

LUNAR EXPLORATION CONCLUDED

To the Mountains of the Moon

Thunderstorms visited launch complex 39A during the month preceding Apollo 15's launch. Four lightning strikes damaged some ground support equipment but the spacecraft and launch vehicle were undamaged.[10](#) Otherwise the countdown for Apollo 15 was, as launch director Walter Kapryan described it, "the most nominal countdown that we have ever had."[11](#) At 9:34 a.m. on July 26, just 187 milliseconds behind schedule, the Saturn V carrying command module *Endeavour*^{*} and its crew blasted off. Twelve minutes later Scott, Irwin, and Worden were in orbit some 92 nautical miles above the earth, and after two revolutions their S-IVB stage reignited to send them on their way to the plain at Hadley. After extracting the lunar module *Falcon* (named for the Air Force Academy's mascot by the all-Air-Force crew) from its stowage atop the S-IVB, they settled down for an uneventful 3-day trip to the moon. Only two small midcourse corrections were required along the way.[12](#)

Four hours before settling into lunar orbit, the crew jettisoned the cover of the scientific instrument module in preparation for the lunar-orbital science to be conducted later. *Endeavour* went smoothly into lunar orbit. Scott and Irwin entered *Falcon* about 40 minutes early, checked out its systems, and had ample time to eat lunch before beginning powered descent. After they undocked, Worden put *Endeavour* into a circular orbit suitable for gathering scientific data.[13](#)

Ten hours into their fourth day, Scott powered up *Falcon* for the approach to Hadley. As had been the case throughout the mission so far, everything went well during the landing approach. At about 9,000 feet (2,750 meters) above the surface Scott noted the peak of Hadley Delta to his left; until he reached 5,000 feet (1,500 meters) the only other landmark he could spot was Hadley Rille. The terrain was less sharply defined than he had expected from simulations. After entering several redesignations of the landing site into his control computer, Scott brought *Falcon* down through blinding dust and touched down at 6:16 p.m. Eastern Daylight Time on July 29. Not sure of his exact location, Scott was sure he was well within the boundaries of his designated landing zone. The lunar module came to rest tilted back and to its left; two of its landing pads were just over the edge of a small crater that Scott had not been able to see as he approached the surface.[14](#)

During the next 67 hours Scott and Irwin were to ride and walk over more of the lunar surface than any of their predecessors. The first chore was a "standup EVA," to survey the landing area for the benefit of the scientists in Houston. Scott removed the upper hatch of the lunar module and stood on the engine cover, describing what he could see and taking photographs that would allow construction of a panorama of the landing area. One remarkable photograph showed clear evidence of stratigraphy in a prominent landmark ("Silver Spur") to the east of Hadley Delta - a feature the explorers were unable to see later because of unfavorable lighting. While Scott and Irwin carried out their assignments on the surface, Al Worden, orbiting above in *Endeavour*, had activated the scientific instruments and cameras and was busy gathering data. On his 15th revolution he spotted *Falcon* on the surface and relayed its position to Houston.[15](#)

The next morning Scott and Irwin were up early and out on the surface. They unloaded their roving vehicle without difficulty, climbed on and buckled their seat belts, and set out on the first traverse. Scott soon discovered that the rover's front wheels could not be steered. He could not correct the anomaly, but went ahead, relying on the rear-wheel steering alone.[16](#)

Their first goal was "Station 1," a spot on the rim of a medium-sized crater ("Elbow") located on the edge of Hadley Rille at the point where it makes a sharp bend. On the way Scott had to get the feel of driving the rover, which he found to be an excellent vehicle. Driving it on the moon, however, was not quite like driving the 1-g trainer, and among other things he had to keep his eyes on the surface ahead, especially when heading toward the sun, because surface features were not always readily visible. The rover's maneuverability was good, but at 8 to 10 kilometers per hour (5 to 6 miles per hour) the ride was a bit bouncy. Driving took all of Scott's attention, so Irwin provided most of the descriptions for Houston's scientists.[17](#)

