



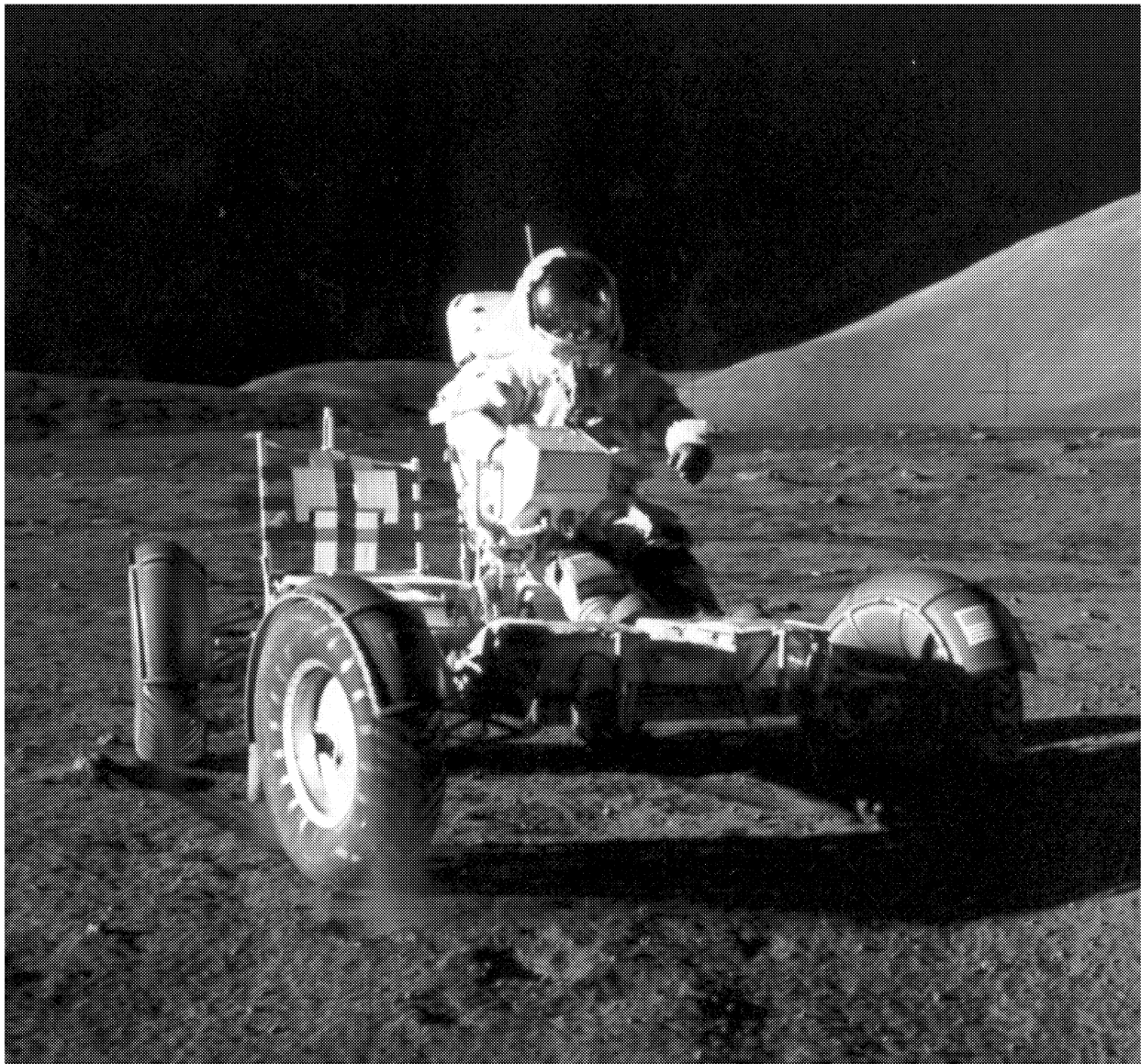
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# mission report

