4. Photographic Summary

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

The photographic objectives of the Apollo 16 mission were to provide precisely oriented mapping-camera photographs and high-resolution panoramic-camera photographs of the lunar surface, to support a wide variety of scientific and operational experiments, and to document operational tasks on the surface and in flight. These photographic tasks were integrated with other mission objectives to achieve a maximum return of data from the mission.

The variety of photographic equipment, the latitude and unique morphological setting of the Descartes landing site, and the planned 147.8-hr stay in lunar orbit enhanced the potential photographic data return from the Apollo 16 mission. A far-ultraviolet (UV) camera/spectrograph introduced on this mission provided a capability to acquire imagery and spectroscopy in the far-UV range. The remaining photographic equipment inventory for the Apollo 16 mission resembles that of the preceding Apollo 15 mission. Panoramic- and mapping-camera systems mounted in the scientific instrument module (SIM) bay of the service module provide each of the J-series missions (Apollo 15 to 17) an orbital photographic capability that was not available on any earlier manned or unmanned mission to the Moon.

The orbital inclination required for a landing at the Descartes site carried the spacecraft 9° north and south of the equator. A plane change that would have carried the command and service module (CSM) approximately 13.5° north and south of the equator during the last day of the mission was canceled because of a real-time modification of the Apollo 16 mission. Moon rotation during the scheduled 6-day lunar-orbit phase of CSM operations would have exceeded 75°; the terminators shifted approximately 65° during the abbreviated mission. Terminator advance during the mission provided the opportunity for observing and photographing targets under a wide range of lighting conditions and also expanded the total surface area lighted for observation during a single mission.

More photographs were returned by the Apollo 16 mission than by any preceding mission. A total of 1587 images were exposed in the 61-cm-focal-length panoramic camera. Of these, more than 1415 are high-resolution photographs from lunar orbit. The remainder were exposed near the beginning of transearth coast (TEC). Each panoramic-camera image is 11.4 cm wide and 114.8 cm long; assuming the nominal spacecraft altitude of 110 km, each image exposed from orbit covers a 21- by 330-km area on the lunar surface. The 7.6-cm-focal-length mapping camera exposed 2514 11.4-cm-square frames that contain lunar-surface imagery. Another 927 frames were exposed while the camera operated over unlighted lunar surface in support of the laser-altimeter experiment. A companion 35-mm frame from the stellar camera permits precise reconstruction of the camera-system orientation at the time of each mapping-camera exposure. Approximately 440 photographs with lunar imagery were exposed between transearth injection (TEI) and the TEC extravehicular activity (EVA).

The Apollo 16 crew also returned approximately 2860 frames of 70-mm photography, 58 frames exposed in the 35-mm camera, and 21 magazines of exposed 16-mm film. Of these, some 1800 frames of 70-mm photography and eight magazines of 16-mm film were exposed in the lunar module (LM) or on the lunar surface. At the time this report was submitted, all photography had been screened and the locations of most of the lunar-surface imagery had been identified. Index preparation was at an advanced stage, and the lunar-surface footprints of orbital photographs were being plotted on lunar charts for index map printing.

[a]NASA Manned Spacecraft Center.

TRANSLUNAR PHOTOGRAPHY

Photographic activity began during the first revolution of Earth orbit when crew-option targets (including the Houston, Texas, area) were photographed with the Hasselblad electric (EL) 70-mm camera. After the translunar injection (TLI) burn, the crew documented the transposition and docking maneuvers with the Hasselblad EL camera and the 16-mm data acquisition camera (DAC) as the world watched real-time television (TV) pictures of the operation. Approximately 4 hr after lift-off, extraction of the LM from the SIVB stage was photographed by the DAC and the Hasselblad camera. Crew-option photographs of the receding Earth were taken before, during, and after the transposition, docking, and ejection maneuvers.

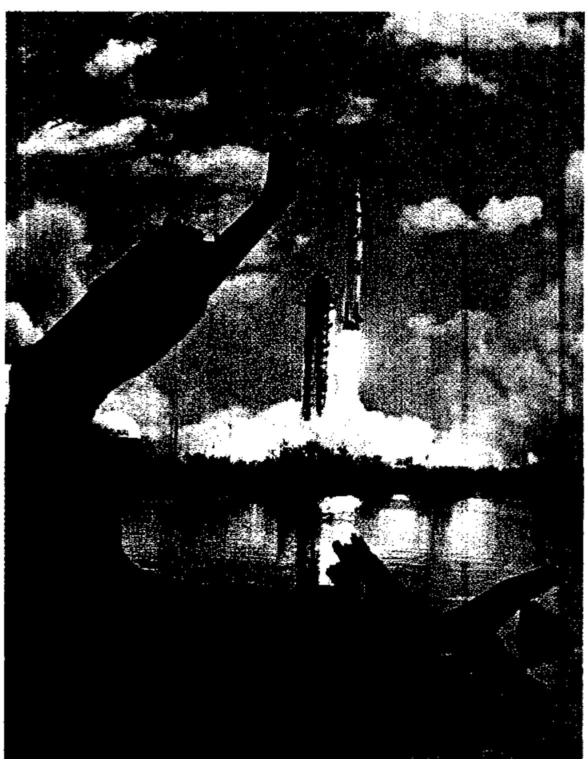


FIGURE 4-1.–The Apollo 16 launch vehicle lifts off from pad A, launch complex 39, Kennedy Space Center, Florida (S-72-35347).

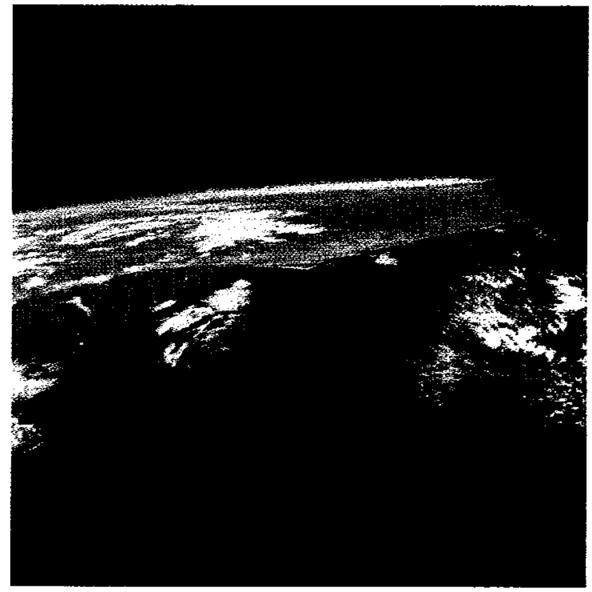


FIGURE 4-2.–View eastward across the Pacific waters to Southern Baja California Peninsula as Apollo 16 approaches the coast of North America on the first revolution in Earth orbit (AS16-118-18859).

Lift-off of the Apollo 16 spacecraft is shown in figure 4-1. Figures 4-2 and 4-3 are photographs taken in Earth orbit. Typical TLC views are shown in figures 4-4 to 4-6, and figures 4-7 to 4-10 are photographs made from either the LM or the CSM following the LOI burn.

Photographic activity was at a low level through most of the translunar-coast (TLC) phase of the Apollo 16 mission. Four sets of UV photographs of the Earth and one set of the Moon were exposed at scheduled times during TLC. Each set consists of a color photograph and four frames recorded on special spectroscopic film sensitive to the shorter wavelengths; one frame was taken through each of four filters that pass energy in different bands of the UV spectrum. A special lens that transmits UV wavelengths was used on the camera. The target was photographed through a special command module (CM) window that is transparent to UV radiation; the window was covered with a shade or a UV filter when not in use.

One Hasselblad magazine of high-speed, black-and-white film was exposed while the electrophoresis experiment was being performed after the first rest period. Jettisoning of the SIM-bay door

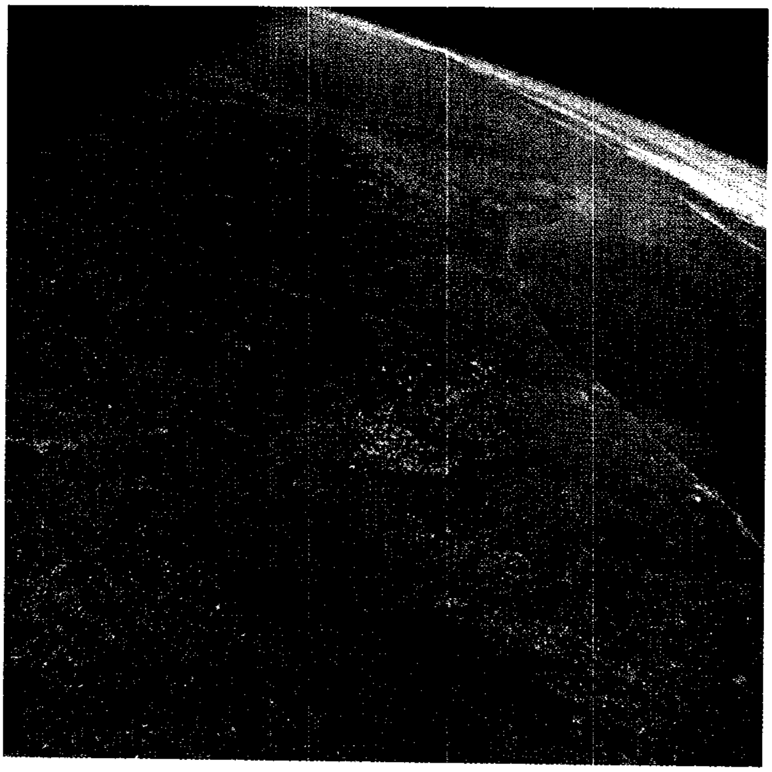


FIGURE 4-3.–View eastward from Earth orbit across the coastal plain of Texas and Louisiana. The thin band of blue that separates Earth from the blackness of outer space along the gently curved horizon (upper right corner) graphically illustrates the limited nature of the Earth atmosphere. Coastal features from Freeport, Texas (right margin), to the Atchafalaya Bay south of Morgan City, Louisiana, are readily identified. Interstate Highway 10 extends from near the center of the bottom margin to Houston, near the center of the frame. Dense forests in northeast Texas, central Louisiana, and Mississippi make up the dark-green area that dominates the upper left quarter of the frame. The Mississippi River flood plain crosses the forest as an irregular, light-colored band that roughly parallels the top margin (AS16-118-18860).

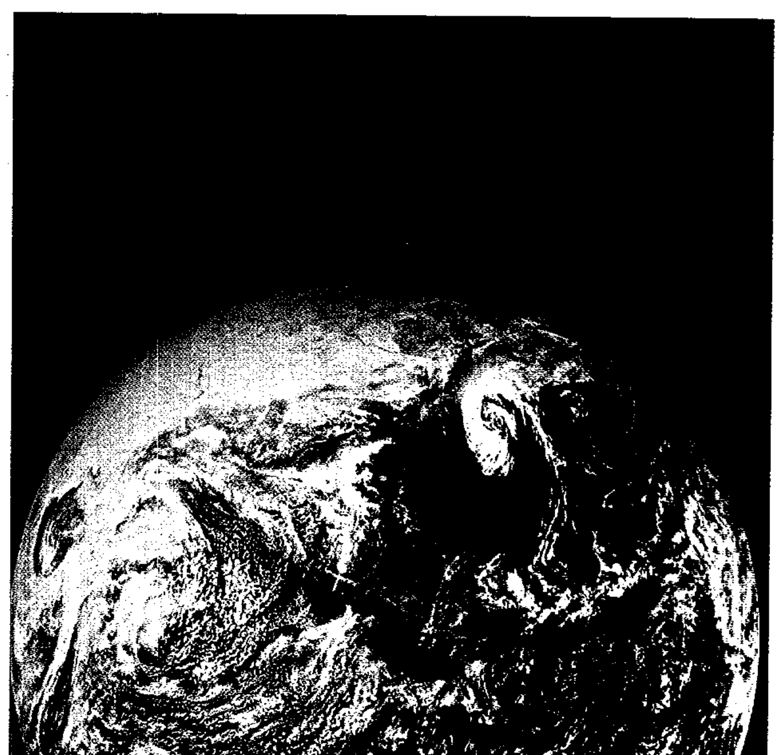


FIGURE 4-4.–This spectacular view of North America was photographed approximately 1 hr 50 min after the TLI burn. The solid white area at the upper left is the north polar icecap and snow-covered terrain in Canada. A pronounced spiral cloud pattern covers the upper Ohio Valley, the eastern Great Lakes, and New England. The western Great Lakes are free of clouds, but western Lake Superior, northern Lake Michigan, and western Lake Huron are ice covered. Snow in the Sierra Nevada, the Cascade Range, the Rocky Mountains, and other mountain ranges combines with some clouds to conceal terrain at places in western Canada and in the northwestern United States. The Yucatan Peninsula and many of the islands bordering the Caribbean Sea are clearly visible, but most of Central and South America is obscured by clouds (AS16-118-18879).

approximately 4.5 hr before lunar orbit insertion (LOI) was documented by DAC photography. Before the protective door was removed, the SIM camera systems required little attention; the mapping and panoramic cameras were cycled once to reduce the chances of film set. After SIM-bay-door jettison, the housekeeping requirements increased because the SIM camera temperatures had to be maintained within operational limits.

Following a nominal LOI burn, the Apollo 16 crew transmitted visual impressions of features observed during revolutions 1 and 2. Selected crew-option targets were photographed with the

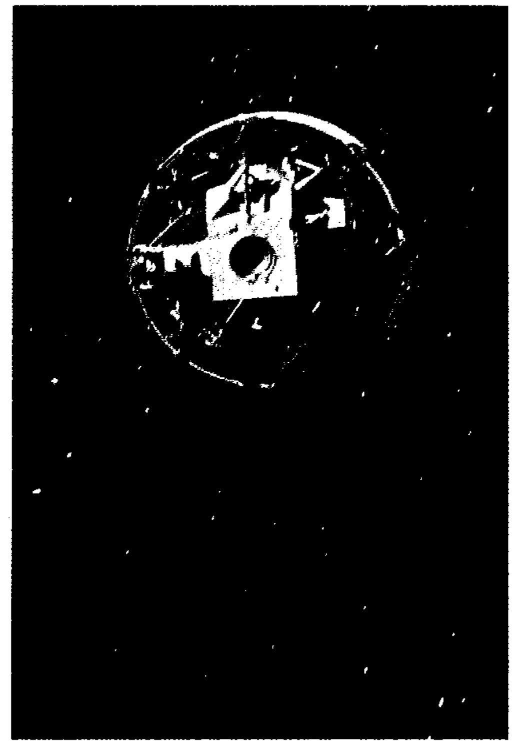


FIGURE 4-5.–The LM before extraction from the SIVB stage. The CSM separated from the SIVB stage approximately 30 min after the TLI burn. This photograph was taken after the vehicle turned to permit examination of the LM before docking. Abundant particles released from the vehicles during separation shine against the blackness of space. The top hatch, used for docking, is clearly visible in this photograph; but the docking target is partly in shadow (AS16-118-18875).

FIGURE 4-6.–The SIVB stage after LM ejection. On command from the Mission Control Center in Houston, the spent SIVB maneuvered away from the hard-docked CSM and LM. The SIVB continued along the modified trajectory to impact on the lunar surface. Part of the LM, including three of the four thrusters in a reaction control system thruster quad, can be seen along the bottom edge of the frame (AS16-118-18881).

