1. Photographic Summary of Apollo 11 Mission

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The geographical exploration of new frontiers has usually occurred many years before scientists visited and studied the areas in detail. For example, the existence of Antarctica as a continent was known from the time Charles Wilkes explored 1500 miles of the coastline in 1840. However, extensive Antarctic exploration did not begin until the 20th century with the voyages of Scott, Amundsen, Shackleton, and Byrd. It was not until the International Geophysical Year (July 1957 to December 1958) that scientists from 12 countries began conducting an ambitious Antarctic research program. In this respect, the first manned lunar exploration was unique. The scientific experiments were carefully planned, and the astronauts were trained as surrogates for scientists representing many disciplines.

A brief description of the Apollo 11 mission, illustrated with photographs taken by the astronauts during the mission, is presented. All photography in this chapter was taken on 70-mm film with Hasselblad cameras except figure 1. The cameras have a motor-driven mechanism powered by two nickel-cadmium batteries to advance the film and cock the shutter after each picture is taken. The photographs taken from the command module (CM) were made with 80- or 250-mm lenses. The lunar surface photography was taken with 80- and 60-mm lenses. The small crosses seen in the lunar surface photography are reseau marks that are used for calibration purposes during postflight data reduction. A 16-mm sequence camera for data acquisition was used to document many phases of the mission.

During the mission, 9 magazines of 70-mm film and 13 magazines of 16-mm film were exposed. The black and white photography was taken on type 3400 Panatomic-X film emulsion on a 2.5-mil Estar polyester base. Ektachrome EF SO168 color film on a 2.5-mil Estar polyester base was exposed on the lunar surface. The higher speed of this color film was expected to be more suitable for lunar surface photography because of the low light levels anticipated and confirmed to exist on the lunar surface. Other color 70-mm exposures of the Earth and Moon were taken on Ektachrome MS SO368 color reversal film on a 2.5-mil Estar polyester base.

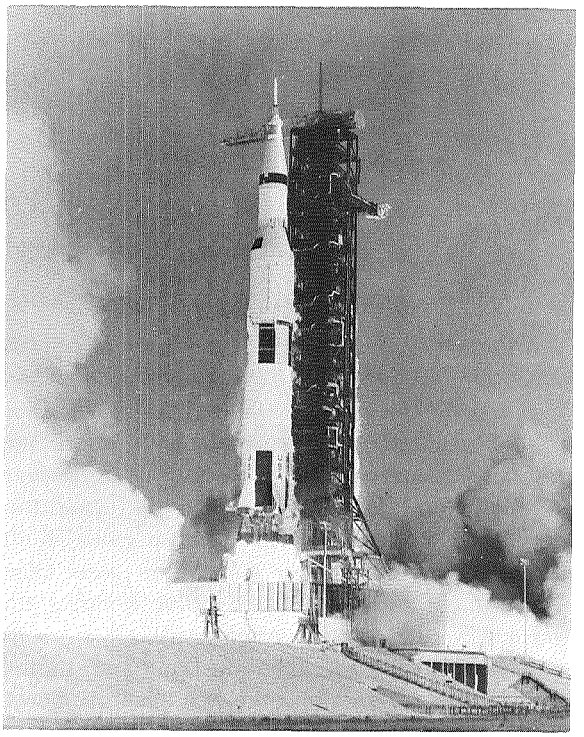
The 16-mm film taken during lunar module (LM) descent provided the first accurate knowledge of the exact landing point on the lunar surface. The 70-mm photographs taken on the lunar surface provided panoramic views of the surface near the landed LM and allowed detailed topographic mapping of the lunar surface near the landing point.

The photographs shown are only a sample of those obtained. Study of the photography will continue for many years.

Launch, Earth Orbit, and Translunar Coast

The Apollo 11 spacecraft was launched at 13:32:01 G.m.t. on July 16, 1969, from Cape Kennedy, Florida. All times indicated later in this chapter are stated in hours and minutes from launch time (ground elapsed time (g.e.t.)), to the nearest minute. At 3 min after launch, Saturn V first-stage (S–IC) engine cutoff and second-stage (S–II) engine ignition occurred, and the launch escape tower was jettisoned. At 9 min after launch, S–II engine cutoff and third-stage (S–IVB) engine ignition took place. Earth-orbit insertion of the spacecraft was achieved at 12 min after launch.

After 2 hr and 33 min in Earth orbit, the S–IVB engine was reignited for acceleration of the spacecraft to the velocity required for Earth-



gravity escape. At 3:17 g.e.t., the command and service module (CSM) was separated from the S–IVB, turned around, and docked with the LM. The LM was removed from the S–IVB at 4:17 g.e.t.

Provision was made in the flight plan for four midcourse corrections (using the service module propulsion system to refine the spacecraft trajectory); however, the only necessary midcourse correction took place at 26:45 g.e.t. Lunar-orbit insertion of the spacecraft began at 75:50 g.e.t.

FIGURE 1-1. – On July 16, 1969, at 9:32 A.M. e.d.t., 7½ million lb of thrust lifted the Apollo-Saturn V spacecraft carrying Astronauts Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin, Jr., from the launch site at Cape Kennedy.

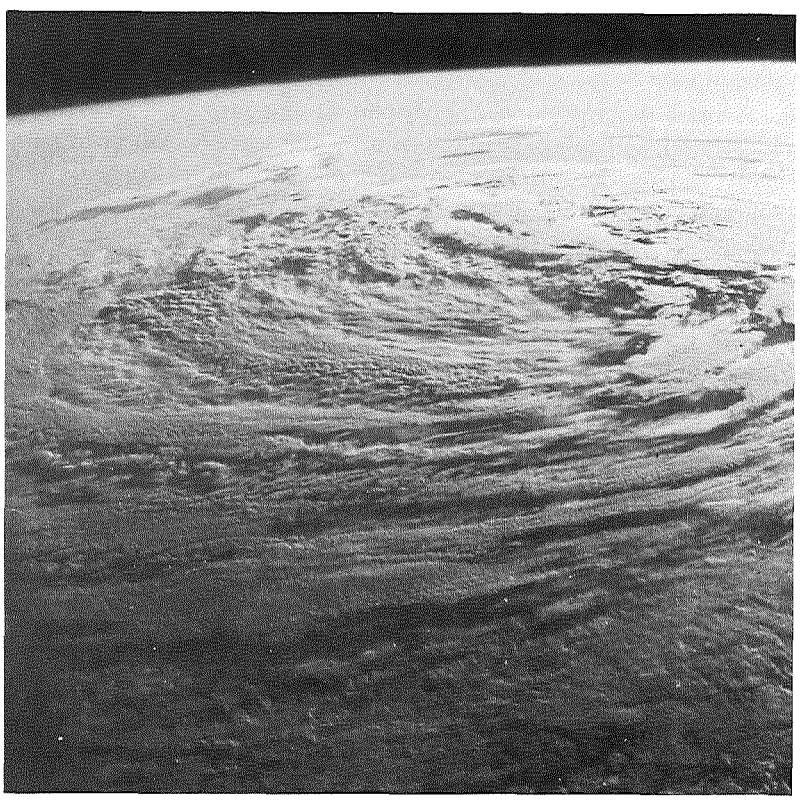


FIGURE 1-2. – Shortly after translunar insertion, the astronauts photographed Tropical Storm Bernice in the western Pacific Ocean off the coast of Baja California. (NASA AS11–36–5298)

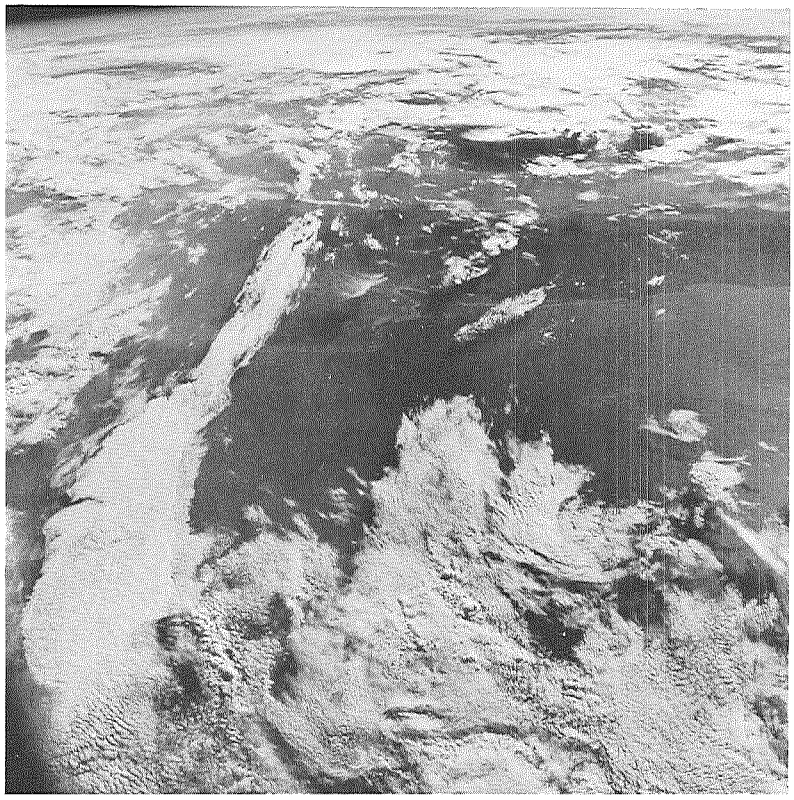


FIGURE 1-3. — Compare this westward view (NASA AS11–36–5300) of the central portion of Baja California, taken shortly after the spacecraft left Earth orbit on a trajectory to the Moon, with the next picture.

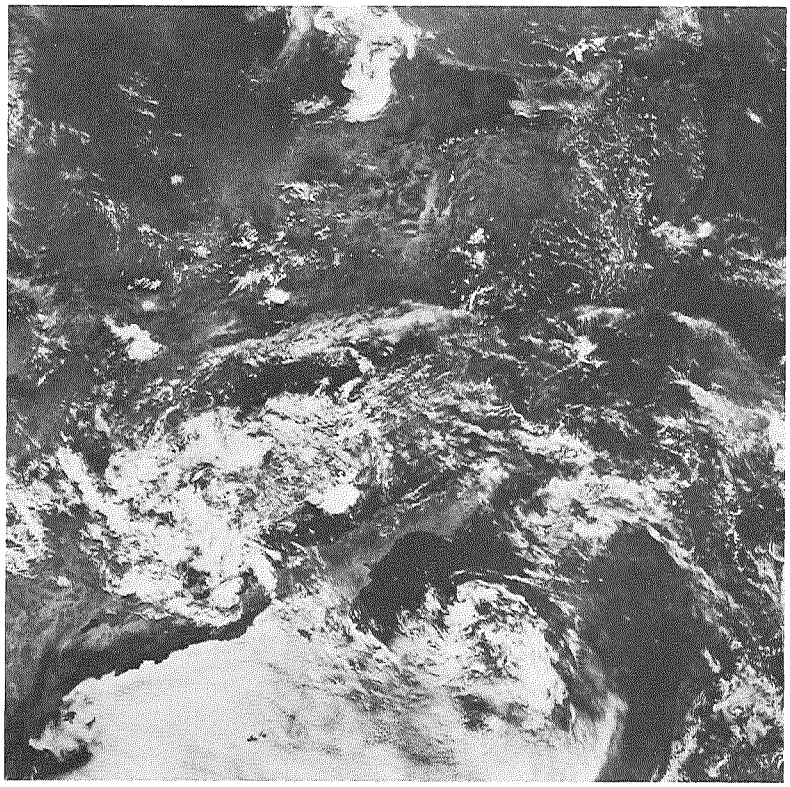


FIGURE 1-4. — This view (NASA AS11–36–5308) of the southern portion of the North American Continent shows Baja California again, the coast of southern California, and the mountains of Mexico.

