MSC-05894

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 16 SCIENCE HANDBOOK

REVISION

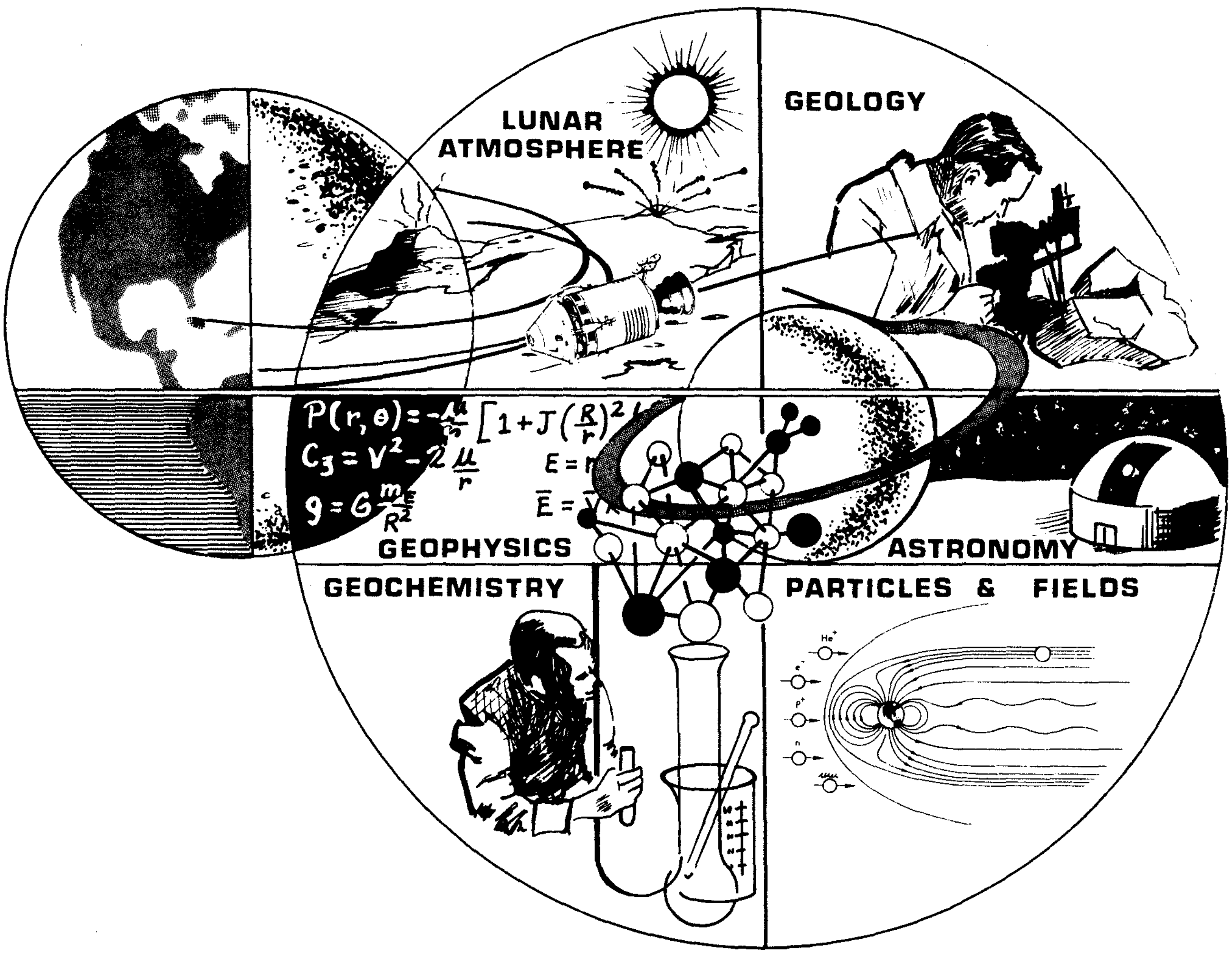
APRIL 7, 1972

SCIENCE MISSIONS SUPPORT DIVISION
SCIENCE AND APPLICATIONS DIRECTORATE
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 16

SCIENCE HANDBOOK



Prepared by TRW Systems

for

SCIENCE MISSIONS SUPPORT DIVISION
SCIENCE AND APPLICATIONS DIRECTORATE
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

INTRODUCTION

The purpose of the Apollo 16 Science Handbook is to provide a summary of key mission events and science activities as an overview for management personnel in the Science and Applications Directorate and for members of the scientific community involved in real-time mission support. This handbook is intended only as a source of general information and should not be used for mission planning purposes. Data included are essentially extracts from various MSC-controlled documents such as the Apollo 16 Mission Requirements Document, Apollo 16 Flight Plan, Apollo 16 Lunar Surface Procedures, and Apollo 16 Mission Rules. In case of data conflicts, the controlled documents take precedence.

The Apollo 16 Science Handbook is divided into four sections: Section I, Mission Science Objectives; Section II, Descartes Summary Data; Section III, Mission Science Profile; and Section IV, Contingency Planning Data. Three appendixes are also included: Appendix A, Summaries for Lunar Surface Experiments; Appendix B, Summaries for Lunar Orbital Experiments/Detailed Objectives; and Appendix C, Map Data Package.

Some of the data presented in this handbook may be outdated since the documents from which these data were obtained are undergoing change at this time. However, change pages will be issued as necessary to assure compatibility between this and other mission documents. Comments concerning this handbook should be directed to the Apollo Missions Science Manager, Mr. R. R. Baldwin/TD5, telephone (713) 483-5851.

CONTENTS

CONTENTS (Continued)

Page

APPENDIXES

ILLUSTRATIONS

ILLUSTRATIONS (Continued)

TABLES

SECTION I

MISSION SCIENCE OBJECTIVES

1.1 PRIMARY SCIENCE OBJECTIVES

Primary science objectives assigned to the Apollo 16 mission by the Office of Manned Space Flight are as follows:

a) Perform selenological inspection, survey, and sampling of materials and surface features in a preselected area of the Descartes region.

b) Emplace and activate surface experiments.

c) Conduct in-flight experiments and photographic tasks from lunar orbit.

1.2 ASSIGNED EXPERIMENTS/SCIENCE DETAILED OBJECTIVES AND PRIORITIES

Experiments and science detailed experiments assigned to the Apollo 16 mission are divided into two groups: lunar surface group and lunar orbital group. The experiments (identified by the letter "S" and three numerical digits) and detailed objectives in each group are listed below in descending order of priority.

LUNAR SURFACE GROUP

Title	Priority
Documented Sample Collection at highest priority traverse station*	1
Apollo 16 ALSEP	
• Heat Flow (S-037)	2
• Lunar Surface Magnetometer (S-034)	3
• Passive Seismic (S-031)	4
• Active Seismic (S-033)	5
Drill Core Sample Collection*	6
Lunar Geology Investigation (S-059)	7
Far UV Camera/Spectroscope (S-201)	8
Solar Wind Composition (S-080)	9
Soil Mechanics (S-200)	10
Portable Magnetometer (S-198)	11
Cosmic Ray Detector (Sheets) (S-152)	12

*Part of Lunar Geology Investigation Experiment (S-059)

LUNAR ORBITAL GROUP

Title	Priority
Gamma-Ray Spectrometer (S-160)	1
X-Ray Fluorescence (S-161)	2
SM Orbital Photographic Tasks	3
Subsatellite: • S-Band Transponder (S-164) • Particle Shadows/Boundary Layer (S-173) • Magnetometer (S-174)	4
S-Band Transponder (CSM/LM) (S-164)	5
Alpha Particle Spectrometer (S-162)	6
Mass Spectrometer (S-165)	7
UV Photography-Earth and Moon (S-177)	8
Gegenschein From Lunar Orbit (S-178)	9
CM Photographic Tasks	10
Visual Observations from Lunar Orbit	11
Bistatic Radar (S-170)	12

1.3 PURPOSE OF LUNAR SURFACE EXPERIMENTS

The basic purposes of the experiments and associated equipment in the lunar surface group are presented below. Physical features are illustrated in Figures 1-1 through 1-9. Appendix A contains a summary sheet for each experiment; each sheet identifies the cognizant Principal Investigator, briefly describes the experiment, and discusses related experiments and missions.

a) Lunar Roving Vehicle (LRV) (Figure 1-1). This battery-powered vehicle is capable of transporting a payload of about 1088 pounds (crew, crew systems, equipment, and samples) over the lunar surface at a maximum speed of 12 kilometers per hour.

b) Lunar Geology Investigation (Figure 1-2). Provides documented lunar geological features and lunar soil/rock samples for use in studies to obtain a better understanding of the Descartes highlands area and of the processes which have modified the highlands surface.

c) Apollo Lunar Surface Experiments Package (ALSEP). The deployment configuration of the Apollo 16 ALSEP is shown in Figure 1-3. This package comprises the central station, radioisotope thermoelectric generator (RTG), and four experiments discussed below:

(1) Central Station (Figure 1-3/A). Provides power, command, thermal, control, and telemetry data interfaces between the RTG/ALSEP experiments and the earth.

(2) Radioisotope Thermoelectric Generator (RTG) (Figure 1-3/B). Heated by a radioisotope fuel capsule, this unit generates the electrical power required for operation of the central station and four experiments.

(3) Heat Flow Experiment (S-037) (Figure 1-3/C). Measures temperatures of the lunar surface and subsurface to determine the rate of heat loss from the lunar interior.

(4) Lunar Surface Magnetometer (S-034) (Figure 1-3/D). Measures the lunar surface magnetic field vector and its temporal variations to determine the magnetic and electrical properties of the moon.

(5) Passive Seismic (S-031) (Figure 1-3/E). Measures seismic signals from all external and internal sources of seismic energy released on and within the moon. These data will be used to determine the internal structure of the moon, the rate of energy release, and the numbers and masses of meteoroids impacting the lunar surface.

(6) Active Seismic (S-033) (Figure 1-3/F). Acquires data to determine the physical properties of lunar surface and subsurface materials. Both naturally occurring and artificially produced seismic waves are monitored. Artificial seismic waves will be produced by thumper charges and explosive grenade charges fired from a mortar box assembly and by impacts of the S-IVB booster and LM ascent stages.

d) Far UV Camera/Spectroscope (S-201) (Figure 1-4). While on the lunar surface, this instrument obtains photographic imagery and spectroscopic data on celestial objects in the far ultraviolet region, principally at the Lyman-alpha wavelength. These data are used to map the location of interplanetary, interstellar, and intergalactic hydrogen.

e) Solar Wind Composition (S-080) (Figure 1-5). Measures particle entrapment on an aluminum and platinum foil sheet exposed on the lunar surface. These measurements are used to determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind.

f) Soil Mechanics (S-200) (Figure 1-6). Through trench excavations and self-recording penetrometer tests, this experiment provides data on the characteristics and mechanical behavior of the lunar soil at the surface and subsurface, and the variation of these properties in a lateral direction.

g) Portable Magnetometer (S-198) (Figure 1-7). Provides data on intensity and direction of the lunar magnetic field at the landing site and at widely separated points along the traverse.

h) Cosmic Ray Detector (Sheets) (S-152) (Figure 1-8). Measures the charge, mass, and energy spectrum of heavy cosmic ray and solar wind particles in the energy ranges from 0.5 to 10 kiloelectron volts/nucleon and from 0.2 to 200 million electron volts/nucleon; provides calibration data for glass detectors including tektite glass; measures the thermal neutron flux at the lunar surface; and assesses the implantation problem of argon isotope Ar^{40}.

i) Photographic Equipment (Figure 1-9). The 16-mm Data Acquisition Camera, Lunar Surface 16-mm Data Acquisition Camera, 70-mm Hasselblad Electric Data Camera, and 500-mm Camera System (Hasselblad Electric Data Camera especially adapted for use with a 500-mm lens) provide still and sequence photography of crew activities, lunar soil and rock samples, and lunar geographical features. A ground-commanded television assembly provides coverage of the following: general astronaut activities at the LM and during traverses; selected experiment deployment and operation; geological sampling; lunar landscape; liftoff of the LM ascent stage and of the landing site after liftoff; lunar impact of the LM ascent stage; and post-liftoff coverage of the lunar landscape, selected rock fields at varying sun angles, and earth and selected celestial objects.

1.4 PURPOSE OF LUNAR ORBITAL EXPERIMENTS AND PHOTOGRAPHIC DETAILED OBJECTIVES

The basic purposes of the experiments and photographic detailed objectives in the lunar orbital group are presented below. Physical features are illustrated in Figures 1-10 and 1-11, respectively. Appendix B contains summary sheets for each experiment and objective; each sheet identifies the cognizant Principal Investigator, briefly describes the experiment or objective, and discusses related experiments and missions.

a) Gamma-Ray Spectrometer. Provides data to determine the composition of the lunar surface and the degree of chemical differentiation the moon has undergone during its development, and performs gamma-ray astronomy during transearth coast.

b) X-Ray Fluorescence. Measures the instantaneous fluorescent X-ray flux from the lunar surface and monitors the direct solar X-ray flux producing this fluorescence to determine the elemental composition of lunar surface materials, and measures the X-ray flux of selected galactic objects for astronomy investigations.

c) SM Orbital Photographic Tasks. The Panoramic Camera, Mapping/Stellar Camera, and Laser Altimeter are used to accomplish this detailed objective. The purpose of each is as follows:

(1) Panoramic Camera. Provides high-resolution panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface.

(2) Mapping/Stellar Cameras. Provides high-quality metric photographs of the lunar surface and simultaneous photographs of star fields.

(3) Laser Altimeter. Measures slant range to the lunar surface, indirectly providing altitude of the CSM above the lunar surface.

d) Subsatellite. Launched from the SIM bay and operating independently of the CSM, this spacecraft contains the following three experiments:

(1) Particle Shadows/Boundary Layer. Provides data for studies of the physics of solar flares and of the plasmic flow and electric fields associated with the solar wind and magnetotail.

(2) S-Band Transponder. Provides data for studies of the lunar gravitational field.

(3) Magnetometer. Collects data on the electrical and magnetic properties of the moon, the interaction of solar wind plasma with the moon, and the physical processes in the solar wind plasma.

e) S-Band Transponder (CSM/LM). Utilizing the CSM communications system, this experiment obtains S-band Doppler resolver tracking data to determine the distribution of mass along the lunar surface ground tracks.

f) Alpha Particle Spectrometer. Determines the rate of radon emission from the lunar surface for use in constructing a radiation map showing inhomogeneities of the lunar surface.

g) Mass Spectrometer. Obtains data on lunar atmosphere composition, locates lunar volcanic areas, and determines amount of contamination in the lunar atmosphere due to spacecraft sources.

h) UV Photography - Earth and Moon. Obtains 70-mm ultraviolet photographs of the earth and moon for use in the study of planetary atmospheres and for the investigation of short wavelength fluorescence from the lunar surface.

i) Gegenschein from Lunar Orbit. Obtains 35-mm photographs of the gegenschein and Moulton point regions to determine if, and to what extent, reflection from dust particles at the Moulton point contributes to the gegenschein.

j) CM Photographic Tasks (Figure 1-11). The 16-mm Data Acquisition Camera, 70-mm Hasselblad Electric Camera, 35-mm Nikon Camera, and associated equipment are used in lunar orbit and during trans-earth coast to accomplish these tasks. This equipment is used to obtain photographs of the following: diffuse galactic light of selected celestial subjects, solar corona, zodiacal light, specific segments of the lunar surface in earthshine and in low light levels near the terminator, and lunar surface areas of prime scientific interest.

k) Visual Observations From Lunar Orbit. Visual observations by crew members of particular lunar surface features and processes to complement photographic and other remote-sensed data.

l) Bistatic Radar. Provides at earth stations S-band and VHF communications downlink radar data reflected from the lunar crust. These data allow determination of geological structure and electrical characteristics of the lunar crust.

1.5 PASSIVE EXPERIMENTS AND INFLIGHT DEMONSTRATIONS

Three passive experiments and one inflight demonstration will be conducted during the Apollo 16 Mission. Passive experiments require no crew time and have no impact on the mission timeline. The experiments are (a) Bone Mineral Measurement, (b) Biostack, and (c) Apollo Window Meteoroid. The inflight demonstration is Fluid Electrophoresis in Space. Basic purposes of the experiments and demonstration are as follows:

a) Bone Mineral Measurement (M-078). Investigates the phenomenon of body structure degradation due to reduced gravity. Of particular interest is the determination of the degree of bone mineral changes which might result from weightlessness and the extent to which the short exposure of 1/6 g on the lunar surface will modify these changes.

b) Biostack (M-211). Investigates the biological effects of individual heavy nuclei of cosmic radiation during space flight. These effects will be determined by flying biological materials interlaced with dosimeters.

c) Apollo Window Meteoroid (S-176). Determines the meteoroid cratering flux for particles responsible for the degradation of surfaces exposed to the space environment.

d) Fluid Electrophoresis in Space. Determines whether the low gravitational levels of space flight will permit marked improvement in the separation and resolution of large dense particles in a liquid.

1.6 RATIONALE FOR EXPERIMENTS/SCIENCE DETAILED OBJECTIVES

Rationale for selection of lunar surface experiments and lunar orbital experiments and science detailed objectives assigned for flight on Apollo 16 are presented in Tables 1-1 and 1-2, respectively. Rationale for passive-type experiments and inflight demonstrations are presented in Table 1-3.

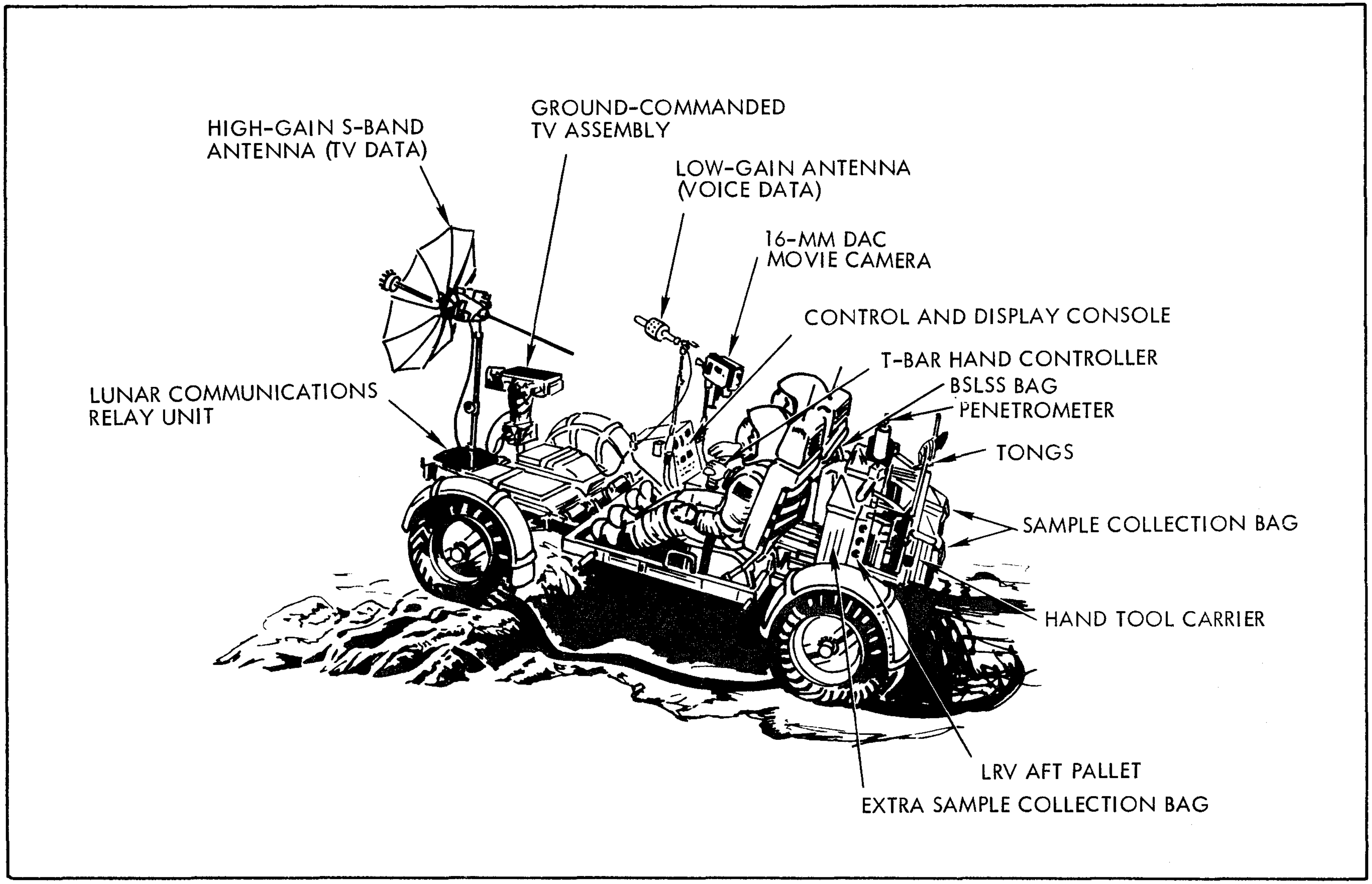


Figure 1-1. Lunar Roving Vehicle (LRV)

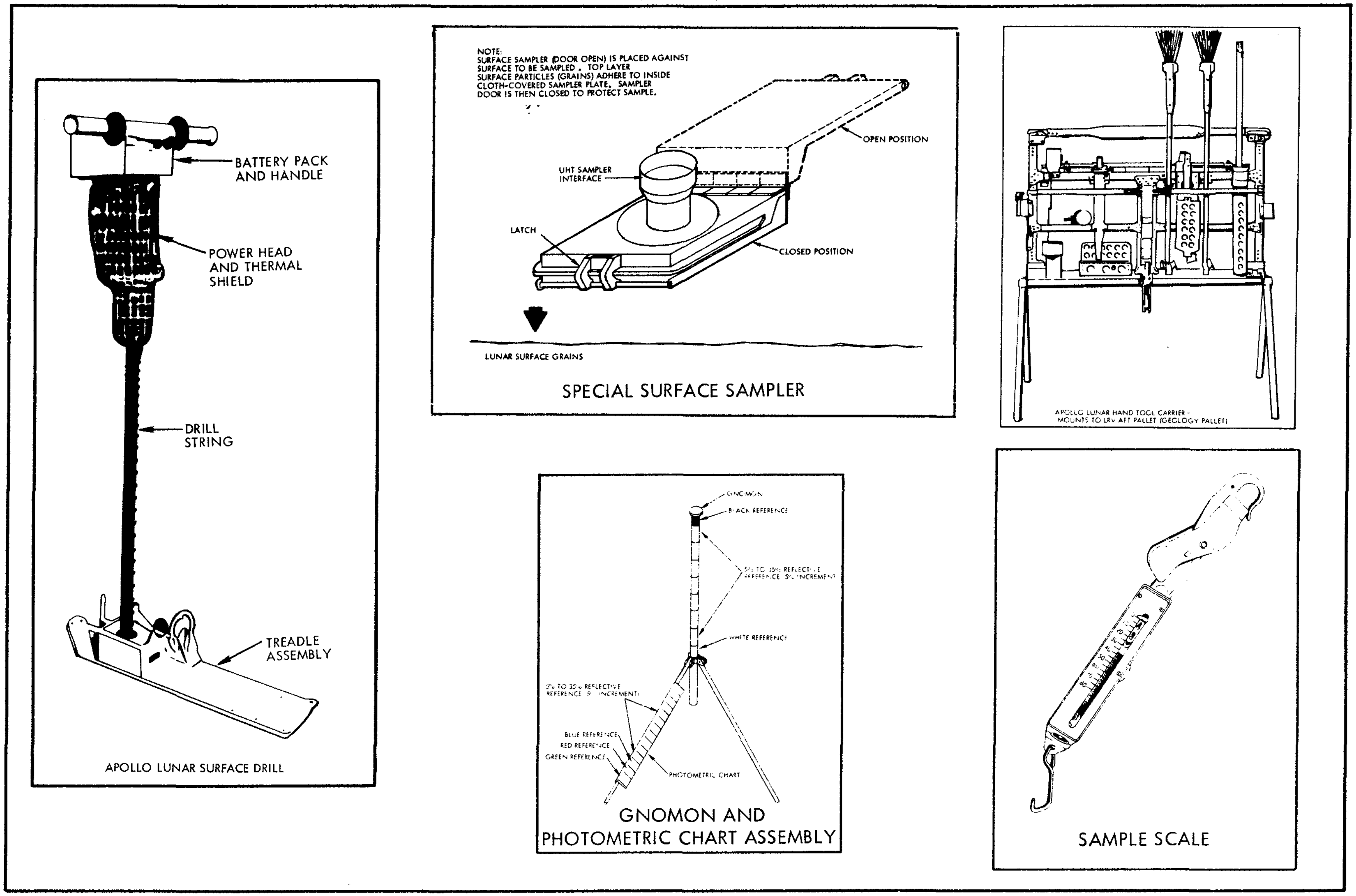


Figure 1-2. Lunar Geology Equipment (Sheet 1 of 4)

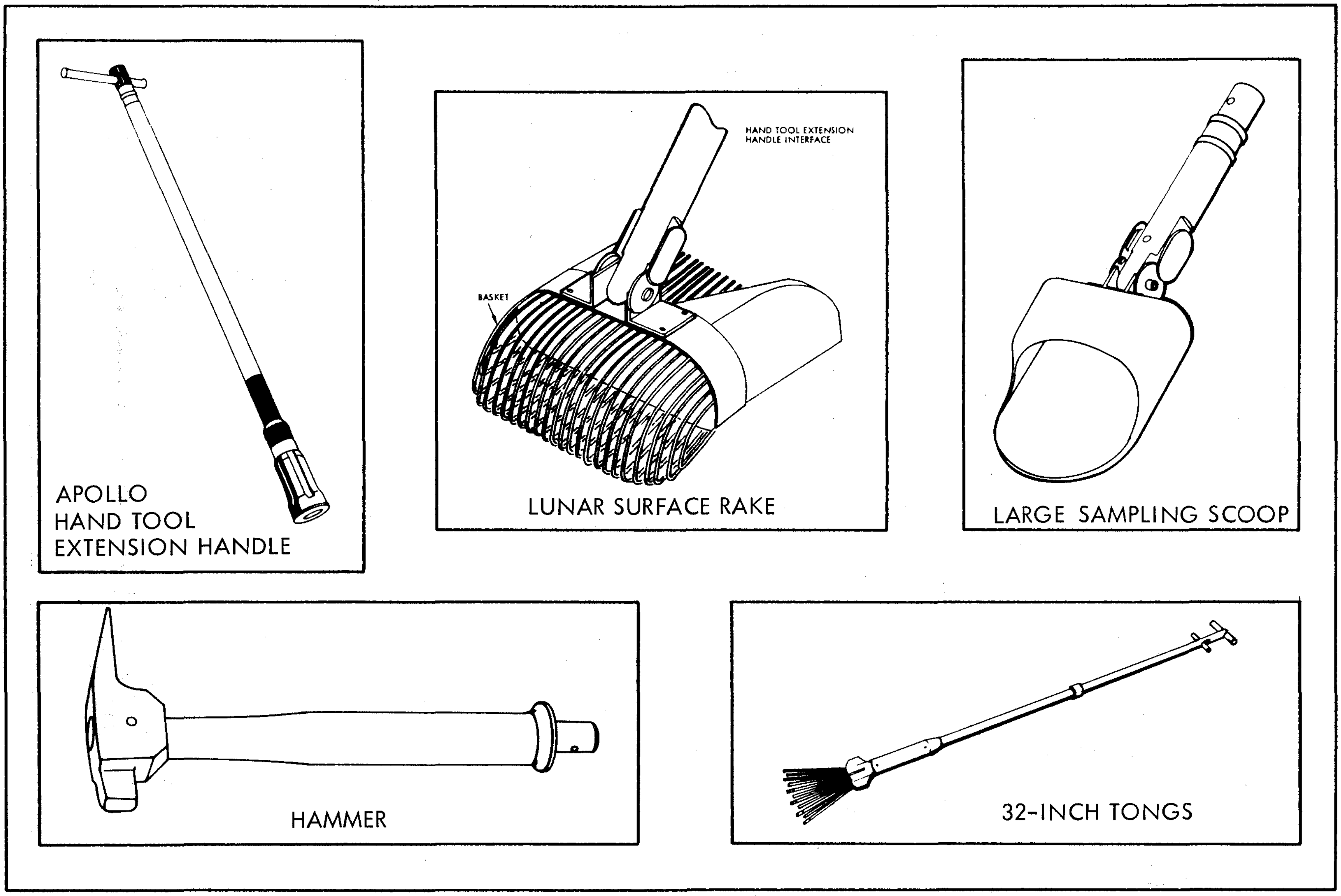


Figure 1-2. Lunar Geology Equipment (Sheet 2 of 4)

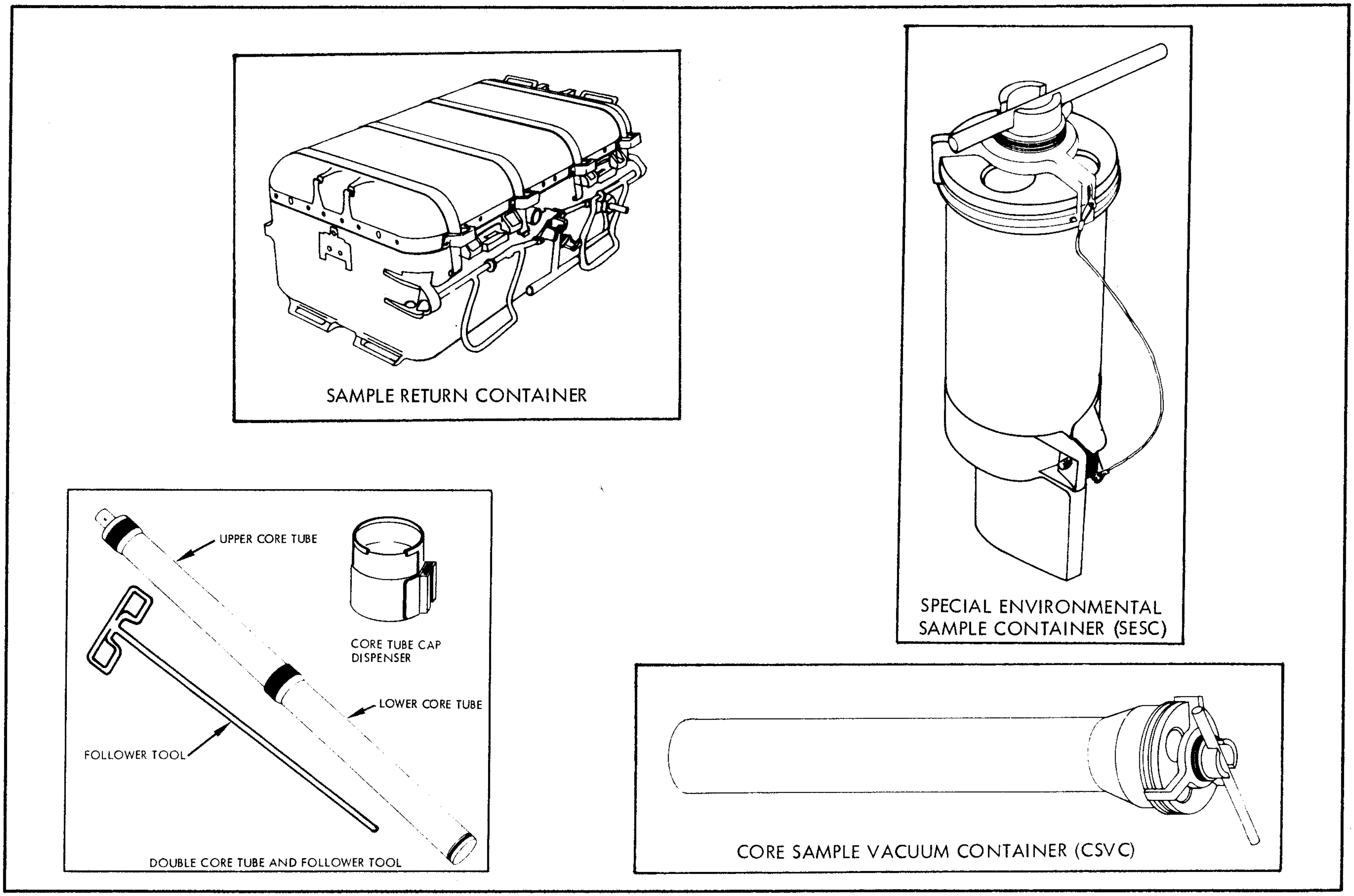


Figure 1-2. Lunar Geology Equipment (Sheet 3 of 4)

Figure 1-2. Lunar Geology Equipment (Sheet 4 of 4)

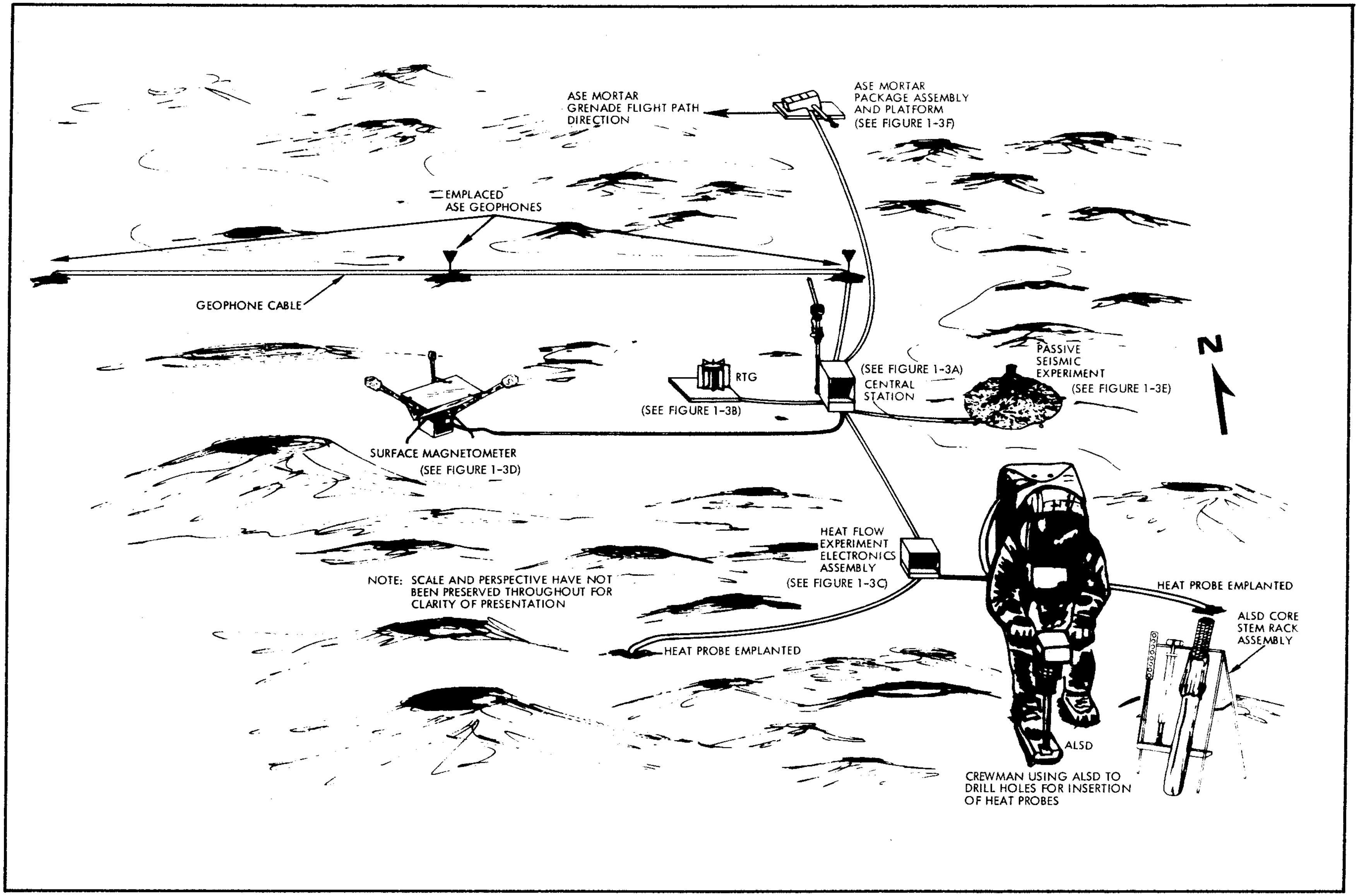
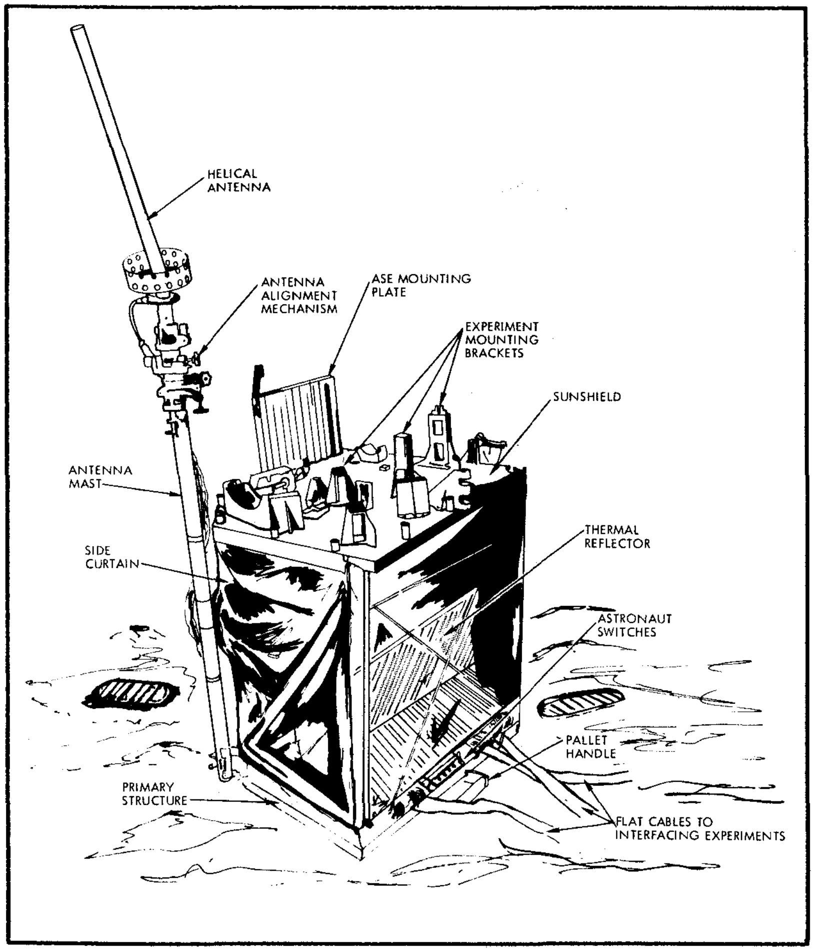
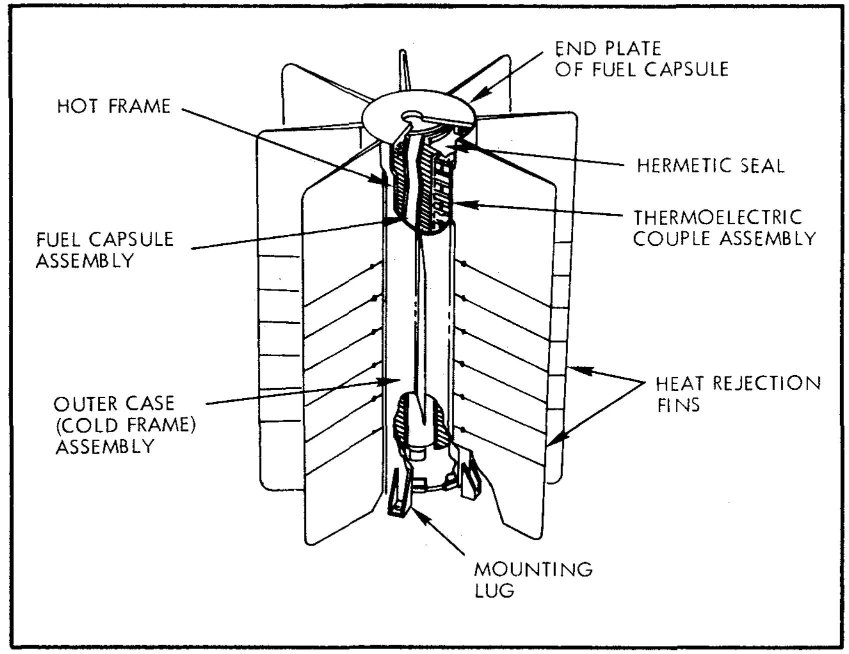


Figure 1-3. Apollo 16 ALSEP Experiments and Equipment (Sheet 1 of 5)

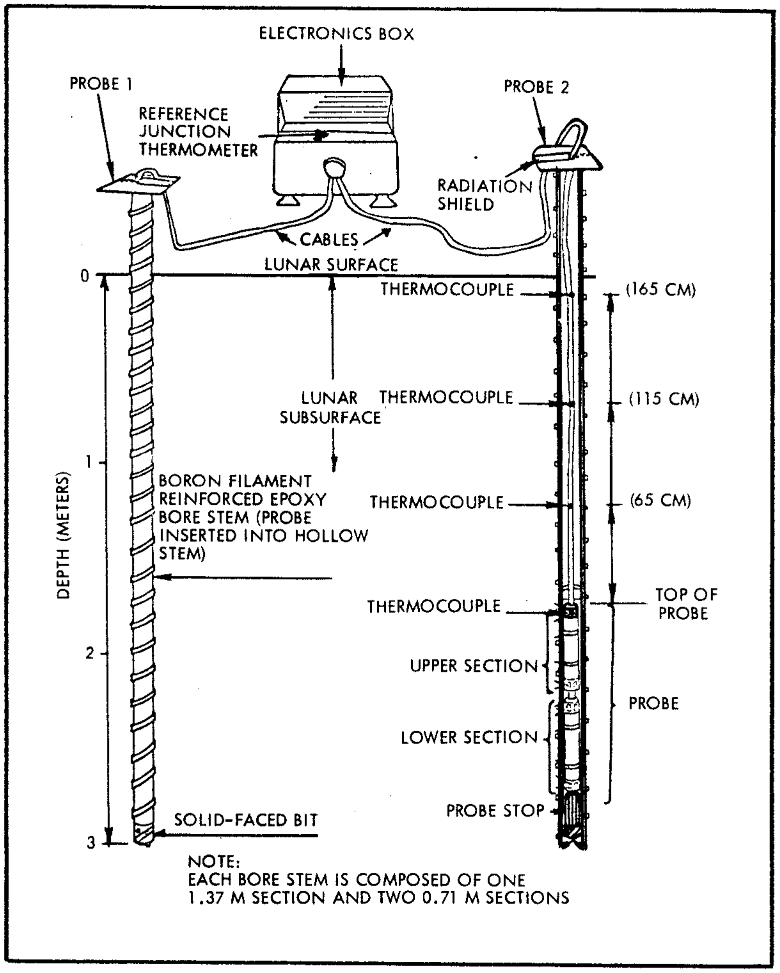


(A) Central Station

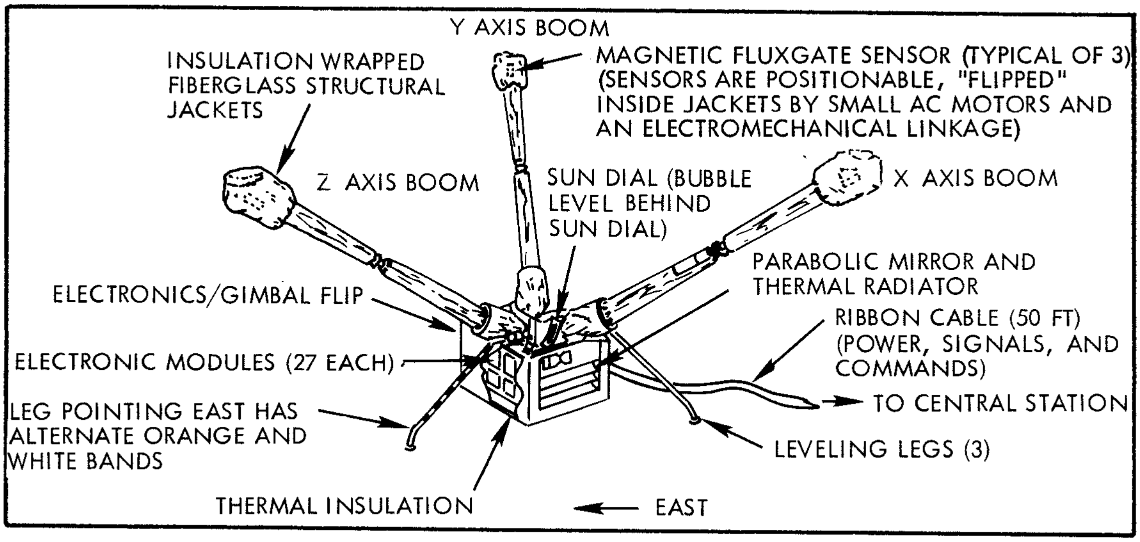


(B) Radioisotope Thermoelectric Generator

Figure 1-3. Apollo 16 ALSEP Experiments and Equipment (Sheet 2 of 5)