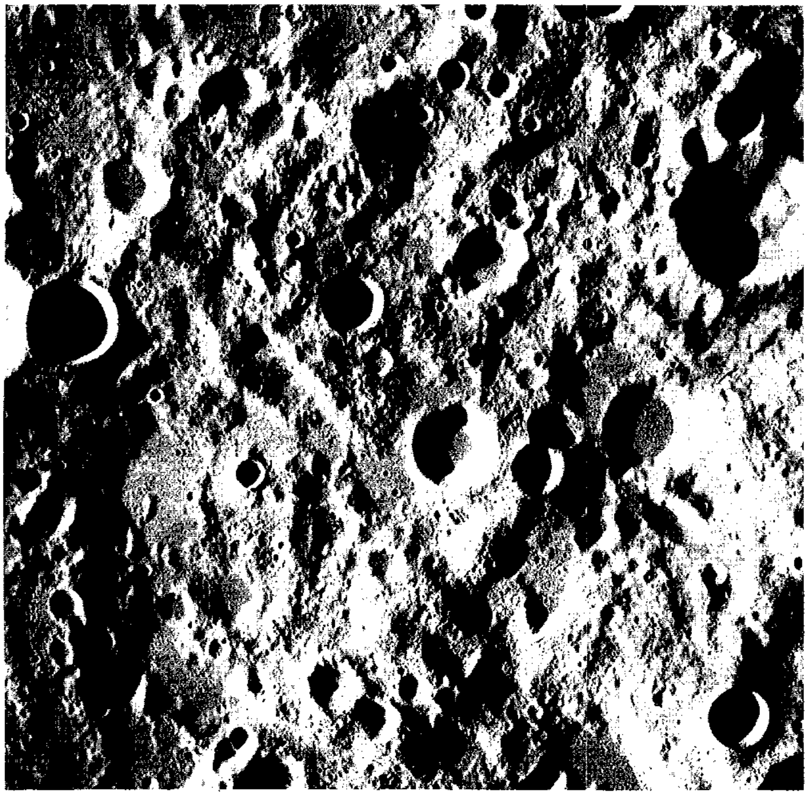


FIGURE 4-7.—Rugged far-side terrain exhibits a wide dynamic range from black shadows to bright, Sun-facing slopes when illuminated by a low Sun. This mapping-camera frame, centered between the Craters Zhukovsky and Stein near latitude 8.6° N, longitude 175.9° W, was exposed before the first rest period in lunar orbit. The sunset terminator crossed this area before the next scheduled period of camera operation. North is at the top of the frame, which is alined within 10° of the selenographic grid (Apollo 16 mapping-camera frame 0011).

Hasselblad EL camera. Mapping- and panoramic-camera operation was scheduled for approximately 8 min near the end of revolution 3 and the beginning of revolution 4 to photograph terrain that would be crossed by the sunset terminator during the first rest period in lunar orbit. Twenty-six frames were exposed with the mapping camera; however, only four frames were exposed with the panoramic camera before it had to be switched to the standby mode because of an electrical anomaly. During revolution 11, the sunrise terminator was in the vicinity of the Descartes landing area. By using the CSM Hasselblad EL camera, the crew obtained low-Sun-angle photographs of the landing site. Undocking occurred on revolution 12.

After separation, the LM Hasselblad data camera (DC) photographed the CSM during stationkeeping and captured a prelanding earthrise sequence that included both the Earth and the distant CSM. On the last scheduled low-altitude pass over the landing site, the DAC (mounted on the CSM sextant) documented the tracking of a landmark near the landing target.

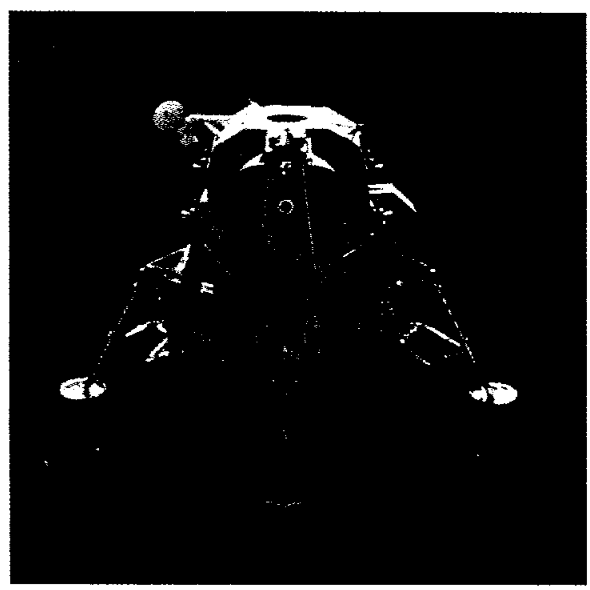


FIGURE 4-8.—The LM prepared for lunar landing. After separation from the CSM, the LM maneuvered to permit inspection by the CMP. Both LM hatches, the round docking hatch in the top surface and the square hatch at the top of the ladder, are clearly visible in this Hasselblad photograph (AS16-118-18897).

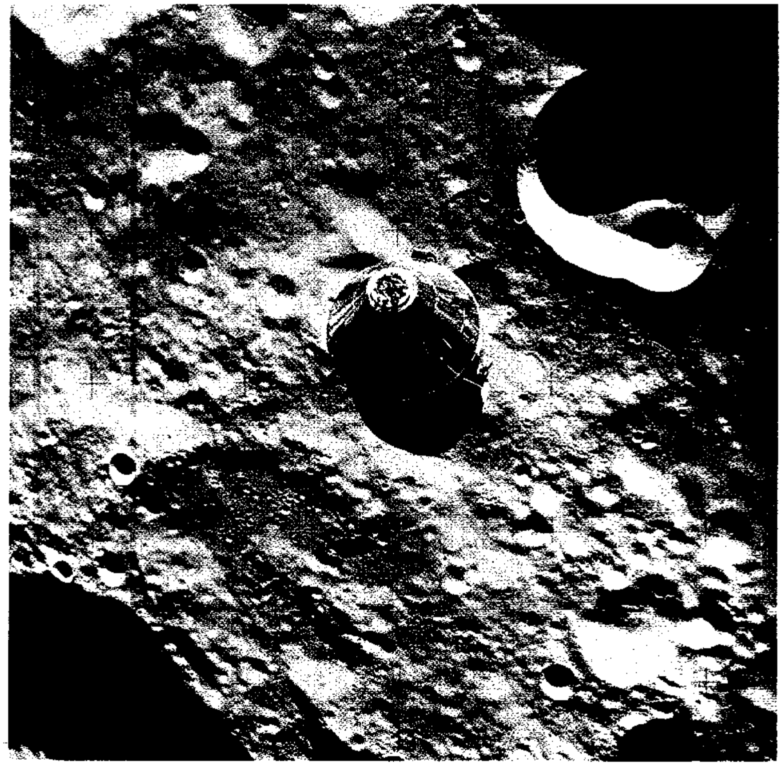


FIGURE 4-9.–The CSM at close range above far-side terrain. In this 60-mm Hasselblad DC photograph, the CSM is above the far-side terrain near latitude 8° N, longitude 172° E. The double crater at the upper right corner of the frame is unnamed. The northwest rim of Valier Crater is at the lower left corner. North is to the right in this near-vertical view (AS16-113-18294).

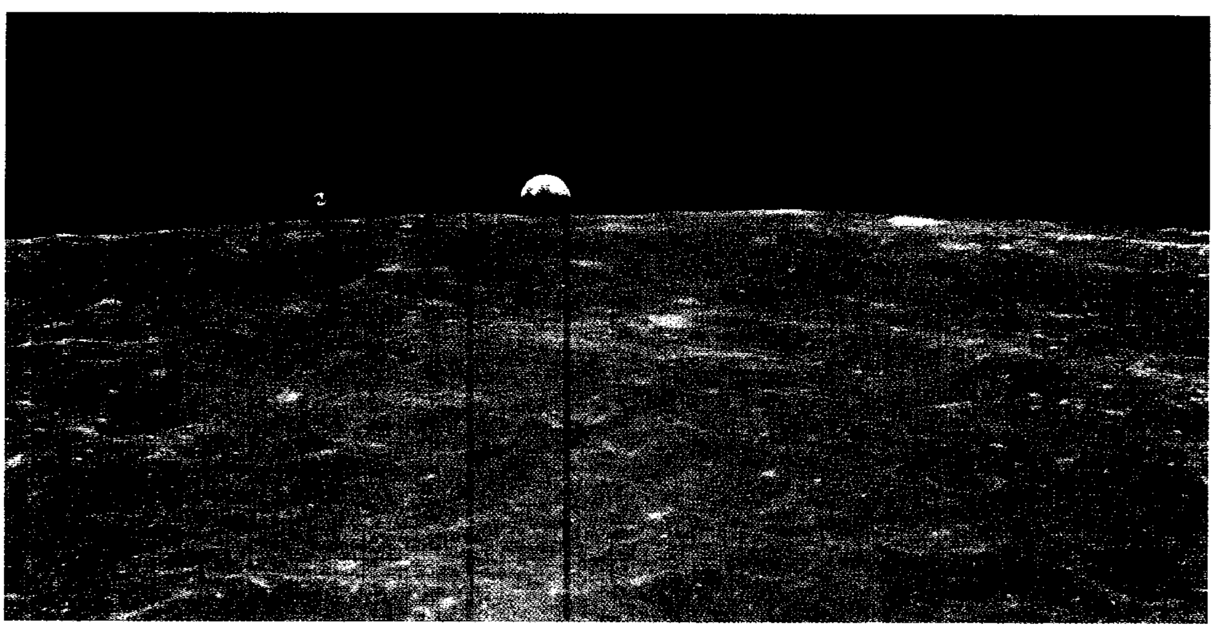


FIGURE 4-10.–Earthrise. In this 60-mm Hasselblad DC photograph from the LM, the CSM is to the left of the Earth. This photograph was taken during the hold period before landing (AS16-113-18288).

LUNAR MODULE/LUNAR-SURFACE PHOTOGRAPHY

The crew used an enlarged inventory of photographic equipment (table 4-I) to document the LM-descent, surface-operations, and LM-ascent phases of the mission and to support scientific experiments on the surface. The new far-UV camera/spectrograph gave the Apollo 16 crew the capability of recording UV radiation from distant sources that the atmosphere blocks from Earth-based observatories and that is below the threshold of detectability with the short time exposures feasible in a moving spacecraft.

The fifth lunar landing was unique in the manned exploration of the Moon. The Apollo 16 mission has been the only opportunity to explore and sample the major geomorphic unit of the Moon, the lunar highlands. The 71 hr 14 min stay time of the LM on the lunar surface accommodated three EVA periods for a total of 40.5 man-hr of lunar-surface activity. The commander (CDR) and the LM pilot (LMP) took 1800 photographs, collected 95 kg of material, and completed three traverses covering 21.7 km. Throughout the stay at the Descartes site, a TV camera mounted on the lunar roving vehicle (LRV) provided real-time viewing of most of the crew's activity on the lunar surface. The crew was required to aline the high-gain antenna at each station to establish contact with the Mission Control Center; but, once alined, the camera could be controlled remotely from Earth. These TV transmissions enabled observers to evaluate the operational capabilities of the crew, to observe the Apollo lunar-surface experiments package (ALSEP) deployment and the collection of samples, and to select samples of special scientific interest to be returned to Earth.

Approximately 4 hr into the first EVA period (EVA-1), with ALSEP deployment completed, the crew drove west to station 1 near Flag and Plum

TABLE 4-I.–Photographic Equipment Used in LM and on Lunar Surface

Camera	Features	Film size and type	Remarks
Hasselblad 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, aerial exposure index (AEI) 64	Handheld within the LM; bracket-mounted on the remote control unit for EVA photography; used for photography 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 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 LRV to document lunar-surface operations
Far-UV camera/ spectrograph	3-in. Schmidt electronographic camera; external batteries with connecting cable, tripod mount, leveling/pointing mechanism, external controls	NTB-3 electronographic film	Deployed and leveled on tripod in LM shadow, with cable-connected batteries in the Sun. Point camera with elevation and azimuth adjustments for each target. Activate automatic exposure sequencer. Changes in EVA times because of delay in landing forced the recalculation of all pointing values

Craters for geologic sampling. The stop at station 2 near Buster and Spook Craters confirmed the findings at station 1; both stations had the same rock types. The scientists had expected volcanic rocks, but the crew found mostly impact breccias.

Back at the LM, the CDR put the LRV through a series of "Gran Prix" maneuvers, which were photographed by the LMP to document the performance characteristics of the vehicle. After closeout, the crew returned to the LM to eat, sleep, and prepare for the second EVA period (EVA-2). Representative EVA-1 photographs are shown in figures 4-11 to 4-21. The far-UV camera/spectrograph is shown in figure 4-22, and figure 4-23 is a color enhancement of a far-UV photograph.

The second EVA period began with a drive to Stone Mountain on a modified traverse. Station 7 had been eliminated from the original traverse to provide more time at station 10. The first stop, at station 4, was high on the side of Stone Mountain. The angular blocks photographed at this location appeared to be ejecta from South Ray Crater. In addition to acquiring the usual 60-mm photography at station 4, the LMP used the Hasselblad camera with the 500-mm telephotographic lens to record details of South Ray and Baby Ray Craters and of the North Ray Crater-Smoky Mountain area.

The crew retraced the LRV tracks down Stone Mountain and located station 5 on the rim of a 15-m-diameter crater. Photographs indicate that this area contains the smallest amount of ejecta from South Ray Crater of any station visited during EVA-2. The crew turned west to find a fresh, blocky crater for station 6. A 10-m-diameter secondary crater was selected, sampled, and photographed.

Station 8 was located on the east side of Wreck Crater in a boulder field. The plan at station 8 was to photograph a boulder and surrounding area and to collect material from the boulder, from around the boulder, and then from under the boulder. Unfortunately, the first three boulders picked by the crew were too deeply embedded to be rolled over. These collections, together with the documenting photography, however, provided examples of glass, breccias, igneous rocks, and soils that are valuable in the investigation of the petrology of the area. The crew drove north and located a small boulder near station 9. At this location, their efforts were successful; a boulder was moved and the photography and sample sequence completed. The crew stopped near the ALSEP site, station 10, on the route back to the LM for additional photography, samples, cores, and penetrometer measurements. Figures 4-24 to 4-27 are photographs taken during EVA-2.

The third EVA period (EVA-3) was modified extensively from the mission plan, both for time and number of stops to be made. The crew drove first to the eastern edge of North Ray Crater, station 11. The usual 60-mm photography at station 11 was complemented with a series of panoramas, using polarizing filters, and with additional telephotography, using the Hasselblad camera with the 500-mm lens to photograph Smoky Mountain. Samples from North Ray Crater and House Rock were found to be impact breccias and not volcanic rocks as anticipated. Closeup photography documented the clastic texture of the breccia boulders. Station 13 provided additional samples, including samples from the shadowed area under Shadow Rock. Material from the shadowed area provided soil and rock samples that had been shaded for millions of years. From station 13, the crew returned to the LM area (station 10) to collect additional samples, to complete activation of the ALSEP, and to package the samples for return to Earth.

The LRV was parked near the LM with the high-gain antenna alined and with the TV camera on and remotely controlled from Earth. From this location, live coverage during final closeout and during the lift-off of the ascent stage from the lunar surface was provided by TV. The LM-window-mounted DAC photographed the receding lunar surface and provided detailed photographic coverage of terrain west of the landing point as the LM headed toward rendezvous with the CSM. Figures 4-28 to 4-36 are representative EVA-3 photographs.