MR-12

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## APOLLO 17 -- THE MOST PRODUCTIVE LUNAR EXPEDITION



*Astronaut Cernan checks lunar roving vehicle.*

The Apollo 17 astronauts stayed longer, traveled farther, and took back more of the Moon than any previous team. Among their records:

- Longest time on the Moon (74 hours, 59 minutes, 38 seconds)
- Longest single extravehicular activity (EVA) time on the Moon (7 hours, 37 minutes, 21 seconds on second EVA)
- Longest total EVA time. There were three separate EVA's. (22 hours, 5 minutes, 6 seconds)
- Longest distance driving the Lunar Roving Vehicle (LRV) during an EVA (19½ kilometers, or about 12 miles on the second EVA)
- Longest total mileage for LRV (35 kilometers, or nearly 22 miles)
- Longest time in lunar orbit (147 hours 48 minutes)
- Longest Apollo mission (301 hours 51 minutes)
- Heaviest total of lunar samples returned to Earth (116 kilograms, or 225 pounds).

Probably the most remarkable occurrence of Apollo 17 was the discovery during the second EVA of reddish-brown material on the rim of a crater. (In the bright lunar sunlight, the material appeared to be orange-colored.) The material may indicate rock alteration by volatiles (steam or other gases) and a possible volcanic fumarole, which is a vent associated with volcanic activity, in a planet's crust. Most lunar soil looks bluegray or tangray. The astronauts' surface gravimeter showed a high reading here, indicating a dense structure, probably hardened basalt lava flows underneath.

The Apollo 17 mission was particularly benefitted by the presence for the first time on the Moon of a trained geologist. This was Dr. Harrison H. Schmitt, who as lunar module pilot accompanied Apollo 17 commander Eugene A. Cernan to the lunar surface.

The two astronauts explored a section of the Moon called Taurus-Littrow, which takes its name from the nearby Taurus Mountains and Littrow Crater. The region is a valley floor pockmarked with craters and littered with boulders. It is set among mountains southeast of Mare Serenitatis which are believed to have been uplifted by the massive collision that created the dry sea.

One of the reasons scientists chose the landing site of Apollo 17 is that Apollo 15 astronaut Alfred M. Worden, Jr., orbiting the Moon in the command module, spotted conical mounds in its vicinity. He identified them as cinder cones, such as are formed on Earth by accumulation of volcanic debris around a vent. Another reason is that the site appeared to be made up of materials ranging from the most ancient highlands to the relatively young mantling material that overlies an older basalt (lava) subfloor. As expected,

Apollo 17 proved to be an exploration through time. Schmitt and Cernan described and sampled highland units probably more than four billion years old, basalts possibly on the order of three billion years, overlying rubble one to two billion years old, and the reddish-brown soil which may have been deposited as recently as some tens of millions years ago.

The countdown for launch of Apollo 17 began at 8:30 a.m. EST, November 30, 1972. Among the early activities were providing electrical power to Saturn V, the launch vehicle, and filling the water tanks of America, the command/service module, and Challenger, the lunar module.

The countdown proceeded smoothly until just 30 seconds before the scheduled launch at 9:53 p.m., on December 6, when an unplanned automatic cut-off took place.

The hold occurred when the Terminal Countdown Sequencer (TCS), the computer controlling the countdown, failed to command pressurization of the liquid oxygen tank of the Saturn V third stage. Cause of the failure was a defective diode on a printed circuit card in the TCS. Although manual pressurization was accomplished, the interlock for pressurization was not actuated.

Using a breadboard, where the computer program was spread out so it could be analyzed, engineers at Marshall Space Flight Center, Huntsville, Ala., devised a jumper to bypass the interlock. This work together with other necessary considerations delayed the launch for 2 hours 40 minutes.

The launch at 12:33 a.m., December 7, the first in darkness, nearly turned night to day. As the Apollo/Saturn V vehicle sped across the sky, its blazing trail, more than 200 feet long, could be seen in clear skies as far away as 500 miles.