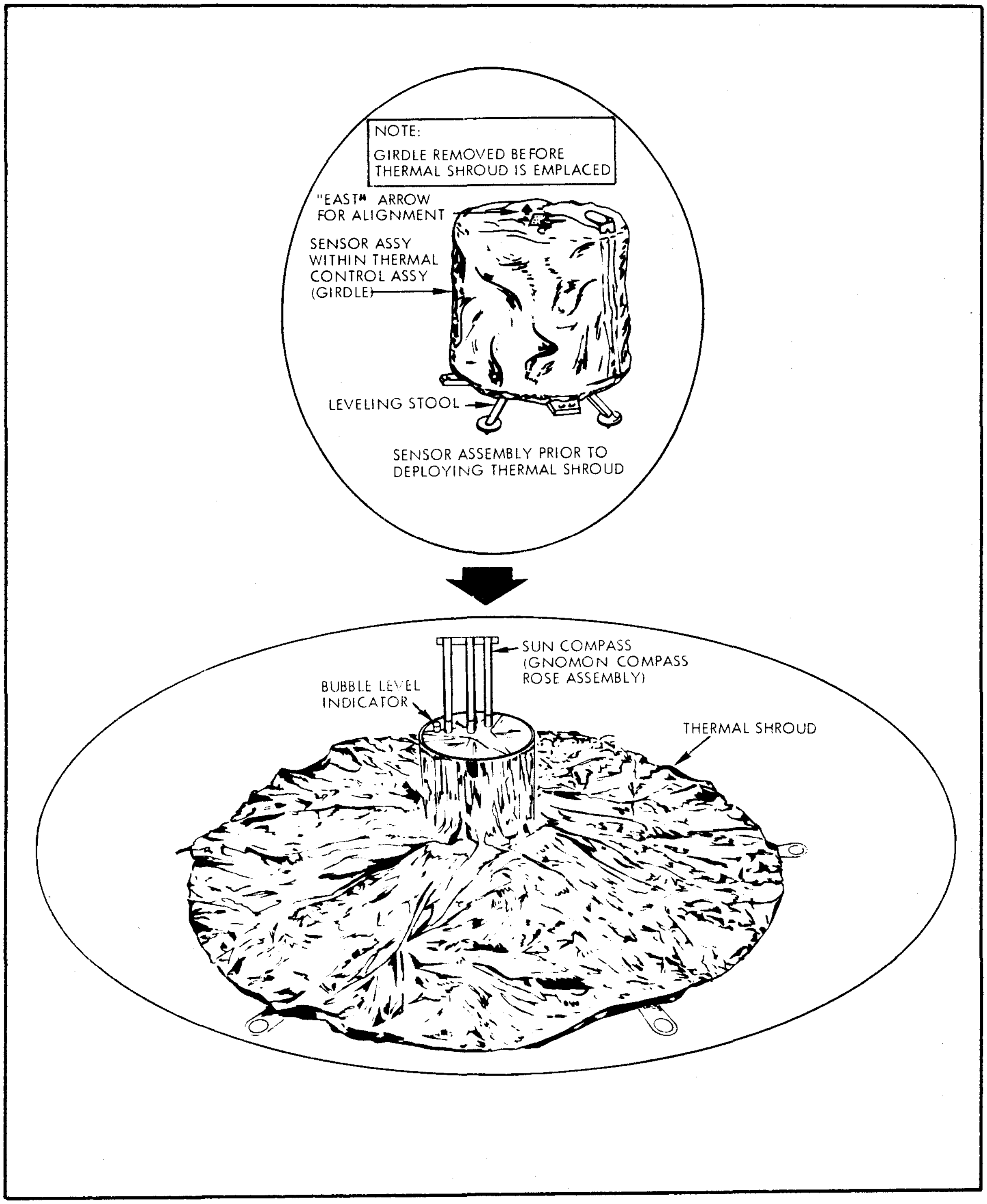


(C) Heat Flow Experiment (S-037)



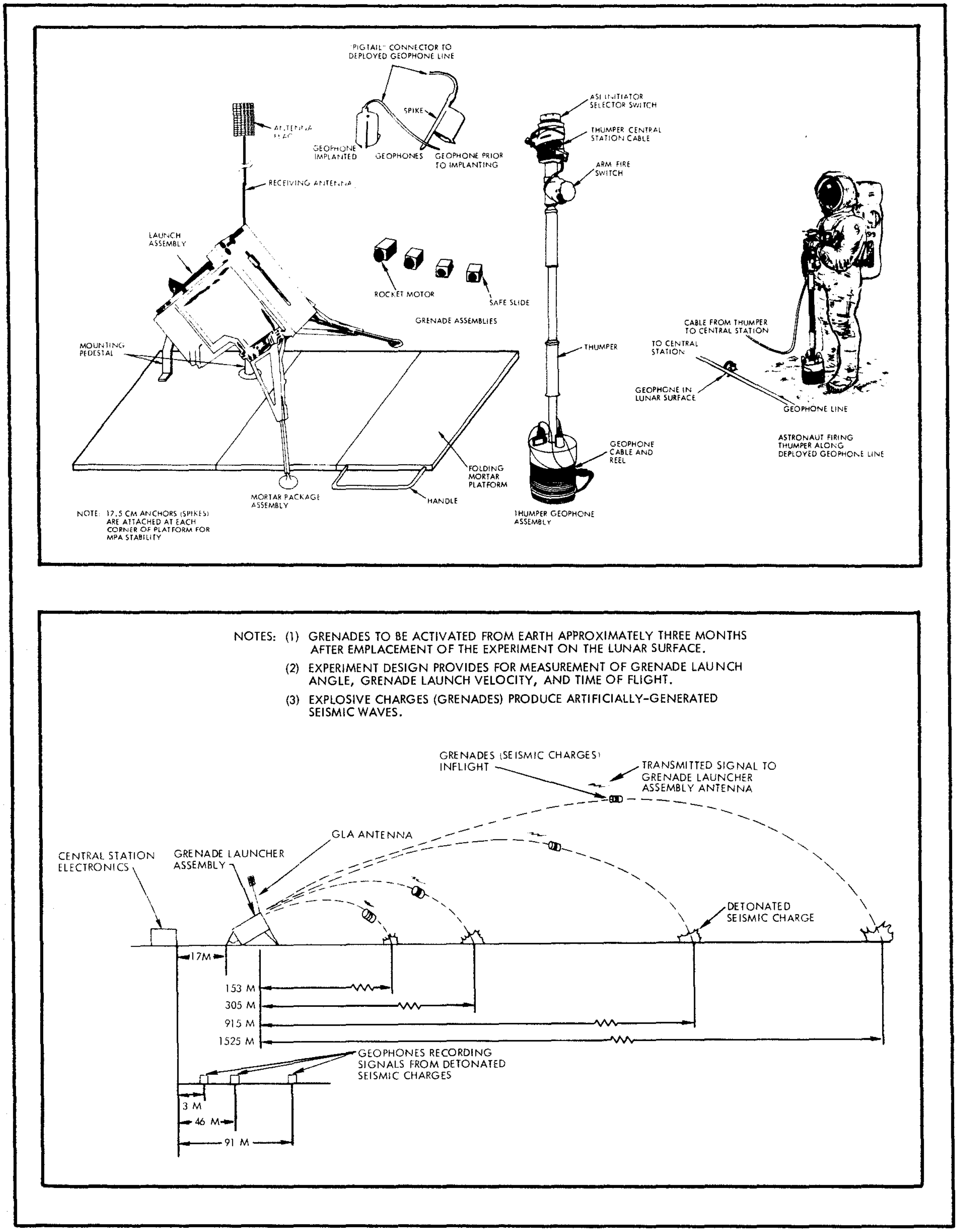
(D) Lunar Surface Magnetometer Experiment (S-034)

Figure 1-3. Apollo 16 ALSEP Experiments and Equipment (Sheet 3 of 5)



(E) Passive Seismic Experiment (S-031)

Figure 1-3. Apollo 16 ALSEP Experiments and Equipment (Sheet 4 of 5)



(F) Active Seismic Experiment (S-033) - Hardware and Grenade Activation

Figure 1-3. Apollo 16 ALSEP Experiments and Equipment (Sheet 5 of 5)

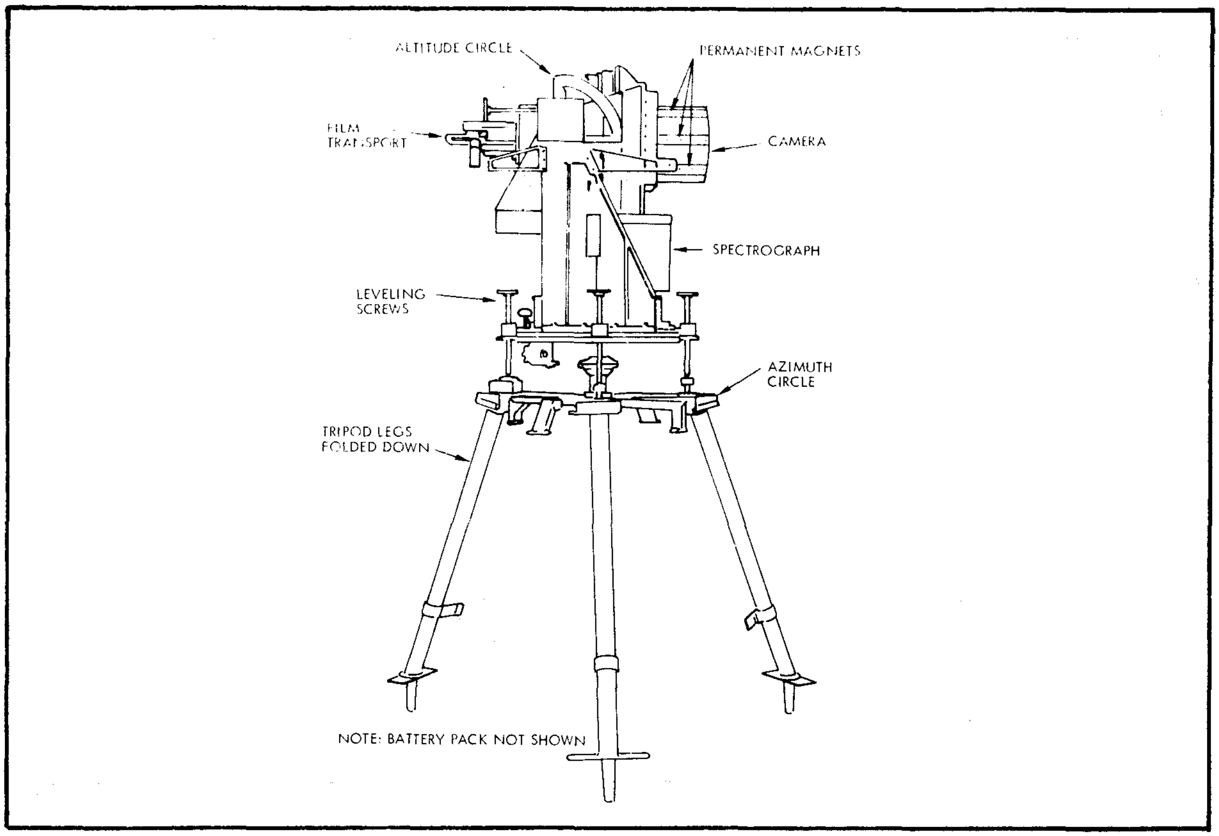


Figure 1-4. Far UV Camera/Spectroscope Experiment (S-201)

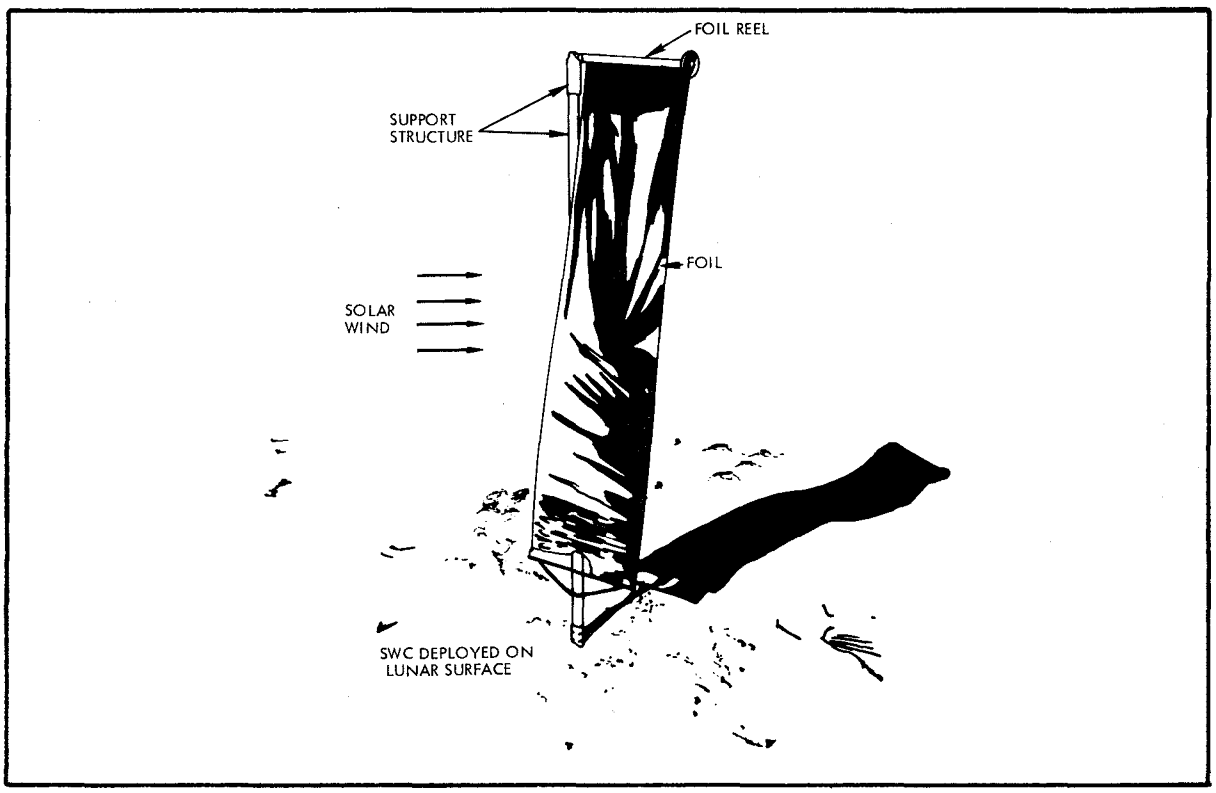


Figure 1-5. Solar Wind Composition Experiment (S-080)

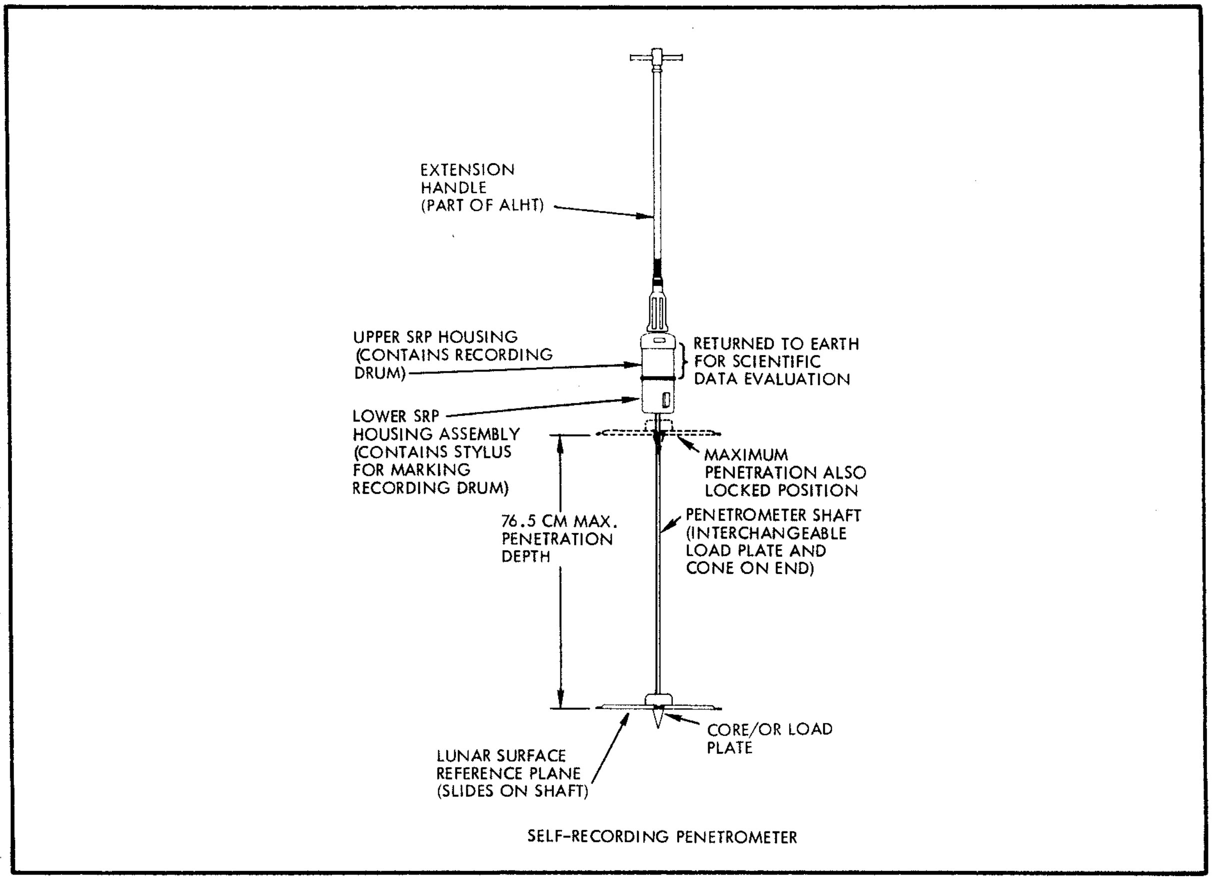


Figure 1-6. Soil Mechanics Experiment (S-200)

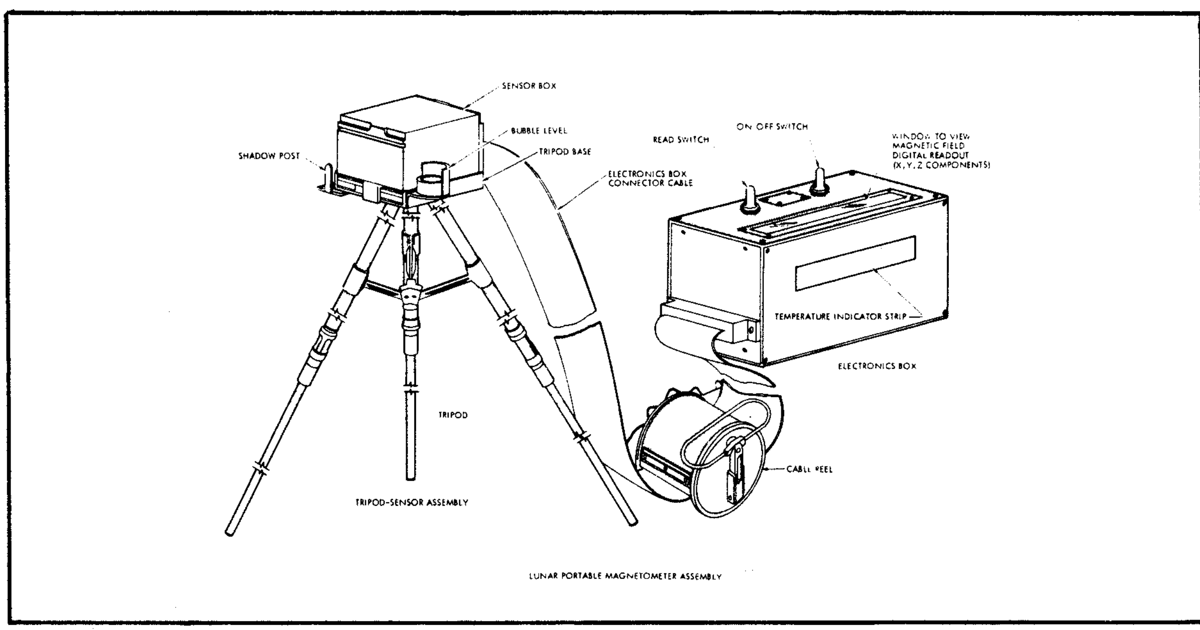


Figure 1-7. Portable Magnetometer Experiment (S-198)

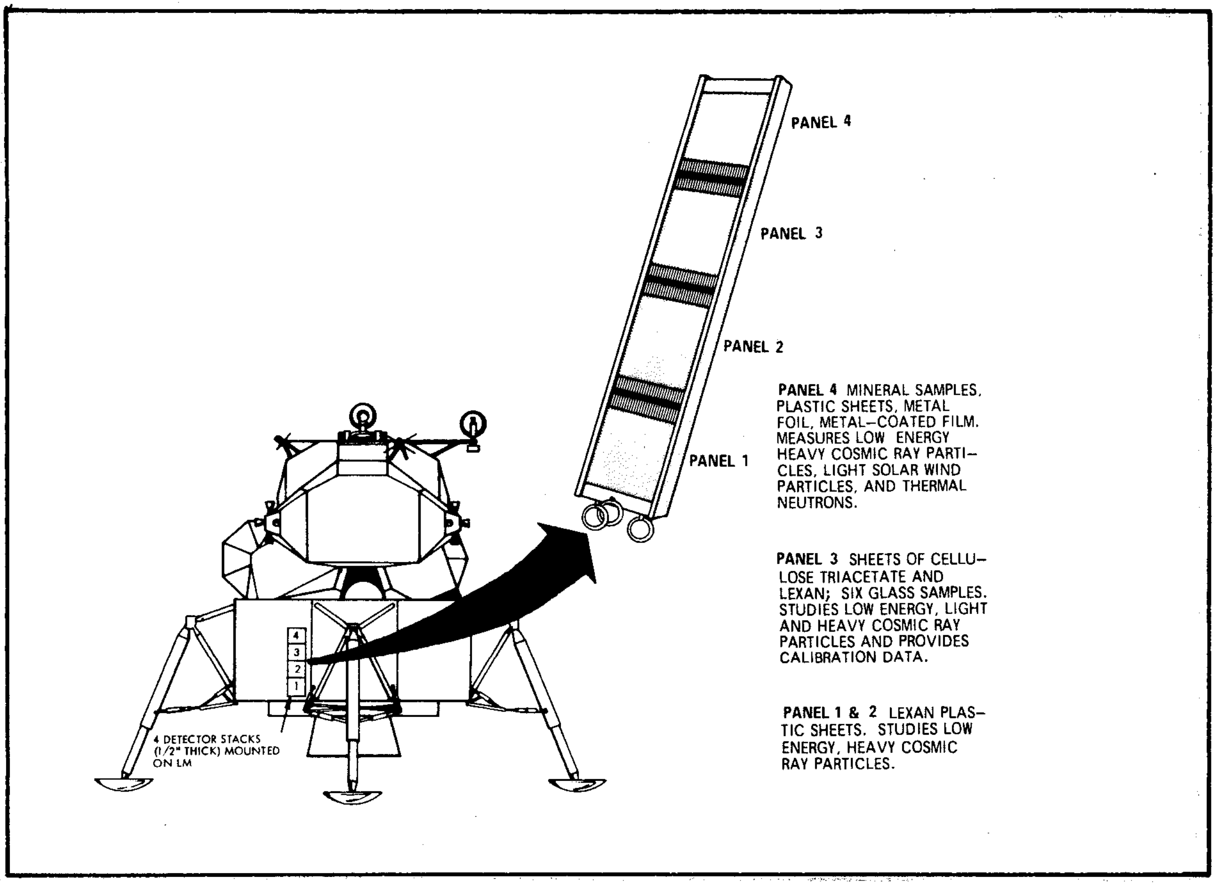


Figure 1-8. Cosmic Ray Detector (Sheets) Experiment (S-152)

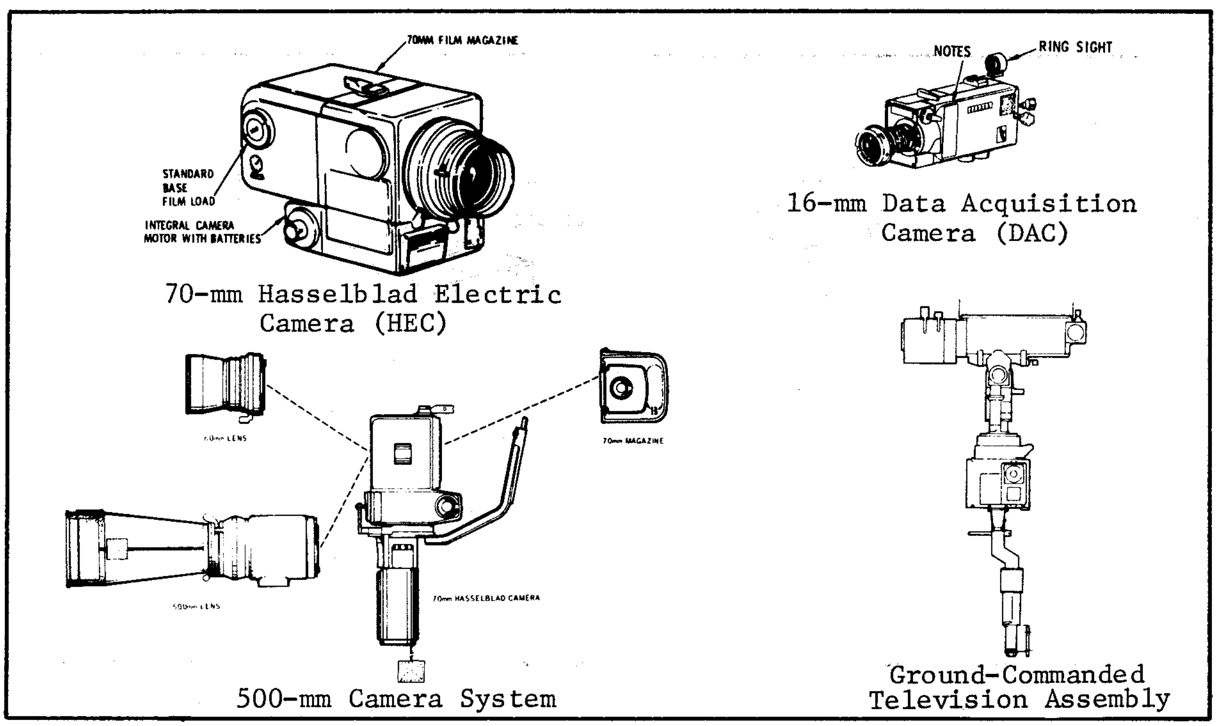


Figure 1-9. Lunar Surface Photographic Equipment

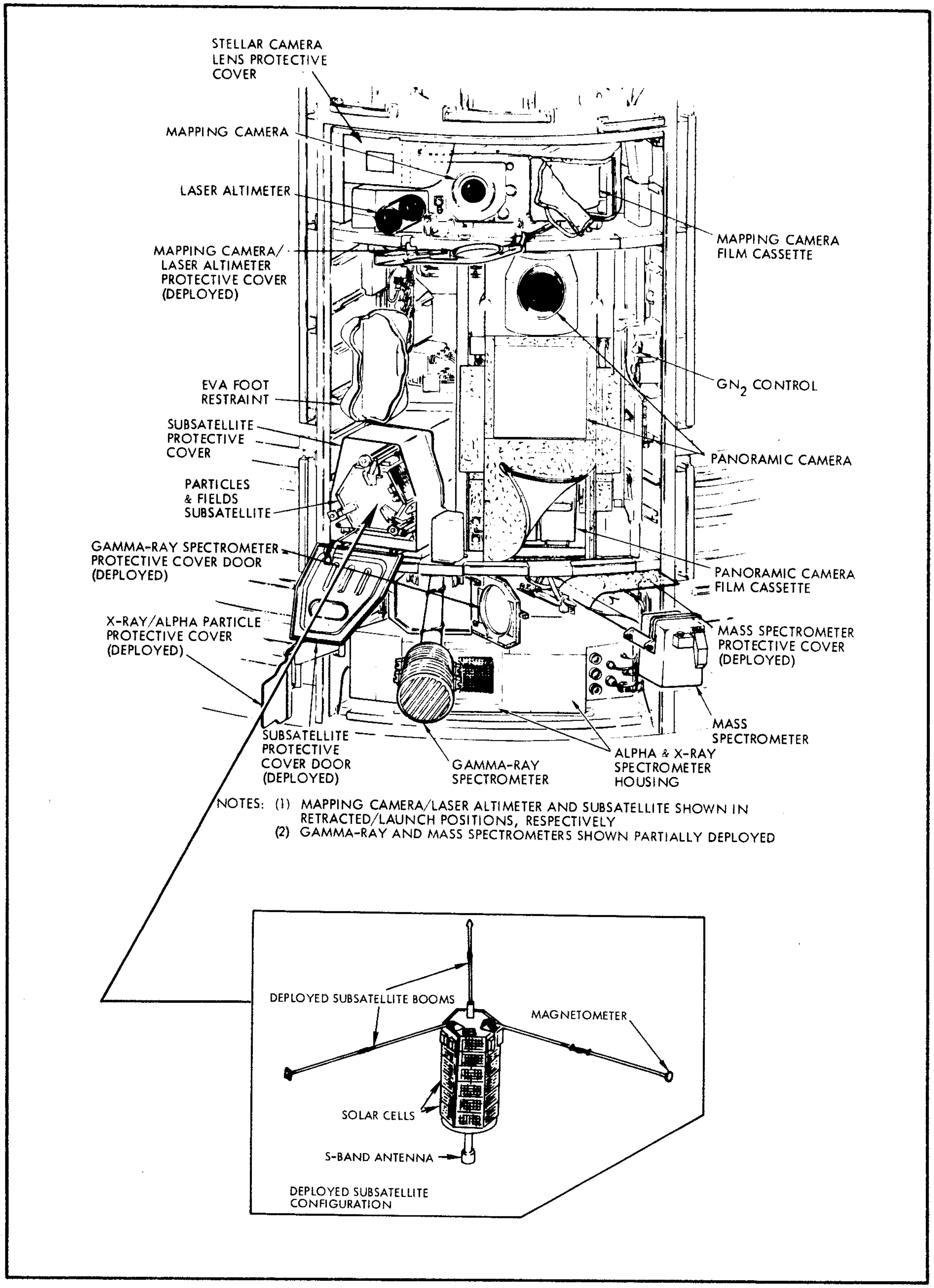
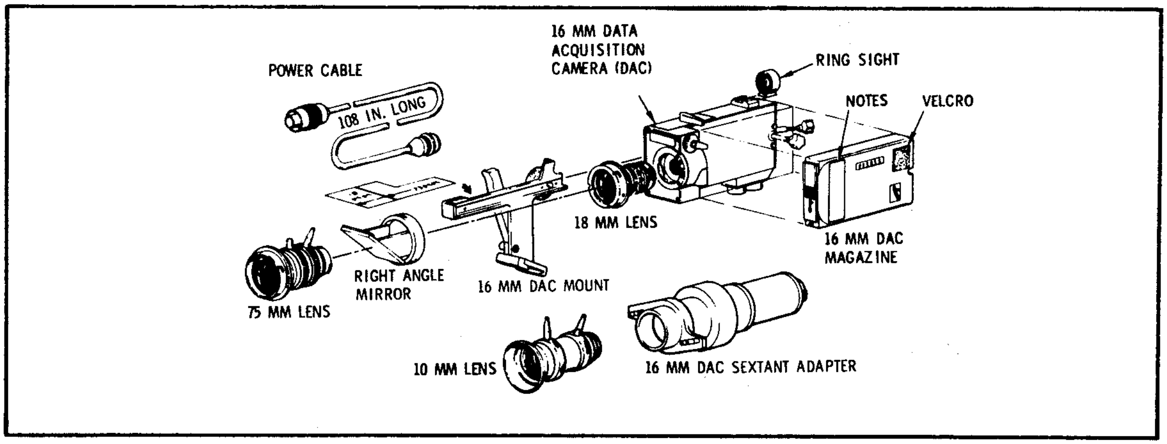
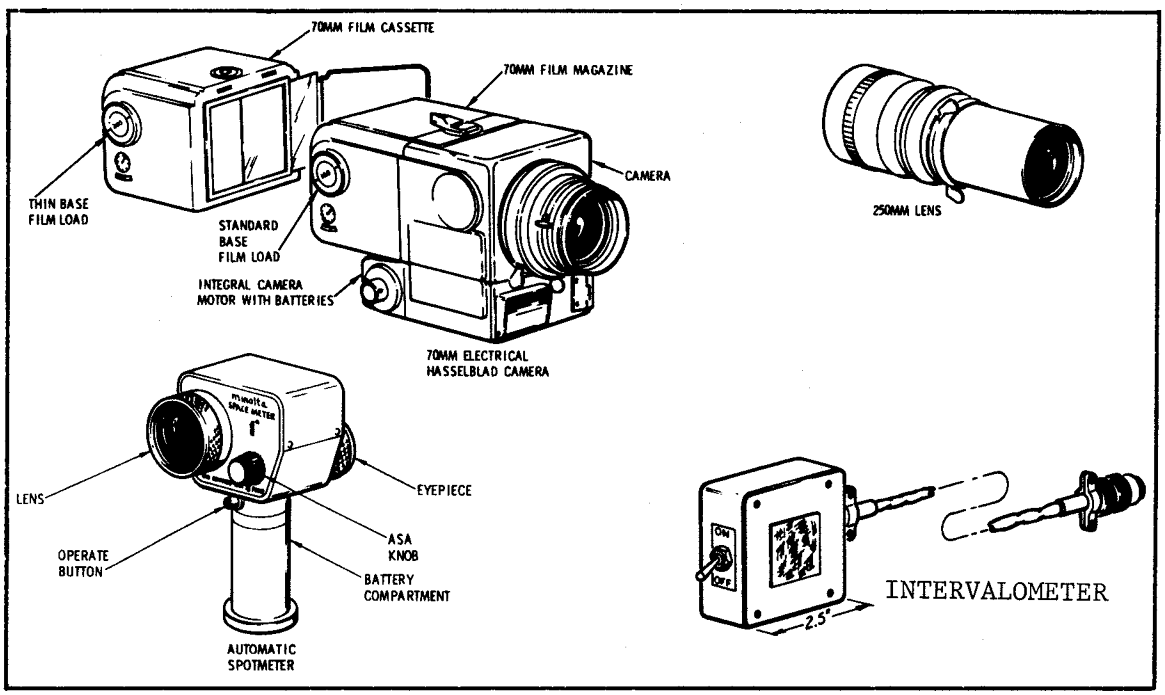


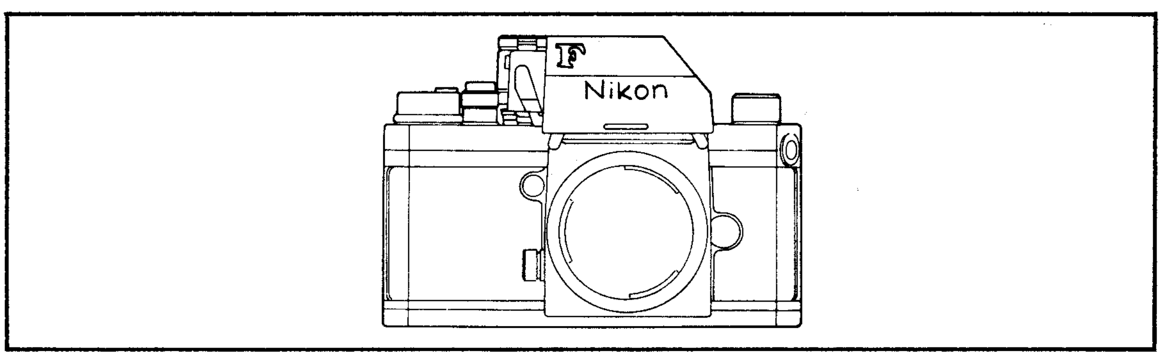
Figure 1-10. Scientific Instrument Module Experiments and Service Module (SM) Orbital Photographic Tasks Equipment



16-mm Data Acquisition Camera (DAC) System



70-mm Hasselblad Electric Camera System



35-mm Nikon Camera

Figure 1-11. Command Module (CM) Photographic Tasks Equipment

Table 1-1. Rationale for Lunar Surface Experiments

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
1. Lunar Geology Investigation Experiment	S-059	A-1	1, 6, 7	The purposes are to obtain a better understanding of the nature and development of the Cayley Plains and Descartes Mountains area and the processes which have modified the highland surface, through the study of documented lunar geology features and returned lunar samples.		Apollo 11 Apollo 12 Apollo 14 Apollo 15
a. Documented sample with documented sample photography			1	The objective is to obtain documented samples at Stone Mountain (highest priority traverse station). The photography will show sample orientation, buried depth, relationship to other geologic features, location with respect to LM or other recognizable feature; with gnomon, to show orientation with respect to sun and lunar local vertical; stereo pairs for precise photogrammetric measurements of features. Color patch gives colorimetric properties.		
b. Drill core			6	This objective provides the only certain deep sample of regolith; a secondary objective is to determine stratigraphy in the sample area.		
c. Contingency sample			-	Taken only in event of actual contingency. First documented sample fulfills the requirement.		

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
d. Craters • Radial sampling • Rim samples • Secondary craters • Distant crater rays • Blocky rim craters			7	The aim is to determine the stratigraphic history of the area. The deepest material should be exposed at the crater rim; the material origin should get progressively shallower moving out from the crater, i.e., materials farthest away should have the shallowest origin in the crater. Photographs of the craters will record size, type, and freshness (freshness is suggested by radiating patterns of high albedo material or by large abundance of angular blocks). Samples of variation in regolith and bedrock with depth at each station. Local bedrock and sample materials excavated by near and distant large craters will be collected. Impacting projectiles which can be associated with secondary craters will tell crater age and radiation history.		
e. Boulders • Larger than 5 m • East-west split • Vertical split • Overturnable • Dust on top of boulder			7	Radiation history. Variation in lithology and rock structure. E-W split gives solar wind shielded sample. Dust will give information on soil formation.		

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
f. Soil and Rocks • Permanently shadowed • Top layer surface • Surface skim • Pristine rock surfaces • Fillet sample			7	Permanently shadowed soil will provide evidence of cold trap of volatile elements. Soil surface materials reveal interaction of solar wind and cosmic radiation with the lunar surface yielding a better understanding of solar and galactic radiation, small scale lunar surface processes. Pristine rocks brought back in padded bags will be used in detailed investigation of track studies, micro craters. Debris (soil) piled up against rock is called a fillet; the volume of the fillet may be directly proportional to the time the rock has been in position and to the rock size.		
g. Panoramic photography			7	These photographs, when joined as mosaics, provide accurate map control data.		
h. Polarimetric photography and samples			7	Comparison of polarimetric signatures with those of known materials will allow classification and correlation of lunar material even though textures are not resolvable.		
i. Long focal length camera photography			7	The 5 to 10 cm resolution at 1 to 2 km distance will allow pictures to be taken of distant features or inaccessible targets.		

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
j. Double core tube sample with photographs			7	This objective provides a small sample for determining stratigraphy and soil type distribution to depths of approximately 1 meter in the lunar surface at selected locations (expected multiple layer areas). The photographs will record the surface characteristics and location of the sample area.		
k. Small exploratory trench sample with photographs			7	The objective is to determine the character of regolith down to 10 cm and small scale stratigraphy in terms of petrologic characteristics and particle size. The photographs will record the surface characteristics and location of the trench sample area and other characteristics.		
l. Lunar environment soil/rock sample: Special environmental sample container (SESC), and core sample vacuum container (CVSC)			7	These samples will be the only truly virgin vacuum samples from the moon; biologically pure samples for organic analysis, for gas analysis, and for chemical and microphysical analysis.		

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE: TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
2. Apollo 16 ALSEP: a. Heat Flow Experiment (HFE)	S-037	A-3	2	Part of ALSEP array. Temperature sensor/heater probes (1.2 m long) are inserted into two 2.5 m deep holes with casings bored into the lunar surface 10 m apart by a crewman. Probes are cable-connected to the HFE electronics package which is cable-connected to the ALSEP central station. The HFE will measure the temperature gradient and thermal conductivity in the near surface layers of the moon, as well as the brightness temperature of the lunar surface. These data will provide information on the thermal history, thermal properties, and radioactive content of the lunar interior.		Apollo 15
b. Lunar Surface Magnetometer Experiment (LSME)	S-034	A-5	3	Part of ALSEP array. Three mutually perpendicular magnetic sensors measure the magnitude, direction, and temporal variations of the lunar magnetic field vector. Data will be used to derive information on the electrical properties and thermal state of the lunar interior and on the interplanetary magnetic field that diffuses through the moon.	LSM must be deployed by a crewman $\geq$12 m from central station. Instrument must be properly oriented in azimuth, leveled, and sensor assembly aligned. When astronauts depart the moon, the LRV must be parked $\geq$61 m from the LSM.	Apollo 12

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE		SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
TITLE	NO.					
c. Passive Seismic Experiment (PSE)	S-031	A-7	4	Part of ALSEP array. Cylinder seismometer assembly, 30.5 cm diameter, 50.8 cm high, deployed by crew on lunar surface, controlled from earth. Will monitor lunar seismic activity for one year, telemetering data to earth. Purpose: to determine number, origin, and character of lunar seismic events, and obtain knowledge of the physical properties and general structure of the moon.	PSE must be deployed by a crewman $\geq$5 m from RTG. Instrument must be properly oriented in azimuth and leveled, and the sensor assembly aligned.	Apollo 11 Apollo 12 Apollo 14 Apollo 15
d. Active Seismic Experiment (ASE)	S-033	A-9	5	Part of ALSEP array. This experiment is designed to generate and monitor artificial seismic waves in the 3 to 250 Hertz range, in the lunar surface and near subsurface. Natural seismic waves in the same frequency range will also be monitored on a limited basis. By varying the location and magnitude of the energy sources, wave velocities through several layers of subsurface materials can be investigated.	Deployment by crew must be such that other ALSEP elements not be damaged when the explosive mortars are fired after the crew departs the moon.	Apollo 14
3. Far UV Camera/ Spectroscope Experiment	S-201	A-10	8	This experiment will measure the amount and excitation of hydrogen in nearby and distant regions of the universe. The imagery obtained in this experiment will help identify characteristic Lyman-Alpha emission of hydrogen from the lunar surface, geocorona, solar wind, interstellar wind, and clusters of galaxies. The spectra obtained will also detect other gases in these regions and provide data on the temperature and density of these gases.	Must be deployed in lunar module shadow. Camera must be realigned in azimuth and elevation by crew several times during lunar stay.	None

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
4. Solar Wind Composition Experiment (SWCE)	S-080	A-11	9	A sheet of aluminum and platinum foil is exposed, in sunlight, to solar wind. Foil is returned to earth for analysis to determine the elemental and isotopic composition of noble gases and other selected elements in the solar wind. Planned exposure, 46 hours.	SWCE must be deployed by crewman, exposed in sunlight on lunar surface for as long as possible, then returned to earth.	Apollo 11 Apollo 12 Apollo 14 Apollo 15
5. Soil Mechanics Experiment (SME)	S-200	A-13	10	The purpose is to obtain data on the physical characteristics and mechanical properties of the lunar soil at the surface and subsurface and their variations in a lateral direction.		Apollo 11 Apollo 12 Apollo 14 Apollo 15
a. Trench with trench photography				The soil layers that will be exposed on the side of a trench excavated by the crew will be photographed. The achievable depth prior to wall failure indicates soil mechanical properties. The experiment will furnish qualitative information for design of lunar shelters using lunar soil as thermal, radiation shield.		
b. Penetrometer and plate load tests with photographs				The objective is to obtain stress versus penetration data that reflect nonhomogeneities in soil profile; the data will be correlated with penetrometer and plate penetration data for simulated lunar soil to determine lateral and vertical particle size distribution of lunar soil.	Penetrometer drum returned in penetrometer head.	