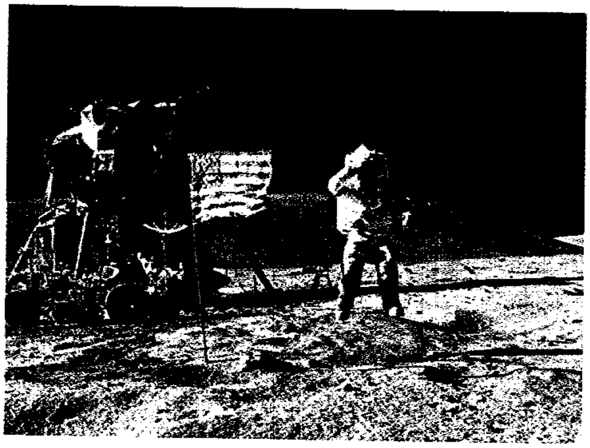


FIGURE 4-11.–With a salute and a leap into space, the CDR honors the flag and the people of the United States of America. Stone Mountain, 5 km in the distance and approximately 500 m higher than the landing site, forms the skyline behind the astronaut. The LRV is parked near the LM. The far-UV camera/spectrograph sits on a tripod partially shaded by the shadow of the LM. Note the astronaut's position and shadow and compare with figure 4-12 (AS16-113-18339).

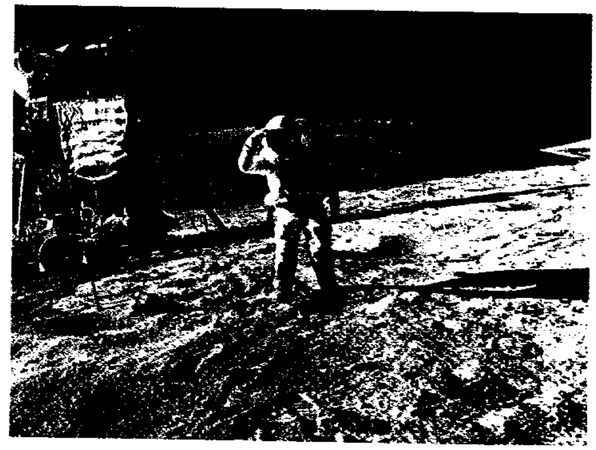


FIGURE 4-12.–The LMP honors the flag, the Nation, and the American people in this salute to the Stars and Stripes. Note especially the astronaut's position and shadow and compare with figure 4-11 (AS16-113-18341).

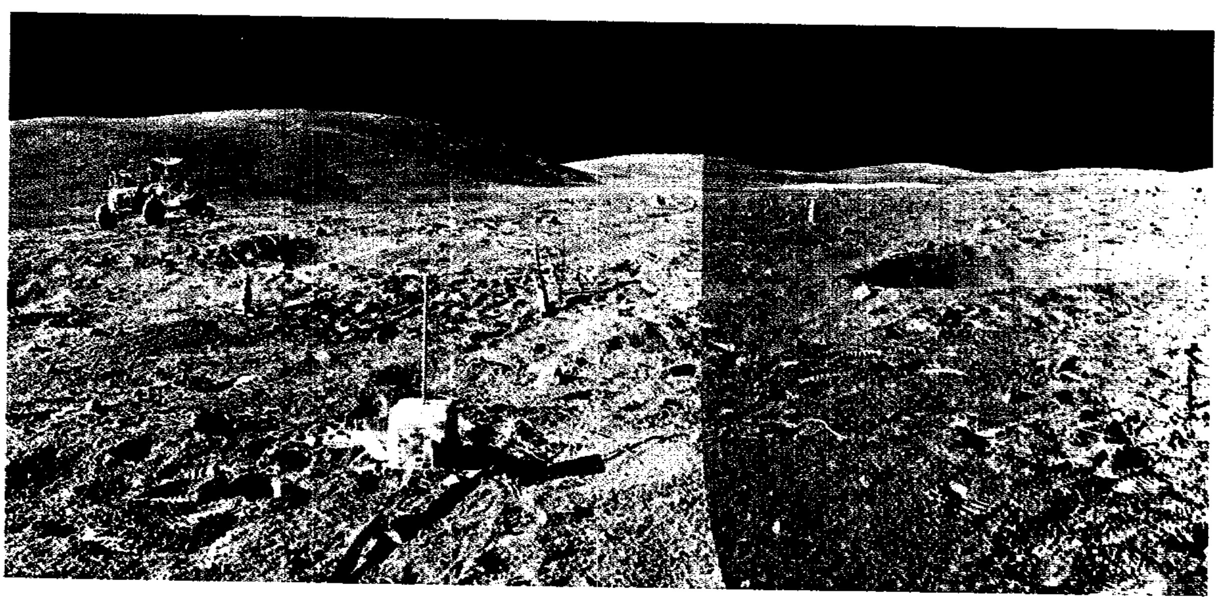


FIGURE 4-13.–Stone Mountain, approximately 5 km in the distance, forms the skyline behind the LRV in this view from the ALSEP site. The white object in the foreground is part of the heat-flow experiment (HFE); the universal handling tool, which is used to level the package, sticks up from the top of the package. The heat-flow probe in the bore stem at the right margin of the photograph is connected by cable to the HFE electronics package. The golden tape in the immediate foreground connects the HFE to the ALSEP central station. To the left rear of the electronics package is the lunar-surface drill; the drill rack with core and bore stems is just behind the electronics package. In the distance to the right rear of the drill rack is the treadle and core stem extractor. The horizontal splash of white above the extractor is South Ray Crater, approximately 6 km in the distance (AS16-113-18366, 18367, 18368).

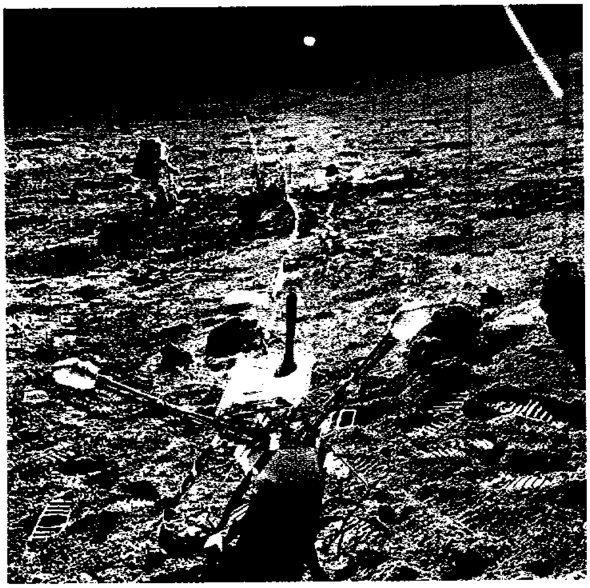


FIGURE 4-14.–The gold-and-white object in the foreground is the lunar-surface magnetometer. The CDR works with the thumper, to provide energy to activate the geophones of the active seismic experiment. The large, golden, rectangular object is the ALSEP central station; the long, white antenna extending from the central station telemeters data to Earth from each of the experiments. The dark, cylindrical object in front of the central station is the radioisotope thermoelectric generator, which provides electrical power for the experiments. Objects to the right of the central station include the passive seismic experiment and the mortar box assembly (MBA), another part of the active seismic experiment. The golden tape at the upper right extends to the HFE (AS16-113-18373).

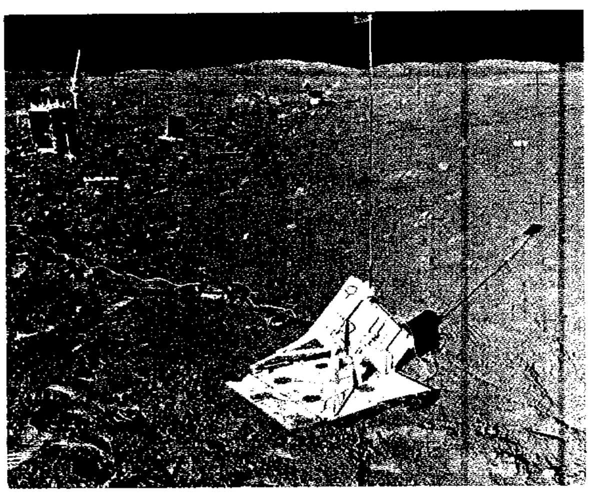


FIGURE 4-15.–The MBA (in the foreground) is part of the active seismic experiment. The MBA contains four grenades that are designed to be fired remotely by ground control. The grenades, which explode on contact with the lunar surface, provide a calibrated seismic-signal source to the geophone line. The geophone line, which extends some 94 m out from the central station, can be seen in the upper center and upper right in this photograph. (Energy from the explosions is used to produce a seismogram, a record of energy propagation through the crust of the Moon. Seismograms provide scientists with information about the internal structure of the Moon.) The golden, rectangular object at the upper left is the ALSEP central station; the gray, finned object is the radioisotope thermoelectric generator; the three-armed, white-and-gold object is the lunar-surface magnetometer (AS16-113-18379).

FIGURE 4-16.–The CDR bags a sample of the Moon at the ALSEP station during EVA-1. Components of the ALSEP cover the surface immediately behind the CDR. The lunar-surface drill appears behind the CDR's left elbow. The square box behind the drill is part of the HFE. The dark object in the background is the radioisotope thermoelectric generator. To the astronaut's right is the drill rack with bore stems. The three-sensor lunar-surface magnetometer is in the background beyond the drill rack (AS16-114-18388).

FIGURE 4-17.–This partial panorama at station 1 shows the beauty and stark bleakness of the lunar surface. With antenna pointed toward Earth, the LRV beams a TV picture to vicarious explorers around the world. To the left, the LMP stands near the rim of Plum Crater. The Hasselblad camera and documented sample bags hang from the remote control unit on his chest. The sample collection bag hangs from the primary life support system on his back. The scoop is stuck into the lunar surface near his left hand. The reflection of the CDR, the photographer for this panorama, can be seen in the LMP's visor. To the right, the "second" astronaut is the LMP after he has moved during the photographic sequence. The apparent change in shadow direction is an illusion caused by flat reproduction of the curved panoramic sequence. Stone Mountain, some 500 m high and 5 km in the distance, forms the skyline to the right (AS16-114-18422, 18423, 18425, 18427).

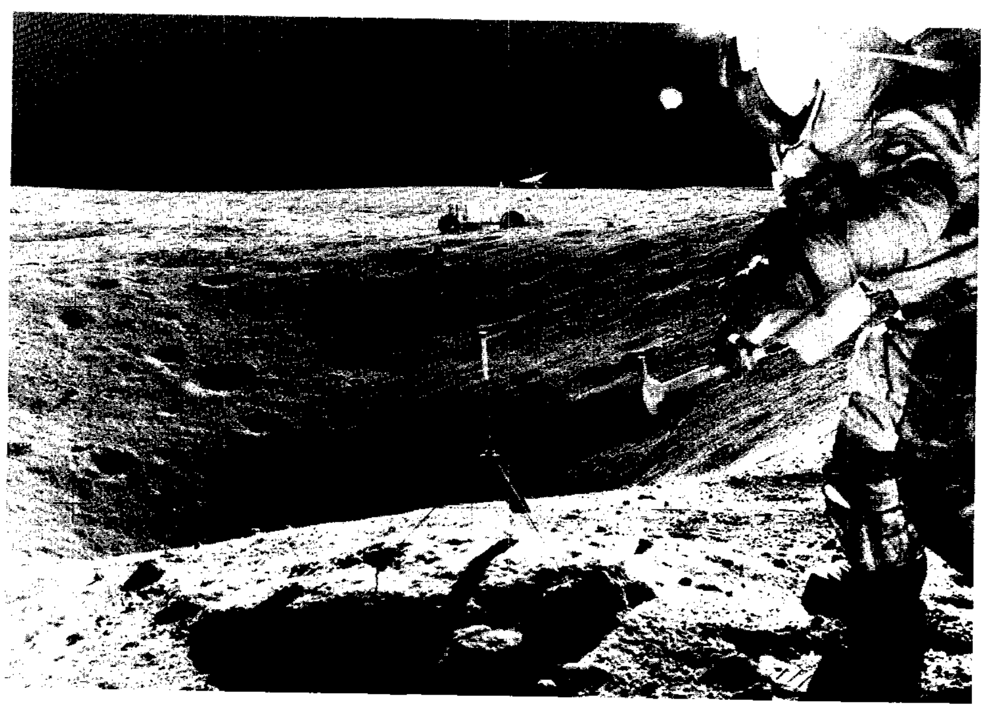


FIGURE 4-18.–The CDR, with hammer in hand, prepares to sample a boulder on the rim of Plum Crater at station 1 during EVA-1. Plum Crater has an unusual morphology; there is a bench or break in the slope along the inner wall of the crater. Smaller craters give a pock-marked appearance to the inner slopes. The gnomon marks the area to be sampled. The Hasselblad camera is partially visible above the CDR's left hand. Sample bags, which are hanging from the camera bracket, appear just below his left hand. Above the gnomon is the LRV. The flash of light in front of the visor is a light reflection on the camera lens (AS16-109-17804).

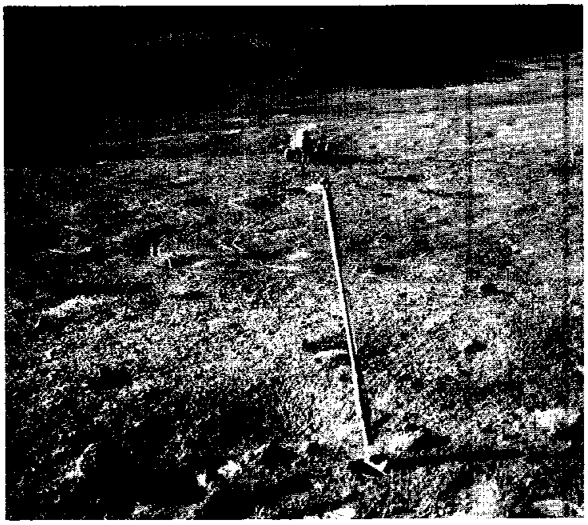


FIGURE 4-19.–The LMP has collected two samples in the immediate foreground near the scoop. This photograph, which was taken to document the location of the samples, catches the CDR (at the LRV) deeply involved with the portable magnetometer experiment. The tripod-sensor assembly is at the right margin of the photograph. The large crater in front of the LRV is Spook Crater, which is approximately 100 m in diameter. Stone Mountain, 500 m high and 5 km in the distance, forms the skyline. Boot tracks and LRV tracks cross in the foreground (AS16-109-17841).

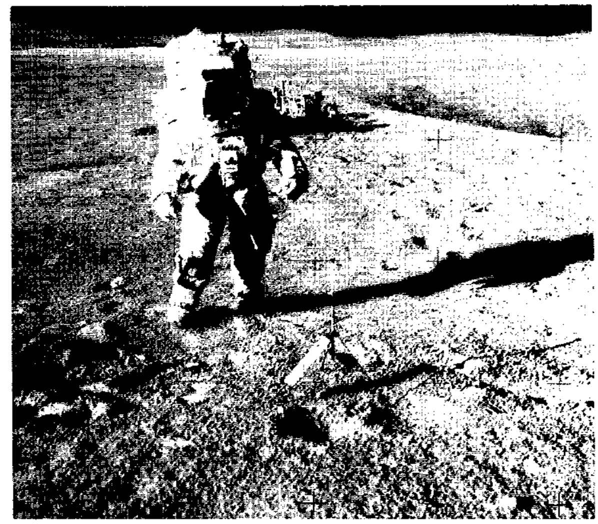


FIGURE 4-20.–The CDR, with Hasselblad camera and documented sample bags hanging from the remote control unit on his chest, folds up a sample bag with his left hand. The LRV is partially visible above the astronaut's left shoulder. The large crater along the right margin of the photograph is Plum Crater. The horizontal splash of white just below the skyline is South Ray Crater and associated ejecta. The gnomon with color chart, marking the locations from which samples have been collected, sits in the foreground (AS16-109-17797).