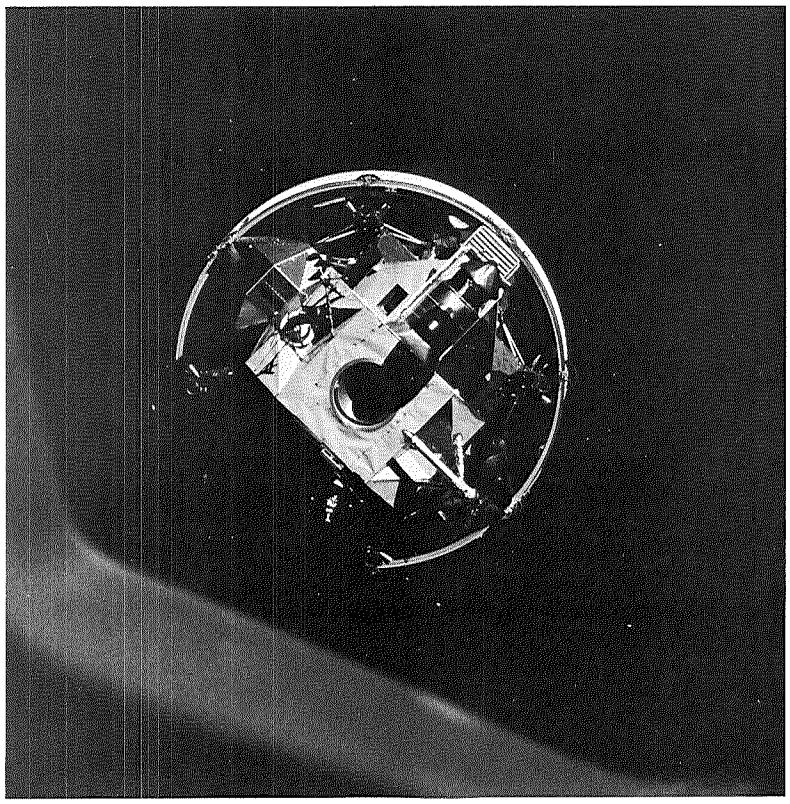


FIGURE 1-5. — Separation of the CSM from the S–IVB occurred at 3:17 g.e.t. The panels that protected the LM during launch were ejected, and the CSM was docked with the LM at 3:25 g.e.t. This photograph (NASA AS11–36–5313) was taken shortly before docking.

FIGURE 1-6. — This photograph (NASA AS11–36–5355) of the Earth, taken from a distance of more than 100 000 n.mi., was made approximately 25 hr after launch. The Eastern Hemisphere was remarkably cloud-free.

Lunar Orbit

The lunar-orbit insertion maneuver was begun at 75:50 g.e.t. The spacecraft was placed in an elliptical orbit (61 by 169 n.mi.), inclined 1.25° to the lunar equatorial plane. At 80:12 g.e.t., the service module propulsion system was reignited, and the orbit was made nearly circular (66 by 54 n.mi.) above the surface of the Moon. During each 2-hr orbit, the terminator (the line between daylight and darkness) moved westward across the Moon at the rate of approximately ½ deg per hour (30 km per orbit).

During the 59 hr and 34 min of spacecraft lunar orbit, approximately 210° of the lunar surface below the spacecraft orbit was illuminated by the Sun and could be photographed. At the orbital altitude, the lunar horizon was approximately 300 n.mi. from the spacecraft nadir.

Photographs taken from lunar orbit provide synoptic views for the study of regional lunar geology. The photographs are used for lunar mapping and geodetic studies, and they have been valuable in training the astronauts for future lunar missions. The following selected photographs, taken from lunar orbit, are arranged in geographical sequence from the far-side terminator to the nearside terminator, without regard to the times at which they were taken. The regions of the Moon covered by the selected photographs are plotted on the map that follows.

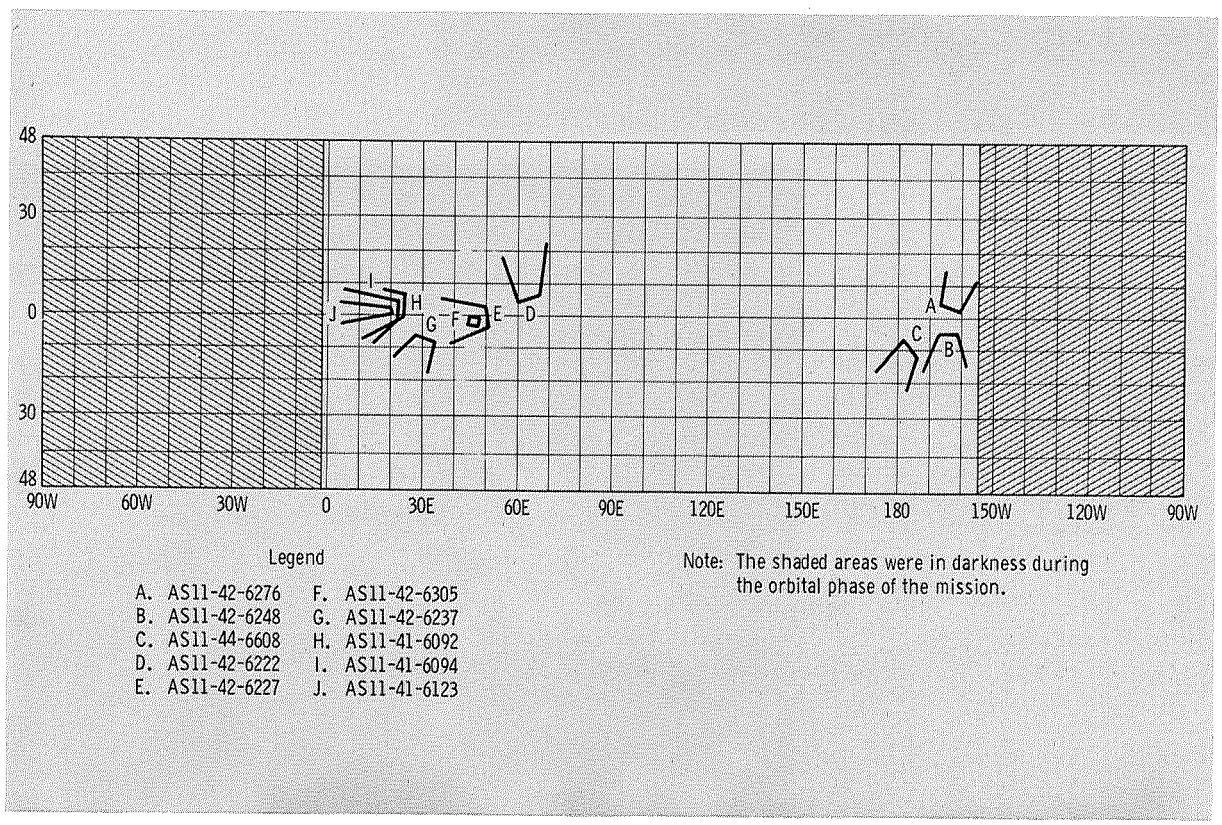


FIGURE 1-7. — This diagram shows the approximate areal coverage plot of selected orbital photographs.

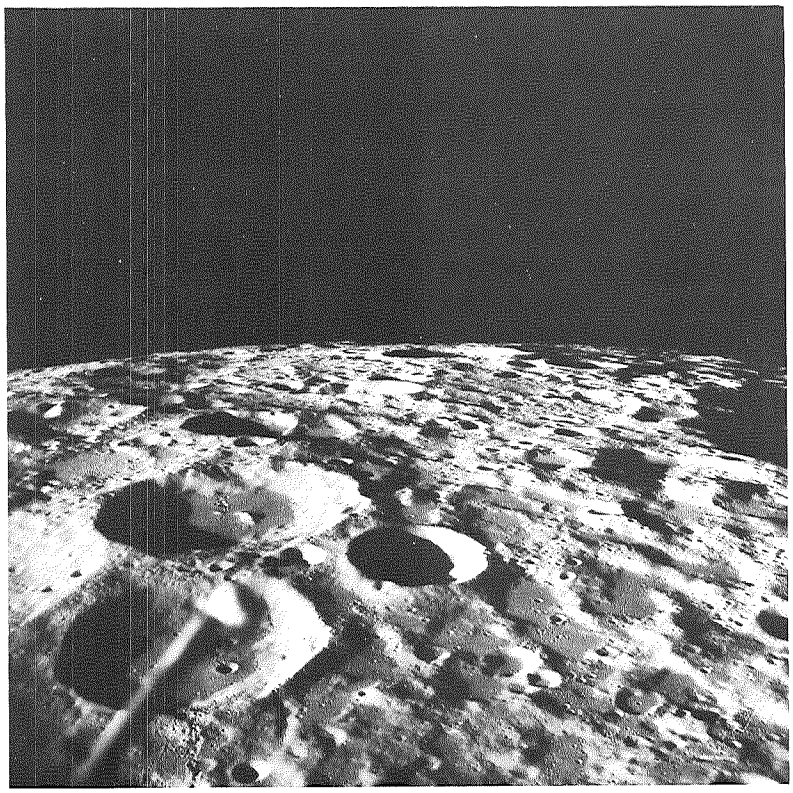


FIGURE 1-8. — The view in this photograph (NASA AS11–42–6276) is toward the northeast near the far-side terminator. The view is centered at 10° N, 163° W. The features shown are not named.

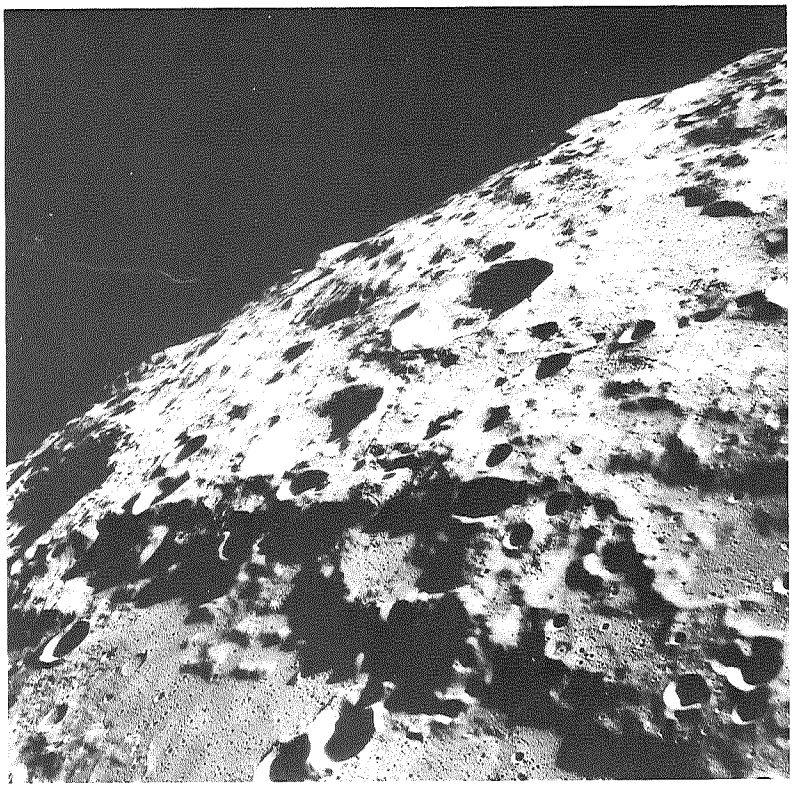


FIGURE 1-9. — The far side of the Moon is pictured, looking south. The features included in this view have not yet been named. The coordinates of the center of this photograph (NASA AS11–42–6248) are approximately 8° S, 164° W.

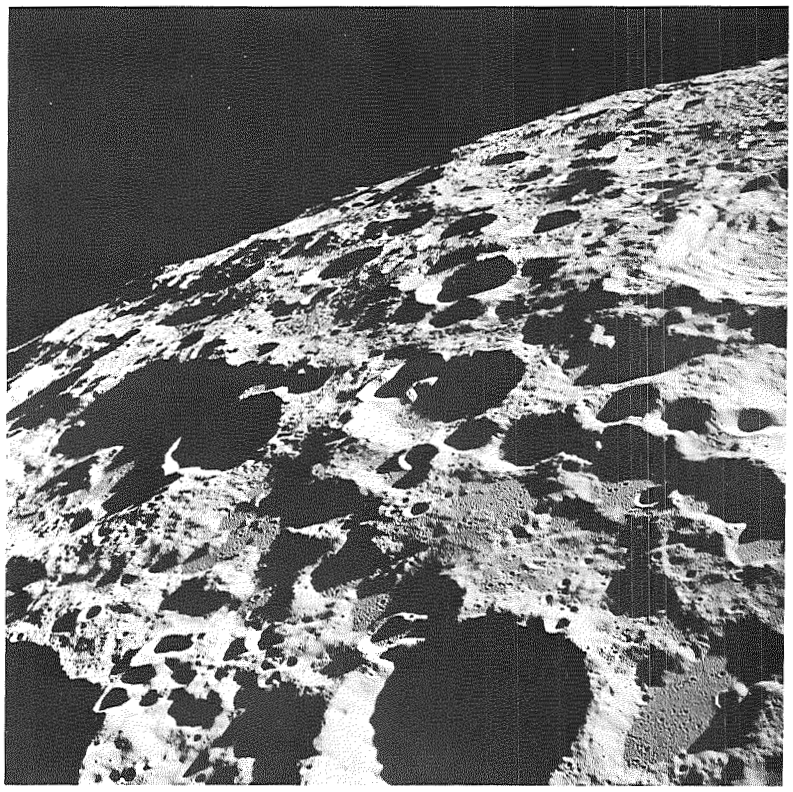


FIGURE 1-10. — The center of this photograph (NASA AS11–44–6608) is located approximately 10° S, 177° W, and shows the view to the southwest from the spacecraft. Note the smooth mare-type fill in the valleys in the foreground.

