3. Photographic Summary

John W. Dietrich[a] *and Uel S. Clanton*[a]

The photographic objectives of the Apollo 15 mission were designed to support a wide variety of scientific and operational experiments, to provide high-resolution panoramic photographs and precisely oriented metric photographs of the lunar surface, and to document operational tasks on the lunar surface and in flight. Detailed premission planning integrated the photographic tasks with the other mission objectives to produce a balanced mission that has returned more data than any previous space voyage. The lift-off of the Apollo 15 vehicle was photographed using ground-based cameras at Kennedy Space Center, Florida (fig. 3-1).

The return of photographic data was enhanced by new equipment, the high latitude of the landing site, and greater time in lunar orbit. New camera systems that were mounted in the scientific instrument module (SIM) bay of the service module provided a major photographic capability that was not available on any previous lunar mission, manned or unmanned. Additional camera equipment available for use within the command module (CM) and on the lunar surface increased the photographic potential of the Apollo 15 mission over previous manned flights. The orbital inclination that was required for a landing at the Hadley-Apennine site carried the Apollo 15 crew over terrain far north and south of the equatorial band observed during earlier Apollo missions. During the 6 days that the Apollo 15 command-service module (CSM) remained in lunar orbit, the Moon rotated more than 75°. This longer stay time increased the total surface area illuminated during the mission and provided opportunities to photograph specific features in a wide range of illumination.

The Apollo 15 crew returned an unprecedented number of photographs. The 61-cm-focal-length panoramic camera exposed 1570 high-resolution photographs. Each frame is 11.4 cm wide and 114.8 cm long; assuming the nominal spacecraft altitude of 110 km, each frame includes a lunar-surface area of 21 by 330 km. Mapping-camera coverage consists of 3375 11.4- by 11.4-cm frames from the 7.6-cm-focal-length camera; a companion 35-mm frame exposed in the stellar camera permits precise reconstruction of the camera-system orientation for each photograph. Approximately 375 photographs were exposed between transearth injection and the deep-space extravehicular activity (EVA). Some of the mapping-camera frames exposed in lunar orbit contain no usable surface imagery because the camera system was operated during selected dark-side passes to support the laser altimeter with stellar-camera orientation data. The Apollo 15 crew also returned approximately 2350 frames of 70-mm photography, 148 frames of 35-mm photography, and 11 magazines of exposed 16-mm film. At the time this report was prepared, the photography had been screened and indexed; lunar-surface footprints of most orbital photography had been plotted on lunar charts; and index data had been transmitted to the appropriate agency for the printing of index maps.

Photographic activity began in Earth orbit when the crew exposed the first of several sets of ultraviolet (uv) photographs scheduled for the Apollo 15 mission. A special spacecraft window designed to transmit energy at uv wavelengths, a uv-transmitting lens for the electric Hasselblad (EL) camera, a spectroscopic film sensitive to the shorter wavelengths, and a set of four filters were required to record spectral data for the experiment. Earth and its atmospheric envelope were photographed from various distances during the lunar mission to provide calibration data to support the study of planetary atmospheres by telescopic observations in the uv spectrum. The uv photographs of the Moon were scheduled for use in the investigation of short-wavelength radiation from the lunar surface.

The special CM window installed for the uv-

[a]NASA Manned Spacecraft Center.

photography experiment had to be covered with a filter most of the time to block the uv radiation. The high levels of uv radiation in direct sunlight or in light reflected from the lunar surface to an orbiting spacecraft limited the safe exposure time of the crew to a few minutes per 24 hr. Although the shield appeared transparent at visual wavelengths, preflight tests predicted a moderate degradation in the resolution of photographs exposed through the filter. This potential degradation influenced the selection of orbital-science photographic targets.

A nominal transposition, docking, and lunar module (LM) extraction maneuver was telecast in real time and recorded by data-acquisition-camera (DAC) and Hasselblad photography (fig. 3-2). After CSM/LM extraction, the spent SIVB stage was photographed (fig. 3-3) as it began a planned trajectory toward an impact on the lunar surface near the Apollo 12 and 14 sites of the Apollo lunar surface experiments packages.

Photographic activity was at a low level through most of the 75-hr translunar-coast phase of the mission. Three sets of uv photographs recorded the spectral signature of the Earth from distances of 50 000, 125 000, and 175 000 n. mi. (fig. 3-4). A fourth set recorded the uv signature of the Moon from a point approximately 50 000 n. mi. from Earth. The initial inspection of the LM was telecast from deep space. A 16-mm DAC sequence recorded the sextant-photography test performed near the halfway point in the trip from Earth to the Moon. During translunar coast, the SIM camera systems were cycled twice to advance the film and reduce the danger of film set.

Approximately 4.5 hr before lunar orbit insertion, the SIM door was jettisoned. The DAC photographs recorded the movements of the slowly tumbling door, which was jettisoned so as to pose no danger to the crew. Removal of the protective door increased the housekeeping requirements of the SIM camera systems because temperatures had to be maintained within operational limits.

The Apollo 15 crew provided extensive and detailed descriptions of lunar-surface features after insertion into lunar orbit. Because of the length of the mission and the amount of film budgeted for specific targets, not all features described on revolution 1 were photographed. The science-support-team requests for photographs to be taken on later revolutions were forwarded by the Mission Control Center. A busy schedule of orbital-science Hasselblad photography on revolution 2 was followed by the first of several sets of terminator photographs.

After the successful descent-orbit-insertion burn, the crew completed some of the real-time requests for photography of features they had described during the initial pass over the Seas of Crises and Serenity (fig. 3-5). Far-side terminator photographs taken with the Hasselblad camera at the end of revolution 3 were followed almost immediately by a 12-min operating period for the SIM camera systems (figs. 3-6 to 3-10). In this pass, the mapping camera and the panoramic camera photographed terrain that would become dark as the sunset terminator moved during the first lunar rest period, which occurred during revolutions 5 to 8. Representative photographs that document orbital and lunar-surface activities are shown in figures 3-11 to 3-52.

Operational tasks preparatory to the LM undocking were interrupted during revolution 9 for the telecast of the landing site and surrounding terrain. Operating difficulties delayed the undocking for approximately 25 min on revolution 12. Scheduled photography of the maneuver was not affected, but the delay canceled a low-altitude tracking pass on a landmark within the landing site. After a far-side engine firing to circularize the CSM orbit, the command module pilot (CMP) successfully tracked the landing-site landmark on revolution 13. The DAC photographs through the sextant documented the high-altitude tracking operation.

During the period that the CSM and LM were operated separately, the CMP followed a busy schedule of operational, experimental, and housekeeping tasks in orbit. The experimental tasks included photographic assignments covering a wide range of targets and requiring the use of various combinations of cameras, lenses, and films (table 3-I) or operation of the complex SIM camera systems (table 3-II). The dominant photographic task performed by the CMP, measured in terms of time and budgeted film, was lunar-surface photography. Other tasks included the documentation of operations with the LM and the photography of Earth and deep-space targets in support of specific experiments.

The LM crew used an enlarged inventory of photographic equipment (table 3-III) to document the descent, surface-operations, and ascent phases of the mission. After photographing the delayed CSM/LM separation on revolution 12 and the landing site and other lunar-surface targets during the low-altitude

TABLE 3-I.—*Photographic Equipment Used In Command Module*

Camera	*Features*	*Film size and type*	*Remarks*
Hasselblad EL	Electric; interchangeable lenses of 80-, 105-, and 250-mm focal length. The 105-mm lens will transmit uv wavelengths	70-mm; SO-368 Ektachrome MS color-reversal film, ASA 64; 3414 high-definition aerial film, aerial exposure index (AEI) 6; 2485 black-and-white film, ASA 6000; IIa-0 spectroscopic film (uv sensitive)	Used with 80-mm lens and color film to document operations and maneuvers involving more than one vehicle. Used with appropriate lens-film combinations to photograph preselected orbital-science lunar targets, different types of terrain at the lunar terminator, astronomical phenomena, views of the Moon after transearth injection, Earth from various distances, and special uv spectral photographs of Earth and Moon
Nikon	Mechanically operated; through-the-lens viewing and metering; 55-mm lens	35-mm; 2485 black-and-white film, ASA 6000	Used for dim-light photography of astronomical phenomena and photography of lunar-surface targets illuminated by earthshine
DAC	Electric; interchangeable lenses of 10-, 18-, and 75-mm focal length; variable frame rates of 1, 6, 12, and 24 frames/sec	16-mm; SO-368 Ektachrome MS color-reversal film, ASA 64; SO-368 Ektachrome EF color-reversal film, exposed and developed at ASA 1000; 2485 black-and-white film, ASA 6000; AEI 16 black-and-white film	Bracket-mounted in CSM rendezvous window to document maneuvers with the LM and CM entry; hand-held to document nearby objects such as SIM door after jettison and subsatellite after launch, and to photograph general targets inside and outside the CSM; bracket-mounted on sextant to document landmark tracking

pass on revolution 13, the LM crew completed the preparations for the lunar landing. After powered descent initiation on revolution 14, the lunar module pilot (LMP) actuated the 16-mm DAC mounted in the right-hand LM window to record the view ahead and to the right from time of pitchover through touchdown.

The 67-hr stay time of the LM on the lunar surface accommodated three EVA periods for a total of almost 38 man-hr of lunar-surface activity. While on the surface, the crew took 1151 photographs with the Hasselblad cameras.

This mission differed significantly from previous missions not only because of the different priorities placed on the experiments and because of new equipment (such as the lunar roving vehicle (Rover) for extended mobility), but also because of changes in the schedule of crew activities after the landing. The first crew activity after powering down the LM was the standup EVA. This activity consisted of the commander's removing the docking hatch of the LM and standing on the ascent-engine cover. From that vantage point, he photographed and described the surrounding area. The value of this early photography under the low-Sun-angle lighting is easily demonstrated by comparing the standup EVA photography with the surface photography.

The first EVA began with the Rover deployment and the drive to Hadley Rille. Throughout the stay on the lunar surface, a television camera mounted on the Rover provided real-time viewing of much of the surface activities. After the crew oriented the high-gain antenna at each stop, the camera was remotely controlled from Earth. These transmissions permitted observers to evaluate the operational capabilities of the crew and to observe the collection of samples to be returned to Earth. In addition to the usual photography at station 1, the commander (CDR) used the

TABLE 3-II.–*Photographic Equipment in the Scientific Instrument Module*

Camera	*Features*	*Film size and type*	*Remarks*
Mapping	Electric; controls in CSM; 7.6-cm-focal-length lens; 74° by 74° field of view; a square array of 121 reseau crosses, 8 fiducial marks, and the camera serial number recorded on each frame with auxiliary data of time, altitude, shutter speed, and forward-motion control setting	457.2 m of 127-mm film type 3400	The 11.4- by 11.4-cm frames with 78-percent forward overlap provide the first Apollo photographs of mapping quality. Data recorded on the film and telemetered to Earth will permit reconstruction of lunar-surface geometry with an accuracy not available with earlier systems.
Stellar	Part of mapping-camera subsystem; 7.6-cm lens; viewing angle at 96° to mapping-camera view; a square array of 25 reseau crosses, 4 edge fiducial marks, and the lens serial number recorded on each frame with binary-coded time and altitude	155.4 m of 35-mm film type 3401	A 3.2-cm circular image with 2.4-cm flats records the star field at a fixed point in space relative to the mapping-camera axis. Reduction of the stellar data permits accurate determination of camera orientation for each mapping-camera frame.
Panoramic	Electric; controls in CSM; 61-cm lens; 10°46′ by 108° field of view; fiducial marks printed along both edges; IRIG B time code printed along forward edge; data block includes frame number, time, mission data, V/h, and camera-pointing altitude	1981.2 m of 127-mm film type EK 3414	The 11.4- by 114.8-cm images are tilted alternately forward and backward 12.5° in stereo mode. Consecutive frames of similar tilt have 10-percent overlap; stereopairs, 100-percent overlap. Panoramic photographs provide high-resolution stereoscopic coverage of a strip approximately 330 km wide, centered on the groundtrack.

Hasselblad camera with the 500-mm telephoto lens to record details of the far side of Hadley Rille. The two panoramas at station 2 on the side of St. George Crater provide excellent detail along the length and bottom of Hadley Rille. The Apollo lunar surface experiments package (ALSEP) was deployed near the end of EVA-1; the only major difficulty occurred during the emplacement of the heat-flow experiment.

On EVA-2, the crew again went south to the base of Hadley Delta to sample the material of the Apennine Front. The telephotographs from station 6A provide excellent detail of lineations in Mt. Hadley. These lineations appear to dip approximately 30° to the northwest and can be traced from the summit to the base of the mountain, a distance of more than 3000 m. The "Genesis" rock was collected at Spur Crater, station 7. A study of the surface photography indicates that this anorthositic fragment was not in situ but occurred as a clast within a breccia fragment. A vesicular basalt with vesicles as large as 9 cm in diameter was documented at Dune Crater, station 4.

The crew then returned to the LM area to finish the ALSEP tasks that had not been completed during EVA-1. The CDR continued the heat-flow-experiment installation and coring, while the LMP completed the three panoramas around the LM and began the trenching and soil-mechanics measurements near the ALSEP location. The second EVA ended with the coring completed but with the corestem still in the hole.