Despite the launch delay, Apollo 17 became the most perfect of all Apollo missions. And all of the time that was lost was made up by modifying the spacecraft's trajectory to speed up translunar coast. By the time Apollo 17 reached the Moon, it was back on schedule.

Apollo 17 entered lunar orbit at 2:47 p.m. EST, December 10. At 7:04 p.m., Apollo 17 adjusted its orbit so that its perilune, or lowest point, was 27 kilometers (about 17 statute miles) above the Moon. During the twelfth revolution, at 12:21 p.m., December 11, Cernan and Schmitt separated the lunar module, Challenger, from the command module, America. Subsequently, Ronald Evans, America's pilot, rocketed his craft into a 130 by 100 kilometer (78 by 62 statute mile) parking orbit from which he would conduct an extensive study of the Moon.

At 2:55 p.m. December 11, Cernan announced that "The Challenger has landed," the sixth time that men have reached the Moon's surface. Landing coordinates were 20°12'16"N. and 30°45'0"E.



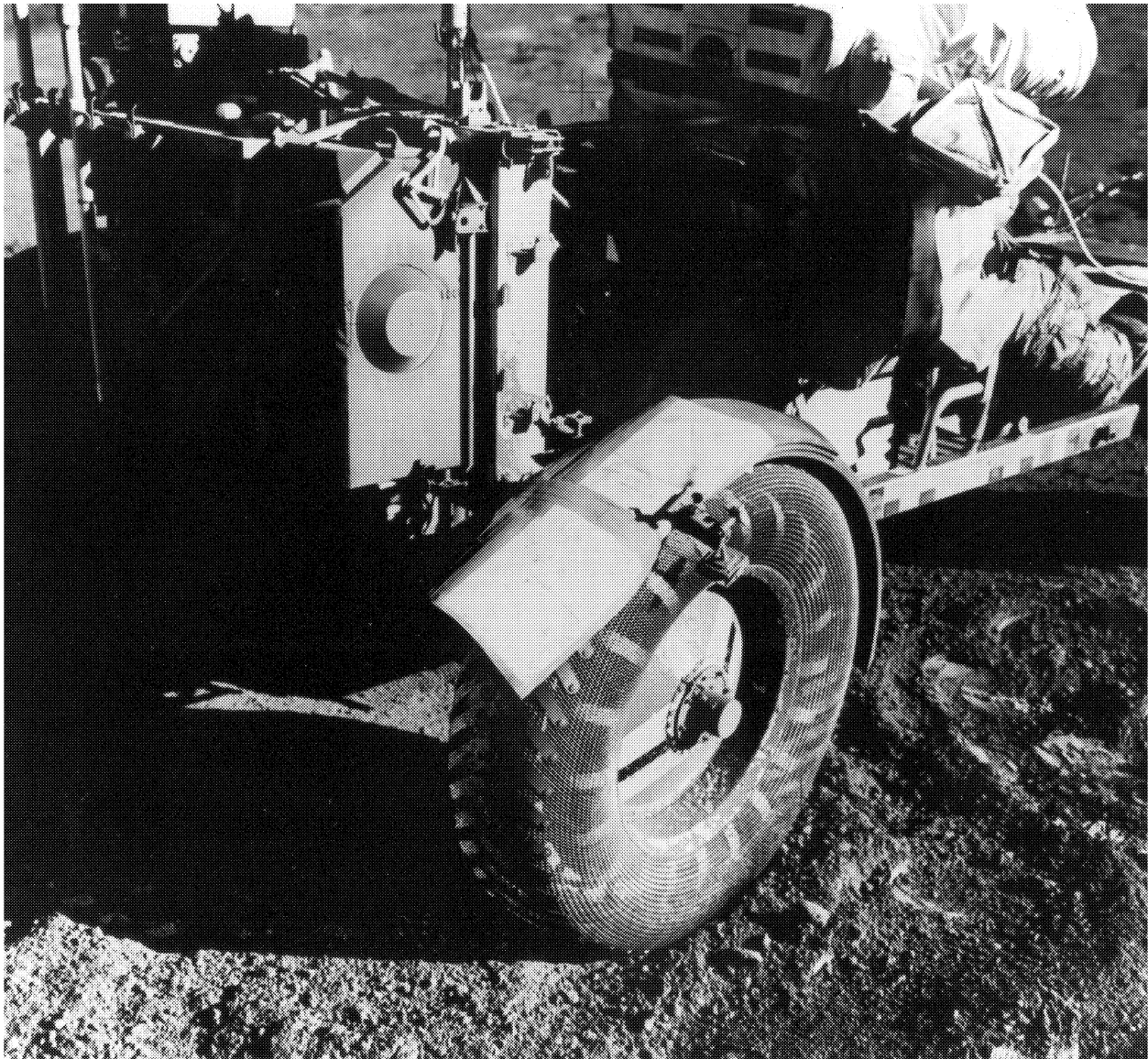
*Night launch of Apollo 17.*

At 7:05 p.m., December 11, Cernan planted his booted foot on the Moon. He declared: "I'd like to dedicate the first step of Apollo 17 to all those who made it possible."

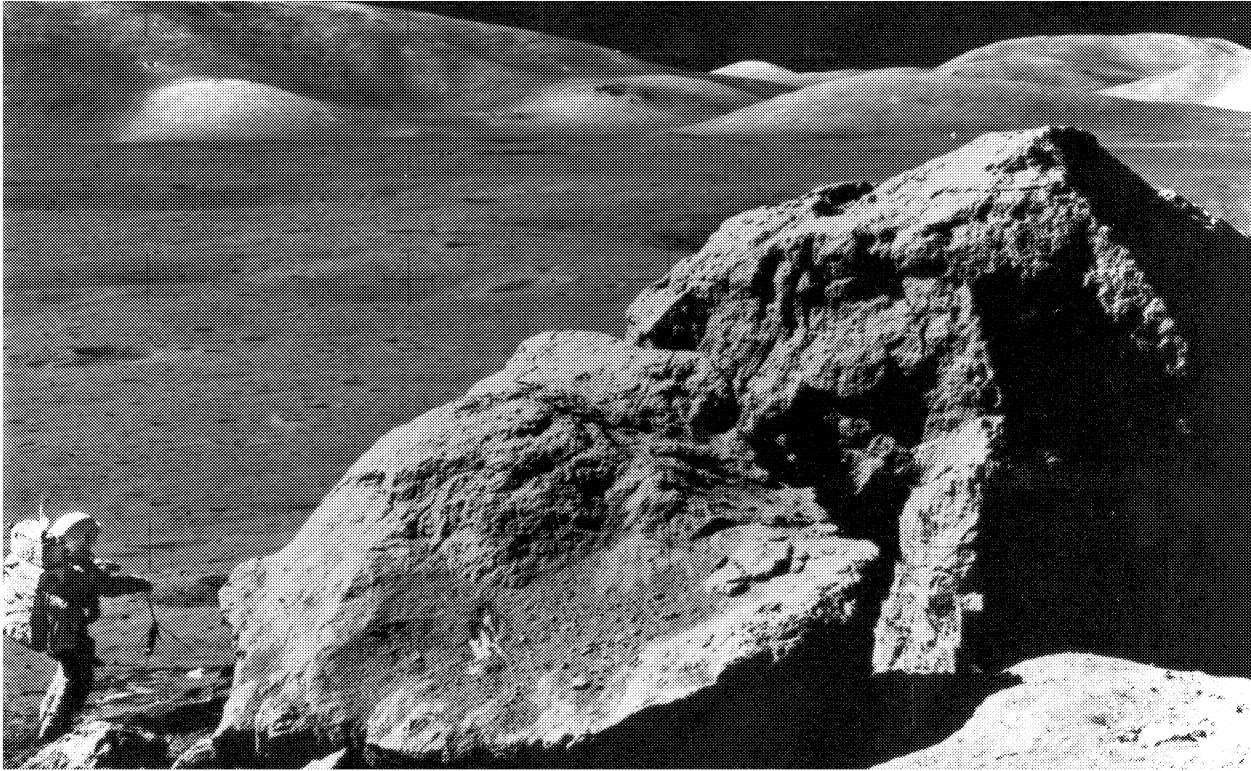
During the first EVA, the right rear extension of the lunar roving vehicle (LRV) fender was inadvertently knocked off. Taped back, it did not hold, and Cernan and Schmitt were showered with Moon dust during a part of their expedition. However, they completed the major part of their assignments, including the setting up of the Apollo Lunar Surface Experiment Package (ALSEP), the cosmic ray detector, a neutron

