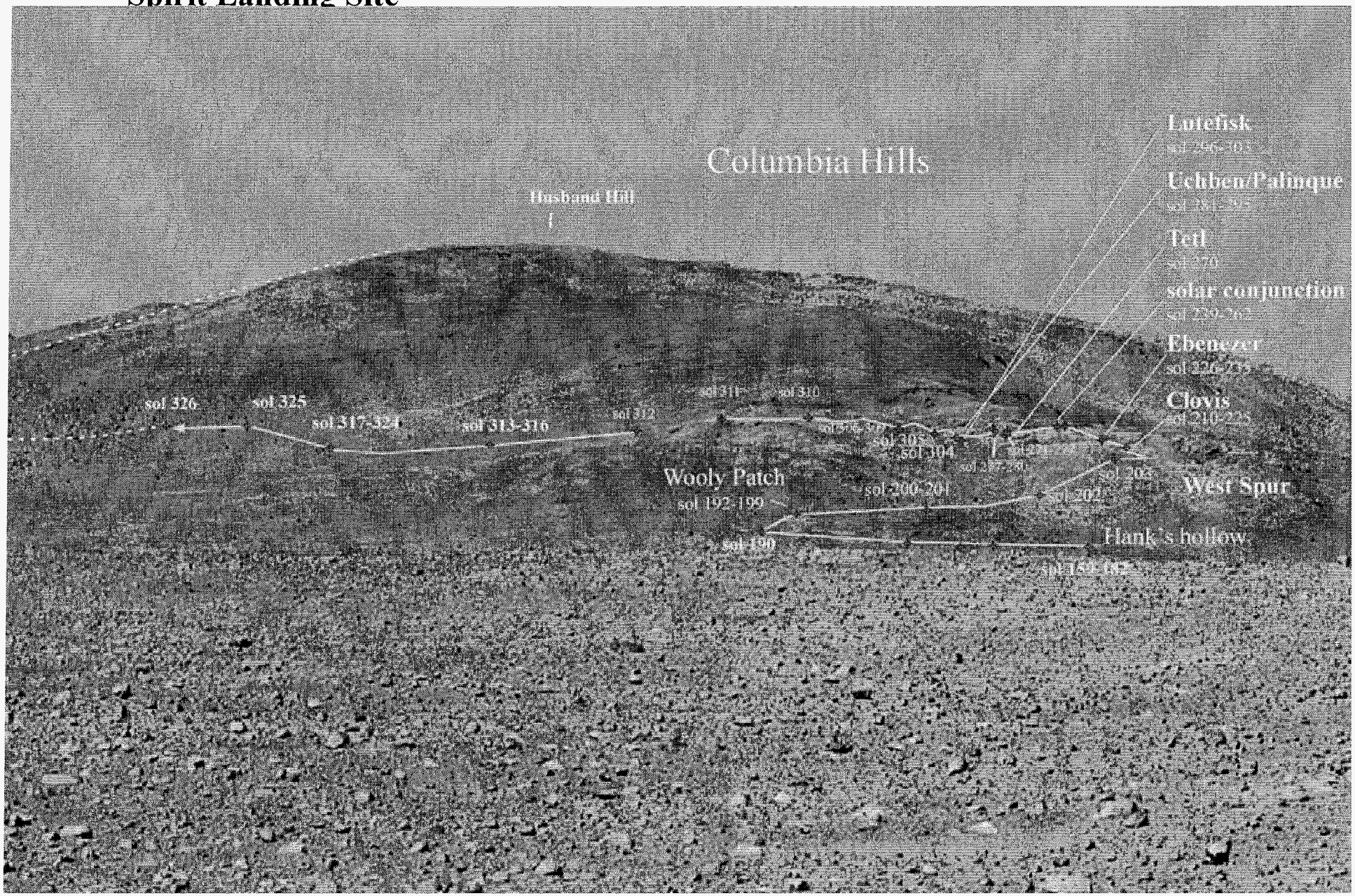
Spirit
Sol 135



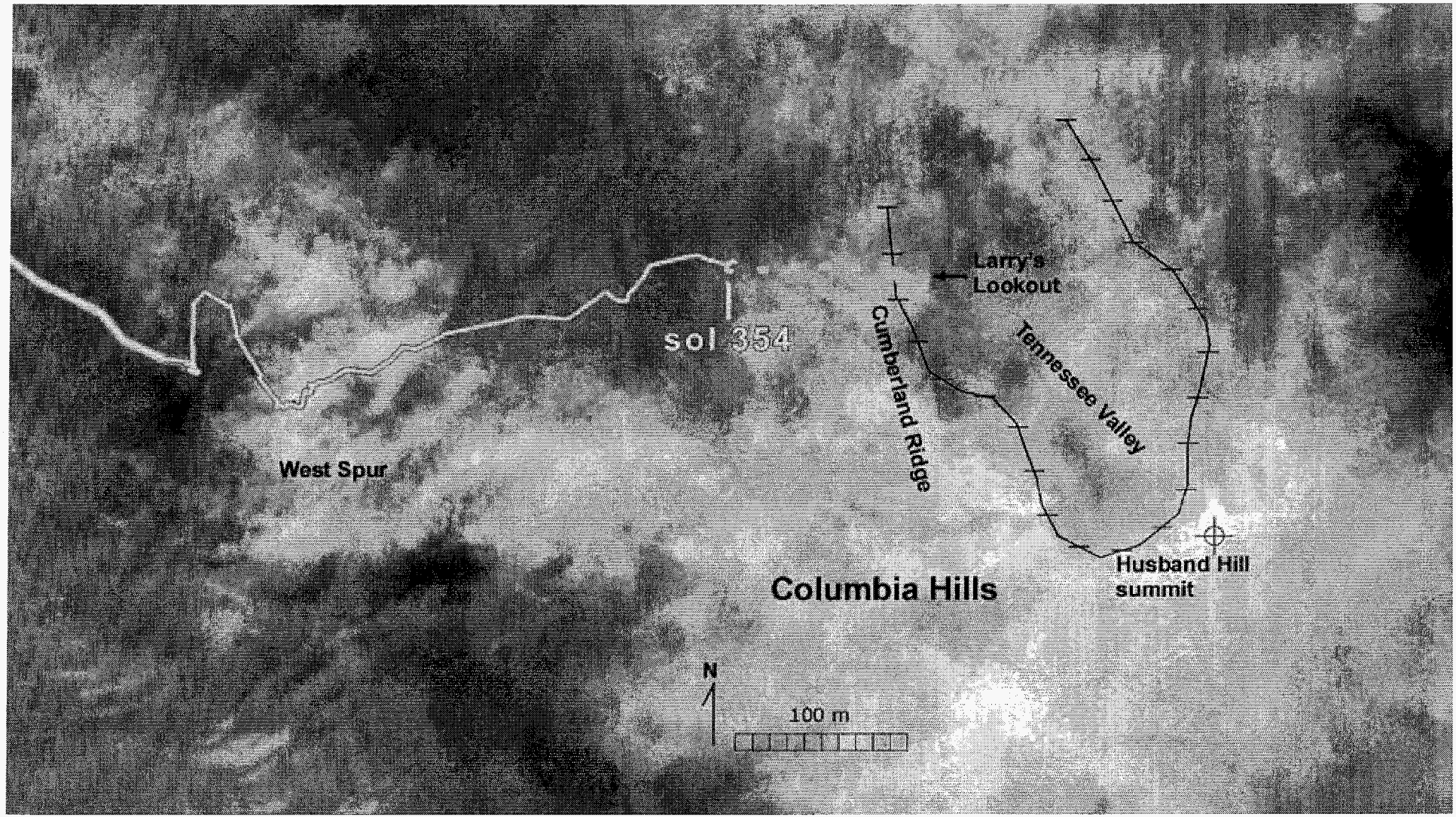