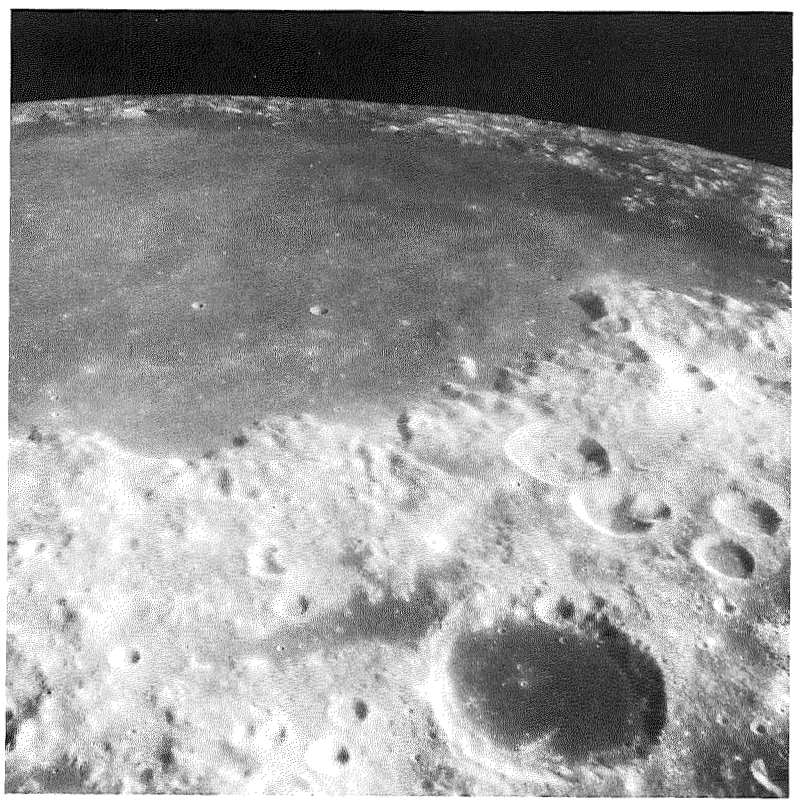


FIGURE 1-11. — The view looks northwest across Mare Crisium (the Sea of Crises). The large, dark-floored crater Firmicus is in the foreground. The average elevation of the highlands is several thousand meters above the floor of the mare. (NASA AS11–42–6222)

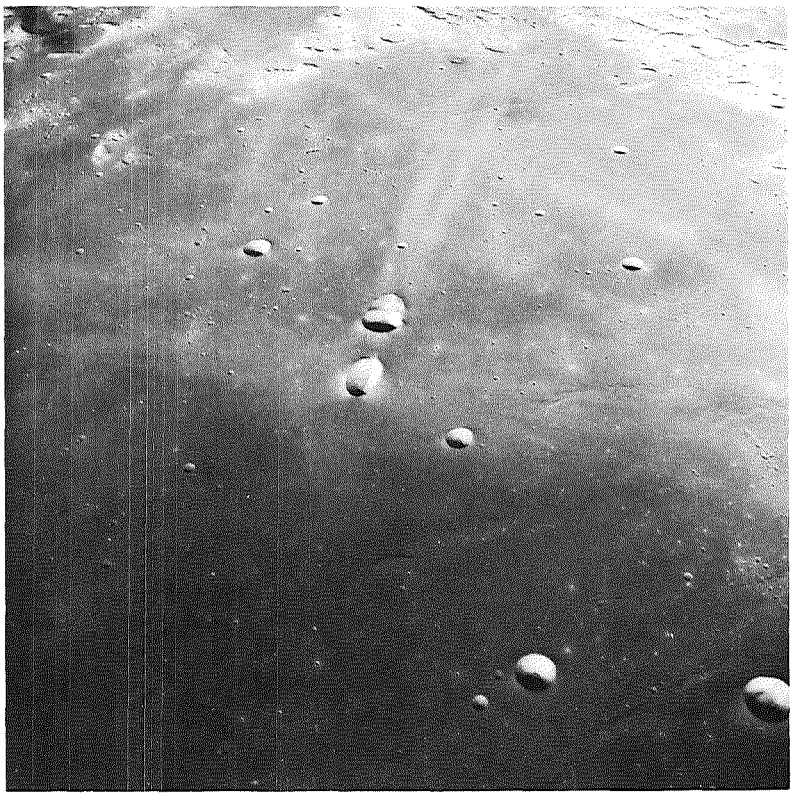


FIGURE 1-12. — The craters Messier, Messier A, and Messier B are grouped in the center of this photograph (NASA AS11-42-6227), looking westward across Mare Fecunditatis. Messier appears nearest the center of the photograph, Messier A is above Messier, and Messier B is below and to the right of Messier.

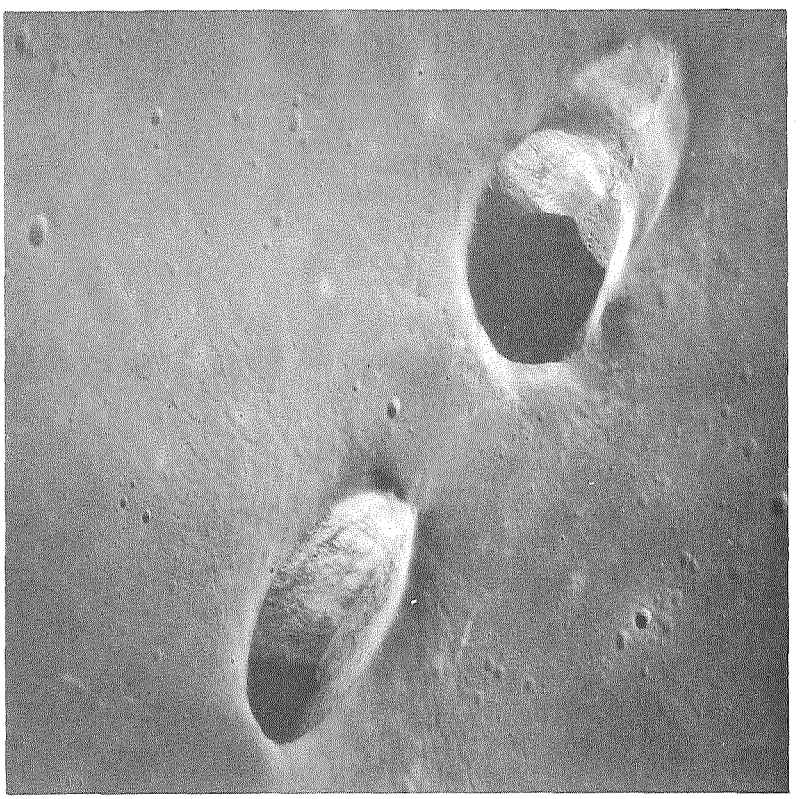


FIGURE 1-13. — This is a telephoto view of the craters Messier and Messier A. The atypical shape of these craters has caused considerable controversy concerning the mode of origin. (NASA AS11-42-6305)

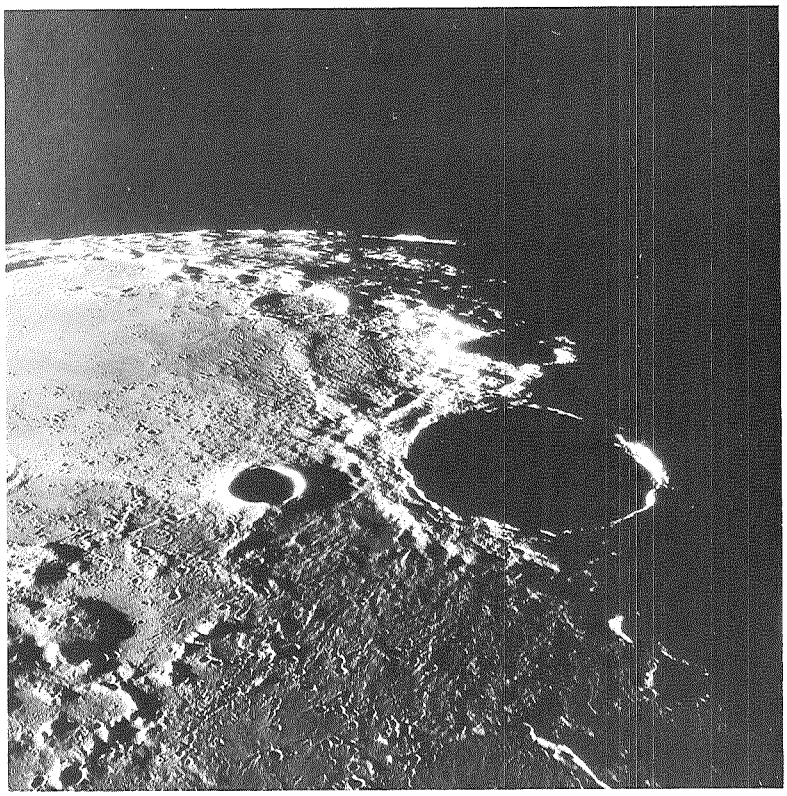


FIGURE 1-14. — This view is looking southward across the crater Theophilus, which is approximately 60 miles in diameter. To the east of Theophilus is Madler, a crater approximately 14 miles in diameter. The center of the view is located approximately 11° S, 29° E. (NASA AS11–42–6237)

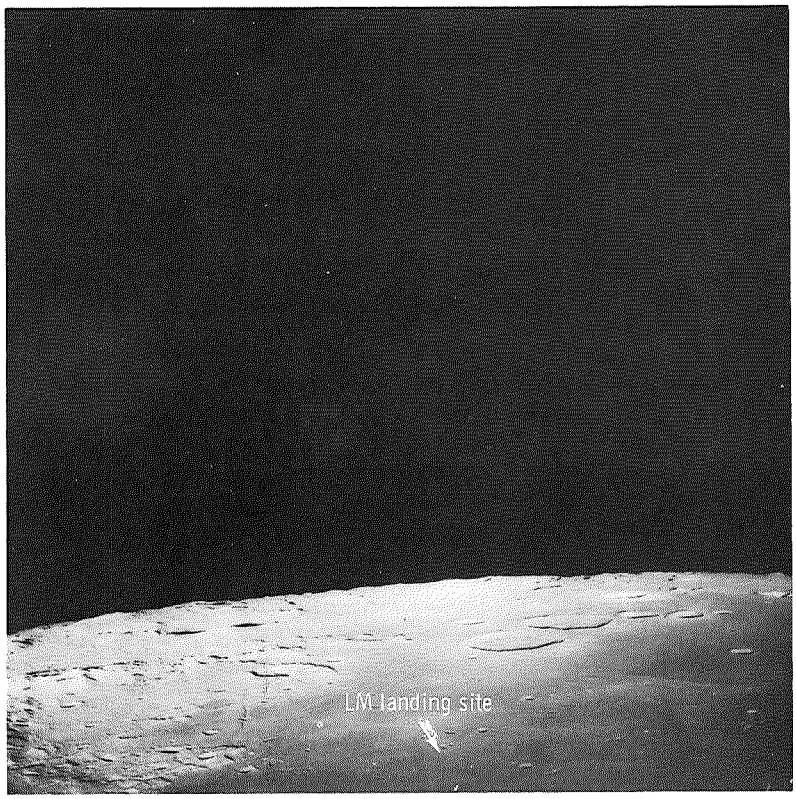


FIGURE 1-15. — The twin craters Sabine and Ritter lie beyond the landing site. (NASA AS11–41–6092)