detector, some of the explosive packages which were to be set off after they left the Moon; raising the American flag; and gathering rock samples. The flag planted on the Moon is the one which had been displayed in Mission Control since Apollo 11 in 1969.

Before starting EVA 2, the crew received instructions from Mission Control for improvising a fender extension. They taped together four plastic maps they no longer needed and attached them to the fender with two clamps from the utility lights in Challenger's cabin. The rigged fender functioned perfectly.



*Improvised fender extension on lunar roving vehicle, Apollo 17.*



*Astronaut Schmitt views huge split boulder at Taurus-Littrow. He is holding gnomon and photometric chart assembly to establish local*

*vertical, Sun angle, scale, and lunar color for photographic reference.*

During this EVA, Cernan and Schmitt explored a rockslide at the bottom of South Massif, a mountain made up of a gigantic mass of fragmented and fractured rock forced upward when the Serenitatis basin was formed. (The astronauts' gravimeter indicated that the mountain material, which is less dense than that of the valley floor, extends several kilometers below the floor.)

Scientists estimate that the slide from South Massif occurred about a half billion years ago. At the slide's edge and punching through it is Shorty Crater, which was apparently formed afterwards. Adjacent to Shorty Crater is the interesting reddish-brown soil which Cernan and Schmitt discovered.

Careful study of the soil in the Lunar Receiving Laboratory on Earth showed that it was composed mostly (about 90 percent) of tiny orange-tinted glass spheres and fragments. The particles were mostly finer than about 50 microns (1/500 inch) and contained about ten times as much zinc as other lunar soil samples. The reddish brown material was evidently a recent deposit as bits of the surrounding rubble were not found mixed with it. (Stirring of the Moon's surface materials results from constant meteorite bombardment by particles from space.)

The distribution of the soil around Shorty Crater plus its obvious reddish-brown color which could be caused by such erupting volcanic gases as oxygen or hydroxyls that oxidize materials as they pass through them contribute to the idea that Shorty is a volcanic crater.

The uniquely colored soil also had much higher proportions of iron, magnesium, and titanium oxides than the surrounding material. The proportions were comparable to those in material from Mare Tranquillitatis where Apollo 11 landed. The significance of this information is yet to be determined.

Cernan and Schmitt drove two 16-inch core tubes attached end to end into the formation. On removing them, Schmitt noted: "The bottom one is black and orange, and the top one is gray and orange." Such color layering is typical of material around a volcanic vent.

Heat flow measurements taken in the Hadley-Apennine area by the Apollo 15 ALSEP exceeded the highest estimates based on the hypothesized quantity of radioactive elements in the Moon. Scientists needed to check another site to determine if the Apollo 15 area is a local hot spot or if the Moon is warmer than earlier assumed.

Data from the heat flow experiment set up at Taurus-Littrow appear comparable to those from

Hadley-Apennine. This has lent further credence to the idea that the Moon is not cold and dead.