Table 1-1. Rationale for Lunar Surface Experiments (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
5. Soil Mechanics Experiment (Continued) c. Soil mechanics observations with photographs				The mechanical behavior of the lunar surface material will be assessed through analyses of the LM footpad-lunar soil interactions, soil accumulation on the LM vertical surfaces, soil mechanics data obtained during EVA, and lunar soil-LRV interactions.		
6. Portable Magnetometer Experiment (PME)	S-198	A-15	11	This experiment will measure vector magnetic field components at several locations in the lunar landing area. The data will aid resolution of questions on the spatial variations of the lunar magnetic environment, and will aid in determining characteristics of lunar geological structures.	Instrument must be deployed away from LRV at each measurement site for minimum interference.	Apollo 14
7. Cosmic Ray Detector (Sheets) Experiment CRD(S)	S-152	A-16	12	This experiment requires the return to earth of plastic detector sheets and other special glass, mineral, and tektite detectors exposed to the galactic cosmic ray and solar wind particle environment during TLC and when on the lunar surface. These sheets will provide data for three scientific investigations which will lead to a better understanding of the contemporary flux of solar and galactic particles.	The detector panel temperature upper limit of +130°F shall not be exceeded.	Apollo 8 (S-151) Apollo 12 (S-151)

Table 1-2. Rationale for Lunar Orbital Experiments/Science Detailed Objectives

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
1. Gamma-Ray Spectrometer Experiment	S-160	B-1	1	Determine the degree of chemical differentiation of the moon and the composition of the lunar surface. Measure radiation flux in cislunar space, obtain a spectrum of cosmological gamma-ray flux, and perform gamma-ray astronomy.	Extended operation is required due to the high background-to-data ratio. Most desirable data is obtained when boom is fully extended and mapping camera cover closed. Experiment detector should point toward the lunar surface within $\pm$11.5 degrees of the lunar local vertical. Boom position to stay fixed during gamma-ray astronomy.	Apollo 15
2. X-Ray Fluorescence Experiment	S-161	B-3	2	Determine the elemental composition of lunar surface material. Measure galactic X-ray flux from two sources and scan the supergalactic equator during transearth coast.	Extended operation is desirable to obtain data from as much of the lunar surface as possible. Experiment detector should point toward the lunar surface within $\pm$6.5 degrees of the lunar local vertical. The required pointing accuracy and stability is $\pm$3 degrees during the pointing portions of transearth data collection. Instrument door will be closed for dumps and direct sunlight prevented from entering the 60-degree square field of view of the experiment detector.	Apollo 15
3. SM Orbital Photographic Tasks Objective	-	B-5	3			
a. 24-Inch Panoramic Camera				High resolution photographs with stereoscopic coverage of possible future landing sites and exploration areas on the moon. One- to two- meter resolution photographs for site analysis, geological interpretation, and support of mapping photography.	45-80 NM operating altitude limits, sun avoidance, restrictions on SM RCS plume impingement, liquid dumps, and FOV obstructions.	Apollo 15
b. 3-Inch Mapping Camera/Stellar Camera				High-quality metric photographs of the lunar surface and stellar photographs time-correlated with the metric photographs. Provide means of establishing a lunar geodetic	Altitude limits of nominal $\pm$10 NM, sun avoidance, restrictions on SM RCS plume impingement and liquid dumps.	Apollo 15

Table 1-2. Rationale for Lunar Orbital Experiments/Science Detailed Objectives (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
3. SM Orbital Photographic Tasks Objective (Continued)						
b. 3-Inch Mapping Camera/Stellar Camera (Continued)				network, form the basis of photogrammetric determination of lunar gravitational field, and aid in production of lunar cartographic maps.		
c. Laser Altimeter				Altitude (slant range) data from lunar orbit, with range resolution of 1 meter. Provide accurate topographic elevations for use in study of internal structure of the moon, provide time-correlated altitude information for use with panoramic and mapping photographs.	Ranging limits of 40 to 80 NM, sun avoidance, possible degradation due to contaminants.	Apollo 15
4. Subsatellite:			4			
a. S-Band Transponder Experiment	S-164	B-11		Collection and analysis of routine MSFN and DSN S-Band Doppler tracking measurements. This analysis will be used to improve the knowledge of the lunar mass distribution and gravity field.	The experiment has no constraints on normal spacecraft and MSFN/DSN tracking operations. Low lunar altitude (16 nautical miles or less) tracking data will be especially valuable.	Apollo 15
b. Particle Shadows/Boundary Layer Experiment	S-173	B-7	-	Study the formation and dynamics of the earth's magnetosphere, the physics of solar flares, and the interaction of plasmas with the moon.	The experiment is onboard the subsatellite which is a free flying body. The polar sounding rocket program will be conducted concurrently with the subsatellite.	Apollo 15
c. Magnetometer Experiment	S-174	B-9	-	Study the physical and electrical properties of the moon, interactions of plasmas with the moon, and identify magnetized regions of the moon.	Due to unpredictable variations of the interplanetary medium, as much data as possible should be collected to minimize the statistical uncertainty of experiment conclusions and to improve the resolution	Apollo 15

Table 1-2. Rationale for Lunar Orbital Experiments/Science Detailed Objectives (Continued)

EXPERIMENT/OBJECTIVE		SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
TITLE	NO.					
4. Subsatellite: (Continued) c. Magnetometer Experiment (Continued)					of the data. Data will be correlated with ALSEP magnetometer data.	
5. S-Band Transponder (CSM/LM)	S-164	B-11	5	Collection and analysis of routine MSFN and DSN S-Band Doppler tracking measurements. This analysis will be used to improve the knowledge of the lunar mass distribution and gravity field.	The Apollo 16 version of this experiment has no constraints on normal spacecraft and MSFN/DSN tracking operations. Low lunar altitude (16 nautical miles or less) tracking data will be especially valuable.	Apollo 14 Apollo 15
6. Alpha Particle Spectrometer Experiment	S-162	B-12	6	Assists in the determination of lunar surface composition, determine the lunar surface radon evolution, and identification of localized sources of enhanced radon emission.	Extended operation is desirable to obtain data from as much of the lunar surface as possible. Experiment detector should point towards the lunar surface within ±6.5 degrees of the lunar local vertical. Direct sunlight should not enter the sensor field-of-view for more than 5 minutes at any one time or for more than 30 minutes total during the experiment operation.	Apollo 15
7. Mass Spectrometer Experiment	S-165	B-14	7	Determine the composition and distribution of the lunar ambient atmosphere, identify areas of lunar volcanism, and determine contamination in the lunar atmosphere and cislunar space. While in lunar orbit and during transearth coast the contamination due to the spacecraft will be measured.	During data collection, the CSM -X axis will be oriented to within ±5 degrees of the velocity vector and the centerline of the SIM. The boom will be fully extended with the experiment OFF or fully retracted and the experiment cover in place for all fuel cell purges, waste water and urine dumps. Data collected within ±15 degrees longitude on each side of the sunset and sunrise terminators are especially valuable. Data collection of the native lunar atmosphere should take place immediately following an orbit change in order to avoid possible spacecraft contamination effects.	Apollo 15

Table 1-2. Rationale for Lunar Orbital Experiments/Science Detailed Objectives (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
8. UV Photography - Earth and Moon Experiment	S-177	B-16	8	Photographs of the earth disc and of the lunar surface, taken in 3 UV regions and 1 visual region of the spectrum. Aid study of planetary atmospheres and show possible lunar surface fluorescence in the UV region of the spectrum. Also determine surface color differences.	The photographs must be taken through the CM right hand side window (special UV window).	Apollo 15
9. Gegenschein From Lunar Orbit Experiment	S-178	B-17	9	Photographs in direction of Moulton point, in anti-solar direction, and direction midway between. Investigate possible contribution to Gegenschein produced by reflection from dust particles at the Moulton point.	Earth-moon-sun geometry: photographs must be taken in lunar double umbra.	Apollo 14 Apollo 15
10. CM Photographic Tasks Objective	-	B-18	10	Photographs of solar corona after CSM sunset and before CSM sunrise. Photographs while solar disc is occulted by moon, to aid study of solar energy outflow.	Lunar darkside required	Apollo 15
				Photographs of zodiacal light as the CSM approaches sunrise. Study distribution of matter in our galaxy.	Lunar darkside photography	Apollo 8 Apollo 14 Apollo 15
				Photographs of lunar surface in low light levels near the terminator and in earthshine. Complement SIM photography.	Near terminator, handheld	Apollo 8 Apollo 12 Apollo 14 Apollo 15
				Photographs of lunar surface areas of scientific interest. Complement SIM photography with viewing angles and sun angles not feasible for SIM cameras.	Proximity of trajectory to desired targets	Apollo 8 Apollo 12 Apollo 14 Apollo 15

Table 1-2. Rationale for Lunar Orbital Experiments/Science Detailed Objectives (Continued)

EXPERIMENT/OBJECTIVE TITLE	NO.	SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
11. Visual Observations From Lunar Orbit Objective	-	B-20	11	Visual observations by the CMP of planned lunar surface areas, with real time transmission or recording of comments. Take advantage of unique characteristics of human visual capability to supplement photographic, geochemical, and geophysical data to be gathered from lunar orbit.	Proximity of trajectory to desired visual science targets	All previous lunar orbital missions; formally scheduled first on Apollo 15.
12. Bistatic Radar Experiment	S-170	B-21	12	The CSM is maneuvered such that the applicable CSM antenna is pointed near the specular point on the moon. The S-Band and VHF transmissions are reflected by the moon and recorded by ground based facilities at Goldstone and Stanford, California. The analysis of this data will yield shape, roughness, and electrical properties of the lunar surface.	The uplink transmission from MSFN will be turned off for the experiment period, and the spacecraft voice and telmetry data will be recorded for subsequent playback to the MSFN.	Apollo 14 Apollo 15

Table 1-3. Rationale for Passive Experiments and Inflight Demonstrations

EXPERIMENT/OBJECTIVE		SUMMARY REF. PAGE	PRIORITY	DESCRIPTION/RATIONALE	CONSTRAINTS	PREVIOUS MISSION(S)
TITLE	NO.					
1. Bone Mineral Measurement Experiment	M-078	N/A	N/A	To investigate the phenomenon of body structure degradation due to reduced gravity. X-ray absorption technique will be used to measure the bone mineral content of the radius, ulna and os calcis preflight and postflight.	N/A	Apollo 14 Apollo 15
2. Biostack Experiment	M-211	N/A	N/A	To investigate the biological effects on individual heavy nuclei of cosmic radiation during space flight. Information will also be obtained on the biological effects of specific radiation sources.	N/A	None
3. Apollo Window Meteoroid Experiment	S-176	N/A	N/A	To determine the meteoroid cratering flux for particles responsible for the degradation of surfaces exposed to space environment. The requirements consist of returning the CM heat shield windows (Numbers 1, 3 and 5) to MSC following recovery of the spacecraft.	CM heat shield windows 1, 3, and 5 will be returned to MSC following recovery of the spacecraft.	Apollo 14 Apollo 15
4. Fluid Electrophoresis In Space Inflight Demonstration	N/A	N/A	N/A	Obtain data on the movement of charged particles in a liquid under the influence of an electric field. The demonstration will be performed while the CSM is in coasting flight.	N/A	Apollo 14

SECTION II

DESCARTES SUMMARY DATA

2.1 LANDING SITE LOCATION

Coordinates of the Apollo 16 Lunar Module (LM) landing site in the Descartes region are as follows:

a) Latitude: 9° 00' 01" South
b) Longitude: 15° 30' 59" East

These coordinates are referenced to the 1:25,000 Descartes Photomap, first edition, October 1971. Figure 2-1 shows the location of the Apollo 16 landing site with respect to the landing sites of previous Apollo Missions 11, 12, 14, and 15.

2.2 SITE DESCRIPTION AND RATIONALE

The Apollo 16 LM is scheduled to land in the Descartes region of the moon at 2:40 pm (CST), April 20, 1972. As shown in Figure 2-2, Descartes is a highlands area located in the southeastern part of the moon. The landing site is southwest of Mare Tranquillitatis, north of Descartes Crater, and several hundred kilometers west-northwest of Theophilus Crater.

Features in the Descartes region are dominated by events which occurred during the second of three stages in the evolution of the moon's surface. This evolutionary stage extended through most of the Imbrian and early Eratosthenian periods, and was characterized by volcanism which erupted the basalt flows of the maria and more varied materials on the terra. The lunar highlands seem to consist of three major types of deposits: undivided pre-Imbrium materials and older degraded crater materials; ejecta blankets composed of material ejected by major basin forming events such as the formation of Mare Imbrium; and volcanic constructional materials. Dominated by features of the second stage of lunar surface evolution, the Descartes region provides an exceptionally favorable site for sampling and study of such features.

The Descartes region is characterized by hilly, grooved, and furrowed terrain which appears to be morphologically similar to many terrestrial areas of volcanism, and is also the site of an extensive development of highland plains material. This region is important to the lunar geologist since knowledge of the composition, age, and extent of magmatic differentiation in a highland volcanic complex is of particular importance in understanding lunar volcanism and its contribution to the evolution of the lunar highlands. A comparison of the Descartes mare complex with those investigated during Apollo 14 (Fra Mauro) and Apollo 15(Apennine Mountains) will also permit an evaluation of a wide spectrum of lunar volcanic activity.

In addition, an understanding of the composition and age of the highland plains material will expand man's knowledge of the processes which modify large areas of the lunar highlands.

Three formations dominate the Descartes region: the Cayley Formation, the Descartes Formation, and materials of the Kant Plateau. All are believed to be of volcanic origin and Imbrian age, and afford an outstanding opportunity for sampling and study of the petrochemistry of volcanic constructional units of the lunar highlands. Fresh craters of various sizes are also present, and allow sampling of the highlands units to various depths; mounded floors of craters with diameters up to 1 kilometer suggest that a lower layer of unknown origin has been penetrated.

The Cayley Formation unit consists of highland plains material distributed over mostly smooth to undulating terrain, probably resulting from fluid volcanic flow rock and pyroclastic detritus; except for the mare regions, this unit is the largest single identifiable rock unit on the near side of the moon, covering about 7 percent of the near side surface. The Descartes Formation unit is composed of hilly and furrowed highland plateau material that probably was caused by more viscous volcanic flow rocks, pyroclastics, and their associated cones; this unit is located at the edge of the larger Kant Plateau unit which covers 4.3 percent of the moon's nearside. These three units provide a unique opportunity for dating and other studies of the morphological evolution of young, bright-rayed craters. From geological information obtained, ages of other visible craters of apparently similar construction can be inferred.

Major geological features in the Descartes region which have been selected for investigation during the Apollo 16 lunar surface traverses are identified in Figure 2-3 and listed below.

a) Cayley Plains which include two young and prominent bright-rayed craters (North Ray and South Ray Craters)

b) South Descartes Formation (Stone Mountain)

c) North Descartes Formation (Smoky Mountains)

d) Subdued craters and crater chains

Rationale for selection of these features for sampling and investigation are presented in the following paragraphs. Figure 2-4 is a geologic sketch map which identifies the types of material and terrain in the Descartes region.

a) <u>Cayley Plains (North Ray and South Ray Craters)</u>. Since the landing area is on the smooth phase of this unit, samples in the vicinity of the LM will provide material from this unit. Bright-rayed craters of sizes up to 1 kilometer in diameter (e.g., North Ray and South Ray Craters) penetrate this unit. Radial sampling of the bright rays emanating from these craters will permit selective sampling of stratigraphic history to a depth of about 200 meters.

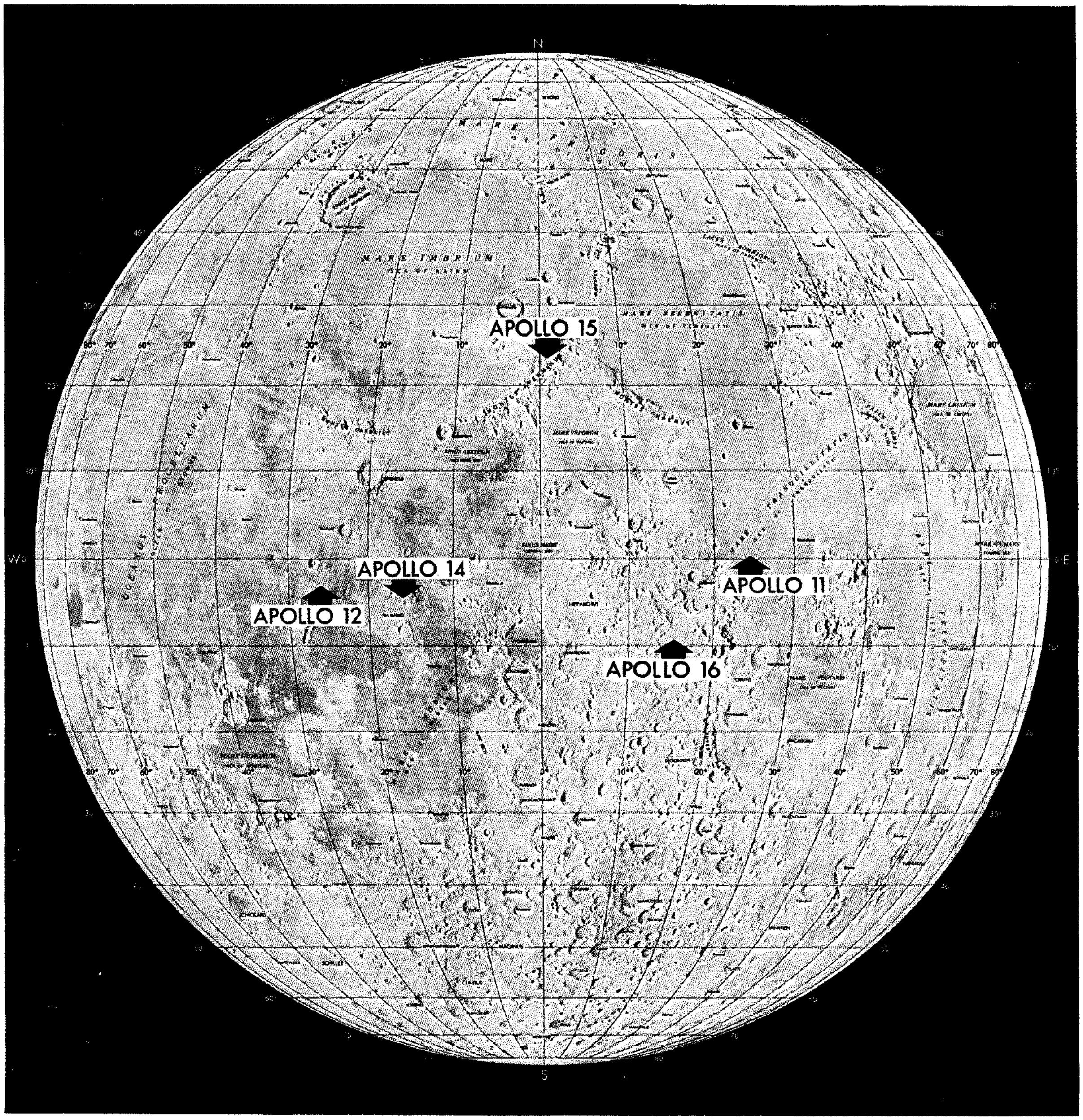
Exposed in the east wall of the bright-rayed North Ray Crater, and recognizable as a scarp-forming unit to the south and east of the crater, is the youngest stratigraphic unit of the Cayley Formation. A lower stratigraphic layer located approximately 150 to 200 meters below the present surface is indicated by mounds in the floors of all craters about 1 kilometer in diameter. Speculations as to the origin of this lower layer include: another type of Cayley constructional unit; Imbrium basin ejecta; Nectaris basin ejecta; or pre-Imbrium local source material. Detailed sampling should provide the answer. Crater rim sampling alone of North Ray Crater should determine if pre-Imbrium material is present (traverse limitations will preclude crew access to the rim of South Ray Crater). Investigations are also to be made of the seemingly rimless craters in this area and of the one very dark crater (Flag Crater) west of the landing point.

b) South Descartes Formation (Stone Mountain). These hills form the north edge of a bright, hilly, and furrowed unit that extends 100 kilometers southward from the LM to Descartes Crater and 50 kilometers eastward across the Kant Plateau. The Kant Plateau unit (from which the Descartes Formation is derived) is recognizable at several highland areas on the near side of the moon and becomes more prevalent on the far side. This unit appears to have been formed of very viscous lava, morphologically the opposite of mare lava. Samples from these hills will provide material from a large regional highland volcanic unit, the Kant Plateau (Descartes formation).

c) North Descartes Formation (Smoky Mountain). This feature might be a pre-Imbrium crater although it is more probably a volcanic constructional form. Sampling would establish whether ancient breccias are present from a different region of the moon or if these hills are just another area of highland volcanics. Samples supporting either hypothesis would afford valuable data. This unit will be sampled at a large crater (Ravine) at the south base of these hills.

d) Subdued Craters and Crater Chains. A number of craters and crater chains, marginally accessible from the Descartes landing area, appear to be the result of ejecta from the crater Theophilus (or possibly Cyrillus). The largest crater group close to the landing area is west of the North Ray Crater. The morphology of this crater-type will aid in understanding the details of formation of large secondary craters and their rate of degradation. The deepest samples of Cayley formation might be collected from the rim. Palmetto Crater is representative of this group.

A small group of irregular craters east of North Ray Crater and against the base of North Hills are either primary impact craters or a secondary crater chain similar to those farther west. These craters will be observed but not sampled because of geological unit priorities and surface timeline/traverse constraints.



Mission	Landing Site and Launch Date
Apollo 11	Sea of Tranquility, 16 July 1969
Apollo 12	Surveyor III Site, 14 November 1969
Apollo 13	Mission aborted during translunar coast, 11 April 1970
Apollo 14	Fra Mauro, 31 January 1971
Apollo 15	Hadley-Apennine, 26 July 1971
Apollo 16	Descartes, 16 April 1972 (scheduled)

Figure 2-1. Apollo Lunar Landing Sites

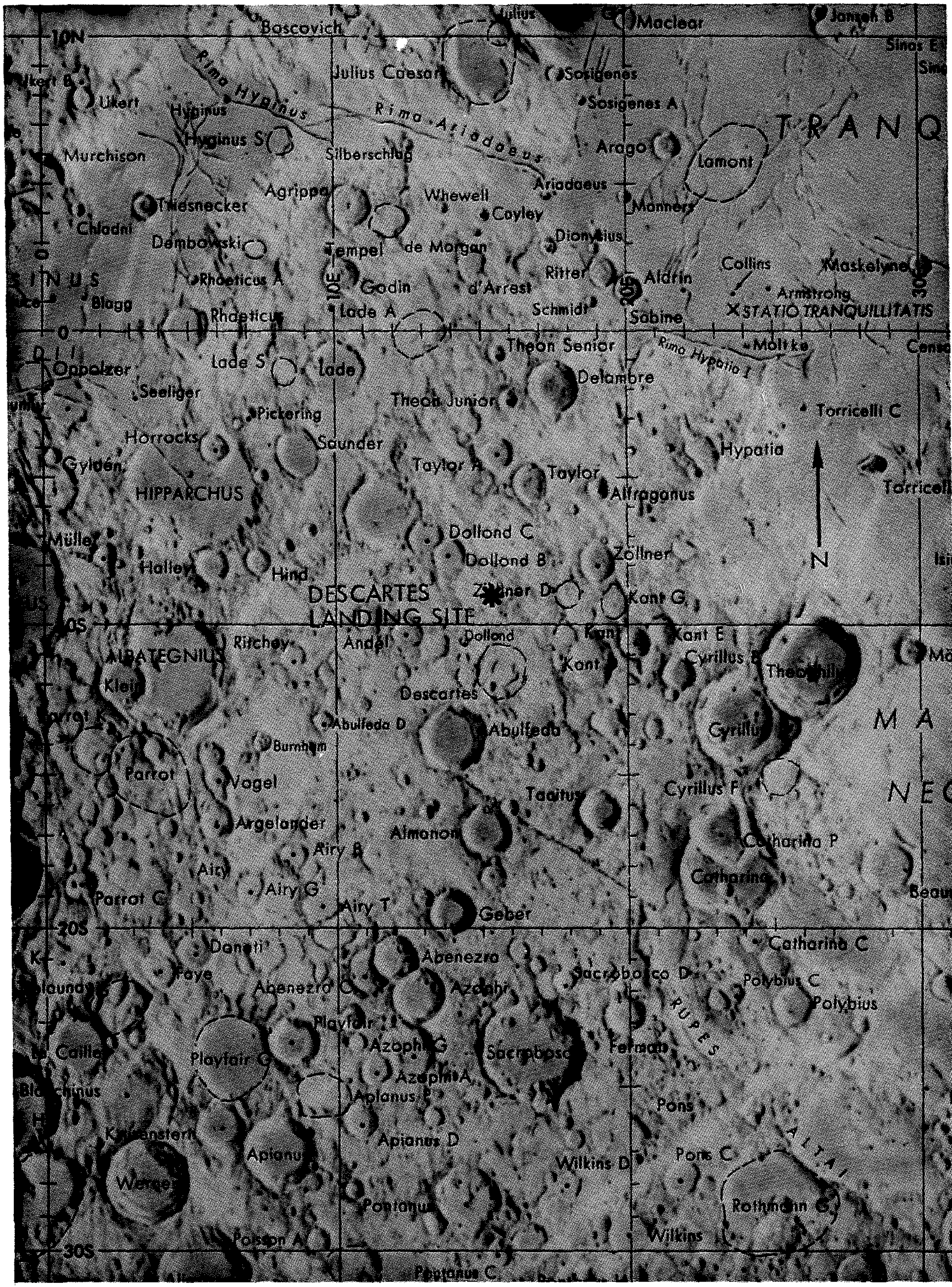


Figure 2-2. Apollo 16 Descartes Landing Area

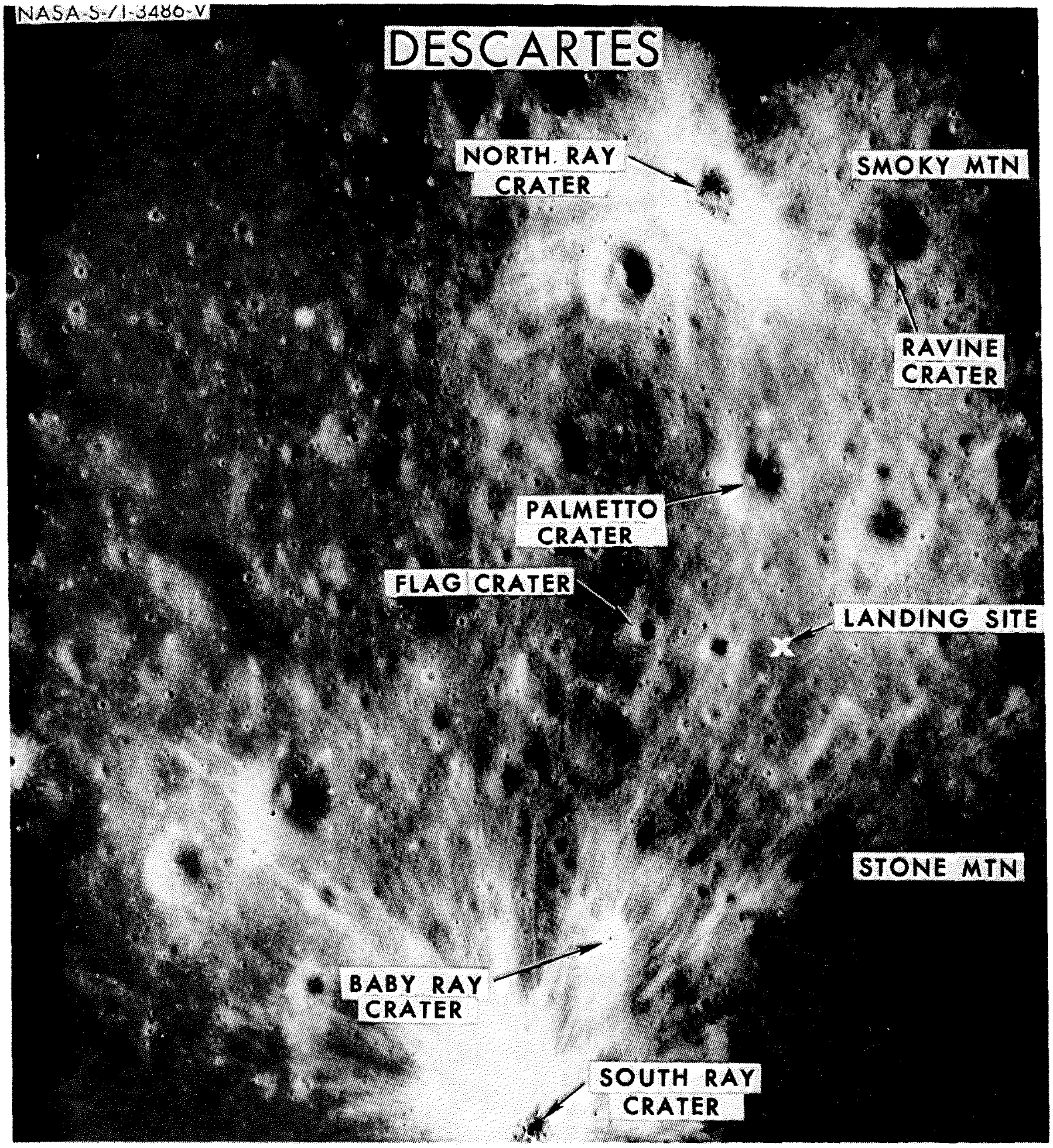


Figure 2-3. Apollo 16 Science Investigation Areas

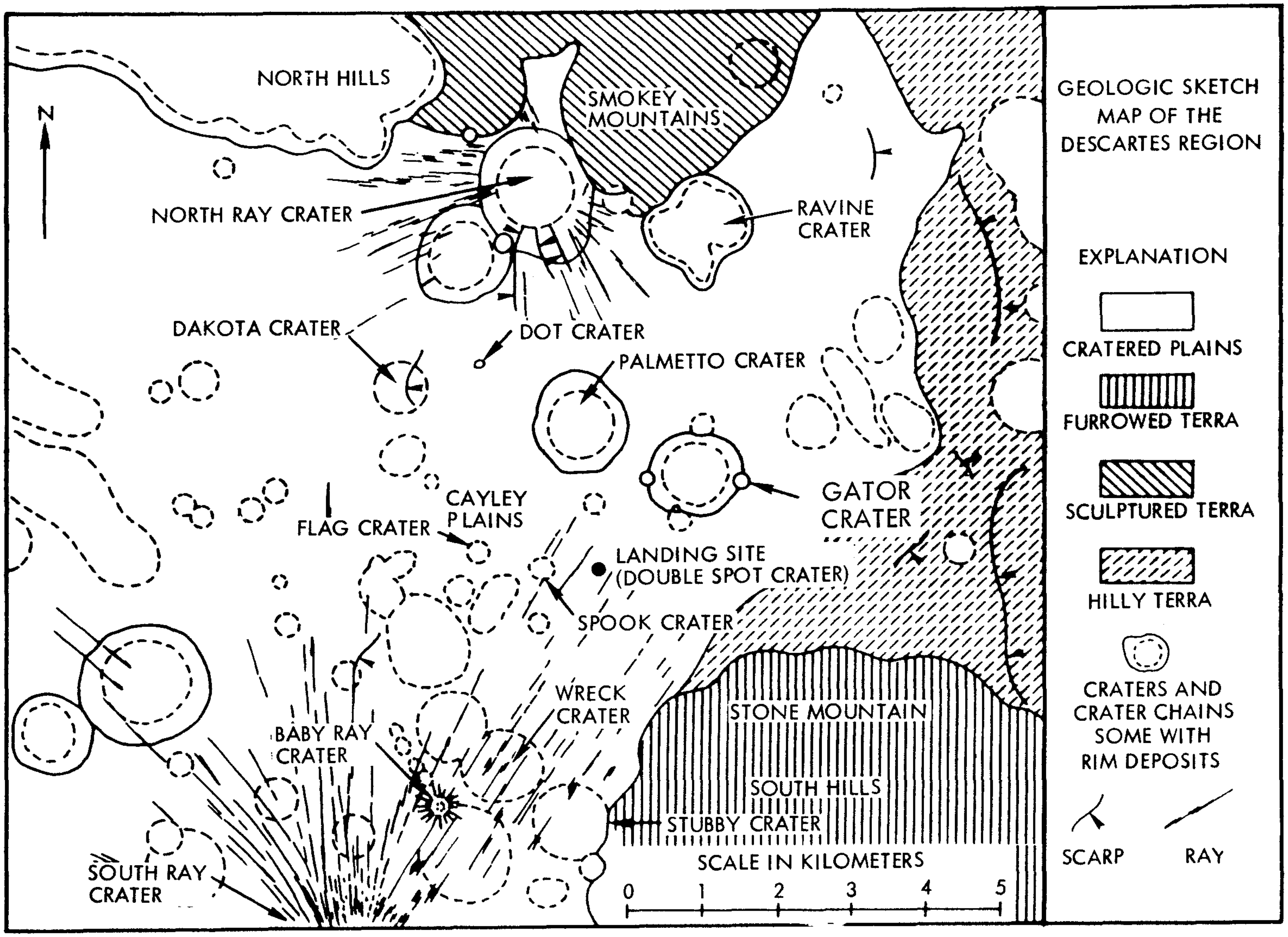


Figure 2-4. Geologic Map of Descartes Region

SECTION III

MISSION SCIENCE PROFILE

3.1 GENERAL MISSION DATA

Pertinent operational data for the Apollo 16 Mission are summarized below.

a) Lift-off: 16 April 1972

b) Launch Window: 11:54 to 3:42 CST

c) Mission Duration: Approximately 12.1 days

d) Landing Site: Descartes

e) Landing Site Coordinates: 9° 00' 01" S latitude*
15° 30' 59" E longitude*

f) Lunar Stay Duration: Approximately 73 hours

g) Number of Traverses (EVA's): 3

h) EVA Durations: EVA 1 (7 hours), EVA 2 (7 hours), EVA 3 (7 hours)

i) Number of Experiments: 21 (10 lunar surface, 11 lunar orbital)

j) Number of Science Detailed Objectives: 3 (lunar orbital)

k) Crew Members:

Designation	Prime Crew	Backup Crew
Commander	John W. Young	Fred W. Haise
Command Module Pilot	Thomas K. Mattingly	Stuart A. Roosa
Lunar Module Pilot	Charles M. Duke	Edgar D. Mitchell

3.2 MISSION SCIENCE ACTIVITIES

Science activities are scheduled during all of the mission phases from translunar injection through splashdown. Discrete mission periods during which these science activities are conducted are listed below:

a) Translunar Injection (TLI) to Lunar Orbit Insertion (LOI)

b) LOI through CSM/LM Undocking

*Source data: 1:25,000 Descartes photomap, first edition, October, 1971.

c) CSM Circularization through Lunar Orbit (LO)

d) LM Descent and Lunar Surface Activities

e) LM Lift-off through Transearth Injection Preparation

f) Transearth Injection (TEI) through Transearth Coast (TEC)

g) Reentry through Recovery

Science activities performed during each of these mission periods are summarized in the following subparagraphs, and listed in chronological sequence of occurrence in Table 3-1. Figure 3-1 shows the operational periods for lunar orbital science activities. The television schedule for the mission is listed in Table 3-2.

3.2.1 TLI TO LOI

a) S-IVB stage burn for eventual impact on the lunar surface and seismic measurement by the Passive Seismic Experiments emplaced on Apollo 12, 14, and 15. Figure 3-2 shows the impact points for the Apollo 13, 14, and 15 S-IVB stages and the proposed impact point for the Apollo 16 S-IVB stage with respect to the several Apollo landing sites.

b) UV Photography - four sets of the earth from varying distances, two sets of the moon late in translunar coast (TLC).

c) Solar Corona Photography (during solar eclipse by the moon just prior to LOI).

d) Fluid Electrophoresis Demonstration

3.2.2 LOI THROUGH CSM/LM UNDOCKING

a) Panoramic Camera Photography

b) Mapping Camera Photography

c) Laser Altimeter Measurements

d) X-Ray Fluorescence Experiment Operation

e) Alpha Particle Spectrometer Experiment Operation

f) Gamma-Ray Spectrometer Experiment Operation

g) Mass Spectrometer Experiment Operation

h) S-Band Transponder Experiment Operation*

---

*Selected periods for data reduction will be determined postmission.

3.2.3 CSM CIRCULARIZATION THROUGH LO

CSM ground tracks on the lunar farside and nearside are shown in Figures 3-3(a) and 3-3(b), respectively. Lunar surface areas scanned by lunar orbital experiments and SIM bay photographic equipment are depicted in Figures 3-4 through 3-11. Major CSM activities during lunar parking orbit are as follows:

a) Panoramic Camera Photography (Figure 3-4)

b) Mapping Camera Photography (Figure 3-5)

c) Laser Altimeter Measurements (Figure 3-6)

d) X-Ray Fluorescence Experiment Operation (Figure 3-7)

e) Alpha Particle Spectrometer Experiment Operation (Figure 3-8)

f) Gamma-Ray Spectrometer Experiment Operation (Figure 3-9)

g) Mass Spectrometer Operation (Figure 3-10)

h) Lunar Surface Photography (areas of prime scientific interest)

i) Solar Corona Photography (sunrise)

j) UV Photography (earth, earth and lunar horizon, lunar terra, and lunar maria)

k) Galactic Survey Photography

l) Terminator Photography

m) Gegenschein Photography

n) Zodiacal Light Photography

o) Bistatic Radar Experiment Operation (Figure 3-11)

p) S-Band Transponder Experiment Operation*

3.2.4 LM DESCENT AND LUNAR SURFACE ACTIVITIES

Lunar surface activities consist of the deployment of experiments and the collection and documentation of lunar surface samples. LRV traverses for each of the three extravehicular activities (EVA 1, EVA 2, and EVA 3) are shown in Figure 3-12. Figures 3-13(a), 3-13(b), and 3-13(c) show the elevation profiles along the LRV traverses. Science activities planned during EVA 1, EVA 2, and EVA 3 are listed in Tables 3-3(a), 3-3(b), and 3-3(c), respectively. Explanations of these are listed below:

*Selected periods for data reduction will be determined postmission.

a) Station or Travel: Indicates the appropriate station number or that the crew is traveling, as appropriate.

b) Distance: Shows the actual traverse distance between the two stations and the cumulative total of these distances. The actual distance is obtained by multiplying the map distance by the map correction factor of 1.1.

c) Station Stop or Travel Time: Indicates the travel times between individual stations and the cumulative travel time, or the individual station stop times and the cumulative station stop time, as appropriate. (Overhead times for LRV traverses are 3 minutes for stops up to 15 minutes, and 7 minutes for stops of 15 minutes or longer.)

d) Station Science Time: Indicates the time at each station devoted to scientific activities, i.e., station stop time minus station stop overhead. The cumulative total is also shown.

e) EVA Time After Event: Shows the time, since beginning the EVA, at the end of each station stop or travel sequence, as appropriate.

f) Geological Features/Observations and Activities: Describes the surface feature at the station or along the traveled route, as appropriate. Lists crew observations and scientific activities considered appropriate for the station or traveled route.

Activities during LM descent and on the lunar surface are listed below:

a) S-Band Transponder Experiment Operation*

b) Touchdown

c) EVA 1. The traverse for EVA I activities is listed below and shown in Figure 3-12.

1) Contingency Sample Collection (only for early abort)

2) Lunar Geology Investigation Experiment

- Documented Samples and Rake/Soil Sample from Flag Crater Vicinity
- Documented Samples from Spook Crater Vicinity
- Soil/Rake and Core Tube Samples from Cayley Plains
- 500-mm and Panoramic Photography

3) Soil Mechanics Experiment (Trench Excavation and Penetrometer Tests) at Cayley Plains

*Selected periods for data reduction will be determined postmission.

4) ALSEP Deployment

- Passive Seismic
- Active Seismic
- Lunar Surface Magnetometer
- Heat Flow

5) Solar Wind Composition Experiment Deployment

6) Far UV Camera/Spectroscope Experiment Deployment, Targeting

7) Portable Magnetometer Measurements

8) Cosmic Ray Detector Experiment Deployment

9) Soil Mechanics Experiment

d) EVA 2. The traverse for EVA 2 activities is listed below and shown in Figure 3-12.

1) Lunar Geology Investigation Experiment

- o Surface Soil and Trench Soil Samples from Cayley Plains
- o Documented Samples, Rake/Soil Sample, Core Tube Samples, CVSC Sample, and Lunar Surface Sampler Samples from Stone Mountain
- o Documented Sampling from Stubby Crater
- o Core Tube, Rake/Soil, and Boulder Samples from South Ray Crater Rays
- o 500-mm and Panoramic Photography

2) Soil Mechanics Experiment

3) Far UV Camera/Spectroscope Experiment Targeting

e) EVA 3. The traverse for EVA 3 activities is listed below and shown in Figure 3-12.

1) Lunar Geology Investigation Experiment

- o Soil Samples and Rock Samples from Dot Crater
- o Rake/Soil, Boulder, Documented Rock Samples from North Ray Crater Vicinity

- o Double Core Tube and Rake/Soil Samples from base of Smoky Mountain
- o Documented Rock Samples and Soil/Rake Samples from Palmetto Crater Vicinity
- o 500-mm, Panoramic, and Polarimetric Photography

2) Portable Magnetometer Measurements at Cayley Plains

3) Soil Mechanics Experiment

4) Far UV Camera/Spectroscope Experiment Targeting

3.2.5 LM LIFT-OFF THROUGH TRANSEARTH INJECTION PREPARATION

a) Panoramic Camera Photography

b) Mapping Camera Photography

c) Laser Altimeter Measurements

d) X-Ray Fluorescence Experiment Operation

e) Alpha Particle Spectrometer Experiment Operation

f) Gamma-Ray Spectrometer Experiment Operation

g) Mass Spectrometer Experiment Operation

h) LM Ascent Stage Jettison, Deorbit, and S-Band Transponder tracking measurements, and Ascent Stage impact on the lunar surface for seismic measurements by the Passive Seismic Experiment recently emplaced (Figure 3-2).

i) Solar Corona Photography (sunrise and sunset)

j) UV Photography (lunar maria and terra)

k) Lunar Surface Photography (areas of prime scientific interest)

l) Gegenschein Photography

m) Bistatic Radar Experiment Operation

n) S-Band Transponder Experiment Operation*

o) Subsatellite Jettison and Experiment Operation

*Selected periods for data reduction will be determined postmission.