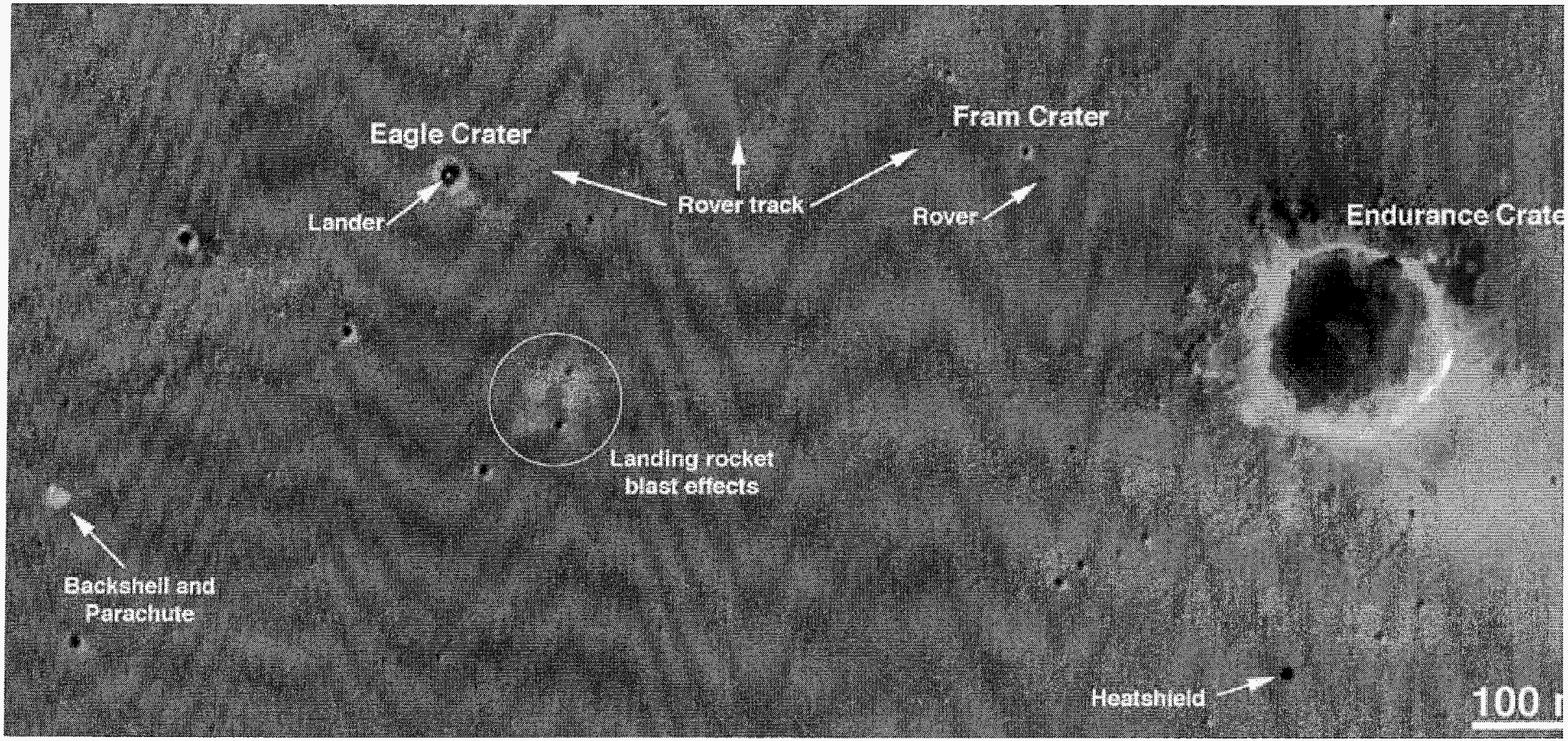
Spirit Landing Site

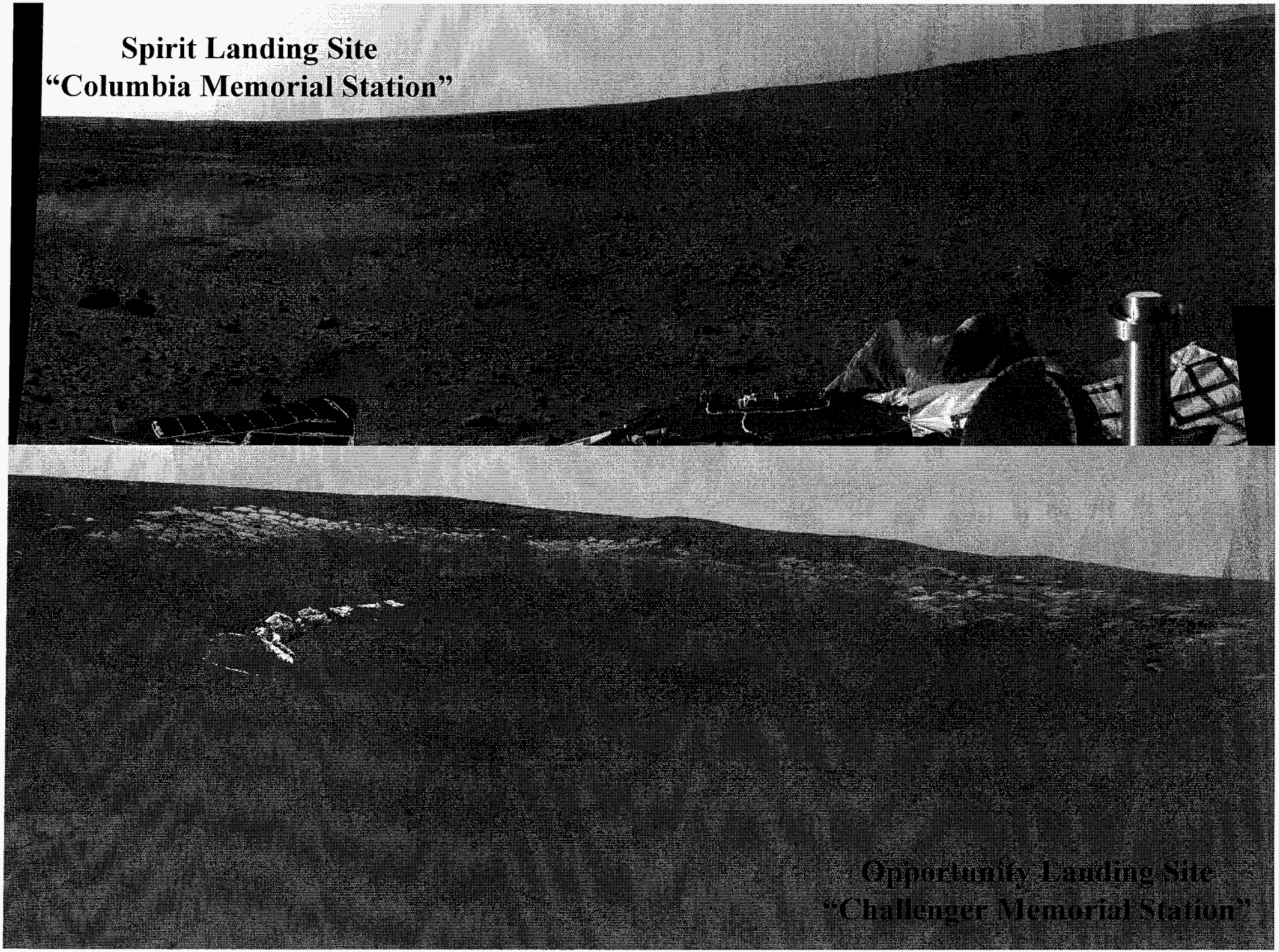


Spirit Landing Site
"Columbia Memorial Station"



Spirit Landing Site
"Columbia Memorial Station"




Spirit Landing Site
"Columbia Memorial Station"
Opportunity Landing Site
"Challenger Memorial Station"

