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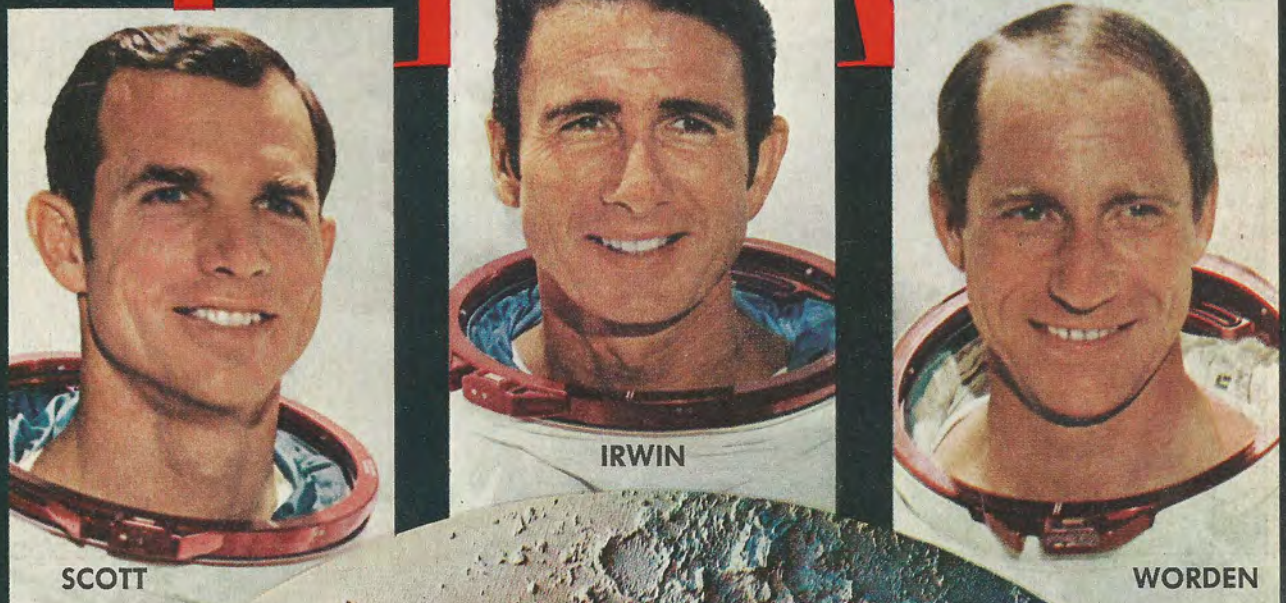
AUGUST 9, 1971

TIME



SCOTT

IRWIN

WORDEN

Apollo 15: The Most Perilous Journey

TIME

THE WEEKLY NEWSMAGAZINE

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A letter from the PUBLISHER

Henry Luce III

THINKING back to the early '60s, Reporter-Researcher Sydnor Vanderschmidt recalls the difficulties that "space journalism" had in getting off the ground: "When the space age began, it seemed that no one was prepared to interpret the developments for a general audience. The scientists used incomprehensible jargon, and a typical reporter's question was 'How in the world does that satellite stay up there?' " Since then, Syd observes, "newsmen have acquainted themselves with orbital mechanics, and the scientists have finally learned to speak English."

Assigned to TIME's Science section for the past 13 years, Syd, like other staffers in our specialized departments, has had ample opportunity to be both pupil and teacher. She has worked on 17 cover stories, and this week's is her eleventh on space travel. Her job last week involved digesting and summarizing complex NASA flight plans, scientific studies of the moon and background dispatches from our own correspondents. After the story was written and edited, her task was to make sure that the dozens of facts and figures in it were accurate. Throughout, she kept an eye on the human details of drama and suspense that make the moon journey an adventure far beyond science and technology.

DAVID GAHR

SYDNOR VANDERSCHMIDT

Reporter-Researcher Vanderschmidt's fascination with the drama of flight does not end in the office. Driving each weekend from their West Side Manhattan apartment to a small airstrip in the Catskills, she and her husband Tom put their knowledge of aerodynamics to the acid test by flying gliders.