Additional support for a currently warm lunar interior comes from data provided July 17, 1972, by four ALSEPS set up by earlier Apollo expeditions. A meteorite estimated at more than a ton in weight hit the Moon's far side sending seismic waves through its center to the ALSEP seismometers on its near side. An impact normally generates two types of seismic waves: shear and compressional. Shear waves do not travel through molten material. None was picked up at certain stations. Moreover, the compressional waves that were recorded were focussed in a way indicative of passage through partially molten material.

The remnant magnetism detected in the Moon rocks also suggests a past or present molten core as well as a lunar history of faster spinning.

At 5:23 p.m. EST, December 13, Cernan and Schmitt began their third EVA. It was during this EVA that Cernan dedicated a Moon rock to all the youth of the world through the eighty teenage science students (representing 79 nations from six continents) who were participants in the NASA-sponsored International Youth Science Tour. The students were at the Manned Spacecraft Center, Houston, watching the EVA when Cernan made the announcement.

Selected by their respective governments, the students had also attended the Apollo 17 launch at the Kennedy Space Center, Florida; and in the course of a two-week tour they visited major United States science facilities, and educational and research centers from coast-to-coast.

The International Youth Science Tour, the first such project, was undertaken in cooperation with the State Department and U. S. Information Agency. It was supported by the National Science Teachers Association as well as industries and other groups and individuals in the private sectors.

While Cernan and Schmitt explored the lunar surface, Evans, circling the Moon in America, was operating an array of equipment to take pictures of the Moon, make a temperature profile of the Moon's surface underneath the spacecraft, check the composition and density of the sparse lunar atmosphere, and acquire a geologic cross-section of the Moon to a depth as great as 1.3 kilometers (.8 mile).

Evans sighted a series of small dark round humps with smooth surfaces in Aitken Crater on the Moon's far side. The humps resembled volcanic domes he studied near Mono Lake in northern California. This is the first time that evidence of possible recent volcanic activity has been observed on the Moon's far side.

Evans also sighted several other volcanic-appearing craters and spotted orange-colored material around craters in Mare Crisium, in the landing site area, and in Mare Serenitatis.

While these observations were in progress, the U.S. Geological Survey reported that a new look at pictures from Apollo 14 showed brown-orange colored soil around the crater Langrenus and a smaller crater. Thus, the phenomenon which Cernan and Schmitt discovered at Shorty Crater appears to be widespread rather than unique.

After completion of their assignments on the Moon, Cernan and Schmitt returned to Challenger, the lunar module, and prepared it for launch. At 5:55 p.m., December 14, 1972, Challenger lifted off from the Moon, ending the era of Apollo lunar surface expeditions. Some two hours later, Challenger docked with America, the command module, in lunar orbit. Subsequently, Cernan and Schmitt returned to the command module with their valuable lunar samples. At 1:50 a.m., December 15, Challenger was crashed as planned into the steep-sided wall of South Massif some 9 kilometers (about 5½ miles) from the landing site, to contribute to obtaining a subsurface profile of the area. By December 13, eight explosive charges that Cernan and Schmitt had distributed around the area were fired remotely from Earth to add to completeness of the survey.

In this connection, the planned impact of the S-IVB upper Saturn V stage at 3:33 p.m., December 10, was picked up by all four passive seismometers left on the Moon by earlier Apollo expeditions. The S-IVB was crashed east of the Apollo 14 Fra Mauro landing site. Analyses of data suggested, among other things, that the Moon's crust may be only 25 kilometers (about 15½ miles) thick. This is approximately half of the previously-made calculation. Earth's crust ranges from about 5 kilometers (3 miles) under the oceans to 50 kilometers (30 miles) under massive mountains.

The three astronauts remained in lunar orbit for two more days to gain the maximum study time for what may be man's last close view of the Moon in this century. Later that day, the astronauts fired their 20,000-pound-thrust service module engine to break loose from lunar orbit and head home.