The duration of the third EVA was shortened

TABLE 3-III.–*Photographic Equipment Used in LM and on Lunar Surface*

Camera	*Features*	*Film size and type*	*Remarks*
Hasselblad data camera (DC), 2	Electric; 60-mm focal-length lens; reseau plate	70-mm; SO-168 Ektachrome EF color-reversal film exposed and developed at ASA 160; 3401 Plus-XX black-and-white film, AEI 64	Handheld within the LM; bracket-mounted on the remote-control unit for EVA photography; used for photography during standup EVA and through the LM window and for documentation of surface activities, sample sites, and experiment installation
Hasselblad DC	Electric; 500-mm lens; reseau plate	70-mm; 3401 Plus-XX black-and-white film, AEI 64	Handheld; used to photograph distant objects during standup EVA and from selected points during the three EVA periods
DAC	Electric; 10-mm lens	16-mm; SO-368 Ektachrome MS color-reversal film, ASA 64	Mounted in the LM right-hand window to record low-altitude views of the landing site one revolution before landing, to record the LMP view of the lunar scene during descent and ascent, and to document maneuvers with the CSM
Lunar DAC	Electric; 10-mm lens; battery pack and handle	16-mm; SO-368 Ektachrome MS color-reversal film, ASA 64	Handheld or mounted on the Rover to document lunar-surface operations; photography from this camera seriously degraded by intermittent malfunction of film feed

from the planned 6 hr to 4.5 hr. After considerable time and effort, both crewmembers recovered the core from the drill hole and continued the traverse to Hadley Rille. At stations 9A and 10, the CDR again obtained telephotographs of the west wall of Hadley Rille. These stations are approximately 300 m apart, and the combined telephotography from these two locations provides exceptional stereocoverage of Hadley Rille features, such as outcrops with massive and thin bedding, columnar jointing, boulder trails, and faulting.

The time used in recovering the core at the start of EVA-3 prevented the traverse to the North Complex from continuing as planned. The crew returned to the LM for closeout. The Rover was parked east of the LM so that the lift-off could be transmitted by the television system on the Rover. Some additional photography, both normal and telephotographic, during the closeout period provided additional coverage of the LM area and of the Apennine Front. The telephotographs obtained before lift-off provide additional detail of the Hadley Delta and the Mt. Hadley areas.

This mission, more than any other, demonstrated the detailed photographic information that is gained and lost as a function of changing Sun angle.

The lift-off of the LM ascent stage from the lunar surface was telecast for the first time by the remotely controlled television camera on the Rover. The DAC photographs of the lunar surface from the right-hand window of the LM during ascent were particularly interesting. The ALSEP site, boot and tire tracks, and surface features along and within Hadley Rille are clearly visible in these photographs. As the LM ascended and moved westward, the DAC field of view moved northward to cover Hadley Rille from the landing site to the point where the sinuous depression swings northward beyond the end of Hill 305.

After the LM was cleared to remain on the lunar surface, the CMP began his full schedule of orbital tasks. On revolutions 15 and 16, the Hasselblad cameras photographed four orbital-science targets and extra targets of opportunity within the Sea of Serenity. Two periods of mapping-camera operation totaled 2 hr 25 min and included a complete revolution of continuous mapping-camera, stellar-camera, and laser-altimeter operation. Two periods of panoramic-camera operation totaled 55 min. Telemetered data indicated an intermittent anomaly in the panoramic-camera velocity-over-height (V/h) sensor during all periods of operation. Real-time analysis suggested that as much as 30 percent of the panoramic frames exposed on revolution 16 were affected by the anomaly. Postmission tests have demonstrated that image smear, though present, generally does not seriously degrade the usefulness of the imagery. The second lunar rest period occurred during revolutions 18 to 21.

A broad spectrum of photographic tasks was scheduled during revolutions 22 to 28. Mapping-camera operations during three revolutions totaled almost 4 hr. Panoramic-camera operation totaled only slightly more than 1 min, but that brief period of activity provided high-resolution photographs of the lunar surface after the completion of EVA-1. A long strip of Hasselblad photographs across the Lick-Littrow orbital-science target, two periods of solar-corona photography, uv photographs of the Earth above the lunar horizon, and photographs supporting studies of dim-light phenomena completed the photographic activities during this period. The mapping camera was operated continuously during revolution 22 and the lighted half of revolution 23. A CSM maneuver near the far-side terminator on revolution 23 tilted the camera axis from the local vertical to provide forward-oblique photographs. The mapping camera was again activated for vertical photography across the lighted half of revolution 27 before the third lunar-orbit rest period, which occurred during revolutions 29 to 32.

Photographic tasks completed during revolutions 33 to 39 included operation of the mapping and panoramic cameras, Hasselblad photography of the orbital-science targets, 35-mm photography of the lunar surface illuminated by earthshine, and 35-mm photography of the gegenschein and zodiacal light in support of dim-light studies. The mapping camera was operated during revolution 33 and the lighted half of revolution 38 with the camera axis alined along the local vertical. Terminator-to-terminator passes of oblique photographs with the camera axis pointed backward and then northward were completed on revolutions 34 and 35, respectively. Three periods of panoramic-camera operation, one on revolution 33 and two on revolution 38, totaled slightly more than 40 min. Revolutions 40 to 43 were reserved for the fourth CMP rest period during lunar orbit.

Preparation for the return of the LM dominated activities in the CSM for the remainder of the solo phase of the mission. The mapping camera was operated through the lighted half of revolution 44, and gegenschein photography was performed after spacecraft earthset on revolution 46. The sextant-mounted DAC recorded the lunar scene during landmark tracking of the LM in preparation for lift-off, which occurred during CSM revolution 48.

The rendezvous between the LM and CSM, which occurred during revolution 49, was documented by DAC and Hasselblad photographs from both spacecraft (fig. 3-53). Before the nominal docking maneuver, the LM crew inspected the SIM bay from close range to determine whether a foreign object was intermittently blocking the V/h sensor port and thus causing the erratic signals from the panoramic camera. All SIM bay equipment appeared to be in satisfactory condition. Mapping-camera photography scheduled for the lighted half of revolution 50 was terminated on instructions from the Mission Control Center after only 42 min of operation. Panoramic-camera photographs obtained during the 2.5-min period of operation document the Hadley Rille site after the LM ascent. After documentation of the delayed LM jettison on revolution 52, photographic tasks were canceled to facilitate CSM cleanup and to complete essential operational tasks. The fifth rest period in lunar orbit occurred during revolutions 55 to 59.

Photographic schedules for revolutions 60 to 64 were revised to permit the accomplishment of most tasks delayed by the jettison problems and the long rest period. The mapping camera operated a total of 3 hr and provided terminator-to-terminator coverage on revolutions 60, 62, and 63. The panoramic camera was operated a total of approximately 40 min; a 10-min operation on revolution 60 was followed by two test sequences near the landing site, a brief period across the target point for LM impact on revolution 61, and continuous operation for 26 min on revolution 63. Hasselblad photography of orbital-science targets was supplemented by unscheduled telephotographs of selected lunar-surface features. The lunar-surface Hasselblad camera was returned to the CSM and, equipped with a 500-mm lens, was used to document targets of opportunity. Hasselblad photography supporting special experiments during this period included near- and far-side terminator photographs and two series of uv photographs recording the spectral data for lunar maria and highlands. The final rest period in lunar orbit occurred during revolutions 65 to 68.

The mapping camera was operated a total of 3 hr to provide terminator-to-terminator vertical photography during revolutions 70 and 72 as well as a sequence of unusually worthwhile oblique photographs that cover terrain out to the southern horizon on revolution 71. Film for the panoramic camera was exhausted near the end of a scheduled 24-min operating period during revolution 72. Other photographic tasks completed before the orbit-shaping engine firing on revolution 73 included orbital-science photography, unscheduled telephotography of targets of opportunity, solar-corona photography near the far-side terminator, and four sets of terminator photography.

The subsatellite launch on revolution 74 was documented with 16-mm DAC and 70-mm Hasselblad photographs (fig. 3-54). A sequence of DAC photographs recorded the initial spin rate and orientation of the small instrumented platform. The DAC sequence and Hasselblad photographs taken at random intervals documented the condition of the surfaces of the subsatellite and confirmed proper deployment of the booms.

Near the end of revolution 74, the successful firing of the service propulsion system engine injected the CSM into a transearth trajectory. Hasselblad and mapping-camera photography of the lunar surface recorded the changing aspects of the visible disk as the distance between the Moon and the CSM increased (figs. 3-55 and 3-56). Operation of the mapping camera during the transearth-coast phase totaled 3 hr 35 min. After a rest period of approximately 7 hr, the crew completed the solar-corona window-calibration photography and prepared to recover the film in the SIM bay. Video, DAC, and Hasselblad cameras were used to document the EVA (fig. 3-57). A sequence of uv photographs of Earth, originally scheduled to be taken before the EVA was performed, was completed shortly after the CMP returned to the CM.

The photographic workload was comparatively light for the remainder of the mission. During the final 2 days, the crew took two more sets of uv photographs of the Earth, performed a sextant-photography test, and exposed a sequence of photographs documenting the lunar eclipse. Documentation of entry phenomena visible from the CM window was the final photographic task assigned the crew in this most scientifically important mission to date. Carrier-based helicopters photographed the crew's somewhat rapid, but successful, splashdown (fig. 3-58).

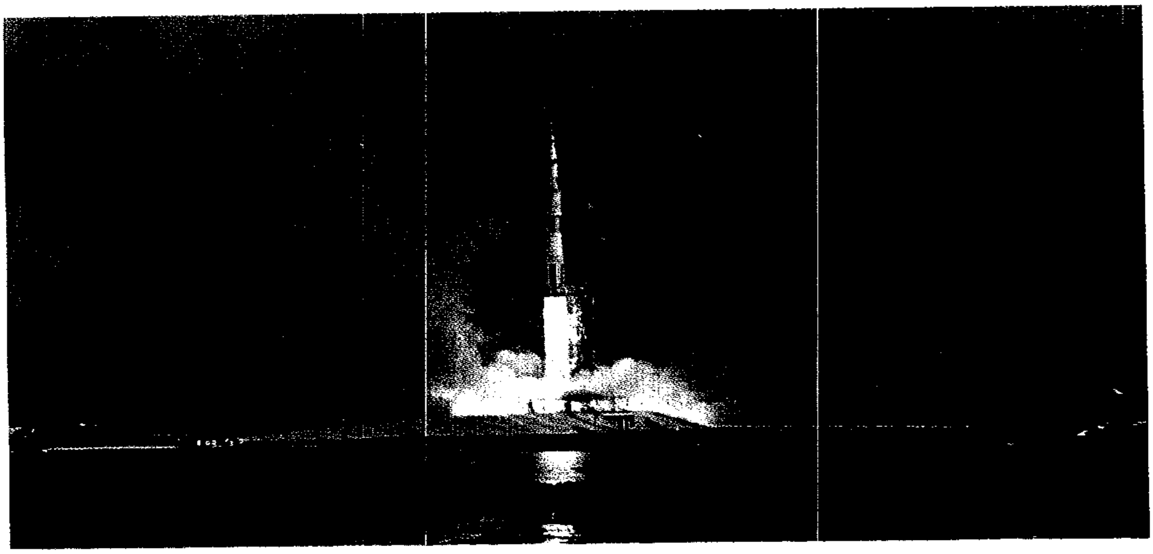


FIGURE 3-1.–Apollo 15 lift-off from pad A, launch complex 39 (S-71-41411).

FIGURE 3-2.–During the translunar-coast phase of the mission, the CSM completed a transposition and docking maneuver to extract the LM from the SIVB stage. The top hatch and docking target on the LM are clearly visible in this predocking photograph (AS15-91-12333).

FIGURE 3-3.–The SIVB stage is visible to the right of the LM thrusters. The compartment formerly occupied by the LM is to the right; the rocket skirt is to the left. After the docking maneuver and the extraction of the LM, the SIVB stage was targeted to impact the Moon. The impact on the lunar surface provided an energy source of known magnitude that was used to calibrate the seismometers emplaced by the Apollo 12 and 14 crews (AS15-91-12341).

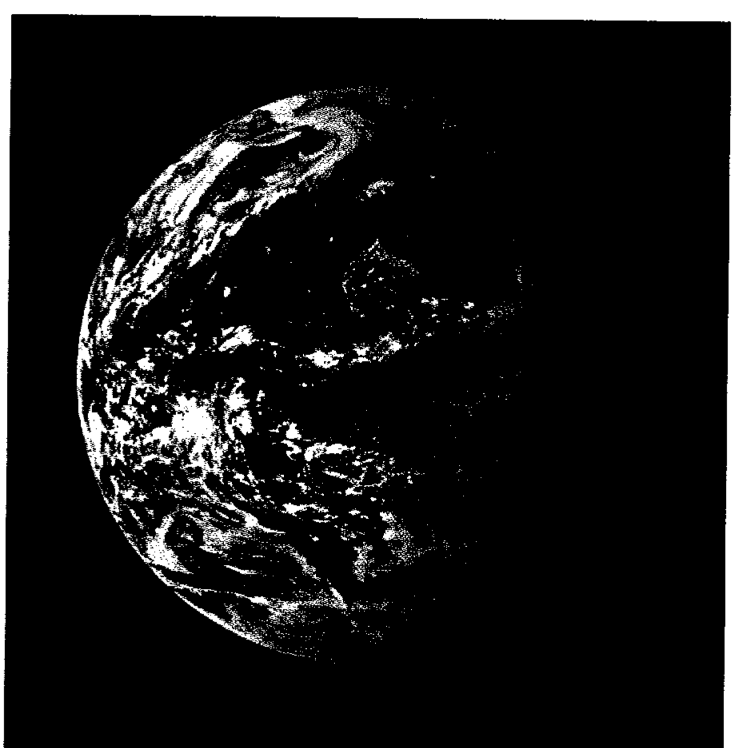


FIGURE 3-4.–The Apollo 15 crew saw a gibbous Earth after the transposition, docking, and LM extraction maneuver. South America, nearly free of clouds, is in the bottom center; Central America and North America are upper left; and the western coasts of Africa and Europe are at the top right (AS15-91-12343).