3.2.6 TRANSEARTH INJECTION (TEI) THROUGH TRANSEARTH COAST (TEC)

a) X-Ray Fluorescence Experiment Operation

b) Alpha Particle Spectrometer Experiment Operation

c) Gamma-Ray Spectrometer Experiment Operation

d) Mass Spectrometer Experiment Operation

e) UV Photography (two sets of moon early in TEC, one set of earth late in TEC)

f) SIM Bay EVA

g) Biostack Experiment

3.2.7 REENTRY THROUGH RECOVERY

a) Science data transfer from CSM to aircraft and transport to Ellington Air Force Base (EAFB), Texas

b) Science data transfer from EAFB to Lunar Receiving Laboratory (LRL), Manned Spacecraft Center, Houston, Texas

c) Storage of samples in LRL and subsequent processing and distribution for investigations

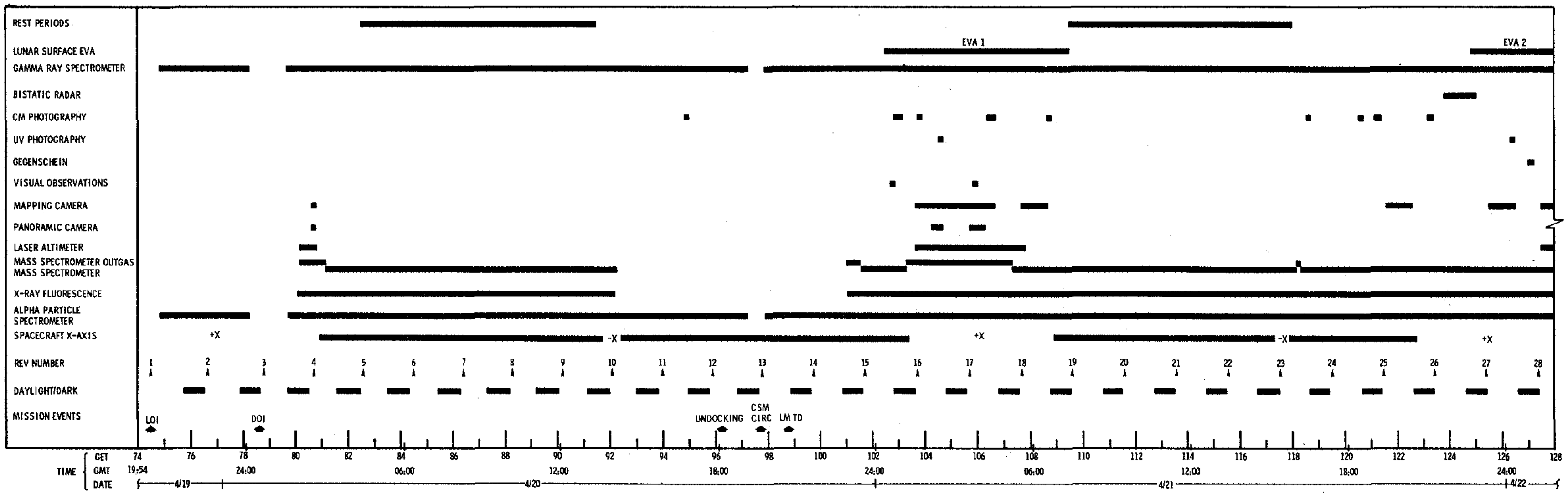


Figure 3-1. Apollo 16 Orbital Science Operational Periods (Sheet 1 of 3)

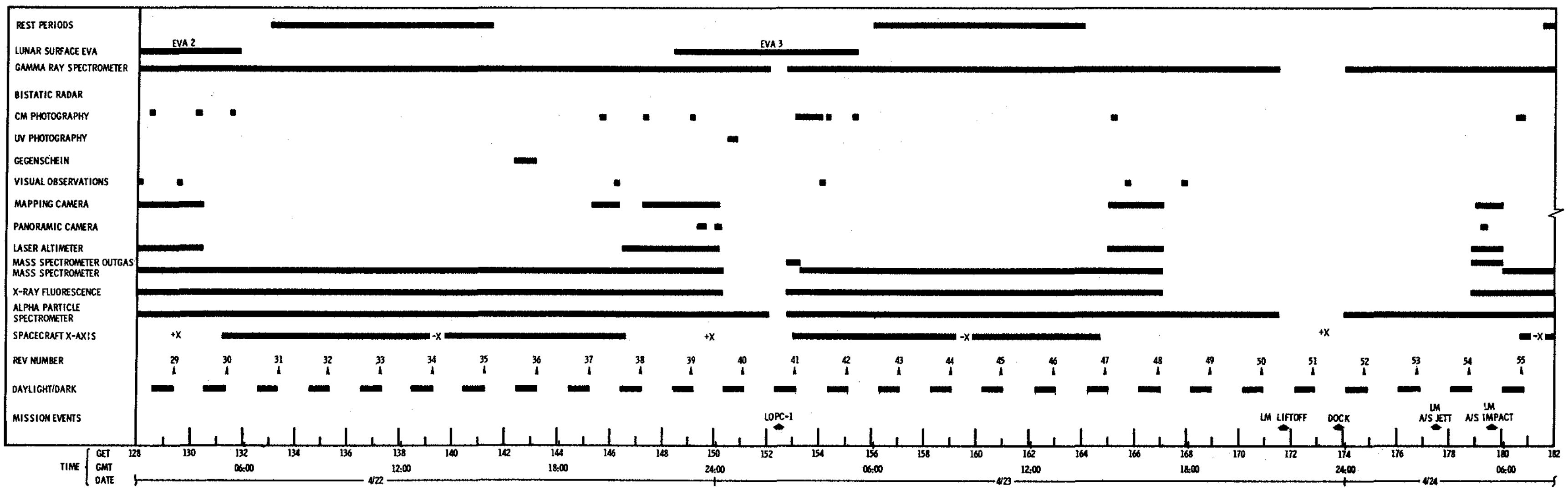


Figure 3-1. Apollo 16 Orbital Science Operational Periods (Sheet 2 of 3)

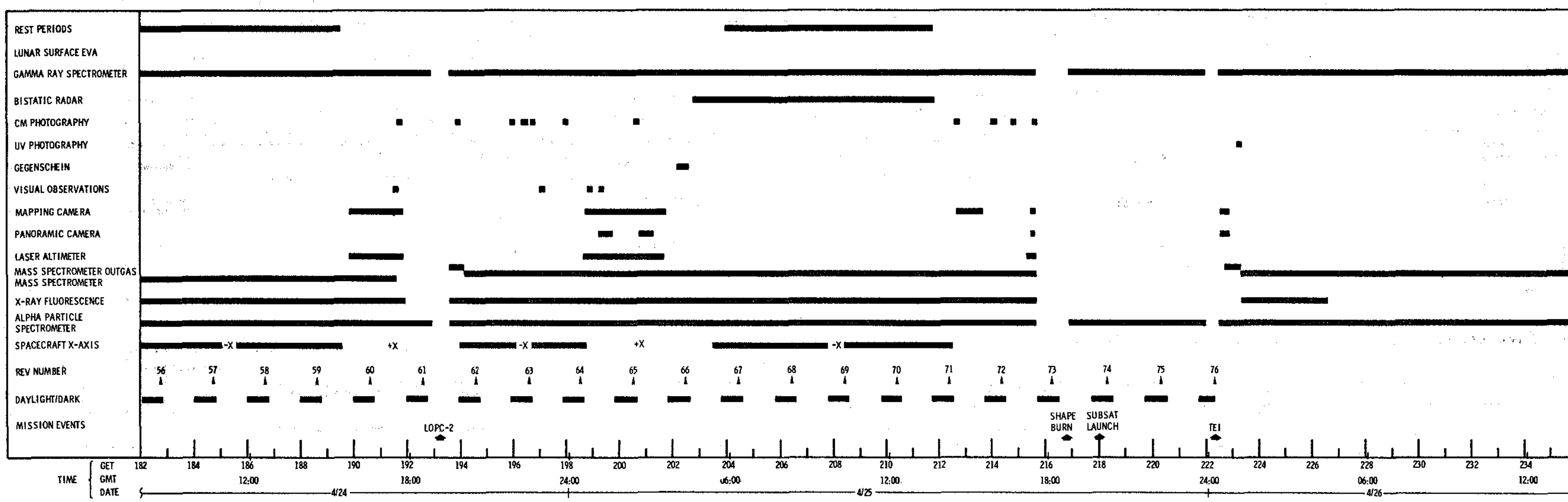


Figure 3-1. Apollo 16 Orbital Science Operational Periods (Sheet 3 of 3)

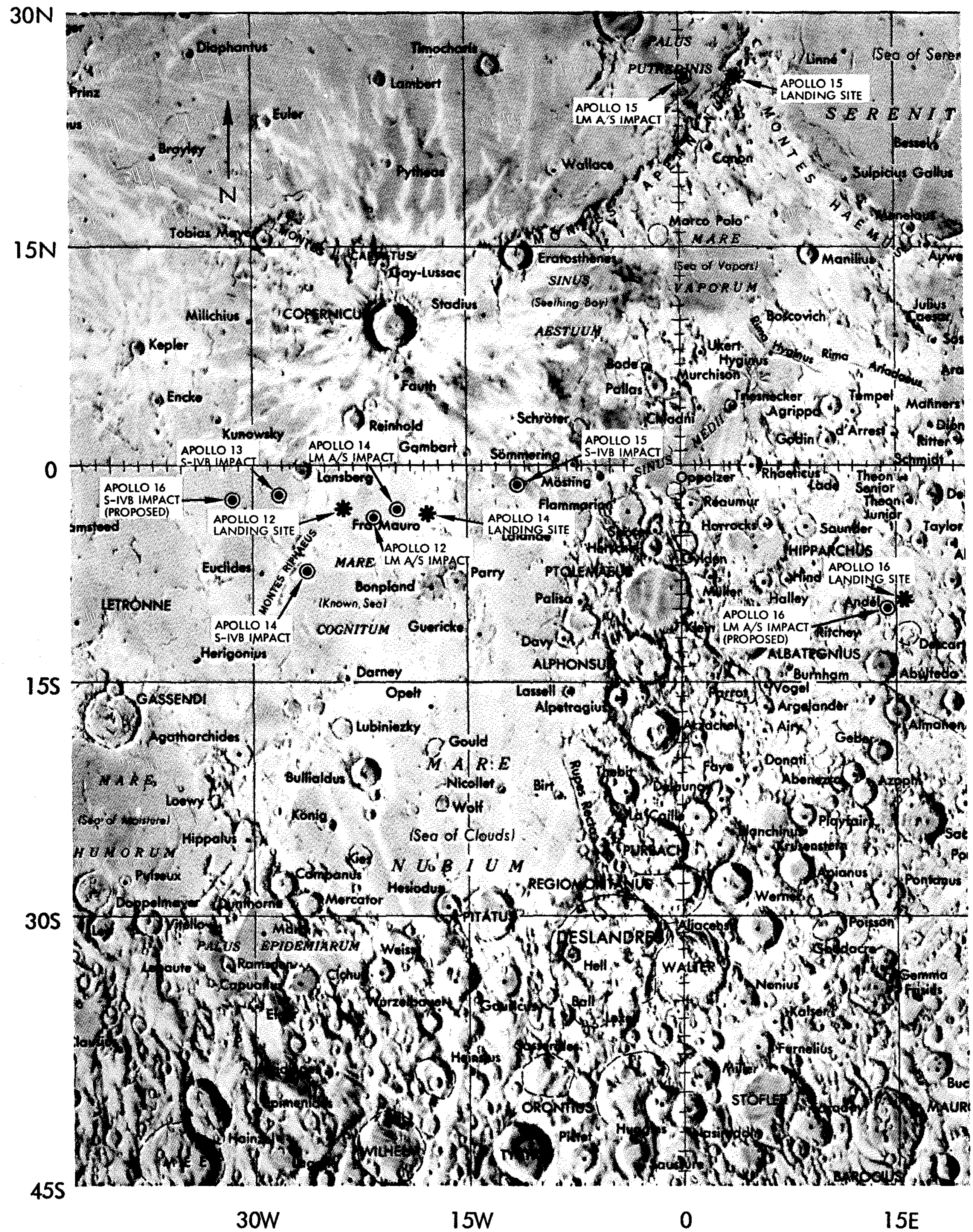


Figure 3-2. Apollo Spacecraft Lunar Surface Impact Locations

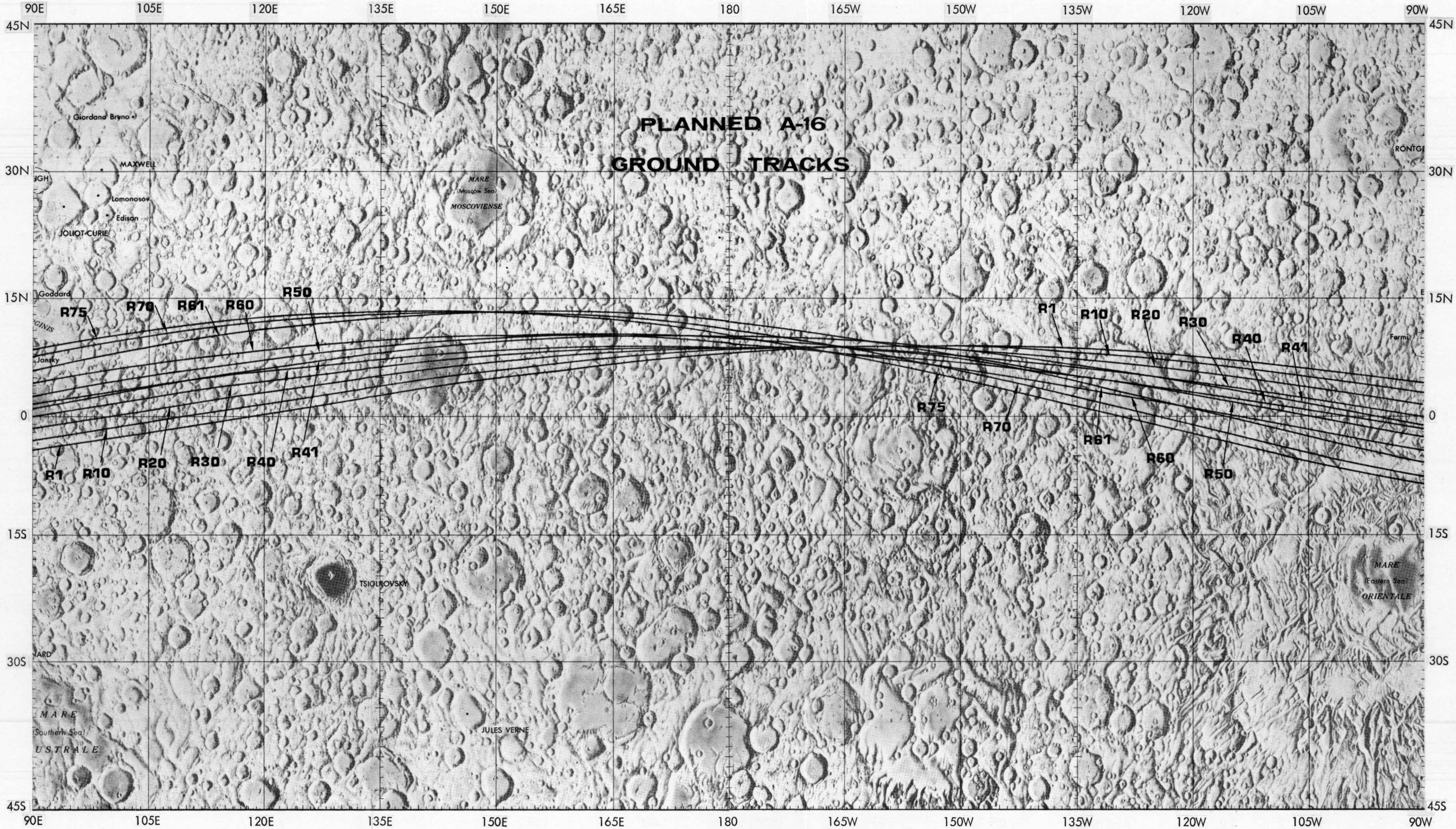


Figure 3-3(a). Apollo 16 CSM Lunar Surface Ground Tracks (Lunar Farside)

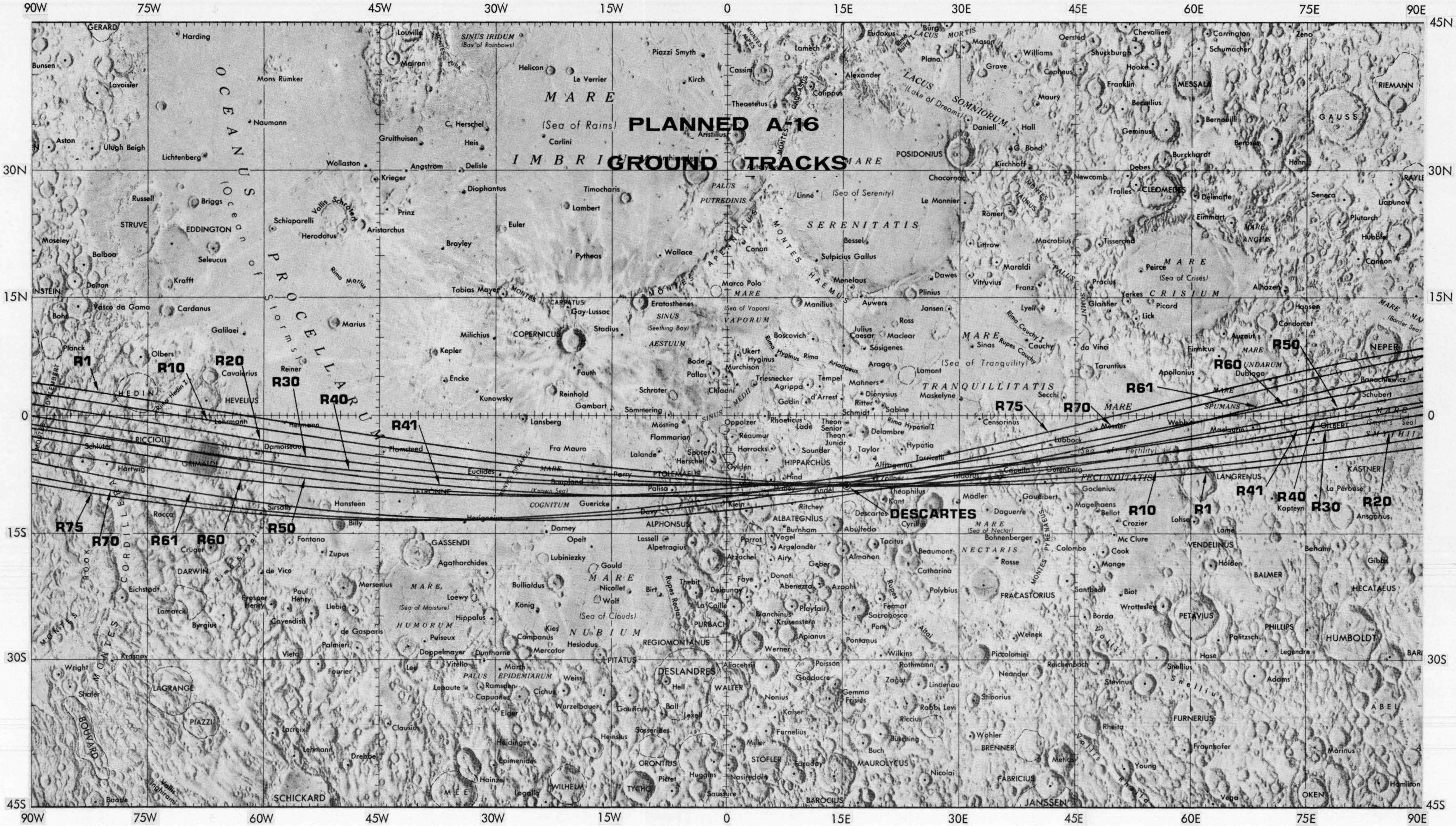


Figure 3-3(b). Apollo 16 CSM Lunar Surface Ground Tracks (Lunar Nearside)