Other members of our own Apollo-15 crew might be uncomfortable in a glider, but they are veterans of space coverage. Filing extensively from Cape Kennedy and Houston on the science of the flight, lunar geology, and the reactions of the crew and controllers as glitches arose, John Wilhelm, Leo Janos and James Schefter made good use of long experience on the space beat. Fred Golden, who wrote the story, has been our Science writer for two years. Don Neff, who edited the article, was TIME's Houston bureau chief in 1968-69 and covered Apollo shots 6 through 13. At Cape Kennedy last week, Golden and Neff found the launch site's jammed press bleachers more than faintly reminiscent of a class reunion. "There's always plenty of backslapping and laughter," says Neff, "but when those rockets fire up, the oldtimers are as wide-eyed and awestruck as kids at the circus."

The Cover: Graphic design by Dennis Wheeler incorporating NASA photographs and a moon painting by James Hendricks.

INDEX

TIME
THE WEEKLY NEWSMAGAZINE
Aug. 9, 1971 Vol. 98, No. 6

THE MOON

From the Good Earth to the Sea of Rains

As I stand out here on the wonders of the unknown at Hadley, I sort of realize there is a fundamental truth to our nature. Man must explore. And this is exploration at its greatest.

APOLLO 15 Astronaut Dave Scott was hardly exaggerating. As he stepped off the ladder of his moon ship *Falcon* to become the seventh man to walk on the lunar crust, Scott faced the most awesome terrain ever explored: stark mountains, treacherous gorges, strange mounds and craters. "I can look straight up and see our good earth there," he said. A quarter of a million miles away, the world looked up and saw Scott, his peculiar light-footed movements carrying him across color-television scenes of stunning clarity.

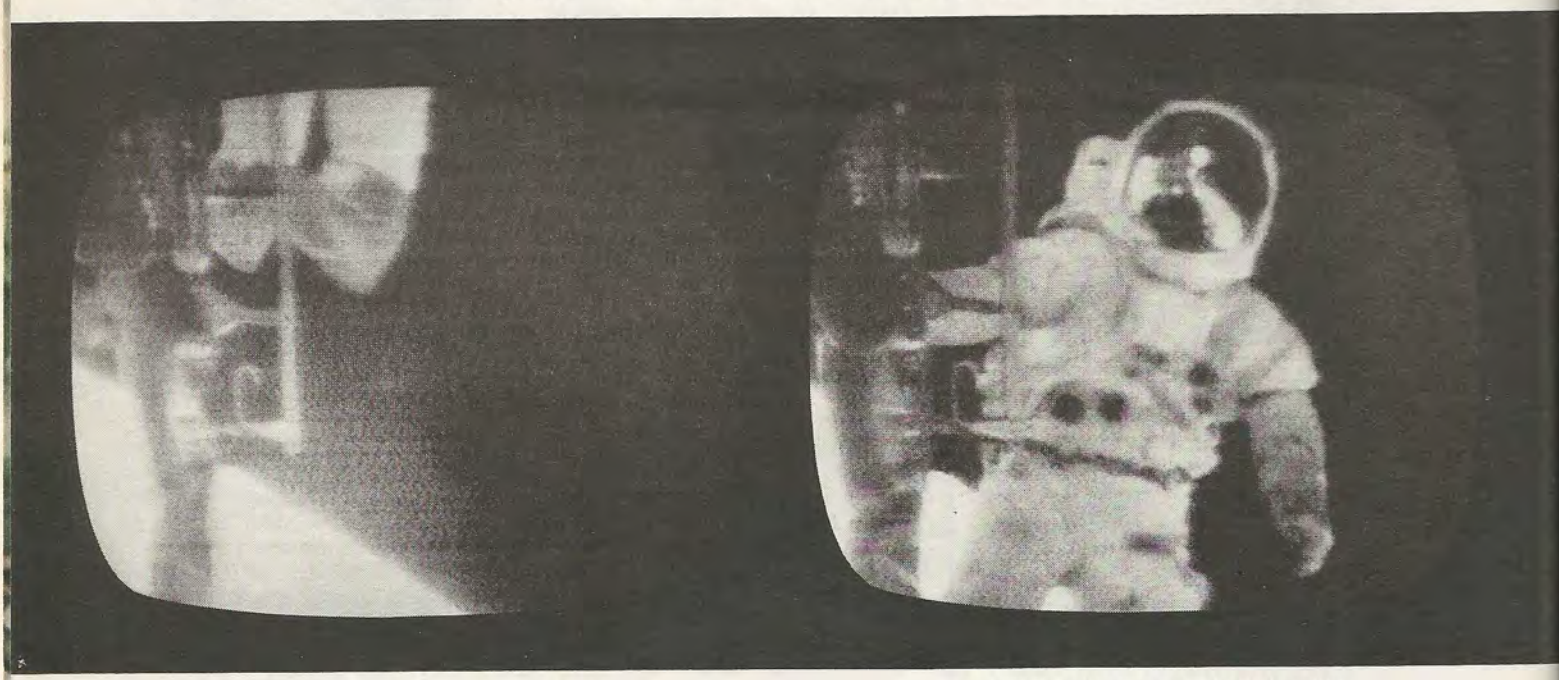
As Astronaut Jim Irwin bounded down the last step of the lunar-module ladder to join Scott, he kicked up a spray of fine black moon dust and shouted: "Oh boy, it's beautiful out here. It reminds me of Sun Valley." Scott reported the dust was 6 in. deep and "like soft, powdered snow." But it presented no problem to the astronauts. Together, the two men quickly launched into the now familiar unloading routine of moon landings. Then they turned their attention to a machine that all the world was waiting to see: the first man-driven vehicle on the moon.

