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DATA USERS' NOTE

APOLLO 15
LUNAR PHOTOGRAPHY

DECEMBER 1972

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APOLLO 15 LUNAR PHOTOGRAPHY

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FOREWORD

The purposes of this Data Users' Note are to announce the availability of Apollo 15 pictorial data and to aid an investigator in the selection of Apollo 15 photographs for study. As background information, the Note includes brief descriptions of the Apollo 15 mission objectives, photographic equipment, and photographic coverage and quality. The National Space Science Data Center (NSSDC) can provide photographic and supporting data as described in the section on Format of Available Photographic and Supporting Data. The availability of any data received by NSSDC after publication of this Note will be announced by NSSDC in a Data Announcement Bulletin.

NSSDC will provide data and information upon request directly to any individual or organization resident in the United States and, through the World Data Center A for Rockets and Satellites, to scientists outside the United States. All requesters should refer to the section on Ordering Procedures for specific ordering instructions and for NSSDC policies concerning dissemination of data.

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APOLLO 15 LUNAR PHOTOGRAPHY

INTRODUCTION

Apollo 15 (1971-063A) was launched from Cape Kennedy, Florida, on July 26, 1971, at 1334 UT (09:34 EDT) on a 12-day lunar landing mission and had a total flight time of 295 hr 11 min 53 sec. The total extravehicular activity (EVA) time was 18 hr 34 min on the lunar surface and 38 min 12 sec for inflight recovery of the film cassettes from the cameras in the spacecraft Scientific Instrument Module (SIM). The spacecraft reached the lunar environment on July 30, 1971, and returned the crew to earth on August 7, 1971, about 507 km north of Pearl Harbor, Hawaii. Approximately 82 kg (180 lb) of lunar samples were returned.

The Apollo spacecraft consisted of: a Command Module (CM) in which Astronauts David Scott (Commander), James B. Irwin (Lunar Module Pilot), and Alfred E. Worden (Command Module Pilot) traveled from earth to lunar orbit; a Lunar Module (LM), which transported Astronauts Scott and Irwin to the lunar surface and also carried the Lunar Roving Vehicle (LRV); a Service Module (SM), which contained the major propulsion units and fuel cells for the spacecraft and in which space (bay) was provided to house the Scientific Instrument Module; and a subsatellite, which was launched from the spacecraft on August 4, 1971, before the trans-earth coast (TEC) period. This mission was the first of the J-series missions, for which (1) the LRV is carried for greater mobility of the astronauts during their EVA on the lunar surface, (2) the astronauts spend three days on the lunar surface, and (3) the SIM bay is included in the spacecraft configuration.

During the lunar orbit insertion (LOI) phase of the mission, the spacecraft maintained a 106- x 299-km orbit. The LM separated after descent orbit insertion (DOI) in an orbit of 5 x 110 km. During the LM landing phase, the CM maintained a slightly elliptical orbit of 90- x 115-km altitude. The LM successfully landed in the Hadley-Apennine region at longitude 3° 39' 30" E and latitude 26° 06' 54" N close to the Hadley Rill and the foot of the Apennine Mountains.

Mission photography was accomplished from the Command Module, from the Lunar Module, during EVAs, and from the SIM of the SM (still joined with the CM) during 5 days in lunar orbit. Located in the SIM were the automatically operated assembly of the Fairchild mapping (metric) camera, the stellar camera, the RCA ruby laser altimeter, and the Itek optical-bar panoramic camera. The Command Module photographic package included a 16-mm Maurer data acquisition camera (DAC) with 10-mm, 18-mm, and 75-mm lenses; a Hasselblad electric camera (HEC) with 80-mm and

250-mm lenses, as well as a 105-mm ultraviolet-transmitting lens; a Nikon 35-mm camera with a 55-mm lens; and a Westinghouse color TV camera. Carried on the Lunar Module were a Maurer 16-mm camera with a 10-mm lens, three Hasselblad data cameras (HDC), two with 60-mm lenses and one with a 500-mm lens, and an RCA TV camera.

MISSION OBJECTIVES

For this fourth Apollo lunar landing (Apollo 13 did not land), the mission objectives were: (1) to perform selenological inspection consisting of a survey of surface features and a sampling of surface materials in a preselected area of the Hadley-Apennine region; (2) to emplace and activate surface experiments; and (3) to conduct inflight experiments and photographic tasks from lunar orbit.

The lunar surface activities included deployment of the Apollo lunar surface experiments package (ALSEP) consisting of the following experiments: (1) heat flow, (2) lunar surface magnetometer, (3) passive seismometer, (4) cold cathode gage, (5) solar wind spectrometer, (6) suprathermal ion detector, and (7) lunar dust detector. In addition, the laser ranging retroreflector and the solar wind composition experiments were deployed. Inspection, survey, and sampling involved the collection of: (1) the contingency sample, (2) soil and rocks of geologic interest, (3) core-tube samples, (4) trench soil samples, (5) drill-core samples, and (6) a descent-engine-exhaust contamination sample for the lunar geological investigation. The soil mechanics experiment was conducted as a part of the geologic investigation. The mobility of the Lunar Roving Vehicle, which permitted excursions of several kilometers from the LM landing site, enabled the astronauts to perform these tasks.

The lunar orbital experiments were: (1) gamma-ray spectrometer, (2) X-ray fluorescence spectrometer, (3) alpha-particle spectrometer, (4) mass spectrometer, (5) bistatic radar, (6) S-band transponder, and (7) the Apollo window meteoroid. The subsatellite that was released contained three experiments: (1) particle shadows/boundary layer, (2) magnetometer, and (3) S-band transponder.

The lunar photographic tasks were: (1) ultraviolet photography of the earth and moon, (2) photography of the gegenschein from lunar orbit, (3) Service Module orbital photographic tasks, and (4) Command Module photographic tasks.

A summary of the experiments carried on Apollo 15 can be found in Appendix A.

PHOTOGRAPHIC EQUIPMENT AND OBJECTIVES

The Apollo 15 mission was designed to obtain the most extensive quantity and variety of photography of any mission thus far. There were several different varieties of photographic equipment, both on the surface and in orbit, that fulfilled entirely different functions. Table 1 summarizes the camera characteristics; the following discussions give brief descriptions of the camera functions.

Surface Photographic Equipment

The camera equipment operated on the lunar surface or in the LM by Astronauts Scott and Irwin included:

(1) three Hasselblad data cameras (HDC) (LM1 and LM2 in Table 1) that were battery powered and semiautomatic. These cameras used 500-mm and 60-mm lenses.

(2) a 16-mm data acquisition camera (DAC) (LM3) with a polarizing filter and a 10-mm lens.

(3) a color TV camera (LM4) and associated equipment.

70-mm Hasselblad Data Cameras

Three 70-mm Hasselblad data cameras were carried by the astronauts on the lunar surface. Two cameras (LM2) were equipped with 60-mm focal length lenses; the other had a high-resolution 500-mm lens (LM1). These cameras were battery powered, semiautomatic, and, for most operations, attached to the astronauts' pressure suits at chest height. The astronauts could initiate the operating sequence by squeezing a trigger mounted on the camera handle, and the cameras were operable at check stops at each half-stop value. A reseau grid was installed in front of the image plane to provide photogrammetric data, and the cameras were accurately calibrated.

16-mm Maurer Data Acquisition Camera

The 16-mm Maurer DAC (LM3 in Table 1) had frame rates of 1, 6, and 12 fps in the automatic mode and 24 fps in the semiautomatic mode with corresponding running times of 93.3, 15.5, 7.8, and 3.7 min, respectively. A green light emitted light pulses at the frame rates. Fiducial marks were recorded on the film. The camera could be hand held or used in a boresight mount on the Lunar Module on windows 1 or 3.

TABLE 1
SUMMARY OF APOLLO 15 PRIMARY PHOTOGRAPHIC EQUIPMENT

	CAMERA	FOCAL LENGTH (mm)	APERTURE OPENING	FOCUS (meters)	SHUTTER SPEED (sec)	FIELD OF VIEW (deg)	CASSETTE CAPACITY	FILM TYPE	RESOLUTION	KIND	ASA RATING	AMOUNT RETURNED (mag)
CM1	70-mm Hasselblad EL											
	lens a	80	f/2.8 to f/22	1 to infinity	0.002 to 1.0	37.9 side 51.8 diag.	58.5 m 49.2 m	SO-368 (CEX)	80 lines/mm	Ekt. MS	64	7***
	lens b	250	f/5.6 to f/45	2.6 to infinity	0.002 to 1.0	12.5 side 17.6 diag.	58.5 m 49.2 m	SO-168 (HCEX) 3400 (B/W)	80 lines/mm	Ekt. MS	160 80	9***
	lens c	105 UV*	f/4.3 to f/8	infinity	0.002 to 20	29.4 side 41.0 diag.	—	II a-0	—			4
CM2	16-mm Maurer DAC (movie)											
	lens a	10	T1.8 to T22	0.2 to infinity	0.001 to 0.167 and T-time frame rate 1,6 12, 24 fps	54.9 hor. 41.1 vert. 65.2 diag.	43 m	SO-168 (HCEX and CIN)	80 lines/mm	Ekt. ES & EF	160-1000 160-1000	11***
	lens b	18	T1.0 to T22	0.03 to infinity		32.6 hor. 23.4 vert. 39.2 diag.	43 m	3400 (B/W) 3414 (LBW)	—	Pan-X	AEI 6 80	
	lens c	75	T2.4 to T22	1.1 to infinity		7.9 hor. 5.7 vert. 10.0 diag.	43 m	3401 (HBW) 2485 (VHBW)	—	Plus-XX	High Speed 6000	
CM3	35-mm Nikon**	55	f/1.2 to f/16	—	0.001 to 1.0, B or T time	36.0 hor. 24.0 vert.	2.6 m	2485 (VHBW)	58 lines/mm 21 lines/mm	—	6000	4
	Sextant	36	f/8	—	variable	—	—	—	—	—	—	
CM4	TV	—	f/4 to f/44	0.6 to infinity 0.5 to infinity	30 fps	—	—	—	200 TV lines/pic 5-12000 f-c	Operation Range	—	—
SIM1	Panoramic	610	f/3.5 stereo and mono	infinity	variable, automatic	36 fore, aft x 108 across (stereo) 11 x 108 (mono)	2060 m	3414 (LBW)	135 lines/mm	Pan	AEI 6	18(2060 m)
SIM2	Laser Altimeter	—	—	—	variable, automatic	200 mrad	—	—	±2 m	—	—	—
SIM3	Mapping	76	f/4.5	infinity	automatic	74 x 74	460 m	3400 (B/W)	90 lines/mm	Pan-X	80	5(460 m)
SIM4	35-mm Stellar	76	f/2.8	infinity	1.5	18.0 hor. 24.0 vert.	156 m	3401 (HBW)	80 lines/mm	Plus-XX	High Speed	1
LM1	70-mm Hasselblad DC	500	f/8.0 to f/11	10^6 (1 km)	0.002 to 1.0, B-bulb	6.2 side 8.8 diag.	49.2 m	SO-174 SO-368 (CEX)	—	Ekt. MS	278, 6000	9***
LM2	70-mm Hasselblad DC	60	f/5.6 to f/22	0.9 to infinity	0.002 to 1.0, B-bulb	46.9 side 63.4 diag.	49.2 m	SO-368 (CEX) SO-168	—	Ekt. MS	64 160	7***
LM3	16-mm Maurer DAC	10	T1.8 to T22	0.15 to infinity	variable	54.9 hor. 41.1 vert. 65.2 diag.	43 m	SO-168 SO-368	—	Ekt. ES & EF	160 6000	11***
LM4	TV	—	f/2 to f/22	0.6 to infinity 0.5 to infinity	30 fps	—	—	—	200 TV lines/pic	Operation Range 5-12000 f-c	—	—

*Experiment S-177. **Experiment S-178. ***CM and LM photography combined.

Lunar Surface TV Camera

The RCA television camera (LM4 in Table 1) used on the lunar surface could be operated from three different positions -- mounted on the LM modularized equipment storage assembly (MESA), mounted on a tripod and connected to the LM by a 30.5-m cable, and installed on the LRV with signal transmission through the lunar communication relay unit (rather than through the LM communications system as in the other two modes).

While used on the LRV, the camera was mounted on the ground controlled television assembly (GCTA). The camera could be aimed and controlled by the astronauts or remotely controlled by personnel in the Mission Control Center. Remote command capability included camera "on" and "off," pan, tilt, zoom, iris open/close (f/2.2 to f/22), and peak or average light control. The scanning rate for the RCA camera was the commercial 30 fps, 525 scan lines/frame, and scan conversion for black and white monitors was not required. The resolution of the camera was 200 TV lines/picture height (limited by S-band equipment) with an aspect ratio of 4:3 and a range of operation from 5 to 12,000 f-c.

Color was achieved by using a rotating disc driven by a synchronous 600-rpm motor. Lunar color scenes were scanned, field sequentially, and down-linked serially to the Manned Space Flight Network (MSFN). Video was received and recorded from lunar distances at any of the three Deep Space Stations: Goldstone (California), Madrid (Spain), and Honeysuckle (Australia). Color conversion was required at the Manned Spacecraft Center (MSC) in order to provide commercial standard signals for display monitors.

Orbital Photographic Equipment - The SIM Bay Cameras

The main photographic tasks during orbit were performed with cameras in the SIM. In the SIM bay were two photographic packages: the mapping camera system (SIM2, 3, 4 in Table 1) and the panoramic camera (SIM1 in Table 1).

Mapping Camera System

The purpose of the mapping camera system was to obtain photographs of high geometric precision of all lunar surface features overflown by the spacecraft in sunlight. This camera system consisted of a 76-mm (3-in.) Fairchild mapping camera (SIM3) using 5-in. film, a 3-in. stellar camera using 35-mm film, and a laser altimeter. The electrically operated system was powered by 115 v, 400 Hz AC, and 28 v DC spacecraft power. A control panel in the CM provided for on/off/standby, track extend/retract, and image motion switches. The mapping camera system flight plan was devised to provide 78% overlap between successive images photographed in the same pass, when the spacecraft was at the altitude at which the velocity/height (V/H) sensor was set, and approximately 55% sidelap between adjacent photographic passes; the stellar camera (SIM4) provided attitude information; and the laser altimeter (SIM2) provided measured distance from spacecraft to lunar surface in synchronism with each mapping camera exposure. The 78% overlap provided stereo coverage that can also be used for topographic information.