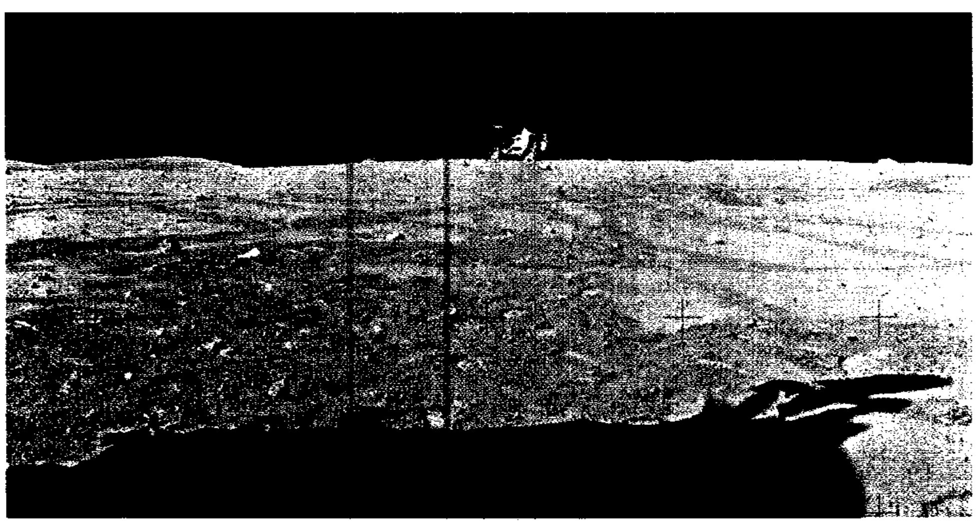
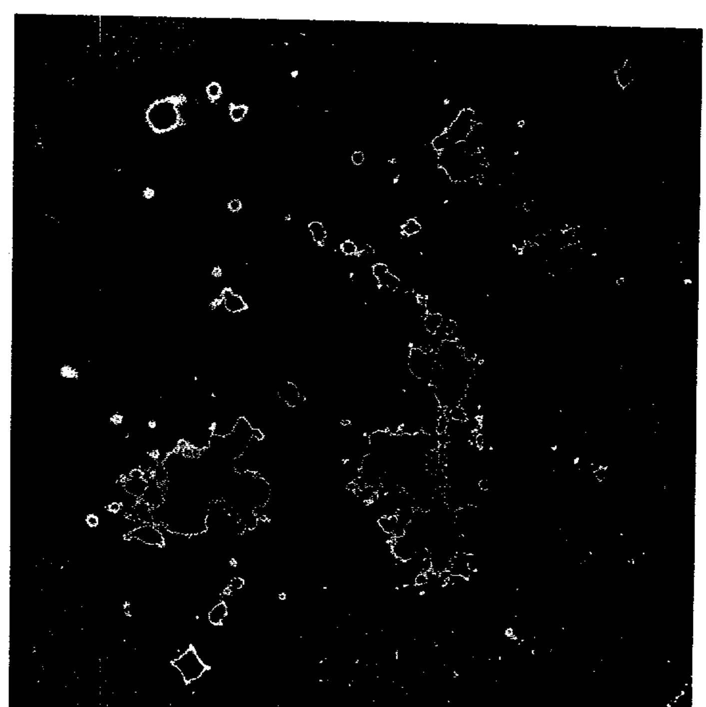


FIGURE 4-21.–The CDR races through a series of Gran Prix maneuvers to demonstrate the performance of the LRV. The vehicle cannot be fully tested on Earth for operational constraints because of the great differences in the environment of the Earth and the Moon. Motion pictures and photographs help to define the performance characteristics of the vehicle in the lunar environment. The bands of dark gray are LRV tracks; bootprints clutter the foreground (AS16-115-18559).

FIGURE 4-22.–The gold-colored far-UV camera/spectrograph stands in the shadow of the LM. The far-UV camera/spectrograph is a miniature observatory that acquires imagery and spectroscopy in the far-UV range. The astronauts must initially deploy the equipment and then periodically retarget the camera/spectrograph during their stay on the lunar surface. At the end of EVA-3, the CDR removed the film cassette from the top of the camera for return to Earth. Behind the far-UV camera/spectrograph is the LRV; to the left is the American flag. The LMP carries a boulder to the footpad by the ladder. During the EVA-3 closeout, this sample was bagged for return to Earth (AS16-114-18439).

FIGURE 4-23.–Color-enhanced far-UV photograph of the Magellanic Cloud. Ultraviolet radiation from specific astronomical targets was recorded on special spectroscopic black-and-white film in the far-UV camera/spectrograph. This photograph of the Magellanic Cloud, the nearest neighboring galaxy to the Milky Way, has been color enhanced to facilitate interpretation. Areas of similar intensity, recorded as a narrow range of gray tones on the black-and-white image of the UV-sensitive film, are reproduced as a color. In this photograph, blue areas indicate UV radiation levels below the threshold of detectability. Several other levels of UV intensity are indicated by different colors, such as red (faint UV), yellow (stronger UV radiation), and orange (most intense UV radiation within this field of view) (S-72-39660).



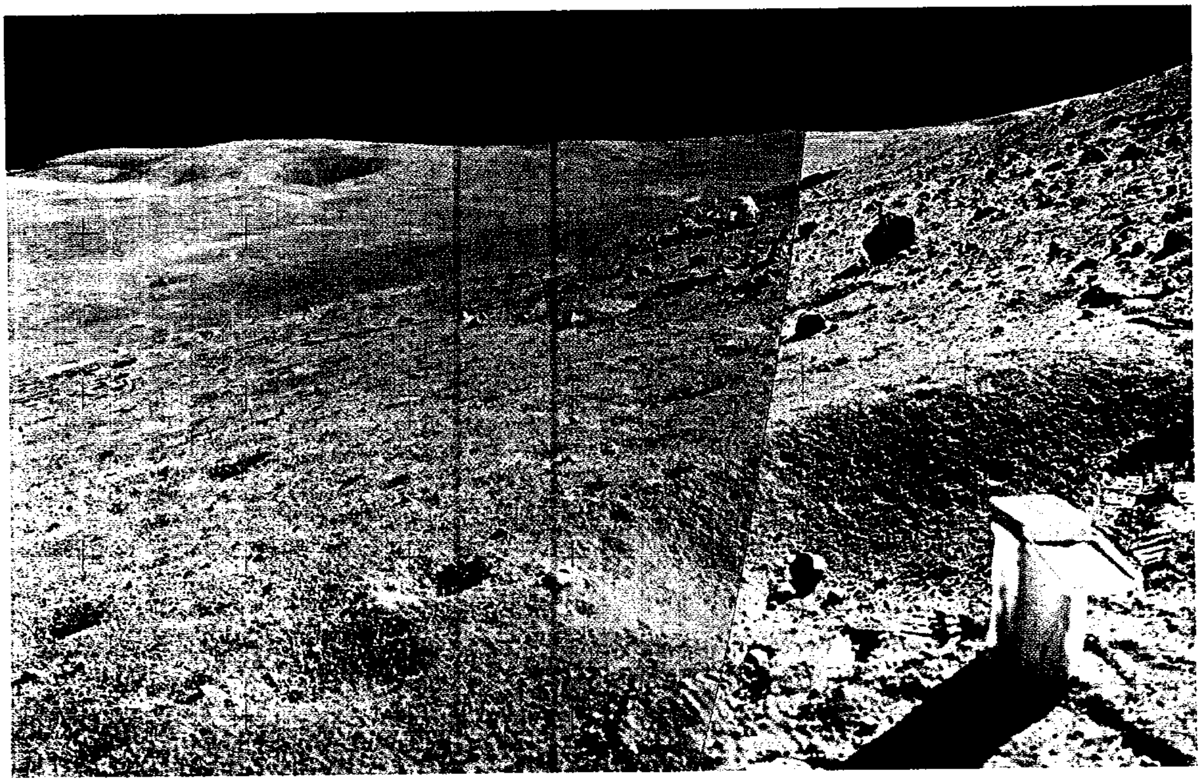


FIGURE 4-24.–At station 4 during EVA-2, the astronauts parked the LRV in a crater to keep it from sliding down the slope of Stone Mountain. A distinct band of boulders crosses this slope. Above the LRV, boulders are numerous; below the LRV, the frequency of boulders is much less. The boulders are ejecta from South Ray Crater, a 600-m-diameter crater that is approximately 4 km to the west of the location shown. The white object in the foreground is a sample collection bag. This container is used to collect large samples and to carry documented sample bags (AS16-107-17472, 17473).

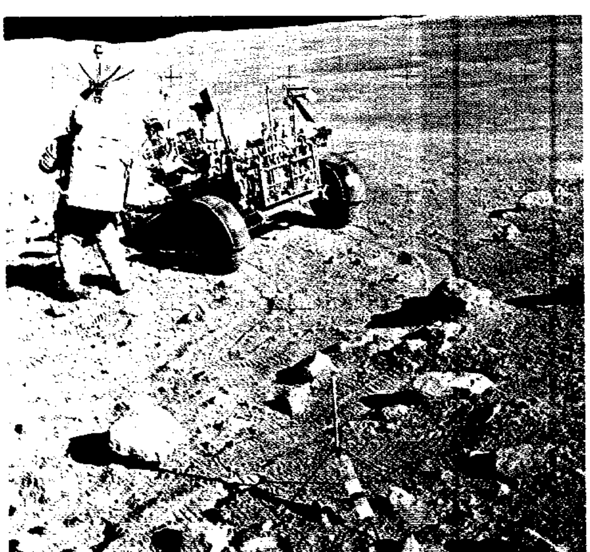


FIGURE 4-25.–The LMP works near the LRV at station 4 high on the side of Stone Mountain. The high-gain antenna appears above the astronaut's head. The golden TV camera, the white low-gain antenna, the dark-gray motion picture camera, and the rectangular map package complete the array of equipment on the front of the vehicle. The gray, cylindrical object near the motion picture camera is a penetrometer. The tool carrier with tongs, handtool extension, and rake are attached to the rear of the vehicle. The golden tape on the right rear of the vehicle is a power cable for the lunar portable magnetometer. The gnomon with color chart, a device to aid in sample documentation, is in the center foreground (AS16-107-17446).

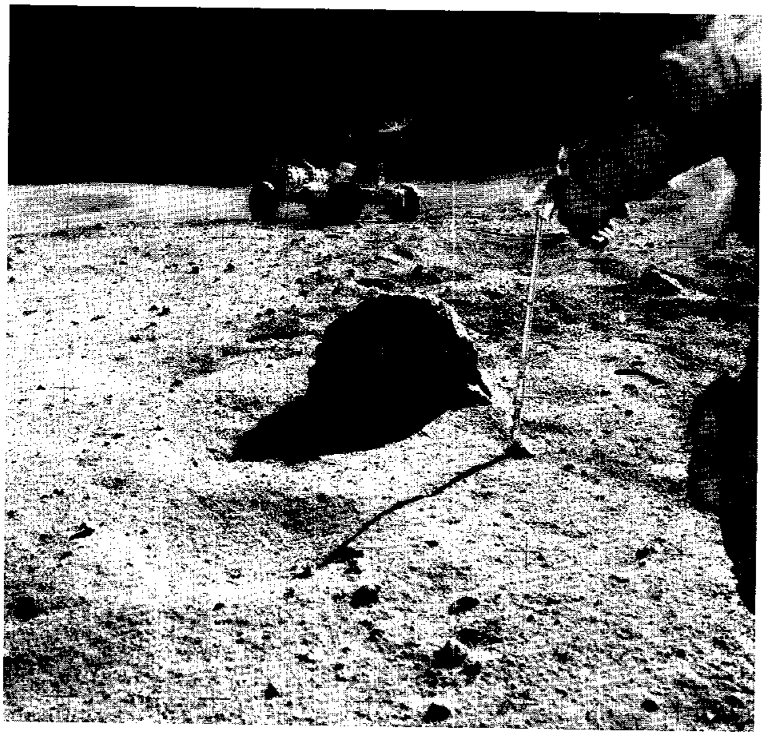


FIGURE 4-26.–Much of the activity at station 9 occurred near the boulder shown in this photograph. This boulder is a breccia, a rock made up of fragments of other rocks. At least three different types of rock fragments or clasts can be identified in this boulder. The scoop marks an area near which soil has been collected. The CDR can be seen in the right margin of the photograph. The cuff checklist is on his left arm; sample bags and the Hasselblad camera hang from the remote control unit. The knee pocket produces the rectangular outline. The LRV stands on the near horizon (AS16-108-17741).

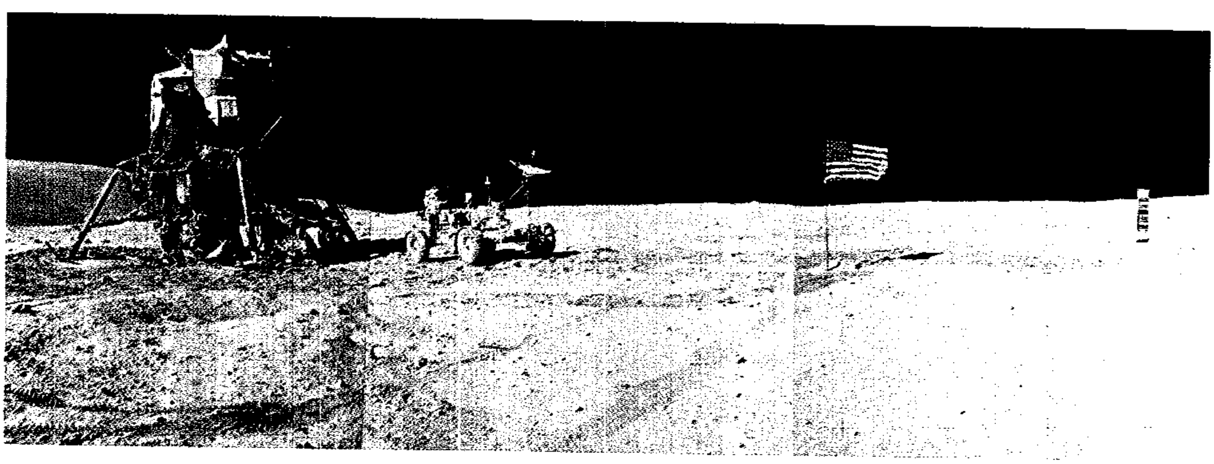


FIGURE 4-27.–The landing area is shown in this partial panorama that was taken by the CDR during EVA-2. Stone Mountain, approximately 5 km in the distance, forms the skyline behind the LM. Below the "United States" sign on the LM is the modularized equipment stowage assembly pallet, a storage area for experiments and tools. A white insulation blanket protects the area from excessive heating and cooling. To the left is a white area with gold-colored insulation draping to the surface. This is the quad III payload area, a storage area for the far-UV camera/spectrograph, the lunar portable magnetometer, and handtools. The probes sticking up from the two landing pads are designed to detect LM touchdown on the Moon and then to crush and bend out of the way during the completion of the landing maneuver. The LRV is parked to the right of the LM. To the right of the American flag is the solar wind composition experiment, which provides data on the elemental and isotopic composition of the solar wind. The dark areas on the surface are boot and vehicle tracks (AS16-107-17435, 17438, 17440).