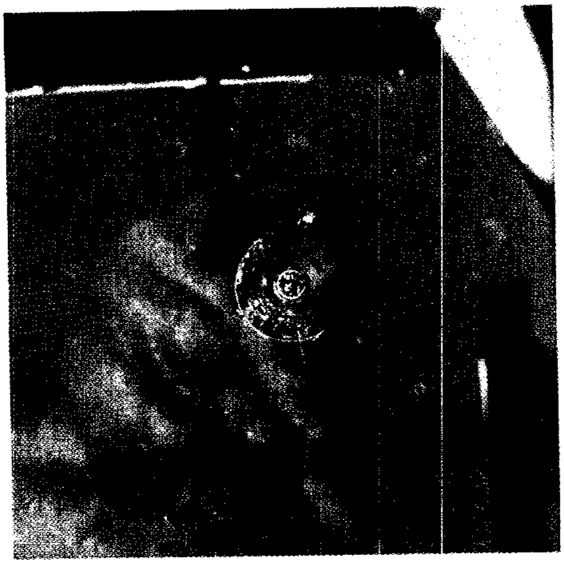


FIGURE 3-5.–The CSM is photographed through the LM window during stationkeeping and just before powered descent initiation. The eastern edge of the Sea of Serenity, south of the crater le Monnier, is below the spacecraft; north is to the right (AS15-87-11696).

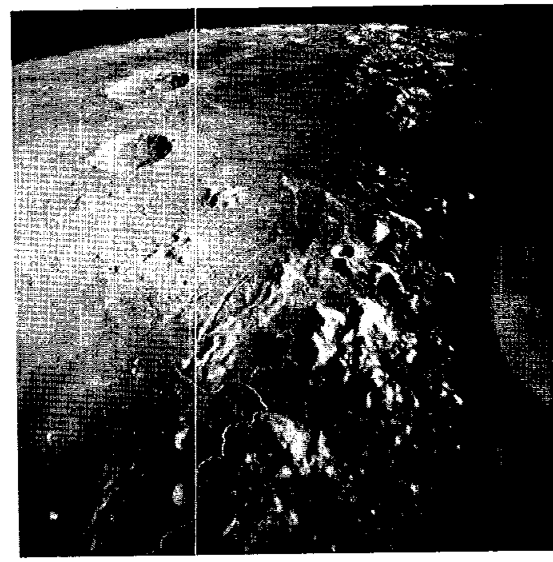


FIGURE 3-6.–Apollo 15 landing site and vicinity. A broad area near the Hadley-Apennine landing site is documented by the mapping camera in this oblique view northward to the horizon. The Apennine Mountains, including the peaks of Mt. Hadley and Hadley Delta; Hadley Rille and the Hadley C Crater; and mare deposits of the Marsh of Decay occupy the lower half of the frame. Near the horizon, the Caucasus Mountains separate the Sea of Serenity at right from the Marsh of Mists (left), which is an arm of the Sea of Rains at far left. Autolycus (near) and Aristillus are the two large craters between the Sea of Rains and the Marsh of Mists (mapping camera frame AS15-1537).

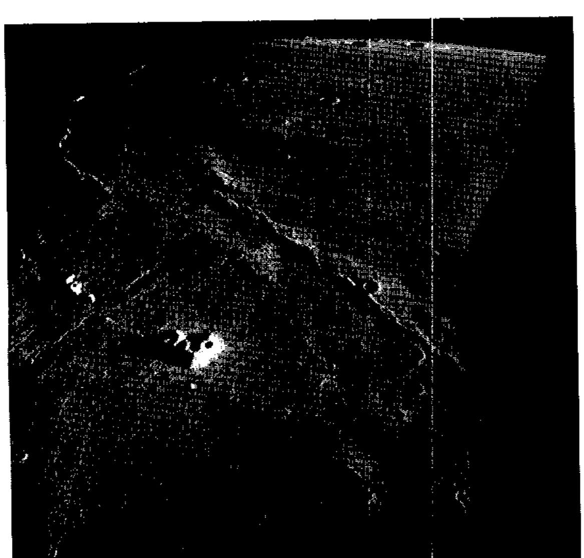


FIGURE 3-7.–The Sea of Rains illuminated by a low Sun angle. The mapping camera was used to photograph continuous strips from terminator to terminator on several revolutions. This oblique view northward across the Sea of Rains demonstrates the effectiveness of low-Sun illumination in accentuating features of low relief. Lambert Crater is just outside the lower right corner of the photograph, but ejecta from the crater extend into the field of view. Mt. Lahire casts a very long shadow across the smooth mare deposits in the left central part of the photograph; Helicon and Le Verrier are the large craters near the horizon. The Imbrian flows extend as a belt to the right and left from the prominent mare ridge. Lobate flow fronts along the north and south margins of the belt are clearly visible in the upper half of this near-terminator view. The protective cover remained within the camera field of view during revolution 35 (mapping camera frame AS15-1555).

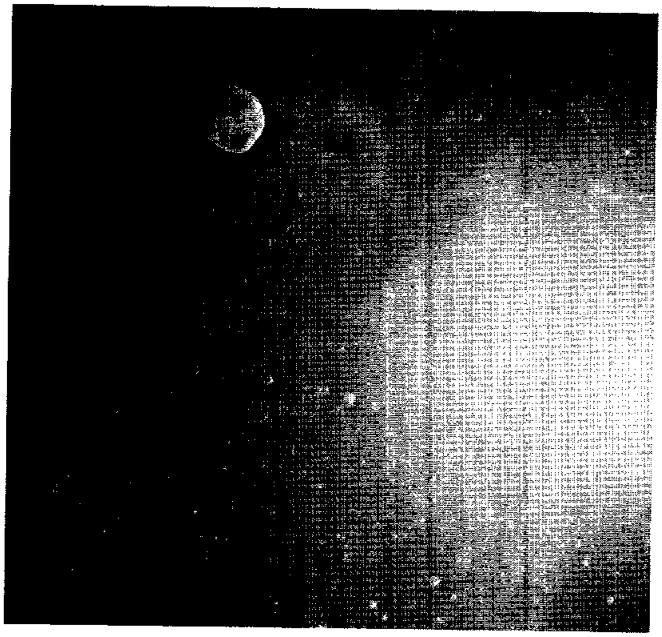


FIGURE 3-8.–Dawes Crater and mare deposits in the Seas of Serenity and Tranquillity are illuminated by a high Sun angle. Lunar-surface retroreflectivity produces the bright spot near the right edge of the photograph, which shows an area of normal mare material in the Sea of Serenity. Darker deposits surrounding Dawes Crater crop out as a ring around the southern margin of the Sea of Serenity. A sharp contact between the two units forms an arc from the upper right corner to the middle of the lower edge of the photograph. The photograph is oriented with south toward the top to facilitate comparison with figure 3-9 (mapping camera frame AS15-1658).

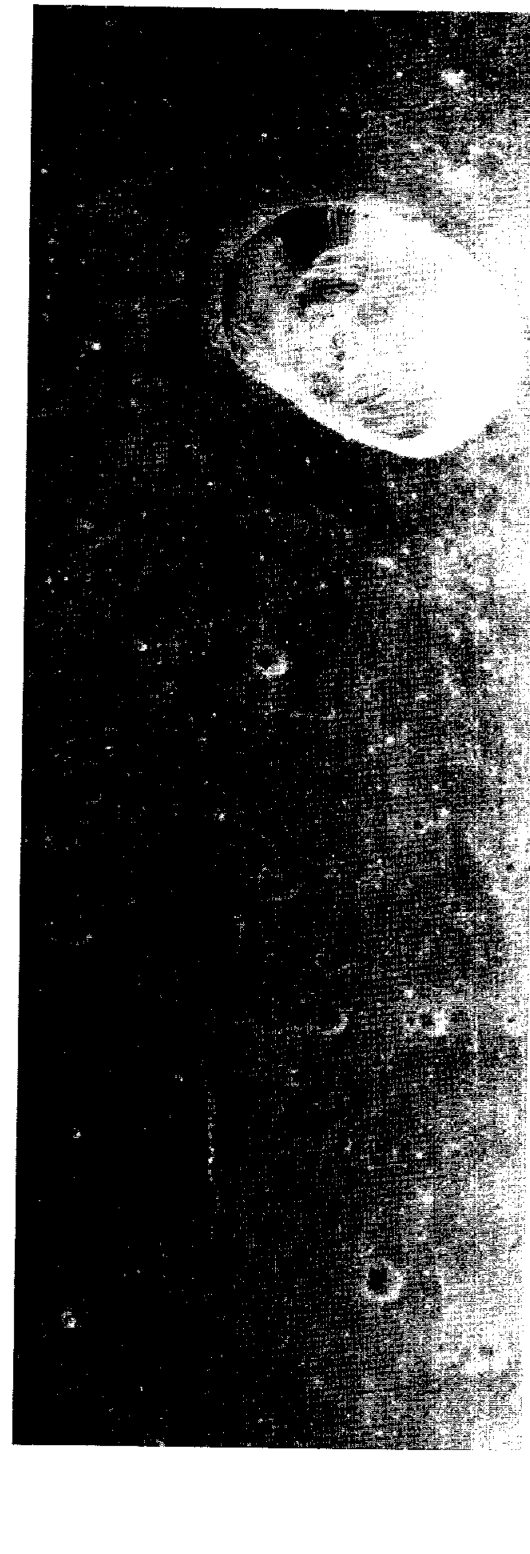


FIGURE 3-9.–Panoramic camera photograph of Dawes Crater. The 60-cm focal-length lens of the camera provides high-resolution photographs of the lunar surface from orbital altitudes. Approximately one-fourth of the 11.4- by 114.8-cm frame is reproduced; the area shown includes terrain south of the CSM at viewing angles between 15° and 45° off the vertical. The surface features in and near Dawes Crater can also be seen in figure 3-8. High-resolution photographs such as this will support continuing studies of lunar-surface features long after the completion of the last Apollo flight (panoramic camera frame AS15-9562).

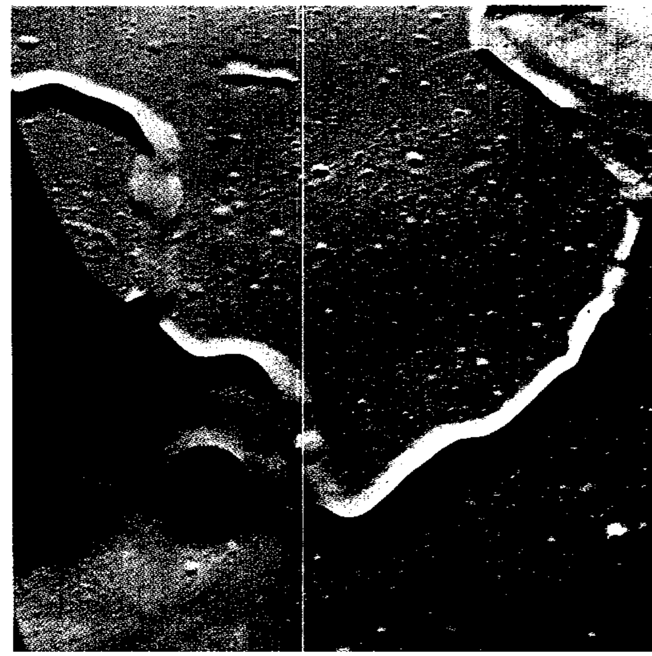


FIGURE 3-10.– The sinuous path of Hadley Rille winds along the Apennine Front. North is to the right, South Complex is at bottom center, North Complex is at the lower right, St. George Crater and Hadley Delta are in the lower left, and Hill 305 is at the upper right. At least two sets of lineations can be identified in Hadley Delta. Both sets exist in St. George Crater and on both sides of the inner slopes of Hadley Rille. Bedding is visible along some parts of the rille wall. At the upper right, the rille narrows and then widens abruptly. A smaller, less well-developed rille branches off from this enlarged area (AS15-87-11720).

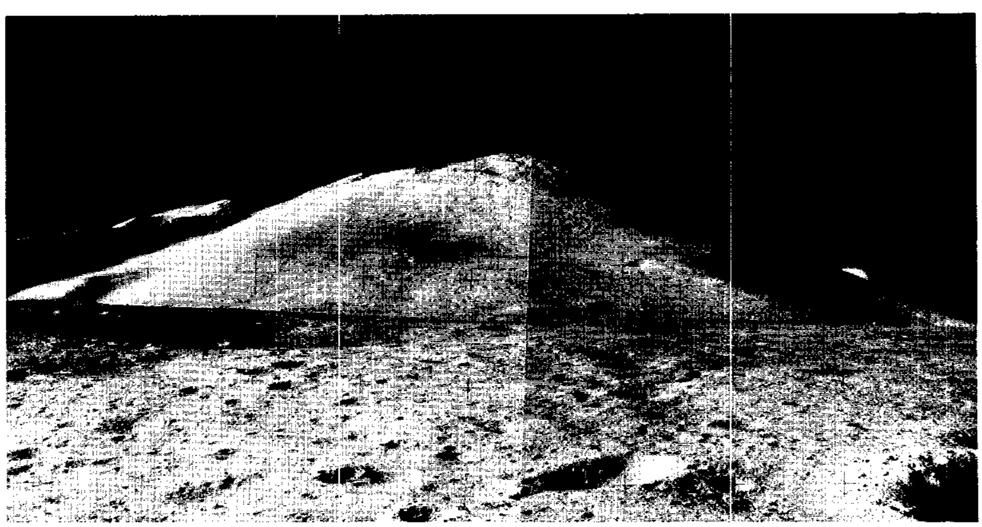


FIGURE 3-11.–Hadley Delta, with Silver Spur to the left and St. George Crater to the right, is shown in this composite photograph taken during the standup EVA. Hadley C is the bright peak above St. George Crater. Photographs taken during the standup EVA show best the east-dipping lineations in Silver Spur and Hadley Delta. Close observation of the rim of St. George Crater shows the presence of a second set of lineations with an east-west strike. These two sets of lineations are somewhat obscured in photographs taken by the crew at higher Sun angles (S-71-51737).