ONE YEAR
ON MARS
MARS EXPLORATION ROVERS

View of Earth from Mars

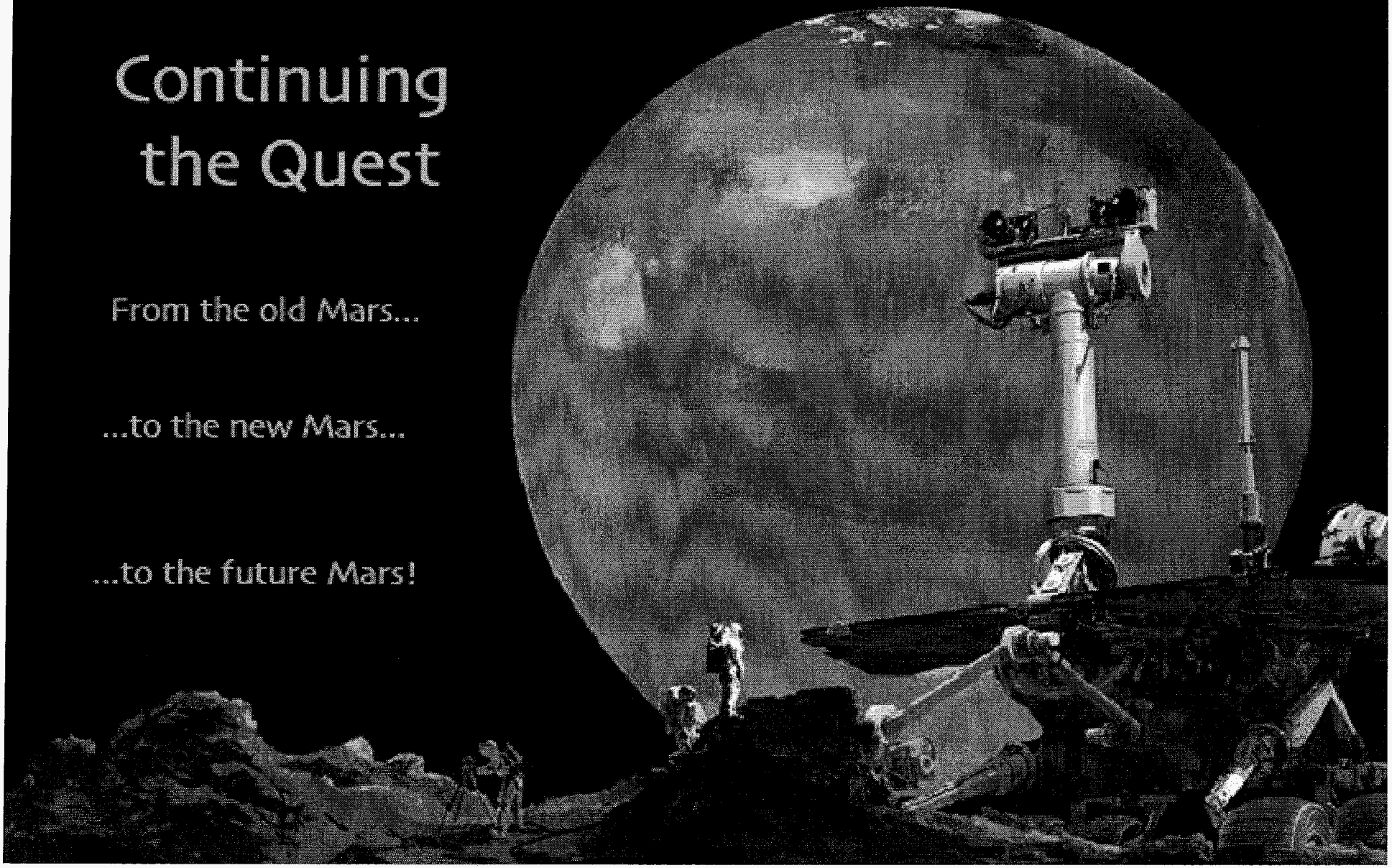