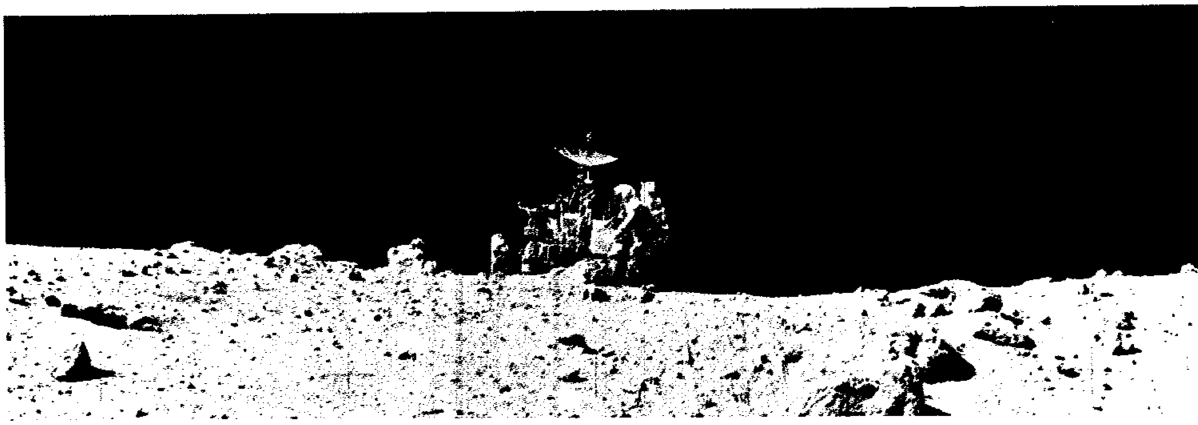


FIGURE 4-28.–The LMP removes the 500-mm Hasselblad camera from the LRV during the stop at station 11. This camera was used to obtain telephotographs of North Ray Crater and Smoky Mountain. The LRV is parked on the rim of North Ray Crater; boulders in the foreground and on the horizon are ejecta from this crater (AS16-116-18607).

FIGURE 4-29.–Station 11 is characterized by an abundance of white breccia boulders. An aphanitic, black rock was collected from the fillet area near the tongs. The CDR carries the rake and sample bags in his left hand. Smoky Mountain forms the skyline; the large boulder in the background is House Rock (AS16-106-17336).

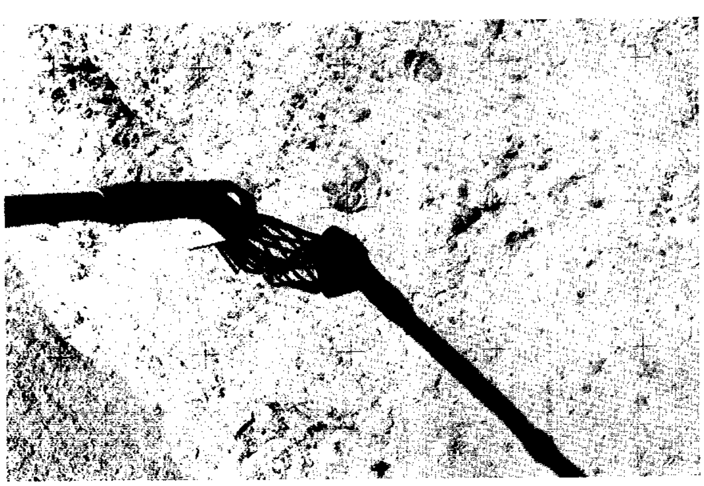


FIGURE 4-30.–The tongs are used to measure the distance between the camera and the boulder for this closeup photograph. The depth of field is approximately 4 cm at this lens setting. This photograph illustrates the fragmental texture of most of the rocks found during the Apollo 16 mission (AS16-106-17328).

FIGURE 4-31.–The LMP inspects House Rock at station 11 before sampling the area. This rock is composed of crushed rock fragments set in a fine-grained matrix. In the area by the astronaut's hands, bands of black glass that have been injected into the boulder can be seen. The intense brecciation and injection suggest a complex history for this boulder. A sample bag is held in the LMP's right hand; the cuff checklist on his left arm indicates the tasks to be performed at each station (AS16-116-18649).

FIGURE 4-32.–The CDR rakes with his right hand and holds a sample bag in his left hand. The tongs mark the area to be sampled. Because of mobility permitted by the suit, raking is a one-arm operation. The rake is used to collect a comprehensive sample, a selective collection of rocks ranging in size from 1 to 3 cm in diameter. These walnut-sized fragments along with the sand-sized material present a more complete history of the area than do isolated rock samples. The LRV sits over the rise in this view at station 11. Note the boulder on the skyline behind the LRV (AS16-106-17340).

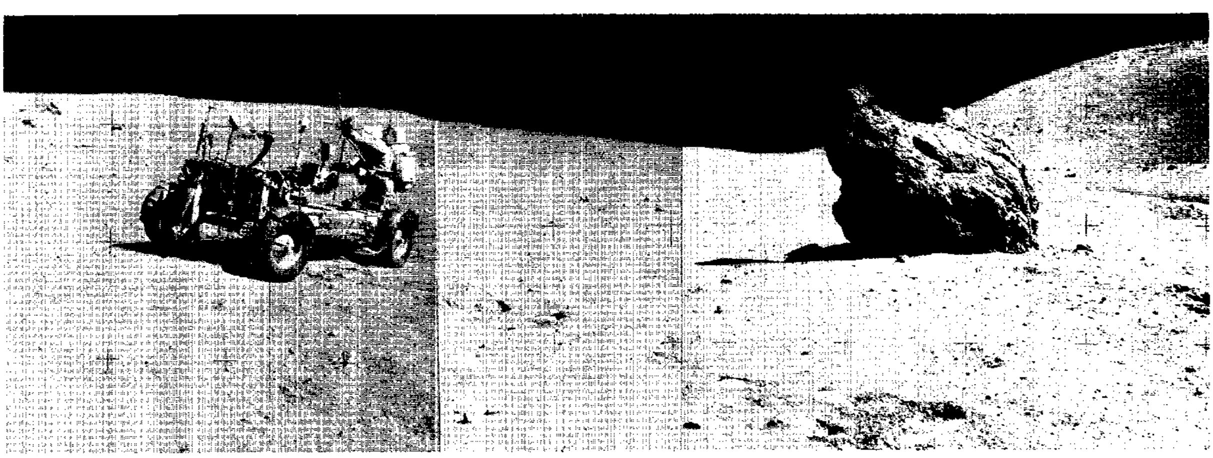


FIGURE 4-33.–The stop at station 13 was to collect a series of samples from a permanently shadowed area. Shadow Rock, a 4-m-diameter boulder to the right in the photograph, was the location of the sampling. Permanently shadowed areas act as cold-traps, or areas where volatile and semivolatile components collect. Studies of samples from these permanently shadowed areas permit scientists to identify volatile components that are present in the lunar environment. The CDR works at the front of the LRV, adjusting the high-gain antenna. The high-gain antenna must be pointed at the Earth before ground control can receive TV. The hill above the LRV is the rim of North Ray Crater; to the right of Shadow Rock on the skyline is Smoky Mountain, approximately 1 km in the distance (AS16-106-17390, 17392, 17393).

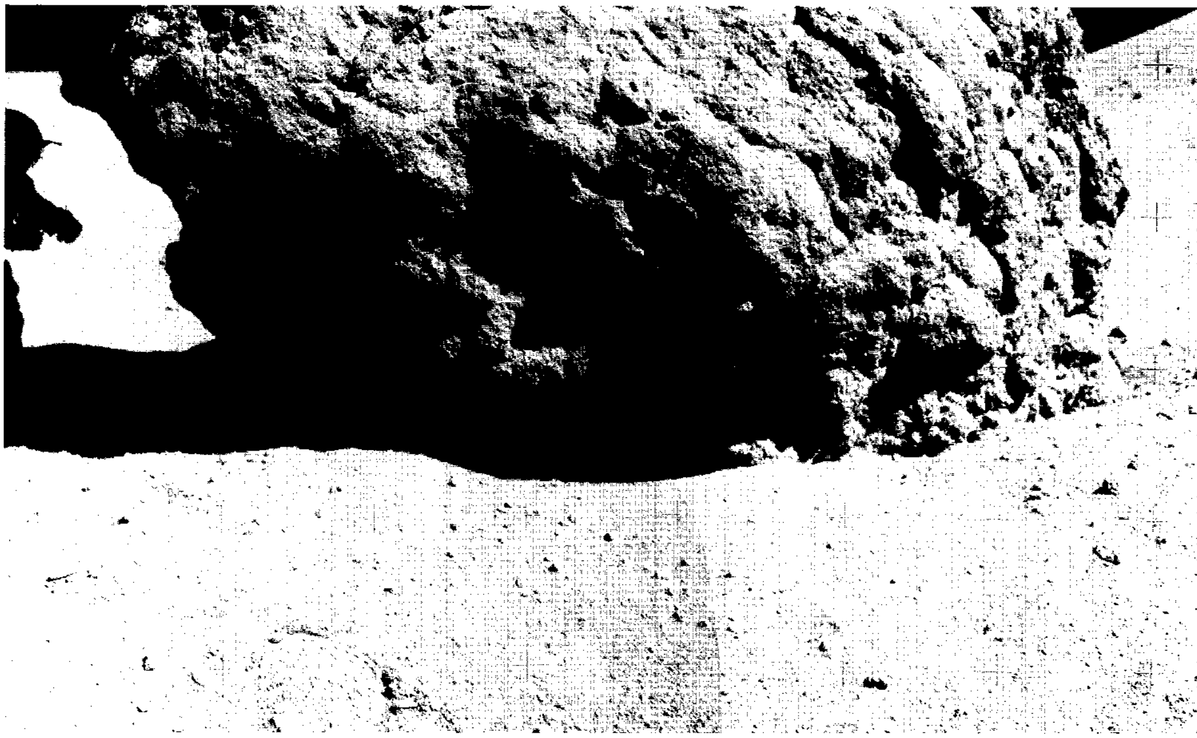


FIGURE 4-34.–The CDR prepares to sample material from the permanently shadowed area under the overhang at Shadow Rock. Close observation of the photographs indicates that Shadow Rock is a multirock breccia, a rock made up of other rock fragments that have been recombined to form a new rock. The holes or vesicles in the rock are much more elongated than previously observed; they appear to be more like vesicle pipes produced by venting gas. The rock also shows the presence of lineations, lines, or bands along the upper and right margin of the boulder. These bands may be caused by differences in lithology or may represent zones where the rock has been fractured and faulted (AS16-106-17413, 17415).

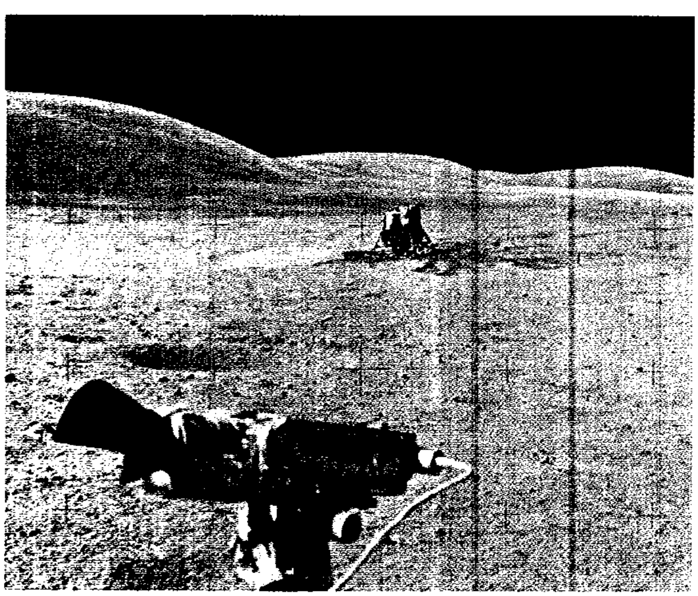


FIGURE 4-35.–This photograph was taken by the LMP from the LRV as the astronauts drove toward the LM near the end of the third EVA period. The dark areas around the LM are vehicle and boot tracks, which reflect the intense activity associated with the vehicle, ALSEP deployment, and sample collection. The ALSEP station can be seen along the right margin of the photograph. The white area just above the ALSEP station is composed of South Ray and Baby Ray Craters approximately 6 km in the distance. The light color is from the blanket of material that was ejected from the craters when they were formed. Just to the left of the LM is a crater that is approximately 25 m in diameter. The CDR flew the LM over this crater just before landing. Stone Mountain forms the skyline along the upper left in the photograph. The golden object in the foreground is the TV camera that provided the Earth with real-time coverage of the mission (AS16-117-18799).

FIGURE 4-36.–The CDR prepares to take samples at station 10 near the end of EVA-3. The gnomon minus the central staff marks the area to be sampled. Sample bags are held in the CDR's left hand, the cuff-card checklist is on his left arm, and the Hasselblad camera is mounted on the remote control unit on his chest. The sample collection bag, which is attached to the primary life support system, is seen behind the CDR's left arm. The LRV, with only a partial right rear fender, stands in the background. Light penetrates the woven wire tires. The tool carrier, handtools, the penetrometer, and the magnetometer extend upward from the rear of the vehicle. The low-gain antenna, the map packet, and the motion picture camera occupy the center of the vehicle. The disk of the high-gain antenna and the TV camera protrude from the front of the vehicle (AS16-117-18825).

COMMAND AND SERVICE MODULE ORBITAL PHOTOGRAPHY

During the period of separate operation of the LM and the CSM, the CM pilot (CMP) completed photographic assignments covering a wide range of targets and requiring the use of various combinations of cameras, lenses, and films (table 4-II) or operation of the complex SIM camera systems (table 4-III). The dominant CMP photographic task, measured in terms of both time and budgeted film, was lunar-surface photography. Other tasks included the documenting of operations with the LM and the photographing of Earth and deep-space targets in support of specific scientific experiments.

TABLE 4-II.–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, AEI 6; 2485 black-and-white film, ASA 6000; IIa-O 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 TEI, 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; handheld to document nearby objects such as SIM door after jettison and to photograph general targets inside and outside the CSM; bracket-mounted on sextant to document landmark tracking

TABLE 4-III.–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, eight 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 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, four 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, velocity/height, 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.

After the LM was cleared to remain on the lunar surface, the CMP turned to a heavy schedule of solo tasks. Revolutions 17 and 18 were used almost exclusively for photographic tasks. A 3-hr operating period for the mapping camera and two 30-min periods of panoramic-camera operation provided terminator-to-terminator coverage by both camera systems. Hasselblad targets that had slipped from earlier revolutions were photographed during these revolutions, and the CMP provided a running commentary on visual observations between and during the periods of camera operation.

The first full day of solo operations covered revolutions 23 to 30. Mapping-camera operations totaled approximately 6 hr on five successive revolutions (25 to 29) to provide vertical and oblique coverage of the lighted lunar surface and to provide stellar orientation for the laser altimeter during one pass across the unlit lunar surface. Panoramic-camera operation was limited to a 14-frame burst over the landing site on revolution 28. The CSM Hasselblad EL camera, used on most of the revolutions, photographed one orbital-science target and several targets of opportunity. Terminator photography scheduled in the Davy Rille area on revolution 23 was bypassed because the feature was still on the dark side of the terminator. As the terminator advanced, parts of the rille were photographed on each of the two following revolutions; two additional terminator targets were covered during this operating day. Highland terrain near the Descartes landing site was photographed on revolution 27 with the special lens, film, and filters specified for the UV photography experiment. Astronomical dim-light targets and photography of the lunar surface illuminated by earthshine occupied the Nikon camera on three revolutions. During revolution 31, the CMP entered a rest period that lasted until revolution 35.