The Apollo 15 mapping camera always operated at maximum aperture, varying the shutter speed to control exposure. The shutter consisted of a pair of continuously rotating disks and a capping blade. An exposure was made when the holes in the rotating disk came into line while the capping blade was turned to the open position. To ensure the geometric precision of successive photographs, the film was held in a plane during exposure, at a fixed distance from the lens nodes, through the use of a glass stage plate with a reseau inscribed on its surface. The reseau made it possible to correct every frame for film processing shrinkage and for any local film distortions. In addition, fiducial marks, which defined on the film the location of the optical axis at the instant of the flash, were exposed just outside of the frame format. These extra marks were required to cope with the complications caused by the movement of the stage plate and the film across the optical field during exposure. This motion compensated for the motion of the terrain image. The mapping camera compensated for forward image motion by driving the stage plate in the direction of flight during exposure. A mapping camera frame (4.5- x 4.5-in. photographic area) covers approximately 165 km on a side.

The laser altimeter, when operating independently, gave altitude data at a frequency of three data points/min when the mapping camera was off and approximately 2.5 points/min when the camera was on. The laser altimeter operated whenever the camera operated on the light side and also operated independently on the dark side. The altimeter malfunctioned during the orbital mission, and no data were obtained after revolution 38. A complete girth of the moon with the altimeter was acquired on revolution 15/16; sporadic data were recorded otherwise. About 30% of the planned altimeter data were obtained.

The stellar camera was mounted on an axis at 96° from that of the mapping camera so that it photographed the sky while the mapping camera photographed the lunar surface. The SM attitude hold during operation for mapping data was confined to the local vertical, with the SIM bay pointed toward the lunar nadir. The inflight pointing accuracy requirement was ±2° in the three axes; postflight pointing knowledge will be derived from the stellar photographs. Any photography designated "stellar" refers to this photography except that discussed under Special Photography and Experiments.

The film cassette containing stellar and mapping photography was removed from the SIM bay by the Command Module Pilot during transearth trajectory and was returned to earth in the Command Module.

Optical Bar Panoramic Camera

The purposes of the panoramic camera (SIM1) were to obtain high-resolution stereo photography of areas of scientific interest including potential landing sites and near terminator areas. This experiment was designed to provide selective, detailed information to support the photogeometry/cartographic goals of the lunar exploration program. The optical bar panoramic camera was comprised of three major assemblies: (1) the roll frame assembly, which basically provided the platform for the rotating lens system; (2) the gimbal structure assembly, which rocked the roll frame assembly back and forth to provide for stereo photography and to compensate for the forward motion of the vehicle; and (3) the main frame assembly, which attached to the vehicle and provided a platform for the film transport system as well as for the roll frame and gimbal structures. The lens was an eight-element, field-flattened Petzval type. Two mirrors folded the 24-in. (610-mm) focal length into a more compact configuration, and the camera had a relative aperture of f/3.5 and field of view (FOV) of 10.77° (20 km of surface at 100-km altitude). The lens was rotated about an axis parallel to the SM, and a capping shutter opened during the time the lens passed through a 108° arc (320 km of lunar surface at 100-km altitude) below the vehicle. The light admitted was focused through a variable width slit from a minimum opening of 0.38 mm to a maximum of 7.6 mm. The slit width and scanning rate (rate of rotation of the lens) established the photographic exposure time.

The gimbal structure, to which the roll frame assembly was attached, provided for both forward motion compensation (FMC) and stereo coverage by rocking forward and aft along the axis of vehicle travel. This structure provided FMC by moving in the direction of apparent ground motion at the exact rate necessary to "freeze" the image, thus avoiding a blurred image. In the stereo mode, the gimbal structure automatically pitched from a position 12.5° forward to 12.5° aft of the vertical between successive exposures, and the cycle rate (4.7 to 8.9 sec) was set so that 100% overlap between stereo pairs separated by five frame numbers (e.g., frames 1 and 6) was maintained and provided a 25° convergent stereo image. There is 10% overlap between successive forward or aft photographs (e.g., frames 1 and 3). The V/H sensor continuously determined the rate of apparent motion of the ground scene, controlling both the motion of the gimbal structure for FMC and the speed of rotation of the lens system (optical bar). The optical bar also controlled the speed of film transportation. A light meter together with the V/H sensor determined the slit width and hence the proper exposure of the film.

The main frame supported the other structures, the film supply, and the takeup mechanism. The film takeup cassette was removed from the panoramic camera by the Command Module Pilot during transearth trajectory, and this cassette was returned to earth in the Command Module. The width of the film was 12.7 cm (5-in.), with a frame format of 11.25 x 112.5 cm (4.5 x 45 in.) corresponding to an area (at 106-km altitude) of 20.5 x 322 km (12 x 183 n.m.) on the lunar surface.

The panoramic camera was mounted on rails that were attached to shelves in the SIM. During camera operation, it was required that the SM positive X axis be in the direction of the velocity vector. The camera and lens assembly was maintained within the optimal resolution temperature constraint limits of 85° to 96° F during operation and between the 10° to 120° F constraint during non-operation times. The camera was thermally isolated from the SIM structure. External contaminants could not be tolerated either by the panoramic or the mapping camera assemblies. Mass spectrometer and gamma-ray spectrometer booms on the SM were normally retracted while the panoramic and metric cameras were in operation.

Orbital Photographic Equipment - Command Module Cameras

Various photographic tasks were also accomplished using four Command Module cameras: a 70-mm Hasselblad electric camera (HEC) (CM1 in Table 1), a 16-mm Maurer DAC (CM2), a 35-mm Nikon (CM3), and a Westinghouse color TV camera (CM4).

70-mm Hasselblad Electric Camera

The 70-mm Hasselblad electric camera (CM1 in Table 1) was used during rendezvous and docking operations and during translunar coast (TLC) and transearth coast (TEC) to photograph the earth and the moon. It was also used to acquire dim light, earthshine, and UV photographs (using a 105-mm lens). This Hasselblad camera had a motor-driven mechanism that was powered by two sealed nickel-cadmium batteries. The mechanism advanced the film to the next frame and cocked the shutter whenever the camera was activated. The normal 80-mm lens could be easily replaced with a 105-mm, 250-mm, or 500-mm lens. The astronauts brought back (unscheduled) the 500-mm-lens HDC camera from the lunar surface and took some photographs from the Command Module.

16-mm Data Acquisition Camera

The 16-mm DAC (CM2 in Table 1) was used to record the following: transposition and docking, LM ejection, docking and undocking operations, LM jettison, the earth and moon during the TLC and TEC phases, reentry, spacecraft interior activities, dim light and gegenschein, and the SIM bay EVA. This camera, which was a duplicate of the 16-mm DAC used in the Lunar Module, was equipped with 10-, 18-, and 75-mm lenses.

35-mm Nikon Camera

The 35-mm Nikon camera (CM3 in Table 1) was selected to obtain photographs of the libration point, L4, and of the gegenschein at the antisolar point, at the Moulton point (gravitationally stable point in the earth-sun system), and at a point midway between. The camera was mounted in the right-hand rendezvous window and periodically made time exposures during the dark portion of the lunar orbit. The purpose of the experiment was to determine whether, and to what extent, reflection from dust particles at the Moulton point contributes to the gegenschein. The gegenschein region was not acquired, but, instead, the camera photographed another part of the Milky Way as a result of a translation error in coordinates from the ground. The libration point region, L4 (trailing stable point in the earth-moon gravitational system), was acquired. Four cassettes of film (125 frames) were exposed, one of which was devoted to calibration data; part of another was used for the earthshine photography.

Command Module TV Camera

A Westinghouse color television camera (CM4 in Table 1), used in the Command Module, could be hand held or bracket mounted. The scanning rate for the camera was the commercial 30 fps, 525 scan lines/frame. The resolution of the camera was 200 TV lines/picture height (limited by S-band equipment) with an aspect ratio of 4:3 and a range of operation from 5 to 12,000 f-c. The camera was operated at variable f-stops from 4 to 44 using a zoom lens. A 5-cm black and white video monitor, which could be velcro-mounted on the camera or at various locations in the Command Module, aided the crew in focus and exposure adjustment. A camera ringsight also aided in directing the lens at the desired target.

SPECIAL PHOTOGRAPHY SEQUENCES AND EXPERIMENTS

From the Command Module during the transearth coast from the moon, two series of Hasselblad electric camera (CM1) and 35-mm camera (CM3) photographs were obtained during lunar eclipse on August 6. The 250-mm lens camera was used (hand held) in the right rendezvous window for the first two and last two photos of the series, and the 80-mm lens camera was used for all the other photos of the eclipse. The 35-mm camera was mounted with a light shield in the right-hand rendezvous window. Each series consisted of six photos. The first series was obtained between 20 min and 10 min after the earth fully occulted the moon, and the other series was obtained during the interval 10 to 20 min after the moon began to leave the earth's umbra.

Two sets of Hasselblad photographs of the star field RTCC 61 (Shaula) (not to be confused with the stellar photography obtained by the mapping camera system) at 18 hr 28 min in R.A. and -37° 10' δ were obtained during TEC with the camera connected by an optical adapter to the CM sextant optics. Each set consisted of four photos, obtained sequentially, with exposure times of 60 sec, 20 sec, 5 sec, and 1 sec. One was obtained with the sextant optical axis approximately 90° to the spacecraft/sun line, and one was obtained when the system optics was shaded from the sun by the CM. Two additional sets were also obtained.

During lunar orbit, the 35-mm Nikon camera (CM3) was used to obtain a series of photos of the lunar libration region, L4. Exposure times were 240 sec, 90 sec, and 30 sec. The libration point was located at R.A. 23 hr, 13 min, δ -1.83°. The 35-mm camera was also used by the CM pilot to obtain 23 photos of the zodiacal light as the CM approached sunrise.

The Hasselblad electric camera (CM1) with 80-mm and 250-mm lenses was used to photograph 10 terminator crossings. The camera was pointed vertically downward at the same time that the terminator was being photographed by the SIM cameras. The camera was commanded by the intervalometer set for stereo with 55% to 60% overlap and started at 1 min before terminator crossing until 40 sec after. These photographs are on Magazine R.

Earthshine photos were obtained during one pass (revolution 34) using the 35-mm camera, starting 1 min after passing the terminator, for a period of 7 min with changes of exposure from 1/15 sec to 1/8 sec and the cabin lighting reduced. About 15 frames were obtained.

Low-resolution black and white photos of particular areas of the lunar surface were obtained using the hand held Hasselblad electric camera with the 80-mm lens. For this experiment, this camera was bracket-mounted with no attitude maneuvers during this sequence. The frame cycle rate was set to provide 55% to 60% forward overlap. Medium-resolution photos of particular regions were obtained with this camera using the 250-mm lens. Some unscheduled high-resolution photos were taken using a 500-mm Hasselblad data camera that was taken back to the Command Module by the LM astronauts after lunar surface EVA.

The UV photography experiment (S-177) was designed to obtain ultraviolet photographs of the earth and moon for use in studies of planetary atmospheres and short wavelength lunar radiation. The experiment package consisted of the Hasselblad electric camera (CM1) mounted behind the right-hand window (constructed of fused quartz) of the Command Module. When black and white film was being used, the camera was fitted with a 105-mm lens (lens c) and an assembly that contained two UV filters with passbands at 2600 A and 3750 A to cover different portions of the UV spectrum and another filter to admit visible radiation. Color photography was obtained using an 80-mm lens and the visible spectrum filter. Although one magazine of good photographs was obtained, the experiment was only partially successful because the 2600-A filter had a light leak at 3400 A, which affected the 2600-A area. The photographs taken using filters through the 3750-A and the visible passband were of good quality. These photographs are not yet deposited at NSSDC.

PHOTOGRAPHIC COVERAGE AND QUALITY

The orbital and surface photography obtained during the mission of Apollo 15 was of high quality. The best resolution of the Apollo panoramic photographs is very nearly the same as the best high-resolution pictures of the Lunar Orbiter 2 and 3 missions. In addition, the Apollo photographs are devoid of the raster lines and framelet divisions that marked the Lunar Orbiter photographs. The lunar surface resolutions of the mapping and panoramic cameras, respectively, were about 20 m and 1 to 2 m.

Some of the Apollo photographs (mapping and panoramic) show features very near and into the terminator. Of interest, also, is the change of the sun elevation by approximately 35° at any point on the lunar surface during the course of the mission. Thus, the effect of the sun angle on reflectivity can be studied.

Photographs were taken in orbit from the Command Module, during standup EVA (SEVA) from the LM, and during EVA excursions. (Refer to Table 1 to review the cameras and film types used for the photographic tasks.) The film coverage from surface exploration using Hasselblad cameras is summarized in Table 2.

A summary of the mapping camera photography, which, generally, was of excellent quality, can be seen in Table 3. Figure 1 (in Appendix B of this document) illustrates the surface track coverage of this camera. (Note: all illustrations and samples of photographic supporting data are given in Appendix B.) Major deviations of the mapping

TABLE 2

HASSELBLAD SURFACE PHOTOGRAPHY SUMMARY*

EVA	MAG.	FILM	60-mm (FRAMES INCLUSIVE)	500-mm (FRAMES INCLUSIVE)	NO. OF FRAMES
SEVA**	LL	B/W	11353-11397		45
	KK	Color	11730-11758		29
	MM	B/W		11235-11249	15
					89
EVA 1	LL	B/W	11398-11471		74
	NN	Color	11530-11603		74
	MM	B/W		11254-11291	38
					186
EVA 2	NN	Color	11604-11694		91
	LL	B/W	11472-11529		59
	MM	B/W		11292-11349	58
	PP	B/W	12179-12248		70
	KK	Color	11759-11860		102
	OO	B/W	12406-12451		46
					426
EVA 3	TT	Color	11861-11930		70
	WW	B/W		12015-12178	164
	SS	B/W	11047-11203		157
					391
Post EVA from LM	PP	B/W		12249-12266	18.
	TT	Color	11931-11954		24
	SS	B/W	11204-11217		14
					56

Category	Total Frames	Mag.	Total Frames	Mag.	Total Frames
Frames	1148				
60-mm	855	LL	178	PP	88
500-mm	293	KK	131	OO	46
Color	390	MM	111	TT	94
B/W	758	NN	165	WW	164
				SS	171

*Data from MSC Apollo 15 Index of 70-mm Photographs; see Table 5 for corresponding frame numbers for ordering purposes.
**SEVA is standup extravehicular activity.