MARS EXPLORATION ROVERS

Continuing the Quest

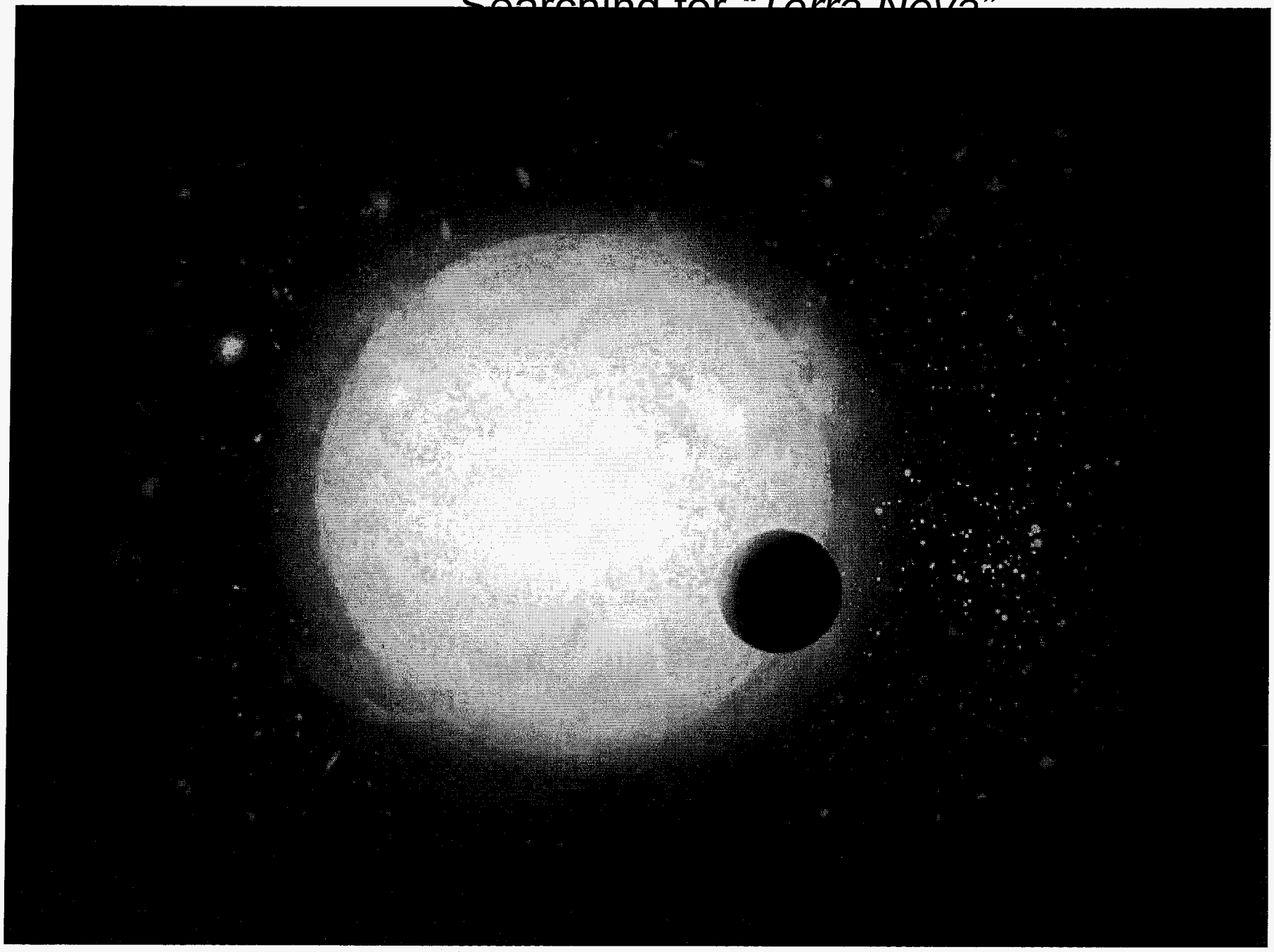
From the old Mars...