FIGURE 3-12.–Seven of the 14 photographs taken from the left- and right-hand LM windows have been used in this composite photograph. The view covers approximately 180° from Hadley Delta in the south to the base of Mt. Hadley in the north (S-71-47078).

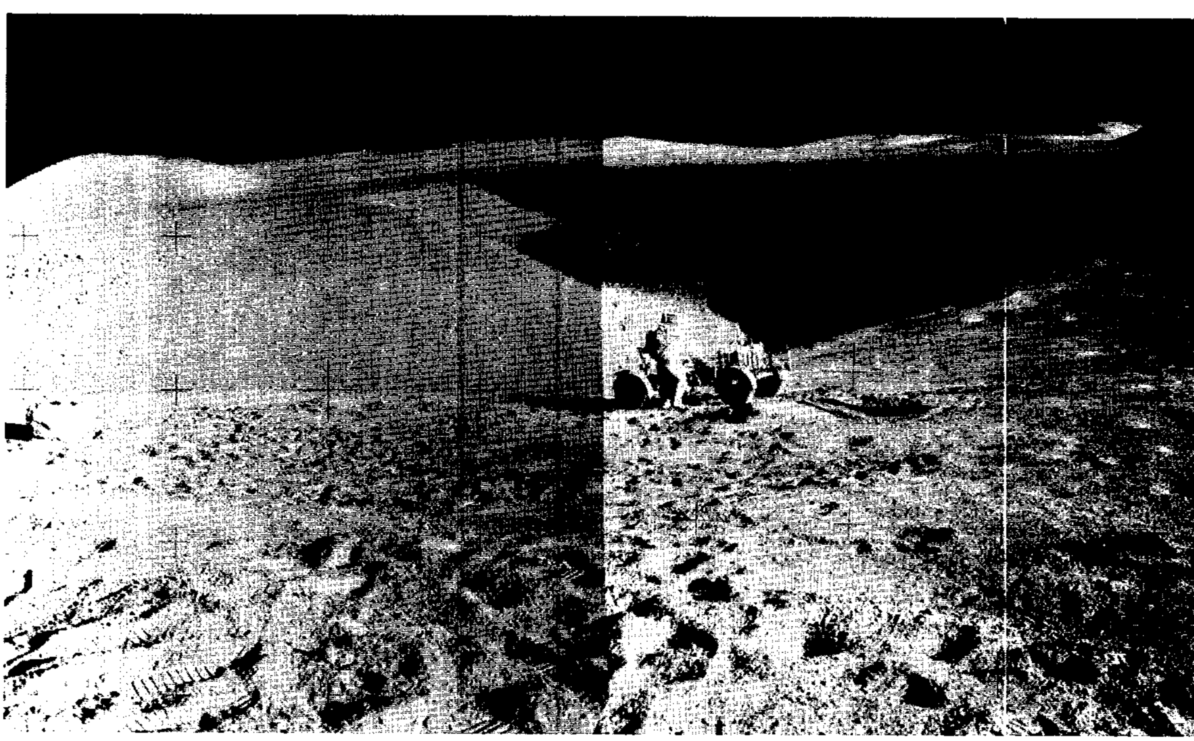


FIGURE 3-13.–Composite photograph forms a view to the north along Hadley Rille. Some horizontal tonal and textural differences, which can be detected in the east wall, may correlate with the horizontal bedding in the west wall of the rille. The boulder to the right center was the location of the major sampling and documentation activity at station 2, where the CDR is unloading equipment from the Rover. Fragments from the boulder and fine material from around and from under the boulder were collected (S-71-51735).

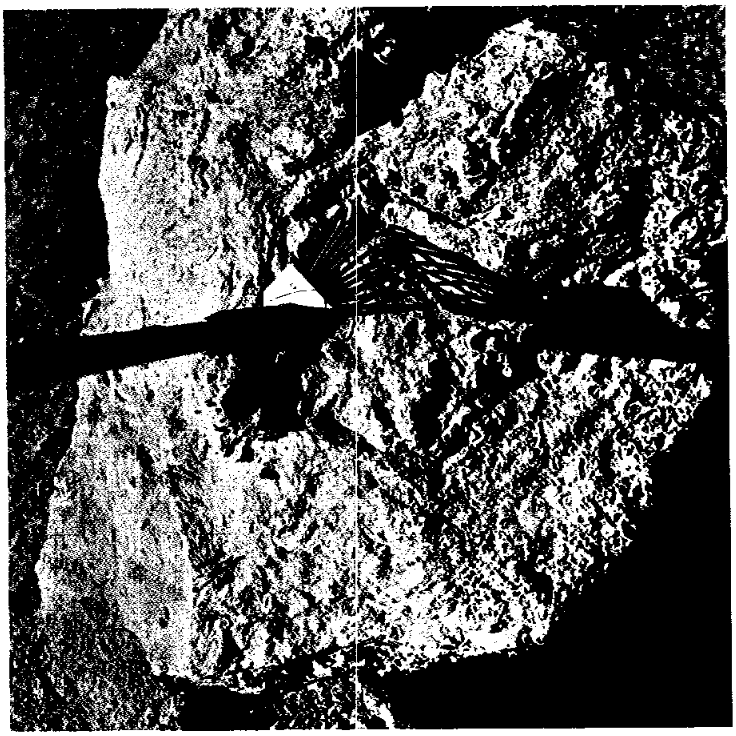


FIGURE 3-14.–The tongs are used to measure the distance between the camera and the object for these closeup photographs. The depth of field is approximately 4 cm at these camera settings. This boulder, the object of much of the activity of station 2, has a well-developed coating of glass that displays a range of vesicle sizes; some vesicles are approximately 2 cm in diameter (AS15-86-11555).

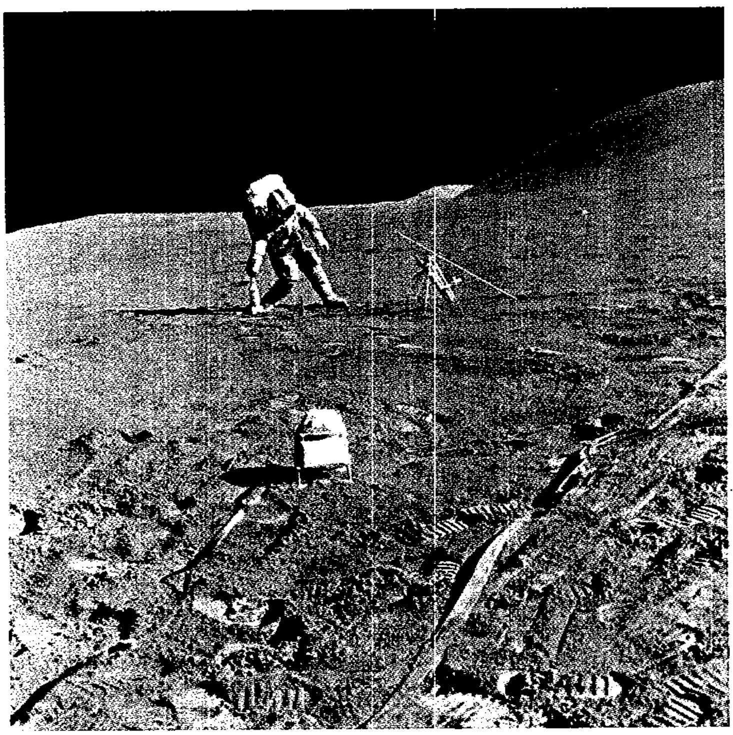


FIGURE 3-15.–The CDR places the Apollo Lunar-surface drill on the surface in preparation for adding additional core stems. The rack with core and bore stems is to his right and the solar wind spectrometer is in the foreground; the tapelike ribbons are cables that connect the central station to the individual ALSEP experiments (AS15-87-11847).

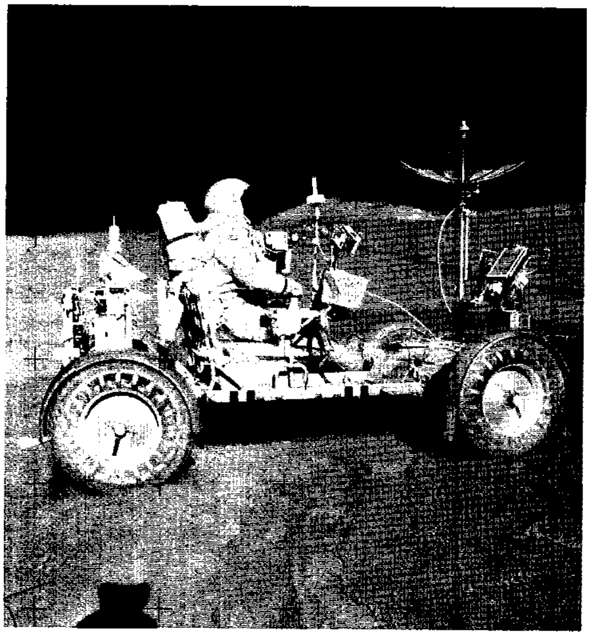


FIGURE 3-16.–The CDR drives the Rover near the LM. Material can be seen dropping from the front and rear wheels. The ALSEP is deployed between the Rover and Hill 305 on the horizon. The solar wind composition experiment appears in the background between the television camera and the antenna mast (AS15-85-11471).

FIGURE 3-17.–The LMP salutes after the flag deployment on the lunar surface. Hadley Delta forms the skyline behind the LM, which is located in a crater on a slope of approximately 10°. The Rover is parked in a north-south orientation because of thermal constraints between EVA periods. The modularized equipment stowage assembly of the LM appears just above the right front fender of the Rover (AS15-92-12446).

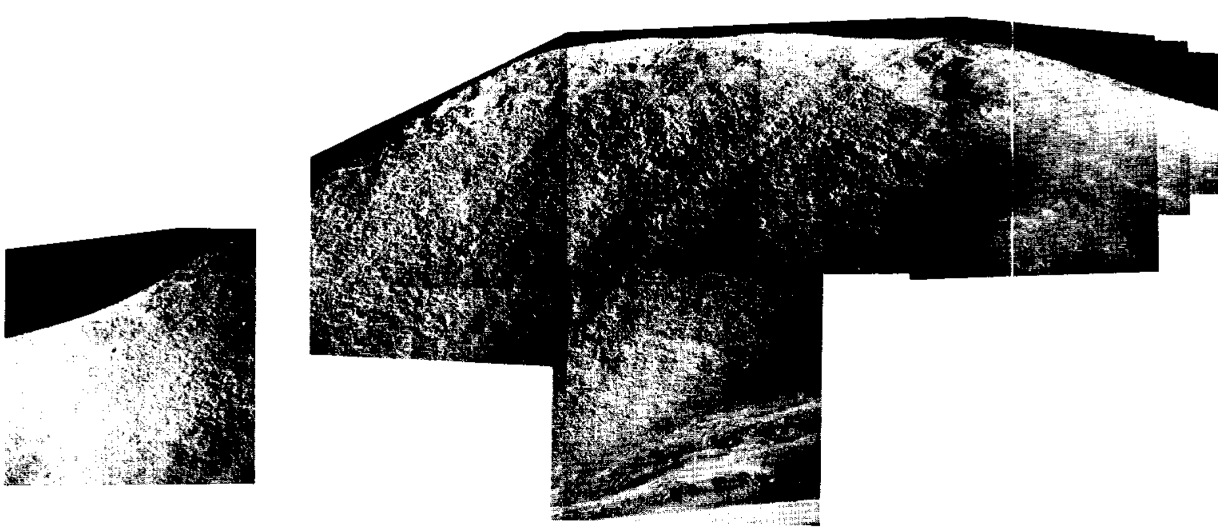


FIGURE 3-18.–During EVA-2, the CDR used the Hasselblad camera with the 500-mm telephoto lens extensively from station 6A on the side of Hadley Delta. This mosaic shows the detail in Mt. Hadley that was recorded from a distance of approximately 18 km. The largest sharp crater in this photograph is approximately 100 m in diameter. The lineations that can be resolved are approximately 10 m thick and can be traced from the summit to the base of the mountain, a distance of approximately 3000 m (S-71-48875).

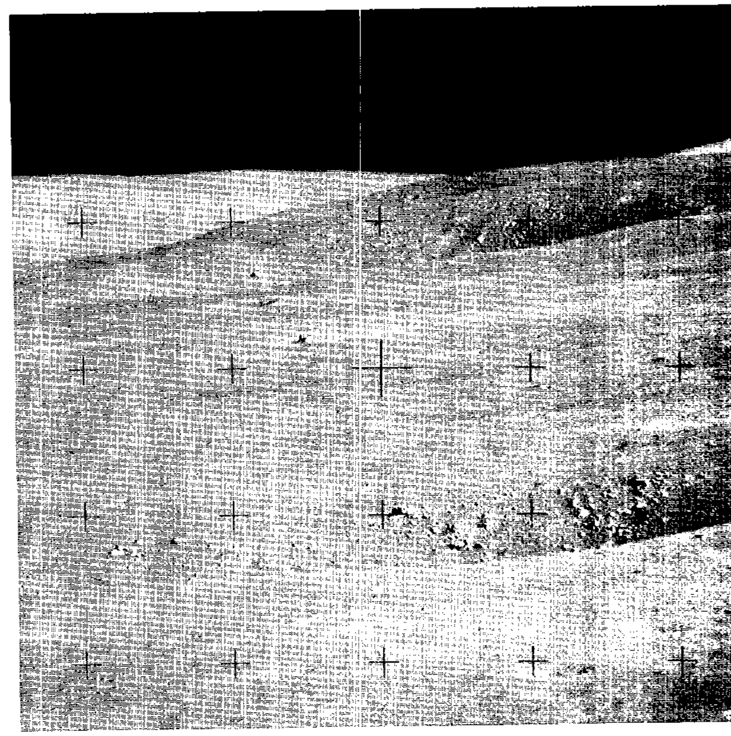


FIGURE 3-19.–On the side of Hadley Delta at station 6A, the CDR took a series of photographs with the 500-mm telephoto lens. The large crater in the foreground, at a distance of approximately 2 km, is Dune; and the series of white dots to the left of the LM (approximately 5 km distant) is the deployed ALSEP. The huge crater that forms the background above the LM is Pluton at a distance of 8 km. Pluton is approximately 800 m in diameter, and the largest boulder in the crater is approximately 20 m in diameter (AS15-84-11324).