TABLE 3

SUMMARY OF MAPPING CAMERA PHOTOGRAPHY

REV	MODE	NASA PHOTO NO. AS15-	NO. FRAMES	START		STOP	
				LAT. (deg)	LONG. (deg)	LAT. (deg)	LONG. (deg)
4	Vert	0070-0103	34	25.5S	179.0E	17.5S	143.5E
15	Vert	0104-0161	58	19.5S	140.5E	10.0N	73.5E
16	Vert	0278-0427	150	25.5S	170.5E	25.5N	14.0W
22	Vert	0457-0602	146	25.0S	161.5E	25.0N	18.0W
23	Fwd. Oblique	0753-0869	117	21.5S	137.5E	24.5N	20.0W
27	Vert	0870-1013	144	25.0S	153.5E	25.5N	23.5W
33	Vert	1014-1161	148	25.0S	150.0E	25.5N	31.5W
34	Aft Oblique	1309-1428	120	25.0S	155.0E	26.0N	7.5W
35	North Oblique	1429-1559	131	21.5S	147.5E	29.0N	31.0W
38	Vert	1560-1703	144	25.5S	145.5E	25.0N	32.5W
44	Vert	1704-1851	148	25.0S	139.0E	25.0N	40.0W
50	Vert	1852-1945	94	26.0S	126.0E	23.0N	15.0E
60	Vert	1946-2091	146	27.5S	123.5E	27.5N	56.5W
62	Vert	2093-2205	113	14.5S	81.0E	28.0N	57.0W
63	Vert	2206-2350	145	28.0S	120.0E	27.5N	59.5W
70	Vert	2351-2493	143	27.0S	113.0E	27.5N	67.0W
71	South Oblique	2494-2623	130	29.0S	107.5E	24.5N	68.0W
72	Vert	2624-2752	129	26.5S	108.5E	27.5N	68.0W
		TOTAL	2240				

camera (SIM3) from the nominal were as follows. On revolution 23, the forward oblique strip was flown with a spacecraft attitude that introduced 17° yaw in the camera orientation. The photo pass on revolution 62 was made with the gamma-ray and mass spectrometer booms extended.

The quality of the panoramic camera photography also was generally excellent. A summary of the photography from this camera is given in Table 4. Figure 2 illustrates the pan camera surface track coverage. Telemetry readouts showed that the panoramic camera V/H sensor gave spurious readings at erratic intervals, which affected the forward motion compensation. More than 90% of the photographs show no degradation, and degradation for most of the others is nearly undetectable. A few frames show density banding as a result of this malfunction. Photogrammetrists should be aware that where spacing between timing marks at the bottom of the frames changes abruptly within a frame, there is a corresponding change in photographic scale.

The majority of the panoramic and mapping camera photographs have stereo companions.

The amount of photographic coverage from this mission is several times more than that acquired during any previous mission. The quantity of photographs as well as the size of the panoramic photography precludes the possibility of cataloging the photographic data in the form of paper prints as has been done in the past (Apollo 11 through Apollo 14). Instead of including the complete printed photographic catalog with this Data Users' Note, we are presenting in Appendix B a few representative photographs (see Figure 3) from each of the principal cameras to show the quality and format of the photographic coverage. These photographs are representative of the Hasselblad photography on the lunar surface taken with both the 60- and 500-mm lenses, the Command Module orbital Hasselblad coverage with the 80-, 250-, and 500-mm lenses, and the photographs obtained by the mapping (metric) and panoramic cameras. Samples from each of the latter two cameras show the same lunar region to allow a comparison of the coverage obtained with the two types. Some Hasselblad panoramic mosaics of the surface are also shown.

The photographic catalogs are available in microform. All of the Hasselblad photography is available on microfiche (60 frames/card) and as 16-mm roll film. A microfilm (35-mm) catalog includes all panoramic camera coverage. The mapping camera photography is also available on microfiche and as 16-mm roll film. These catalogs can be obtained from NSSDC, and from them, the user can select the frames desired for analysis.

TABLE 4

SUMMARY OF PANORAMIC CAMERA PHOTOGRAPHY*

REV	MODE	NASA PHOTO NO. AS15-	NO. FRAMES	START		STOP	
				LAT. (deg)	LONG. (deg)	LAT. (deg)	LONG. (deg)
4	Vert	8844-8857	14	25.0S	178.5E	24.0S	170.0E
4	Stereo	8858-8944	87	23.5S	168.5E	17.0S	142.0E
15	Stereo	8945-9087	143	19.0S	139.0E	2.0S	99.5E
15	Vert	9088-9118	31	2.0S	99.0E	5.0N	83.0E
15	Stereo	9119-9151	33	5.0N	83.0E	10.0N	73.0E
16	Stereo	9152-9424	273	9.0N	75.0E	25.0N	14.5W
27	Stereo	9425-9433	9	25.5N	4.0E	26.0N	1.0E
33	Stereo	9434-9578	145	5.5N	66.5E	21.5N	23.0E
38	Stereo	9579-9767	189	23.0S	132.0E	2.5S	76.5E
38	Vert	9768-9790	23	3.0S	77.0E	3.5N	66.0E
38	Stereo	9791-9808	18	24.5N	4.5E	25.0N	1.5W
50	Stereo	9809-9827	19	25.5N	3.5E	27.5N	3.0W
60	Stereo	9828-9919	92	8.0N	39.0E	21.0N	11.0E
60	Vert	9920-9929	10	23.0N	4.5E	25.5N	4.0W
61	Vert	9930-9933	4	24.5N	0.5W	25.0N	2.0W
61	Stereo	9934-9941	8	25.5N	3.5W	26.5N	6.0W
63	Stereo	9942-0092	151	25.0S	109.5E	6.5S	64.0E
63	Vert	0093-0116	24	7.5S	65.5E	0.5S	52.0E
63	Stereo	0117-0165	49	0.0	51.5E	7.5N	37.5E
72	Stereo	0166-0357	192	17.5N	8.0E	28.5N	57.5W
72	Vert	0358-0372	15	28.5N	58.5W	27.5N	67.5W
		TOTAL	1529				

*From A-15 Index of Mapping and Panoramic Camera Photography.

Enclosed in this data package are 10 photo index maps for the Apollo 15 mission. Sheet 1 shows panoramic camera coverage, sheets 2 through 6 show mapping camera coverage, sheets 7 and 8 show the areas photographed in black and white using the Hasselblad cameras, and sheets 9 and 10 show the areas of Hasselblad color coverage. Sheet 10 also shows the areas photographed on 16-mm film strips.

FORMAT OF AVAILABLE PHOTOGRAPHIC AND SUPPORTING DATA

The Apollo 15 films on file at NSSDC include second generation master positive copies of the original (first generation) 70-mm, 35-mm, 16-mm, mapping, panoramic, and stellar films that are stored at the NASA Manned Spacecraft Center. NSSDC also has reversal second generation negatives made from the original (first generation) film for the panoramic and mapping photography. NSSDC has produced working duplicates (third generation) of the films received from the Manned Spacecraft Center for servicing requests with fourth generation photographs. NSSDC can provide the photographs and the related supporting data in the formats described in the remainder of this section. Investigators should complete the order form at the end of this Data Users' Note to specify the data they require.

70-mm Hasselblad Photography

Seventeen magazines, or approximately 2400 frames, of Hasselblad photos were exposed during the Apollo 15 mission. A summary, by magazine, of the Hasselblad photography available from NSSDC is given in Table 5. Individual black and white frames, 52 x 52 mm in image area, can be produced as positive or negative contact film duplicates on 4- x 5-in. film sheets or as enlarged 8- x 10-in. prints. (Enlargements in various other format sizes will be prepared in response to special requests.) Complete magazines or complete sets of Hasselblad photography can be produced as positive or negative contact film duplicates (70-mm roll film) or as positive contact paper prints (70-mm roll paper). Color reproductions in the form of positive or negative contact film copies on 4- x 5-in. film sheets will be provided only to those persons performing specific detailed scientific investigations. Requests should specify the complete frame number, e.g., AS15-85-11353, for each photograph requested.

NSSDC has available one-line indexes that give frame parameters such as longitude and latitude of the principal point, sun elevation, approximate altitude of the spacecraft, general mission activity at the time the photograph was taken, and outstanding features of the photographs. These indexes, on 16-mm microfilm or on microfiche, are available in three orders of listing: (1) all photographs are listed

TABLE 5

NSSDC INVENTORY FOR PANORAMIC, MAPPING, AND HASSELBLAD PHOTOGRAPHY

PANORAMIC

CAN (MAGAZINE) NO.	FRAME NO.	CAN (MAGAZINE) NO.	FRAME NO.
1	8801-8892	10	9620-9710
2	8893-8983	11	9711-9800
3	8984-9074	12	9801-9891
4	9075-9165	13	9892-9982
5	9166-9255	14	9983-0073
6	9256-9346	15	0074-0164
7	9347-9437	16	0165-0255
8	9438-9528	17	0256-0346
9	9529-9619	18	0347-0372
YW1	Pan Terminator		

MAPPING

CAN (MAGAZINE) NO.	FRAME NO.
1	0002-0679
2	0680-1428
3	1429-2205
4	2206-2929
5	2930-3376*
YV1	Mapping Terminator

*Distant views of moon; not scientifically useful.

HASSELBLAD

MAGAZINE	DESIGNATION	FRAME NO.
COLOR (CAN NO. 1)		
NN	AS15-86	11530-11694
KK	AS15-87	11695-11860
TT	AS15-88	11861-12014
M	AS15-91	12329-12405
P	AS15-93	12577-12736
Q	AS15-96	13003-13136
O	AS15-97	13137-13298
BLACK AND WHITE (CAN NO. 2)		
QQ	AS15-81	10869-11046
SS	AS15-82	11047-11217
MM	AS15-84	11235-11352
LL	AS15-85	11353-11529
WW	AS15-89	12015-12178
PP	AS15-90	12179-12328
OO	AS15-92	12406-12576
S	AS15-94	12737-12869
RR	AS15-95	12870-13002
R	AS15-98	13299-13401

in sequence by photo number (see Figure 4); (2) lunar surface photographs are listed in chronological order within categories (e.g., EVA 1, EVA 2, etc.) (see Figure 5); and (3) photographs of the lunar surface taken from lunar orbit are cross-indexed by longitude in 10° increments (see Figure 6). These indexes will routinely be provided as 16-mm roll film duplicates when complete magazines or sets of photography are requested. Microprinter paper copies of the index data will be provided when requests are received for selected individual frames. More complete supporting data listing corner coordinates of the picture frame, refined spacecraft position, and other spacecraft and lunar data were not available at the time of this writing.

Panoramic Hasselblad Mosaics

The panoramic series of Hasselblad photographs has been assembled into mosaics that are now portrayed on 4- x 5-in. film. Table 6 lists the mosaics by assigned number, area designation, brief description, and number of individual frames comprising each mosaic. The assigned number (column 1) is the number by which the mosaic should be ordered from NSSDC. Note that 21 of the mosaics are color photographs and 58 are black and white. Reproductions may be requested in the form of 4- x 5-in. positive or negative contact film duplicates or as enlarged paper prints. The mosaics have been included in the 16-mm microfilm (or microfiche) Hasselblad catalog.

35-mm Nikon Photographs

The complete set of available Nikon photographs consists of 125 useful frames. The complete set can be obtained as contact negative or positive copies on 35-mm roll film. Individual frames can be requested as 8- x 10-in. paper print enlargements or as 3-1/4- x 4-in. or 2- x 2-in. slides. The index to this film set is not yet available.

Mapping Camera Photographs

Individual frames (ordered by frame number, e.g., metric AS15-0076) from the mapping (metric) camera can be obtained as 5- x 5-in. negative or positive contact film, as positive contact paper prints, or as 8- x 10-in. paper enlargements. (Enlargements in various other format sizes will be prepared in response to special requests.) The 4.5- x 4.5-in. image area on the film will give an image area of approximately 7.5- x 7.5-in. on the 8- x 10-in. enlargements, or an enlargement factor of 1.6 over the original film format. Separate magazines or the complete set of mapping photography can be obtained as contact positive or negative film on 5-in. rolls or as 5-in. roll contact paper prints. There are five magazines containing 2240 useful frames in

TABLE 6
SUMMARY OF PANORAMIC MOSAICS

APOLLO 15 70-mm SURFACE MOSAICS – 4- X 5-IN. COLOR TRANSPARENCIES

MOSAIC FRAME NUMBER	DESIGNATION	NUMBER OF FRAMES IN MOSAIC	MOSAIC FRAME NUMBER	DESIGNATION	NUMBER OF FRAMES IN MOSAIC
S-71-43940	Rover "Rip" Pan_3	5	S-71-44699	ALSEP Pan_2	6
S-71-43941	LM Window Mosaic	9	S-71-44700	LM East Pan_2	5
S-71-43942	Rover "Rip" Pan_1	4	S-71-44701	LM North Pan_2	5
S-71-43943	Rover "Rip" Pan_2	6	S-71-44702	SEVA Pan_3	4
S-71-44692	LM West Pan_2	6	S-71-44703	LM North Pan_3	6
S-71-44693	LM North Pan_1	5	S-71-44704	Stop 3 (Partial Pan)	5
S-71-44694	LM West Pan_1	6	S-71-44705	SEVA Pan_1	6
S-71-44695	ALSEP Pan_1	5	S-71-44706	LM East Pan_3	5
S-71-44696	LM East Pan_1	5	S-71-44707	ALSEP Pan_3	5
S-71-44697	LM West Pan_3	5	S-71-47236	Stop 6	3
S-71-44698	SEVA Pan_2	4	TOTAL = 21 Mosaic Strips, 110 Frames		