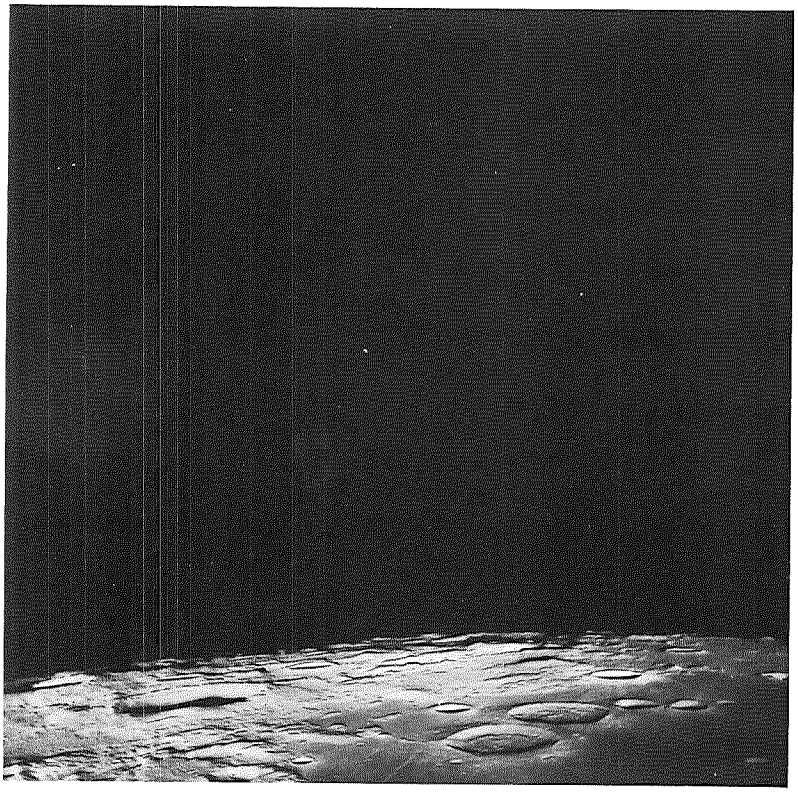


FIGURE 1-16. – Beyond the landing site, looking toward the sunrise terminator on the Moon, the craters Sabine and Ritter lead into the highlands between the Sea of Tranquility (Mare Tranquillitatis) and the Central Bay (Sinus Medii). (NASA AS11–41–6094)

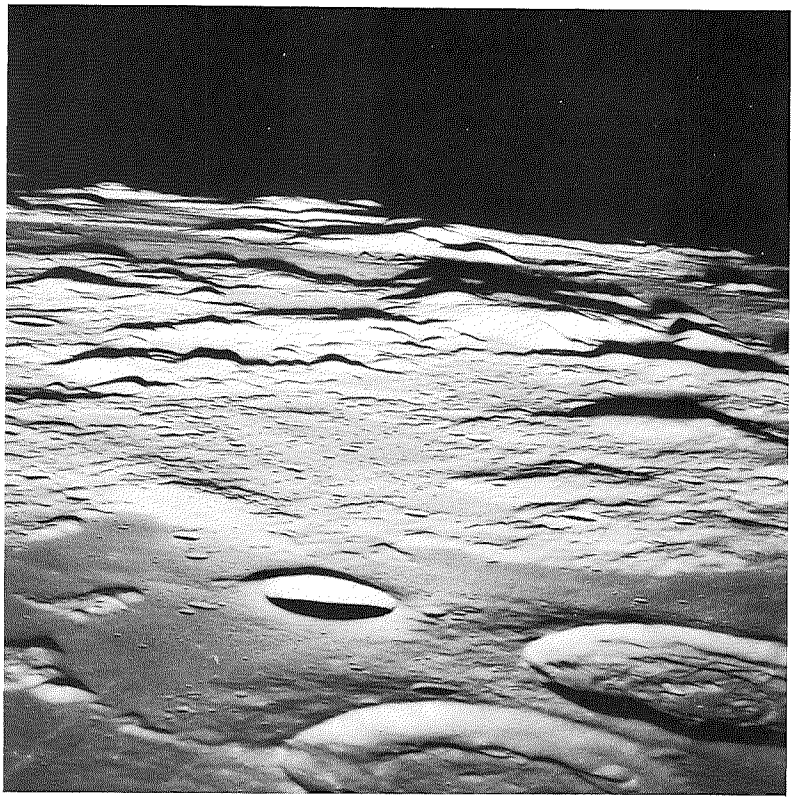
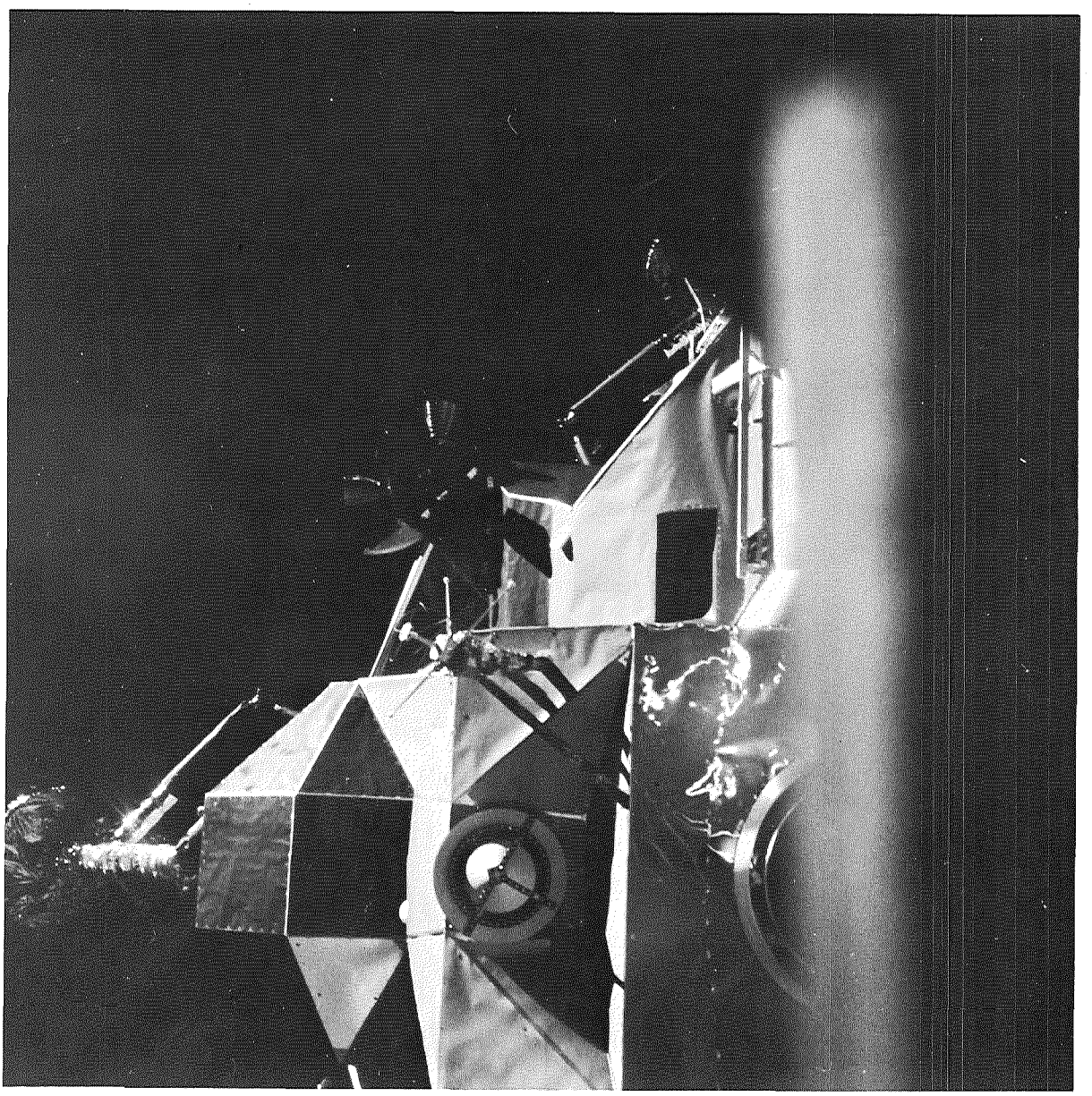


FIGURE 1-17. – The lunar highlands west of the Sea of Tranquility stand out in stark relief when illuminated by the morning Sun. The twin craters Sabine and Ritter are in the right foreground, and the crater Schmidt is in the central foreground. (NASA AS11–41–6123)

Lunar Module Descent and Landing

The LM, with Astronauts Armstrong and Aldrin aboard, was undocked from the CSM at 100:14 g.e.t., following a thorough check of all the LM systems. The CSM (radio call sign "Columbia") was maneuvered away from the LM (radio call sign "Eagle"). At 101:36 g.e.t., the LM descent engine was fired for approximately 29 sec, and the descent to the lunar surface began. At 102:33 g.e.t., the LM descent engine was started for the last time and burned until touchdown on the lunar surface. Eagle landed on the Moon 102 hr, 45 min, and 40 sec after launch.

FIGURE 1-18. — Eagle was photographed from Columbia by Astronaut Collins at the moment the two spacecraft undocked. (NASA AS11–44–6566)



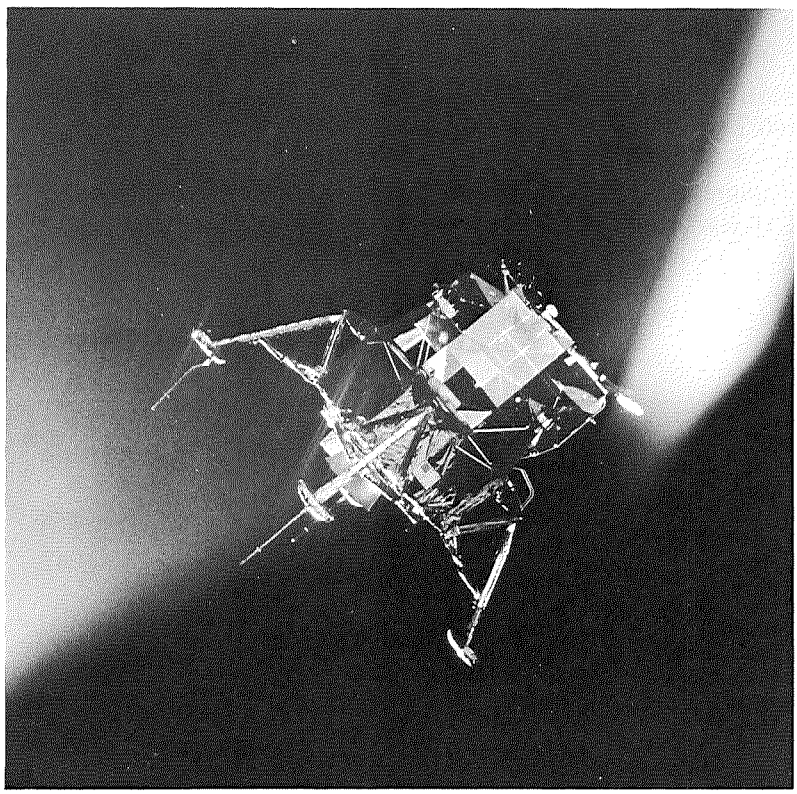


FIGURE 1-19. — Shortly after undocking, Eagle was rotated to permit a visual inspection by Astronaut Collins in Columbia. The probes that extend downward from three of the LM footpads sensed contact with the surface during touchdown. (NASA AS11–44–6584)

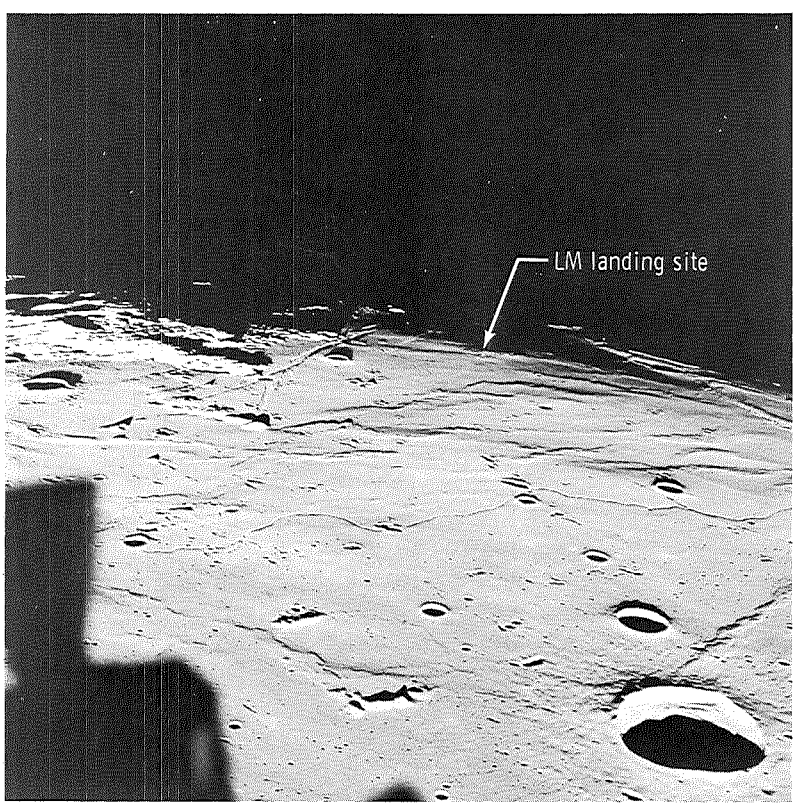


FIGURE 1-20. — A remarkable sequence of three photographs, taken from Eagle. (a) An oblique view (NASA AS11–37–5437) of the LM landing site.