Proceeding along the edge of Hadley Rille, the explorers had an excellent view of the entire width of the canyon (about 1.5 kilometers or almost 1 mile) and down its length to the sharp bend by "Elbow" crater. Landmarks along the route were not always easy to identify, but their course was laid out by range and bearing and they were never as uncertain about their position as Shepard and Mitchell had been on Apollo 14. Less than half an hour after leaving the LM, and having traveled something over 3 kilometers (about 2 miles) they reached their first stop, dismounted, and turned on the television camera to give Houston a view of the area. Using a telephoto lens, Scott photographed the far side of Hadley Rille where layering was obvious in outcrops not far below the rim. Panoramic photography and sample collection completed their work at Site 1.[18](#)

Remounting their vehicle, Irwin and Scott drove around "Elbow" crater to Site 2, about 500 meters (1,600 feet) farther down at a point where ejecta from St. George crater encroached on the edge of the rille. Here they began to encounter large blocks lying on the surface. One that excited Irwin particularly was a meter or so (3 to 4 feet) across, its downslope edge buried in the loose soil and its upslope edge free of the surface. He photographed and sampled it; then once again they took panoramic photographs and soil samples and drove a double core tube into the edge of a crater.[19](#)

With no more stops scheduled, Scott now turned the rover on to the heading prescribed by his navigation system to return to the LM. On the way he cautiously tried some maneuvers with the rover. Attempting a turn on a downslope, he discovered that "you can't go fast downhill in this thing, because if you try and turn with the front wheels locked up like that, they dig in and the rear end breaks away, and around you go; and we just did a 180 [degree turn]."[20](#) Near Elbow crater Scott noted that there was a "neat place to go down into the rille," but Capcom reminded him that "we'd rather that you don't take that option."[21](#)

Riding back toward *Falcon*, Scott and Irwin frequently saw features they would have liked to stop and examine, but they had no time, so they briefly described them to Houston and continued.[22](#) When they first caught sight of the LM they estimated its bearing from the rover at 15 degrees, but the navigation system showed 34, indicating some drift in the system. They reached the lunar module 2 hours and 15 minutes after they had left, parked the rover, and unloaded the surface experiments package. Scott had picked a spot about 110 meters (360 feet) west-northwest of the *Falcon* to deploy the instruments. Apollo 15's experiments package included a new heat flow experiment, which required drilling two holes in which temperature sensors would be placed. The experiments were deployed without difficulty, but the second heat-flow drill hole caused problems when the drill stuck and proved difficult to remove. By this time the astronauts were approaching the limit of their life-support systems, so Mission Control directed Scott to leave the drill in the hole and get on to other tasks. After deploying the laser reflector and the solar-wind collector he and Irwin returned to *Falcon* and closed the hatch. They had been out for six and a half hours and covered 10.3 kilometers (5.6 miles) on the lunar surface - more than twice as far as the Apollo 14 astronauts had traversed (on foot) during their entire mission.[23](#) A 40-minute debriefing with Houston completed their first day of lunar exploration.[24](#)

In the press briefing immediately following the first day's surface activity, flight director Gerald Griffin expressed satisfaction with the astronauts' performance. Apart from the failure of the rover's front-wheel steering, which had not significantly impaired the planned activity, everything had gone well. Scott had shown a somewhat higher metabolic rate than anticipated, resulting in faster consumption of oxygen than had been allowed for. This was not a serious concern, but it would have to be taken into account in planning the remaining excursions. About the only changes anticipated for the next day's activity were to attempt to solve the rover's steering problem and to try to extract the drill core for the heat-flow experiment.[25](#) However, the science planning team still had to review the day's results; plans for the second traverse could well be changed in light of what had been accomplished.