APOLLO 15 70-mm SURFACE MOSAICS – 4 X 5-IN. B/W TRANSPARENCIES

MOSAIC FRAME NUMBER	DESIGNATION	NUMBER OF FRAMES IN MOSAIC	REMARKS
S-71-45906	Stop 2, St. George No. 2_1	6	Rill, Rover
S-71-45907	Stop 2, St. George No. 1_3	5	Rover, astronaut
S-71-45908	Stop $6A_3$	5	
S-71-45909	Stop $6A_2$	9	
S-71-45910	Stop $6A_1$	6	Tracks
S-71-45911	Stop 2, St. George No. 1_2	7	
S-71-45912	Stop 2, St. George No. 1_1	6	
S-71-45913	Stop 7, Spur Crater Pan_2	8	
S-71-45914	Stop 7, Spur Crater Pan_3	7	Rover
S-71-45915	Stop 7, Spur Crater Pan_1	9	
S-71-45916	Stop 2, St. George No. 2_3	5	
S-71-45917	Stop 2, St. George No. 2_2	7	
S-71-47077	Dune $Crater_1$	6	

TABLE 6 (continued)

APOLLO 15 70-mm SURFACE MOSAICS – 4 X 5-IN. B/W TRANSPARENCIES

MOSAIC FRAME NUMBER	DESIGNATION	NUMBER OF FRAMES IN MOSAIC	REMARKS
S-71-47078	LM Window Pan	7	St. George Crater
S-71-47079	Pluton Crater	7	
S-71-47080	Dune Crater$_2$	7	Mountain shows layering
S-71-47579	Scarp Pan$_1$	5	Mountains in background
S-71-47580	Scarp Pan$_3$	6	
S-71-47581	Scarp Pan$_2$	6	
S-71-47582	ALSEP Pan$_1$	6	
S-71-47583	SEVA Pan$_2$	8	Hadley Delta, Spur layering
S-71-47584	SEVA Pan$_1$	5	Antenna, mountains in shadow
S-71-47585	ALSEP Pan$_2$	6	LM, Spur, Hadley Delta
S-71-47586	SEVA Pan$_3$	5	Hadley Delta layering, St. George Crater
S-71-47589	Elbow Pan$_3$	7	Rover, astronaut
S-71-47590	Stop 10$_1$	4	Rover, astronaut
S-71-47591	EVA 3 rill mosaic	9	Shows layers
S-71-47592	EVA 3 rill mosaic	8	Shows layering
S-71-47593	Elbow Pan$_1$	6	Hadley Rill in background, mountains heavily shadowed
S-71-47594	ALSEP Pan$_3$	6	Hadley Delta, Spur, Rover, astronaut
S-71-47595	Stop 10$_3$	6	Hadley Rill, Hadley Delta, St. George Crater
S-71-47596	Stop 10$_2$	6	
S-71-47597	Partial Pan from LRV	6	
S-71-47598	West Pan, Stop 6$_2$	8	
S-71-47599	Elbow Pan$_2$	9	
S-71-47600	West Pan, Stop 6$_1$	4 (+1 blank)	Hadley Delta
S-71-47602	Stop 9A$_2$	6	Hadley Delta, Spur, Rover
S-71-47604	Stop 9A$_1$	5	
S-71-47606	Stop 9A$_3$	5	
S-71-47607	West Pan, Stop 6$_3$	6	
S-71-48513	ALSEP Pan$_1$	6	
S-71-48514	ALSEP Pan$_3$	6	Rover

TABLE 6 (continued)
APOLLO 15 70-mm SURFACE MOSAICS – 4 X 5-IN. B/W TRANSPARENCIES

MOSAIC FRAME NUMBER	DESIGNATION	NUMBER OF FRAMES IN MOSAIC	REMARKS
S-71-48515	ALSEP Pan_2	6	Astronaut, LM
S-71-48516	Stop 10, $R3_2$	11	Hadley Rill
S-71-48517	Stop 10, $R3_1$	7	Hadley Rill
S-71-48518	Stop 10, $R5_2$	7	Hadley Rill
S-71-48519	Stop 10, $R5_1$	7	Hadley Rill
S-71-48520	R3, Stop 9a rill mosaic 2	10	Hadley Rill
S-71-48521	R6, Stop 9a rill mosaic 1, R3	8	Hadley Rill
S-71-48522	Stop 10, R4	5	Hadley Rill
S-71-48523	Hadley mosaic, Stop 10	7	Hadley Rill
S-71-48524	Stop 9a, rill mosaic, R11	5	Hadley Rill
S-71-48525	Stop 10, R7	2	Hadley Rill
S-71-48526	Stop 9a, rill mosaic, R7	7	Hadley Rill
S-71-48874	Stop 2, R_1	15	Hadley Rill
S-71-48875	Stop 6A, Mt. Hadley	10	
S-71-48876	SEVA, Hill 305	3	
S-71-48877	Stop 6A, Hadley Delta	5	
TOTAL = 58 mosaic strips, 382 frames.			

this photography (see Table 5). In addition, there is one 500-ft roll in which all of the near-terminator photographic coverage has been collected. Reproductions from this magazine can be obtained in the above mentioned formats.

The mapping camera supporting data are available on 16-mm microfilm. A sample of the data for a frame is given in Figure 7. In addition, a one-line index of all frames on 16-mm microfilm or microfiche is available for the mapping camera photography. A sample of this index can be seen in Figure 8. The parameters listed for each frame are: orbit revolution number; approximate spacecraft altitude; latitude and longitude (in deg) of the principal point (center) of the frame; tilt and azimuth of the camera; percent of forward overlap between successive frames; sun elevation (in deg); and a brief description of features contained. The frame numbers of the mapping photographs start with 0002. The full index is preceded by a summary of the mapping and panoramic photographic coverage. Users will receive paper prints of the index and supporting data frames appropriate for the photographs requested. In cases of requests for an entire roll of film, film copies of supporting data will be supplied to the requester (16-mm roll film).

Although NSSDC has on deposit the 35-mm stellar photography (approximately 3350 frames) from the mapping-stellar-laser altimeter camera system, it should be emphasized that the stellar photographs are of little or no use for scientific purposes as required by the general user of NSSDC data. They are being used by the experimenters for selenodetic purposes to determine spacecraft attitude more accurately. NSSDC has no supporting data available to accompany the stellar photography, and the frames have no number designations from which individual selections could be made by the requester. In addition, many of the frames have been degraded by dirt or dust.

Panoramic Camera Photographs

NSSDC has all 18 rolls of panoramic photography, 17 of which contain approximately 90 frames (the 18th has 26 frames) for a total of 1529 useful frames. The image area of each frame is 4.5 x 45 in.; the photographs are stored on 5-in. roll film. A summary of the frame coverage per magazine for the panoramic camera is given in Table 5. In addition, all of the near-terminator photography has been gathered into a single magazine containing 149 frames in the same film format as the complete set of photographs described above. Individual frames (ordered by frame number, e.g., AS15-PAN-8844) can be obtained as 4.5- x 48-in. contact negative or positive film copies on 5-in. film or as contact paper prints on 5- x 48-in. paper. Complete magazines (ordered by magazine number as in Table 5) or a complete set of panoramic photography can be obtained as contact positive roll film or paper or as negative roll film reproductions.

Supporting data for the panoramic photographs, in a 16-mm microfilm format, are also available from NSSDC. A sample of the frame supporting data is presented in Figure 9. A one-line index, on 16-mm microfilm and microfiche, of the frames is also available. The index contains information for each frame including: latitude and longitude of the principal point (center) of the frame (in deg), sun elevation (in deg), approximate altitude of the spacecraft, camera attitude, orbit revolution number, the frame number of the accompanying stereo pair, and a brief description of features contained. A sample page of this index can be seen in Figure 10. It should be noted that the frame numbers start with 8844, then pass from 9999 to 0000 rather than 10,000 because the computer program was set for four digits only. The appropriate panoramic camera supporting data and index data will be sent with each request as paper prints (as in Figures 9 and 10). NSSDC will respond to requests for complete magazines or complete panoramic camera photography with 16-mm roll film reproductions of the support data and indexes.

Panoramic Camera Rectified Photographs

The panoramic camera photographs will be rectified to remove the geometric effects of panoramic scan and stereo convergence. Only the central 74° of the total 108° scan will be rectified. The rectified version of the panoramic frames, with frame dimensions in a 9- x 72-in. format, will be acquired by NSSDC. An announcement providing detailed information on the rectification process and ordering procedures will be prepared and issued when NSSDC is ready to respond to requests for these photographs.

16-mm Maurer Films

The 16-mm Maurer films are available as 16-mm positive color film duplicates. Eleven magazines have been spliced together and are available as one 1600-ft reel. The cabin and earth-looking footage has been deleted and has been deposited at the Technology Application Center, Albuquerque, New Mexico. The 16-mm films at NSSDC are not intended for general or classroom use since they are suitable only for precise scientific investigation. They are available on a 3-month loan basis although, in special instances, arrangements can be made for permanent retention. Table 7 summarizes 16-mm Maurer coverage.

16-mm Television Films

The television coverage for the entire mission has been recorded on 16-mm kinescope roll film. Those parts involving the surface activities and liftoff, as shown in the film log in Table 8, are stored

TABLE 7
SUMMARY OF MAURER 16-mm COVERAGE

DESIGNATION	CONTENTS
A	Earth orbit, flying debris, docking
B	Lunar orbit undocking (cabin sequences are not available at NSSDC)
AA	Command Module from Lunar Module, prior to landing on moon
E	Landing site, Hadley Rill from Command Module in orbit
EE	Lunar Rover and EVA 2
BB	Liftoff from moon
C	Rendezvous and docking after lunar liftoff
JJ	Sky, moon's limb, subsatellite release (cabin sequences are not available at NSSDC)
F	Transearth EVA
K	Reentry
J	Chute deployment, splashdown

TABLE 8
16-MM TV KINESCOPE FILM LOG

MSC FILM ID NUMBER	TIMESPAN (DAY/HR:MIN (GMT))	COVERAGE	
S71-231	207/1701-1709	Docking with LM	
-232	208/2330-2359	IVT to LM	CM
-233	208/2358-209/0020	IVT to LM	
-234	211/1228-1243	Landing Site from CSM	
-235	212/1326-1358	EVA 1	
-236	212/1358-1426	EVA 1	
-237	212/1439-1558	EVA 1	
-238	212/1558-1643	EVA 1	
-239	212/1642-1818	EVA 1	
-240	212/1818-1850	EVA 1	
-241	212/1850-1910	EVA 1	
-242	213/1303-1404	EVA 2	
-243	213/1404-1430	EVA 2	
-244	213/1505-1538	EVA 2	
-245	213/1537-1717	EVA 2	LM
-246	213/1716-1748	EVA 2	
-247	213/1747-1831	EVA 2	
-248	213/1838-1850	EVA 2	
-249	214/0908-0948	EVA 3	
-250	214/0947-1044	EVA 3	
-251	214/1043-1117	EVA 3	
-252	214/1116-1144	EVA 3	
-253	214/1143-1243	EVA 3	
-254	214/1242-1333	EVA 3	
-258	214/1711-1713	LM Liftoff	

at NSSDC. Any section or the entire film is available on a 3-month loan basis. Designation of the desired part should be made by indicating the MSC Film ID Number as shown in the first column of Table 8.

ORDERING PROCEDURES

Investigators engaged in specific lunar studies will find the photographic indexes and catalogs very important for selecting photographs appropriate to their studies. As stated earlier, a catalog of all panoramic frames can be obtained on one reel of 35-mm microfilm whereas all mapping and Hasselblad photos can be obtained on 4- x 6-in. microfiche or 16-mm roll film. Corresponding indexes for these types of photos can be obtained on 16-mm microfilm or microfiche.

When ordering Apollo 15 data, please refer to the index maps that are included with this Data Users' Note for the desired coverage and to the catalogs for the frame numbers of the desired photographs. Indicate the following in the request order:

- Apollo mission number
- Complete frame number(s), e.g., AS15-85-11375 (AS = Apollo Spacecraft; 15 = mission number; 85 = magazine number; 11375 = frame number.)
- Form and size of reproduction, e.g., 8- x 10-in. B/W print (glossy) or 4- x 5-in. color positive transparency
- Other identifying information, e.g., crater or feature name or location of desired portion within a frame of the panoramic camera.

The Apollo 15 Lunar Photography order form enclosed with this Note is provided for the requester's convenience. All parts of the form must be completed to ensure satisfactory request fulfillment. All required photography should be identified in a single order to expedite the processing of the request.

Requesters should be aware of NSSDC policies concerning the dissemination of data. The purpose of the National Space Science Data Center is to provide data and information from space science experiments in support of additional studies beyond those performed by the principal investigators. Therefore, NSSDC will provide data and information upon request to any individual or organization resident in the United States. In addition, the same services are available to scientists outside the United States through the World Data

Center A for Rockets and Satellites. Normally, a charge is made for the requested data to cover the cost of reproduction and the processing of the request. The requester will be notified of the cost, and payment must be received prior to processing the request. The Director of NSSDC may waive, as resources permit, the charge for modest amounts of data when they are to be used for scientific studies or for specific educational purposes and when they are requested by an individual affiliated with: (1) NASA installations, NASA contractors, or NASA grantees; (2) other U.S. Government agencies, their contractors, or their grantees; (3) universities and colleges; (4) state and local governments; or (5) non-profit organizations.

NSSDC requires knowledge of the scientific use to which the data provided are being put. The Data Center would also appreciate receiving copies of all publications resulting from studies in which data supplied by NSSDC have been used. It is further requested that NSSDC be acknowledged as the source of the data in all publications resulting from use of the data provided.

Requesters may view the Apollo 15 photographs at NSSDC. Inquiries about or requests for photographs from U.S. scientists should be addressed to:

National Space Science Data Center
Code 601.4
Goddard Space Flight Center
Greenbelt, Maryland 20771
Telephone: (301) 982-6695

Requests from researchers outside the U.S.A. should be directed to:

World Data Center A for Rockets and Satellites
Code 601
Goddard Space Flight Center
Greenbelt, Maryland 20771 U.S.A.

Individuals or organizations that wish to obtain Apollo 15 photographic reproductions for purposes other than use in specific scientific research projects or college level space science courses should address their requests to:

Public Information Division
Code FP
National Aeronautics and Space Administration
Washington, D.C. 20546

Printed materials to satisfy general information requests are also available from the Public Information Division.