FIGURE 1-20(b). — An almost vertical view (NASA AS11–37–5447) of Columbia over the LM landing site.

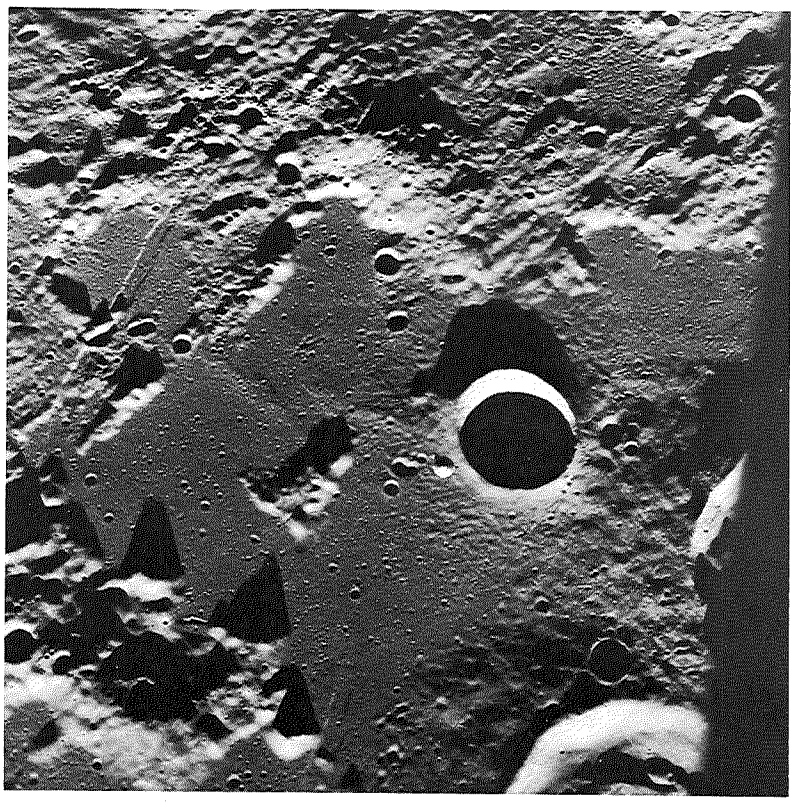


FIGURE 1-20(c). — A vertical view (NASA AS11–37–5448) of Columbia almost 60 n.mi. above the crater Schmidt as the two spacecraft approach the terminator.

Lunar Surface Activities

Immediately after landing on the Moon, Astronauts Armstrong and Aldrin prepared the LM for liftoff as a contingency measure. A series of photographs was taken through the LM windows during this activity; and when the simulated liftoff countdown was completed, the astronauts ate. Following the meal, a scheduled sleep period was postponed at the astronauts' request, and the astronauts began preparations for descent to the lunar surface.

Astronaut Armstrong emerged from the spacecraft first. While descending, he released the Modularized Equipment Stowage Assembly (MESA) on which the surface television camera was stowed, and the camera recorded man's first step on the Moon at 109:24:19 g.e.t. A sample of the lunar surface material was collected and stowed to assure that, if a contingency required an early end to the planned surface activities, samples of lunar surface material would be returned to Earth. Astronaut Aldrin subsequently descended to the lunar surface.

The astronauts carried out the planned sequence of activities that included deployment of a Solar Wind Composition (SWC) experiment, collection of a larger sample of lunar surface material, panoramic photographs of the region near the landing site and the lunar horizon, closeup photographs of inplace lunar surface material, deployment of a Laser-Ranging Retroreflector (LRRR) and a Passive Seismic Experiment Package (PSEP), and collection of two core-tube samples of the lunar surface. Approximately 2¼ hours after descending to the surface, the astronauts began preparations to reenter the LM, after which the astronauts slept. The ascent from the lunar surface began at 124:22 g.e.t., 21 hr and 36 min after the lunar landing.

The photographs reproduced in this section consist of mosaics (photographs joined together to form panoramic views) and single photographs (to show more detail in specific areas). The single photographs are arranged in the sequence in which they were taken.

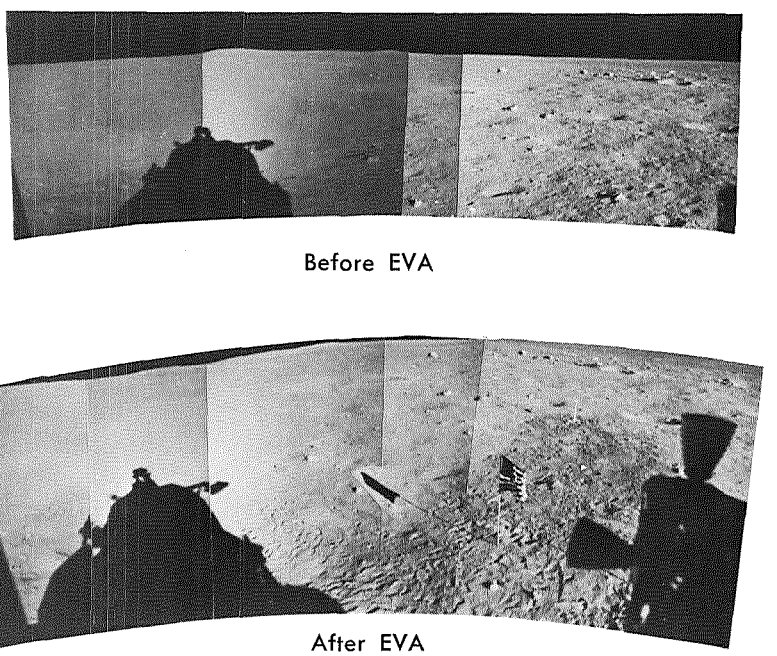
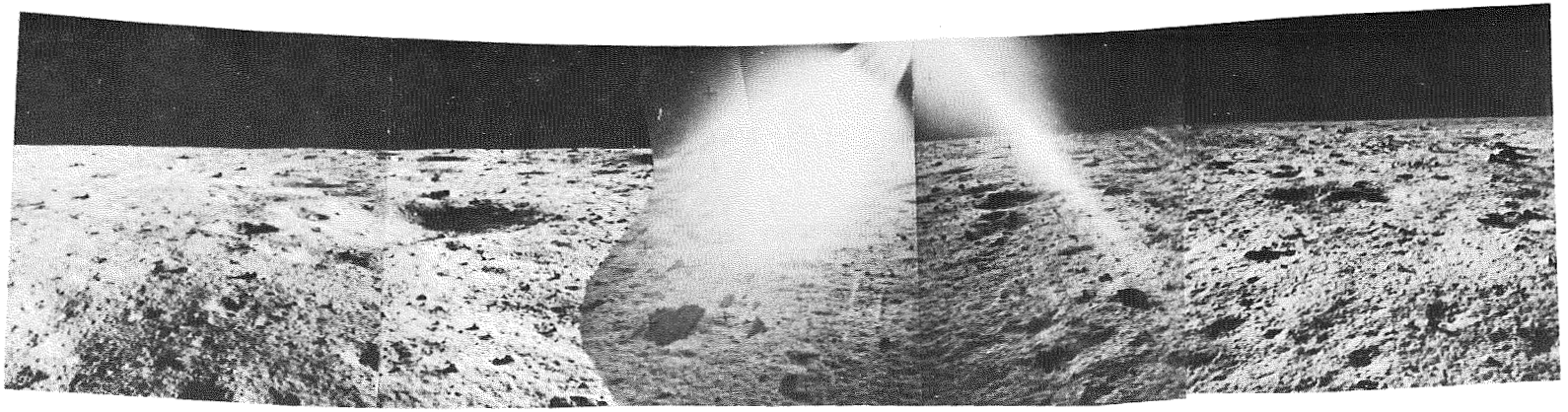
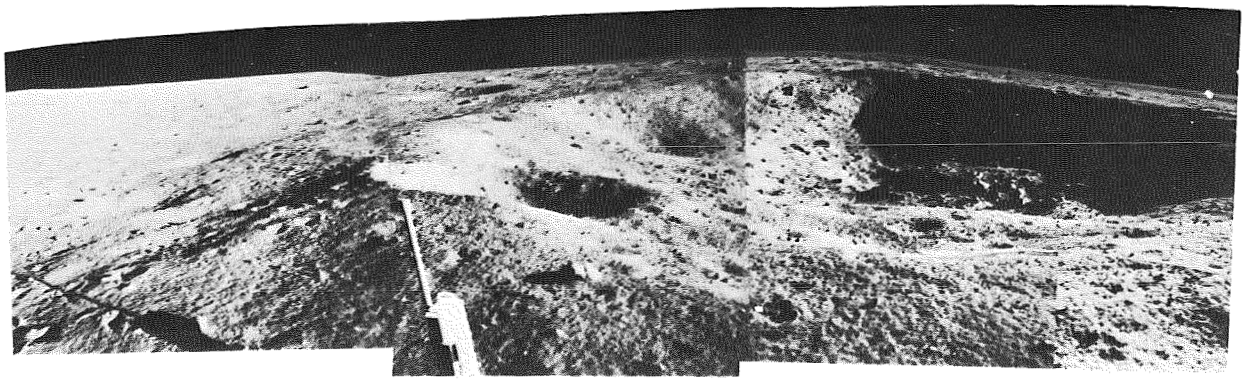


FIGURE 1-21. — Apollo 11 lunar surface panoramas taken from the LM.

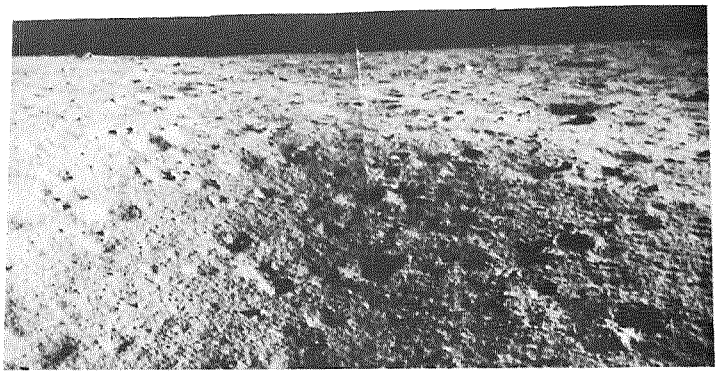


Panorama of the lunar surface looking east

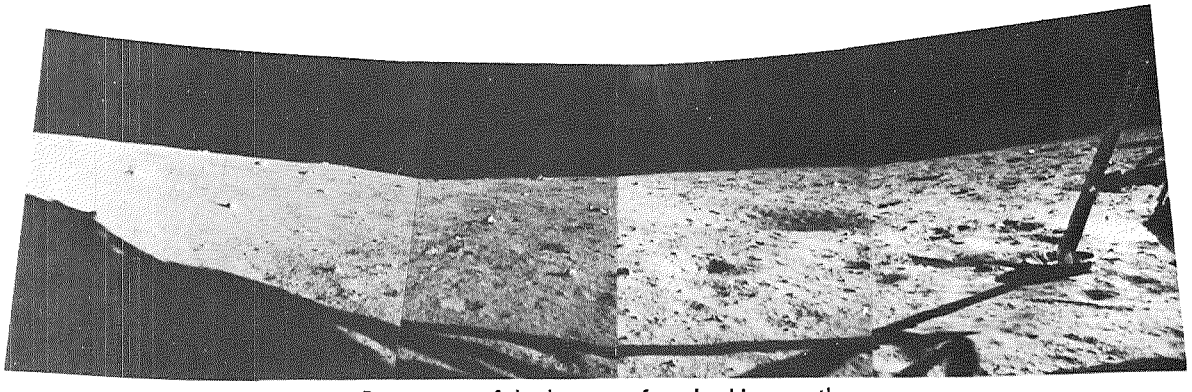


Panorama of the large crater approximately 200 ft east of the LM

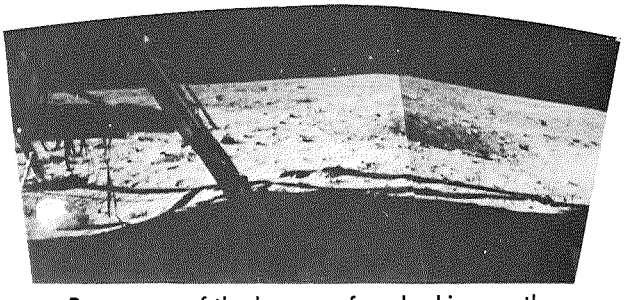
FIGURE 1-22. — Apollo 11 panoramas taken from the surface.