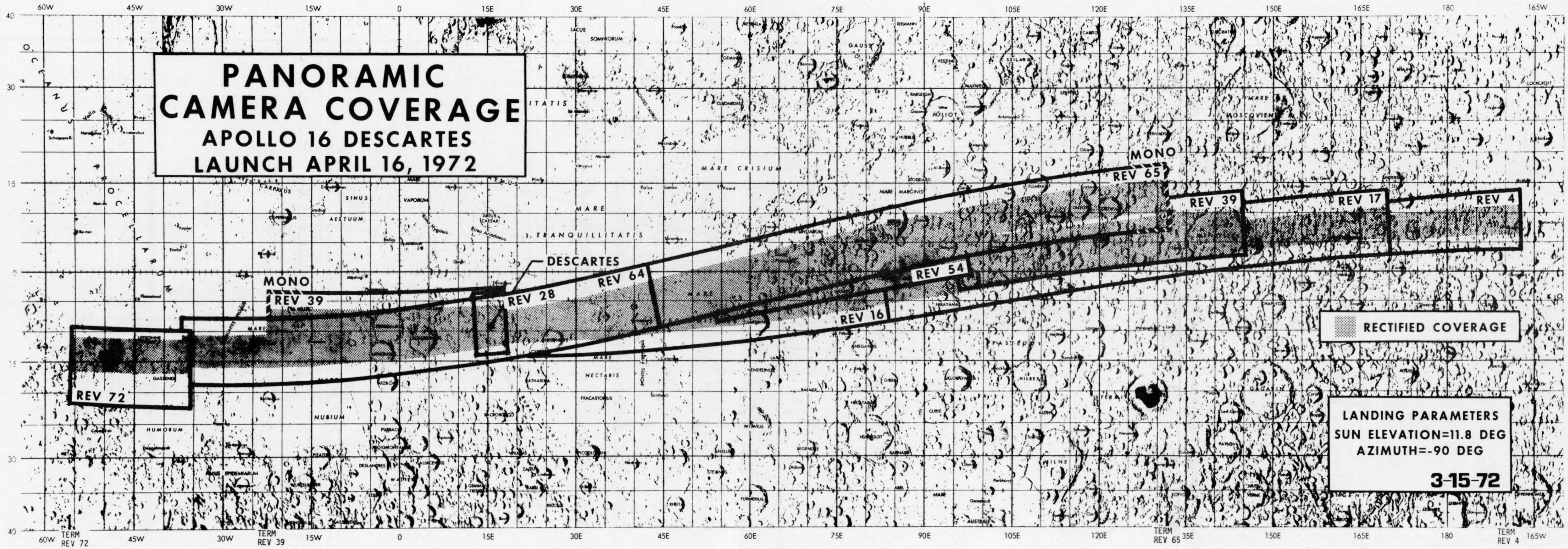


Figure 3-4. Lunar Surface Area Scan, Panoramic Camera

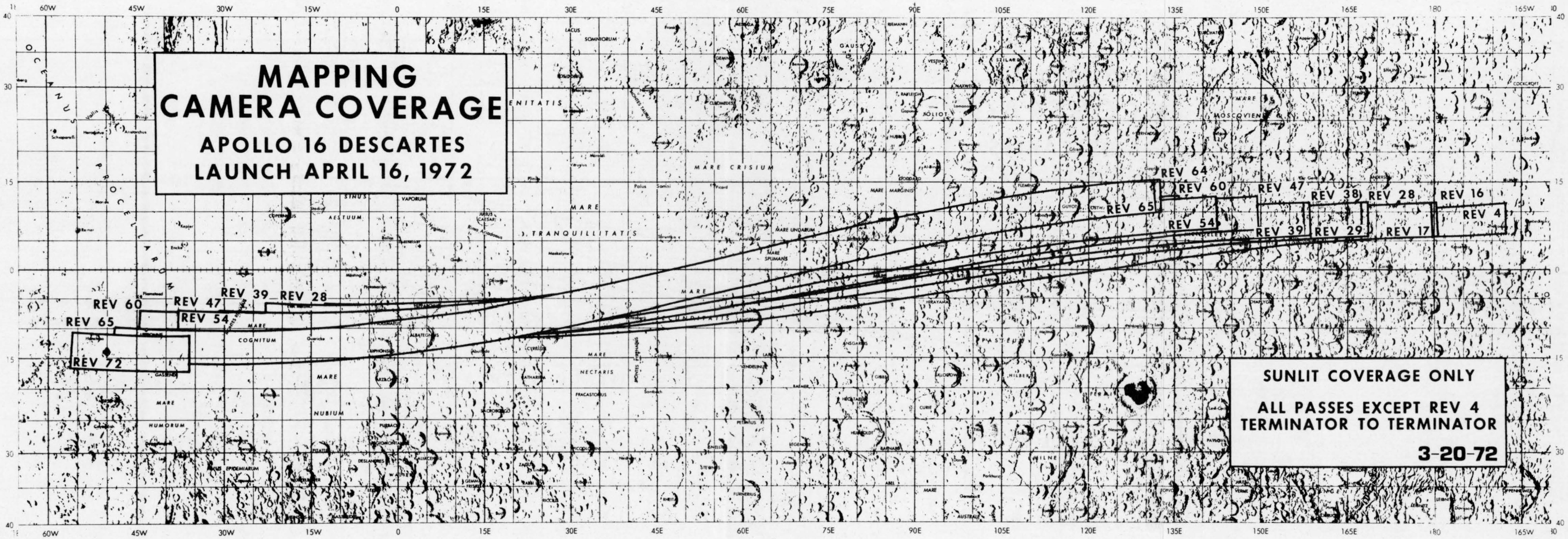


Figure 3-5. Lunar Surface Area Scan, Mapping Camera

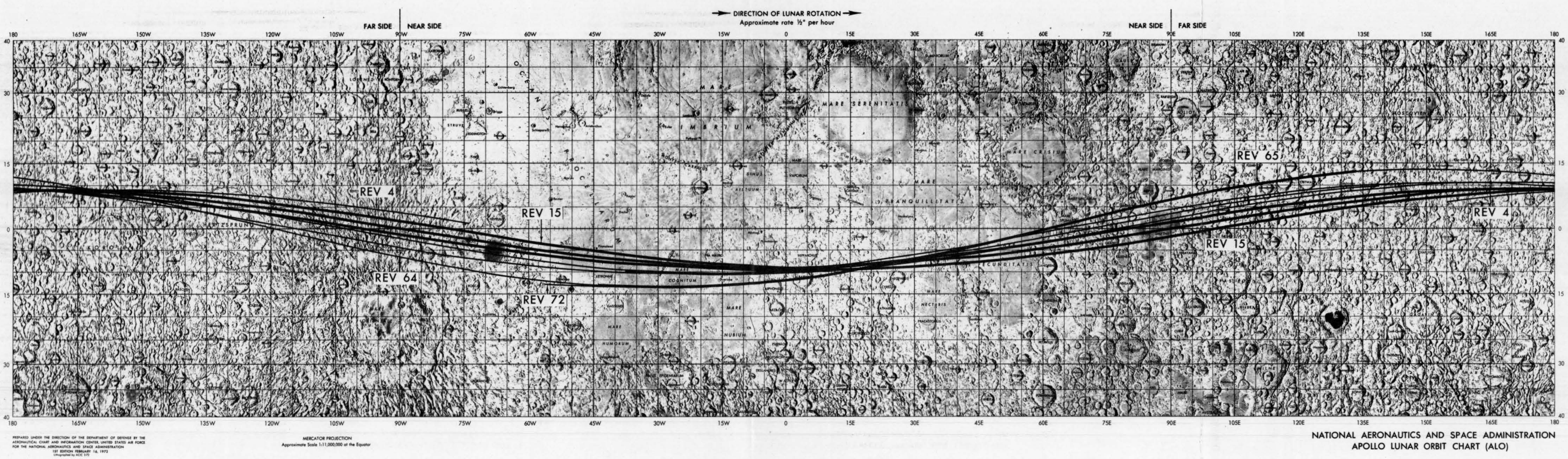


Figure 3-6. Lunar Surface Area Scan, Laser Altimeter

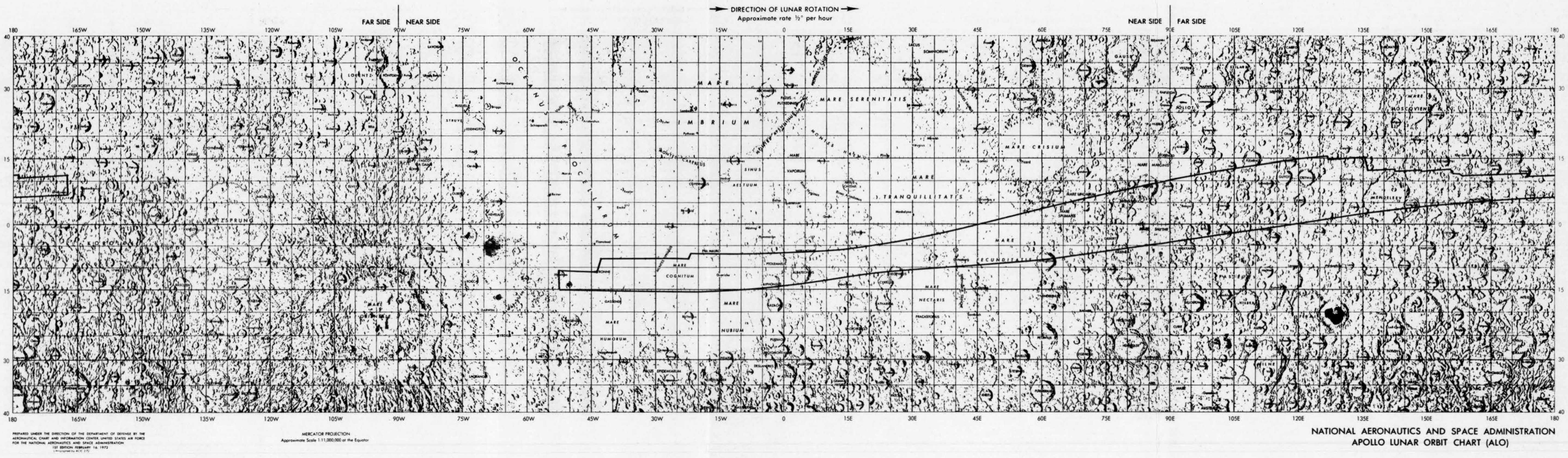


Figure 3-7. Lunar Surface Area Scan, X-Ray Fluorescence Experiment

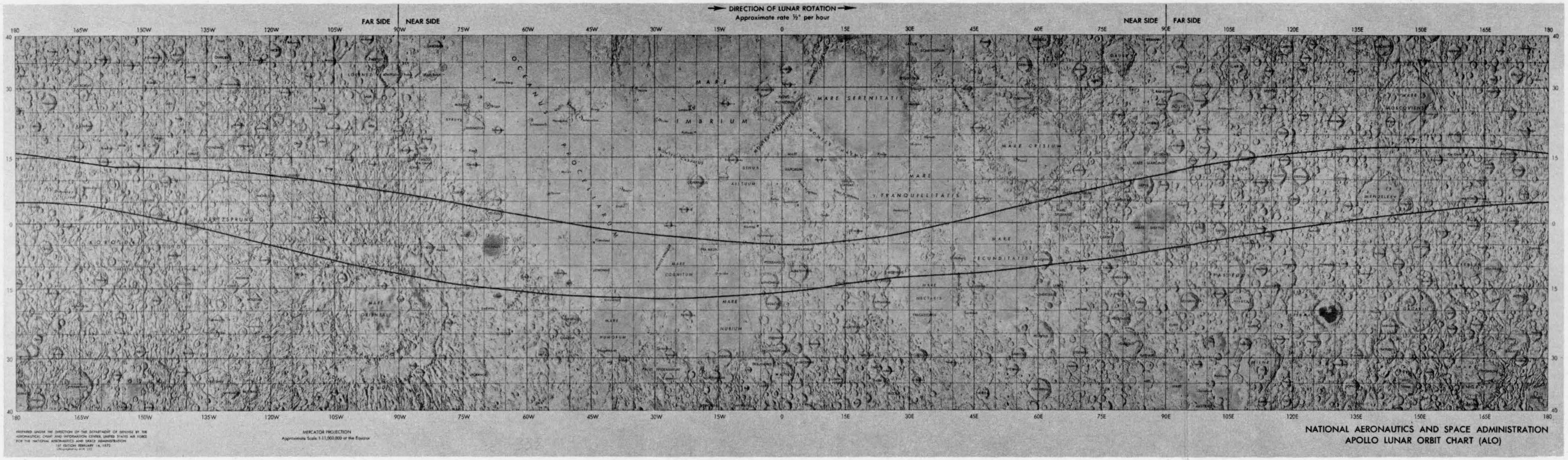


Figure 3-8. Lunar Surface Area Scan, Alpha Particle Spectrometer Experiment

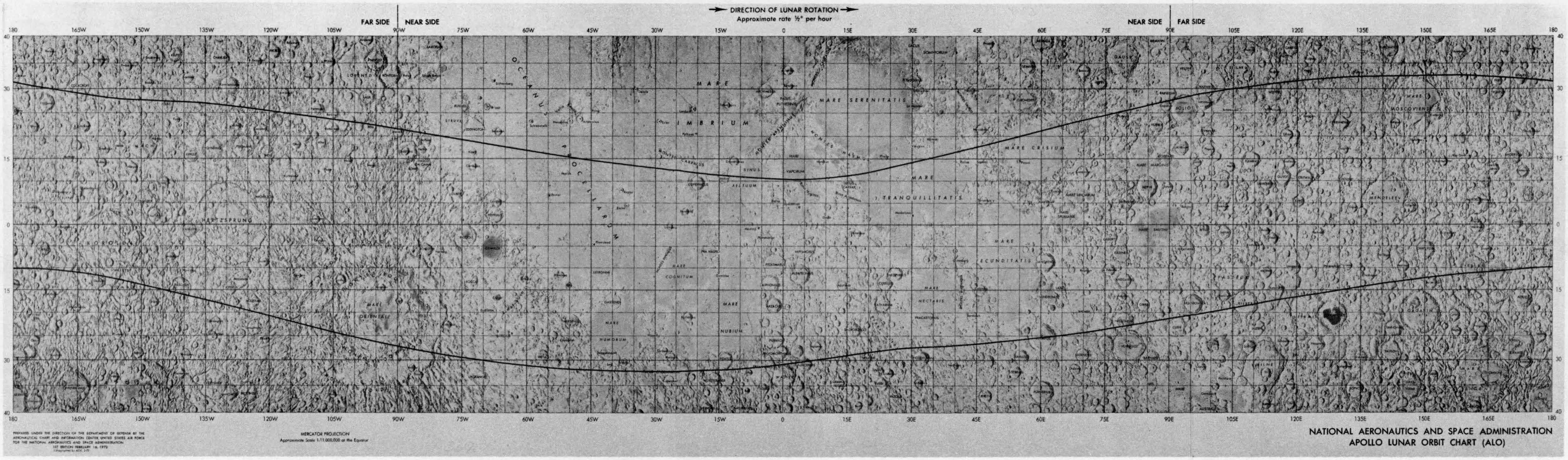


Figure 3-9. Lunar Surface Area Scan, Gamma-Ray Spectrometer Experiment

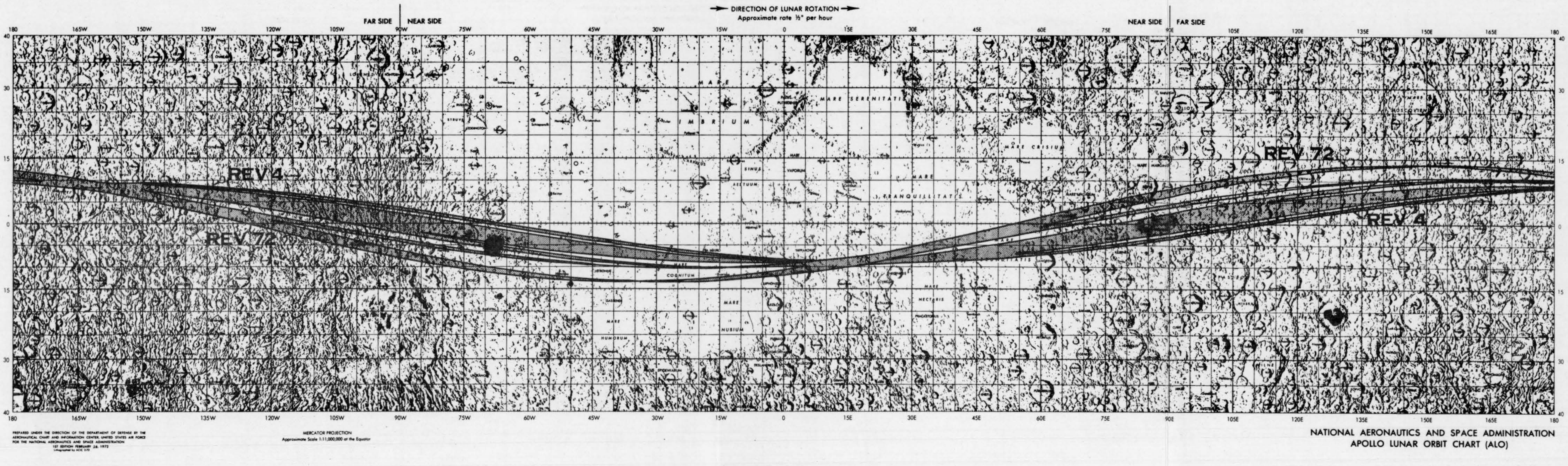


Figure 3-10. Lunar Surface Area Scan, Mass Spectrometer Experiment

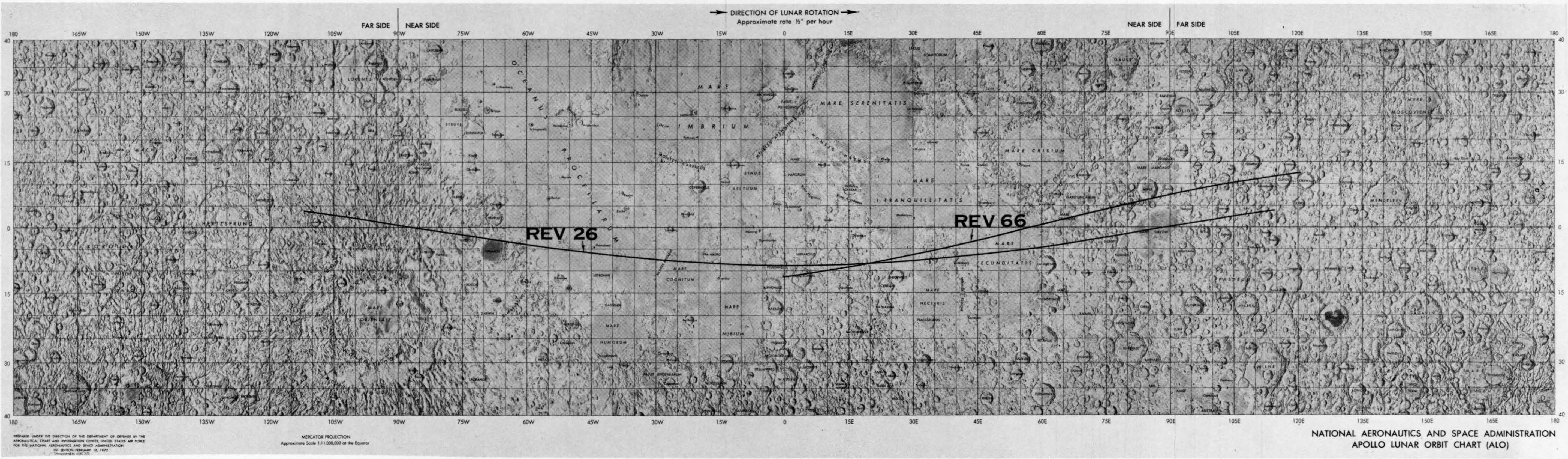


Figure 3-11. Lunar Surface Area Scan, Bistatic Radar Experiment

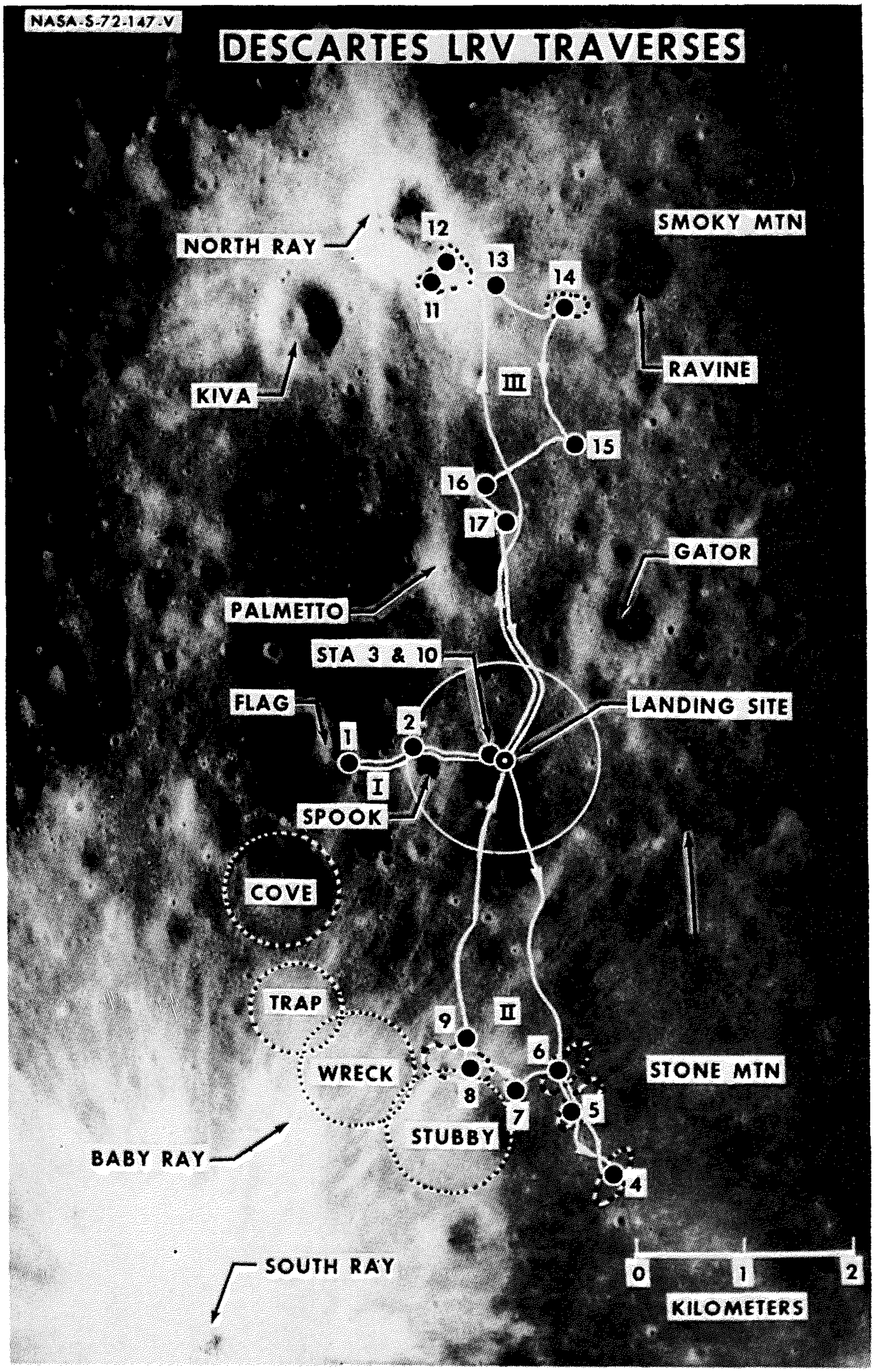


Figure 3-12. LRV Traverses - EVA 1, EVA 2, and EVA 3

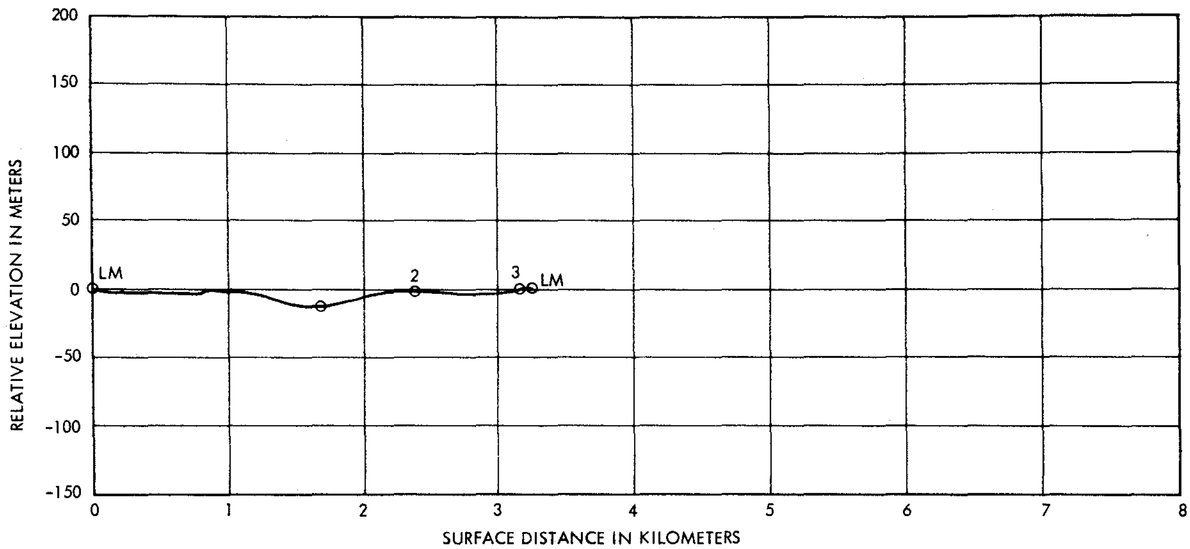


Figure 3-13(a). LRV Traverse Elevation Profile - EVA 1

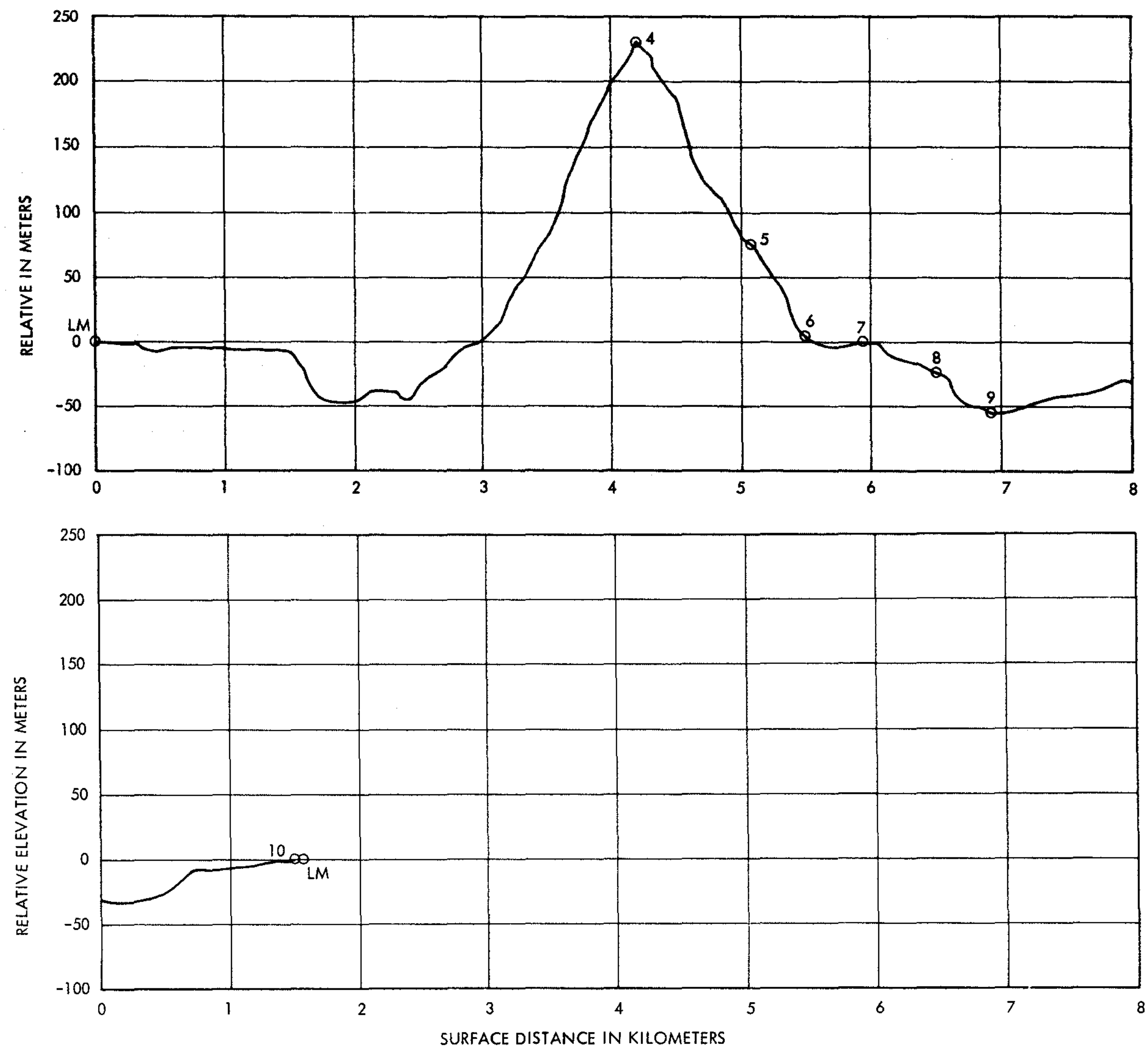


Figure 3-13(b). LRV Traverse Elevation Profile - EVA 2

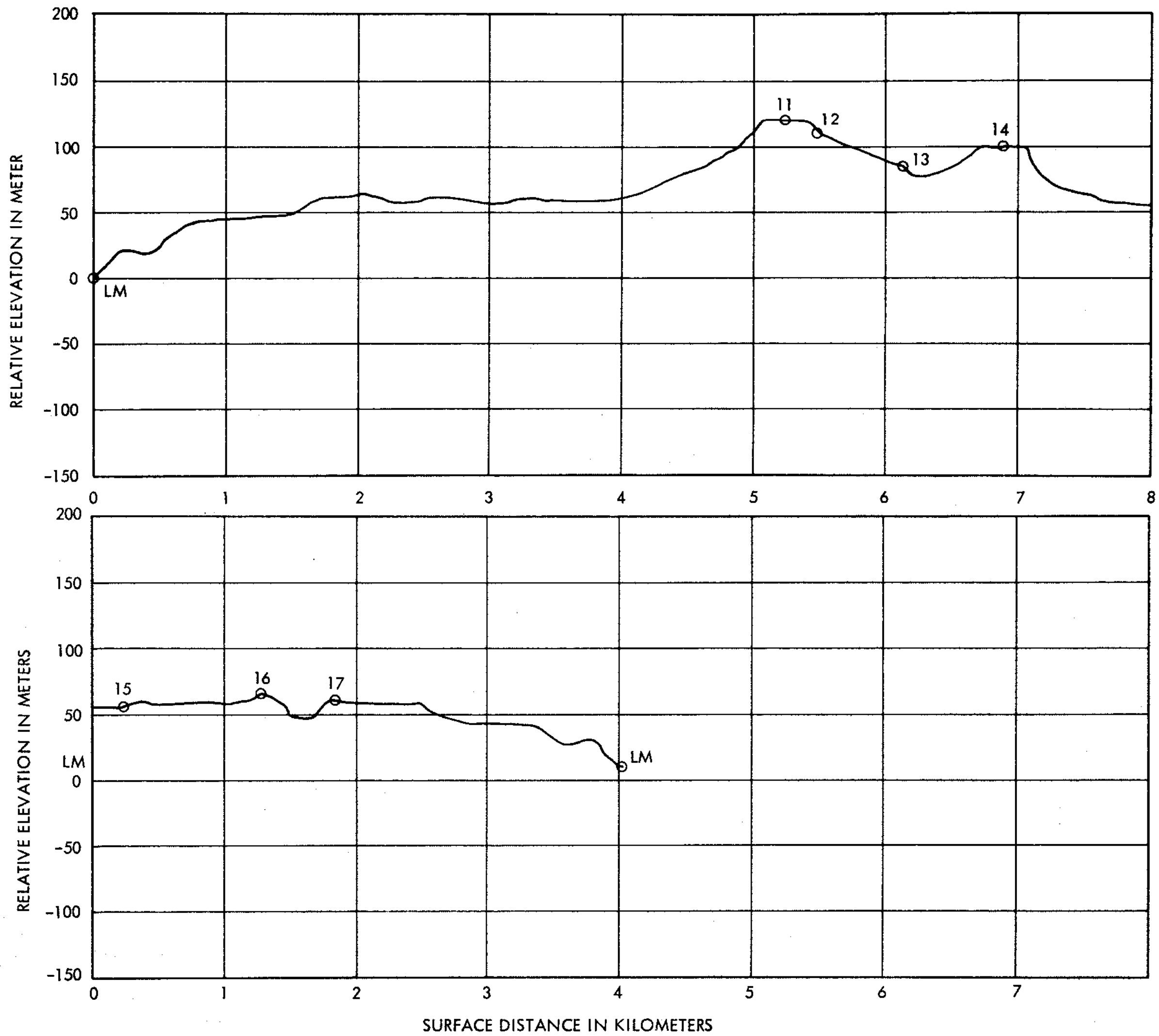


Figure 3-13(c). LRV Traverse Elevation Profile - EVA 3

Table 3-1. Apollo 16 Science Activities Schedule

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/16/72 (SUN)	11:54	0:00	LIFT-OFF		
	14:28	2:34	TLI		
	14:48	2:54	S-IVB MANEUVER TO SEPARATION ATTITUDE		
	14:58	3:04	CSM/S-IVB SEPARATION		
	15:08	3:14	CSM/LM DOCKING		
	15:53	3:59	CSM/LM EJECTION		
	16:16	4:22	S-IVB APS EVASIVE BURN		
	18:54	7:00		UV PHOTOS OF EARTH (15 MINS)	
	23:33	11:39	MCC-1		
4/17/72 (MON)	0:24	12:30		UV PHOTOS OF EARTH (15 MINS)	
	12:54	25:00		ELECTROPHORESIS DEMONSTRATION (1 HR 45 MINS)	
	17:24	29:30		UV PHOTOS OF EARTH	
	18:33	30:39	MCC-2		
4/18/72 (TUES)	10:54	47:00		VISUAL LIGHT FLASH TEST (1 HR 30 MINS)	
	13:54	50:00	SKYLAB FOOD TEST		
	16:23	52:29	MCC-3 (IF REQUIRED)		
	16:24	52:30		UV PHOTOS OF EARTH (15 MINS)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/19/72 (WED)	7:54	68:00		UV PHOTOS OF MOON (15 MINS)	
	9:23	69:29	MCC-4		
	9:53	69:59		SIM DOOR JETTISON; ALPHA PARTICLE (3 HRS 30 MINS)	
	10:54	71:00		GAMMA-RAY (2 HRS 30 MINS)	
	14:23	74:29	LOI		
	14:24	74:30	S-IVB LUNAR IMPACT		
	14:44	74:50		GAMMA-RAY, ALPHA PARTICLE (3 HRS 25 MINS)	
	18:30	78:36	DOI		
	19:36	79:42		GAMMA-RAY, ALPHA PARTICLE (17 HRS 33 MINS)	
	19:59	80:05		X-RAY (12 HRS 10 MINS)	
	20:04	80:10		MASS SPEC (12 HRS 5 MINS) LASER ALTM (38 MINS)	
	20:32	80:38		MAPPING CAMERA, PAN CAMERA (8 MINS)	
4/20/72 (THUR)	10:44	94:50		TERMINATOR PHOTOS (IF TIME AVAIL)	
	12:07	96:13	CSM/LM UNDOCKING AND SEPARATION		
	13:36	97:42	CSM CIRCULARIZATION BURN		
	13:49	97:55		GAMMA-RAY, ALPHA PARTICLE (54 HRS 10 MINS)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/20/72 (THUR) (CONTINUED)	14:29	98:35	PDI		
	14:41	98:47	LM LUNAR TOUCHDOWN		
	16:59	101:05		X-RAY, MASS SPEC (49 HRS, 15 MINS)	
	18:24	102:30	START EVA-1		
	18:35	102:41		ORBITAL SCIENCE VISUALS (LANDING SITE)	
	18:46	102:52		EARTHSHINE PHOTOS (S-IVB IMPACT AREA)	
	18:55	103:01		EARTHSHINE PHOTOS (REINER GAMMA AREA)	
	18:59	103:15			OFFLOAD, DEPLOY, INITIALIZE UV CAMERA
	19:32	103:38		MAPPING CAMERA (3 HRS 4 MINS) LASER ALTM (4 HRS)	
	19:37	103:43		ORBITAL SCIENCE PHOTOS (SHARONOV, MENDELEEV)	
	19:54	104:00			RESET UV CAMERA
	20:07	104:13			CONNECT RTG
	20:09	104:15		PAN CAMERA (26 MINS)	
	20:12	104:18			DEPLOY HEAT FLOW EXPERIMENT
	20:18	104:24			DEPLOY PASSIVE SEISMIC EXPERIMENT
	20:26	104:32	UV PHOTOS (LUNAR MARIA)		

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/20/72 (THUR) (CONTINUED)	20:34	104:40			ERECT CENTRAL STATION
	20:59	105:05			DEPLOY LUNAR SURFACE MAGNETOMETER
	21:09	105:15			DEPLOY ASE GEOPHONES
	21:24	105:30			PHOTOGRAPH ALSEP ARRAY
	21:39	105:45		PAN CAMERA (30 MINS)	
	21:46	105:52		ORBITAL SCIENCE VISUALS (MENDELEEV)	
	21:49	105:55			DEPLOY ASE MORTAR PACKAGE
	21:52	105:58			DRILL CORE SAMPLE
	22:17	106:23		ORBITAL SCIENCE PHOTOS (CROZIER)	
	22:27	106:33		ORBITAL SCIENCE PHOTOS (DESCARTES)	
	22:34	106:40			RAKE/SOIL SAMPLE, DOCUMENTED SAMPLES, AND PAN PHOTOGRAPHS AT STATION 1 (FLAG CRATER, ADJACENT TO RAY FROM SOUTH RAY CRATER)
4/21/72 (FRI)	23:24	107:30			LPM SITE MEASUREMENT, DOCUMENTED SAMPLING, PAN AND 500-MM PHOTOGRAPHS AT STATION 2 (SPOOK CRATER AND SMALL BLOCKY CRATER TO THE NORTH)
	23:34	107:40		MAPPING CAMERA (S. OBLIQUES) (1 HR)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/21/72 (FRI) (CONTINUED)	00:24	108:30			ARM MORTAR PACKAGE, RETRIEVE CORE STEMS, GRAND PRIX, SAMPLES AT STATION 3 (BETWEEN LM AND ALSEP)
	00:33	108:39		TERMINATOR PHOTOS (PTOLEMAEUS)	
	00:43	108:49			RESET UV CAMERA
	00:44	108:50			DEPLOY SOLAR WIND COMPOSITION EXPERIMENT
	00:45	108:51			PHOTOGRAPH UV CAMERA
	1:09	109:15			RESET UV CAMERA
	1:19	109:25	END EVA-1		
	10:30	118:36		TERMINATOR PHOTOS (DAVY RILLE)	
	12:27	120:33		TERMINATOR PHOTOS (ALPHONSUS)	
	13:04	121:10		GALACTIC PHOTOS (GUM NEBULA) (15 MINS)	
	13:28	121:34		MAPPING CAMERA (FORWARD OBLIQUES) (1 HR)	
	15:04	123:10		ZODIACAL LIGHT PHOTOS (15 MINS)	
	15:43	123:49		BISTATIC RADAR TEST (1 HR 11 MINS)	
	16:44	124:50	START EVA-2		
	16:59	125:05			RESET UV CAMERA

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/21/72 (FRI) (CONTINUED)	17:24	125:30		MAPPING CAMERA (N. OBLIQUES) (1 HR)	
	17:27	125:33			RESET UV CAMERA
	18:09	126:15			PENETROMETER MEASUREMENT, DOUBLE CORE TUBE SAMPLE, DOCUMENTED SAMPLING, PAN AND 500-MM PHOTOGRAPHS AT STATION 4 (HIGHEST POINT REACHED ON STONE MOUNTAIN)
	18:14	126:20		UV PHOTOS (LUNAR TERRA)	
	18:58	127:04		GEGENSCHEIN CALIBRATION PHOTOS	
	19:14	127:20			PAN PHOTOGRAPHS AND SAMPLING AT STATION 5 (INTERMEDIATE POINT ON WAY DOWN STONE MOUNTAIN)
	19:22	127:28		MAPPING CAMERA, LASER ALTM (3 HRS)	
	19:55	128:01		ORBITAL SCIENCE VISUALS (KAPTEYN)	
	19:57	128:03			PAN PHOTOGRAPHS AND SAMPLING AT STATION 6 (AT BASE OF TERRACE IN DESCARTES FORMATION ON STONE MOUNTAIN)
	20:19	128:25			PAN AND 500-MM PHOTOGRAPHS AND SAMPLING AT STATION 7 (BASE OF STONE MOUNTAIN NEAR STUBBY CRATER)
	20:21	128:27		TERMINATOR PHOTOS (GUERICKE)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/21/72 (FRI) (CONTINUED)	20:39	128:45			PAN AND 500-MM PHOTOGRAPHS, DOUBLE CORE TUBE SAMPLE, DOCUMENTED SAMPLES (INCLUDING BOULDER OPERATIONS) AT STATION 8 (NEAR STUBBY CRATER)
	21:22	129:28		ORBITAL SCIENCE VISUALS (FARSIDE HIGHLANDS)	
	21:43	129:49			PAN PHOTOGRAPHS, SINGLE CORE TUBE SAMPLE, CSVC, AND SURFACE SAMPLER OPERATION AT STATION 9 (IN RAYS FROM SOUTH RAY CENTER)
	22:06	130:12		ORBITAL SCIENCE PHOTOS (CATHARINA)	
	22:30	130:36			PAN PHOTOGRAPHS, DOUBLE CORE TUBE SAMPLE, DOCUMENTED SAMPLING, PENETROMETER MEASUREMENTS AT STATION 10 (SAME AS STATION 3)
	23:07	131:13			RESET UV CAMERA
	23:22	131:28		TERMINATOR PHOTOS (SPENCER JONES)	
	23:37	131:43			RESET UV CAMERA
	23:44	131:50	END EVA-2		
4/22/72 (SAT)	10:24	142:30		GEGENSCHEIN PHOTOS (43 MINS)	
	13:12	145:18		MAPPING CAMERA (N. OBLIQUES) (1 HR)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/22/72 (SAT) (CONTINUED)	13:30	145:36		ORBITAL SCIENCE PHOTOS (SAENGER)	
	14:03	146:09		ORBITAL SCIENCE VISUALS (ALPHONSUS)	
	14:21	146:27		LASER ALTM (3 HRS 53 MINS)	
	15:06	147:12		MAPPING CAMERA (3 HRS)	
	15:09	147:15		TERMINATOR PHOTOS (MILLS)	
	16:19	148:25	START EVA-3		
	16:36	148:42			RESET UV CAMERA
	16:54	149:00			RESET UV CAMERA
	16:56	149:02		SOLAR CORONA PHOTOS (SUNRISE)	
	17:14	149:20		PAN CAMERA (19 MINS)	
	17:49	149:55			PAN AND 500-MM PHOTOGRAPHS, POLARIMETRIC PHOTOGRAPHY AND SAMPLES, DOCUMENTED SAMPLING AT STATION 11 (VICINITY OF DOT CRATER)
	17:56	150:02		PAN. CAMERA (14 MINS)	
	18:45	150:51			SAMPLING AND PHOTOGRAPHS AT STATION 12 (NEAR OUTER EJECTA BLANKET OF NORTH RAY CRATER)
	19:22	151:28		UV PHOTOS (LUNAR HORIZON AND EARTH)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/22/72 (SAT) (CONTINUED)	19:46	151:52			SAMPLING AND PHOTOGRAPHS AT STATION 13 (SOUTH RIM OF NORTH RAY CRATER)
	19:60	152:06			SAMPLING (INCLUDING DOUBLE CORE) AND PHOTOGRAPHS AT STATION 14 (SOUTHEAST RIM OF NORTH RAY)
	20:23	152:29	CSM PLANE CHANGE NUMBER ONE		
	20:39	152:45		X-RAY, MASS SPEC (14 HRS 23 MINS) GAMMA-RAY, ALPHA PARTICLE (18 HRS 45 MINS)	
	20:54	153:00			PHOTOGRAPHS, LPM MEASUREMENT, AND SAMPLES AT STATION 15 (CRATER CLUSTER AT BASE OF SMOKY MOUNTAIN)
	20:59	153:05		MASS SPEC BOOM PHOTOS (1 HR 17 MINS)	
	21:14	153:20			PHOTOGRAPHS, LPM MEASUREMENT, AND SAMPLES AT STATION 16 (RIM OF PALMETTO CRATER)
	21:27	153:33			PHOTOGRAPHS, LPM MEASUREMENTS (2), AND SAMPLES AT STATION 17 (SOUTH RIM OF PALMETTO CRATER)
	21:55	154:01		ORBITAL SCIENCE VISUALS (LANDING SITE)	
	22:08	154:14		TERMINATOR PHOTOS (DARNEY)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/22/72 (SAT) (CONTINUED)	22:29	154:35			RESET UV CAMERA
	23:07	155:13		ORBITAL SCIENCE PHOTOS (KOHLSCHUTTER) (11 MINS)	
	23:19	155:25	END EVA-3		
4/23/72 (SUN)	8:54	165:00		MAPPING CAMERA, LASER ALTM (2 HRS 5 MINS)	
	8:58	165:04		TERMINATOR PHOTOS (ST. JOHN)	
	9:33	165:39		ORBITAL SCIENCE VISUALS (COLOMBO HIGHLANDS)	
	11:43	167:49		ORBITAL SCIENCE VISUALS (LANDING SITE)	
	15:39	171:45	LM LUNAR LIFT-OFF		
	15:46	171:52	LM LUNAR ORBIT INSERTION		
	16:33	172:39	TPI		
	16:48	172:54	LM MCC-1		
	17:03	173:09	LM MCC-2		
	17:44	173:50	CSM/LM DOCKING		
	17:54	174:00		GAMMA-RAY, ALPHA PARTICLE (18 HRS 55 MINS)	
	21:25	177:31	LM JETTISON		
	21:30	177:36	CSM SEPARATION		

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/23/72 (SUN) (CONTINUED)	22:44	178:50		MASS SPEC (12 HRS 45 MINS) X-RAY (13 HRS 5 MINS) LASER ALTM (1 HR 10 MINS)	
	22:52	178:58		MAPPING CAMERA (1 HR)	
	23:07	179:13		PAN CAMERA (15 MINS)	
	23:33	179:39	LM A/S LUNAR IMPACT		
4/24/72 (MON)	00:28	180:34		GALACTIC PHOTOS (GUM NEBULA) (15 MINS)	
	9:46	189:52		MAPPING CAMERA, LASER ALTM (2 HRS)	
	11:23	191:29		ORBITAL SCIENCE VISUALS (LANDING SITE)	
	11:34	191:40		ORBITAL SCIENCE PHOTOS (PARRY)	
	13:08	193:14	CSM PLANE CHANGE NUMBER TWO		
	13:29	193:35		ALPHA PARTICLE, X-RAY (22 HRS 5 MINS); GAMMA-RAY, MASS SPEC (21 HRS 45 MINS)	
	13:44	193:50		TERMINATOR PHOTOS (LETRONNE)	
	15:49	195:55		SOLAR CORONA PHOTOS (SUNSET)	
	16:13	196:19		GALACTIC PHOTOS (GUM NEBULA) (15 MINS)	
	16:43	196:49		TERMINATOR PHOTOS (VETCHINKIN)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/24/72 (MON) (CONTINUED)	16:56	197:02		ORBITAL SCIENCE VISUALS (GODDARD)	
	17:48	197:54		SOLAR CORONA PHOTOS (SUNSET)	
	18:37	198:43		MAPPING CAMERA, LASER ALTM (3 HRS)	
	18:43	198:49		ORBITAL SCIENCE VISUALS (KING)	
	19:10	199:16		PAN CAMERA (27 MINS)	
	19:11	199:17		ORBITAL SCIENCE VISUALS (ISODORUS/CAPELLA)	
	20:30	200:36		SOLAR CORONA PHOTOS (SUNRISE)	
	20:40	200:46		PAN CAMERA (30 MINS)	
	22:05	202:11		GEGENSCHEIN PHOTOS (25 MINS)	
	22:42	202:48		BISTATIC RADAR TEST (9 HRS)	
4/25/72 (TUES)	8:32	212:38		ORBITAL SCIENCE PHOTOS (FLEMING)	
	8:34	212:40		MAPPING CAMERA (S. OBLIQUES) (1 HR)	
	9:55	214:01		GALACTIC PHOTOS	
	10:41	214:47		ORBITAL SCIENCE PHOTOS (AL-BIRUNI)	
	11:05	215:11		ORBITAL SCIENCE PHOTOS (DESCARTES)	
	11:10	215:16		ORBITAL SCIENCE PHOTOS (VOGEL/LASSELL)	

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/25/72 (TUES) (CONTINUED)	11:18	215:24		ORBITAL SCIENCE PHOTOS (BULLIALDUS/GASSENDI)	
	11:24	215:30		PAN CAMERA, MAPPING CAMERA (7 MINS)	
	11:28	215:34		ORBITAL SCIENCE PHOTOS (HANSTEEN)	
	12:43	216:49	CSM SHAPING BURN		
	12:49	216:55		GAMMA-RAY, ALPHA PARTICLE (5 HRS 5 MINS)	
	13:56	218:02		SUBSATELLITE LAUNCH	
	18:15	222:21	TEI		
	18:24	222:30		GAMMA-RAY, ALPHA PARTICLE (16 HRS 40 MINS)	
	18:29	222:35		PAN CAMERA, MAPPING CAMERA (TO FILM DEPLETION)	
	18:41	222:47		MASS SPEC (16 HRS 23 MINS)	
	19:05	223:11		UV PHOTOS OF MOON	
	19:16	223:22		X-RAY (3 HRS 13 MINS)	
	19:46	223:52		X-RAY POINTING (SCO X-1)	
4/26/72 (WED)	9:58	238:04		SOLAR CORONA CALIBRATION PHOTOS	
	11:15	239:21	MCC-5		
	13:54	242:00	TEC EVA (1 HR)		
	14:04	242:10	30 MINS TV COVERAGE		

Table 3-1. Apollo 16 Science Activities Schedule (Continued)

DATE (DAY)	TIME		MISSION EVENT	SCIENCE EVENT	
	CST	GET		CSM	LM/LUNAR SURFACE
4/26/72 (WED) (CONTINUED)	16:16	244:22		X-RAY POINTING (CYG X-1)	
	17:04	245:10		GAMMA-RAY, ALPHA PARTICLE, MASS SPEC (40 HRS 20 MINS); X-RAY (3 HRS 32 MINS)	
	20:54	249:00		X-RAY (SCO X-1) (2 HRS 26 MINS)	
4/27/72 (THUR)	14:39	266:45		X-RAY (3 HRS 10 MINS)	
	15:09	267:15		X-RAY POINTING (SCO X-1)	
	16:17	268:23	MCC-6 (IF REQUIRED)		
	20:54	273:00		X-RAY (12 HRS 30 MINS)	
	21:24	273:30		X-RAY POINTING (CYG X-1)	
4/28/72 (FRI)	11:17	287:23	MCC-7 (IF REQUIRED)		
	11:44	287:50		UV PHOTOS OF EARTH	
	14:01	290:07	CM/SM SEPARATION		
	14:17	290:23	ENTRY INTERFACE		
	14:30	290:36	SPLASHDOWN		

Table 3-2. Apollo 16 Television Schedule

DAY	DATE	CST	GET (HR:MIN)	DURATION (HR:MIN)	ACTIVITY SUBJECT	VEHICLE	STATION
SUNDAY	16 APR	3:03 PM	3:09	0:19	TRANSPOSITION AND DOCKING	CSM	GDS
THURSDAY	20 APR	6:19 PM	102:25	6:47	LUNAR SURFACE EVA-1*	LM/LRV	GDS
FRIDAY	21 APR	5:04 PM	125:10	6:35	LUNAR SURFACE EVA-2*	LRV	GDS
SATURDAY	22 APR	4:40 PM	148:45	6:39	LUNAR SURFACE EVA-3*	LRV	GDS
SUNDAY	23 APR	3:24 PM	171:30	0:25	LM LIFT-OFF	LRV	MAD
SUNDAY	23 APR	5:16 PM	173:20	0:06	RENDEZVOUS	CSM	GDS
SUNDAY	23 APR	5:40 PM	173:46	0:05	DOCKING	CSM	GDS
WEDNES-DAY	26 APR	1:49 PM	241:55	1:10	TRANSEARTH EVA	CSM	MAD

*TV will not be used while LRV is in motion.

Table 3-3(a). LRV Traverse Data - EVA 1

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
LM	-	-	97	97	N/A	N/A	1:37	Cayley Plains	Egress and EVA preparation.
Travel	0.10	0.10	01	98	-	-	1:38	Cayley Plains	Travel to ALSEP location.
ALSEP	-	-	144	242	N/A	N/A	4:02	Cayley Plains	ALSEP deployment.
Travel	1.5	1.60	12	254	-	-	4:14	Across Cayley Plains and Rays	Observe Station 2 area and distribution of ray material.
1 (Flag Crater)	-	-	43	297	36	36	4:57	Flag Crater, about 300 meters in diameter in Caylay Plains; adjacent ray from South Ray Crater	Exploration of crater and observations of adjacent ray: • Pan; Take 2nd Pan if time permits • Crater sampling (use padded bags here) • Rake/Soil Sample
Travel	0.65	2.25	5	302	-	-	5:02	Across Cayley Plains and Rays	Assess Station 2 region for best sampling area.
2 (Spook Crater locale)	-	-	56	358	49	85	5:58	Spook Crater (about 300-m diameter) and small blocky crater to the north	Assess site geology and, based on this and results from Flag Crater, divide time between Spook and small blocky crater: • Pan • Documented sampling • Spook Crater rim • Blocks associated with small crater • 500-mm photography of outlying areas • LPM Site Measurement
Travel	0.85	3.10	7	365	-	-	6:05	Cayley Plains	Observe ray patterns and terrain of EVA II route to Stone Mountain.

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 3-3(a). LRV Traverse Data - EVA 1 (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
3 (LM/ ALSEP Vicinity)	-	-	14	379	11	96	6:19	Cayley Plains between LM and ALSEP	• LRV Grand Prix • Retrieve 2.6m Core Sample • Arm Mortar Package
Travel	0.05	3.15	1	380	-	-	6:20		Travel to LM.
LM	-	-	40	420	NAP	NAP	7:00	Cayley Plains	EVA closeout.

Table 3-3(b). LRV Traverse Data - EVA 2

STATION OR TRAVEL	DISTANCE (km) TO STATION	DISTANCE (km) CUMULATIVE	STATION STOP OR TRAVEL TIME (min) INDIVIDUAL	STATION STOP OR TRAVEL TIME (min) CUMULATIVE	STATION SCIENCE TIME (min)* INDIVIDUAL	STATION SCIENCE TIME (min)* CUMULATIVE	EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
LM	-	-	50	50	N/A	N/A	0:50	Cayley Plains	Egress and EVA preparation.
Travel	4.20	4.20	35	85	-	-	1:25	Across Cayley Plains and rays from South Ray Crater and up on Stone Mountain	Observe distribution of rays, abundance of blocks, and secondary craters. Observe any changes of regolith characteristics upon approach to and on Stone Mountain slope.
4 (Stone Mt. Highest Traverse Elevation)	-	-	58	143	51	51	2:23	Small craters at base of terrace in Descartes Formation. The highest point reached in the Descartes Formation on Stone Mountain.	Observation and sampling of Descartes formation: • Pan; Take 2nd Pan at end of stop, time permitting • Penetrometer Tests • Documented Sampling • Rake/Soil Samples • Double Core Sample • 500-mm Photography
Travel	0.80	5.00	7	150	-	-	2:30	Descartes Formation (Stone Mountain Slope)	Observe any changes of regolith characteristics upon descent from Stone Mountain. Note slope characteristics on Stone Mountain.
5 (Stone Mt-Midway down slope)	-	-	40	190	33	84	3:10	Intermediate area in cratered and terraced region of Descartes Formation.	• Pan; Take 2nd Pan at end of stop, time permitting • Documented Sampling
Travel	0.40	5.40	3	193	-	-	3:13	Descartes Formation to base of Stone Mountain	Observe terraces and any bedrock/regolith changes.
6 (Stone Mt. - Base)	-	-	20	213	17	101	3:33	Descartes Formation at base of Stone Mountain	Observation and sampling of Descartes Formation: • Pan • Documented Sampling

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 3-3(b). LRV Traverse Data - EVA 2 (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
Travel	0.40	5.80	3	216	-	-	3:36	Descartes Formation	Observe terraces and any bedrock/regolith changes.

7 (Stone Mt. Base and Stubby Crater Locale)	-	-	15	231	8	110	3:51	In Descartes Formation at base of Stone Mountain near Stubby Crater	Observe relations between Cayley and Descartes Formation in Stubby Crater area:
									• Pan
									• Documented Sampling
									  • Stubby Rim
									• 500-mm photography
									  • South wall of Stubby Crater
									  • Other targets

Travel	0.60	6.40	5	236	-	-	3:56	Across Cayley Formation to rays from South Ray Crater	Observe changes in regolith and note characteristics of rays.
8 (South Ray Rays and Stubby Crater Locale)	-	-	60	296	53	163	4:56	In rays from South Ray Crater overlying Cayley and Stubby Crater rim	In blocky ray area: • Pan; Take 2nd Pan, time permitting • Documented Sampling • Rake/Soil Sample • Double Core Sample • Boulder Sampling Operations
Travel	0.45	6.85	4	300	-	-	5:00	Across Cayley Formation	Observe changes in regolith and note characteristics of rays
9 (Cayley Plains)	-	-	25	325	18	181	5:25	Cayley Plains area	• Pan • Documented Sampling • CSVC • Top Surface Layer Samples

Table 3-3(b). LRV Traverse Data - EVA 2 (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
Travel	2.60	9.45	21	346	-	-	5:46	Across Cayley Plains	Observe ray and block distribution, compare to other rays and regolith.
10 (LM/ ALSEP Area-Station 3 Locale)	-	-	33	379	26	207	6:19	Cayley Plains between LM and ALSEP	• Double Core Sample • Soil Mechanics Trench • Trench Samples • Penetrometer Tests • Brief Documented Sampling Period
Travel	0.05	9.50	1	380	-	-	6:20	Cayley Plains	Characteristics of Cayley and Rays.
LM	-	-	40	420	N/A	N/A	7:00	Cayley Plains	Closeout.

Table 3-3(c). LRV Traverse Data - EVA 3

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
LM	-	-	45	45	N/A	N/A	0:45	Cayley Plains	Egress and prepare for traverse
Travel	5.50	5.50	44	89	-	-	1:29	Across Cayley to North Ray Crater	Observe Cayley and Rays from North Ray Crater Observe block distribution and variety while maneuvering through outer ejecta blanket
11 (North Ray Crater Rim)	-	-	55	144	48	48	2:24	South rim of North Ray Crater	• Pan; Take 2nd Pan prior to leaving station • 500-mm photography of north crater rim and interior • Documented Sampling • Near field and far field polarimetric photography and near field polarimetry sampling • 2nd far field polarimetric photography before leaving station
Travel	0.35	5.85	3	147	-	-	2:27	Around rim of North Ray Crater	Observe rays and approach to ejecta blanket - Note block variety and distribution
12 (North Ray Crater Rim)	-	-	55	202	48	96	3:22	Area of very large blocks on southeast rim of North Ray Crater	• Pan; Take 2nd Pan before leaving, time permitting • Documented Sampling • Rake/Soil Sample • 500-mm photography of far crater rim and interior
Travel	0.65	6.50	5	207	-	-	3:27	Down slope and outer ejecta blanket of North Ray Crater	Observe block distribution and variety
13 (North Ray Crater Ejecta Blanket)	-		10	217	7	103	3:37	Area near outer ejecta blanket of North Ray Crater	Examine Ejecta: • Pan • Rock/Soil Sample

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 3-3(c). LRV Traverse Data - EVA 3 (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
Travel	0.85	7.13	7	224	-	-	3:44	From North Ray blanket ejecta to base of Smoky Mountain (Descartes Formation) near Ravine Crater	Observe transition with Smoky Mountain.
14 (Smoky Mountain Base)	-	-	40	264	33	136	4:24	Crater cluster at base of Smoky Mountain near Ravine Crater	In Descartes Formation • Pan; Take 2nd Pan before leaving, time permitting • 500-mm photography of Smoky Mountain • Documented Sampling • Rake/Soil Sample • Double Core Sample
Travel	1.35	8.70	11	275	-	-	4:35	From base of Smoky Mountain (Descartes Formation) To Dog Leg Crater in the Cayley Formation	Observe transition with Smoky Mountain.
15 (Dog Leg Crater)	-	-	10	285	7	143	4:45	Small crater in the Cayley Formation	In Cayley Plains: • Pan • LPM measurement • Rock/Soil Sample
Travel	1.10	9.80	9	294	-	-	4:54	South across Cayley Plains to Dot Crater	Observe Cayley formation and rays emanating from North Ray Crater.
16 (Dot Crater)	-	-	10	304	7	150	5:04	Dot Crater, Blocky-Rimmed, possibly concentric crater	• Pan • Rock/Soil Sample • LPM measurement

Table 3-3(c). LRV Traverse Data - EVA 3 (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
Travel	0.55	10.35	5	309	-	-	5:09	Across Cayley Plains to Palmetto Crater	Observe lateral changes in Cayley characteristics.
17 (Pal-metto Crater)	-	-	38	347	31	181	5:47	Cayley Plains near Palmetto Crater	• Pan; Take 2nd Pan at end of stay, time permitting • Documented Sampling • Rake/Soil Sample • LPM site measurement • LPM igneous sample measurement
Travel	2.25	12.60	18	365	-	-	6:05	Across Cayley Plains toward LM	Observe characteristics of Cayley Plains.
LM	-	-	55	420	N/A	N/A	7:00	Cayley Plains	LRV Grand Prix No. 2 Closeout

SECTION IV

CONTINGENCY PLANNING DATA

4.1 GENERAL

This section contains summary data for use in replanning science activities if scheduled activities cannot be accomplished because of a contingency or abnormal situation. Included are alternate missions and contingency guidelines for real-time replanning use. Detailed contingency information and procedures are contained in the "Scientific Experiments Contingency and Planning Procedures, Mission J-2/Apollo 16."

4.2 EARTH AND LUNAR ORBIT PLANNING DATA

Table 4-1 lists the lunar orbit experiments and science-related detailed objectives assigned to the mission, and indicates the following for each: effects of a scrubbed mission in terms of recycling requirements, and whether science data can be obtained on various alternate missions. These alternate missions are listed below and briefly discussed in the following paragraphs:

a) Earth orbit (EO)

b) Lunar flyby (LF)

c) Lunar orbit/no lunar landing (LO/NLL)

d) No transearth coast EVA (NTE)

4.2.1 EARTH ORBIT (EO) MISSION

In case there is no TLI burn, an earth orbit alternate mission will be accomplished with a mission duration of approximately 6-1/3 days. The Subsatellite will be jettisoned in the highest apogee, longest lifetime available. A photography orbit of 240 by 114 nautical miles will be established with apogee over the United States to ensure optimum operation of the SIM cameras. The Mass Spectrometer, the Alpha Particle Spectrometer, and the Laser Altimeter will be operated to verify the operability of the hardware. The X-Ray Fluorescence equipment will be used to map the universe from pole to pole and to gather data on Sco X-1. The Gamma-Ray Spectrometer will be operated in a 702- by 115-nautical mile orbit to obtain limited data on the earth's magnetosphere. The camera cassettes will be retrieved during EVA on the last day.

4.2.2 LUNAR FLYBY (LF) MISSION

This case is not an official alternate mission. Table 4-1 indicates the impact on orbital experiments and objectives if this situation occurs. The science return for the SIM experiments is basically for the transearth coast portion of the objectives.

4.2.3 LUNAR ORBIT/NO LUNAR LANDING (LO/NLL) MISSION

There are three alternate missions for this situation: CSM alone, CSM/LM with operable DPS, and CSM/LM with an inoperable DPS. Each of these is described below:

a) CSM Alone. In case the LM cannot be taken into lunar orbit, there will be an alternate lunar orbit mission with the CSM alone. The SIM door will be jettisoned prior to LOI. The duration of the lunar orbit will be approximately 6 days. The lunar orbit will be circularized at approximately 60 nautical miles and the SIM experiments will be operated. The SIM cameras will be used to photograph targets of prime scientific interest at an inclination of approximately 20 degrees in order to have the same ground track as limited by use of the descent propulsion system (DPS) in paragraph b) below. The Subsatellite will be launched in the normal manner prior to TEI. An EVA will be planned for cassette retrieval during TEC.

b) CSM/LM With Operable DPS. In case the LM is taken into lunar orbit with an operable DPS but a decision not to land, the mission will have a duration of 6 days in lunar orbit. The DPS will be used to effect a plane change of approximately 13 degrees (i.e., maximum practical change) and the LM will be jettisoned after this maneuver. The lunar orbit will be circularized at approximately 60 nautical miles and the SIM cameras and experiments will be operated. The Subsatellite will be launched in the normal manner prior to TEI. An EVA will be planned for cassette retrieval during TEC.

c) CSM/LM With Inoperable DPS. In case the LM is taken into lunar orbit with an operable DPS or the DPS propellant has been expended due to LM abort during attempted landing, a 6-day lunar orbit mission will be conducted and the SIM cameras and experiments will be operated. There will be no lunar orbit plane change (as normally occurs on lunar orbit revolutions 40 and 60). The Subsatellite will be launched in the normal manner prior to TEI. The SIM camera cassettes will be retrieved during an EVA in TEC.

4.2.4 NO TRANSEARTH COAST EVA (NTE) MISSION

As with the Lunar Flyby situation, this is not an official alternate mission. If no TEC EVA occurs, the impact is loss of SIM camera film.

4.3 LUNAR SURFACE PLANNING DATA

Table 4-2 lists alternate lunar surface science activities which can be conducted in the event of the following contingencies:

a) Crew unable to locate touchdown point in the landing ellipse

b) Not enough time for EVA

c) Time available for brief EVA 1 only (1 or 2 men)

d) Time available for EVA 1 only (2 men)

e) Time available for one-man EVA 1 only (No EVA 2 or EVA 3)

f) One-man EVA 1 (EVA 2 planned, no EVA 3)

g) Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)

h) One-man EVA 2 or EVA 3

If the LRV fails to operate, selected science activities will be accomplished on walking traverses. Traverses for EVA 1, EVA 2, and EVA 3 are shown in Figure 4-1. Tables 4-3(a), 4-3(b), and 4-3(c) contain supplementary data for the walking traverses. Explanations of table headings are listed below:

a) Station or Travel: Indicates the appropriate station letter or that the crew is traveling, as appropriate.

b) Distance: Shows the actual traverse distance between the two stations and the cumulative total of these distances. The actual distance is obtained by multiplying the map distance by the map correction factor of 1.1.

c) Station Stop or Travel Time: Indicates the travel times between individual stations and the cumulative travel time, or the individual station stop times and the cumulative station stop time, as appropriate. (Overhead times for walking traverse stops are 3 minutes.)

d) Station Science Time: Indicates the time at each station devoted to scientific activities, i.e., station stop time minus station stop overhead. The cumulative total is also shown.

e) EVA Time After Event: Shows the time, since beginning the EVA, at the end of each station stop or travel sequence, as appropriate.

f) Geological Features/Observations and Activities: Describes the surface feature at the station or along the traveled route, as appropriate. Lists crew observations and scientific activities considered appropriate for the station or traveled route.

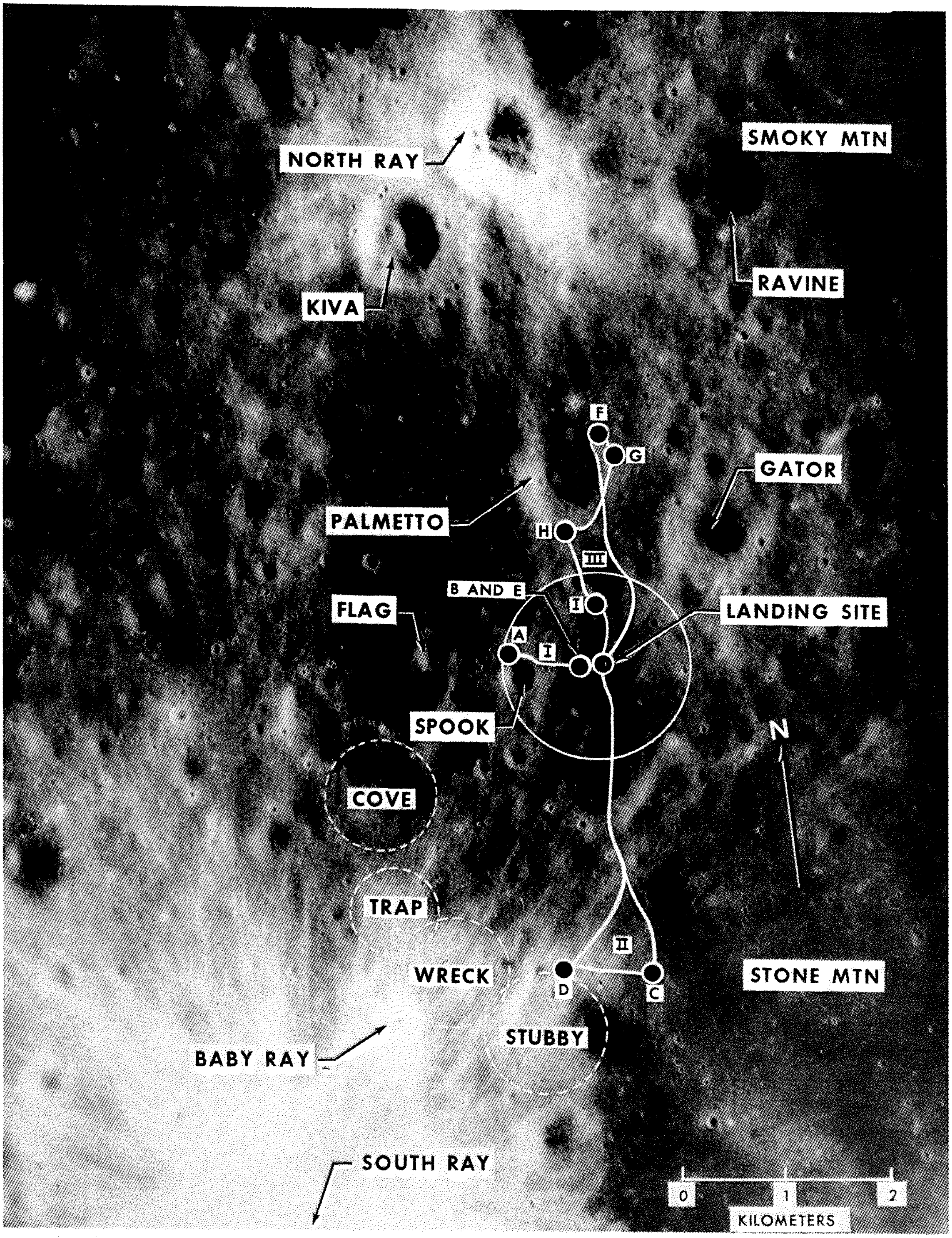


Figure 4-1. Walking Traverses - EVA 1, EVA 2, and EVA 3

Table 4-1. Lunar Orbit Science Experiments/Objectives - Science Data Return Matrix for Contingency Missions

EXPERIMENT/OBJECTIVE	SL	CONTINGENCY MISSION			
		EO	LF	LO/NLL	NTE
SM Orbital Photographic Tasks (DO):					
• 24-Inch Panoramic Camera	G^3	G^1	N	G	N^6
• 3-Inch Mapping Camera/Stellar Camera	G^3	G^1	N	G	N^6
• Laser Altimeter	G	N	N	G	N/A
Visual Observations From Lunar Orbit (DO)	G	G^1	N	G	N/A
CM Photographic Tasks (DO)	G	G^1	G^4	G	N/A
UV Photography - Earth and Moon(S-177)	G	N	G^4	G	N/A
Gegenschein From Lunar Orbit (S-178)	G	N	N	G	N/A
Gamma-Ray Spectrometer (S-160)	G^5	N	G^{4*}	G^{**}	N/A
Alpha Particle Spectrometer (S-162)	G^5	N	G^4	G	N/A
X-Ray Fluorescence (S-161)	G^5	G^1	G^4	G	N/A
Mass Spectrometer (S-165)	G^5	G^4	G^4	G	N/A
S-Band Transponder (CSM/LM) (S-164)	G	N	N	G	N/A
Bistatic Radar (S-170)	G	N	N	G	N/A
Subsatellite:	N^2	G^1	G^4	G	N/A
• Magnetometer (S-174)	N/A	N	G^4	G	N/A
• Particle Shadows/Boundary Layer (S-173)	N/A	G^1	G^4	G	N/A
• S-Band Transponder (S-164)	N/A	N	N	G	N/A

LEGEND:

SL - Scrubbed Launch: can be recycled without experiment effect
EO - Earth Orbit
LF - Lunar Flyby
LO/NLL - Lunar Orbit/No Lunar Landing
NTE - No TEC EVA Period
G - Go (Useful science data can be acquired)
N - No/Go (No useful science date can be acquired)
N/A - Not Applicable
DO - Detailed Objective

SUPERSCRIPTS:

1 - Objectives may be changed if operated during this contingency mission
2 - Batteries may have to be charged
3 - Film may require reloading
4 - Possibly partial or degraded data
5 - Dependent on time period (calibration sources may require renewal)
6 - No returned imagery data

*More severely degraded data results if the LM (RTG radiation source) is docked to the CSM.
**Degraded data results only if the LM is docked to the CSM.