Representative sets of Apollo photographs suitable for framing can be obtained (at cost) as full-color lithographs from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Requests should specify NASA picture sets as follows:

- NASA Picture Set 1, "Apollo - In the Beginning" ($1.25)
- NASA Picture Set 2, "Men of Apollo" ($1.00)
- NASA Picture Set 3, "Eyewitness to Space" ($2.75)
- NASA Picture Set 4, "First Manned Lunar Landing" ($1.75)
- NASA Picture Set 5, "Man on the Moon" ($1.00)
- NASA Picture Set 6, "Pinpoint for Science" ($1.50)
- NASA Picture Set 7, "Apollo 15" (1.50)

Inquiries or requests regarding pictures of the earth taken during the Apollo missions should be directed to:

Technology Application Center
University of New Mexico
Albuquerque, New Mexico 87106

LIST OF ACRONYMS AND ABBREVIATIONS

AC	alternating current
ALSEP	Apollo lunar surface experiments package
AZ	azimuth
B/W	black and white (film)
CEX	color exterior (film)
CIN	color interior (film)
CM	Command Module
CSM	Command and Service Module
DAC	data acquisition camera
DC	direct current or data camera
deg	degree
diag.	diagonal
DOI	descent orbit insertion
EC	electric camera
EDT	Eastern Daylight Time
Ekt.	Ektachrome
EL	electric
EVA	extravehicular activity
f	ratio of aperture to focal length
f-c	foot candle
FMC	forward motion compensation
FOV	field of view
fps	feet per second
GCTA	ground controlled television assembly
HBW	high-speed black and white (film)
HCEX	high-speed color exterior (film)
HDC	Hasselblad data camera
HEC	Hasselblad electric camera
hor.	horizontal
hr	hour
Hz	hertz
in.	inch
IVT	intravehicular traverse
kg	kilogram
km	kilometer
LBW	low-speed black and white (film)
LM	Lunar Module
LOI	lunar orbit insertion
LRV	Lunar Roving Vehicle
m	meter
MESA	modularized equipment storage assembly
min	minute
mm	millimeter
mrad	milliradian
MSC	Manned Spacecraft Center

n.m.	nautical mile
NSSDC	National Space Science Data Center
pic	picture
R.A.	right ascension
rpm	revolutions per minute
sec	second
SEVA	standup extravehicular activity
SIM	Scientific Instrument Module
SM	Service Module
TEC	transearth coast
TLC	translunar coast
UT	universal time
UV	ultraviolet
v	volt
vert.	vertical
V/H	velocity to height ratio
VHBW	very high-speed black and white (film)
δ	declination

ACKNOWLEDGMENTS

The Data Center wishes to thank the individuals and organizations responsible for the photographs and supporting data obtained during the Apollo 15 mission. This mission photography was accomplished by the Apollo 15 crew: Astronauts David Scott, James B. Irwin, and Alfred E. Worden.

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BIBLIOGRAPHY

"Apollo 15 Index of Mapping Camera and Panoramic Camera Photographs," Mapping Sciences Branch, Science and Applications Directorate, NASA Manned Spacecraft Center, Houston, Texas, Jan. 1972.

"Apollo Optical Bar Panoramic Camera," Description Brochure, by Itek Optical Systems Division.

Apollo 15 Preliminary Science Report, NASA SP-289, 1972.

"Apollo 15 SIM bay Photographic Equipment and Mission Summary," Mapping Sciences Branch, NASA Manned Spacecraft Center, Houston, Texas, Aug. 1971.

Batson, R. M., K. B. Larson, V. S. Reed, J. J. Rennilson, R. L. Sutton, R. L. Tyner, G. E. Ulrich, and E. W. Wolfe, "Preliminary Catalog of Pictures Taken on the Lunar Surface During the Apollo 15 Mission," U.S. Geological Survey Inter-Agency Report, 35, Aug. 27, 1971.

"CSM/LM Spacecraft Operational Data Book, for J-Missions," North American Rockwell Corp., SNA-8-D-027, NASA Manned Spacecraft Center, Houston, Texas, Sept. 22, 1970.

Doyle, F. J., "Photographic Systems for Apollo," Photogrammetric Engineering, 25, Oct. 1970.

"The Role of Optics in the Apollo Program," Optical Spectra, 3, Sept.-Oct. 1969.

Teague, W. T., "Final Photographic and TV Procedure - Apollo 15," Experiments Procedures Section, EVA/IVA Branch, Crew Procedures Division, NASA Manned Spacecraft Center, Houston, Texas, July 23, 1971.

APPENDIX A

SUMMARY OF EXPERIMENTS CARRIED ON APOLLO 15

APPENDIX A

SUMMARY OF EXPERIMENTS CARRIED ON APOLLO 15

EXPERIMENT	NO.*	PRINCIPAL INVESTIGATOR(S)	ADDRESS	OBJECTIVE
		COMMAND MODULE (Photographic)		
Hasselblad (EL)		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Photography of scientific interest targets
Hasselblad (DC)		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Photography of scientific interest targets
Maurer (DAC)		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Photography of scientific interest targets
Window Meteoroid	S-176	Mr. B. G. Cour-Palais	Geology Branch Planetary & Earth Sciences Div. NASA-Manned Spacecraft Ctr. Houston, Texas 77058 (713) 483-4757	Determination of meteor flux, mass, and cratering
UV Photography	S-177	Dr. T. C. Owen	Dept. of Earth & Space Sciences The State University of N.Y. Stony Brook, N.Y. 11790 (516) 246-5000	Acquisition of UV photos of earth and moon
Gegenschein	S-178	Mr. L. Dunkelman	Code 613.3 Planetary Optics Section NASA-GSFC Greenbelt, Md. 20771 (301) 982-4988	Determination of position, geometrics, and sources of particles
		SERVICE MODULE (Photographic)		
24-in. Panoramic Camera		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Photography of targets of scientific interest and geologic site selection. Acquisition of stereo coverage and high-resolution coverage.
3-in. Mapping (Metric) Camera		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Obtain photographs of geological and geodetic interest

*Experiment numbers not available for all instrumentation.

APPENDIX A (continued)

EXPERIMENT	NO.*	PRINCIPAL INVESTIGATOR(S)	ADDRESS	OBJECTIVE
		SERVICE MODULE (Photographic) (continued)		
Laser Altimeter		CSM Orbital Science Photo Team, F. J. Doyle, Chairman	U.S. Geological Survey 1340 Old Chain Bridge Road McLean, Va. 22101 (202) 343-9445	Determination of altitude and topographic data
		OTHER EXPERIMENTS		
γ-Ray Spectrometer	S-160	Dr. J. R. Arnold	Chemistry Dept. U. of California, San Diego La Jolla, Calif. 92037 (714) 453-2000, X-1453	Determination of lunar surface composition and gamma-ray flux
X-Ray Fluorescence	S-161	Dr. I. Adler	Code 641 Theoretical Studies Branch NASA-GSFC Greenbelt, Md. 20771 (301) 982-5759	Determination of aluminum abundances in orbital path
α-Particle Spectrometer	S-162	Dr. P. Gorenstein	AS&E 11 Carleton St. Cambridge, Mass. 02142 (617) 868-1600, X-214	Determination of surface composition in orbital path from radon isotopes
Mass Spectrometer	S-165	Dr. J. H. Hoffman	Atmospheric and Space Sciences U. of Texas, Dallas P.O. Box 30365 Dallas, Tex. 75230 (214) 231-1471, X-322	Determination of lunar atmospheric composition
Bistatic Radar	S-170	Mr. H. T. Howard	Stanford Electronics Lab. Stanford University Stanford, Calif. 94305 (415) 321-2300, X-3537	Radar determination of surface roughness and shape and material in orbital path
		SUBSATELLITE EXPERIMENTS		
S-Band Transponder	S-164	Mr. W. L. Sjogren	Code 156-251 Jet Propulsion Lab. 4800 Oak Grove Dr. Pasadena, Calif. 91103 (213) 354-4868	Orbital tracking gravity field determination

*Experiment numbers not available for all instrumentation.

APPENDIX A (continued)

EXPERIMENT	NO.*	PRINCIPAL INVESTIGATOR(S)	ADDRESS	OBJECTIVE
		SUBSATELLITE EXPERIMENTS (continued)		
Particle Shadows/ Boundary Layer	S-173	Dr. K. A. Anderson	Space Science Lab. U. of California, Berkeley Berkeley, Calif. 94726 (415) 642-1313	Determination of particle interactions from solar wind and behavior of plasmas and electric fields
Magnetometer	S-174	Dr. P. J. Coleman, Jr.	Dept. Planetary and Space Science U. of California, L.A. Los Angeles, Calif. 90024 (213) 825-1776	Determination of lunar magnetic field and earth's magnetosphere
		LUNAR MODULE – SURFACE EXPERIMENTS		
Contingency and Selected Samples Collection		MSC Science Working Panel Subgroup Dr. R. O. Pepin, Chairman	School of Physics and Astronomy U. of Minnesota Minneapolis, Minn. 55455 (612) 373-7874	Collection of rock samples for geologic composition and origin
		ALSEP EXPERIMENTS		
Passive Seismic	S-031	Dr. G. V. Latham	The Marine Biomedical Institute 200 University Blvd. Galveston, Texas 77550 (713) 765-2181	Observation of internal activity and constitution and meteorite activity
Magnetometer	S-034	Dr. P. Dyal	Code N204-4 Space Science Division/ Electrodynamics Branch NASA Ames Research Center Moffett Field, Calif. 94034 (415) 961-1111, X-2706	Observations of lunar magnetic field and its variations
Solar Wind Spectrometer	S-035	Dr. C. W. Snyder	Jet Propulsion Lab. 4800 Oak Grove Dr. Pasadena, Calif. 91103 (213) 354-3744, X-2302	Determination of solar wind composition, energies, densities, incidence angles, and variations

*Experiment numbers not available for all instrumentation.

APPENDIX A (continued)

EXPERIMENT	NO.*	PRINCIPAL INVESTIGATOR(S)	ADDRESS	OBJECTIVE
		ALSEP EXPERIMENTS (continued)		
Supra-Thermal Ion Detector	S-036	Dr. J. W. Freeman	Dept. of Space Science Rice University Houston, Tex. 77001 (713) 528-4141, X-1297	Observations of lunar atmosphere and escaping gases
Heat Flow	S-037	Dr. M. E. Langseth	Lamont-Doherty Geological Observatory Columbia University Palisades, N.Y. 10964 (914) 359-2900	Determination of internal heat and constitution of moon
Dust Detector	S-515	Dr. S. C. Freden	Code 650 Lab. for Meteorology and Earth Sciences NASA-GSFC Greenbelt, Md. 20771 (301) 982-5249	Separation and measurement of high-energy radiation damage
Cold Cathode Ion Gauge	S-058	Dr. F. S. Johnson	U. of Texas, Dallas P.O. Box 30365 Dallas, Tex. 75230 (214) 231-1471, X-201	Observation of lunar atmosphere and escaping ionized gases
		OTHER SURFACE EXPERIMENTS		
Lunar Field Geology	S-059	Dr. G. A. Swann	Center of Astrogeology U.S. Geological Survey 601 E. Cedar Ave. Flagstaff, Ariz. 86001 (602) 774-1406	Observation of geology of site and origin of surface features
Laser Ranging Retroreflector	S-078	Dr. J. E. Faller	Wesleyan University Middletown, Conn. 06457 (203) 347-4421	Determination of accurate selenographic location and earth distance, geodetic purposes
Soil Mechanics	S-200	Dr. J. K. Mitchell	Dept. of Civil Engineering 4400 Davis Hall U. of California, Berkeley Berkeley, Calif. 94726 (415) 642-1262	Determination of soil properties, bearing strength, behavior

*Experiment numbers not available for all instrumentation.