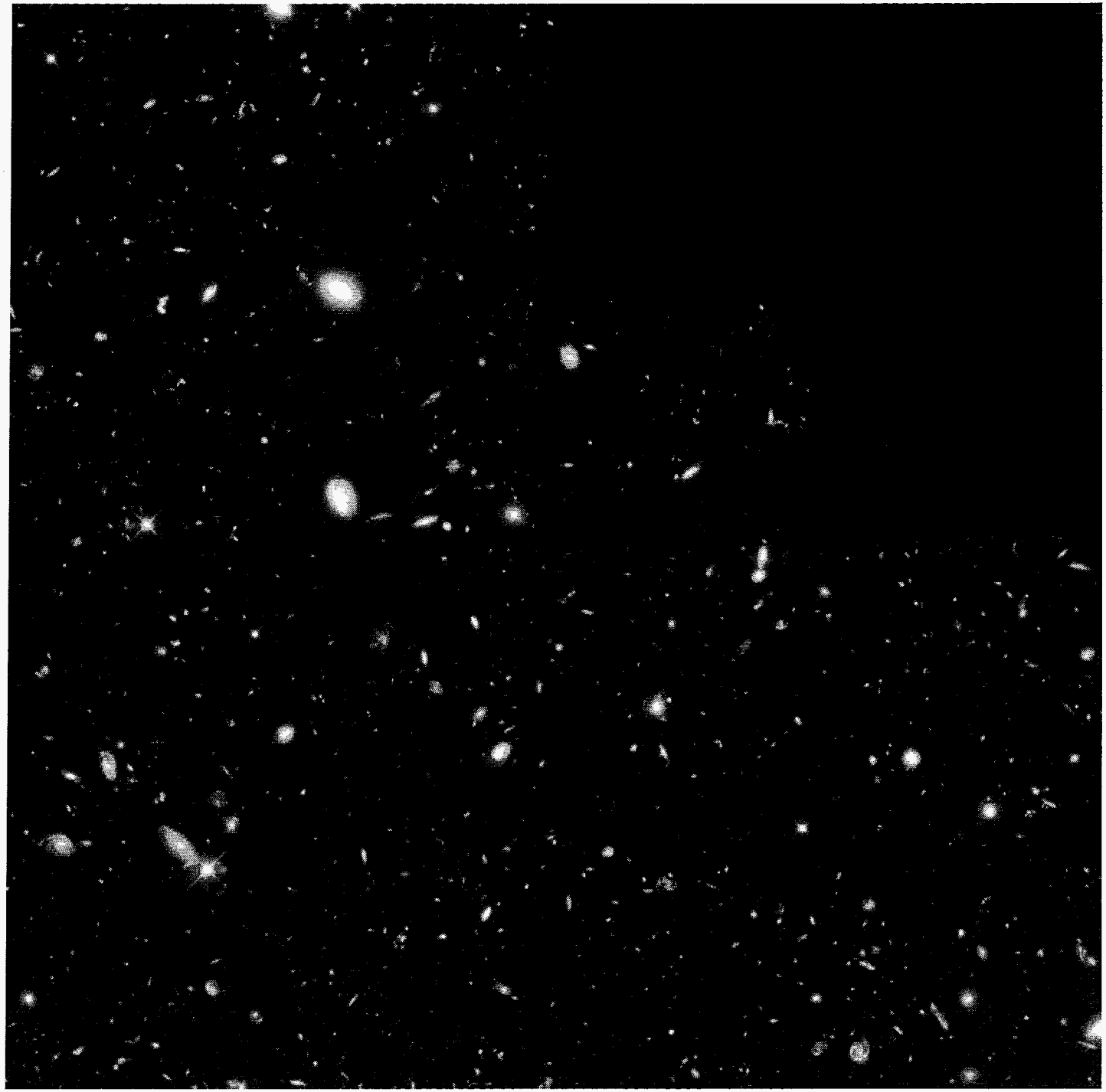
...to the new Mars...

...to the future Mars!



Searching for "*Terra Nova*"





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