Next morning, after Scott and Irwin had finished breakfast and attended to some chores in the LM, Capcom Joe Allen briefed them on the upcoming day's work. Science planners had decided to shorten the traverse somewhat to provide more exploration with less travel time. A low-priority sampling stop had been tentatively deleted and the route at the foot of Hadley Delta curtailed. The scientists were giving the astronauts considerable freedom on this traverse, as Allen's instructions showed:

We're going to depend very much on the observations from the two of you, and it's going to be . . . your choice on exactly where you'd like to range and where you'd like to carry out your major sampling tasks....

We're looking now, primarily, for a wide variety of rock samples from the [Apennine] Front. You've seen the breccias already. We think there may very well be some large crystal[line] igneous [rocks], and we'd like samples of those and whatever variety of rocks which you're able to find for us - but primarily, a large number of documented samples and fragment samples. . . . I'll [stop] now and ask for any more questions.[26](#)

Scott replied, "No, no questions, Joe. You're really talking our language today."[27](#) During their extensive geological training, Scott had come to enjoy field geology and considered himself a serious amateur,[28](#) and this was the kind of freedom he wanted. It was the kind of exploration the geologists had wanted as well, and although they would have preferred to have one of their own on the moon, apparently they were confident enough of Scott's and Irwin's training to give them a much freer hand than any previous team of lunar explorers.

Suited up and out on the surface, Scott and Irwin got aboard the rover and belted in, pausing before they started to flip the circuit breaker for the front steering open and then closed again. When Scott moved the hand controller the front wheels moved. Nobody knew why, but he now had full four-wheel steering.[29](#) Then they set out, on a southerly heading, for the sloping terrain at the foot of Hadley Delta. Rolling along at 8 to 9 kilometers per hour (5 to 6 miles per hour), they described the craters and rocks along the route. In about 40 minutes they were in the vicinity of "Spur" crater, one of their sampling stops, and they parked the rover to reconnoiter and collect specimens.[30](#) With continuous commentary for Houston, the astronauts roamed the area for the next hour, taking pictures and bagging samples. Then, as they examined a boulder that had attracted their attention, Scott remarked, "Guess what we just found." Then Irwin came over for a look:

Irwin: I think we just found what we came for.

Scott: Look at the plage [plagioclase] in there. . . . I think we might [have found] ourselves something close to anorthosite, because it's crystalline, and . . . it's just almost all plage. What a beaut!

Irwin: That really is a beauty. And . . . there's another one down there.[31](#)

"What we came for" was a specimen of the primitive lunar crust - anorthosite, the rock that some scientists believed was the first material that solidified from the molten outer layer of the moon. The possibility of finding this material was one reason the Hadley-Apennines site had been chosen; scientists thought that if anorthosite was to be found on the moon, a highland site (and one adjacent to a large collisional mare) would be the best place to look for it. Scott put the sample into a bag by itself; back on earth it was dubbed the "Genesis rock."[32](#)

After a few more minutes of sampling and photographing the site, they climbed back on the rover and started back to the lunar module. Since there was time available, Houston directed them to stop at site 4 (the one that had been deleted before the traverse started) where they took more samples. Then it was back to Falcon to unload their cargo and return to the surface experiments site. Scott made another attempt to remove the core drill he had left in the ground the day before, but succeeded only when Irwin helped him pull it out. The second hole for the heat-flow experiment was drilled and the temperature sensors were emplaced in both holes. After performing a few more experiments in soil mechanics, Scott and Irwin drove back to the lunar module, where they had one more task to perform: planting the American flag at the landing site. That done, they transferred the samples to the LM, and closed the hatch, having completed the most productive lunar science traverse of the program so far.[33](#)