Panorama of the lunar surface looking northwest



Panorama of the lunar surface looking south



Panorama of the lunar surface looking north

FIGURE 1-23. — Additional panoramas from the lunar surface.

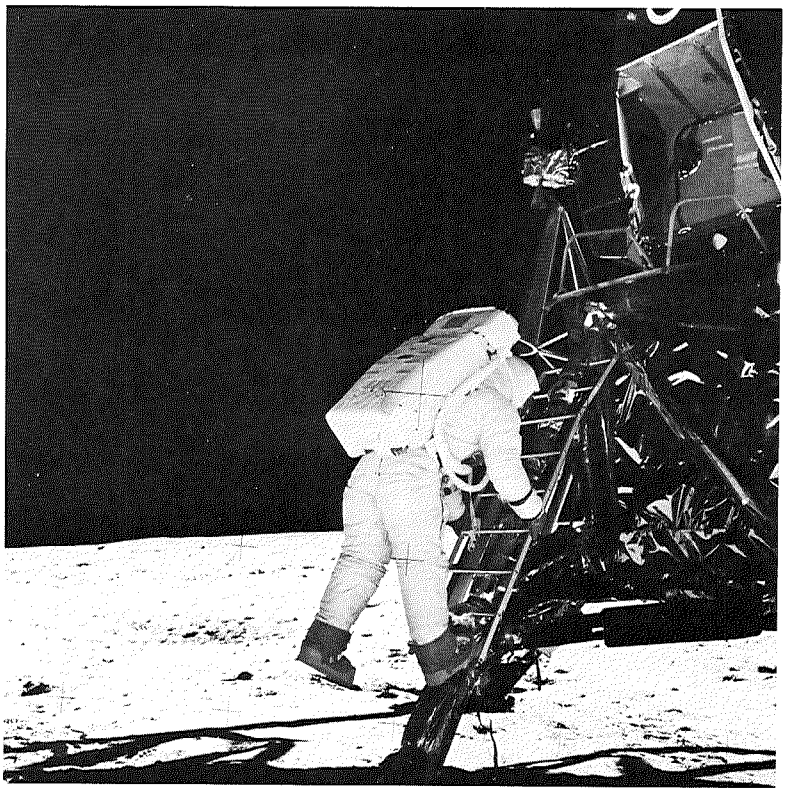


FIGURE 1-24. — Astronaut Aldrin descends the ladder to the lunar surface. (NASA AS11–40–5868)

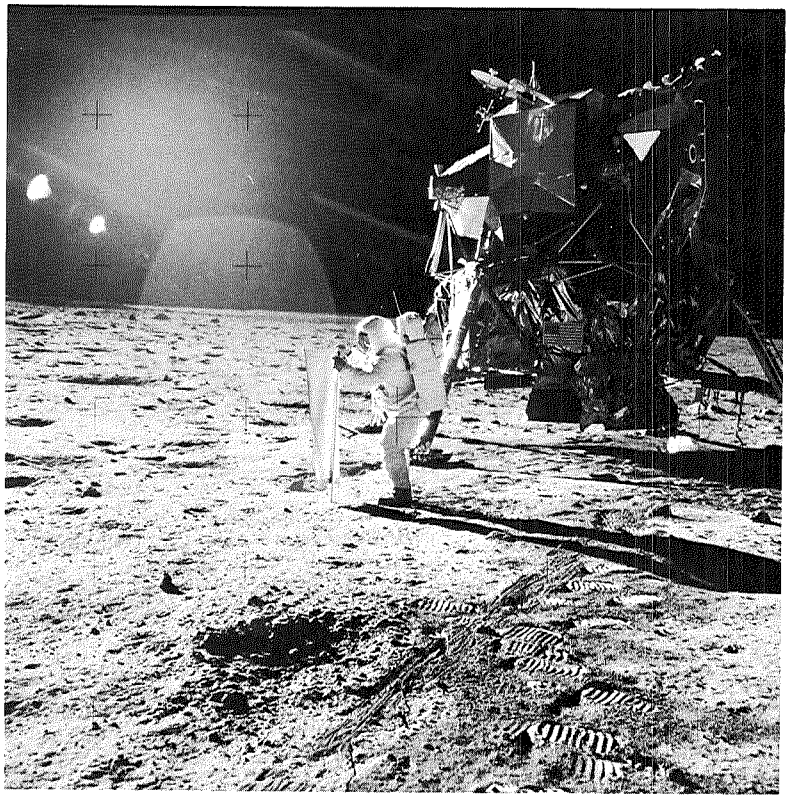


FIGURE 1-25. — The SWC experiment is unrolled and turned to face the Sun. The experiment was deployed on the surface for approximately 1 hr and 17 min. The linear trails from the foreground toward the LM were formed by the cable of the surface television camera. (NASA AS11–40–5872)

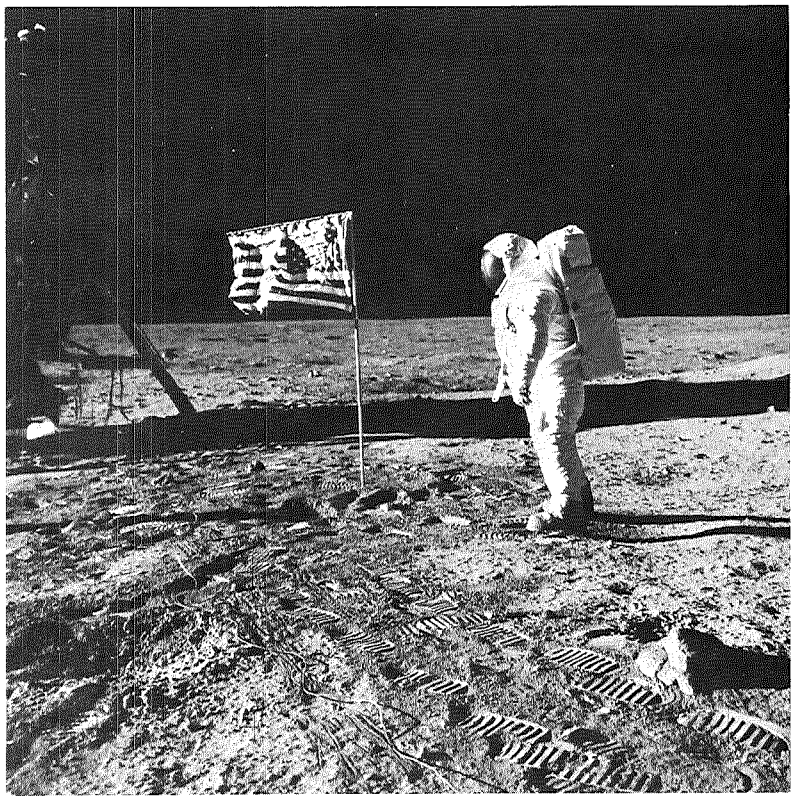


FIGURE 1-26. — Note the rounded, eroded appearance of the rock in the right foreground. (NASA AS11–40–5875)

FIGURE 1-27. — The astronaut photographed his own footprint to permit later study of the lunar surface bearing strength. The thin, crusty appearance of the surface was similar to that discovered during the Surveyor soil mechanics experiments. (NASA AS11–40–5877)

FIGURE 1-28. – The LM footpads were also photographed for later study of the surface mechanical properties. The foil wrapping provides thermal insulation. (NASA AS11–40–5926)

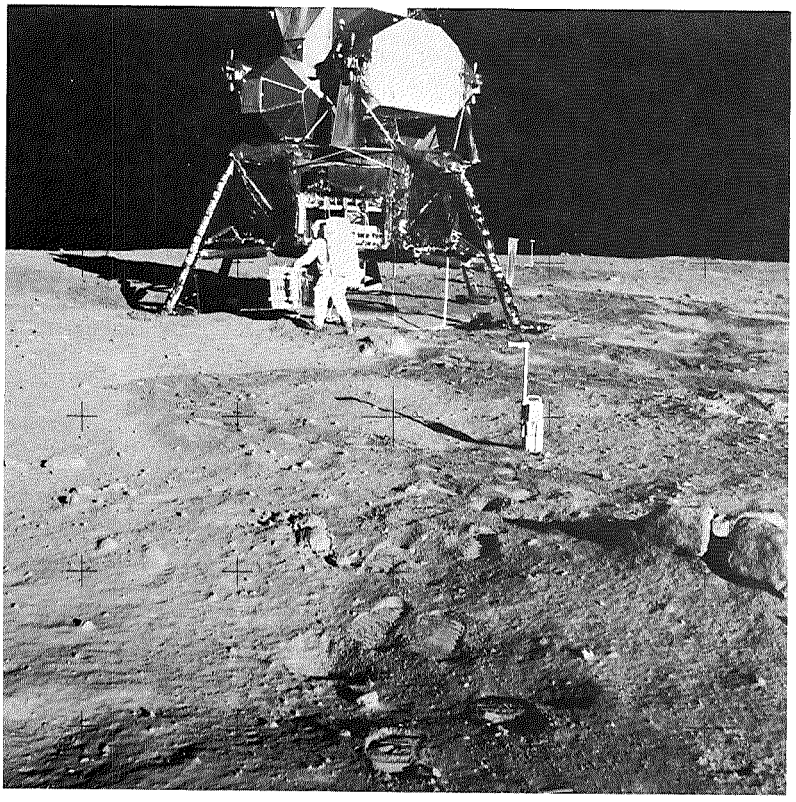


FIGURE 1-29. – The LRRR and the PSEP are being removed from the MESA in the LM descent stage. The Apollo Lunar Surface Closeup Camera (ALSCC), which provides stereoscopic pictures of the fine surface structure, is in the foreground. The television camera can be seen beyond and to the right of the SWC. (NASA AS11–40–5931)

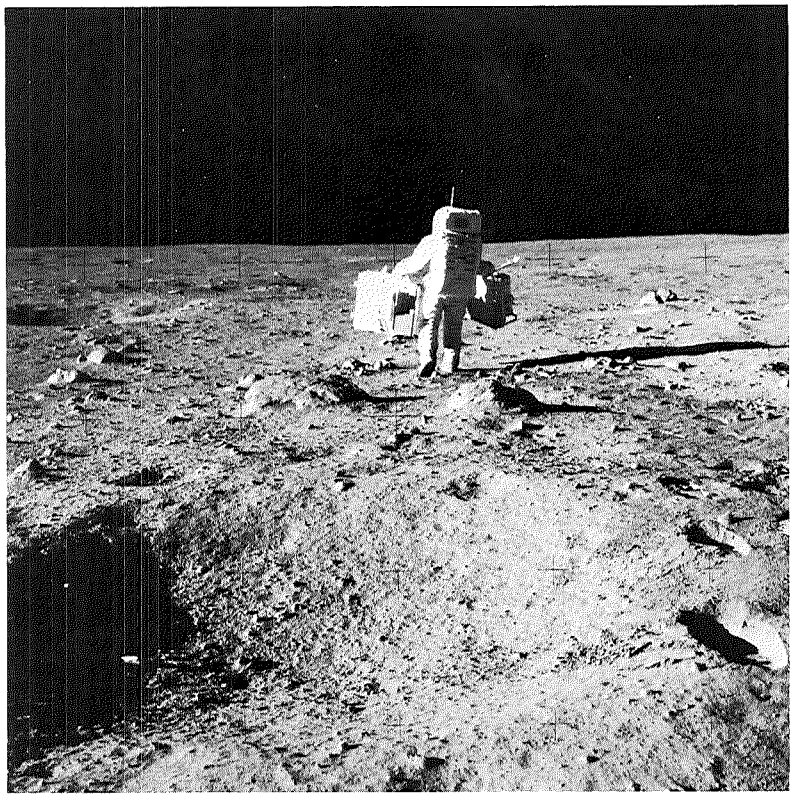


FIGURE 1-30. — The LRRR and the PSEP are carried to the deployment area. The surface was softer near the rim of the small crater in the foreground, as can be seen by the depth of Astronaut Aldrin's footprints. (NASA AS11–40–5944)