Table 4-2. Surface Science Experiments - EVA Decisions

SITUATION	CONTINGENCY	AGENT	ACTION
a)	Crew unable to locate touchdown point in the landing ellipse.	Crew	1. Make visual observations through Lunar Module (LM) window and describe features around the LM.
		MCC	2. Compare television images and the astronauts' description of features to overall features in the map package.
		MCC/Crew	3. Revise the ALSEP deployment and traverse plans as required.
b)	Not enough time for an EVA.	Crew	1. Make careful observations and descriptions of surface through LM windows or by a SEVA. Numerous still camera photos should be taken with both black and white and color film. Photos with polarizing filter in three different positions should be made.
		MCC	2. Study landing area on maps and submit pertinent questions relating to surface smoothness or roughness, the contours of surface, size of rocks, and craters in the area.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
c)	Time for brief EVA 1 only (1 or 2 men)	Crew	1. Make careful observations and descriptions of surface through LM windows. Numerous still camera photos should be taken with both black and white and color film. Photos with polarizing filter in three different positions should be made.
		MCC	2. Study landing area on maps and submit pertinent questions relating to surface smoothness or roughness, the contours of surface, size of rocks, and craters in the area.
		Crew	3. Collect the soil (contingency) sample.
		Crew	4. If possible, take a photographic panorama of the landing area and photos of nearby surface features. Take photos of surface under LM descent engine and around footpads.
		Crew	5. Retrieve the CRD (S-152) panels.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
d)	Time for EVA 1 only (2 men)	Crew	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crew	2. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crew	3. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crew	4. Retrieve the CRD (S-152) panels.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
e)	Time for a one-man EVA 1 only. (No EVA 2 or 3 possible)	Crewman	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crewman	2. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crewman	3. Perform lunar geology investigations during the traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crewman	4. Retrieve the CRD (S-152) panels.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
f)	One-man EVA 1 (EVA 2 planned, no EVA 3 possible)	Crewman	1. Pull "red" lanyard on CRD (S-152) experiment.
		Crewman	2. Deploy the Solar Wind Composition (S-080) experiment.
		Crewman	3. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crewman	4. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crewman	5. Deploy the Far UV Camera/Spectroscope (S-201) experiment.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
g)	Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)	Crew	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crew	2. Deploy the Solar Wind Composition (S-080) experiment.
		Crew	3. Deploy the Far UV Camera/Spectroscope (S-201) experiment. NOTE Decisions for settings to obtain new targets will be made in real time.
		Crew	4. Deploy ALSEP according to priorities. • HFE • LSM • ASE • PSE
		Crew	5. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples).

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
g)	Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)(Cont'd)	Crew	NOTE • Reduce the number of stations and distance attempted.
h)	One-man EVA 2 or EVA 3	Crewman	1. If LRV is operable: a. Perform geology sample collection and documentation, and take portable magnetometer measurements during the LRV traverse. b. Take panorama photographs at stations along the traverse. c. Retrieve the CRD (S-152) panels. NOTE Decision for retrieving the CRD (S-152) panels during EVA 2 or EVA 3 will be made in real time. d. Retrieve the film transport device from the Far UV Camera/Spectroscope (S-201) experiment.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	NOTE Decision for retrieving the film transport device during EVA 2 or EVA 3 will be made in real time. e. Retrieve the foil from the Solar Wind Composition (S-080) experiment. NOTE Decision for retrieving the SWC foil during EVA 2 or EVA 3 will be made in real time.
		Crewman	2. If LRV is inoperable: a. Perform geology sample collection and documentation during the walking traverse. NOTE Crewman may abbreviate documentation requirements for samples if MCC concurs.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	b. Take panorama photographs at stations along the traverse. c. Take a portable magnetometer measurement as far as possible from LM. NOTE Decisions to take additional measurements at other locations will be made in real time. d. Retrieve the CRD (S-152) panels. NOTE Decision for retrieving the CRD (S-152) panels during EVA 2 or EVA 3 will be made in real time. e. Retrieve the film transport device from the Far UV Camera/Spectroscope (S-201) experiment. NOTE Decision for retrieving the film transport device during EVA 2 or EVA 3 will be made in real time.

Table 4-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	f. Retrieve the foil from the Solar Wind Composition (S-080) experiment. NOTE Decision for retrieving the SWC foil during EVA 2 or EVA 3 will be made in real time.

Table 4-3(a). Walking Traverse Data - EVA 1

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE		
LM	-	-	97	97	N/A	N/A	1:37	Cayley Plains - Rolling to smooth volcanic forms of the lunar highlands. Egress LM ALSEP, Science Equipment unloading
Travel	0:10	0:10	2	99	-	-	1:39	Across Cayley Plains to ALSEP deployment area.
ALSEP Site	-	-	144	243	N/A	N/A	4:03	ALSEP Deployment
Travel	0:85	0:95	21	264	-	-	4:24	Across Cayley Plains and large crater rays to vicinity of Spook Crater and small blocky crater to the north of Spook.
A (Spook Crater Locale)	-	-	60	324	57	57	5:24	Exploration of crater, assess geology • Pan • Crater sampling (padded bags) of Spook Crater Rim and blocks associated with small crater • 500-mm photography
Travel	0:90	1:85	22	346	-	-	5:46	Cayley Plains Observe ray patterns and terrain of EVA II route
B (Midway Between LM and ALSEP Site)	-	-	39	385	36	93	6:25	Cayley Plains - Midway between LM and ALSEP site • Pan • Soil/Rake Sample • Double Core Tube • Trench and Penetrometer Measurements • Soil Samples from Trench
Travel	0:05	1:90	1	386	-	-	6:26	Travel to LM
LM	-	-	35	421	N/A	N/A	7:01	EVA closeout

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-3(b). Walking Traverse Data - EVA 2

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE		
LM	-	-	45	45	N/A	N/A	0:45	Cayley Plains - Egress & EVA preparation
Travel	2.9	2.9	70	115	-	-	1:55	Across Cayley Plains to base of terrace in Descartes formation. Observe terraces and any bedrock/regolith changes.
C (Base of Stone Mountain)	-	-	75	190	72	72	3:10	Small craters at base of terrace in Descartes formation (Stone Mt.). Note characteristics of Descartes formation and local geology - compare to Cayley, assess terraces. ● Pan ● Documented Sampling Surface Sampler Rake/Soil Sample ● 500-mm Photography
Travel	0.8	3.7	19	209	-	-	3:29	Descartes Formation - Observe Craters/Blocks
D (Base of Stone Mountain)	-	-	71	280	68	140	4:40	Stone Mountain/Stubby Crater vicinity - Descartes Formation at base of Stone Mountain. Observe relations between Cayley and Descartes Formation in this area. ● Pan ● Documented Sampling of Stubby Rim ● 500-mm Photography
Travel	3.0	6.7	72	352	-	-	5:52	Across Cayley to area midway between ALSEP site and LM
E (Small Fresh Crater)	-	-	32	384	29	169	6:24	● Pan ● Documented Sampling ● Special Surface Sampler ● Rake/Soil Sample ● CSVC Single Core

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-3(b). Walking Traverse Data - EVA 2 (Continued)

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE		
Travel	0.05	6.8	1	385	-	-	6:25	Return to LM across Cayley Plains.
LM	-	-	35	420	N/A	N/A	7:00	EVA closeout.

Table 4-3(c). Walking Traverse Data - EVA 3

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE		
LM	-	-	40	40	N/A	N/A	0:40	Egress and prepare for traverse
Travel	2.10	2.10	50	90	-	-	1:30	Across Cayley skirting subdued crater (Palmetto) stopping slightly north and east of this crater.
F (NE Rim of Palmetto Crater)	-	-	75	165	72	72	2:45	Rim of subdued crater-Palmetto Crater - in Cayley Plains • Pan • Documented samples of crater rim • Soil/Rake Samples • 500-mm Photography
Travel	0.25	2.35	6	171	-	-	2:51	Across Cayley Plains near rim of Palmetto Crater Observe lateral changes in Cayley characteristics.
G (East Rim of Palmetto Crater)	-	-	50	221	47	119	3:41	• Documented Sampling • Double Core Sample • Soil/Rock Sample
Travel	0.8	3.15	19	241	-	-	4:01	Around SE rim of Palmetto Crater Observe lateral changes in Cayley characteristics
H (South Rim of Palmetto Crater)	-	-	26	267	23	142	4:27	• Pan • Documented Sampling of Palmetto Crater rim • Soil/Rake Sample
Travel	0.80	3.95	19	286	-	-	4:46	Across Cayley Plains - south of Palmetto Crater - toward LM.

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-3(c). Walking Traverse Data - EVA 3 (Continued)

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE		
I (Volcanic Region N of LM)	-	-	50	336	47	189	5:36	Investigate small volcanic area Documented Sampling
Travel	0.60	4.55	14	346	-	-	5:50	Across Cayley Plains to the LM
LM	-	-	65	411	N/A	N/A	6:55	EVA closeout.

APPENDIX A

SUMMARIES FOR LUNAR SURFACE EXPERIMENTS

Four lunar geophysical observatories, remotely controlled from earth, have been installed, and successfully operated, on the moon by the Apollo 11, 12, 14, and 15 astronauts. These Apollo Lunar Surface Experiments Packages (ALSEP's) telemeter data to the earth on a continuous or selective basis according to commands radioed from earth. The Apollo 12, 14, and 15 ALSEP's are still operating and telemetering data to earth. These observatories have acquired and transmitted to earth data on lunar seismology, magnetometry, interior and surface temperatures and heat flow, the atomic and subatomic particle environment at the lunar surface, and the long range effect of the lunar radiation and dust particle environment on materials.

In addition to these long-lived observatories, lunar surface scientific activities performed by Apollo astronauts include lunar geology and soil mechanics data collection in the form of trained observations, photographic documentation, special experiments, and the return of lunar rocks and soil to earth. Exposure of materials to the solar wind and cosmic ray environment on the lunar surface has also been accomplished by astronauts during these manned lunar missions so that the particles entrapped in the materials could be analyzed by scientists when the materials were returned to earth.

Data from lunar surface and lunar orbital experiments from past Apollo missions and from those planned for this mission will contribute to our knowledge and understanding of the moon and its space environment. A model, or theory, of the history and present nature of the moon, earth, and the rest of the solar system will be developed from these basic data and our existing foundation of scientific knowledge. This, in turn, will enable us to utilize our space environment to better advantages as well as to provide a better understanding of our solar system, past, present, and future.

The lunar surface experiments that are planned for this mission, Apollo Mission J-2 (Apollo 16), are tabulated below. Each experiment is individually discussed in the following pages:

<u>Apollo Mission J-2 Lunar Surface Experiments</u>

- Lunar Geology Investigation
- ALSEP
  - Heat Flow
  - Lunar Surface Magnetometer
  - Passive Seismic
  - Active Seismic
- Far UV Camera/Spectroscope
- Solar Wind Composition
- Soil Mechanics
- Portable Magnetometer
- Cosmic Ray Detector (Sheets)

EXPERIMENT SUMMARY

TITLE: LUNAR GEOLOGY INVESTIGATION EXPERIMENT (S-059)

PRINCIPAL INVESTIGATOR: Dr. W. R. Muehlberger
United States
Geological Survey
Flagstaff, Arizona 86001

EXPERIMENT SUMMARY:

This activity comprises scientific observations by the astronauts, photographic documentation of geologic features, and the collection and return to earth of various types of lunar material. In performing this geological survey the astronauts will travel in the "Rover" vehicle to distances of up to 8 kilometers from the Lunar Module.

The Descartes area is an outstanding location to sample and study the petrochemistry of two volcanic constructional units of the lunar highlands, the Cayley formation unit (Cayley Plains) and the Descartes formation (a derivative of the Kant Plateau unit). Fresh craters of various sizes are also present within the planned landing area. This will allow sampling of these highland units to various depths. The mounded floors of craters in this area suggest that a lower layer of unknown origin has been penetrated.

RELATED EXPERIMENTS AND MISSIONS:

Lunar Geology Investigations were conducted on Apollo 11, 12, 14, and 15. Apollo 11 returned 22 kilograms of lunar material, Apollo 12 returned 35 kilograms, Apollo 14 returned 43 kilograms, and Apollo 15 returned 77 kilograms of lunar material.

Comparison of the Apollo 12 samples from Oceanus Procellarum with the Apollo 11 samples from Mare Tranquillitatis shows that the chemistry at the two mare sites is clearly related. Both sites show the distinctive features of high concentrations of refractory elements and low contents of volatile elements; these two features most clearly distinguish lunar material from other material.

Chemical analyses of the Apollo 14 material show it to be distinct from the material returned from the Apollo 11 and 12 landing sites in that lower concentrations of iron, titanium, manganese, chromium, and scandium and higher concentrations of silicon, aluminum, zirconium, rubidium, strontium, sodium, lithium, lanthanum, thorium, and uranium are present. The total carbon contents of the soil samples fall within the carbon-content range found for material returned from the Apollo 11 and 12 sites. The rocks have carbon contents that range from 28 to 225 parts per million.

The extended capability of the life-support equipment and the new mobility provided by the lunar roving vehicle (Rover) enabled the Apollo 15 astronauts to explore a much larger area than on previous missions. The three major geological objectives investigated during the traverses were the Apennine Front along Hadley Delta, Hadley Rille at locations west and southwest of the landing site, and the mare plain at various locations. The soils returned from the Hadley-Apennine area are similar in most respects to soil samples returned from previous missions. The chemical composition of the soil samples, particularly from the mare regions, is distinctly different from the composition of the rocks from presumably the same locales. A linear correlation involving the iron oxide and aluminum oxide constituents of the soil and rocks from the Apollo sites suggests that the soil may be derived from a range of rock material, with the two end members being the iron-rich mare basalt and the aluminum-rich, iron-poor nonmare basalt.

EXPERIMENT SUMMARY

TITLE: HEAT FLOW EXPERIMENT (S-037)

PRINCIPAL INVESTIGATOR: Dr. Marcus E. Langseth
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York 10964

EXPERIMENT SUMMARY

The Heat Flow Experiment (HFE) is part of the Apollo 16 ALSEP. The deployed experiment measures the temperature gradient, the thermal conductivity in the near surface layers of the moon, and the brightness temperature of the local lunar surface. From these measurements the rate of heat flow into or out of the interior of the moon can be calculated. These data will provide information on:

- A comparison of the radioactive content of the moon's interior and the earth's mantle.
- The thermal history of the moon.
- Lunar temperature versus depth profile.
- Measured values of thermal parameters in the first 3 meters of the lunar surface.
- Together with seismic measurements, the composition and physical state of the lunar interior.

Two holes, separated by 10 meters, are drilled in the lunar surface by an astronaut to a depth of 3 meters by driving bore stems (casings) into the ground. These stems remain in the lunar surface to prevent hole collapse. Two probes (each 1.2 meters long) consisting of temperature sensors and heaters are inserted, one into each casing or hole. Each probe is cable-connected to the HFE electronics package which in turn is cable-connected to the ALSEP Central Station. Thermocouples on the exposed part of the cables will measure the lunar surface brightness temperature. The experiment systematically measures subsurface and surface temperatures and temperature differences in response to commands from earth throughout the operational life of ALSEP.

RELATED EXPERIMENTS AND MISSIONS:

A Heat Flow Experiment was deployed during Apollo 15. Results after one complete lunation and six conductivity measurements indicate that the heat flow from the interior of the moon outward is about 3.3×10^{-6} watts/cm^2, one-half the average heat flow of the earth.

From this it can be deduced that the relative amounts of heat producing elements, U, Th, K, are about the same as that of the earth. Although the temperature sensors were not deployed to their full planned depth, the low thermal conductivity of the lunar regolith permits a successful heat flow measurement to be made. The diurnal temperature variation measured at the surface is about 271°C (from -185°C to +86°C), but a meter below the surface these variations are on the order of a few thousandths of a degree.

EXPERIMENT SUMMARY

TITLE: LUNAR SURFACE MAGNETOMETER EXPERIMENT (S-034)

PRINCIPAL INVESTIGATOR: Dr. Palmer Dyal, Code N204-4
Ames Research Center
Moffett Field, California 94034

EXPERIMENT SUMMARY:

The Lunar Surface Magnetometer (LSM) experiment is part of the Apollo 15 ALSEP array. This three-axis magnetometer measures the magnitude, direction, and temporal variations of the lunar magnetic field at a fixed point on the surface. The measurements will determine the lunar response to the interplanetary magnetic field as well as the stationary field associated with the moon. The data will enable calculations of the electrical conductivity and thermal state of the lunar interior. This information is critical to theories of lunar formation and history. The Lunar Surface Magnetometer will operate, as commanded from earth, for a year or more and thus show how the field varies with time as the moon passes through the magnetotail of the earth.

The experiment hardware comprises three magnetic sensors, each mounted at the end of a 3-foot long support arm with the other end of each arm mounted on the associated electronics assembly. The electronics assembly is cable-connected to the ALSEP Central Station.

Lunar Surface Magnetometers that were deployed during Apollo 12 and 15 are still operating. The Principal Investigator anticipates that he will be able to deduce a temperature profile from the surface of the moon to the center because of the increased sensitivity of the Apollo 15 instrument. The model could then be checked by the Heat Flow Experiment results.

A Portable Magnetometer Experiment was conducted by Apollo 14 astronauts. This experiment demonstrated that relatively large magnetic field gradients exist on the lunar surface.

For the first time, scientists are beginning to correlate data from three surface experiments to formulate a consistent model of the moon. The seismometer, magnetometer and heat flow data, plus sample analyses, all point to a layered or differentiated moon. As is to be expected at this early date, agreement has not been reached as to the depth or thickness of the differentiated zone.

RELATED EXPERIMENTS AND MISSIONS:

In addition to the previously deployed LSM's (Apollo 12 and 15), and the Apollo 14 Portable Magnetometer Experiment, a Portable Magnetometer Experiment is planned for this mission and will be conducted by the astronauts during their geological traverses in the Descartes area. During Apollo 15 a magnetometer carried aboard a small subsatellite was ejected from the CSM into a lunar orbit. The instrument is still orbiting the moon and transmitting data to earth. A similar subsatellite is planned for Apollo 16. These magnetometers are to provide information on the interplanetary magnetic field and the moon as a whole whereas the lunar surface measurements provide data on local magnetic field levels which are generally quite different.

TITLE: PASSIVE SEISMIC EXPERIMENT (S-031)

PRINCIPAL INVESTIGATOR: Dr. G. V. Latham
Lamont-Doherty
Geological Observatory
Columbia University
Palisades, New York 10964

EXPERIMENT SUMMARY:

The Passive Seismic Experiment (PSE) is part of the Apollo 16 ALSEP array. It is a cylinder approximately 30.5 cm in diameter and 50.8 cm high, requires deployment by an astronaut, and is controlled by commands radioed from earth. The experiment is designed to measure natural lunar seismic activity resulting from meteoroid impacts, internal stresses deep within the moon, free oscillations of the moon, and surface tidal deformations caused by gravitational fields acting upon the moon. In addition, measurement of the seismic signals generated by impact of the Apollo S-IVB stage (to be monitored by Apollo 12, 14, and 15 PSE's) and the spent LM ascent stage (to be monitored by Apollo 12, 14, 15, and 16 PSE's) on the lunar surface provides important baseline data. To be successful, the experiment must operate for at least one lunar day (28 earth days). It is planned to operate the experiment for at least the 1-year ALSEP design lifetime or longer to maximize the scientific data return. The telemetered data will be analyzed to determine the occurrence rate of seismic events and the frequency, amplitude, and attenuation characteristics of the seismic disturbances. A network of stations emplaced at different locations on the lunar surface enables the determination of the velocity of seismic wave propagation, the epicenter of the disturbances, and the general characteristics of the lunar interior.

RELATED EXPERIMENTS AND MISSIONS:

Successful Passive Seismic Experiments (PSE's) were deployed during Apollo 11, 12, 14, and 15, and an Active Seismic Experiment (ASE) was also deployed during Apollo 14.

During the first lunar perigee after deployment of the Apollo 15 PSE, a large moonquake occurred that was determined by triangulation to be approximately 700-800 kilometers beneath the surface and 600 kilometers west of the crater Tycho. This event has been correlated by the PI with the most active seismic zone observed during previous perigees.

There appears to be a gradual increase in velocity with depth to approximately 25 kilometers at which point there is a sharp velocity increase. This sharp increase in velocity suggests a change in the composition of the lunar material that may be equivalent to the base of a primitive lunar crust. At a depth of 50 kilometers the velocity is estimated to be as high as 9.0 kilometers per second. This high velocity at such a shallow depth, i.e., at low pressure, raises basic questions about the nature of the lunar material. Equivalent velocities do not occur in the earth until depths of 400 to 500 kilometers. None of the rocks examined thus far exhibit the required mineralogical composition which, under suitable pressure, would transmit seismic impulses at this velocity.

Utilizing a new data analysis technique the PI has been able to observe "swarms" of small moonquakes not associated with previously observed perigee events. One swarm, which occurred in April, 1970, culminated with the largest event ever before recorded on the moon. Analyses of the swarms will continue to determine their source and significance to lunar seismology.

EXPERIMENT SUMMARY

TITLE: ACTIVE SEISMIC EXPERIMENT (S-033)

PRINCIPAL INVESTIGATOR: Dr. R. L. Kovach
Dept. of Geophysics
Stanford University
Stanford, California 94305

EXPERIMENT SUMMARY:

The Active Seismic Experiment (ASE) is part of the Apollo 16 ALSEP. The ASE consists of a 95-meter cable containing 3 geophones (detectors) spaced 3 meters, 49 meters, and 95 meters from the ALSEP central station (when the cable is deployed), a mortar box assembly containing 4 explosive grenades, and a 1-meter-long "thumper" assembly containing 19 explosive cartridges. An astronaut will carry the "thumper" alongside the deployed geophone cable and create artificial seismic events at about 5-meter intervals by firing an explosive cartridge (contained in the "thumper" base) at each of 19 locations. The 3 geophones which are part of the geophone cable and are implanted in the lunar soil will monitor the seismic activity produced and telemeter the data to earth. After the astronauts depart, the ASE will monitor natural seismic activity during selected time intervals for some weeks or months until commands radioed from earth cause the 4 explosive grenades to be launched, one by one, from the mortar box. The seismic waves generated by the explosions will be monitored and telemetered to earth as before. These energy sources, whose magnitudes and locations relative to the sensors are known, will yield data on lunar subsurface material properties to depths of 20 to 25 meters for "thumper"-induced seismic activity, and up to 150 meters for grenade-induced seismic activity. In this manner, information will be acquired on the physical properties of the lunar soil and subsurface.

RELATED EXPERIMENTS AND MISSIONS:

An ASE was deployed during Apollo 14 and seismic data from thumper operation were obtained. The Apollo 14 ASE grenades are planned to be activated at a later time. The related Passive Seismic Experiments were deployed during Apollo 11, 12, 14, and 15. The latter three are still operating and acquiring data. A summary of the PSE results to date is presented on page A-7.

EXPERIMENT SUMMARY

TITLE: FAR UV CAMERA/SPECTROSCOPE EXPERIMENT (S-201)

PRINCIPAL INVESTIGATOR: Dr. George Carruthers
Code 7124.3
Naval Research Laboratory
Washington, D.C. 20390

EXPERIMENT SUMMARY:

Photographic imagery and spectroscopic data in the far ultraviolet region of the spectrum will be obtained using an electronographic Schmidt camera. Observations of selected celestial objects will be made from the lunar surface. The experiment will measure the amount and excitation of hydrogen in nearby and distant regions of the universe, by obtaining imagery and spectra at wavelengths characteristic of hydrogen absorption and emission. The principal wavelength to be measured is the hydrogen Lyman-alpha line at 1216 Å. The imagery obtained in this experiment will help to sort out Lyman-alpha emission from the earth's geocorona, the solar wind, the newly-discovered interstellar wind, and distant clusters of galaxies. Spectra from low-elevation targets (<20°) may detect the presence of volcanic gases that could be escaping from the lunar surface in the line of sight.

It is expected that the electronographic Schmidt camera will provide quantitative data on the distribution of hydrogen within the Milky Way. Intergalactic hydrogen clouds will also be observable; absorption by nearby hydrogen clouds does not occur due to red shifts of the order of 10 Å.

Spectroscopic data will also be obtained from several chemical species other than hydrogen, the total wavelength region being approximately 500 to 1550 Å. The filtering mechanism of the instrument will provide direct imagery in the 1230-1550 Å range, producing pictures of the earth's upper atmosphere and the polar auroral-zones in the light of atomic oxygen (1302-1306 Å).

RELATED EXPERIMENTS AND MISSIONS:

Far UV data has been obtained by the University of Wisconsin Experiment and the Smithsonian Institute's Celeoscope, both flown on the OAO-II. Lyman-alpha sky background measurements have been obtained from Mariner-V, from the Soviet VENURA space probe, and from the OGO-V.

Apollo 16 will provide the first planetary-based measurements of solar system, galactic, and extragalactic hydrogen from outside the earth's geocorona, and will constitute the initial use of the moon as an astronomical observatory.

EXPERIMENT SUMMARY

TITLE: SOLAR WIND COMPOSITION EXPERIMENT (S-080)

PRINCIPAL INVESTIGATOR: Dr. J. Geiss
University of Berne
Berne, Switzerland

EXPERIMENT SUMMARY:

The Solar Wind Composition (SWC) experiment comprises a sheet (30 x 140 cm) of aluminum and platinum foil, a reel, and a staff to which the reel and foil are attached. An astronaut implants the staff in the lunar surface so that the foil is entirely exposed, normal to the sun's rays. The SWC will be deployed early during the lunar stay, remain exposed to the solar wind for about 46 hours, and then will be retrieved by the astronauts for return to earth and subsequent analysis by the Principal Investigator.

The purpose of the experiment is to determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind by measurement of particle entrapment on the exposed sheet of foil. Results of the foil analysis are expected to contribute in deciding between competitive theories of the solar system, history of planetary atmospheres, and solar wind dynamics.

The average isotopic compositions of the solar wind are of significant astrophysical importance because comparisons can be made with ancient compositions derived from solar wind gases trapped in lunar materials. Since the solar activity varies with time, the isotopic abundances in the solar wind are expected to vary also. Therefore, in order to obtain accurate average abundances which obtain during this age of the solar system, it is necessary to perform the measurements numerous times, separated in time, and with extended data collection periods (long foil exposure times).

RELATED EXPERIMENTS AND MISSIONS:

SWC experiments were deployed during Apollo 11 (exposure time 77 minutes), 12 (exposure time 18 hours 42 minutes), 14 (exposure time 20 hours 58 minutes), and 15 (exposure time 41 hours). The Apollo 11 and 12 results indicated that the isotopic compositions of helium in the solar wind generally correspond to the abundance estimates in the sun and to estimates derived from measurements taken in gas-rich meteorites. The Apollo 14 analysis is still in progress. However, results so far indicate a lower helium - 4 flux than was detected on previous missions, but the ratio of helium - 4 to helium - 3 is similar to that detected during Apollo 12. Several isotopes of neon have been detected and their concentrations measured. For the first time, the presence of argon in the solar wind has been detected. The longer exposure time for the Apollo 15 SWC is expected to enable the Principal Investigator to obtain precise abundances of neon - 21 and argon - 38 and to further define the acceleration and fractionation processes in the solar atmosphere.

EXPERIMENT SUMMARY

TITLE: SOIL MECHANICS EXPERIMENT (S-200)

PRINCIPAL INVESTIGATOR: Dr. J. K. Mitchell
University of California
Berkeley, California 94726

EXPERIMENT SUMMARY:

Increased knowledge of lunar terrain features and mechanical behavior of the soil is essential in the conduct of lunar exploration. Planned crew activities are designed to gather lunar surface and subsurface soil samples which will establish characteristics of the terrain in the test area. Excavation of a hole or trench will provide useful data relative to subsurface strata, sidewall crumbling, density and natural slope of the excavated material as well as an estimation of the work required to perform the excavation. Lunar soil compactness and the existence of any hard subsurface boulders or hard stratum will be determined by comparing penetrometer data with that required to probe terrestrial soil.

RELATED EXPERIMENTS AND MISSIONS:

Soil Mechanics data were obtained during surface operations on Apollo 11, 12, 14, and 15, and from the Surveyor 3 mission.

Although the surface texture and appearance of the soil at the Apollo 14 landing site are similar to those at the Apollo 11, 12, and Surveyor landing sites, a larger variation in the soil characteristics exists at depths of a few centimeters in both lateral and vertical directions than had previously been encountered. The walls of a trench that was dug by the commander collapsed at a shallower depth than had been predicted, evidently because of lessened soil cohesion. Calculations indicate that the soil-cohesion value at the Apollo 14 trench site may be as small as 10 percent of the values calculated for soils at previous landing sites. The grain-size distributions of most of the soil samples returned from the Apollo 14 site are similar to the grain-size distributions of soil samples from the Apollo 11 and 12 sites, with two significant exceptions: (1) a soil sample collected from near the rim of Cone Crater and (2) a soil sample from the bottom of the trench. At both of these locations, the soil was considerably coarser, with the median grain size as much as 10 times greater than at other Apollo 14 soil-sample locations.

The LM pilot was unable to push the Apollo simple penetrometer into the lunar surface near the ALSEP as deeply as had been expected. Similarly, the Apollo 14 crew encountered more difficulty in driving the core tubes than did the Apollo 12 crew. These results indicate that the soil at the Apollo 14 landing site is stronger with depth than had been previously supposed. The calculated bulk density of the soil in the lower half of the double core tube was significantly less than that determined for soil in the lower half of the Apollo 12 double core tube. Variations in the soil grain-size distribution or specific gravity (or both) may account for this difference in bulk density. The MET* track observations confirm that the soil is less dense, more compressible, and weaker at the rims of small craters than in level intercrater regions.

The lunar surface at the Hadley site is similar in color and texture to the surfaces at the previous landing sites. Although the variability of grain-size distribution of samples from the Apollo 15 site appears to be less than the variability found at the Apollo 12 and 14 sites, considerable variety exists, both with depth and laterally, in the soil properties of strength and compressibility. For example, the compressibility ranges from soft along the mountain front to much firmer near the rim of Hadley Rille. Evidence exists of downslope movement of surficial material on the walls of Hadley Rille; however, no evidence of deepseated slope failures along the mountain front was found. Soil densities derived from both the core-tube and the deep-drill core-stem samples exhibit considerable variability that ranges from approximately 1.3 to 2.2 g/cm^3. The self-recording penetrometer data indicate an in situ density of approximately 2.0 g/cm^3, a high soil strength, and a low soil compressibility. When coupled with additional data from the soil-mechanics trench dug near the ALSEP site, the penetrometer information can be used to estimate the cohesion and friction angle of the lunar soil. The values for both these parameters are higher than the values that resulted from experiments conducted during previous missions.

---

*Mobile Equipment Transporter ("wheelbarrow")

EXPERIMENT SUMMARY

TITLE: PORTABLE MAGNETOMETER EXPERIMENT (S-198)

PRINCIPAL INVESTIGATOR: Dr. Palmer Dyal
Ames Research Center
Moffett Field, California 94034

EXPERIMENT SUMMARY:

This experiment will measure vector magnetic field components at several locations in the lunar landing area. A portable 3-axis magnetometer will be carried on the "Rover" vehicle during the geological traverses. At selected locations (varying distances from a crater) the astronauts will place the magnetometer on the lunar surface, away from the Rover, and measure the local magnetic field. At the last measurement site, the crew will place a lunar rock on top of the instrument and take a reading. This will provide data to be used, along with other data, to separate hard from soft remanent magnetism found in many returned lunar samples. The magnetic field measurements taken at the various locations will enable determination of the magnetic field gradient in the Descartes area and possibly enable correlation of field measurements with geologic structure. The results of this experiment will aid resolution of questions on the spatial variation of the lunar magnetic environment, will aid in determining characteristics of lunar geologic structures, and will provide data which must be accounted for in theories of lunar history or models of the contemporary moon.

RELATED EXPERIMENTS AND MISSIONS:

A Portable Magnetometer experiment was performed during Apollo 14, Lunar Surface Magnetometer experiments (part of ALSEP) were deployed during Apollo 12, 14, and 15, and a Subsatellite Magnetometer was inserted into lunar orbit during Apollo 15. The Lunar Surface Magnetometer experiment is planned for Apollo 16, also. These experiments have shown that significant magnetic field gradients exist at the lunar surface and that much higher field strengths are present than was expected based upon data obtained from a magnetometer in lunar orbit. The Explorer 35 magnetometer (in lunar orbit) indicated that the lunar magnetic field at the surface should not exceed 8γ. However, the Apollo 12 Lunar Surface Magnetometer measured a 38γ field, and the Apollo 14 Portable Magnetometer measured fields of 103γ and 43γ at two locations separated by 1.1 kilometers.

EXPERIMENT SUMMARY

TITLE: COSMIC RAY DETECTOR (SHEETS) EXPERIMENT (S-152)

PRINCIPAL INVESTIGATOR: Dr. R. L. Fleischer (Team Leader)
General Physics Lab.
GE R&D Center
Schenectady, New York 12301

EXPERIMENT SUMMARY:

This experiment requires the return to earth of plastic detector sheets and other special glass, mineral, and tektite detectors exposed to the galactic cosmic ray and solar wind particle environment during translunar coast and on the lunar surface. These exposed materials will provide data for three scientific investigations which will lead to a better understanding of the contemporary flux of solar and galactic particles.

One investigation will determine the abundances of individual nuclei above helium in the energy range 0.2 to 100 MeV/nucleon; and resolve isotopes of elements such as beryllium, neon, aluminum, silicon, sulphur, argon, calcium, and iron.

A second investigation will: (1) measure the energy spectra and elemental and isotopic abundances of solar and galactic cosmic ray nuclei of $Z \geq 3$ in the energy range 1 to 200 MeV/nucleon; (2) calibrate glass detectors for use in future space missions by identifying the tracks of iron nuclei; and (3) determine whether the space exposure and place of origin of tektites can be determined from the characteristics of the iron.

A third investigation will: (1) measure the composition and distribution of nuclear particles in the solar wind in the energy ranges 0.5 to 10 KeV/nucleon and 1 to 100 MeV/nucleon; and (2) measure the flux of neutrons on the lunar surface.

RELATED EXPERIMENTS AND MISSIONS:

Although this experiment has not been performed before, related experiments have been performed during previous Apollo missions. The Cosmic Ray Detector (Helmets) experiment was performed during Apollo 8 and 12. Past and planned experiments which involve the collection of data on the atomic and subatomic particle environment in cislunar space include:

<u>Apollo lunar orbit experiments</u>:
- Alpha Particle Spectrometer (Apollo 15 and 16)
- Mass Spectrometer (Apollo 15 and 16)
- Particle Shadows/Boundary Layer Subsatellite (Apollo 15 and 16)

Apollo lunar surface experiments:

- Solar Wind Spectrometer (Apollo 12 and 15)
- Suprathermal Ion Detector (Apollo 12, 14, and 15)
- Cold Cathode Ionization Gauge (Apollo 12, 14, and 15)
- Solar Wind Composition (Apollo 11, 12, 14, 15, and 16)
- Lunar Atmospheric Composition (Apollo 17)
- Charged Particle Lunar Environment (Apollo 14)

These listed experiments are complementary with the Cosmic Ray Detector (Sheets) Experiment.

APPENDIX B

SUMMARIES FOR LUNAR ORBITAL EXPERIMENTS/DETAILED OBJECTIVES

The lunar orbital experiments can be separated into groupings of geochemical, physical structure, and electric and magnetic environment activities.

The broad objective of the geochemical experiments is to map the lunar surface. Because the landing sites for which chemical information is available are limited in number and not necessarily representative, it is important in understanding the origin and evolution of the moon to have a source of data concerning chemical composition over as wide an area of the moon as possible. The very detailed studies of returned lunar samples have permitted some progress in identifying major components of the soil, some indigenous to the sites explored, and some external to them. One task of the orbital geochemical experiments is to verify the occurrence of these suggested components, or of others. It is more important to be able to map regions of the moon in which each distinct material is the dominant constituent. The mass spectrometer can also be identified with the geochemical group since one of its important objectives is to identify the chemical structure of the native lunar atmosphere.

Lunar physical structure is obtained from the analysis of reflected electromagnetic radiation and tracking information. The tracking information will eventually result in a lunar gravitational model which is pertinent to any theory of the origin of the moon.

The electric and magnetic environment of the moon will be studied by the data collected from experiments onboard the Subsatellite. The Subsatellite is expected to have at least a one-year life and will be controlled in real time to maximize the collection of scientific information.

Orbital photographic activities can be divided into coverage of the lunar surface and coverage of low-brightness astronomical subjects.

Photography of the lunar surface has two major objectives: firstly, the mapping of the moon and, secondly, the study of lunar origin and evolution through interpretation of photographic imagery. For the mapping objective it is desired to establish the largest possible selenodetic control network, ideally the entire lunar surface. Thus, on any single lunar orbit mission, it is important to maximize the areal coverage of metric-quality photography. Determination of the form, composition, and history of lunar terrain features employs photographs of high spatial resolution, as well as photographs with different viewing angles and sun elevation angles.

Photography of low-brightness astronomical subjects can be divided into the study of phenomena in the solar system and the study of galactic or extragalactic light sources. For the solar system the purpose is to photograph the sun itself (for example, the solar corona) and the locations, extensions, and light levels of various sources of reflected sunlight. Outside the solar system it is desired to photographically record the configurations and light levels of stars, nebulae, and clusters of galaxies.

EXPERIMENT SUMMARY

TITLE: GAMMA-RAY SPECTROMETER EXPERIMENT (S-160)

PRINCIPAL INVESTIGATOR: Dr. James R. Arnold
Chemical Department
University of California at San Diego
La Jolla, California 92037

EXPERIMENT SUMMARY:

The Gamma-Ray Spectrometer Experiment is intended to obtain evidence relating to the origin and evolution of the moon. This will be accomplished by measuring the gamma-ray flux from the surface of the moon while the CSM is in lunar orbit. The gamma-rays arise from two sources:

a) The radioactive decay of certain isotopes whose half-lives are comparable to the time since nucleosynthesis--principally K-40, TH-232, and U-238 and the daughter products of the last two.

b) The interaction of cosmic rays with the surface material.

The intensity of the contributors from source a) is a sensitive function of the degree of chemical differentiation of the moon. Chemical differentiation is the result of the substantial melting within the moon at any time in the past or present, and will be indicated at the lunar surface by concentrations of various elements which are distinctive from the mean solar abundance and values measured in meteorites. Source b) will provide information on chemical elements making up the lunar surface. This experiment will extend our chemical information from a few landing sites to the area overflown by the CSM.

Operation of the gamma-ray spectrometer during the early portions of transearth coast will provide calibration data on the CSM/SIM background fluxes and will provide data that will permit an evaluation of the change in galactic flux as a function of lunar occultation.

The remainder of transearth coast will be devoted to gamma-ray astronomy. The experiment will measure a value (or limit) for the maximum anisotropy of the general sky background and may identify regions of the sky which are more active than others, permitting other experimenters to zero in on possible sources of gamma-rays.

RELATED EXPERIMENTS AND MISSIONS:

While similar experiments were flown on Rangers III, IV, V, and Luna 10, the Apollo 15 experiment was one allowing detailed chemical analysis. The experiment hardware performed its functions successfully and approximately 45 hours of usable data at full boom extension were collected. Data analysis to date has shown a significant degree of variation in radioactivity across the regions overflown by the CSM after LM separation. The most radioactive regions were in Mare Imbrium and Oceanus Procellarum; the least radioactive were the backside highlands.

The Apollo Mission J-2 experiment will use the same kind of hardware as was used on Apollo 15. With an inclination of 9 to 13 degrees for Apollo Mission J-2 as compared to the 30-degree inclination of Apollo 15, a smaller lunar area will be overflown, but it is anticipated that a greater precision in composition determination will be achieved because of more extensive data over each area, with improved statistical precision.

EXPERIMENT SUMMARY

TITLE: X-RAY FLUORESCENCE EXPERIMENT (S-161)

PRINCIPAL INVESTIGATOR: Dr. Isidore Adler, Code 641
Theoretical Studies Branch
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

EXPERIMENT SUMMARY:

The X-Ray Fluorescence Experiment is one of a group of experiments designed to perform a remote compositional survey of the lunar surface from lunar orbit. The other experiments in this group involve gamma-ray and alpha particle measurements made from lunar orbit. Solar X-rays will interact with the lunar surface material to produce characteristic fluorescence X-rays. The measurement of these X-rays would then be expected to yield the following information about the lunar surface:

a) Nature of surface material.

b) A measure of the homogeneity of the upper few millimeters of the lunar surface as the spacecraft orbits the moon.

c) By comparison with the Gamma-Ray Spectrometer and Alpha Particle Experiment results, some idea of the extent of "gardening" and whether the composition of the surface is like that of the subsurface.

In particular, the solar X-ray flux incident on the lunar surface will produce a substantial X-ray albedo that will consist primarily of "K" and "L" lines from the more abundant elements. This will enable the detection of the relative abundance of the elements sodium, magnesium, aluminum, and silicon as determined from the measured flourescence yield of the lunar surface obtained during quiet, active, and flare periods of the sun during the experiment period. The simultaneous measurement of the solar X-ray spectrum for background information will determine the excitation conditions for the radiation yield measured.

X-ray fluxes also arise as the result of energetic physical interactions within and beyond our galaxy. The measurement of these fluxes has become the basis of X-ray astronomy. The properties of location, intensity, line and continuum energy distribution, time variability and correlation with emissions at longer wavelengths promise to provide much information on the current state and past evolutionary processes of the universe. Apollo 16 will make five 2-hour observations of two selected galactic sources (Sco X-1 and Cyg X-1) during transearth coast and will scan the supergalactic equator in search of additional X-ray sources. The observations of the selected galactic sources will provide data on the intensity and spectral variations of isolated X-ray sources for longer continuous time periods than previous experiments. The X-ray data will be correlated with simultaneous earth-based observations in the radio and optical spectra.

RELATED EXPERIMENTS AND MISSIONS:

The X-Ray Fluorescence Experiment flown on Apollo 15 performed as expected and with the following results:

The sharply varying aluminum-to-silicon ratio measured confirms that the maria and the highlands are indeed chemically different, and the distinguishing albedo differences between these major features must be, in part, the signature of this difference. The anorthositic component of the returned lunar samples is certainly related to the high aluminum content measured in the highland regions, and the correspondingly low aluminum content of the returned mare basalts is consistent with the low measurement values over the maria. The experiment X-ray data, further support the theory that the Moon, shortly after formation, developed a differentiated, aluminum-rich crust. The sharp change in the aluminum-to-silicon intensity ratio between the highland and mare areas places stringent limitations on the amount of horizontal displacement of the aluminum-rich material after the mare flooding. Indications definitely exist in the more gradual data trends that the circular maria have a lower aluminum content than the irregular maria, and within particular maria (for example, Crisium and Serenitatis), the centers have a lower aluminum content than the edges. Finally, the large ejecta blankets, such as the Fra Mauro formation, seem to be chemically different from the unmantled highlands.

During the transearth coast, X-ray data were obtained from three discrete X-ray sources and from four locations dominated by the diffuse X-ray flux. The count rate from two of the sources, Sco X-1 and Cyg X-1, did show significant changes in intensity of approximately 10 percent over time periods of several minutes; however, a final analysis of Apollo data is required to rule out completely the possibility that changes in spacecraft attitude during the counting periods might account for the counting-rate variations.

Similar X-ray spectrometer experiments either have been flown or have been planned for the OGO, OSO, AIMP, and Orbiter spacecraft. The Russians have also attempted such an experiment in their Luna series of spacecraft. X-ray astronomy has been conducted from sounding rockets, balloons, and the satellite Uhuru (Explorer 42).