At 3:33 p.m., December 17, while about 180,000 miles from Earth, Evans left the command module and clambered along the side to the open SIM bay in the service module to retrieve cassettes with film from the lunar sounder that probed below the Moon's surface, the mapping camera, and the panoramic camera. Evans' EVA lasted until 4:33 p.m. when the command module hatch was secured for the remainder of the voyage.

Evans' space walk, which was telecast to Earth, was necessary because the service module is discarded before the astronauts return to Earth.

Among preliminary results of data acquired by instruments in lunar orbit were the following:

- The lunar sounder gave information on lunar materials as deep as 1.3 kilometers (about four-fifths of a mile) under the surface. Analysis of its film data may indicate the number and types of geologic layers existing down to this depth.

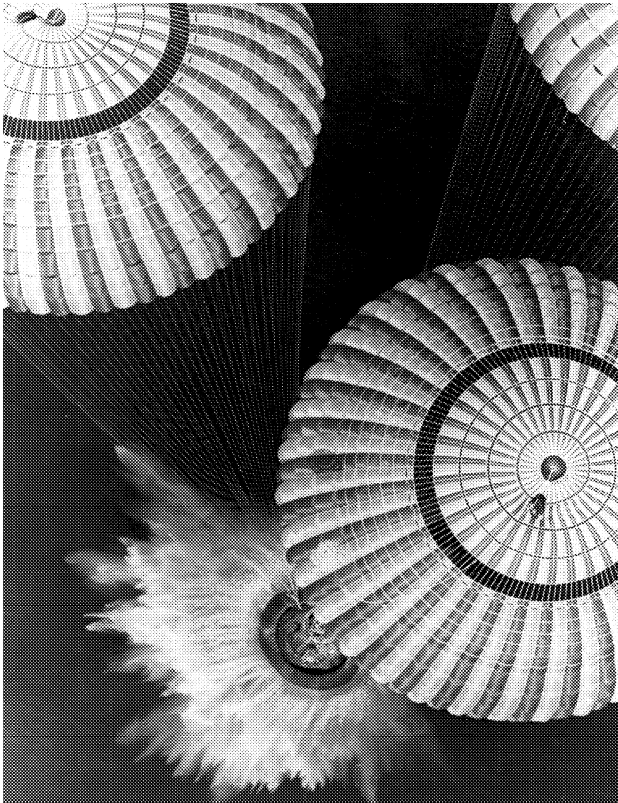
- Ultraviolet spectrometer data indicate that there is virtually no gas escaping from the Moon. Traces of a lunar atmosphere do, however, exist, the amount of any measured constituent being no more than one percent of the total pressure indicated earlier by the Apollo 12 ALSEP ion gage.

- The infrared radiometer made a hundred million temperature measurements. Temperatures were as much as 5 times as high at lunar noon as at lunar sunrise. Various locations probed at night showed hot or cold spots compared to the surrounding surface. Hot spots were usually associated with boulder fields or exposed bedrock near fresh impact features while cold spots appear to be covered with material of low density that retains little heat, such as volcanic ash. One cold spot is near a feature thought to be a cinder cone in Mare Oriental near the crater Hohman.

*View of Earth from the Mediterranean Sea to Antarctica from Apollo 17. Africa at upper right.*



*Overhead view of Apollo 17 at moment of splash-down.*



On December 19, Apollo 17 reached Earth's vicinity. After a flaming reentry, its three huge orange and white striped parachutes opened to lower it slowly into the Pacific about 650 kilometers (400 miles) southeast of Samoa and 6.4 kilometers (about 4 miles) from the recovery ship, Ticonderoga. Splashdown at 2:25 p.m. ended an era that began 11 years ago.

*Apollo 17 recovery operations. In background is U.S.S. Ticonderoga, prime recovery vessel.*



“... let us neither mistake the significance nor miss the majesty of what we have witnessed. Few events have ever marked so clearly the passage of history from one epoch to another. If we understand this about the last flight of Apollo, then truly we shall have touched a ‘many-splendored thing.’”

—President Richard M. Nixon  
December 14, 1972