The second full day of solo operations included approximately 7 hr of mapping-camera operation that provided 429 frames of lunar-surface imagery on three successive revolutions (37 to 39). Operation during the intervening dark-side passes provided stellar-camera attitude data to support laser-altimeter data analysis. During 32 min of panoramic-camera operation on two revolutions, 284 frames were exposed. The Hasselblad camera was used to photograph two orbital-science photographic targets and two sets of terminator images. Visual descriptions accompanied taking of the photographs. During revolution 41, more than one-half magazine of DAC film was exposed at slow frame rate while the deployed mass spectrometer boom was monitored. Gegenschein, solar-corona, and Gum Nebula photographs were taken with the Nikon 35-mm camera during the dark-side portions of three revolutions. The CMP entered a rest period during revolution 43.

The fourth rest period in lunar orbit ended during CSM revolution 46. Flight-plan changes read up to the CMP consumed much of the communication periods on several subsequent revolutions. After scheduled terminator photography and an orbital-science visual description on revolution 47 were canceled, the CMP requested assignment of two periods on several subsequent revolutions. After scheduled terminator photography and an orbital-science visual description on revolution 47 were canceled, the CMP requested assignment of two DAC magazines for photographing the scene passing the CM window on the following light-side pass.

The mapping camera was turned on in the far-side darkness of revolution 46 to begin a 3.5-hr operation period that yielded 196 frames of lunar imagery from light-side passes on revolutions 47 and 48. Starting near the far-side terminator, the panoramic camera operated for 32 min on revolution 47; close to the near-side terminator, the CMP briefly described extensive benches around positive features near the Riphaeus Mountains. On revolution 48, a solar-corona sequence was exposed and a large water bubble that had formed in the onboard gas separator was photographed. The requested DAC magazines recorded the lunar scene visible out the CM window throughout most of the light-side pass of revolution 48.

From the plane-change 1 burn shortly after acquisition of signal on revolution 49 to LM lift-off on revolution 52, operational tasks and flight-plan modifications occupied most of the CMP's time. Gegenschein photography near the end of revolution 49 and sextant-mounted DAC documentation of landmark tracking during revolution 51 were accomplished as scheduled. An area near the Riphaeus Mountains, where the CMP had described low benches around most positive features, was photographed during revolution 50 as a target of opportunity. Figures 4-37 to 4-50 are representative photographs from the orbiting CSM.

The remotely controlled, LRV-mounted TV camera permitted earthbound viewers to watch the LM lift-off from the lunar surface during CSM revolution 52. A special photographic and visual survey of the LM followed the revolution 53 rendezvous because flying debris seen during lift-off suggested to some observers a possible failure of the LM insulation.

Sample and equipment transfer, LM shutdown tasks, and extensive flight-plan changes occupied the remainder of the working day after the successful docking. As the crew rested during revolutions 53 to 59, the planning teams reevaluated priorities and modified experiment schedules in terms of the shortened mission and the decision to drop the plane-change 2 maneuver. The final wakeup in lunar orbit began a day of extensive updates to the flight plan.

Mapping-camera operations totaled 2 hr 20 min of revolutions 59 and 60. To document possible anomalies in the rates of cover movement or camera extension, the mapping camera was started a few seconds before opening the cover and was stopped after cover closing was completed. Detailed analysis of positions relative to the image of the gamma-ray boom in frames near the ends of the sequence will document the regularity of movement.

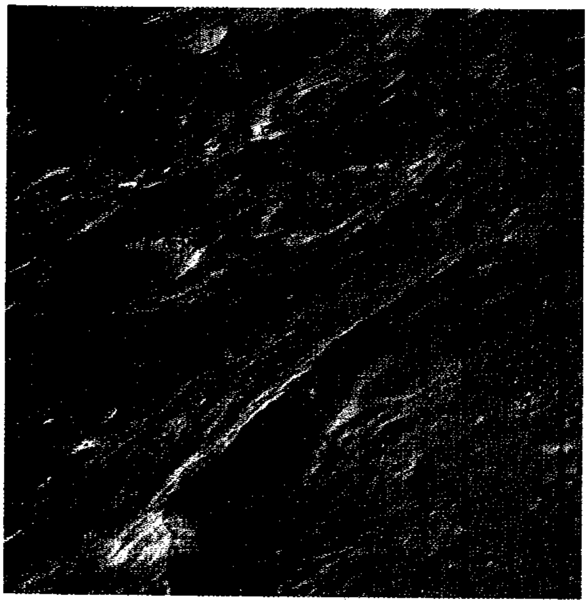


FIGURE 4-37.–West wall of the far-side Crater Lobachevsky. The CMP described a black flow associated with a small crater in the wall of a large far-side crater. This oblique telephotograph northwestward across terrain in and northwest of Lobachevsky, an 80-km-diameter crater centered near latitude 9° N, longitude 113° E, shows a 2.5-km-diameter crater near the top of the west wall of the large crater. A tongue of low-albedo material extends approximately 2 km down the steep wall of Lobachevsky from the low point on the rim of the small crater (AS16-121-19407).

FIGURE 4-38.–Alpetragius Crater. Shadows are rare in this high-Sun, oblique view southward across Alpetragius. This 35-km-diameter neighbor of the Crater Alphonsus has a conspicuous, dome-like central peak larger than 10 km in diameter. The southwest rim of Alphonsus cuts the lower left corner of the frame (AS16-119-19057).

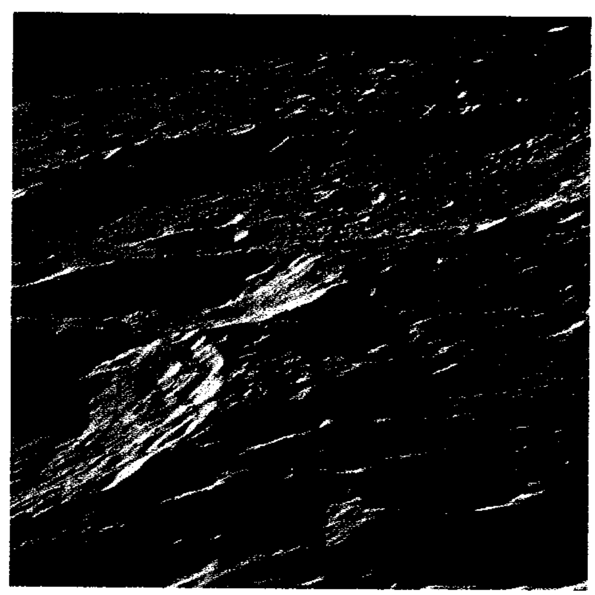


FIGURE 4-39.–Highland terrain illuminated by a low Sun. Anderson, the large crater that extends across the frame, is centered near latitude 16° N, longitude 171° E, in terrain that is typical of the far-side highlands. Sun elevations in this oblique view toward the northwest range from approximately 6° at the lower right corner of the frame to 12° at the far rim of Anderson. The high proportion of shadow in highland terrain demonstrates the abundance of slopes exceeding the Sun elevations (AS16-118-18905).

Jettison of the LM on revolution 62 was documented by DAC photographs. Operating periods of 1 hr for the mapping camera and 35 min for the panoramic camera during revolution 63 completed the SIM-bay camera orbital photography; a long strip of 250-mm Hasselblad photographs documented terrain south of the SIM camera coverage from Vogel Crater to the near-side terminator. Preparations for the TEI burn occupied revolution 64, the last in lunar orbit. Figures 4-51 and 4-52 are views of the LM ascent stage after lunar lift-off.

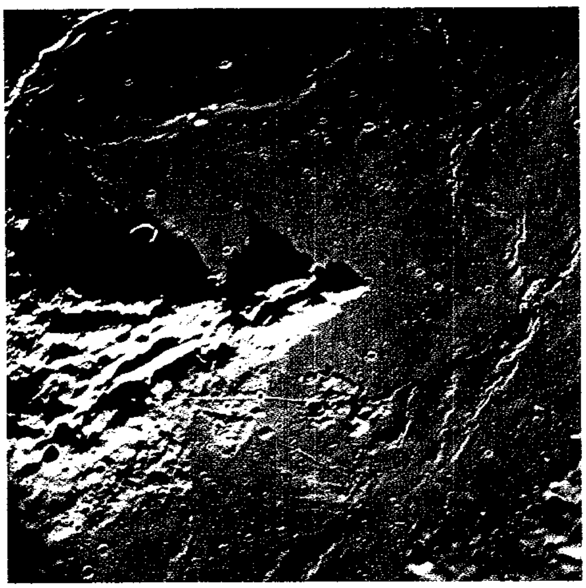


FIGURE 4-40.–Typical mare terrain illuminated by a high Sun. The smooth surface of the Sea of Clouds approximately 20 km west of the Crater Lassell C is pocked by craters as large as 6 km in diameter. A conspicuous 3-km-diameter crater and scattered craters less than 200 m across exhibit bright halos when illuminated by a Sun 35° to 40° above the eastern horizon. The craters without halos appear almost as sharp as the bright-halo craters; Sun-facing crater walls commonly are brighter than adjacent rim deposits. Most craters have low, narrow rims that merge imperceptibly with the adjacent mare materials. An anomalously dark 3-km-diameter crater in the lower right quarter of the frame has no detectable halo, either light or dark. The Sun-facing wall is approximately as dark as the adjacent mare materials; the rim does not merge with the surrounding mare because of a sharp change in slope along its outer margin (AS16-119-19071). (Compare with fig. 4-42 (AS16-120-19223).)

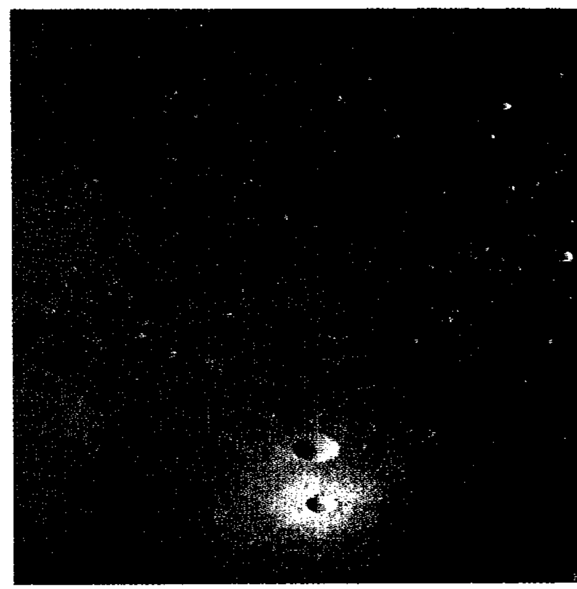


FIGURE 4-41.–Mixed mare and highland terrain illuminated by a low Sun. In this oblique view westward across the mare-flooded Crater Letronne, Sun elevations range from approximately 6° at the lower right corner to 0° near the upper left corner. This low illumination shows the ropy features mapped as mare ridges to be superimposed on gentle swells generally 5 to 10 km wide; yet, except within craters, shadows are rare on the mare materials. By comparison, large areas of the highland materials are shadowed at elevations as great as 6° in the lower half of the photograph. Approximately half the rim of the 110-km-diameter Crater Letronne is exposed. The crater is centered near latitude 10° S, longitude 42.5° W (AS16-122-19553).

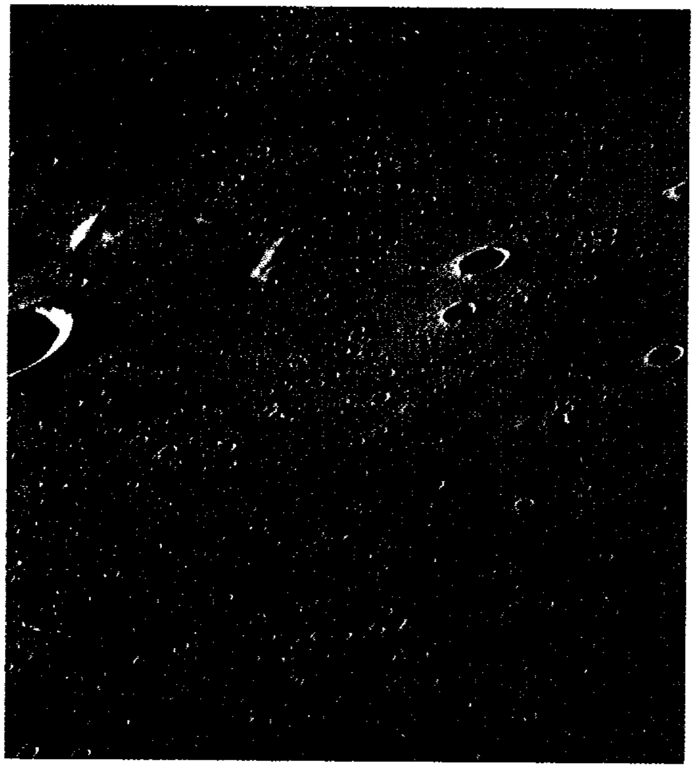


FIGURE 4-42.–Mare terrain illuminated by a low Sun. The Sea of Rains west of the Crater Lassell C is illuminated by an extremely low Sun. Sun elevation ranges from 3° to 4° along the left margin of the frame and from 1° to 2° along the right margin. (Compare the upper right quarter of this figure with the lower right quarter of fig. 4-41 (AS16-119-19071). Four prominent craters permit correlation of the two figures.) The low Sun enhances the detectability of faint slopes. Numerous linear patterns similar to features that have been described as flow fronts or faint mare ridges cross the surface that appeared smooth under the higher Sun. The crater population appears to have increased because the faint depressions that were inconspicuous at higher Sun now are marked by hard shadows. The prominent bright halo of the 3-km-diameter crater has faded. Although not conspicuous, the dark 3-km-diameter crater retains its anomalously dark Sun-facing inner wall and the break in slope at the outer margin of the rim which set it apart at higher Sun (AS16-120-19223).

FIGURE 4-43.–Southeastern Alphonsus Crater. The dark-halo crater and the rilles near the bottom of the frame are in the southeastern quarter of the floor of Alphonsus. Grooves or irregular valleys, like the conspicuous feature extending upward from the base of the wall near the dark-halo crater, are the dominant crater wall structures in the eastern half of Alphonsus. These features are radial to the Imbrium Basin and are part of that family of widespread structures called Imbrium sculpture. Terraces, which are more typical of the walls of large craters, predominate on the northern wall of Arzachel Crater at the extreme top of the frame (AS16-119-19050).