APPENDIX B

LUNAR SURFACE TRACK COVERAGE AND SAMPLES OF APOLLO 15 PHOTOGRAPHIC AND SUPPORTING DATA

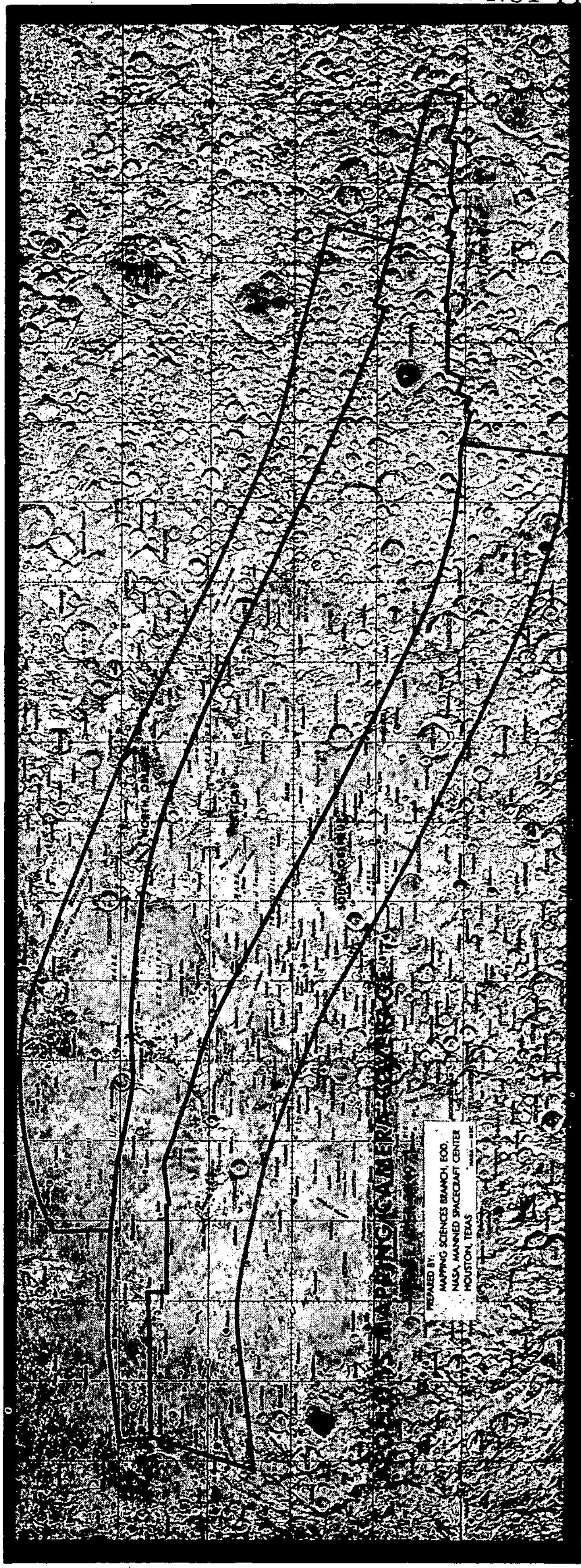


Figure 1. Lunar Surface Track Coverage of Mapping Camera

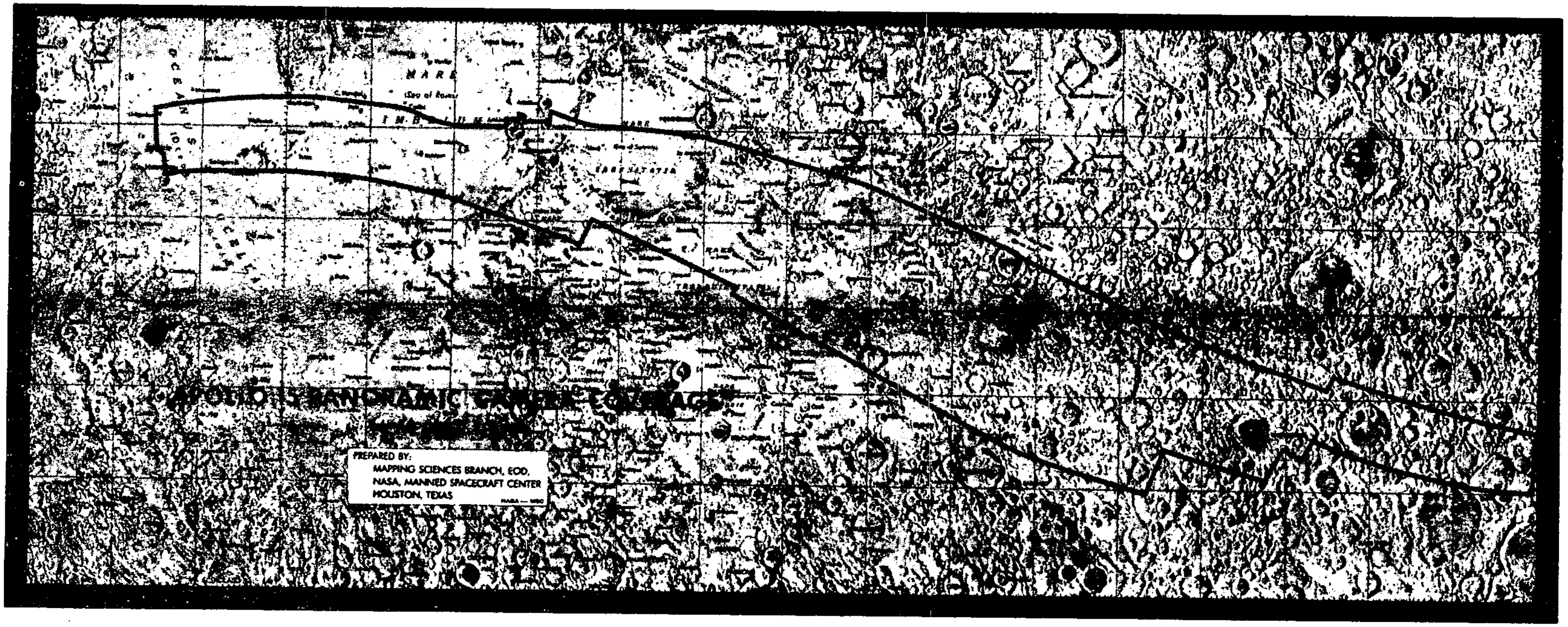


Figure 2. Lunar Surface Track Coverage of Panoramic Camera

Figure 3. Representative Apollo 15 Photographs

The following pages contain representative photographs, as identified below, taken during the Apollo 15 mission.

a. 80-mm Hasselbald photograph AS15-87-11697 taken in orbit: View of Mare Serenitatis north of Bessel Crater; LM in orbit.

b. 250-mm Hasselblad photograph AS15-96-12601 taken in orbit: Oblique view of Prinz Crater region, Aristarchus and Herodotus.

c. 500-mm Hasselblad photograph AS15-96-13044 taken in orbit: Prinz Crater and Prinz sinuous rills.

d. 60-mm Hasselblad surface photograph AS15-87-11749: Panoramic view of Hadley delta (Spur Mountain in background).

e. 60-mm Hasselblad surface photograph AS15-88-11865: LM, Lunar Rover, Astronaut Irwin, Hadley delta to north.

f. 500-mm Hasselblad surface photograph AS15-84-11250: East flank of Hadley delta (Spur Mountain).

g. Mapping camera photograph AS15-2610: Lunar nearside view showing Aristarchus, Herodotus, and Shröter's Valley region.

h. Mapping camera photograph AS15-1820: Lunar nearside view showing Bradley Rill, Apennines, Conon Crater, and Hadley Rill (landing site).

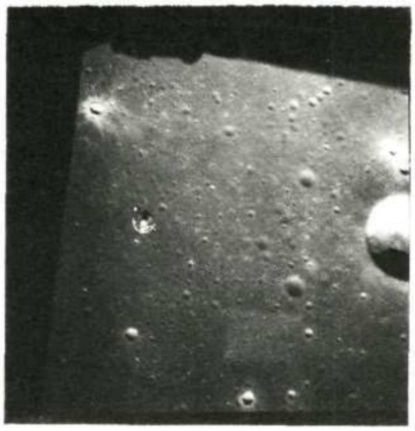
i. Mapping camera photograph AS15-0414: Lunar nearside view of Hadley Rill (landing site) and Apennine Mountains.

j. Mapping camera photograph AS15-1032: Lunar farside view of Tsiolkovsky.

k. Panoramic camera photograph: Reduced from actual size of 9- x 45-in.; detail shows LM landing site.

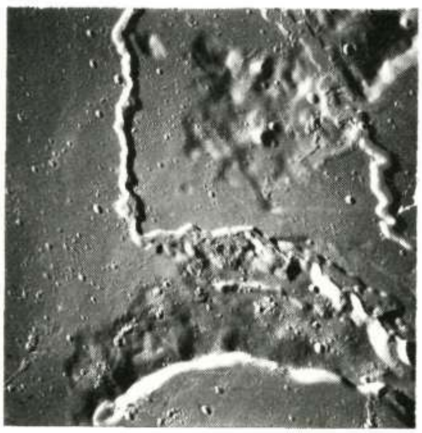
l. 70-mm Hasselblad panoramic mosaic AS15-48518 of Hadley Rill taken during EVA 3 on the lunar surface.

m. 70-mm Hasselblad panoramic mosaic AS15-47591 (contact print) taken during EVA 3.

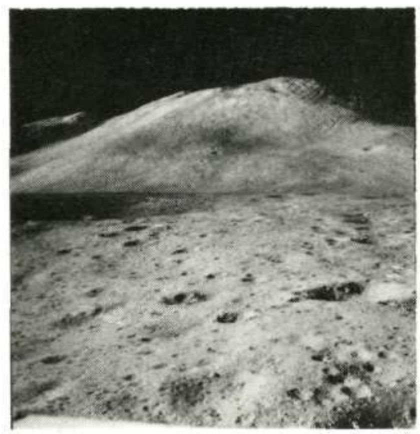


3a. 80-mm Hasselblad (Orbit)

3b. 250-mm Hasselblad (Orbit)

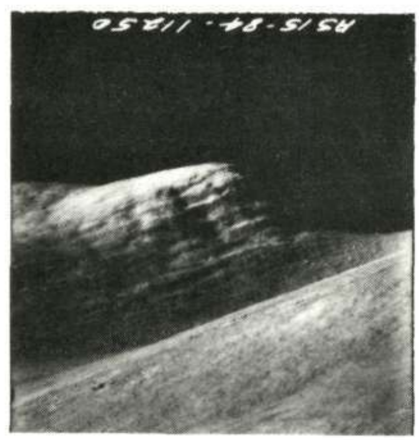


3c. 500-mm Hasselblad (Orbit)



3d. 60-mm Hasselblad (Surface)

3e. 60-mm Hasselblad (Surface)



3f. 500-mm Hasselblad (Surface)

Figure 3g. Mapping Camera (lunar nearside)

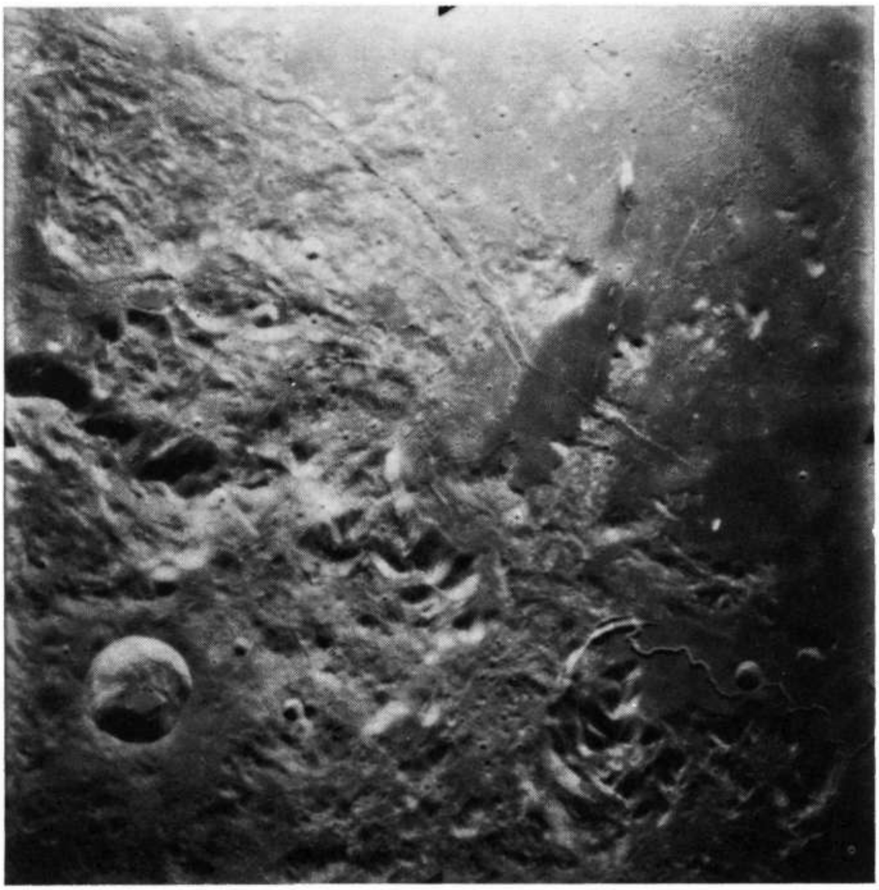


Figure 3h. Mapping Camera (lunar nearside)

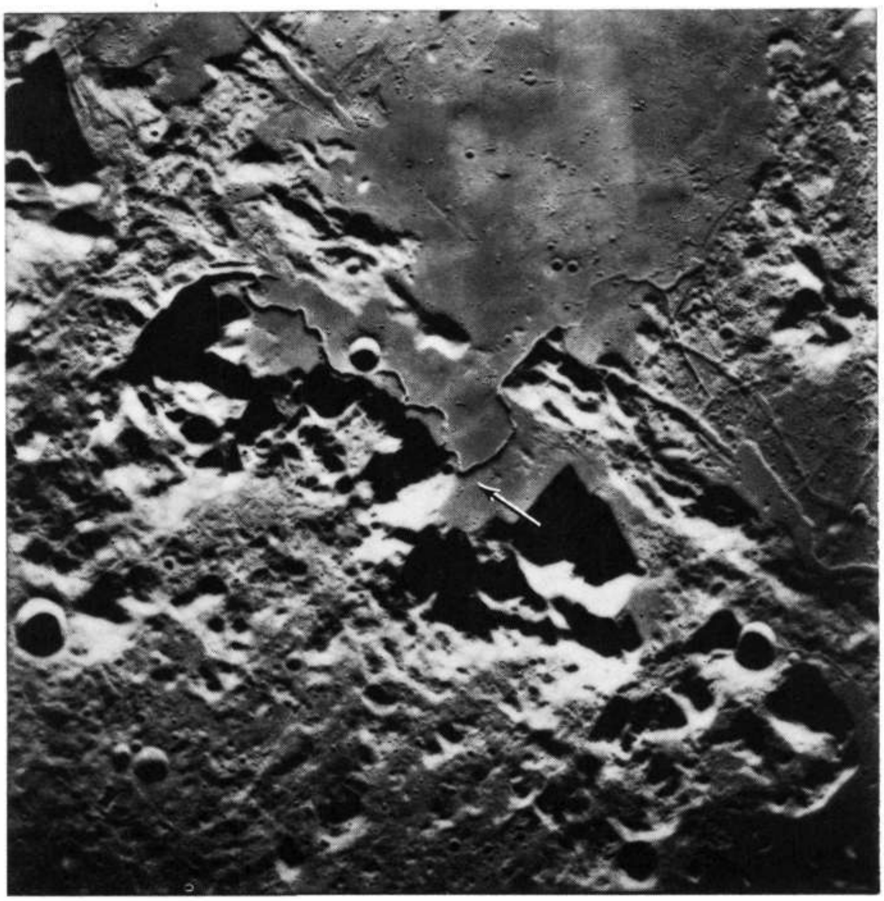


Figure 3i. Mapping Camera (lunar nearside)

Figure 3j. Mapping Camera (lunar farside)

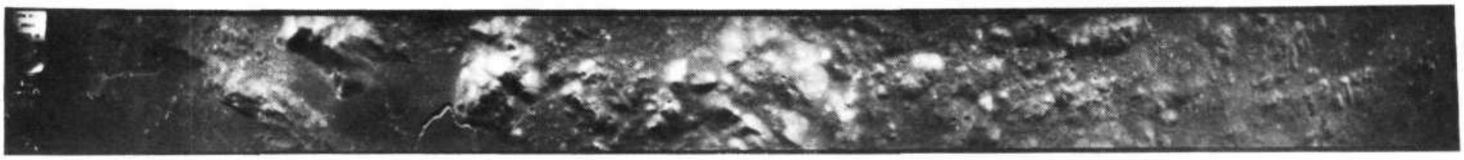


Figure 3k. Panoramic Camera (reduced from 9 x 45 in.)