With a tug on a cable, the $12.9 million lunar rover folded slowly out of *Falcon's* side. Its hollow, wire-mesh wheels snapped into place, and the moon car was lowered to the ground. Like most earthly vehicles the rover had a problem: the front-wheel steering did not work. Nonetheless, a 25-yard test drive showed that it was ready to go with its back wheels steering. After a motherly reminder from Mission Control ("Okay, Dave, remember to buckle up for safety"), the astronauts clambered aboard, strapped themselves into place, pushed the control stick forward and moved off, bouncing into their first jaunt across the moon. "Whew!" yelled Scott. "Hang on!" Then, as they reached their top speed of 8 m.p.h., he added: "It's really rolling hills. Up and down we go." Yipped Irwin: "Buckin' bronco!"

Thus last week began man's most audacious exploration of the moon. After a 3½-day journey that was nagged by small problems, Apollo 15 had set down in the midst of lunar highlands almost precisely on target. Their site in the Hadley Rille area at the edge of the mountain-ringed Sea of Rains is so varied that scientists are convinced it will prove a geological gold mine offering important new clues to understanding the moon and earth. The mission, to be sure, comes at a troubled moment in NASA's history (*see box, page 14*). But, as the astronauts crisscrossed the pulverized moonscape gathering priceless new knowledge, it was also a dramatic reminder that man's exploration of the solar system has only begun.

As the moon buggy headed toward the south, it proved to be thoroughly reliable, though Scott reported that steering with only the back wheels was more like handling a boat than a car. No matter. Scott had more important news for the anxious geologists in Houston's science support room. "Oh!" he exclaimed, "There's some beautiful geology out there."

Climbing up toward the Apennine front for the initial stop, Scott found the going increasingly rough. "Whoa!" he shouted as the buggy rebounded from one hard bump. The hill-and-dale ter-



SCOTT DESCENDS FROM LUNAR MODULE

TOUCHING DOWN ON THE MOON'S CRUST

rain made it difficult to keep track of their location. While the buggy's navigational system performed without a hitch, the astronauts had trouble picking out their cratered landmarks in the deceptive moonscape and frequently did not know precisely where they were. But the problem was suddenly solved. "Hey! there's the rille," said Irwin. Almost accidentally, the moon riders had driven smack to the edge of Hadley Rille, the 1,200-ft.-deep winding gorge whose origins are one of the moon's many mysteries.

Playing with Rocks

The astronauts found that on their side the rille sloped gently, while across the way it plummeted at a steep angle. In addition, the far side was strewn with large, angular boulders; their side was clear of big rocks. In Houston, geologists listened attentively to the astronauts' descriptions and decided that such conditions could support one commonly accepted theory that rilles were created by lava flows. Because the astronauts were already 25 min. behind schedule in the first EVA (extravehicular activity), Scott and Irwin had to press on to Elbow Crater, a large landmark about 1.8 miles from *Falcon*. "Okay," said Scott as he finally brought the rover to a halt, "we're at our first stop."