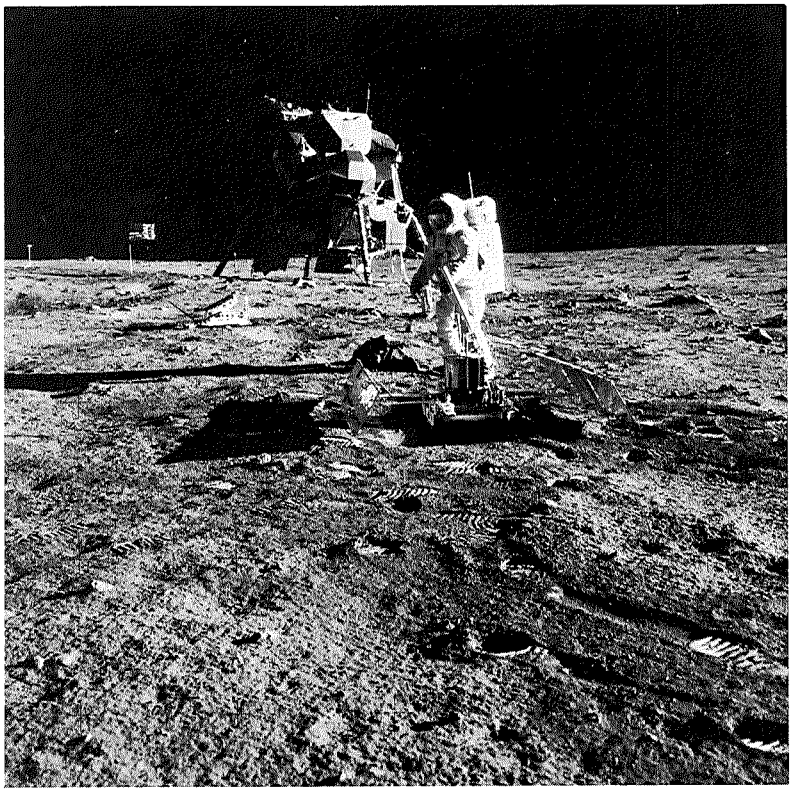


FIGURE 1-31. — The LRRR has been set up to face the Earth, and the PSEP is being leveled. The PSEP was placed behind the large rock to shield the experiment from the effects of liftoff. (NASA AS11–40–5949)

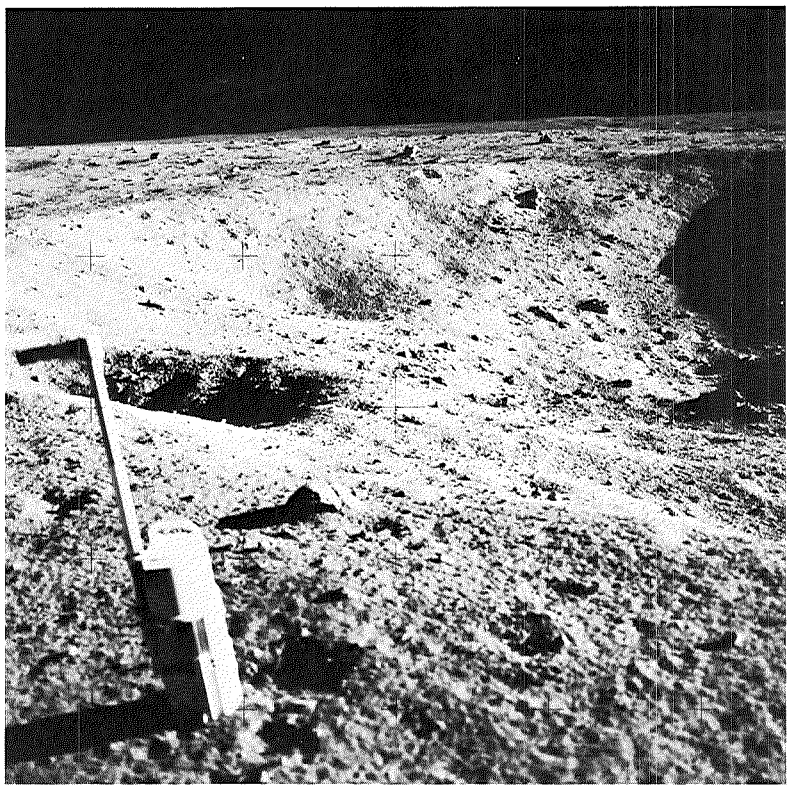


FIGURE 1-32. — Shortly before entering the LM, Astronaut Armstrong walked back approximately 200 ft eastward to photograph the interior of a crater he noted during descent. The ALSCC is in the foreground. (NASA AS11–40–5957)

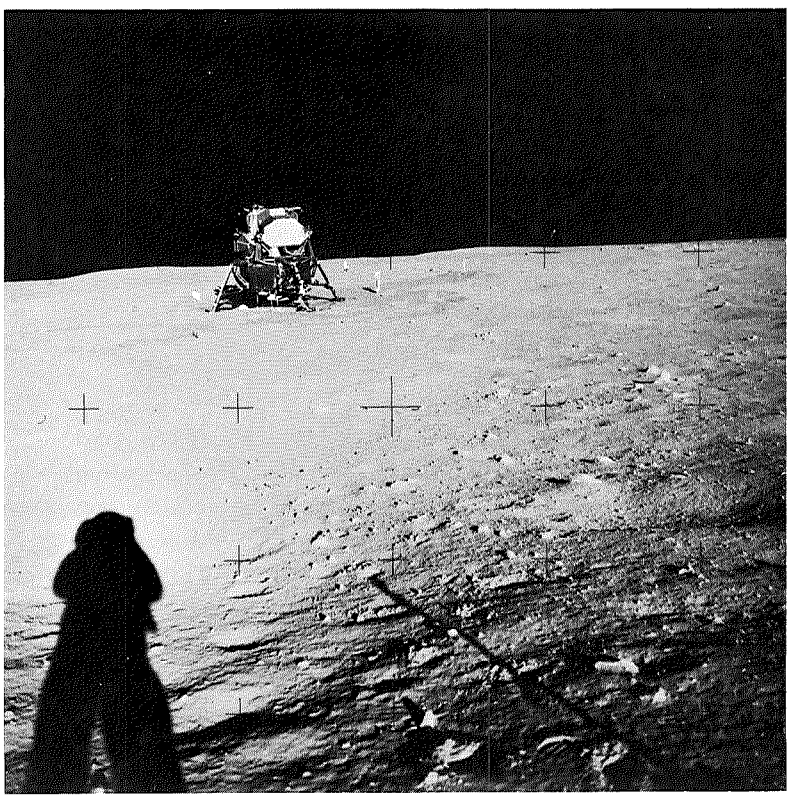


FIGURE 1-33. — Tranquility Base is shown from the rim of the crater shown in the previous photograph. Astronaut Armstrong's shadow is in the left foreground, and the shadow of the ALSCC is in the right foreground. (NASA AS11–40–5961)

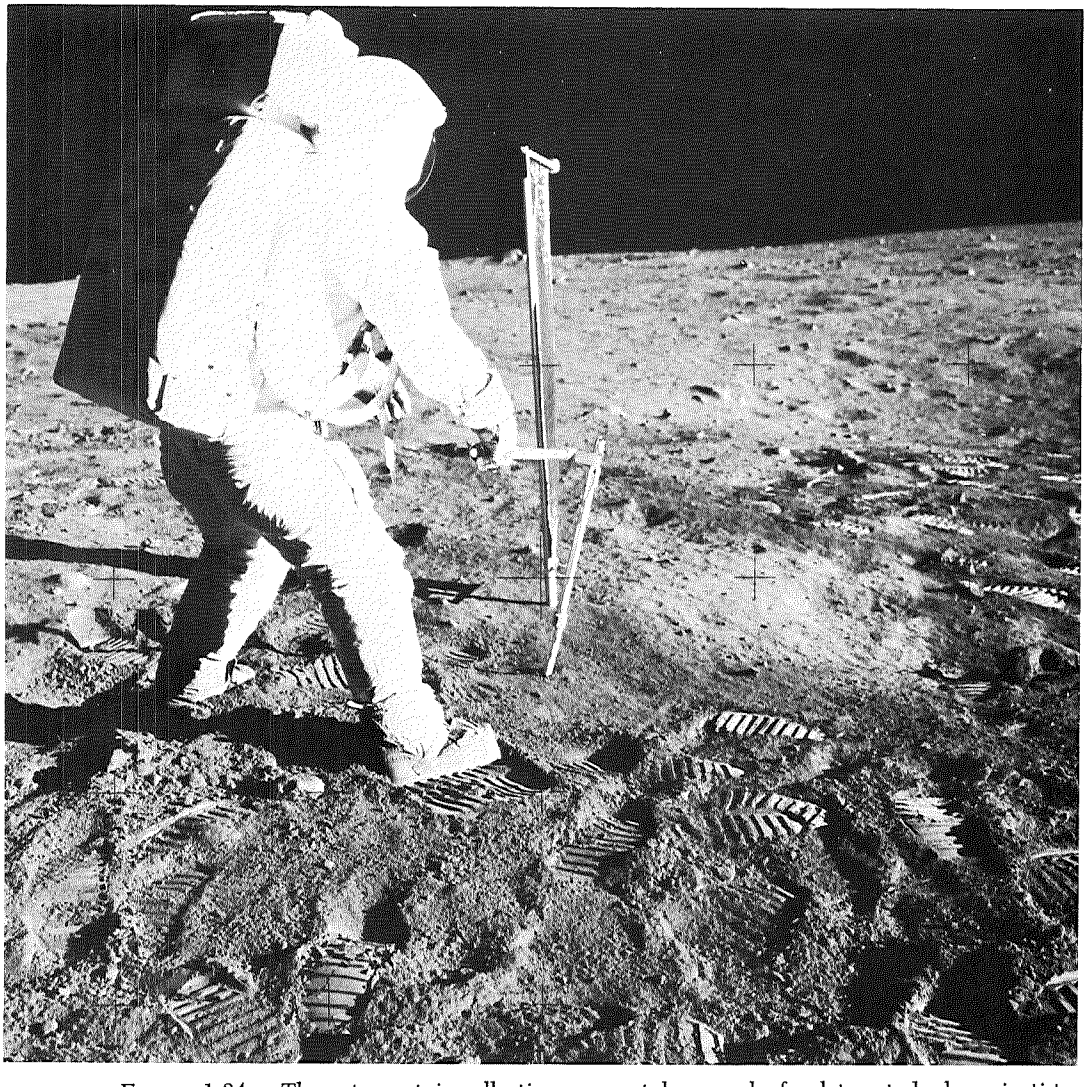


FIGURE 1-34. — The astronaut is collecting a core-tube sample for later study by scientists. The SWC experiment is still deployed. (NASA AS11–40–5964)

The Return to Earth

At 124:22 g.e.t., the engine of the LM ascent stage was ignited, and a series of maneuvers was begun to permit rendezvous with Astronaut Collins in the CM. Docking took place at 128:03 g.e.t. Astronauts Armstrong and Aldrin transferred to the CM, and the LM ascent stage was jettisoned at 130:09 g.e.t. The service module (SM) engine was reignited at 135:24 g.e.t. to increase the spacecraft velocity by 3279 fps for escape from lunar orbit.

In transearth coast, as in translunar coast, only one of four planned midcourse corrections was required. This midcourse correction was performed at 150:30 g.e.t. The SM was separated from the CM at 194:49 g.e.t. The CM entered the atmosphere of the Earth with a velocity of 36 194 fps and landed in the Pacific Ocean 195 hr, 18 min, and 35 sec after launch. Procedures to prevent biological back-contamination of the Earth were followed in recovering the crew, the lunar samples, and the spacecraft.