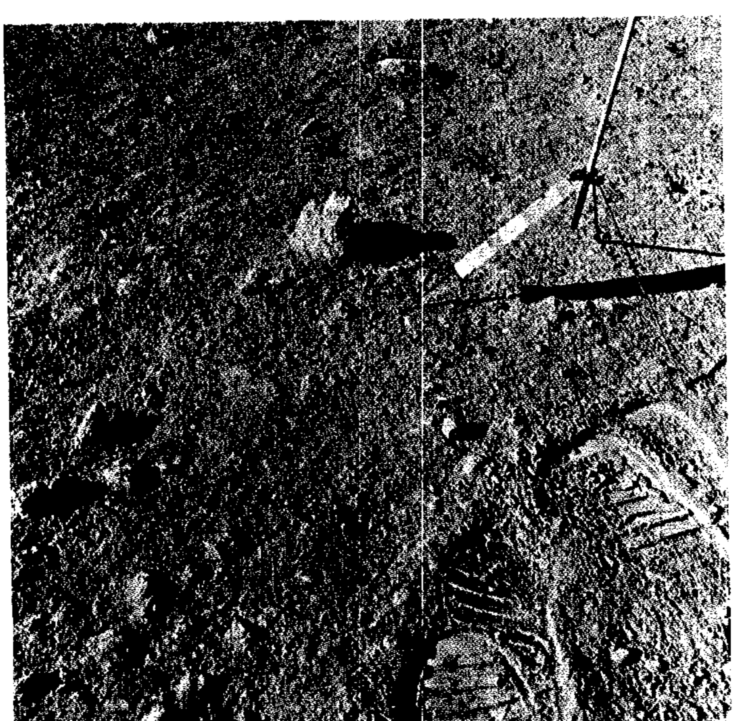


FIGURE 3-20.–The small white clast on top of the larger gray fragment located to the upper left of the gnomon is the "genesis" rock as the Apollo 15 crew found it on the lunar surface. It should be noted that this anorthositic fragment is not in situ but occurs as a clast within a breccia. This sample was collected at station 7, Spur Crater, on EVA-2 (AS15-86-11670).

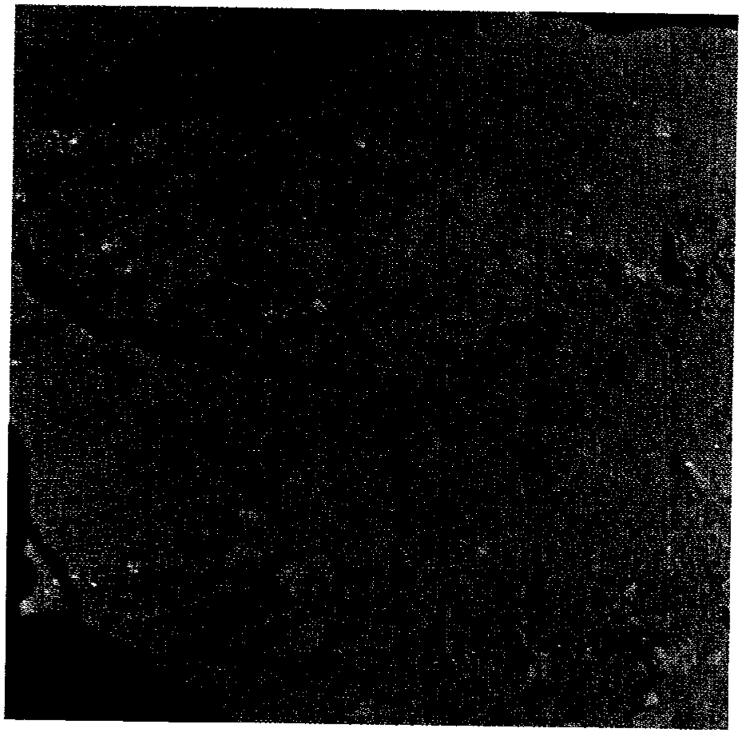


FIGURE 3-21.—During EVA-2, the Apollo 15 crew found this boulder at station 7, Spur Crater. This boulder is a breccia with a dark matrix and white clasts. A representative specimen of this type of breccia was returned to Earth as sample 15445 (AS15-86-11689).

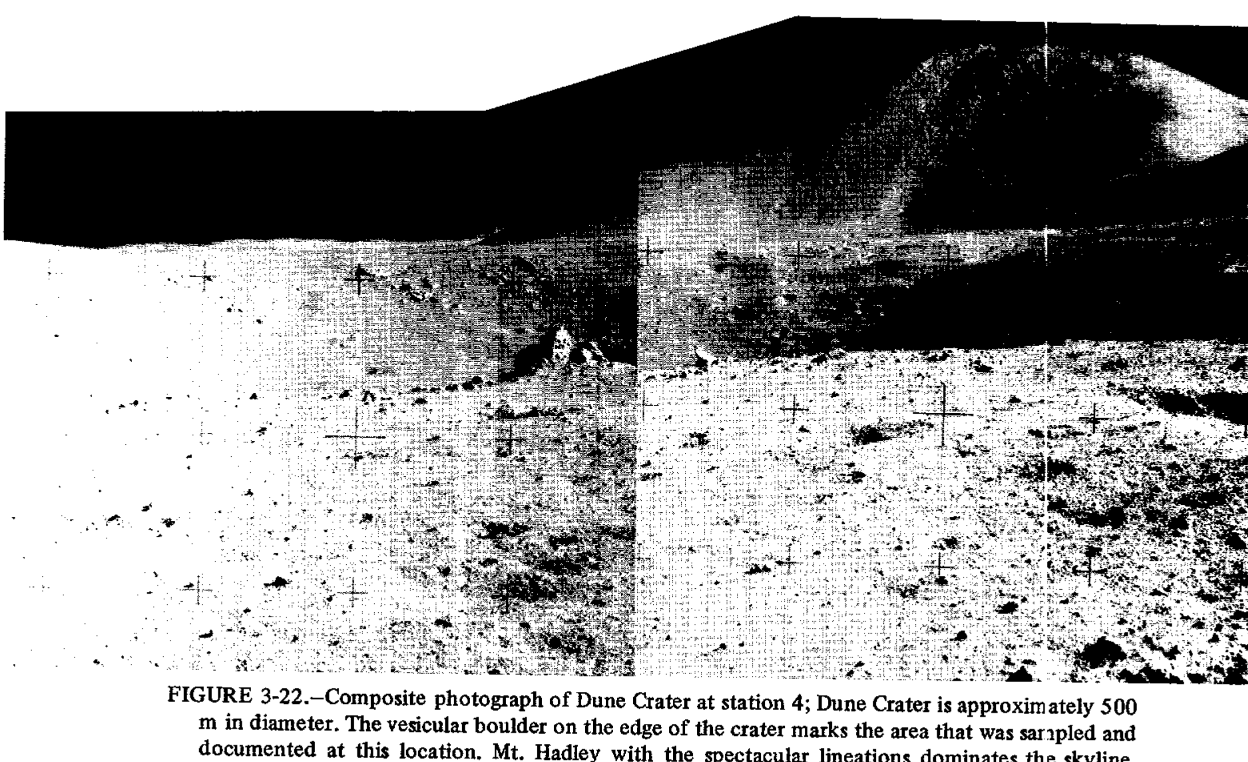


FIGURE 3-22.—Composite photograph of Dune Crater at station 4; Dune Crater is approximately 500 m in diameter. The vesicular boulder on the edge of the crater marks the area that was sampled and documented at this location. Mt. Hadley with the spectacular lineations dominates the skyline. Two of the three terraces observed by the crew can be seen at the base of Mt. Hadley (S-71-51736).

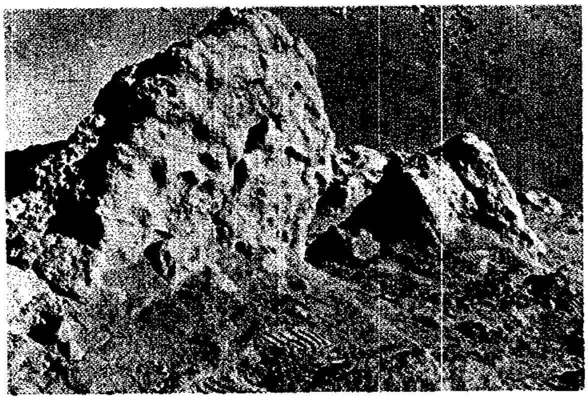


FIGURE 3-23.–Much of the activity at station 4 was devoted to the boulders shown in this photograph. These boulders are basalts and represent material excavated during the formation of Dune Crater. The crew reported that vesicles were abundant in the boulders at this location and that some vesicles were as large as 9 cm in diameter. The abundance and size of the vesicles in these boulders suggest that this basaltic material cooled on or very near the lunar surface (AS15-87-11779).

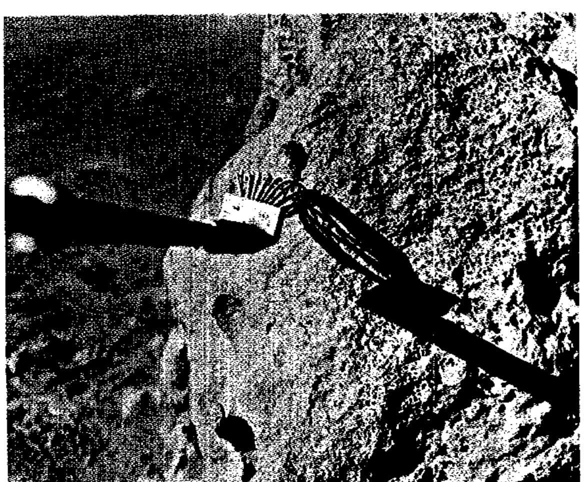


FIGURE 3-24.–The crew made a series of closeup photographs of the large boulder at Dune Crater. The tongs are used to measure the distance from the camera to the object because of the limited depth of field. This photograph shows the size range of vesicles on this surface of the boulder; plagioclase laths are also visible (AS15-87-11773).

FIGURE 3-25.–The LMP digs a trench near the ALSEP site at the end of EVA-2. This trench, used for some of the soil-mechanics measurements, was the source of samples 15030, 15040, 15013, and the special environment sample container. At a depth of 30 to 35 cm, the LMP reported the presence of a hard layer that he could not penetrate with the scoop (AS15-92-12424).

FIGURE 3-26.–Composite photograph of the LM taken from the ALSEP location. The Apennine Front forms the background behind the LM. Wheel and foot tracks crisscross in the foreground (S-71-51738).

FIGURE 3-27.–Hadley Delta, Silver Spur, and St. George Crater form the skyline in this view toward the south of Hadley Rille from station 9A. The CDR works at the Rover to remove the Hasselblad camera for the telephotographs. It is noteworthy that the front panel on the left front fender of the Rover has been lost (AS15-82-11121).

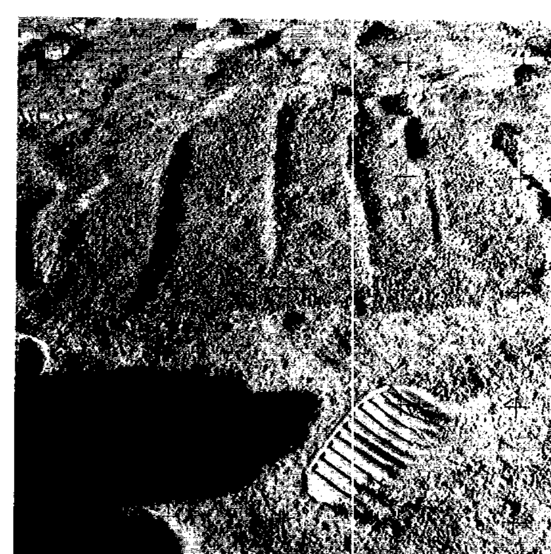


FIGURE 3-28.–The textured pattern in the upper center of this photograph was made by the LMP with the lunar rake. The rake is used to collect a comprehensive sample–a selective collection of rocks in the 1- to 3-cm size range. Samples 15600 and 15610 were collected at station 9A (AS15-82-11155).

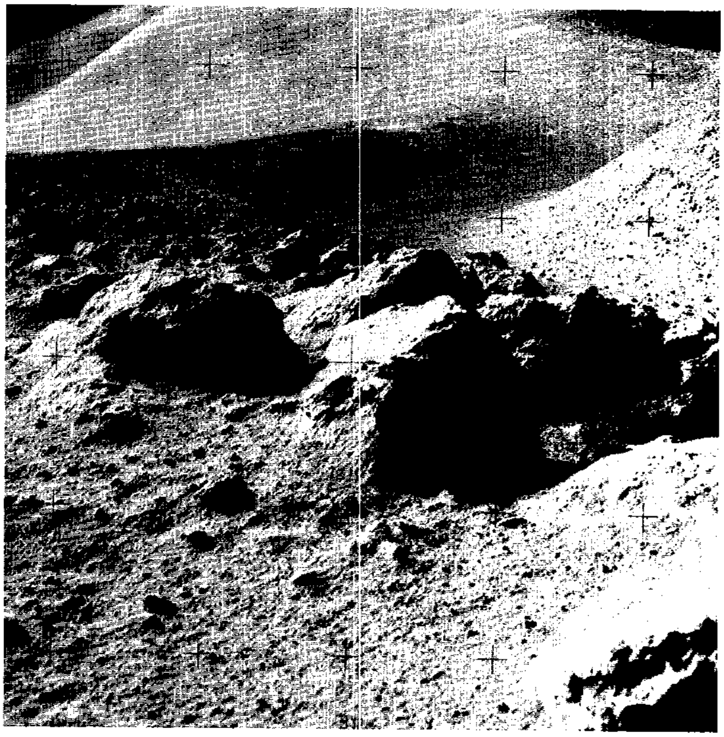


FIGURE 3-29.–View to the south down Hadley Rille from station 9A. Both the eastern and western sides of the rille are shown. Hadley Delta is the mountain in the background, and St. George Crater is partially visible in the upper right. The boulders in the foreground are basalts from the units that crop out along the rille (AS15-82-11147).