It took them only a minute to align the antenna for the rover's remote-controlled camera with the distant earth (*see box, next page*), and soon another series of dramatic images of the astronauts and the forbidding terrain appeared on TV screens. Leaving the rover, they walked with the familiar kangaroo hop of explorers in the one-sixth gravity of the moon. Each step on the soft surface splashed up a cloud of clinging dust. Among the bits of moon that they picked up was a long, crystalline rock, obviously heat-formed and possibly a precious fragment of the original crust. The geological pickings were so good that Scott regretted leaving the crater. "I wish we could just sit down and play with the rocks for a while," he said. "Just look at those babies—so shiny and sparkling." But there was no time. The astronauts took a bouncing ride to their second scheduled stop at the north slope of St. George Crater. "Houston, just wait until we hook up the TV. You're going to get a great view this time. The most beautiful thing I've ever seen." What had caught Scott's eye was a glass-speckled boulder sitting in splendid isolation uphill from the rover. "Imagine," said Scott, "it's been here since before creatures roamed the sea or land." Putting in a plug for the Apollo program, he added: "Tell me this isn't worth doing, boy."

It was only when they headed back toward *Falcon* that the moon riders fully appreciated how high they had gone. "Hang on," shouted Irwin as they speeded downhill. When they finally reached the flatlands of the Marsh of Decay (a name derived from old lunar maps), Scott mockingly announced: "Somebody else has been here." He had spotted tracks made by the rover on its outbound journey.

Back at *Falcon's* landing site, the astronauts began setting up the scientific instruments known as ALSEP (for Apollo lunar surface experiments package). But Scott ran into trouble when he tried to drill two 10-ft.-deep holes for a new experiment designed to measure the flow of heat from the moon's interior. Such readings could offer valuable clues to the composition and origin of the moon. After drilling one hole of little more than 5 ft., Scott found that no matter how hard he pushed on the electric drill, he could not make the second hole any deeper than about 3½ ft. "I'll tell you one thing. The base at Hadley is firm."

Scott's exertions were costly. Because he was working harder than expected, he rapidly depleted the oxygen supply in his life-support pack. Unwilling to take any extra risks, Mission Control ordered the astronauts to call an end to their outdoor activities for the day. Total time of the EVA: 6 hrs. 9 min., more than two hours longer than any previous moon walk.