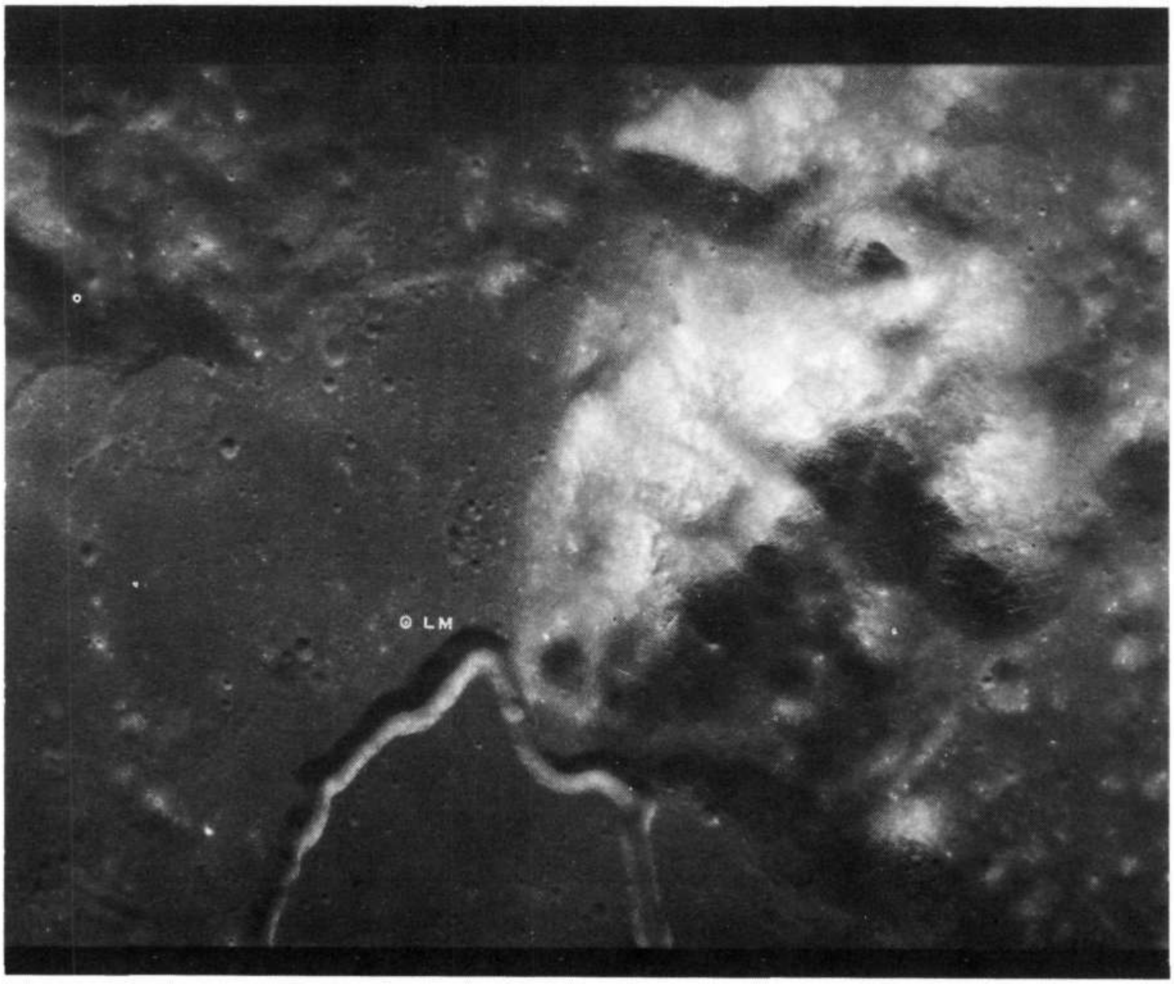


Figure 3k. Panoramic Camera (actual size; detail shows LM landing site)

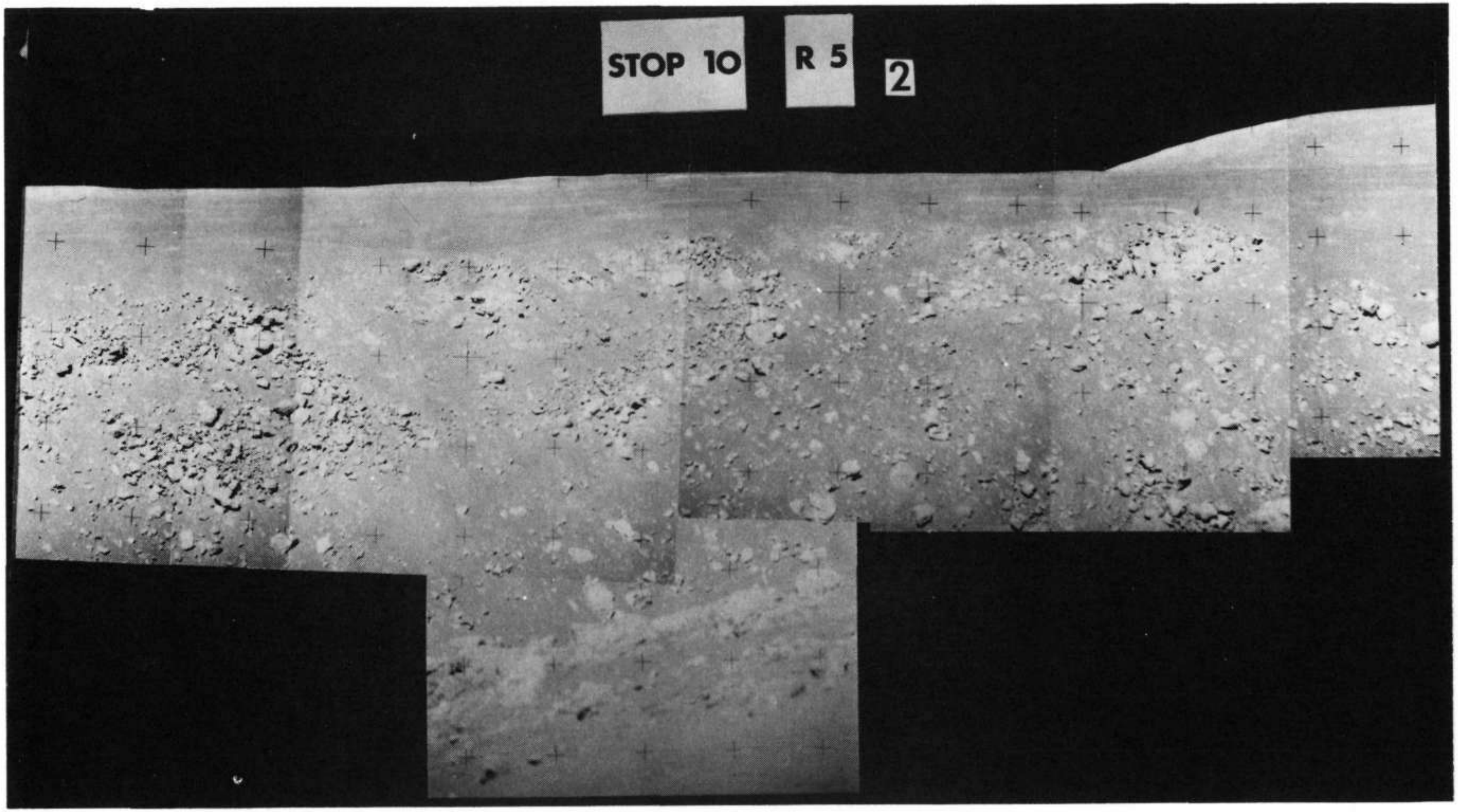


Figure 31. 70-mm Hasselblad Panoramic Mosaic

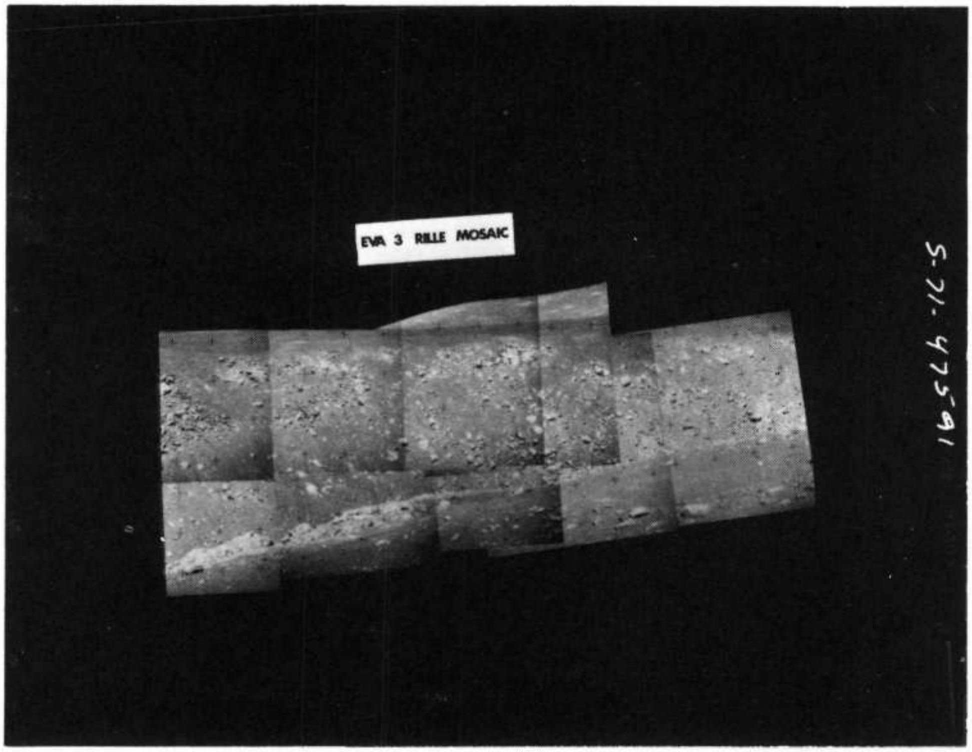


Figure 3m. 70-mm Hasselblad Panoramic Mosaic (contact print)

APOLLO 15

HASSELBLAD 70mm (FILM WIDTH) PHOTOGRAPHS

MAGAZINE QQ (AS15-81) FILM TYPE 3401

NASA PHOTO NO. AS15-81	MISSION ACTIVITY	LENS f/l mm	APPROX. ALT. km	PRINCIPAL POINT		CAMERA		SUN EL.	DESCRIPTION
				LAT.	LONG.	TILT	AZ		
10884	REV 61	500	113	24.0 N	4.5 E	VERT		53°	ARATUS CRATER
10885	REV 61	500	113	26.0 N	4.0 E	VERT		52°	HADLEY RILLE, LANDING SITE
10886	REV 61	500	113	26.5 N	3.5 E	VERT		51°	HADLEY RILLE, LANDING SITE
10887	REV 61	500	113	26.0 N	3.5 E	VERT		51°	HADLEY RILLE, LANDING SITE
10888	REV 61	500	113	24.0 N	4.5 E	VERT		53°	ARATUS CRATER
10889	REV 61	500	113	26.0 N	4.5 E	VERT		52°	HADLEY LANDING SITE
10890	REV 61	500	113	26.0 N	3.5 E	VERT		51°	HADLEY RILLE, LANDING SITE
10891	REV 61	500	113	26.0 N	3.5 E	VERT		51°	HADLEY RILLE, LANDING SITE
10892	REV 61	500	113	26.0 N	3.0 E	VERT		51°	HADLEY RILLE, S OF LANDING SITE
10893	REV 61	500	113	26.0 N	3.0 E	VERT		51°	HADLEY RILLE, S OF LANDING SITE
10894	REV 61	500	113	25.5 N	3.0 E	VERT		51°	HADLEY RILLE, CRATER HADLEY C
10895	REV 61	500	113	25.5 N	3.0 E	VERT		51°	HADLEY RILLE, CRATER HADLEY C
10896	REV 61	500	113	25.0 N	2.5 E	VERT		51°	HADLEY RILLE, S OF CRATER HADLEY C
10897	REV 61	500	113	25.0 N	2.5 E	VERT		51°	HADLEY RILLE, NEAR S END
10898	REV 61	500	113	25.0 N	2.0 E	VERT		51°	HADLEY RILLE, NEAR S END

Figure 4. Sample of Hasselblad Index, by Photo Number

APOLLO 15

HASSELBLAD 70 mm (FILM WIDTH) PHOTOGRAPHS

LUNAR SURFACE

LM WINDOW, STANDUP EVA (SEVA)

NASA PHOTO NO. AS15-	LENS f/1 mm	MAG	FILM TYPE	SUN		CAMERA	DESCRIPTION
				AZ	EL.		
87-11730	60	KK	S0368	96°	13°	CDR	SEVA PAN, BENNETT HILL
87-11731	60	KK	S0368	96°	13°	CDR	SEVA PAN, HILL 305
87-11732	60	KK	S0368	96°	13°	CDR	SEVA PAN, HILL 305
87-11733	60	KK	S0368	96°	13°	CDR	SEVA PAN, HILL 305
87-11734	60	KK	S0368	96°	13°	CDR	SEVA PAN, HILL 305
87-11735	60	KK	S0368	96°	13°	CDR	SEVA PAN, NORTH COMPLEX
87-11736	60	KK	S0368	96°	13°	CDR	SEVA PAN, NORTH COMPLEX, MT. HADLEY
87-11737	60	KK	S0368	96°	13°	CDR	SEVA PAN, NORTH COMPLEX, MT. HADLEY
87-11738	60	KK	S0368	96°	13°	CDR	SEVA PAN, NORTH COMPLEX, MT. HADLEY
87-11739	60	KK	S0368	96°	13°	CDR	SEVA PAN, MT. HADLEY
87-11740	60	KK	S0368	96°	13°	CDR	SEVA PAN, MT. HADLEY
87-11741	60	KK	S0368	96°	13°	CDR	SEVA PAN, APENNINE FRONT
87-11742	60	KK	S0368	96°	13°	CDR	SEVA PAN, APENNINE FRONT
87-11743	60	KK	S0368	96°	13°	CDR	SEVA PAN, UP SUN
87-11744	60	KK	S0368	96°	13°	CDR	SEVA PAN, UP SUN