Flight director Gerald Griffin expressed that evaluation more strongly at the change-of-shift press briefing: in his opinion, "we probably have just witnessed the greatest day of scientific exploration . . . in the space program that we've ever seen."[34](#) Allowing for his understandable enthusiasm, Griffin's statement had solid foundation in fact. Lunar missions had made advances in two years' time that few would have expected. The equipment had functioned virtually without flaw, with margins of expendables to spare. Scientists and network audiences on earth had received live color television pictures far surpassing the crude black-and-white images transmitted by Apollo 11. The astronauts had wasted no time, they had provided excellent descriptions of what they could see, they had exercised their judgment in collaboration with the ground-based scientists, and had documented and collected more than 100 pounds (45 kilograms) of rocks, soil, and core samples. Observers in Mission Control thought they could tell that Scott and Irwin adapted to lunar gravity on the first traverse and as a result were more sure-footed and confident on the second.[35](#) One

more traverse remained, a trip to the edge of Hadley Rille, but 15 would have been rated a success without it. Capcom Joe Alien passed the word from scientists to the crew just after they returned to the LM:

I'm told that we checked off the 100 percent science completion square some time during EVA-1 or maybe even shortly into EVA-2. From here on out, it's gravy all the way, and we're just going to play it cool, take it easy, and see some interesting geology. It should be a most enjoyable day.

"Okay, Joe," Scott replied, "Thank you. We're looking forward to it."[36](#)

Their work was not the mission's only contribution to lunar science. While they had been dashing around the surface, Al Worden in *Endeavour* had been circling the moon operating the cameras and instruments. In *Endeavour's* highly inclined orbit he was able to see features that no previous observers had laid eyes on, and he provided detailed descriptions each time he crossed the earth-facing side of the moon.[37](#)

Early the next morning Irwin and Scott left the lunar module on a west-northwesterly heading to get a good look at Hadley Rille. After describing, photographing, and televising the features of the broad canyon, including evident layering in the walls, they completed their third traverse in just under 5 hours.[38](#)

Back at their base, they collected the solar-wind experiment, after which Irwin produced a postal cover carrying a new stamp commemorating "a decade of achievement" in space, and applied a first-day cancellation provided by the Postal Service.[39](#) A few minutes later Scott stood before the rover's TV camera to conduct a scientific demonstration:

. . . In my left hand, I have a feather. In my right hand, a hammer. . . . One of the reasons we got here today was because of a gentleman named Galileo a long time ago who made a rather significant discovery about falling objects in gravity fields. . . . The feather happens to be, appropriately, a falcon feather, for our Falcon, and I'll drop the two of them here and hopefully they'll hit the ground at the same time. [They did.] . . . This proves that Mr. Galileo was correct in his findings.[40](#)

Scott then drove the rover about 300 feet (90 meters) away, where he parked it with the television camera pointed at *Falcon*, aligned the antenna with earth, and walked back to help Irwin load sample bags into the lunar module.

For the next three hours the crew of the *Falcon* were occupied with stowing equipment and sample containers and configuring the LM for takeoff. Then, while the television camera watched, *Falcon's* ascent stage shot up from the surface in a shower of fragments of insulation, visible for only a second or two. Flight controllers had intended to follow *Falcon* with the camera, but decided against it when problems developed in the camera's control system.[41](#) The result contrasted sharply with the majestic rise of a Saturn V; with a "quick pop" and "a shower of sparks [that] looked more like something left over from the Fourth of July," as one columnist put it, *Falcon* quickly disappeared from the TV screen.[42](#)

Falcon and *Endeavour* linked up an hour and 34 minutes later, and after jettisoning the lunar module the three astronauts settled in for two days of additional lunar-orbital data-gathering.[43](#) On their last orbit they released the scientific subsatellite, then headed for home. While the spacecraft was still nearly 200,000 miles (320,000 kilometers) from earth, Al Worden carried out the last extravehicular excursion of the mission, a 38-minute "space walk" to remove film cassettes from the cameras in the scientific instrument module.[44](#) The long voyage home ended on August 7, when *Endeavour* dropped into the Pacific Ocean about 320 miles (515 kilometers) north of Hawaii. The landing was a little harder than normal because one of the three parachutes failed to open fully, but no damage or injury resulted.[45](#)

* Conscious of the importance of science on their mission, the crew named their spacecraft for the ship commanded by Lieut. James Cook, who had sailed from England to Tahiti in 1768 to observe the transit (passage between the earth and the sun) of the planet Venus in August 1769. Apollo Prime Crew Press Conference, June 18, 1971, transcript.