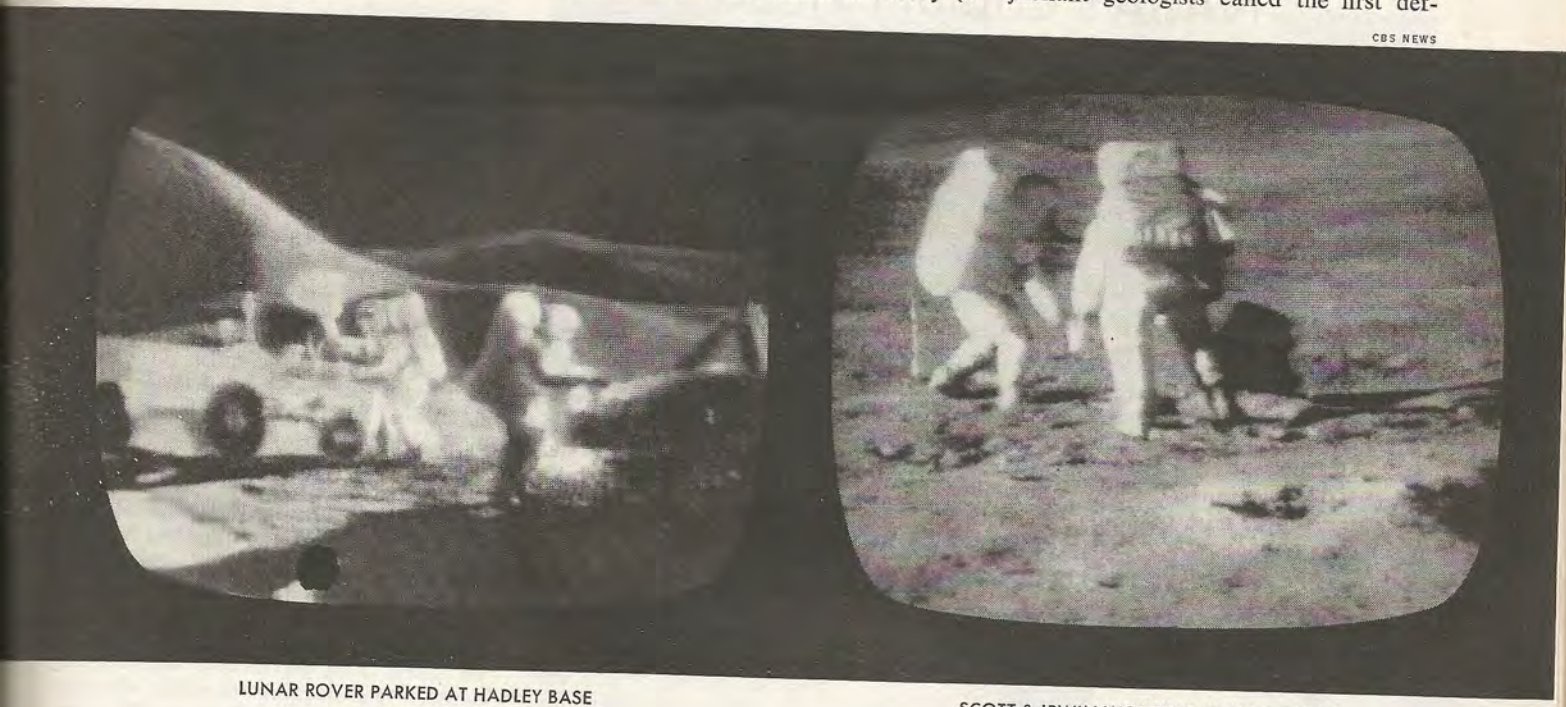
Second Moon Ride

On their second moon ride, with the front steering back in action, the astronauts drove to the Apennine Front and quickly gave geologists more cause for excitement. At Spur Crater, they picked up a small crystallized rock that was clearly highland material and possibly a fragment of the moon's original crust. From his high-flying laboratory, meanwhile, Worden spotted a 40-sq.-mi.-field of cinder cones, which jubilant geologists called the first definite sign of explosive volcanism on the moon—evidence of "one of the moon's last belches."

Next day the astronauts would take their final spin across the moon, beginning with a drive along the edge of Hadley Rille. That would provide still more spectacular scenery for television viewers back on earth and perhaps further insights into the origin of the puzzling lunar feature. At week's end Apollo 15's exploration of the moon had been as successful as the mission's launch: virtually flawless.

Rising from Cape Kennedy's Pad 39A, the 363-ft. Saturn 5 was a scant 187 milliseconds behind schedule. Said

CBS NEWS



LUNAR ROVER PARKED AT HADLEY BASE

SCOTT & IRWIN WORKING ON THE MOON

Launch Director Walter J. Kapryan in the unemotional argot of the Apollo project: "This is the most nominal countdown we've ever had."

Apollo 15 climbed majestically into orbit, then began the first of a series of new, daring maneuvers introduced into all phases of the mission to make the flight the most scientifically profitable yet. After blasting out of earth orbit, Apollo 15 went directly into a nonfree return trajectory to the moon. This fuel-saving measure meant that in the event of failure, the spacecraft would not automatically loop around the moon and return to earth; instead, it would go skittering beyond the earth and leave the astronauts marooned in space. Minutes later, Command Module Pilot Al Worden separated the command ship *Endeavour* (named after British Explorer James Cook's ship on his first expedition to the South Pacific) from the third-stage S-4B, turned his ship about in space, docked with the lunar module *Falcon* and effortlessly extracted it from its perch inside the rocket.

For all the apparent precision, there were glitches—those unexpected bugs that seem to plague the 15 million-part Apollos on all space voyages. The astronauts were just about to settle down for a leisurely coast to the moon when suddenly a yellow light flashed on, signaling that the command ship's main rocket, the 20,500-lb. service propulsion engine, had been switched on. Immediately there was fear that the moon landing would have to be aborted, but the experts in Houston soon diagnosed the problem as a faulty switch.

Flashes in the Eye

Next day Scott and Irwin discovered that a glass covering on a dial in the lunar module had mysteriously shattered. Although the breakage itself was inconsequential, Mission Control was anxious to have them sweep up glass fragments lest they damage the astronauts' pressure suits. The shards were collected with a piece of sticky, flypaper-like tape and a vacuum hose.