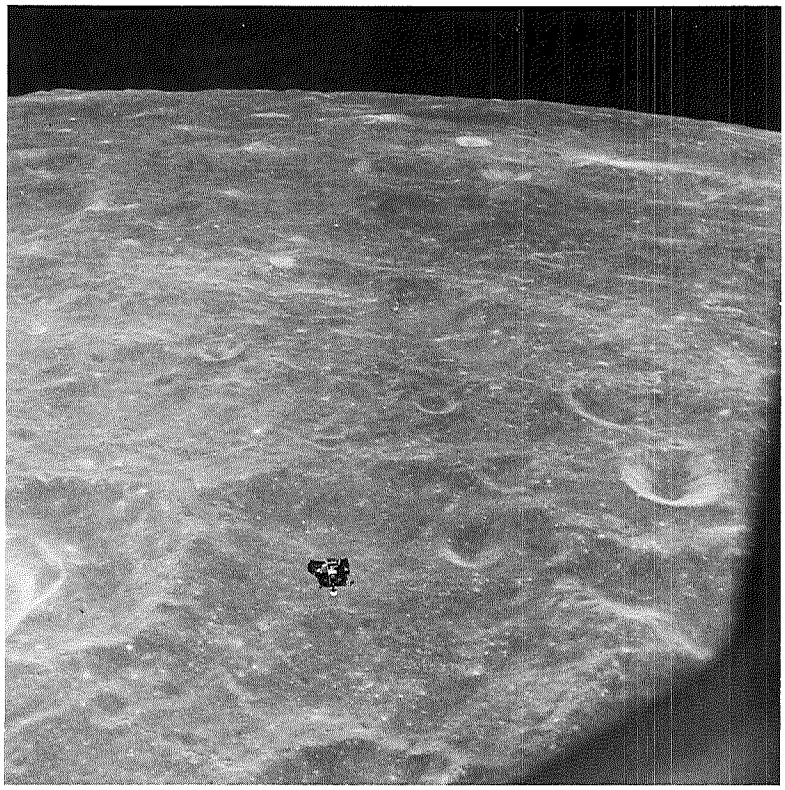


FIGURE 1-35. – The lonely vigil of Astronaut Collins in the CM nears an end with the approach of Astronauts Armstrong and Aldrin in the ascent stage of the LM. The center of the view is at lunar coordinates 1.5° N, 105° E. (NASA AS11–44–6621)

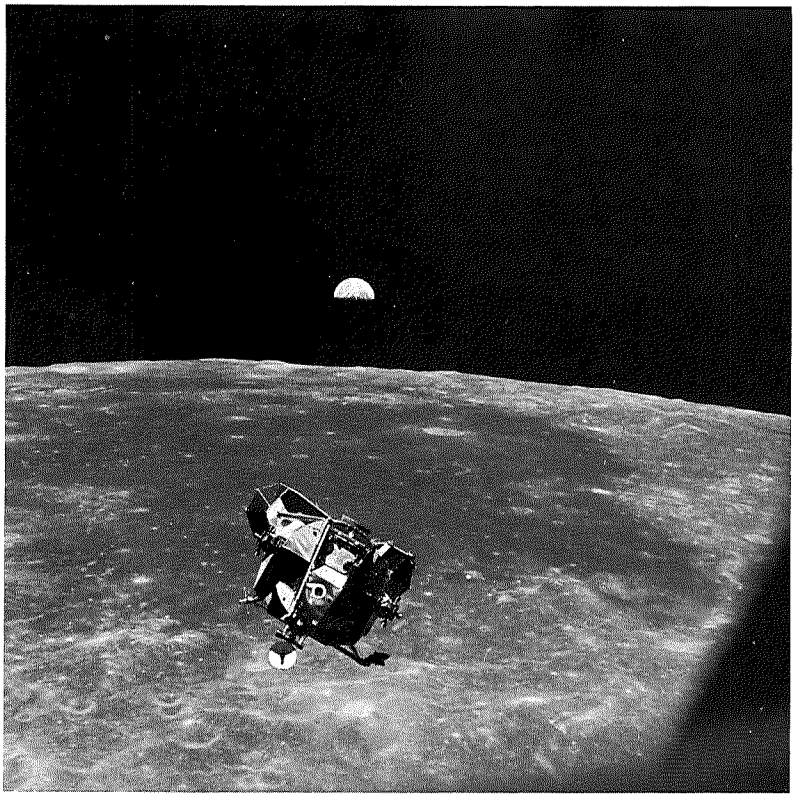


FIGURE 1-36. – Near 88° E, the two spacecraft approach Mare Smythii as the Earth rises above the lunar horizon. (NASA AS11–44–6642)

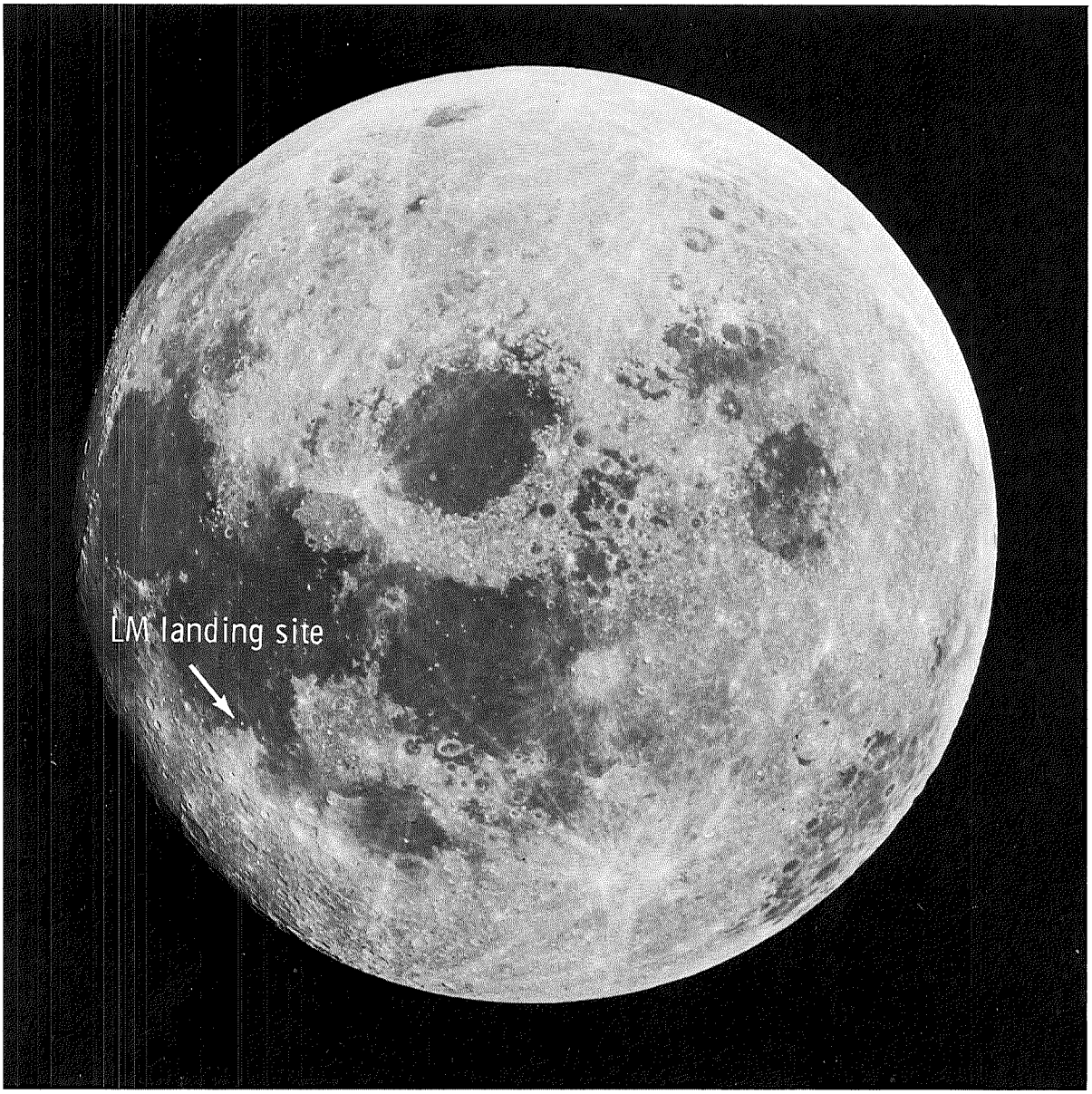


FIGURE 1-37. — A nearly full Moon is viewed from a perspective never seen from Earth, approximately 60° E. The LM landing site is far to the west in this view. (NASA AS11–44–6665)

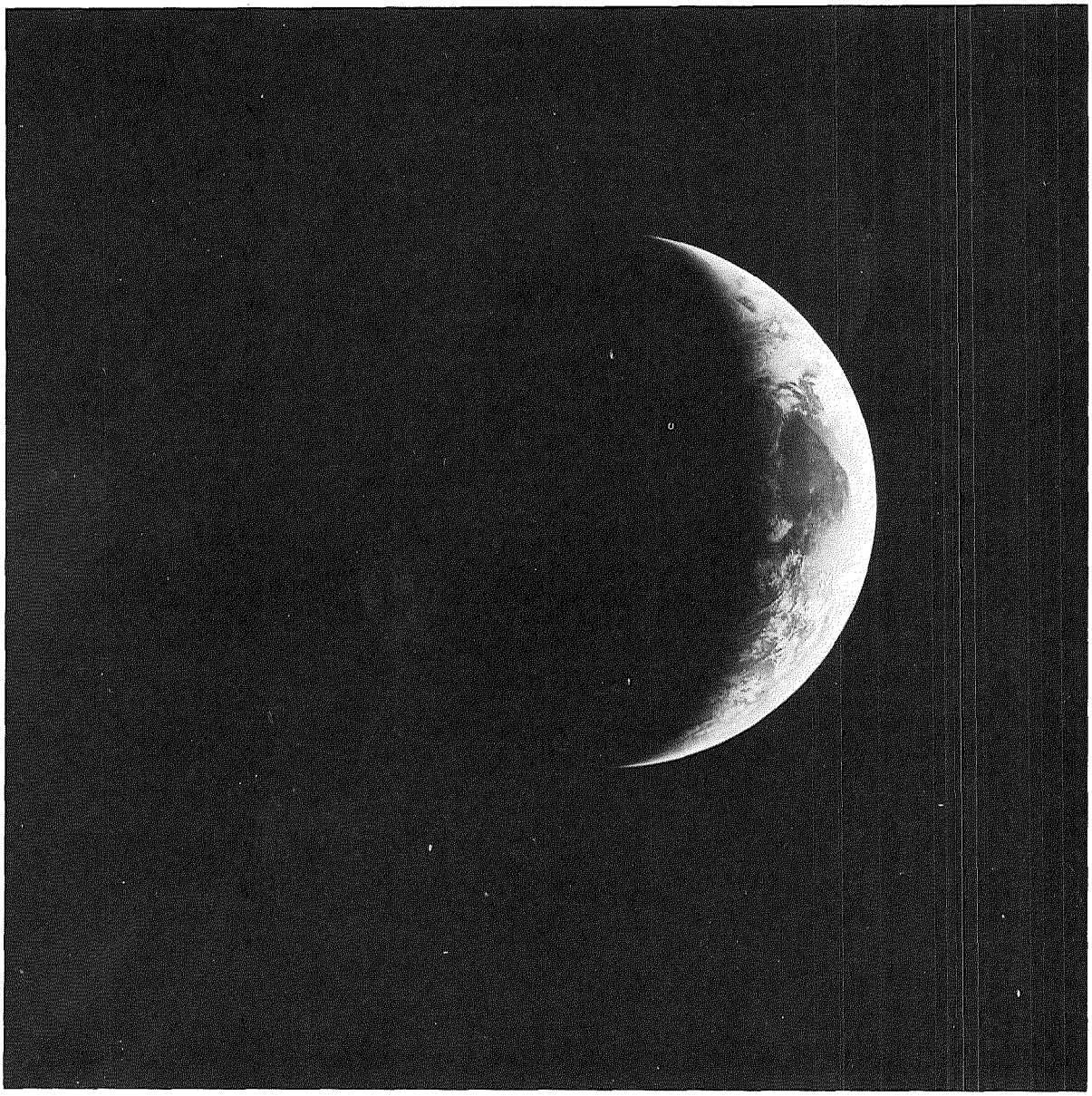


FIGURE 1-38. — A crescent Earth awaits the return of the first men to set foot on the Moon. (NASA AS11–44–6689)