FIGURE 3-30.–Just below the CDR's right hand and approximately 5 cm to the right of the hammer handle is the area where samples 15595 to 15598 were chipped from this boulder. The fragments are in the bag that the CDR has in his left hand. He wears one of the EVA cuff checklists on his right wrist. The gnomon, which is used to determine the local vertical, is positioned on the sampled boulder (AS15-82-11145).

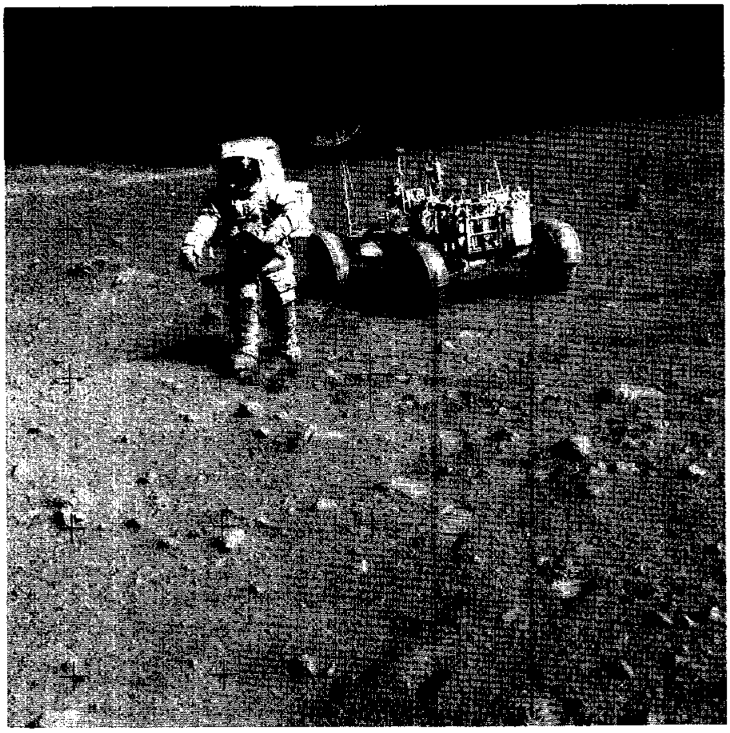


FIGURE 3-31.–The CDR walks toward Hadley Rille at station 10 to take telephotographs of the far side. He carries the Hasselblad camera with a 500-mm lens in his left hand as he walks away from the Rover (AS15-82-11168).

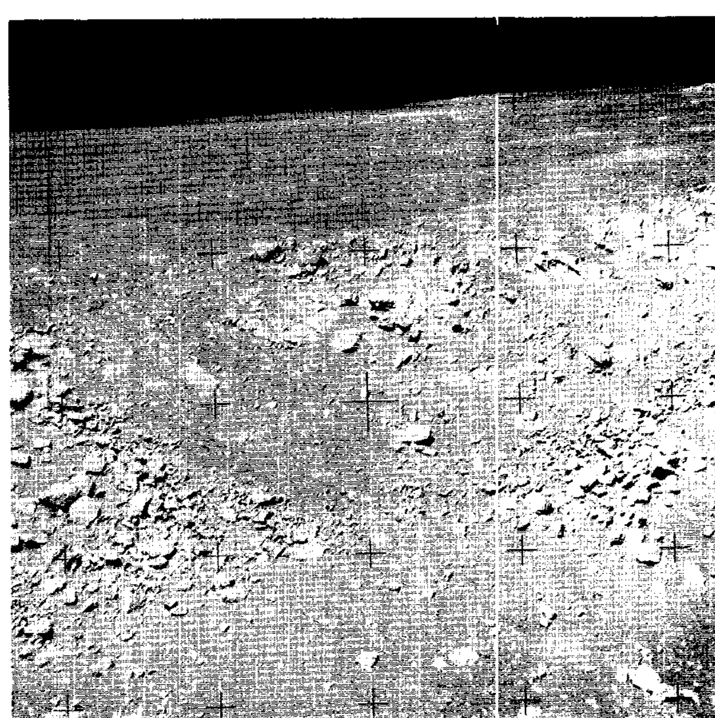
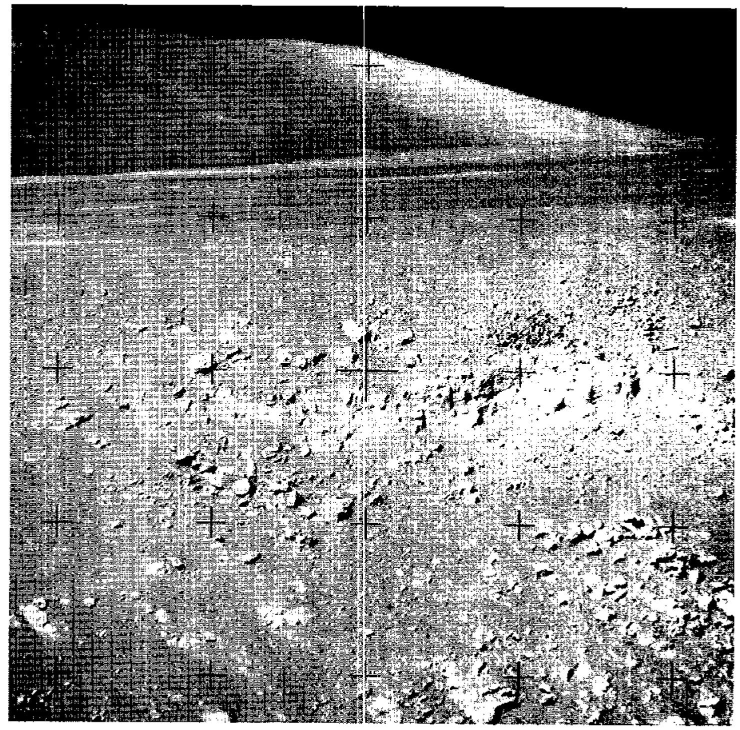


FIGURE 3-32.–Telephotograph of the western wall of Hadley Rille from station 10. The more obvious bedded units are overlain by a massive unit with a pronounced fracture pattern that dips to the right (north). The large white boulder at the upper right margin is approximately 8 m long. The distance along the western edge of the rille as shown in this view is approximately 150 m (AS15-89-12105).

FIGURE 3-33.–Telephotograph of Hadley Rille from station 10 showing the bedded units in situ on the western wall. This outcrop shows both massive and thin bedded units; the massive units have well-developed columnar jointing. The thin-bedded units have individual beds that are less than 1 m thick. The largest boulders on the western slope are 8 to 10 m in diameter (AS15-89-12116).



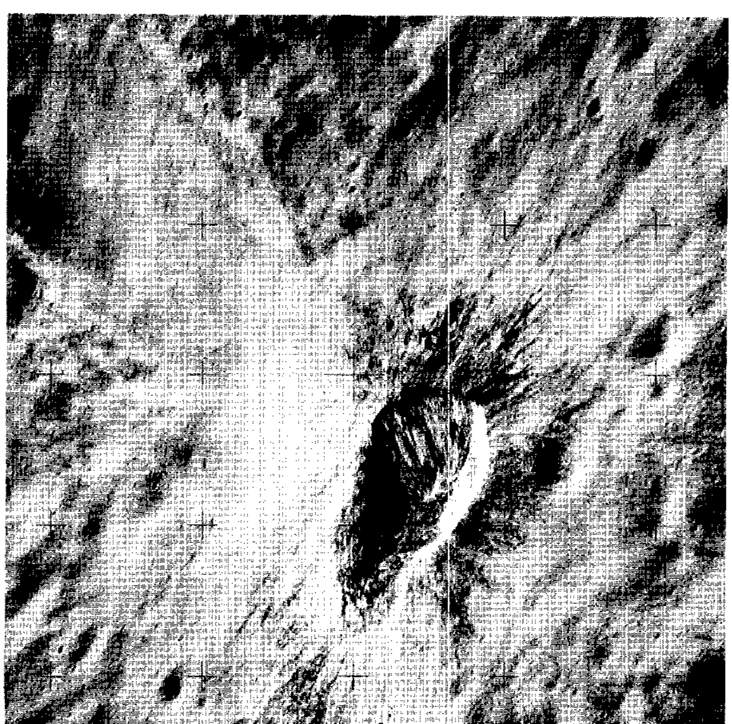


FIGURE 3-34.–Sharp raised-rim crater with rays. Rays of dark ejecta streak the bright halo surrounding this sharp crater on the crest of the northeast rim of Gibbs Crater. The rim of Gibbs, which trends from upper right to lower left through the center reseau cross and through the sharp crater, is not prominent in this telephotograph taken with the 500-mm lens. This feature was selected during premission planning for photography if the opportunity and film were available. The Apollo 15 astronauts photographed many such contingency targets during the final revolutions in lunar orbit (AS15-81-10920).

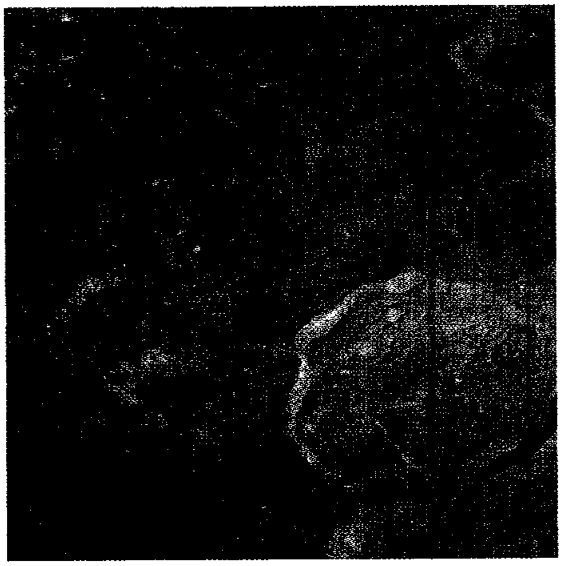


FIGURE 3-35.–Oblique view northwestward across Newcomb Crater in highland terrain northeast of the Sea of Crises near latitude 30° N, longitude 44° E. The slight embayment toward the lower left was considered (on the basis of Earth-based observations) to be another crater, which was named Newcomb A (AS15-91-12353).

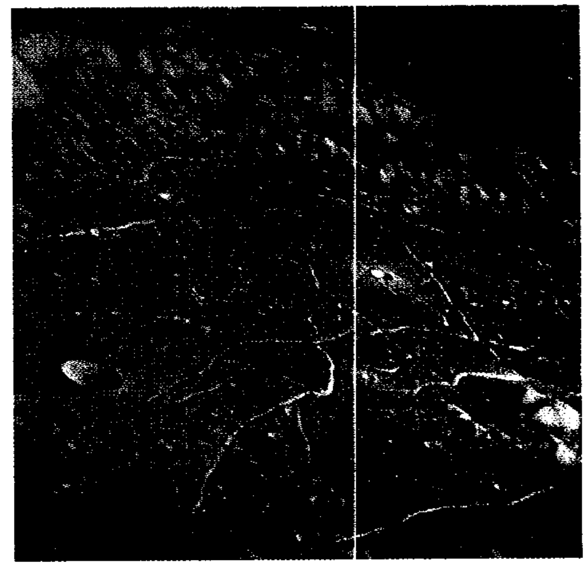


FIGURE 3-36.–Eastern floor of Humboldt Crater. The mare-type material on the floor contains radial cracks and concentric rilles. A dark-halo area is visible at the lower left corner. Low hills of material that resemble the central peak protrude through the smooth crater floor. Bright-halo craters are also evident. The "doughnut" filling of the crater at the left margin is a rare feature (AS15-93-12641).

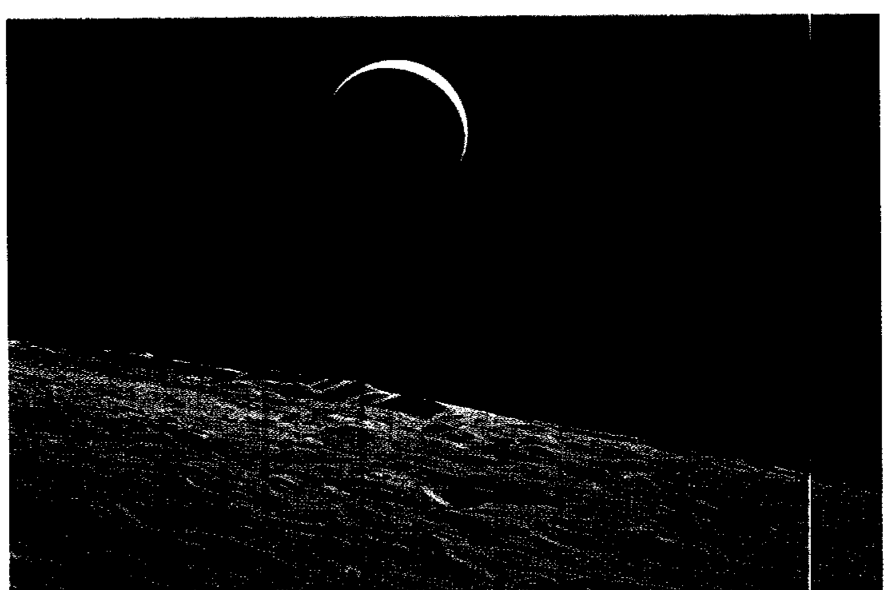


FIGURE 3-37.–Crescent Earth low over the lunar horizon. This photograph, one of a series, was exposed through the 250-mm lens. The CSM was above a point near latitude 24° S, longitude 99° E, when this picture was taken. Steep slopes on the left horizon are the southwestern inner rim of Humboldt Crater near latitude 25° S, longitude 78° E (AS15-97-13268).