10. Ibid., pp. 517-18.

11. MSC Public Affairs Office, "Apollo 15 Postlaunch Briefing," July 26, 1971.
12. MSC-05161, "Apollo 15 Mission Report," Dec. 1971, pp. 1-1, 3-2.
13. *Ibid.*, pp. 3-1 to 3-7, 9-1 to 9-6.
14. *Ibid.*, pp. 9-7 to 9-8.
15. MSC-04558, "Apollo 15 Technical Air-to-Ground Voice Transcription" (hereinafter cited as "15 Air-to-Ground"), pp. 337-66; Apollo 15 Mission Report, p. 9-9.
16. Apollo 15 Mission Report, pp. 9-14 to 9-15; 15 Air-to-Ground, p. 453.
17. 15 Air-to-Ground, 485-89.
18. *Ibid.*, pp. 490-506.
19. *Ibid.*, pp. 536-39.
20. *Ibid.*, p. 546.
21. *Ibid.*, p. 544.
22. *Ibid.*, pp. 547-48, 550, 554, 556, 560-61.
23. *Ibid.*, pp. 568-610; Apollo 15 Mission Report, p. 4-1; JSC-09423, "Apollo Program Summary Report," Apr. 1975, p. A-7.
24. 15 Air-to-Ground, pp. 635-77.
25. MSC, Change of Shift Briefing, July 31, 1971, 6:20 p.m. CDT, transcript.
26. 15 Air-to-Ground, pp. 675-76.
27. *Ibid.*, p. 676.
28. David R. Scott, "Finding the Golden Easter Egg," *New York Times*, Aug. 13, 1971.
29. 15 Air-to-Ground, p. 732; Apollo 15 Mission Report, p. 14-86.
30. 15 Air-to-Ground, pp. 734-824.
31. *Ibid.*, p. 827.
32. William K. Stevens, "Astronauts Fly to Texas Bearing Moon Rock Cargo," *New York Times*, Aug. 9, 1971.
33. Apollo 15 Mission Report, pp. 4-1 to 4-3, 14-62 to 14-68; 15 Air-to-Ground, pp. 832-952.
34. MSC, "Change of Shift Briefing, August 1, 1971, 2:40 p.m. (CDT)," transcript.
35. *Ibid.*
36. 15 Air-to-Ground, p. 994.
37. *Ibid.*, pp. 366-70, 460-67, 512-14, and elsewhere; Apollo 15 Mission Report, p. 5-14; Abigail Brett, "Worden Discovers 'Hot Spot' Of Radioactive Deposits," *Washington Post*, Aug. 3, 1971.

38. Apollo 15 Mission Report, p. 4-3.

39. 15 Air-to-Ground, p. 1140. Another batch of stamps caused acute embarrassment to NASA and resulted in disciplinary action for the three Apollo 15 astronauts. After a stamp dealer in West Germany advertised philatelic covers that had been to the moon on Apollo 15, it came to light that the crew had taken 400 covers with them. Before the flight the covers, which bore 10-cent Apollo 11 commemorative stamps, were canceled at KSC; on return, the astronauts affixed two 8-cent "decade of achievement" commemoratives (the same as the one canceled on the moon for the U.S. Postal Service) and had them canceled aboard ship. These covers were later autographed by the three astronauts and a notarized statement intended to authenticate them was typed on each. One hundred of these covers were given to the German dealer, who reportedly sold them for 4,850 deutschmarks (about \$1,500) each. Belmont Faries, "A Lunar Bonanza," *Washington Star*, June 18, 1972.

Investigation revealed that the astronauts had been authorized to carry a smaller number of souvenir covers in their personal preference kits - normal practice for manned space flights, it being understood that such souvenirs would not be exploited for personal profit. When the reports became the subject of inquiries to Deke Slayton and John P. Donnelly, assistant administrator for public affairs at Headquarters, NASA impounded the remaining covers and began an official investigation. William Hines, "NASA Probing Moon Stamp Caper," *Washington Star*, July 2, 1972.