DETAILED OBJECTIVE SUMMARY

TITLE: SM ORBITAL PHOTOGRAPHIC TASKS DETAILED OBJECTIVE

PRINCIPAL INVESTIGATOR: Apollo Orbital Photographic Team (Frederick J. Doyle, Chairman)

OBJECTIVE SUMMARY:

24-Inch Panoramic Camera - This camera will be used to obtain 1- to 2-meter resolution photographs of possible post-Apollo landing sites and selected areas of high scientific interest. The camera will provide stereoscopic coverage (with a stereo convergence angle of 25 degrees) and, for the lower light areas near the terminators, can be used in the monoscopic mode. Film supply for the 24-Inch Panoramic Camera (6500 feet) will allow for approximately 200 minutes of operation. Panoramic photographs will help identify features of scientific interest in the vicinity of possible landing sites, will aid geologic interpretation of surface features, and will supply detailed information to support selenodetic work with 3-Inch Mapping Camera photographs.

3-Inch Mapping Camera - This camera will provide high-quality metric photographs for accurate photogrammetric analysis of the lunar surface overflown by the spacecraft. Exposure frequency of the camera is such that 78 percent forward overlap is obtained between successive frames. The scheduled camera coverage during the mission will provide 55 percent sidelap between successive photographic revolutions. Mapping Camera photographs will permit establishment of a lunar geodetic network for positional reference on the moon, and for photogrammetric determination of the lunar gravitational field. The photographs will also be used to make specialized cartographic maps. The Mapping Camera system includes a 3-Inch Stellar Camera to photograph star fields in a preset direction with respect to the Mapping Camera optical axis. The stellar photographs are time-correlated with mapping photographs. They will provide attitude data for use in analyzing mapping photographs and to support the reduction of Laser Altimeter data.

Laser Altimeter - This instrument will provide ranging data from lunar orbit. The ranging data will be combined with attitude data to yield altitude above the lunar surface. Two modes of operation will be used with the altimeter. When the 3-Inch Mapping Camera is operating, the altimeter fires simultaneously with each photographic exposure. When the Mapping Camera is not operating, the altimeter can fire automatically every 20 seconds. Obtaining accurate altitudes above the lunar surface will make it possible to subtract out the visible topography, thus aiding study of the large-scale structure of the moon. Laser Altimeter data will also be used in conjunction with tracking data and mapping and panoramic photographs.

RELATED OBJECTIVES AND MISSIONS:

Photographs of candidate landing sites have been obtained on Apollo 8, 12, and 14. Landmark tracking and associated photography were performed on Apollo 12 and 14. The SIM bay cameras on Apollo 15 provided the most extensive lunar photographic coverage to date, with higher-resolution photographs of candidate sites and more accurate metric photographs than have been obtained on previous missions. Panoramic photographs of the Apollo 15 landing site show the LM and the local disturbance of the lunar surface.

Because of approximately 33.5 degrees latitude difference between Hadley Rille (Apollo 15) and the Apollo 16 landing site, Descartes, the SIM cameras on Apollo 16 will provide coverage of large areas not photographed on Apollo 15.

EXPERIMENT SUMMARY

TITLE: PARTICLE SHADOWS/BOUNDARY LAYER EXPERIMENT (SUBSATELLITE) (S-173)

PRINCIPAL INVESTIGATOR: Dr. Kinsey A. Anderson
Space Science Laboratory
University of California at Berkeley
Berkeley, California 94726

EXPERIMENT SUMMARY:

The purposes of the Subsatellite Particle Shadows/Boundary Layer Experiment are to obtain data to study the formation and dynamics of the earth's magnetosphere, the interaction of plasmas with the moon, and the physics of solar flares.

The subsatellite charged particle detectors and corresponding subsatellite support systems are used to conduct this experiment. Two types of particle detectors are used: telescope detectors and spherical electrostatic detectors.

The two silicon nuclear particle telescope detectors ("A" and "B") are capable of detecting both protons and electrons. Telescope detector "A" detects electrons in the energy range from 20 to 320 keV and protons in the energy range from 50 keV to 2.0 MeV. Telescope detector "B" detects electrons in the energy range from 20 to 320 keV and protons in the energy range from 320 keV to 2.3 MeV.

The subsatellite also has four spherical electrostatic analyzer detectors that are used to detect electrons. The A1 analyzer has one electron counting channel available for detecting electrons in the energy range from 0.58 to 0.65 keV. The A2 analyzer, also with one electron counting channel, detects electrons in the energy range from 1.93 to 2.17 keV. Analyzer A3 has two electron counting channels that detect electrons in the energy range from 5.72 to 6.40 keV and 5.65 to 6.55 keV, respectively. Analyzer A4 has five parallel funnel channeltrons that detect electrons in the energy range from 13.6 to 15.0 keV.

Recently a new method (Particle Shadows) complementary to vector magnetomers has been described. This method is used to determine the large scale topology of field lines under certain conditions. It is essentially a particle tracing technique which determines where particles have been and where they go on the particular field lines under study. The tracer particles are supplied by the sun. The method also requires the presence of a large absorber such as the moon. As a spacecraft orbits the moon, a pattern of varying solar electron intensity is produced. The characteristics of the field lines are then deduced from the symmetry properties of these patterns.

On the basis of present evidence, the interaction of the solar wind with the moon occurs very close to the lunar surface. The boundary layer for this interaction extends from the lunar surface outward to some distance which is as yet unknown, but which is estimated to be about 100 kilometers. The goal of this part of the Subsatellite experiment is to obtain data on the physics of this interaction region or boundary layer. The characteristics of the boundary layer are determined by the properties of the plasma as well as those of the moon. Thus, the study of the interaction region will yield information on the external plasma, the interior of the moon, the surface, and the lunar ionosphere. At present, very little work has been done on the theory of the microscopic behavior of the plasma in the boundary layer immediately above the lunar surface. On the daylight side, the solar wind particles probably reach the surface in their steady state condition but photoelectric fields and ionized particles from the moon may complicate the situation.

RELATED EXPERIMENTS AND MISSIONS:

Analysis of initial data from the plasma and energetic-particle experiment on the Apollo 15 subsatellite has led to the following conclusions.

The cavity formed in the solar wind by the moon has been observed in the fast-electron component of the solar wind. When the interplanetary magnetic field is aligned approximately along the solar-wind flow, the electrons are almost completely excluded from the cavity. When the magnetic field is more nearly aligned perpendicular to the solar-wind flow, the shadow structure, as defined by the fast-electron component, of the solar-wind becomes extremely complex. The shadow structure becomes much broader than the lunar diameter and may become very shallow. (That is, a considerable fraction of the electrons is able to enter the cavity.)

A weak flux of electrons in the energy range of 25 to 300 keV was found to move predominantly in a sunward direction for a period of several days while the moon was upstream from the earth in interplanetary space. The intensity of this flux was approximately 20 electrons/cm^2-sr-sec for electrons in the 25 to 300 keV energy range. Whether these particles have a solar or terrestrial origin has not yet been determined.

Following an important solar flare on 1 September 1971, a flux of solar electrons was measured at the Subsatellite. The electron spectrum was determined for the energy range of 6 to 300 keV.

EXPERIMENT SUMMARY

TITLE: MAGNETOMETER (SUBSATELLITE) EXPERIMENT (S-174)

PRINCIPAL INVESTIGATOR: Dr. Paul J. Coleman, Jr.
Department of Planetary and Space Science
University of California at Los Angeles
Los Angeles, California 90024

EXPERIMENT SUMMARY:

The purpose of the Subsatellite Magnetometer Experiment is to obtain data on the physical and electrical properties of the moon and the interaction of plasmas with the moon.

The subsatellite magnetometer, magnetic sector generator, and subsatellite support subsystems are used for this experiment. The magnetometer that acquires the prime data for this experiment is of the biaxial flux-gate type and is boom-deployed from the subsatellite. This magnetometer measures the magnitude and polarity of two mutually orthogonal vector components: one parallel and the other perpendicular to the spin axis of the subsatellite. Rotation of the subsatellite in conjunction with the magnetic sector generator provides the third vector component. The magnetometer acquires magnetic field data over a dynamic range of $\pm 50\gamma$ in the low operating mode range and $\pm 200\gamma$ in the high operating mode range.

Measurements of magnetic fields in the transient and steady state boundary layers should provide indirect information on the lunar ionosphere and transient lunar atmosphere. It is estimated that the altitude of the top of the boundary layer at the surface, or the skin depth of the lunar perturbation in the solar wind plasma, will vary from 5 to 500 kilometers. The dynamic processes, e.g., wave-particle and field-particle interactions, are probably very important in this region. Magnetic field measurements at the high data rate should provide exploratory data on such phenomena.

In the cavity directly behind the moon, the properties of the plasma and magnetic field are very different from those of the solar wind flowing in the adjacent regions. At the boundary between this downstream cavity and the solar wind, there are strong gradients in the density and velocity of the plasma.

The anticipated orbit will traverse this layer in two places. Thus, one of the main purposes of this experiment would be to obtain data on the microscopic behavior in this region.

RELATED EXPERIMENTS AND MISSIONS:

Initial data from the two subsatellite fluxgate sensors onboard the Apollo 15 Subsatellite indicate that detailed mapping of the remanent magnetization, although complex, is entirely feasible with the present experiment. For example, preliminary analysis shows a fine structure in the magnetic field associated with the large craters Hertzsprung, Korolev, Gagarin, Milne, Mare Smythii I, and, in particular, Van de Graaff, which produces a 1-gamma variation in the field measured by the Subsatellite passing overhead. Furthermore, magnetic fields induced within the moon by externally imposed interplanetary magnetic fields are detectable at the subsatellite orbit. Estimated variations of lunar conductivity as a function of latitude and longitude will be possible from magnetometer data. Finally, the data show that the plasma void that forms behind the moon when it is in the solar wind extends probably to the lunar surface, and the flow of the solar wind is itself rather strongly disturbed near the limbs of the moon.

TITLE: S-BAND TRANSPONDER EXPERIMENT (CSM/LM/SUBSATELLITE) (S-164)

PRINCIPAL INVESTIGATOR: Mr. W. L. Sjogren, Code 156-251
Jet Propulsion Laboratory
Pasadena, California 91103

EXPERIMENT SUMMARY:

The S-Band Transponder Experiment on Apollo 16 is essentially a passive experiment. This experiment consists of the analysis of Doppler tracking measurements routinely obtained by the Manned Space Flight Network. The purpose of the experiment is to identify lunar gravitational anomalies and, in conjunction with previous and future experiment data, develop an improved lunar gravitational model. Tracking information from low altitude orbits (i.e., below 16 NM) will provide the most meaningful data on the lunar gravitational anomalies (mascons). These data, supplemented with high altitude (i.e., approximately 60 NM) data will provide information to describe the size and shape of the mascons. All the data will be utilized in the development of the lunar gravitational model.

Correlation of gravity data with photographic and other scientific records will give a more complete picture of the lunar environment and support future lunar activities. Inclusion of this improved gravitational field description is pertinent to any theory of the origin of the moon and the study of the lunar subsurface structure. There is also the additional benefit of better navigational capabilities in future lunar missions with an improved lunar gravity model.

RELATED EXPERIMENTS AND MISSIONS:

The S-Band Doppler tracking measurements from Lunar Orbiter missions were analyzed and distinct variations in the lunar gravity field were detected. Further analysis indicated the existence of mass concentrations (mascons) below the surface of ringed maria. Apollo 8 and 10 tracking confirmed the Lunar Orbiter results. Low altitude data from the Apollo Program will provide an order of magnitude improvement in spatial resolution over pre-Apollo experiments.

Analyses of the Apollo 15 low-altitude CSM data have resulted in new gravity profiles of the Serenitatis and Crisium mascons; these results are in good agreement with the Apollo 14 data analysis and strongly suggest that the mascons are near-surface features with a mass distribution per unit area of approximately 800 kg/cm^2. The Apennine Mountains show a local gravity high of 85 mgal but have undergone partial isostatic compensation, and the Marius Hills likewise have a gravity high of 62 mgal.

Excellent tracking data was collected on the Subsatellite from November 29 through December 19, 1972 when the Subsatellite dropped to an altitude as low as 38 km.

EXPERIMENT SUMMARY

TITLE: ALPHA PARTICLE SPECTROMETER EXPERIMENT (S-162)

PRINCIPAL INVESTIGATOR: Dr. Paul Gorenstein
American Science and Engineering, Inc.
955 Massachusetts Avenue
Cambridge, Massachusetts 02139

EXPERIMENT SUMMARY:

A recent analysis of lunar surface data obtained during background measurements of the Surveyor alpha backscattering instruments has revealed a surface deposit of alpha particle activity at the Surveyor V landing site. The surface deposit indicated the presence of radon diffusion.

There are several reasons for a study of radon evolution from the moon. Perhaps the most important is that the concentrations of uranium and thorium in different lunar regions can be directly compared when the alpha particle and gamma-ray results are correlated. With information from a gamma sensor, the concentration of uranium can be determined so that it is possible to determine the diffusion characteristics of the soil. In turn, the diffusion properties are related to the porosity and quantity of absorbed gases in the lunar soil. If there is significant diffusion of radon to the surface, then the active deposit from the radon decay will increase the gamma activity of the surface. The alpha measurement is needed in order to subtract the effect of surface deposits and give a clearer interpretation to the gamma measurements in terms of uranium concentrations. The location of regions with enhanced radon emission is an indication of one or more of the following interesting features: the occurrence of crevices or fissures on the lunar surface; areas which release volatiles generally; or possibly regions with unusual concentrations of thorium.

The alpha particle data will be considered along with the X-ray and gamma-ray data to determine a map of the lunar chemical composition.

RELATED EXPERIMENTS AND MISSIONS:

The Alpha Particle Spectrometer Experiment was conducted on the Apollo 15 mission. Analysis of data from Apollo 15 gives evidence that a nonhomogeneous distribution of radioactive Po^{210} deposit exists on the lunar surface. This deposit is probably due to transient outgassing through the lunar surface. The observed radioactivity is in the region of Crater Tsiolkovsky and Mare Crisium. Preliminary analysis of alpha-particle data corresponding to Radon decay reveals that the average count rate is at most equal to 0.004 counts/cm^2-sec-sr ($\pm$1 percent) in the energy band from 4.7 to 9.1 MeV. This measured alpha-particle activity is considerably less than was anticipated before the mission. For example, if the uranium and thorium concentrations measured in the samples returned from the Apollo 11 and 12 sites are typical Moon-wide values, then the alpha-particle counting rate that results from radon emission is at least a factor of 60 lower than the rate predicted using terrestial radon-diffusion models.

EXPERIMENT SUMMARY

TITLE: MASS SPECTROMETER EXPERIMENT (S-165)

PRINCIPAL INVESTIGATOR: Dr. John H. Hoffman
Atmospheric and Space Sciences
University of Texas at Dallas
P.O. Box 30365
Dallas, Texas 75230

EXPERIMENT SUMMARY:

The purpose of the Mass Spectrometer Experiment is to obtain data on the composition of the lunar ambient atmosphere, on areas of lunar volcanism, and on contamination in lunar orbit and cislunar space. During transearth coast, the mass spectrometer will obtain data on the amount of local contamination caused by the spacecraft. This instrument has the capability of identifying species possessing an atomic mass from 12 to 28 atomic mass units (AMU) with its Number 1 ion counter and from 28 to 66 AMU's with its Number 2 ion counter.

The spectrometer experiment assembly consists of the mass spectrometer itself, its associated electronic components, and a boom deployment mechanism. When gathering prime data, the spectrometer assembly is fully deployed on a boom by its deployment mechanism to remove the mass spectrometer from the influence of CSM contaminant sources. This fully deployed distance is 24 feet past the SM mold line.

Study of the composition and distribution of gases in the lunar atmosphere is important to two current problems. The first problem is the understanding of the origin of the lunar atmosphere. Light gases, such as hydrogen, helium, and neon, probably originate from neutralization of solar wind ions at the surface of the moon, whereas Ar^{40} is most likely due to radioactive decay of K^{40}; Ar^{36} and Ar^{38} may be expected as spallation products of cosmic ray interactions with surface materials. Molecular gases, such as carbon dioxide, carbon monoxide, hydrogen sulfide, ammonia, sulphur dioxide, and water vapor may be produced by lunar volcanism.

The second problem is related to transport processes in planetary exospheres. The exosphere of the earth, and that of almost any other planet, is bounded by a dense atmosphere in which hydrodynamic wind systems complicate the problem of specifying appropriate boundary conditions for exospheric transport. This contrasts sharply with the situation in the lunar atmosphere, which is entirely a classical exosphere, having as its base the surface of the moon. The lunar exosphere should be amenable to accurate, analytical study. Experimental determination of the global distribution of lunar gases can provide a reasonable check on theory, giving confidence to the application of theoretical techniques to transport problems in the terrestrial exosphere.

RELATED EXPERIMENTS AND MISSIONS:

The Mass Spectrometer Experiment was flown on the Apollo 15 Mission. These data show that a large number of sublimated gas molecules from frozen particles of water, hydrocarbons, and RCS fuel combustion products exist in the vicinity of the spacecraft. This gas cloud seems to be moving with the CSM, since its measured density is largely independent of whether the SIM is in the +X or -X orientation. This suggests that the CSM is its most probable source. During TEC the amplitudes of all peaks in the gas cloud spectra decreased by a factor of five to ten and a boom retraction test showed no increase in gas densities down to 1.25 meters from the CSM surface. The presence of this gas cloud was not expected in that it had been hypothesized that gas molecules leaving the CSM would rapidly leave the area due to their large mean free paths.

Some evidence of possible neon concentration variation from lunar day to night was detected. However, since the instrument was temperature sensitive, this evidence is not conclusive. A design change to the ion scoop for the J-2 Mission will add an inner heated plenum. This change in conjunction with baffling of the outgassing ports to eliminate direct sunlight impingement on heat sensitive electronics will provide more effective scoop temperature and outgassing control.

On the J-2 Mission, prime data will be collected as soon as possible in lunar orbit and after orbit changes to minimize the effect of possible CSM contamination on measuring a native lunar atmosphere. Since the gas cloud measured on Apollo 15 did not rapidly dissipate, many contamination measurements will be made to assist the Skylab Program in evaluating the characteristics of this contamination cloud. The spatial density of the gas cloud in both lunar orbit and trans-earth coast will be measured as well as the effect of water and urine dumps, oxygen purges, and RCS jet firings which are usually inhibited during SIM bay operations.

EXPERIMENT SUMMARY

TITLE: UV PHOTOGRAPHY - EARTH AND MOON EXPERIMENT (S-177)

PRINCIPAL INVESTIGATOR: Dr. Tobias Owen
Department of Earth and Space Sciences
The State University of New York
Stony Brook, New York 11790

OBJECTIVE SUMMARY:

Ultraviolet photographs of the earth and moon will be obtained using a Hasselblad electric camera. The camera will be equipped with a 105-mm UV transmitting lens and 3 bandpass filters in the UV region of the spectrum. The photographs will be taken in sets of 4, including 1 with each UV filter and 1 in the visible spectrum. UV photographs will be taken through the CM right hand side window during translunar coast, lunar orbit, and transearth coast. This CM window transmits a higher fraction of incident UV radiation than standard windows. The primary objective of this experiment is an investigation of the terrestrial atmosphere, as it appears in the ultraviolet spectrum, for comparison with UV photographs of other planetary atmospheres. UV photographs of the moon taken in lunar orbit will be used to search for color differences and possible fluorescence from the lunar surface.

RELATED OBJECTIVES AND MISSIONS:

Photographs of the earth and moon in two UV spectral regions and in the visible spectrum were obtained on Apollo 15. A third UV bandpass filter failed to meet preflight qualification tests. These photographs indicate that the surface of the earth is clearly visible at 3750 Å, partially visible at 3400 Å, and that no significant changes in the visibility of high-altitude particles occur at these wavelengths.

Photographs and spectra of the earth in the far ultraviolet will also be obtained during Apollo 16 by the Far UV Camera/Spectroscope Experiment on the lunar surface.

EXPERIMENT SUMMARY

TITLE: GEGENSCHEIN FROM LUNAR ORBIT EXPERIMENT (S-178)

PRINCIPAL INVESTIGATOR: Mr. Lawrence Dunkelman, Code 613.3
Goddard Spaceflight Center
Greenbelt, Maryland 20771

EXPERIMENT SUMMARY:

Gegenschein (counter glow) is a diffuse area of visible illumination which is detectable in the terrestrial night sky in a 20° field of view centered on the earth-sun line. Interplanetary dust scatters sunlight back to the earth to produce the glow. Gegenschein photographs taken from lunar orbit can provide information on the distribution and dynamics of interplanetary dust near the earth-moon system. Parallax enhancement due to earth-moon distance will permit the determination of the distance to the source of reflection. From the double umbra region of the lunar orbit, the 35-mm Nikon camera will be used to obtain photographs of the gegenschein and Moulton point regions. Photographs will be taken in the antisolar direction, in the Moulton point direction, and in the direction midway between. These photographs will be used to investigate the spatial distribution of the gegenschein, and to test the theory that one contribution to the gegenschein is sunlight reflected from an accumulation of dust particles in relative gravitational equilibrium at the Moulton point.

RELATED EXPERIMENTS AND MISSIONS:

The Moulton point region is a libration region in the sun-earth system, analogous to the lunar libration regions in the earth-moon system. It is located on the night portion of the earth-sun line approximately 940,000 statute miles from the earth. Photography of the gegenschein is closely related to lunar libration photography performed on Apollo 14 and 15. Apollo 14 was the first mission to obtain gegenschein photographs from lunar orbit. On Apollo 15 a better light-gathering system (35-mm Nikon camera) was used, but the gegenschein area was not photographed due to incorrect spacecraft attitude.

DETAILED OBJECTIVE SUMMARY

TITLE: CM PHOTOGRAPHIC TASKS DETAILED OBJECTIVE

PRINCIPAL INVESTIGATOR: Apollo Orbital Science Photographic Team

OBJECTIVE SUMMARY:

Hand-held and bracket-mounted cameras will be used from the CM to obtain photographs of the lunar surface and of astronomical subjects. Photographic equipment will include the Hasselblad electric camera (HEC) with the 80-mm and 250-mm lenses, the data acquisition camera (DAC) with the 18-mm lens, and the 35-mm Nikon camera. Photographic subjects will be as follows:

- The solar corona, photographed prior to LOI and during lunar orbit after CSM sunset and before CSM sunrise. Photographs of the solar corona taken while the solar disc is occulted by the moon will be used to study the pattern of energy outflow from the sun, and to obtain polarization information on the coronal region. These photographs will be taken over a period of four to five days, allowing limited observation of solar rotation.

- Zodiacal light, photographed during a lunar dark-side pass as the CSM approaches sunrise. Photographs of the zodiacal light will aid study of the distribution of small asteroids within the solar system, by showing sunlight reflected from collections of these bodies. A polarization filter will be used to obtain data on the size and composition of the reflecting bodies.

- The lunar surface in low light levels near the terminator and in earthshine, photographed from lunar orbit. These low light level photographs will complement photographs taken by the SIM bay cameras. Near-terminator photographs are at very low sun angles which enhance the identification of small surface features.

- Selected lunar surface areas of high scientific interest, photographed from lunar orbit. This photography will complement SIM bay photography in that specific targets will be available at viewing angles and sun angles not feasible for the SIM bay cameras due to their attitude and altitude constraints.

RELATED OBJECTIVES AND MISSIONS:

Apollo 8 obtained vertical and oblique overlapping photographs terminator to terminator which were used to update lunar charts of the lunar farside. Apollo 12 and 14 used a technique of landmark tracking combined with photography to aid in updating selenodetic reference points on the near side of the moon. Dim light photography was done during the Mercury and Gemini programs and on Apollo 8 and 14. Apollo 15 obtained excellent quality photographs of solar corona, zodiacal light, lunar libration region L4, and the lunar surface near the terminator.

Preliminary investigation indicates that Apollo 15 photographs of the L4 libration region show higher than average sky brightness from this region.

DETAILED OBJECTIVE SUMMARY

TITLE: VISUAL OBSERVATIONS FROM LUNAR ORBIT DETAILED OBJECTIVE

PRINCIPAL INVESTIGATOR: Dr. Farouk El-Baz
Lunar Exploration Department
Bellcomm, Inc.
955 L'Enfant Plaza North, S.W.
Washington, D.C. 20546

OBJECTIVE SUMMARY:

Visual observations will be made by the command module pilot of specific lunar surface features and processes. Observations will be relayed to earth in real time or, on the lunar backside, will be recorded on tape. The purpose of visual observations is to complement photographic and other remote sensing data by taking advantage of the human eye's dynamic range and color sensitivity. Visual observation also provides on-the-scene interpretation of any unexpected features or phenomena. The color sensitivity of the eye permits the deciphering of subtle differences between lunar surface units under varying sun angles and viewing directions. The dynamic range of the eye allows visibility, under proper adaptation conditions, within what appears in photographs as hard shadows and washout regions. Visual observations will aid in the regional mapping and characteristics of major lunar surface units, and in the understanding of various small scale features.

RELATED OBJECTIVES AND MISSIONS:

Visual observations of the moon have been made on all lunar orbital missions, but formal scheduling of visual science targets was done first on Apollo 15. The recorded observations will be correlated with photographs taken with both hand-held cameras and the SIM bay cameras.

EXPERIMENT SUMMARY

TITLE: BISTATIC RADAR EXPERIMENT (S-170)

PRINCIPAL INVESTIGATOR: Mr. H. Taylor Howard
Stanford Electronics Laboratory
Stanford University
Stanford, California 94305

EXPERIMENT SUMMARY:

The Down-Link Bistatic Radar Observations of the Moon Experiment utilizes the Apollo S-band and VHF communication systems and associated ground facilities. Properties of the lunar crust will be investigated by means of VHF and S-band radio beams directed toward the lunar surface by antennas on the CSM. The beams are reflected at the lunar surface and deflected earthward where they are detected and recorded by ground-based receivers. The 210-foot Mars antenna at Goldstone will be used for S-band reception; the 150-foot antenna at Stanford University will be used for VHF reception. Changes in signal amplitude and phase shift versus signal frequency and the incident and reflection angles of the beam at the lunar surface will be analyzed to determine lunar surface roughness, surface shape, geological structure, and Brewster angle. From the Brewster angle, the electrical properties of the soil can be inferred. The results will provide lunar S-band and VHF bistatic radar calibrations which will have considerable utility in the interpretation of similar experiments conducted in the future at the planets.

RELATED EXPERIMENTS AND MISSIONS:

Experiments have been conducted using down-linked telemetry carriers from Lunar Orbiters I and III which operated essentially as lunar orbiting radar beacons. The Lunar Orbiter observations were conducted at the S-band wavelength (13 centimeters) whereas Explorer XXXV observations were conducted at a 2-meter wavelength. The experiment performed on Apollo 14 showed that signal-to-noise ratios during both S-band and VHF operation were sufficient to achieve experiment objectives.

The VHF data obtained during the Apollo 15 mission have approximately one order of magnitude higher signal-to-noise ratio than previously obtained, and the effects of the bulk electrical properties and slope statistics of the surface are clearly present in the data. The S-band data show the areas surveyed during the mission to be similar to those regions sampled at latitudes farther south during the Apollo 14 mission. Distinct variations in the slopes of the lunar terrain in the centimeter-to-meter range exist, and some areas contain an unusually heavy population of centimeter-size rock fragments. The bistatic radar data are currently being combined with the CSM ephemeris data to correlate these results with orbital photography and corresponding geological interpretations in order to better distinguish between adjacent and sub-adjacent geological units.

APPENDIX C

MAP DATA PACKAGE

Lunar surface maps of the Descartes landing site for Apollo 16 are used for crew traverse training and for planning and execution of lunar surface activities. Maps showing each LRV and contingency walking traverse, and the geologic and topographic points of interest are included in the data package. The symbols for each of the maps are shown in the Geologic Map Explanation at the beginning of the Map Data Package.

LUNAR SURFACE TRAVERSE PACKAGE

APOLLO 16
LANDING SITE DESCARTES

PREPARED UNDER THE DIRECTION OF THE U. S. G. S., CENTER OF ASTROGEOLOGY FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND PRINTED BY THE U. S. ARMY TOPOGRAPHIC COMMAND (TPC).

EXPLANATION FOR GEOLOGIC MAPS (1:12,500 and 1:25,000 SCALES) APOLLO 16 (DESCARTES) LANDING SITE AREA

STRATIGRAPHY

Ici

CAYLEY FORMATION

Stratified materials, with layers about 10-40 m thick. Underlying rolling, irregular surface; interpreted to be mafic to intermediate volcanics.

Idd | **Idd_1** | **Idd_2**

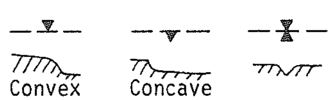
MATERIALS OF THE DESCARTES MOUNTAINS

Stratified, with layers about 10-40 m thick; forms domes. Divided on Stone Mountain into a light medium-gray lower unit (Idd_1) and a dark medium-gray upper unit (Idd_2). Interpreted to be intermediate volcanics with lower part gradational into Ici.

IMBRIAN

GEOLOGIC AND TOPOGRAPHIC SYMBOLS (WHITE)

GEOLOGIC CONTACT
Dashed where approximately located



ESCARPMENT CREASE

TRAVERSE SYMBOLS (BLACK)

NOMINAL LM SITE

LINE OF TRAVERSE

12 • LRV • A WALKING

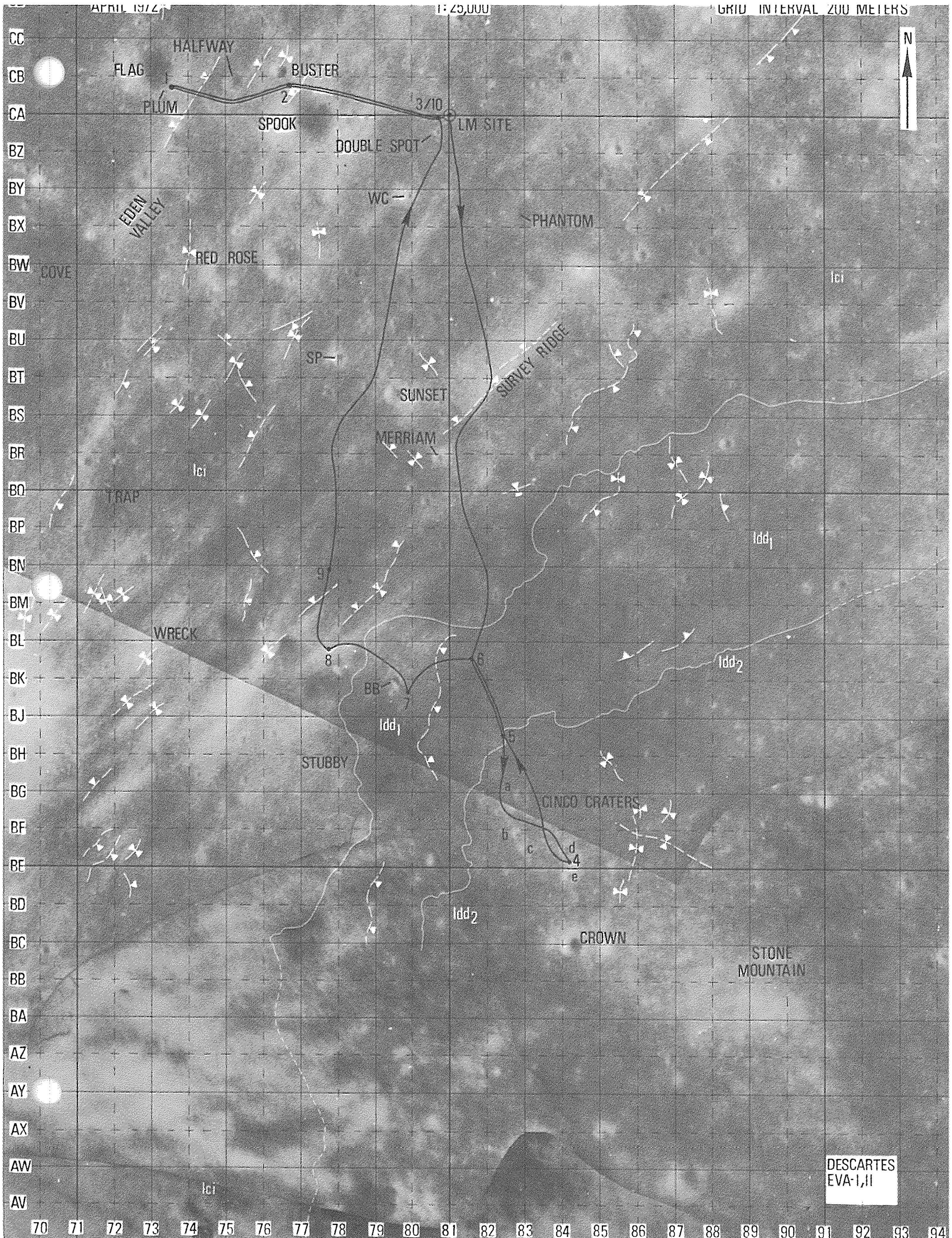
STATIONS

16 — 251° / 1.0 — 15

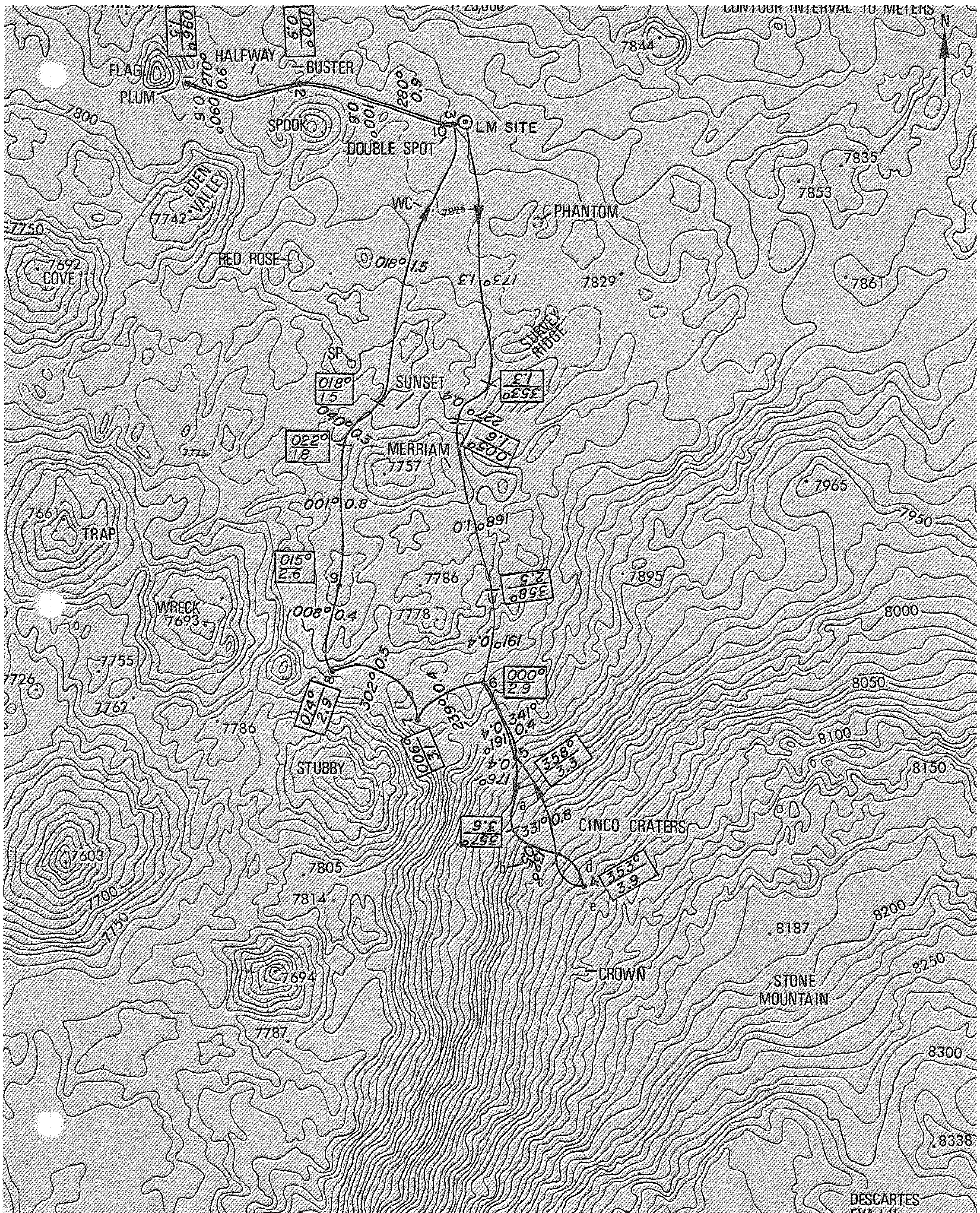
AZIMUTH (251°) AND APPROXIMATE DISTANCE (1.0) BETWEEN STATIONS: AVERAGE AZIMUTHS GIVEN ON CURVING TRAVERSE SEGMENTS.

— 179° / 4.6 • 12

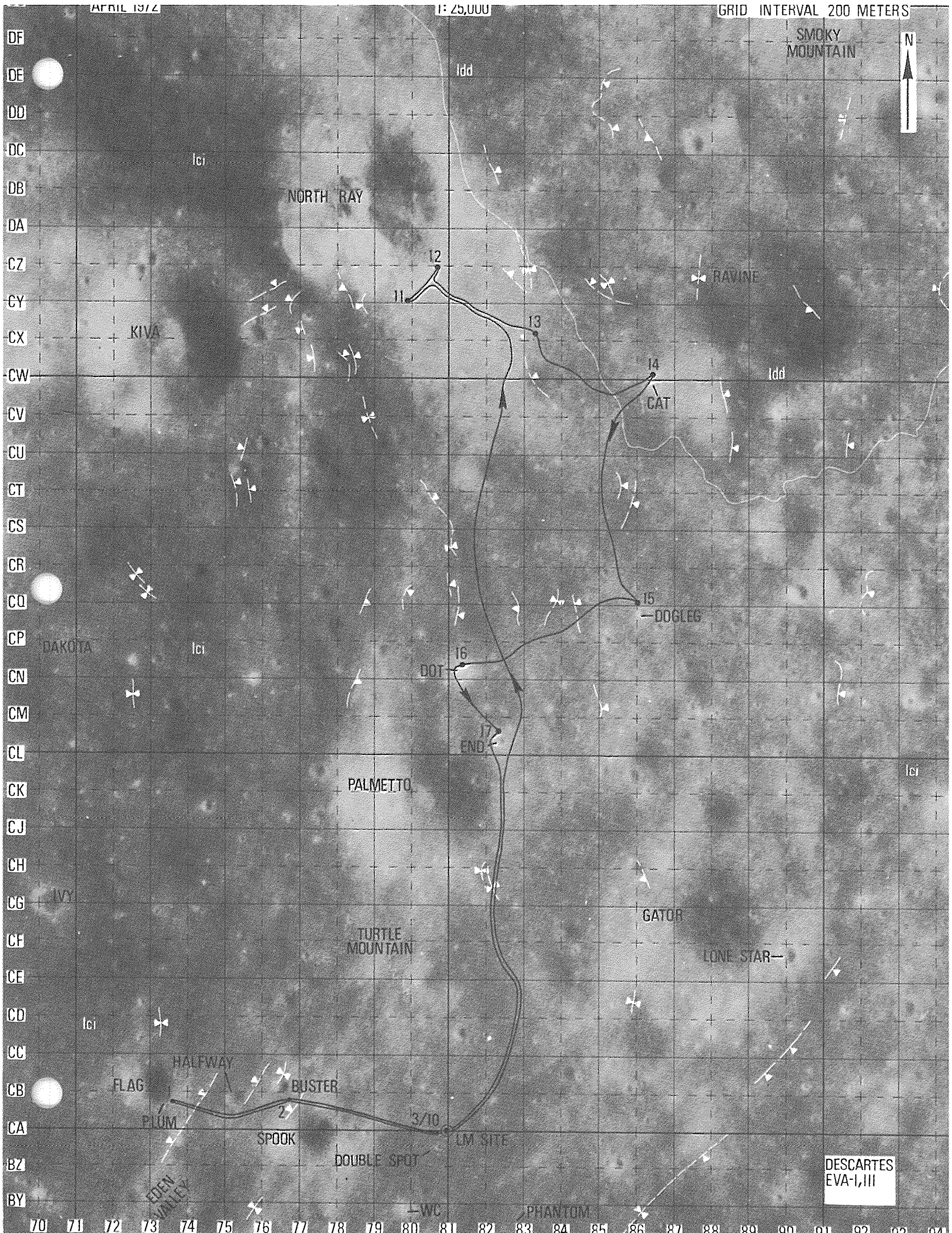
BEARING (179°) AND RANGE (4.6) OF SHORTEST DISTANCE TO LM FROM STATION OR FROM MAJOR CHANGE IN TRAVERSE DIRECTION.