Figure 5. Sample of Hasselblad Index, by Surface Activities

APOLLO 15

HASSELBLAD 70mm (FILM WIDTH) PHOTOGRAPHS

LUNAR ORBIT

INDEXED BY LONGITUDE

LONGI-TUDE	NASA PHOTO NO. AS15-	DESCRIPTION	MAG.	FILM TYPE	LENS f/l mm	APPROX. ALT. km	PRINCIPAL POINT		CAMERA		SUN EL.
							LAT.	LONG.	TILT	AZ	
140-150°E	97-13156	CRATER GAGARIN, W RIM	O	SO368	250	118	18 S	144 E	30°	190°	24°
140-150°E	97-13157	CRATER TSIOLKOVSKY, E RIM	O	SO368	250	118	21 S	132.5 E	30°	180°	34°
140-150°E	97-13158	CRATER TSIOLKOVSKY, E RIM	O	SO368	250	118	21 S	132 E	30°	180°	34°
140-150°E	97-13159	CRATER TSIOLKOVSKY, E RIM	O	SO368	250	118	21 S	131.5 E	30°	180°	35°
130-140°E	87-11726	CRATER TSIOLKOVSKY	KK	SO168	60	89	20 S	130 E	45°	225°	37°
130-140°E	87-11727	CRATER TSIOLKOVSKY	KK	SO168	60	89	20 S	130 E	45°	225°	37°
130-140°E	87-11728	CRATER TSIOLKOVSKY	KK	SO168	60	89	20 S	130 E	45°	225°	37°
130-140°E	87-11729	CRATER TSIOLKOVSKY	KK	SO168	60	89	20 S	130 E	45°	225°	37°
130-140°E	94-12740	NE OF CRATER TSIOLKOVSKY	S	3414	250	118	18.5 S	133 E	VERT		33°
130-140°E	94-12741	NE OF CRATER TSIOLKOVSKY	S	3414	250	118	18 S	133 E	VERT		33°
130-140°	94-12742	NE OF CRATER TSIOLKOVSKY	S	3414	250	118	18 S	133 E	VERT		33°
130-140°E	94-12743	CRATER TSIOLKOVSKY, NE WALL	S	3414	250	118	18.5 S	131.5 E	VERT		35°
120-130°E	91-12381	CRATER TSIOLKOVSKY	M	SO368	250	68	19.5 S	126 E	55°	265°	50°
120-130°E	91-12382	CRATER TSIOLKOVSKY	M	SO368	250	69	20 S	129 E	55°	270°	48°
120-130°E	91-12383	CRATER TSIOLKOVSKY	M	SO368	250	69	20 S	127 E	30°	270°	49°

Figure 6. Sample of Hasselblad Index, by Longitude

APOLLO 15 A15 R-62 MAP 12/71 FIN PAGE - 2091

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	20	18	41.462
GET			8	6	44	40.664

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1796.2511139	145.7121296	-452.1584511	-.2065907	1.1115338	1.1585694
SELENOGRAPHIC	210.1791592	1774.9752502	-507.4297218	1.4846436	.0137926	.6450683
SIGMA(SELENO)	1.84	.11	.88	.000	.002	.000

LONGITUDE OF NADIR POINT	83.2469082	DEG	LATITUDE OF NADIR POINT	-15.8490558	DEG
SIGMA NADIR LONGITUDE	.0010193	DEG	SIGMA NADIR LATITUDE	.0004873	DEG
LONG OF CAMERA AXIS INTERSECT	83.2382889	DEG	LATI OF CAMERA AXIS INTERSECT	-15.8692123	DEG
SPACECRAFT RADIUS	1858.0089417	KM	SPACECRAFT ALTITUDE	119.9189148	KM
SIGMA SPACECRAFT RADIUS	.0000229	KM	AZIMUTH OF VELOCITY VECTOR	294.5259933	DEG
MEAN ALTITUDE RATE	.0049493	KM/SEC	HORIZONTAL VEROCITY	1.6187495	KM/SEC
TILT AZIMUTH	202.3596478	DEG	TILT ANGLE	.3158990	DEG
SIGMA TILT AZIMUTH	.3627330	DEG	SIGMA TILT ANGLE	.0020010	DEG
SUN ELEVATION AT PRIN GRND PNT	37.4651670	DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	282.7785110	DEG
LONGITUDE OF SUBSOLAR POINT	32.5177565	DEG	LATITUDE OF SUBSOLAR POINT	.1454069	DEG
ALPHA	-.0577027	DEG	SWING ANGLE	178.2399521	DEG
EMISSION ANGLE	.3376793	DEG	SIGMA SWING ANGLE	.3627326	DEG
PHASE ANGLE	52.5917954	DEG	NORTH DEVIATION ANGLE	155.8776665	DEG
PHI	-.0097076	DEG	X-TILT	-.3157511	DEG
SIGMA PHI	.0020000	DEG	SIGMA X-TILT	.0020000	DEG
KAPPA	-155.8803482	DEG	Y-TILT	.0097074	DEG
SIGMA KAPPA	.0020000	DEG	SIGMA Y-TILT	.0020000	DEG
OMEGA	-.3157511	DEG	HEADING	-65.8804035	DEG
SIGMA OMEGA	.0020000	DEG	SIGMA HEADING	.0020000	DEG
SCALE FACTOR	.0000000	M/KM	LASER SLANT RANGE	.0000000	KM
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	ALTITUDE DIFFERENCE	-119.9189148	KM

APOLLO 15 A15, REV 62, CONSTRAINED A, 1, AND OMEGA

EPOCH (GMT): AUG 3, 1971 19 45 000
INITIAL FRAME: JUL 30, 1971 0 000
FINAL FRAME: AUG 30, 1971 4 0 34.160

INPUT STATE VECTOR, SELENOCENTRIC 1950.0 AT TIME FROM EPOCH: .00000 MIN

X .00000000 Y .00000000 Z .00000000 XDOT .00000000 YDOT .00000000 ZDOT .00000000

PHYSICAL CONSTANTS

LOCAL LUNAR RADIUS	1738.09	KM
LUNAR GRAVITATIONAL CONSTANT	4902.58	KM**3/SEC**2
EPHEMERIS TIME-UNIVERSAL TIME	41.7500	SEC
SCALE FACTOR FOR S/C EPHEMERIS	6378.1492	KM

* DIVIDE CHECK AT 034207

* DIVIDE CHECK AT 034207

* DIVIDE CHECK AT 037612

Figure 7. Sample of Supporting Data for Mapping Camera Photographs

APOLLO 15
METRIC CAMERA PHOTOGRAPHS
3 INCH (7.62 cm) FOCAL LENGTH

NASA PHOTO NO. AS15-	REV NO.	APPROX. ALT. km	PRINCIPAL POINT		CAMERA		FWD OVERLAP %	SUN EL.	DESCRIPTION
			LAT.	LONG.	TILT	AZ			
0097	4	85	19.0 S	150 E	VERT		75	29	CRATER GAGARIN
0098	4	84	19.0 S	148.5 E	VERT		75	30	CRATER GAGARIN
0099	4	83	18.5 S	147.5 E	VERT		75	31	CRATER GAGARIN
0100	4	83	18 S	146.5 E	VERT		75	32	CRATER GAGARIN
0101	4	83	18 S	145.5 E	VERT		75	33	NW WALL OF GAGARIN CRATER
0102	4	82	17.5 S	144.5 E	VERT		75	34	NW WALL OF GAGARIN CRATER
0103	4	81	17.5 S	143.5 E	VERT		75	35	ONE DEGREE SE OF DENNING CRATER
0104	15	118	19.5 S	140.5 E	VERT		75	27	DOUBLE EXPOSED, ONE DEGREE NW OF PIRQUET CRATER
0105	15	118	19.0 S	139 E	VERT		75	28	ONE DEGREE NW OF CRATER PIRQUET
0106	15	118	18.5 S	138 E	VERT		75	29	THREE DEGREES NW OF CRATER PIRQUET
0107	15	118	18 S	136.5 E	VERT		75	31	FOUR DEGREES NW OF CRATER PIRQUET
0108	15	118	18 S	135.5 E	VERT		75	32	FIVE DEGREES NW OF CRATER PIRQUET
0109	15	118	17.0 S	134.0 E	VERT		75	33	NE OF TSIOLKOVSKY CRATER
0110	15	118	17.0 S	132.5 E	VERT		75	35	NE OF TSIOLKOVSKY CRATER
0111	15	118	16.5 S	131.0 E	VERT		75	36	NE OF TSIOLKOVSKY CRATER

Figure 8. Sample of One-Line Index for Mapping Camera Photographs

APOLLO 15 A15 R-4 PAN 12/71 FIN PAGE - 8849

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	2	18	.953
GET			3	12	44	.161

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1457.6200714	-497.4031143	-1003.2864456	-.8696580	1.1474606	.7309515
SELENOGRAPHIC	-1663.7350922	148.5849686	-767.1752548	.0617772	1.5980249	.2230714
	.08	1.98	.28	.002	.000	.001

LONGITUDE OF NADIR POINT	174.8965607 DEG	LATITUDE OF NADIR POINT	-24.6687617 DEG
SIGMA NADIR LONGITUDE	.0011830 DEG	SIGMA NADIR LATITUDE	.0001591 DEG
LONG OF COMERA AXIS INTERSECT	174.8577728 DEG	LATI OF CAMERA AXIS INTERSECT	-24.6787076 DEG
SPACECRAFT RADIUS	1838.1103668 KM	SPACECRAFT ALTITUDE	100.0203400 KM
SIGMA SPACECRAFT RADIUS	.0000039 KM	AZIMUTH OF VELOCITY VECTOR	278.4178658 DEG
MEAN ALTITUDE RATE	-.0198428 KM/SEC	HORIZONTAL VELOCITY	1.6145502 KM/SEC
TILT AZIMUTH	254.2351532 DEG	TILT ANGLE	.6364292 DEG
SIGMA TILT AZIMUTH	.1811536 DEG	SIGMA TILT ANGLE	.0019885 DEG
SUN ELEVATION AT PRIN GRND PNT	5.0247898 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	272.6008949 DEG
LONGITUDE OF SUBSOLAR POINT	90.5083866 DEG	LATITUDE OF SUBSOLAR POINT	.2581425 DEG
ALPHA	-.6388978 DEG	SWING ANGLE	245.8044662 DEG
EMISSION ANGLE	.6730397 DEG	SIGMA SWING ANGLE	.1811536 DEG
PHASE ANGLE	85.6140738 DEG	NORTH DEVIATION ANGEL	171.5524731 DEG
PHI	.5805240 DEG	X-TILT	-.2608333 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	-171.5710239 DEG	Y-TILT	-.5805180 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	-.2608333 DEG	HEADING	-81.5683775 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-100.0203400 KM

	X	Y	Z	MAGNITUDE (KM)
SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	.90262640	-.11338522	.41522207	98.999817

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.52108333+00	.71879082+00	.46023031+00
.26996950+00	.65034504+00	-.71004767+00
-.80968430+00	-.24574588+00	-.53293562+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98685250+00	.16123465+00	.11204741-01
-.16127417+00	-.98690586+00	-.27144739-02
.10620368-01	-.44858327-02	.99993358+00

LATITUDE	LONGITUDE
-28.741	173.177
-20.271	174.614
-20.347	175.237
-28.842	173.834

Figure 9. Sample of Supporting Data for Panoramic Camera Photographs

APOLLO 15

PANORAMIC CAMERA PHOTOGRAPHS

24 INCH (60.96 cm) FOCAL LENGTH

NASA PHOTO NO. AS15-	CAMERA LOOK	STEREO FRAME AS15-	PRINCIPAL POINT		APPROX. ALT. km	REV NO.	SUN EL.	DESCRIPTION
			LAT.	LONG.				
8859	AFT		24.0 S	169.0 E	96	4	10	NW. OF VAN DE GRAAFF CRATER
8860	FWD	8865	23.5 S	168.0 E	96	4	11	E. OF PARACELSUS CRATER
8862	FWD	8867	23.5 S	167.0 E	95	4	12	E. OF PARACELSUS CRATER
8864	FWD	8869	23.0 S	167.0 E	95	4	12	E. OF PARACELSUS CRATER
8866	FWD	8871	23.0 S	166.0 E	95	4	13	E. OF PARACELSUS CRATER
8868	FWD	8873	23.0 S	165.0 E	94	4	14	E. RIM PARACELSUS CRATER
8870	FWD	8875	23.0 S	164.5 E	94	4	14	FLOOR PARACELSUS CRATER
8872	FWD	8877	22.5 S	164.0 E	94	4	15	FLOOR PARACELSUS CRATER
8874	FWD	8879	22.5 S	163.0 E	93	4	16	FLOOR PARACELSUS CRATER
8876	FWD	8881	22.5 S	162.5 E	93	4	16	FLOOR PARACELSUS CRATER
8878	FWD	8883	22.5 S	162.0 E	93	4	17	W. RIM PARACELSUS CRATER
8880	FWD	8885	22.0 S	161.5 E	93	4	17	W. OF PARACELSUS CRATER
8882	FWD	8887	22.0 S	161.0 E	92	4	18	W. OF PARACELSUS CRATER
8884	FWD	8889	22.0 S	160.0 E	92	4	18	W. OF PARACELSUS CRATER
8886	FWD	8891	22.0 S	160.0 E	92	4	18	NE. OF BARBIER CRATER

Figure 10. Sample of One-Line Index for Panoramic Camera Photographs

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Dear Colleague:

This Apollo 15 Data Users' Note has been prepared by the National Space Science Data Center (NSSDC) with important contributions being provided by Mr. Fred Doyle, Topographic Division, U.S. Geological Survey, and Mr. George Esenwein and Mr. Leon Kosofsky, Apollo Lunar Exploration Office, NASA Headquarters. The purpose of this document is to provide you with substantial information on the photography taken during the Apollo 15 mission and to aid you in the selection of Apollo 15 photographs for study. Ten index maps indicating the areas covered by the photographs are being sent with this Note.

It should be noted that this information package is quite different from those for previous missions. For the Apollo 11 through 14 missions, NSSDC, with the aid of the Mapping Sciences Laboratory, Manned Spacecraft Center, prepared photographic proof print catalogs and frame index data in the form of printed documents. The volume of photography and data increased so greatly with Apollo 15, however, that they have been prepared in microform. They are therefore not included with this package. A complete description of the microform photographic catalogs and supporting data available from NSSDC can be found in this Note in the sections titled "Photographic Coverage and Quality" and "Format of Available Photographic and Supporting Data." An order form is provided at the end of the Data Users' Note for your use in ordering all forms of Apollo 15 data available from NSSDC.

Your comments on the contents of the Apollo 15 documentation and on the services offered by NSSDC are invited.

Very truly yours,

James I. Vette

James I. Vette
Director, NSSDC