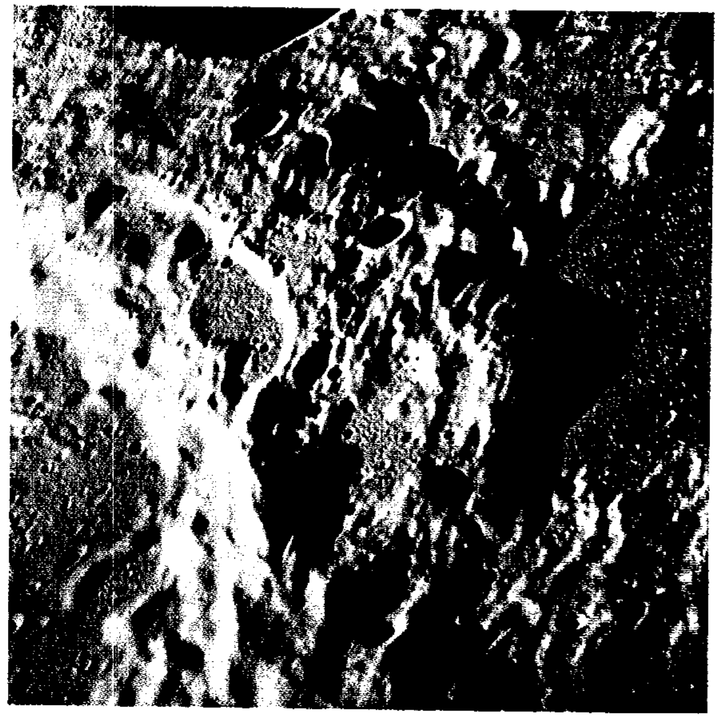


FIGURE 4-44.—Oblique view southeastward along the southwestern rim of the Crater Alphonsus. Smooth terrain at the right side of the frame is the eastern Sea of Clouds. Deep shadows at the top of the photograph are in the Crater Alpetragius. The dark-halo-crater area on the western floor of Alphonsus, considered as a candidate site during the selection of the landing sites for the Apollo 16 and 17 missions, is at the lower left corner of the photograph. The albedo contrast between the normal Alphonsus floor and dark-halo material is not striking at this viewing angle and low Sun elevation. The dark-halo material is approximately 100 km south of the groundtrack as this photograph was exposed. Note the large pockets of flat terrain similar to the Alphonsus floor that are perched at intermediate levels up the terraced western wall of Alphonsus (AS16-120-19222).

FIGURE 4-45.—Gassendi Crater. Low Sun illumination enhances the contrast between the rough and cracked surface on the floor of Gassendi and the smoother surface of the Sea of Moisture beyond the low crater rim at the top of the frame. The high northern rim of Gassendi is at the lower right corner of this oblique view southward across the 110-km-diameter crater. Gassendi was one of three candidate sites for the Apollo 17 lunar landing mission; sampling and study of the central peak complex would have been the scientific objective of the proposed mission. The shadow at the lower left corner of the frame conceals the floor of the Crater Gassendi A (AS16-120-19295).

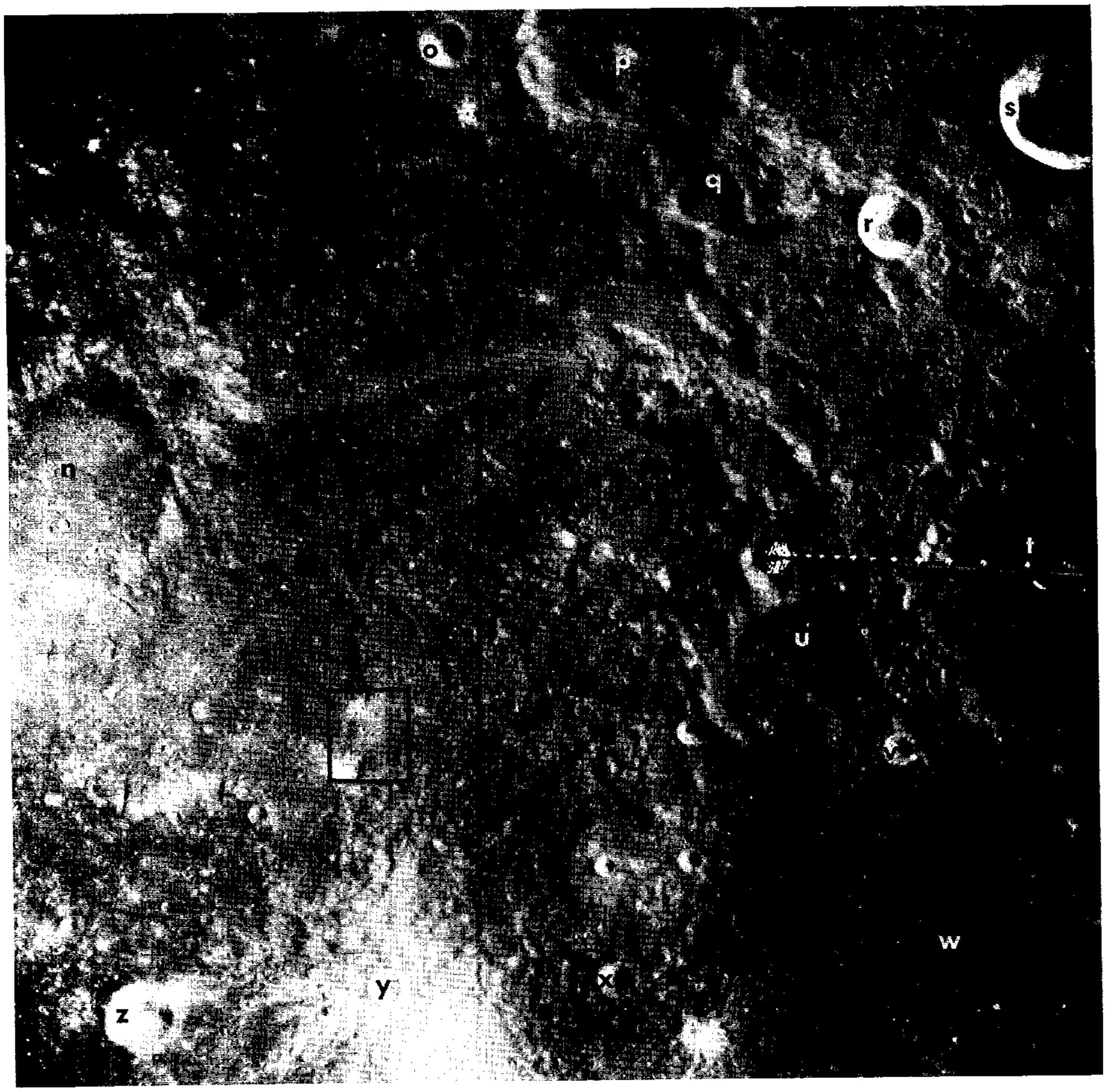


FIGURE 4-46.–The Apollo 16 landing site and surrounding terrain is illuminated by a moderately high Sun in this mapping-camera frame exposed on CSM revolution 47. North is at the top of the frame, which is alined within 5° of the selenographic grid. Sun elevation ranges through 6° across the 180- by 180-km surface area, from 49° along the east side to 43° along the west. The Apollo 16 landing site is within the rectangular outline, which indicates the area of figure 4-47. The mass spectrometer boom, mounted behind the mapping camera in the SIM bay, extends into the field of view from the east side of the frame. Selected craters are identified by the letters n to z. The 11-km-diameter Crater Alfraganus C (r) near the northeast corner is one of several sharp craters with minor accumulations of floor materials. Others include Taylor D (o), Zöllner E (v), Dollond (z), Dollond E (y), and Dollond M (x). Other craters have smooth to slightly degraded walls and abundant filling that forms floors ranging from textured to smooth. Examples are Alfraganus (s), Zöllner D (u), Taylor E (q), and Kant B (w). The three named craters larger than 30 km in diameter, Taylor (p), Zöllner (t), and Dollond B (n), are highly degraded. Dollond B (n) has a flat, filled floor; the other two have sparse floor deposits. The north rim of Descartes Crater is approximately 20 km south of Dollond E (y), just outside the south boundary of the photographed area (Apollo 16 mapping-camera frame 2179).

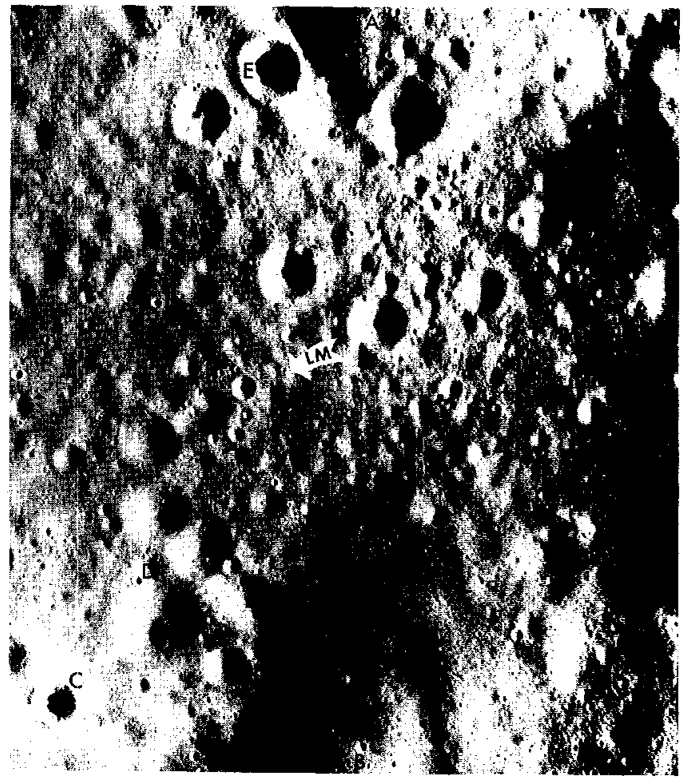


FIGURE 4-47.–Position of the landed LM is shown on this panoramic-camera image of the landing site. The Sun was only 17° above the eastern horizon when this frame was exposed; western slopes on Smoky (A) and Stone (B) Mountains are shadowed. Rays extending outward from South Ray (C) and Baby Ray (D) Craters are sharp but not conspicuous; the rays of North Ray Crater (E) are hardly detectable in this low-Sun illumination (part of Apollo 16 pan-camera frame 4563).

FIGURE 4-48.–Herigonius Crater. The 16-km polygonal crater Herigonius is centered near latitude 13.5° S, longitude 34.0° W, near the southern margin of the Ocean of Storms. Part of the irregular crater floor and the extensive ejecta blanket west of the crater can be seen with greater clarity in this photograph than in any available before the Apollo 16 mission (AS16-119-19156).

FIGURE 4-49.–Telephotographic view southward across the Sea of Clouds to the Mercator Scarp. Bullialdus, a 60-km-diameter crater centered near latitude 21° S, longitude 22° W, and the two smaller craters, Bullialdus A and B, dominate the foreground. Ejecta deposits associated with the three craters are extensive (AS16-119-19094).

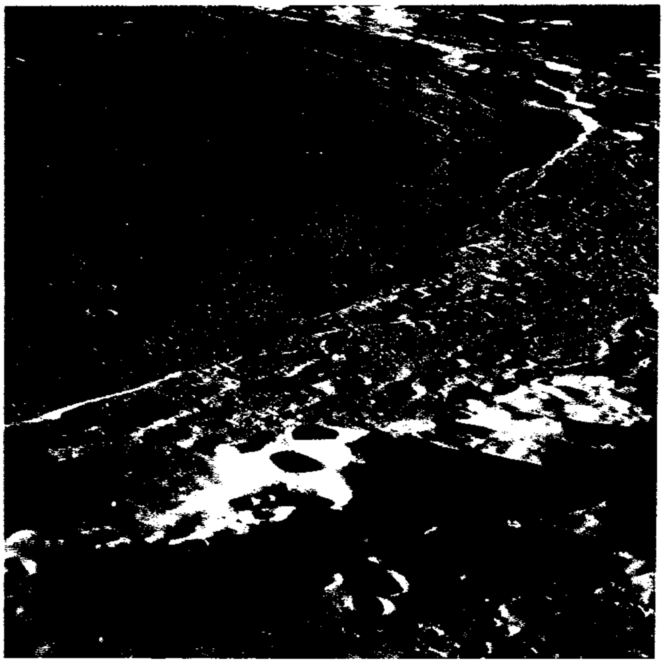


FIGURE 4-50.–Oblique view southward along the western margin of the Sea of Moisture. The sharp contact between smooth mare deposits and rougher highland materials has been mapped as Mersenius Rille Number III. Note that the mare deposits stand higher than the highland block near the center of the photograph, whereas the highlands stand higher along both sides of the frame (AS16-120-19323).

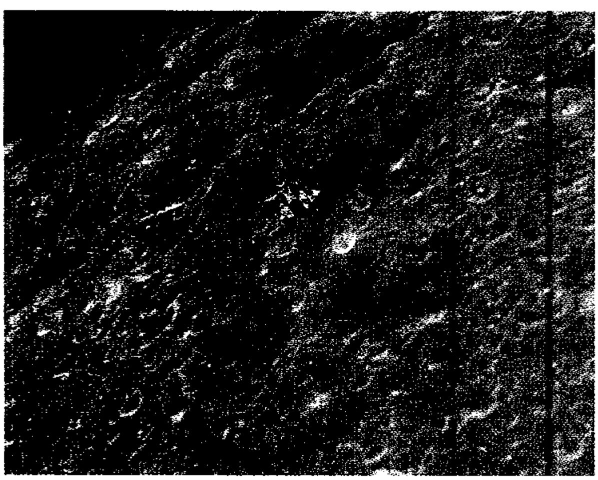


FIGURE 4-51.–The LM ascent stage approaches rendezvous above rugged highland terrain east of the Foaming Sea. The LM conceals terrain near latitude 1° S, longitude 70° E, in this view westward across heavily cratered highlands between Smyth's Sea and the Sea of Fertility. High Sun illumination enhances the albedo difference. At the horizon, smooth mare deposits in the northeastern Sea of Fertility are broken by ridges and craters northwest of the Crater Langrenus (AS16-122-19530).

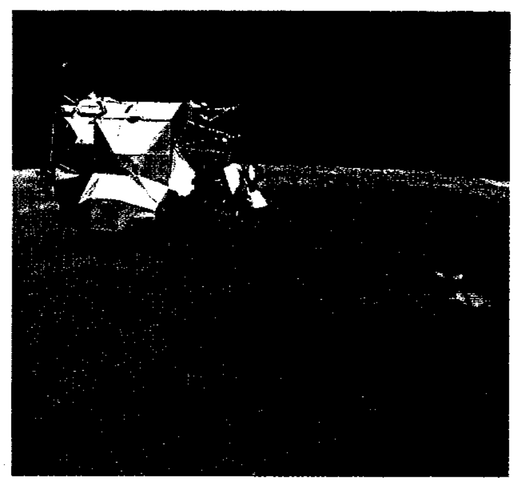


FIGURE 4-52.–The LM ascent stage over the Sea of Fertility. Before docking, the LM ascent stage maneuvered to permit complete inspection by the CMP. The distinctive Craters Messier and Messier A are near the right edge of this view westward across the Sea of Fertility. Extensive ray systems, bright crater walls, and bright halos stand out sharply because of the high Sun angle. Highlands separating the Seas of Tranquility and Nectar to the west of the Sea of Fertility form the irregular horizon beyond the LM (AS16-122-19536).

TRANSEARTH PHOTOGRAPHY

As the CSM came around the Moon headed toward the Earth, the crew photographed earthrise (fig. 4-53), the first TEC earthrise sequence documented by an Apollo crew. Hasselblad photographs of the lunar surface (figs. 4-54 to 4-57) were exposed over an extended period as the Moon receded. Many frames have provided significant supplementary coverage; some provided the best coverage of far-side areas north of the equator that have been obtained. The mapping camera exposed 442 frames during 2.5 hr of operation. After TEI, the panoramic camera exposed 171 frames (fig. 4-58) before the film was exhausted. This sequence could provide basic data for evaluating the use of similar camera systems in a whole-Moon photographic survey when lunar exploration is revived. An hour after TEI, a sequence of UV photographs of the Moon ended the Moon phase of the UV photography experiment. Approximately 3 hr into TEC, the crew shared views of the receding Moon (fig. 4-59) with the Earth by way of television. A 9-hr rest period began 3.8 hr after the TEI burn.