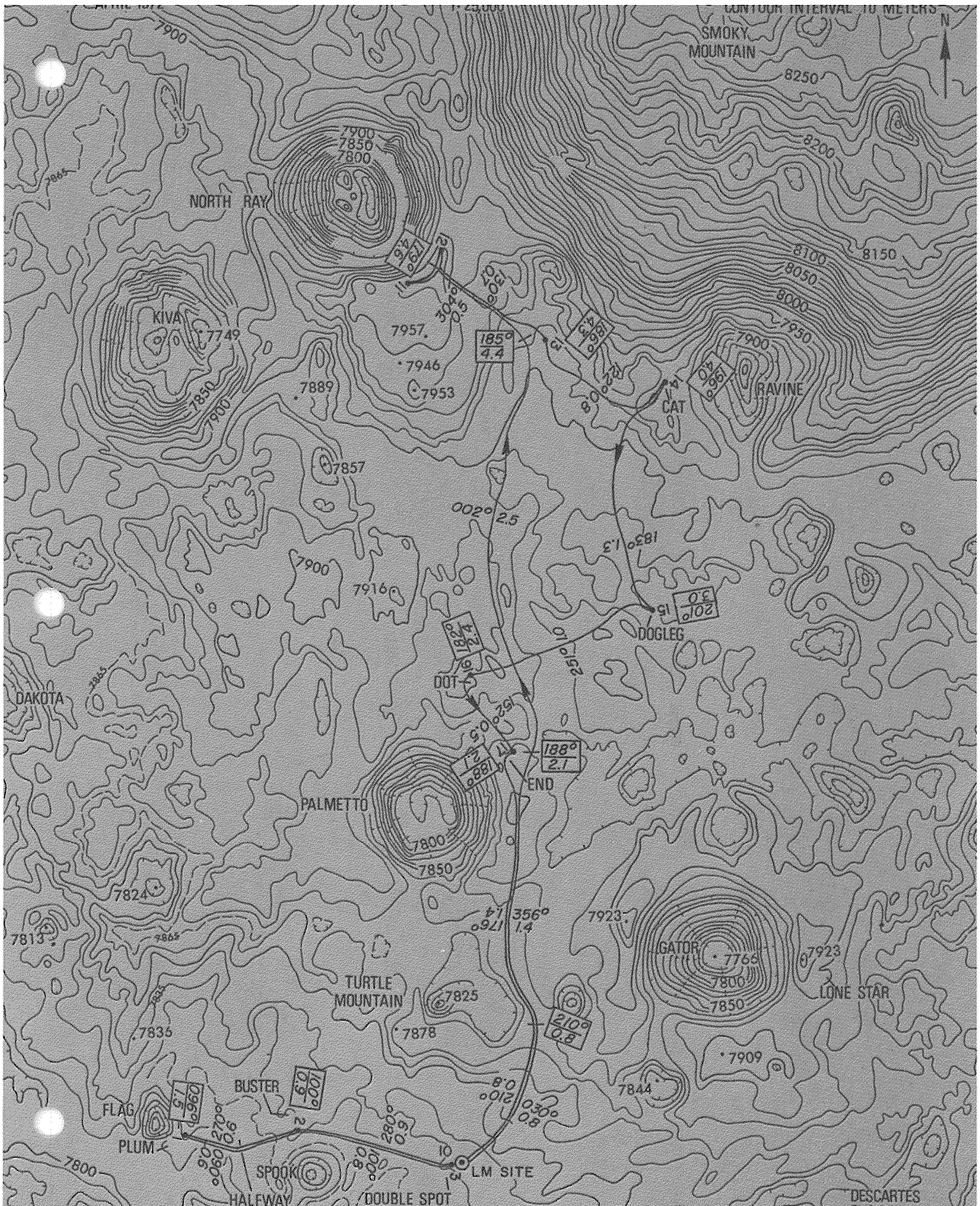
APRIL 1972
1: 25,000
GRID INTERVAL 200 METERS
N
HALFWAY
FLAG
BUSTER
PLUM
2
3/10
SPOOK
LM SITE
DOUBLE SPOT
WC
EDEN VALLEY
PHANTOM
RED ROSE
COVE
Ici
SP
SURVEY RIDGE
SUNSET
MERRIAM
Ici
TRAP
Idd1
9
WRECK
8
6
Idd2
BB
7
Idd1
5
STUBBY
a
CINCO CRATERS
b
c
d
4
e
Idd2
CROWN
STONE MOUNTAIN
DESCARTES EVA-I,II
Ici
CC
CB
CA
BZ
BY
BX
BW
BV
BU
BT
BS
BR
BQ
BP
BN
BM
BL
BK
BJ
BH
BG
BF
BE
BD
BC
BB
BA
AZ
AY
AX
AW
AV
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94

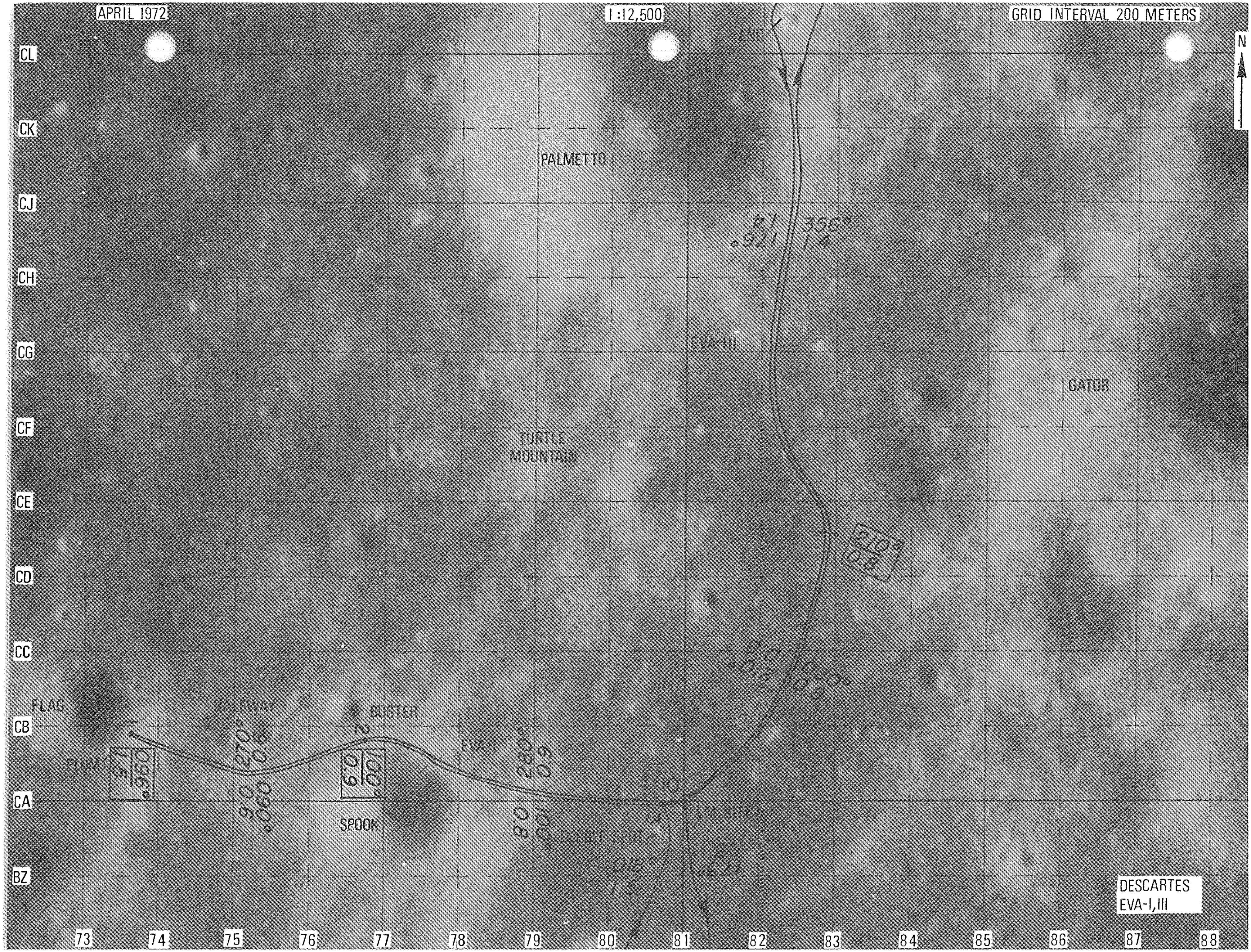


CONTOUR INTERVAL 10 METERS
N
FLAG
PLUM
HALFWAY
BUSTER
SPOOK
DOUBLE SPOT
LM SITE
7844
7800
7835
7853
EDEN VALLEY
7742
7750
WC
7825
PHANTOM
7692
COVE
RED ROSE
018° 1.5
173° 1.3
7829
7861
SURVEY RIDGE
SP
SUNSET
018° 1.5
353° 1.3
040° 0.3
227° 0.4
022° 1.8
MERRIAM
7757
050° 1.6
7775
7965
7661
TRAP
001° 0.8
168° 1.0
7950
015° 2.6
7786
358° 2.5
7895
WRECK
7693
008° 0.4
7778
8000
191° 0.4
7755
7726
302° 0.5
000° 2.9
8050
014° 2.9
7762
239° 0.4
341° 0.4
7786
161° 0.4
8100
006° 3.1
STUBBY
176° 0.4
358° 3.3
8150
331° 0.8
CINCO CRATERS
357° 3.6
7603
7805
353° 3.9
7700
7814
7750
8187
8200
CROWN
7694
STONE MOUNTAIN
8250
7787
8300
8338
DESCARTES EVA I,II
8345

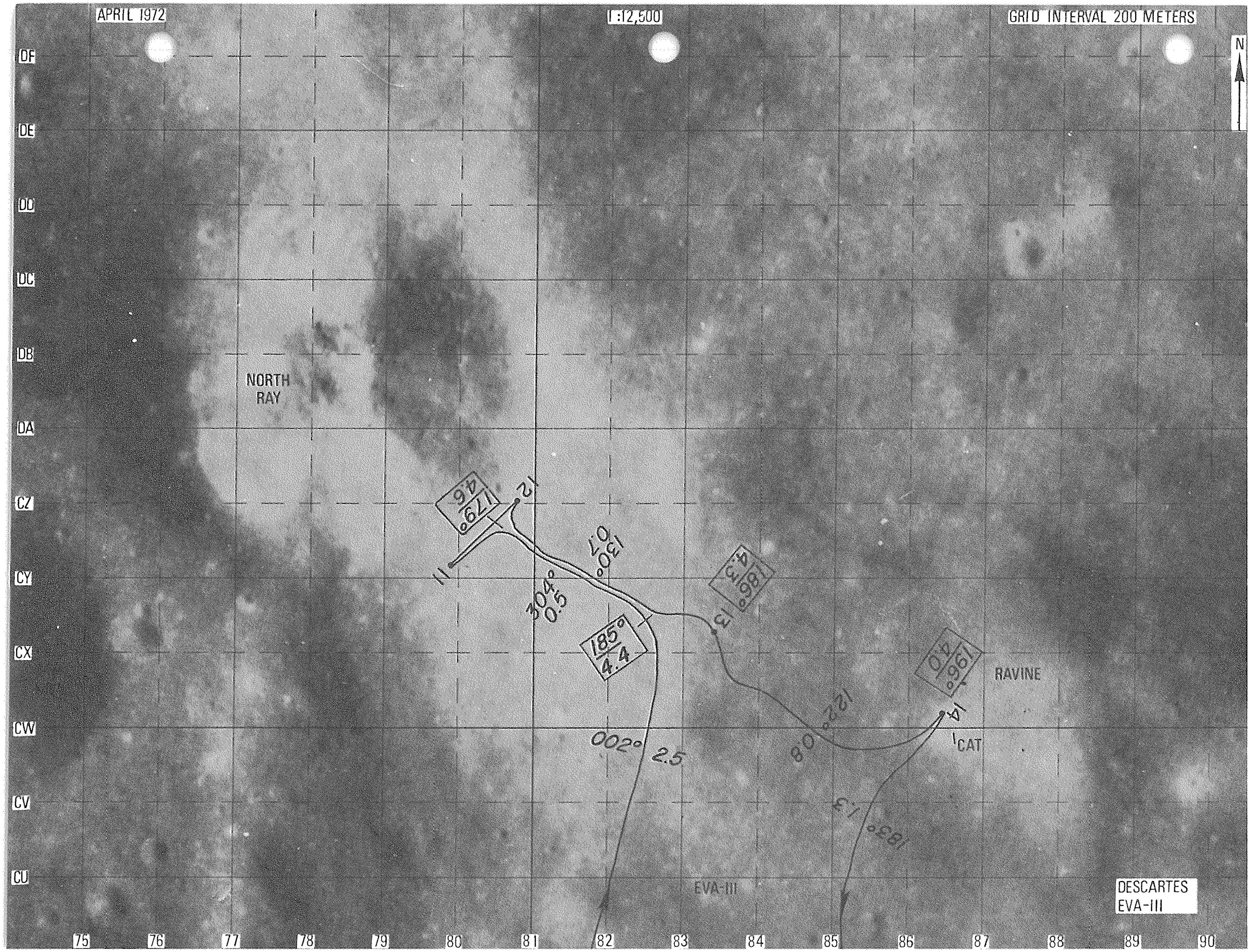


APRIL 1972
1: 25,000
GRID INTERVAL 200 METERS
N
SMOKY MOUNTAIN
NORTH RAY
KIVA
RAVINE
CAT
DOGLEG
DOT
END
DAKOTA
PALMETTO
IVY
TURTLE MOUNTAIN
GATOR
LONE STAR
HALFWAY
FLAG
BUSTER
PLUM
SPOOK
DOUBLE SPOT
LM SITE
EDEN VALLEY
WC
PHANTOM
I1
I2
I3
I4
I5
I6
I7
2
3/10
Ici
Idd
DESCARTES
EVA-I, III

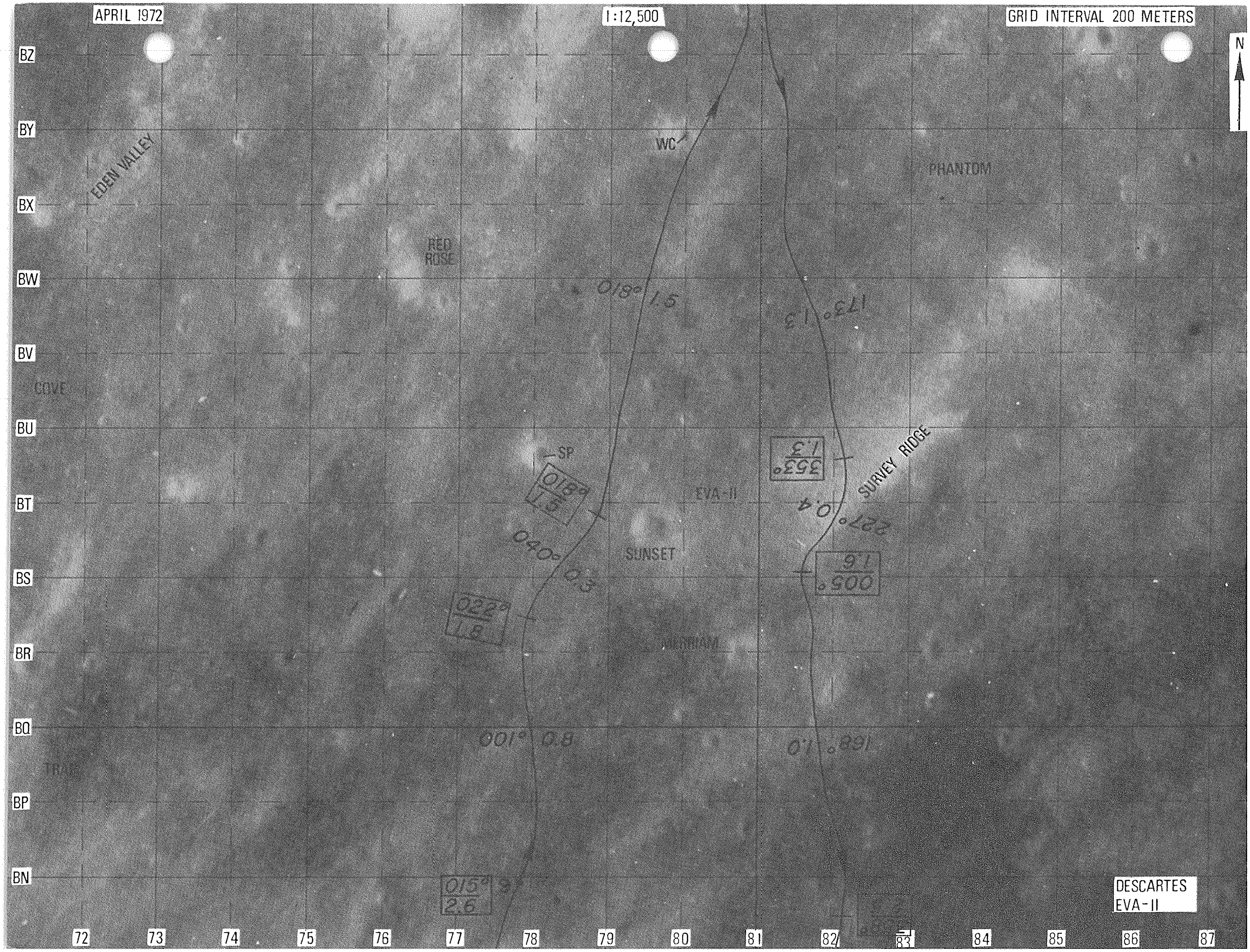

N
SMOKY MOUNTAIN
NORTH RAY
KIVA
RAVINE
CAT
DOGLEG
DOT
END
PALMETTO
DAKOTA
GATOR
LONE STAR
TURTLE MOUNTAIN
BUSTER
FLAG
PLUM
SPOOK
HALFWAY
DOUBLE SPOT
LM SITE
WC
PHANTOM
EDEN VALLEY
DESCARTES
EVA-I, III
185°
4.4
002° 2.5
183° 1.3
201°
3.0
188°
2.1
356°
1.4
176° 1.4
210°
0.8
030°
0.8
8250
8200
8150
8100
8050
8000
7950
7900
7850
7800
7749
7957
7946
7953
7889
7857
7916
7824
7813
7835
7825
7878
7923
7766
7909
7844
7853
7742

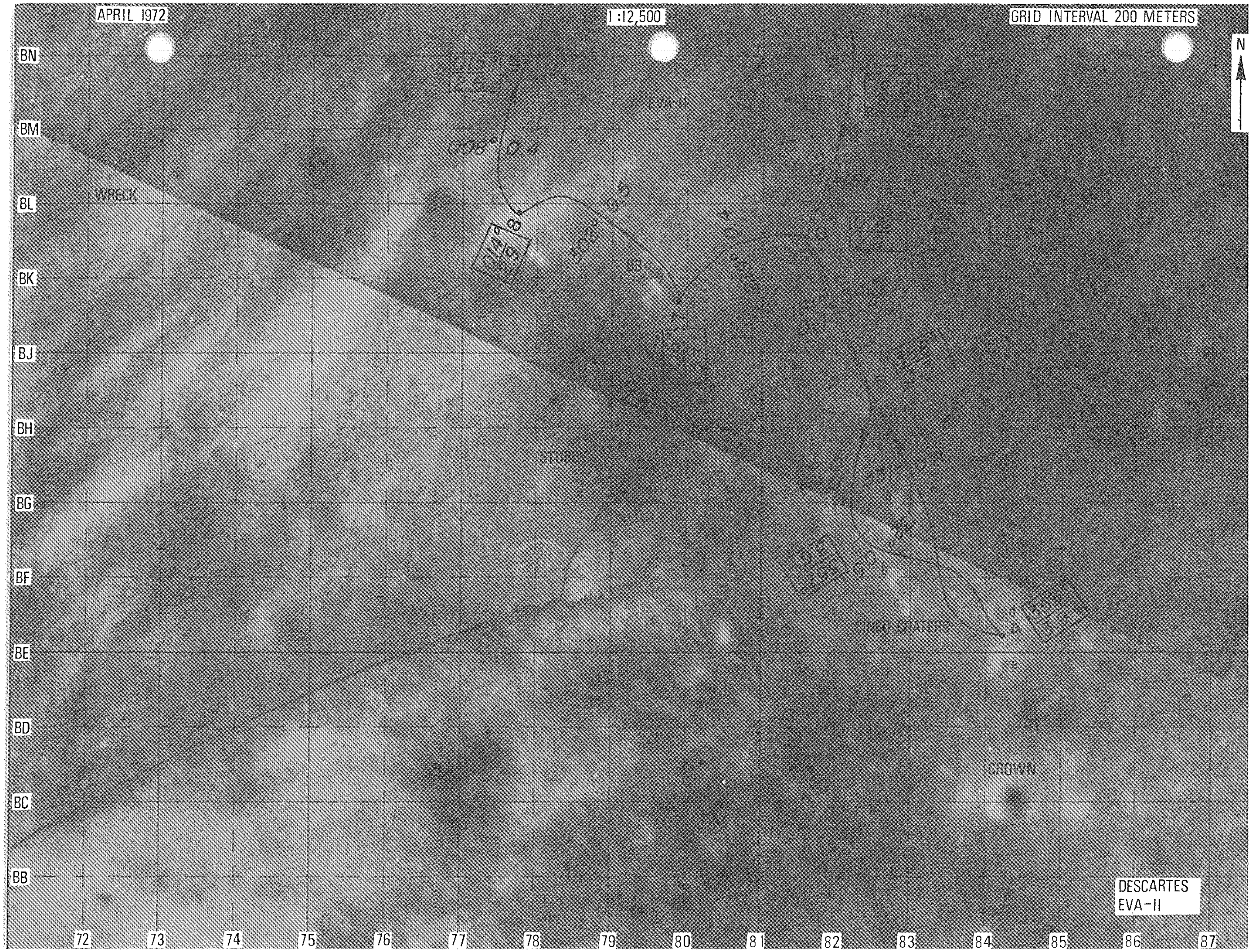


APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
CL
CK
CJ
CH
CG
CF
CE
CD
CC
CB
CA
BZ
END
PALMETTO
176° 1.4
356° 1.4
EVA-III
GATOR
TURTLE MOUNTAIN
210° 0.8
210° 0.8
030° 0.8
FLAG
HALFWAY
BUSTER
PLUM
096° 1.5
270° 0.6
090° 0.6
100° 0.9
EVA-I
280° 0.9
100° 0.8
10
LM SITE
SPOOK
DOUBLE SPOT
018° 1.5
173° 1.3
DESCARTES
EVA-I,III
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88

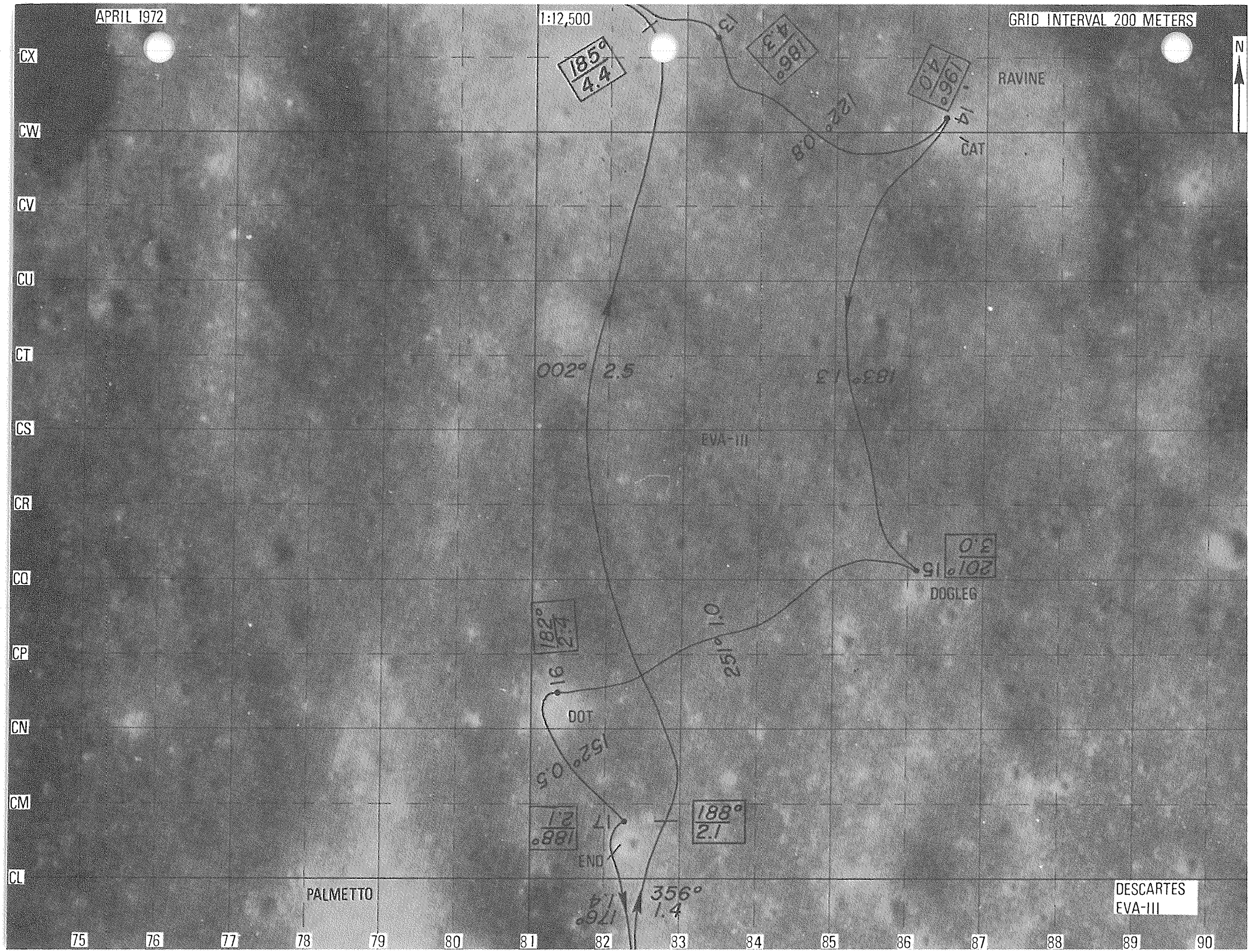


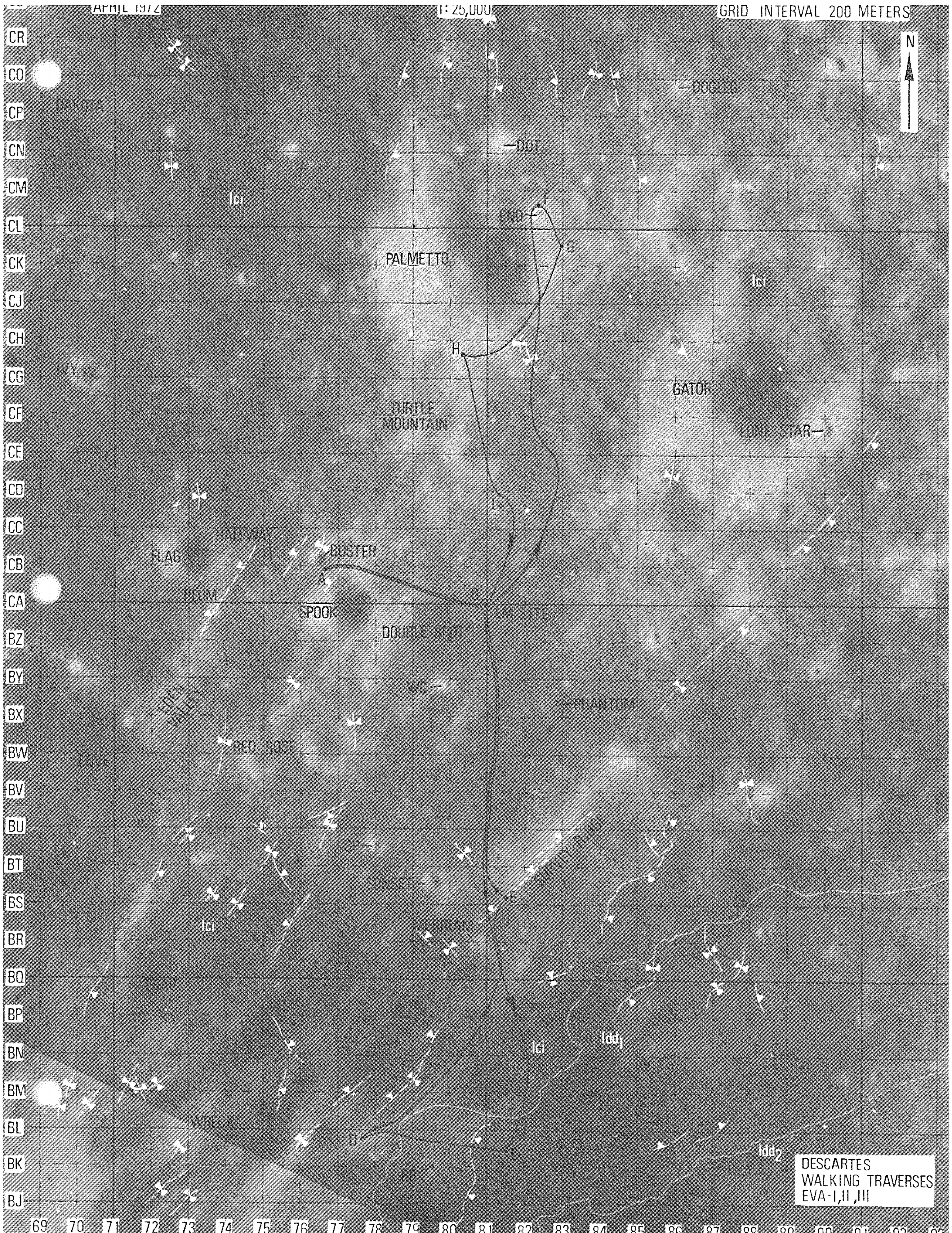
APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
DF
DE
DD
DC
DB
DA
CZ
CY
CX
CW
CV
CU
NORTH RAY
179°
4.6
12
11
130° 0.7
304° 0.5
186°
4.3
13
185°
4.4
196°
4.0
RAVINE
14
CAT
002° 2.5
122° 0.8
183° 1.3
EVA-III
DESCARTES
EVA-III
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

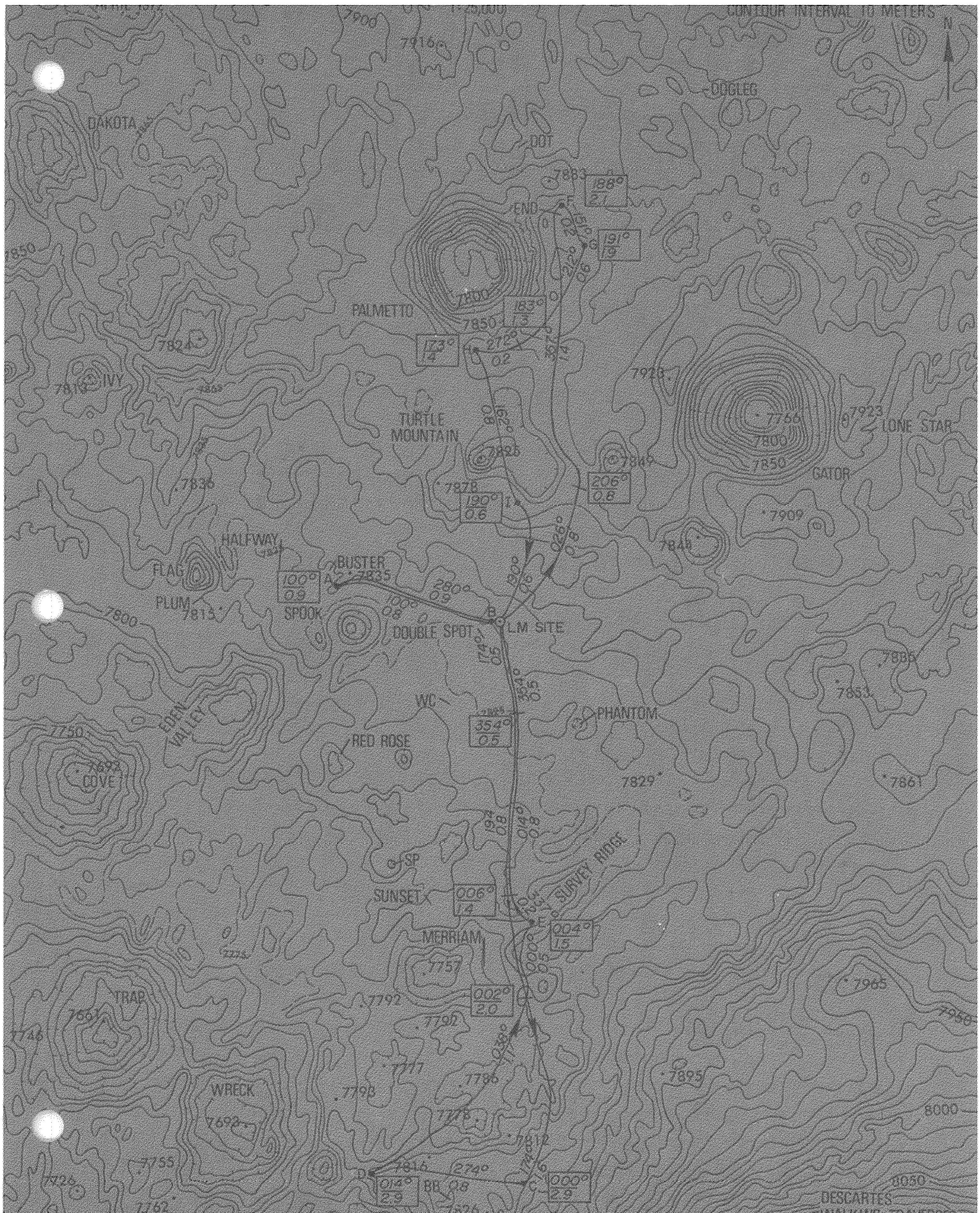

APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
BZ
BY
BX
BW
BV
BU
BT
BS
BR
BQ
BP
BN
EDEN VALLEY
WC
PHANTOM
RED ROSE
COVE
SP
EVA-II
SURVEY RIDGE
SUNSET
MERRIAM
018° 1.5
173° 1.3
018° 1.5
353° 1.3
227° 0.4
040° 0.3
005° 1.6
022° 1.8
001° 0.8
188° 1.0
015° 2.6
DESCARTES
EVA-II
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87



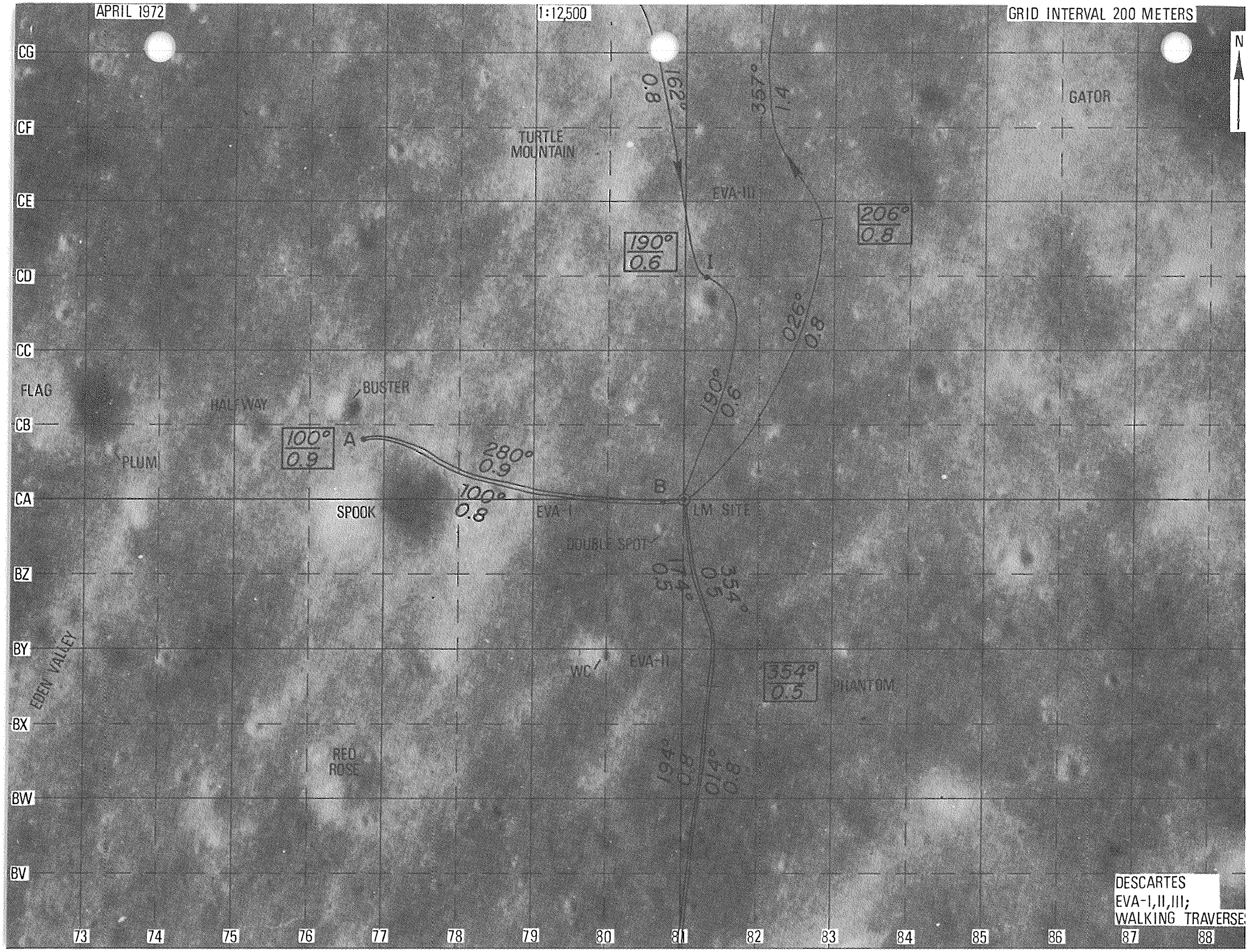
APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
EVA-II
WRECK
STUBBY
CINCO CRATERS
CROWN
BB
DESCARTES
EVA-II
BN
BM
BL
BK
BJ
BH
BG
BF
BE
BD
BC
BB
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87


APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
RAVINE
CAT
EVA-III
DOGLEG
DOT
END
PALMETTO
DESCARTES
EVA-III
CX
CW
CV
CU
CT
CS
CR
CQ
CP
CN
CM
CL
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
185° 4.4
186° 4.3
196° 4.0
122° 0.8
002° 2.5
183° 1.3
201° 3.0
251° 1.0
182° 2.4
152° 0.5
188° 2.1
188° 2.1
356° 1.4
176° 1.4
13
14
15
16
17

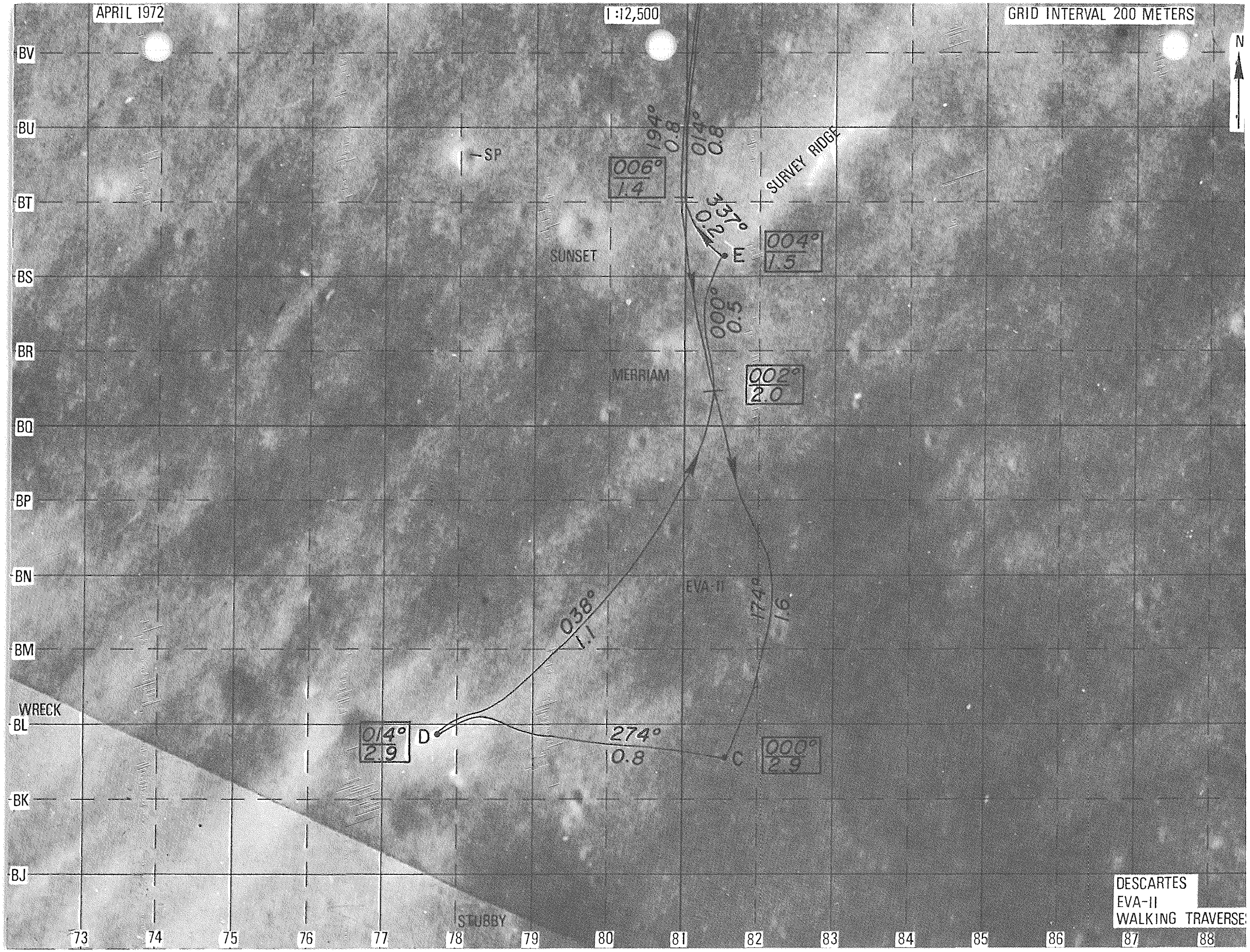

APRIL 1972
1:25,000
GRID INTERVAL 200 METERS
N
DAKOTA
DOGLEG
DOT
Ici
F
END
G
PALMETTO
Ici
H
IVY
GATOR
TURTLE MOUNTAIN
LONE STAR
I
HALFWAY
FLAG
BUSTER
A
PLUM
B
SPOOK
LM SITE
DOUBLE SPOT
WC
EDEN VALLEY
PHANTOM
RED ROSE
COVE
SP
SURVEY RIDGE
SUNSET
E
Ici
MERRIAM
TRAP
Ici
Idd1
WRECK
D
C
Idd2
BB
DESCARTES
WALKING TRAVERSES
EVA-I,II,III
CR
CQ
CP
CN
CM
CL
CK
CJ
CH
CG
CF
CE
CD
CC
CB
CA
BZ
BY
BX
BW
BV
BU
BT
BS
BR
BQ
BP
BN
BM
BL
BK
BJ
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93



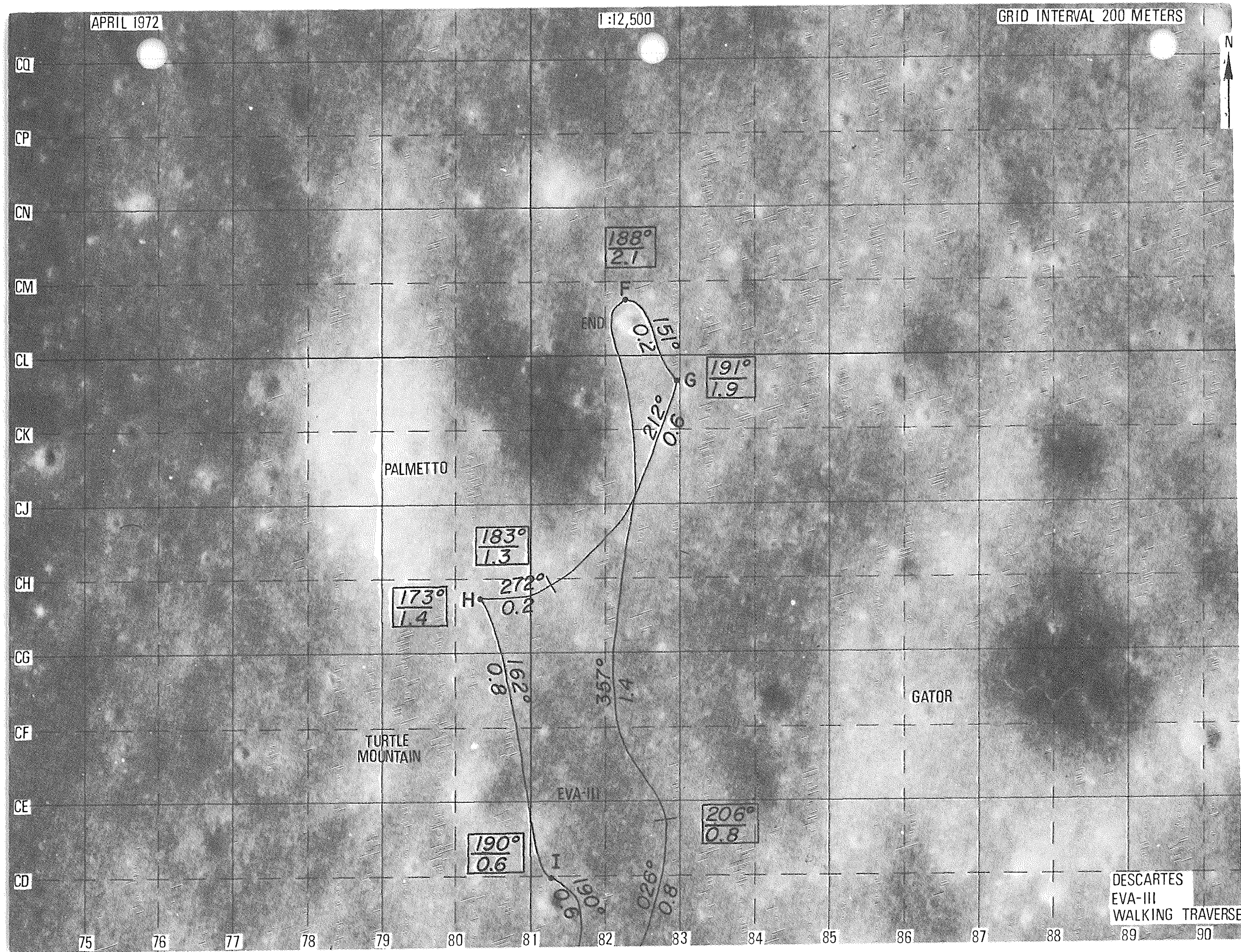
CONTOUR INTERVAL 10 METERS
N
DOGLEG
DAKOTA
DOT
END
PALMETTO
IVY
TURTLE MOUNTAIN
LONE STAR
GATOR
HALFWAY
BUSTER
FLAG
PLUM
SPOOK
DOUBLE SPOT
LM SITE
WC
PHANTOM
EDEN VALLEY
RED ROSE
COVE
SP
SUNSET
SURVEY RIDGE
MERRIAM
TRAP
WRECK
BB
STUBBY
DESCARTES WALKING TRAVERSES EVA-I,II,III



APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
GATOR
TURTLE MOUNTAIN
EVA-III
190° 0.6
206° 0.8
162° 0.8
357° 1.4
026° 0.8
190° 0.6
FLAG
HALFWAY
BUSTER
100° 0.9
A
280° 0.9
100° 0.8
B
PLUM
SPOOK
EVA-I
LM SITE
DOUBLE SPOT
174° 0.5
354° 0.5
WC
EVA-II
354° 0.5
PHANTOM
EDEN VALLEY
RED ROSE
194° 0.8
014° 0.8
CG
CF
CE
CD
CC
CB
CA
BZ
BY
BX
BW
BV
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
DESCARTES
EVA-I,II,III;
WALKING TRAVERSES



APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
BV
BU
BT
BS
BR
BQ
BP
BN
BM
BL
BK
BJ
SP
SUNSET
SURVEY RIDGE
MERRIAM
EVA-II
WRECK
STUBBY
194° 0.8
014° 0.8
006° 1.4
337° 0.2
E
004° 1.5
000° 0.5
002° 2.0
038° 1.1
174° 1.6
014° 2.9
D
274° 0.8
C
000° 2.9
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
DESCARTES
EVA-II
WALKING TRAVERSES



APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
CQ
CP
CN
CM
CL
CK
CJ
CH
CG
CF
CE
CD
188°
2.1
F
END
0.2
151°
G
191°
1.9
212°
0.6
PALMETTO
183°
1.3
173°
1.4
H
272°
0.2
0.8
162°
357°
1.4
GATOR
TURTLE
MOUNTAIN
EVA-III
206°
0.8
190°
0.6
I
0.6
190°
026°
0.8
DESCARTES
EVA-III
WALKING TRAVERSE
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90