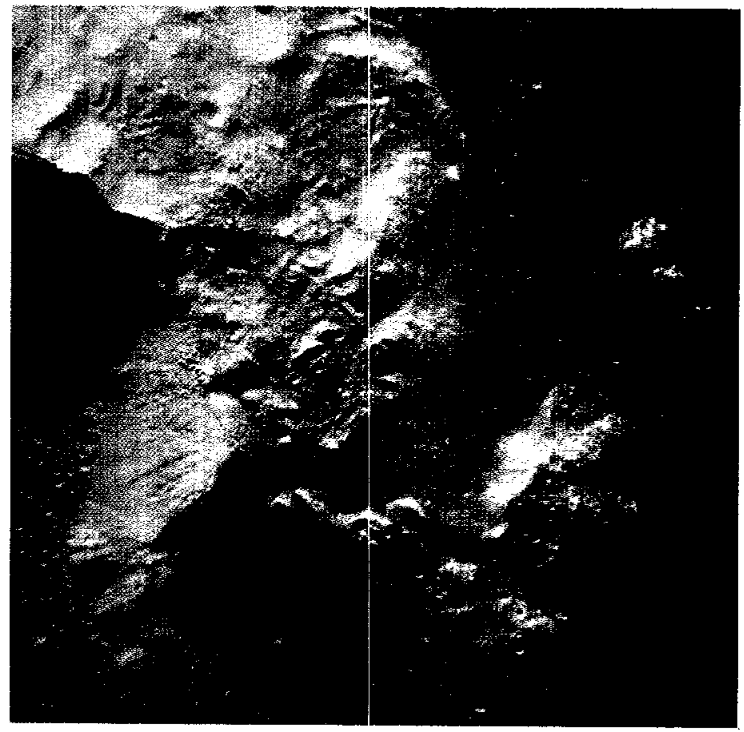


FIGURE 3-38.–East end of the central peak in Tsiolkovsky Crater. In this near-vertical view, dark crater-floor deposits contrast sharply with the high-albedo rocks of the central peak. West is toward the top of the photograph. The clearly visible outcrop along the left-facing sheer wall, near the point of the peak, is the bedding the CMP described while in orbit (AS15-96-13017).

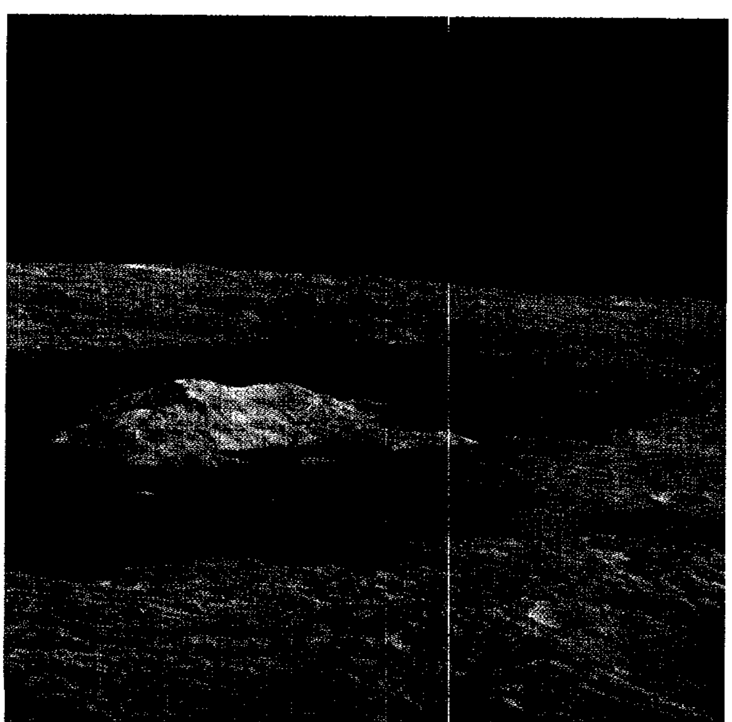


FIGURE 3-39.–Oblique view southwestward across the far-side Crater Tsiolkovsky. The central peak of high-albedo material contrasts sharply with the dark deposit on the crater floor. The central peak is 265 km southwest of the ground track in this telephotographic view through the 250-mm lens. The far-side wall, 336 km from the camera, is much steeper and a little higher than the near rim of the crater (AS15-91-12383).

FIGURE 3-40.—Oblique view northwestward across the Littrow Rille area of the eastern Sea of Serenity. A high Sun enhances the albedo contrast. Steep slopes in the highlands, crater walls, and rays are much brighter than the normal mare materials in the central Sea of Serenity at the top of the photograph. The ring of darker mare material and the still darker mantling material of the Littrow region are near the highlands margin (AS15-94-12846).

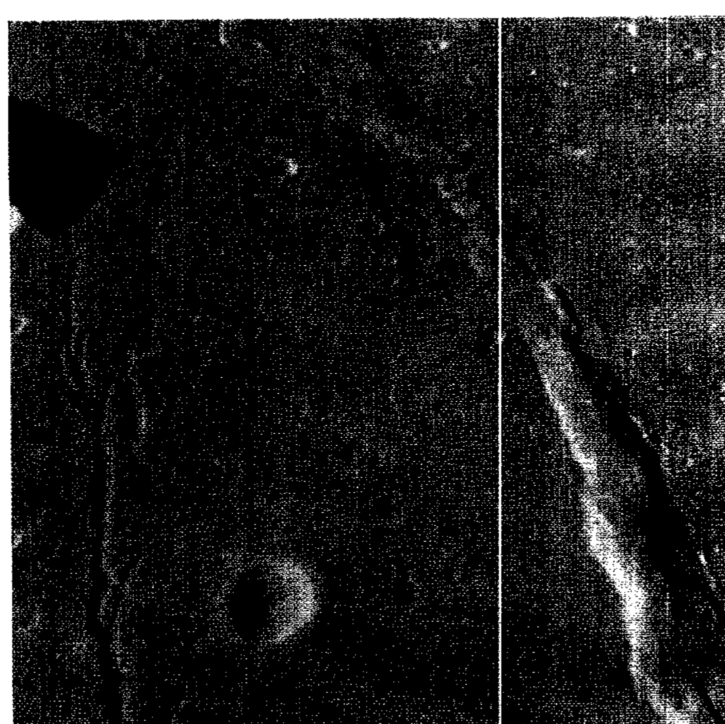


FIGURE 3-41.—South-southwestward oblique view from the LM across eastern Sea of Serenity. A branching rille (depressed center) near the left edge of the photograph contrasts sharply with the broad mare ridge (raised center) at right. The partly concealed crater to the left of the thruster is le Monnier LA. The photograph was taken with a Hasselblad camera equipped with a 60-mm lens one revolution before landing (AS15-87-11712).

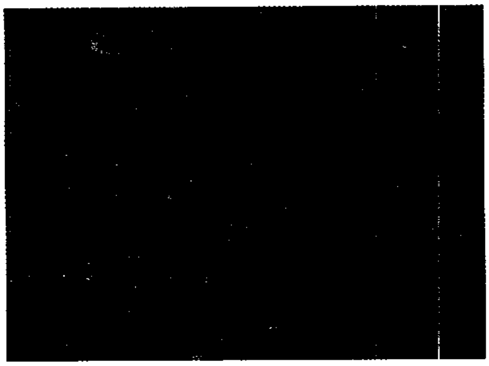


FIGURE 3-42.–Oblique view northward across the Ocean of Storms. The feature that extends directly away from the camera consists of a mare ridge near the lower edge of the photograph, of a chain of elongate craters with raised rims in the central section, and of a sinuous rille near the margin of the highlands. The prominent crater near the upper right is Gruithuisen K (AS15-93-12725).

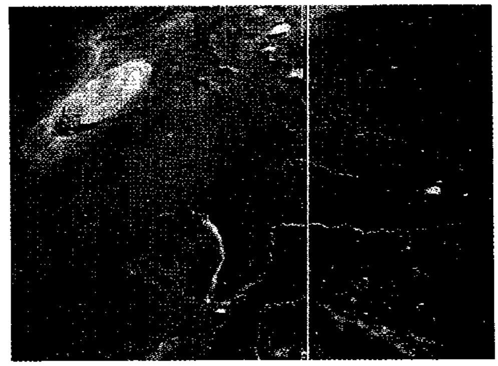


FIGURE 3-43.–View southwestward across Prinz, Aristarchus, and Herodotus Craters. The Prinz rilles are in the foreground; the Aristarchus rilles flow generally toward the camera from the Aristarchus Plateau in the background. Cobra Head and the upper end of Schröter's Valley are near the center of the upper margin. The extremely high albedo of the Aristarchus rays and halo is noteworthy (AS15-93-12602).

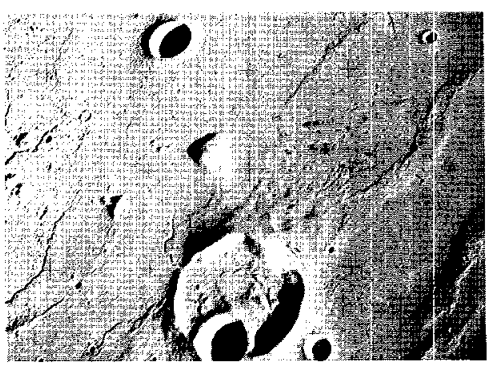


FIGURE 3-44.–View northwestward across the Ocean of Storms at the north margin of the Aristarchus Plateau. Krieger Crater, near the lower edge of the photograph, has a rim broken in two places. Krieger B, approximately one-fifth the diameter of the larger crater, is centered just inside the rim at one point. A prominent rille appears to emerge from the other break. Wollaston is the large, raised-rim crater in the upper left quadrant of the photograph. The similar orientation of mare ridges in the upper right quadrant and the ridges and rilles in the lower left quadrant are noteworthy (AS15-90-12272).

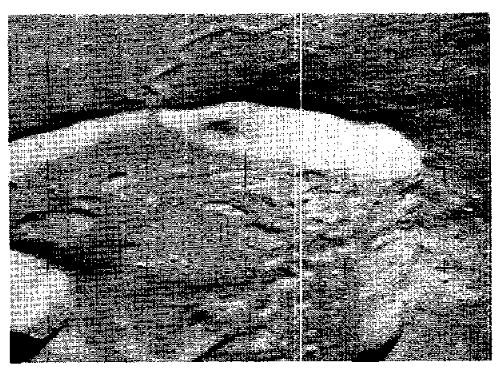


FIGURE 3-45.–Telephotographic oblique view westward across Krieger Crater. Two small dark-halo craters occupy an anomalous bench on the inner slope of the crater wall to the right of the break in the crater wall. Within the crater, no evidence exists of the sinuous channel that is prominent beyond the wall (AS15-92-12480).

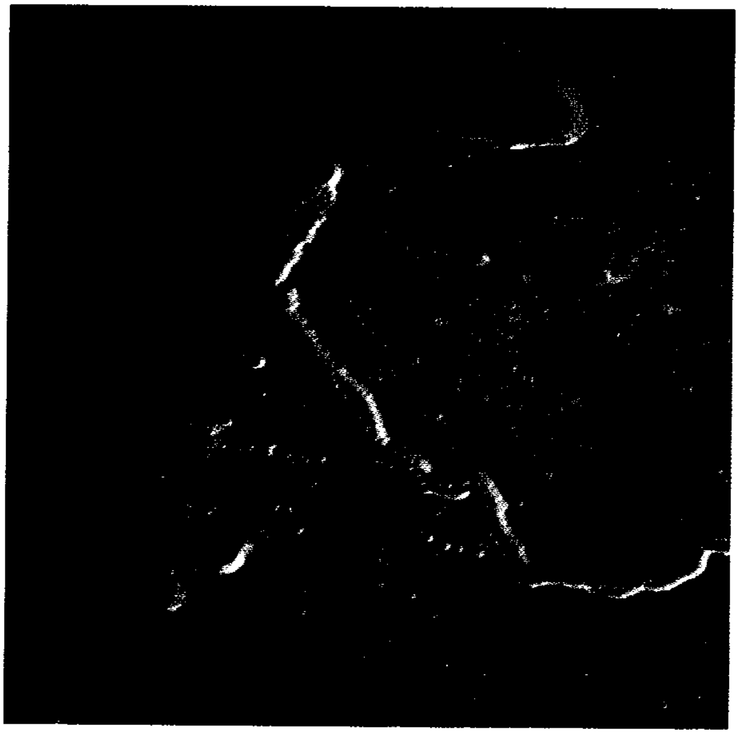


FIGURE 3-46.–Cobra Head and upper Schröter's Valley. The broad outer channel of Schröter's Valley consists of numerous more or less straight segments that join at angles, but the inner channel is truly sinuous. Cobra Head is near the high point of the Aristarchus Plateau and due north of Herodotus Crater. In this view toward the southwest, the remnants of an older, wider, and higher channel can be seen along the segment of the rille that trends toward the camera (AS15-93-12624).