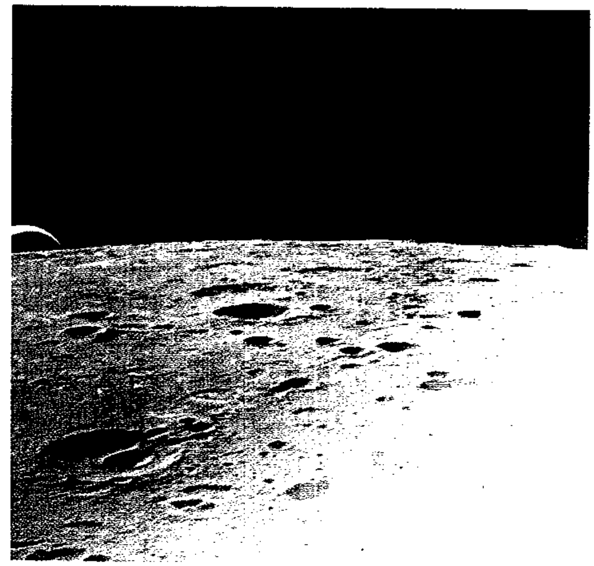


FIGURE 4-53.–Crescent Earth rises as the Apollo 16 crew heads home. This frame is from the first earthrise sequence photographed after TEI by an Apollo crew. The large crater in the lower left quarter of the frame is Chang Heng, a 35-km-diameter crater centered near latitude 18.5° N, longitude 111.5° E (AS16-122-19563).

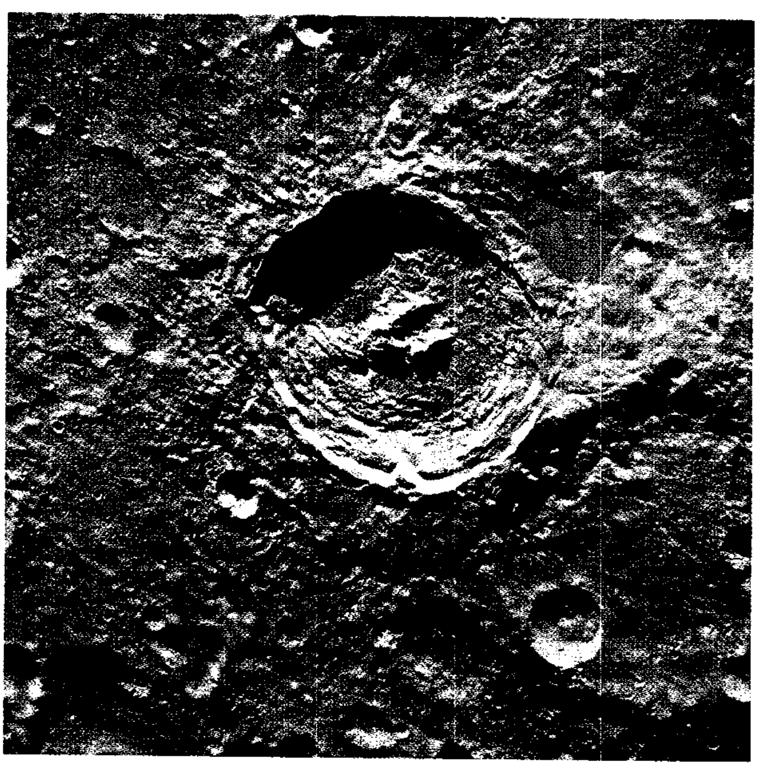


FIGURE 4-54.--Post-TEI view of King Crater near latitude 5.5° N, longitude 120.5° E. King has an unusual central peak. The crater was the subject of visual observations and photography on more than one revolution during the Apollo 16 mission. Oblique views from orbit show specific features in and near the crater in greater detail. See also figures 4-55 (AS16-120-19268) and 4-56 (AS16-120-19273). North is to the right in this near-vertical view (AS16-122-19580).

After the initial period of high activity, photographic tasks were minimal throughout TEC. Following completion of the first rest period, the mapping camera was operated with the cover closed until the film supply was exhausted. The CMP recovered film cassettes from the mapping-camera system and from the panoramic camera during a 1-hr EVA period approximately 18 hr after the TEI burn (fig. 4-60). Television and DAC photography documented the activity outside the depressurized spacecraft. Sequences of still and DAC photography during the second day of TEC documented experiments supporting the Skylab Program. The final sequence of UV photographs of Earth was exposed during the third day of TEC, approximately 3 hr before splashdown. Reentry, documented by the window-mounted DAC, closed this successful photographic mission. Splashdown is shown in figure 4-61.

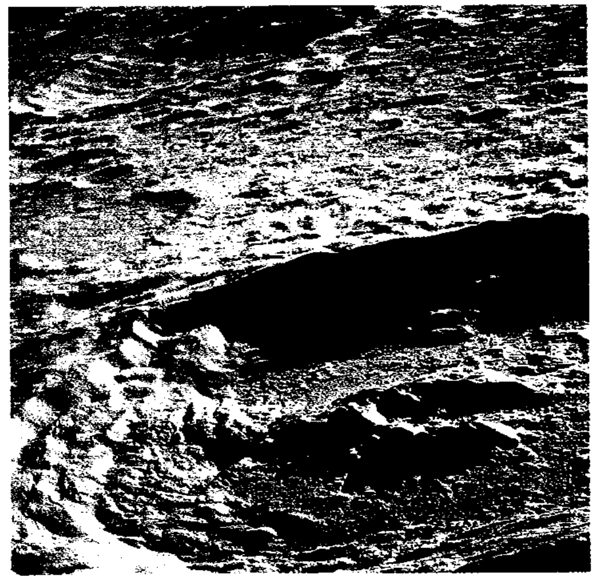


FIGURE 4-55.–Oblique view southwestward across King Crater. The wishbone-shaped central peak and the terraced southern wall are clearly visible in this 250-mm Hasselblad photograph. The crater near the upper left corner of this frame is Abul Wáfa, which is centered near latitude 1.5° N, longitude 116.5° E (AS16-120-19268).

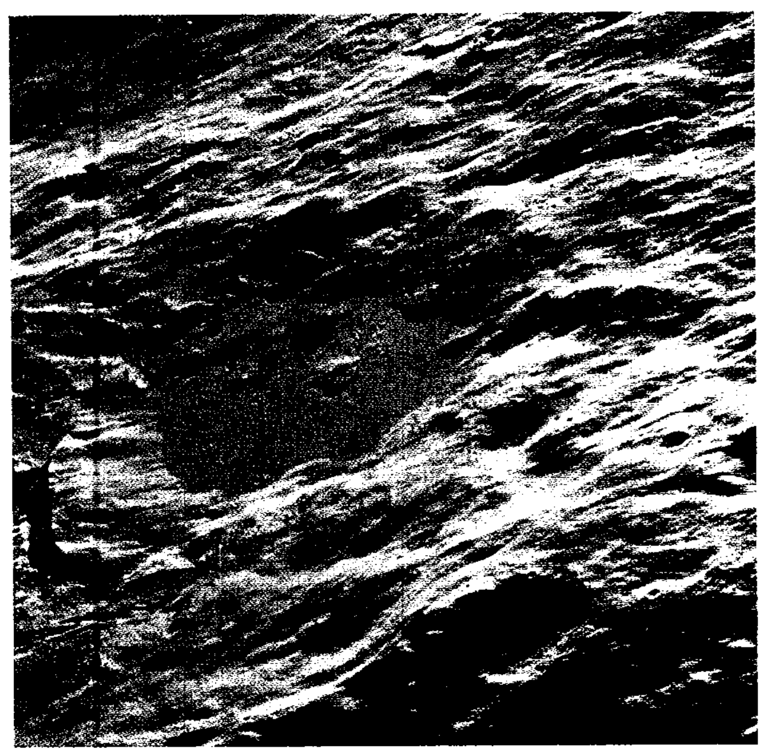


FIGURE 4-56.–Partly filled crater north of King. The smooth, flat filling resembles mare material except that it is lighter in color. Note the numerous small "ponds" with similar filling materials that are perched at various levels above the floor in rim deposits of the crater. Similar ponds have been described near Tycho and Copernicus Craters. The north rim of King Crater extends into the left side of this oblique view westward (AS16-120-19273).

FIGURE 4-57.–Post-TEI view northwestward across farside terrain. The irregular, shallow crater with a flat floor to the left of frame center is the 70-km-diameter Crater Artamonov located near latitude 26° N, longitude 104° E. A straight chain of craters trends northwest farther than 170 km, with minor interruptions, from near the lower edge to the center of the frame. At the upper left corner of the frame, the crater with the smooth, dark floor is the 95-km-diameter Crater Lomonosov (AS16-122-19575).

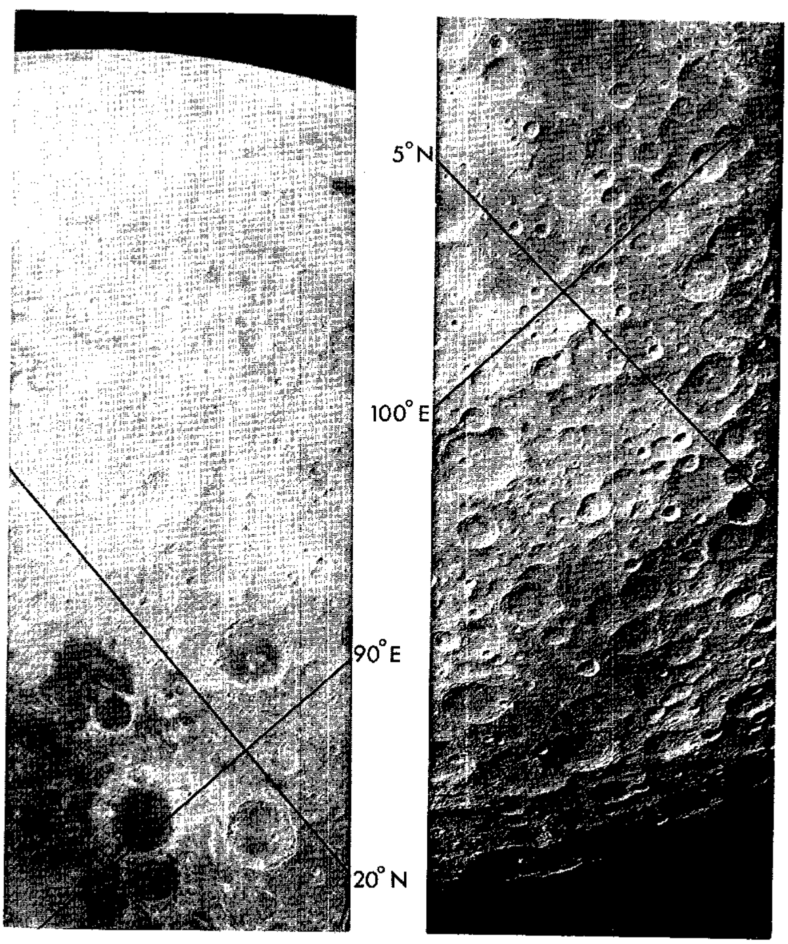


FIGURE 4-58.–Panoramic-camera frame exposed after TEI. The frame is centered near latitude 13° N, longitude 93° E, and spans the lunar disk with its long axis oriented northwest-southeast. The frame has been cut in half; the northwest half is on the left side of this figure, the southeast half is on the right. Approximate selenographic coordinates are indicated on each half of the figure. Near the southeastern limb, an extremely low Sun illuminates the crater Tsiolkovsky, which is centered near latitude 20° S, longitude 129° E. The Crater Hercules, centered near latitude 47° N, longitude 39° E, is illuminated by a high Sun near the northwest limb. The large area of mare material near the northwestern limb is in the Lake of Dreams northeast of the Sea of Serenity (Apollo 16 pan-camera frame 5586).

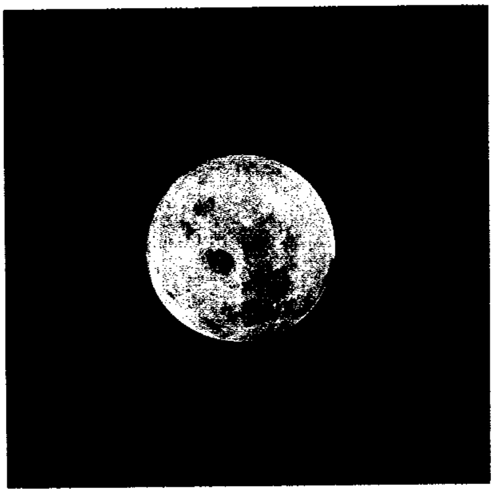


FIGURE 4-59.–Post-TEI view of the Moon. This Hasselblad EL photograph was exposed after the TEC trajectory had carried the CSM high above a point near the lunar equator at approximately 55° E longitude. Near-full-Moon illumination accentuates the difference in albedo and permits detailed examination of the extensive ray patterns associated with craters that are near or beyond the eastern limb when the Moon is viewed from the Earth (AS16-121-19451).

FIGURE 4-60.–Transearth coast extravehicular activity. The CMP left the depressurized CM during the TEC to recover film from the SIM camera systems. The CMP is assisted by the LMP, who is standing in the open CM hatch. This view is a frame from DAC motion pictures of the EVA (S-72-37001).

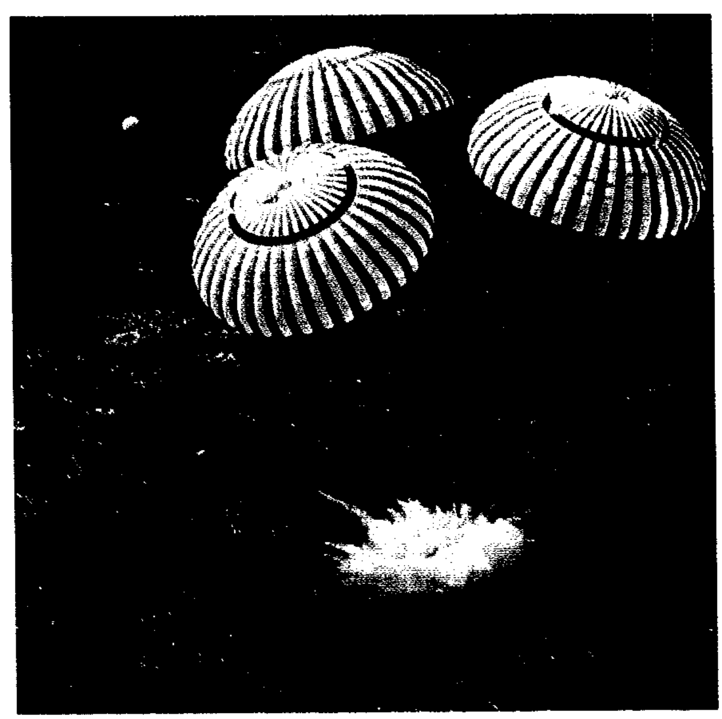


FIGURE 4-61.–Apollo 16 splashdown. The CM entered the central Pacific Ocean approximately 215 miles southeast of Christmas Island to successfully conclude the Apollo 16 mission 265 hr 51 min after launch. Television cameras on board the U.S.S. Ticonderoga and its helicopters transmitted real-time coverage of the landing to the world by way of communication satellites (S-72-36293).