It developed that the astronauts had given the flown covers to an intermediary in Florida, who passed them on to the German dealer. It was understood that the proceeds from sale of the covers would be put into a trust fund for the astronauts' children; but they later had second thoughts and refused the offer. Nonetheless, after the basic facts were made known, NASA officially reprimanded Scott, Worden, and Irwin with the statement that they had used "poor judgment" and "their actions will be given due consideration in their selection for future assignments." Harold M. Schmeck, Jr., "Apollo 15 Crew Is Reprimanded," *New York Times*, July 12, 1972; "Apollo 15 'Postmen' Officially Reprimanded," *Houston Post*, July 12, 1972; "Postmark: The Moon," *Newsweek*, July 24, 1972; Thomas O'Toole, "Ex-Astronauts Disregarded Warning Against 'Souvenirs'," *Washington Post*, Aug. 1, 1972. The Senate space committee looked into the matter, concluded that no laws had been violated, and took no action. They discovered that unauthorized items had been taken on other lunar landing missions as well. Richard D. Lyons, "Astronauts and Space Officials Heard At Inquiry on Exploitation of Souvenirs," *New York Times*, Aug. 4, 1972. The results of NASA's own investigation were publicized in an 18-page press release, NASA Release 72-189, "Articles Carried on Manned Space Flights," Sept. 15, 1972, which stated that the astronauts' "official Efficiency Reports as military officers reflect a formal finding of lack of judgment," and also noted changes in NASA Regulations that were promulgated to prevent recurrence of such embarrassing incidents.

The incident caused an uproar among American philatelists. The journal of the American Philatelic Society carried two reports of an investigation intended to make known exactly what happened, so that collectors would be aware of the possibilities of fraud. Lester E. Winick, "Report on Apollo 15 Covers - Smuggled and Authorized," *The American Philatelist* 86(10) (1972):887-95, and "'Lookalike' Apollo 15 Covers Prompt Philatelists' Caution," *ibid.*, 86(11) (Nov. 1972):992-98.

40. 15 Air-to-Ground, p. 1142. Scott correctly credited Galileo Galilei (1564-1642), Italian astronomer and physicist, with the deduction that bodies of different weight should fall with the same velocity in the absence of air resistance. He would have been more accurate to assign the credit for getting him to the moon to Sir Isaac Newton (1642-1727), who first formulated the laws that govern the motion of a body moving in a gravitational field and provided a mathematical basis for Galileo's hypothesis. Only with the development of high-speed electronic computers, however, was it possible to solve the equations for the motion of a spacecraft with sufficient accuracy to allow Scott to land at a specific spot on the plain at Hadley. The only notice taken of Scott's demonstration, other than press reports, was in the preliminary science report. Joe Allen, concluding a paper summarizing the scientific results, noted that the result was "predicted by well-established theory, but [was] nonetheless reassuring considering . . . that the homeward journey was based critically on the validity of the particular theory being tested." *Apollo 15 Preliminary Science Report*, NASA SP-289 (Washington, 1972), p. 2-11.

41. Fred Farrar, "Astronauts Leave Moon, Link Up with Mother Ship," *Chicago Tribune*, Aug. 3, 1971; Apollo 15 Mission Report, pp. 14-71 to 14-72.

42. Tom Wicker, "Man and the Moon," *New York Times*, Aug. 3, 1971.

43. Apollo 15 Mission Report, p. 1-3.

44. Ibid., p. 14; John Noble Wilford, "Worden Ventures Outside the Cabin of Apollo Craft," *New York Times*, Aug. 6, 1971.

45. O'Toole, "Apollo 15 Lands Hard but Safely," *Washington Post*, Aug. 8, 1971; Apollo 15 Mission Report, pp. 1-4, 14-17 to 14-21.