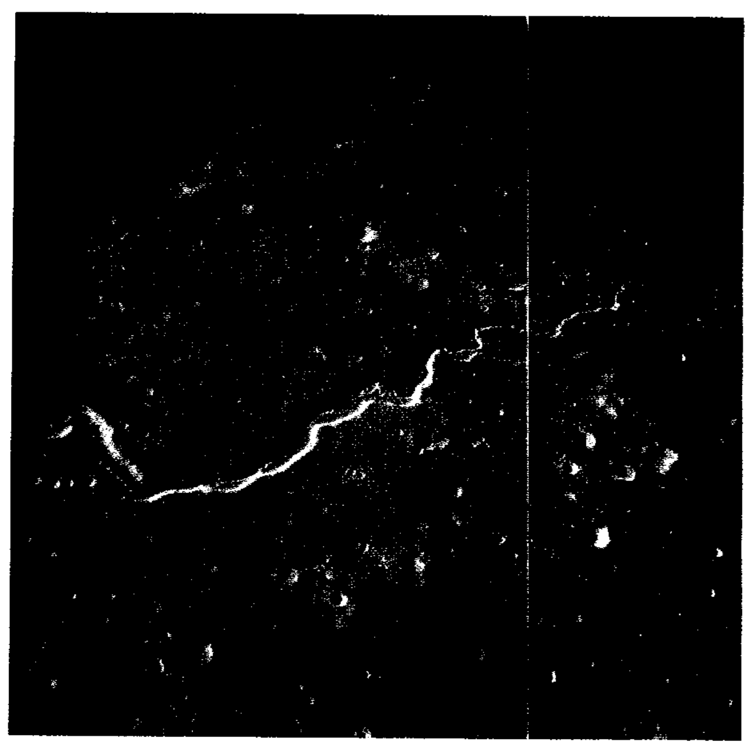


FIGURE 3-47.–This lower segment of Schröter's Valley trends southwestward down the gently sloping surface of Aristarchus Plateau. The outer channel is more segmented than sinuous, but the narrow inner channel is truly sinuous. At a point to the right of center, the narrow sinuous channel breaks through the far wall of the outer channel and winds southward toward the flatter surface of the Ocean of Storms (AS15-93-12628).

FIGURE 3-48.–A very low Sun illuminates this view of southwestern Aristarchus Plateau. The effects of changing Sun angle are best demonstrated by examining the same area illuminated by the Sun at a range of elevation angles. This eastward view includes three distinctive rilles that can be easily identified in figure 3-49 (AS15-98-13345).

FIGURE 3-49.–Telephotograph of an area of southwestern Aristarchus Plateau. The plateau was illuminated by a Sun only 15° to 20° above the horizon at the time this photograph was taken. Although this elevation is still low, a dramatic change in the surface appearance has resulted from the 10° to 15° increase in Sun angle since figure 3-48 was exposed (AS15-95-12978).

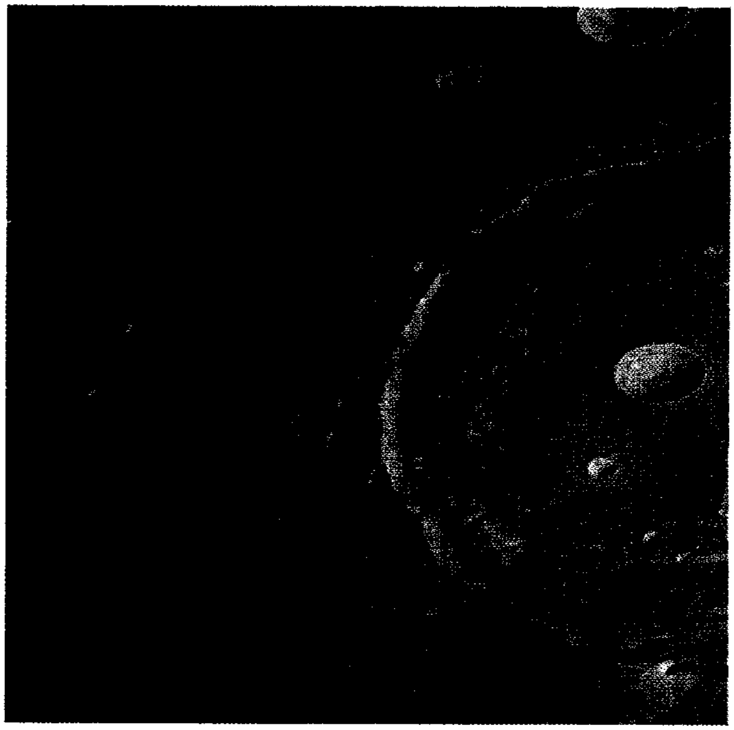


FIGURE 3-50.–Western half of Posidonius Crater on the eastern margin of the Sea of Serenity. A tightly convoluted sinuous rille crosses the raised floor of the crater, turns back, and follows the rim to a low point in the western rim (AS15-91-12366).

FIGURE 3-51.–View westward to the terminator in eastern Sea of Rains. The low Sun angle exaggerates small differences in elevation. Beer and Feuillée Craters, near the center, are at the edge of material that looks like rough mare deposits in a higher Sun angle. In this view, the affinity of this material to nearby highlands seems more likely. The chain of craters extending toward the camera from Beer Crater is Archimedes Rille I (AS15-94-12776).

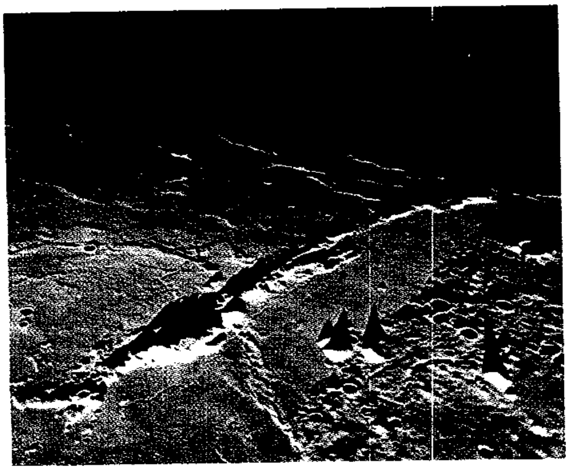


FIGURE 3-52.–View westward across southern Aristarchus Plateau. The low Sun angle accentuates mounds on the plateau and dramatically enhances the low mare ridges along the terminator in the Ocean of Storms (AS15-88-11982).

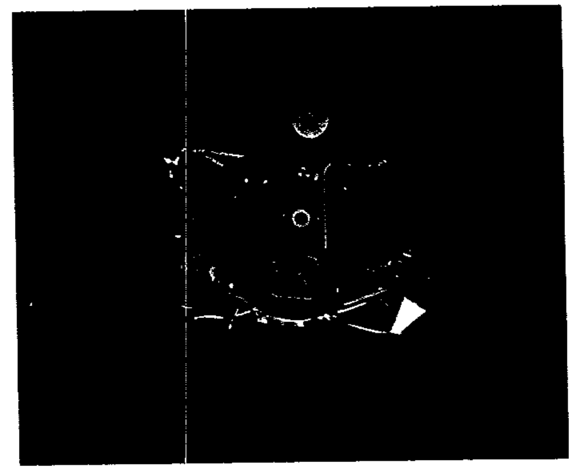


FIGURE 3-53.–The ascent stage of the LM. Between the successful rendezvous and the docking maneuver, 15 min of stationkeeping at ranges of approximately 30 m permitted close inspection of both spacecraft. Photographs like this are used to document the condition of the LM exterior. During this period, the LM crew inspected the SIM bay of the CSM from close range in an attempt to ascertain the cause of the panoramic camera V/h anomalies (AS15-96-13035).

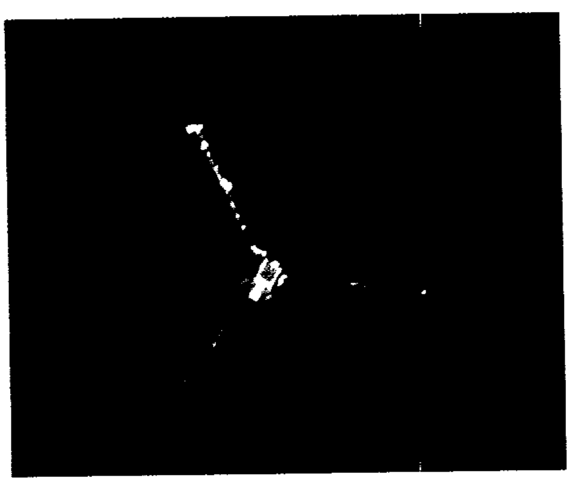


FIGURE 3-54.–The Apollo 15 subsatellite. Before transearth injection, the CSM launched a subsatellite containing three experiments: the S-band transponder, the particle shadow/boundary layer experiment, and a magnetometer. Still photographs such as this were used to document the condition of the subsatellite surfaces and deployment of the booms. The DAC photographs recorded the spin rate and wobble of the spinning subsatellite (AS15-96-13068).

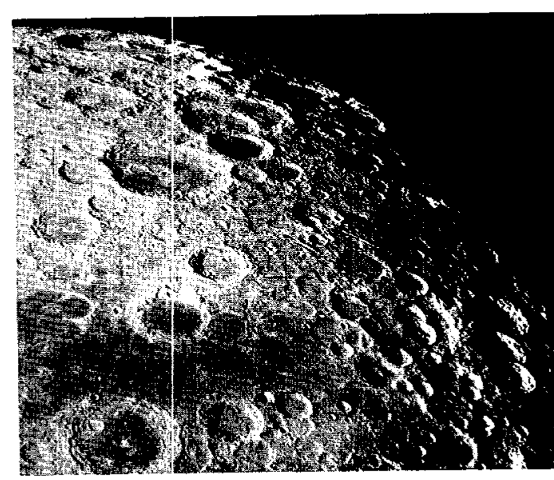


FIGURE 3-55.–View of the Moon taken after transearth injection. This photograph shows the northeast quarter of the lunar scene visible in the early portion of the transearth coast. Smyth's Sea, at the bottom, and Border Sea, just below the middle, have been observed by most of the Apollo crews; but only the Apollo 15 astronauts photographed this area with a low Sun angle. The large reseau cross at the center overlies a point near latitude 16° N, longitude 94.5° E. Fabray, the large crater near the horizon at the upper left corner, is centered near latitude 43° N, longitude 101° E (AS15-95-12998).

FIGURE 3-56.–This photograph, taken after transearth injection, shows the southwest quarter of the lunar scene. The bright halo and rays of Tycho Crater dominate the southwest quarter of the lunar surface. Langrenus is at the east edge of the Sea of Fertility. A narrow strip of cratered highlands separates the Sea of Fertility from the Seas of Tranquillity and Nectar. Tranquility Base, site of the Apollo 11 landing, is near the top of the photograph (AS15-94-12849).

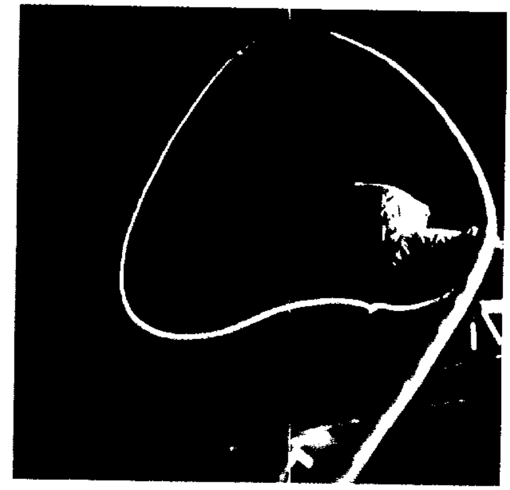


FIGURE 3-57.–Approximately 18 hr after transearth injection, the CMP egressed the CM to retrieve film cassettes from the SIM. In this Hasselblad photograph, an open spiral of the umbilical frames the oxygen purge system mounted low on the CMP's back. He is inspecting equipment mounted in the SIM bay after handing the panoramic-camera film cassette to the crewmen in the CM. After retrieving the mapping and stellar camera film containers, the CMP ended the first transearthcoast EVA (AS15-96-13100).

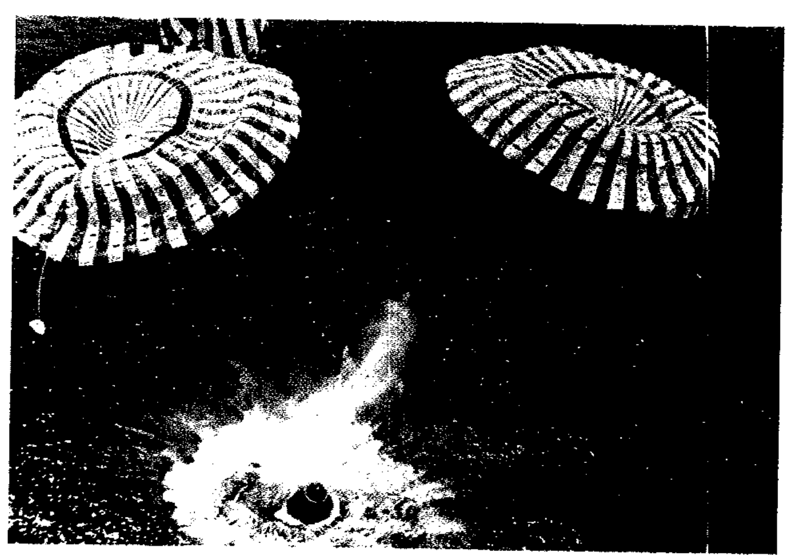


FIGURE 3-58.–Apollo 15 splashdown in the Pacific Ocean. During the final stages of descent, the parachute farthest from the camera was partially streaming. The other two parachutes are beginning to collapse as the CM rises after the initial contact (S-71-43541).