Later the astronauts were confronted by the first plumbing crisis in space: *Endeavour's* drinking-water tank developed a leak. Like any suburban homeowner, Scott whipped out a wrench stowed for just such an emergency, tightened a suspect valve and succeeded in stemming the flow. "We had a small flood up here," he said. "All we have to do now is hang up a few towels to dry."

With their problems under control, the astronauts conducted the first of their scientific experiments. Placing black sleep shades over their eyes, the astronauts saw the strange light flashes that have been reported by spacemen on previous voyages. Scientists believe high-energy cosmic rays impacting on the eye's retina or the brain's optical center cause the flashes. During the hour-long test, the astronauts reported seeing a total of 61 flashes, which Scott com-

NASA's Captain Video

THE stunning telecasts from Apollo 15's landing site involved an army of technicians, a worldwide network of tracking stations and a remarkable new $582,000 color camera developed by RCA. Yet if any single person can be credited with the success of the lunar sound-and-light show, he is a quiet, cherubic-looking NASA engineer named Edward I. Fendell, 39, who clearly ranks as the space agency's own Captain Video.

It was Fendell's responsibility to control the moon rover's camera during the astronauts' lunar explorations. Sitting at his large, 15-button console in Houston, Fendell operated the RCA camera from a quarter of a million miles away. With a push of the appropriate button, he could swing it across the mountain-ringed horizon, raise it up to focus on a peak or lower it to peer down Hadley Rille. He could zoom in on the astronauts for a closeup or even adjust the lens opening to compensate for the moon's harsh lighting conditions.

•

For all the technological help at his disposal, the job was unusually tricky. Because radio signals travel at the speed of light—186,000 miles per second—Fendell's commands took 1.8 seconds to reach the camera. Another three seconds elapsed before the image arrived back in Houston (the extra time was needed to convert the signals into a standard TV picture). Thus, before he or his assistant, Al Pennington, 27, saw the camera's response to their commands, a total of nearly five full seconds had gone by.

NASA

FENDELL AT CONSOLE IN MISSION CONTROL

Mastering such sluggish, long-distance photography required painstaking months of rehearsal during which electronic time delays were built into the system's circuitry to simulate the moon's distance. Perhaps just as difficult was the need to satisfy the conflicting demands of two masters: scientists and the public. NASA's geologists were primarily interested in terrain and rocks, while NASA's public relations men and the television networks wanted to focus on the astronauts themselves for a maximum amount of time. NASA worked out a compromise to appease both scientific inquiry and public curiosity.

At the beginning of every stop along the rover's route (there were no telecasts while the car was moving because its high-gain antenna could not be kept aligned with the earth), Fendell's "shooting script" called for what was dubbed a "WAP," or wide-angle panorama. The camera slowly swept in a full circle around the horizon, enabling the scientists in Mission Control's science support room to take a series of overlapping Polaroid snapshots off their TV monitor, quickly study them for any oddity and then request Fendell to zoom in on it. Such a closeup was called a "NATO," or narrow-angle target of opportunity. While the scientists pored over their pictures, Fendell adroitly mixed his WAPs and NATOs with numerous shots of the moon walkers.

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An electronics engineer with no previous TV experience, Fendell faced his toughest challenge at the end of the lunar visit. Left behind on the moon along with the rover, the remote-controlled camera was scheduled to give the world its first pictures of a lunar lift-off taken from the moon's surface. Because of the nagging time lags, Fendell could not afford to look at the TV monitor himself. He had to go completely by the clock. At exactly T-minus-zero, Fendell had to begin tilting the camera upward. Thus, by the time his command reached the moon, the camera would—he hoped—follow *Falcon's* ascent stage until it drifted off the tube. Then, in order to bring it back into sight, Fendell would have to press another button precisely two seconds after lift-off, ordering the camera to pull back to a wide-angle view. Noting NASA's—and the public's—keen interest in watching the lunar lift-off, Fendell conceded that "if we don't see it, I'd better get out of town."

pared to a flashbulb's popping in a darkened arena.

Nearing the moon, the astronauts performed yet another new maneuver by firing an explosive tape to knock the panel off a section of the service module called SIM (for scientific instrument module). An innovation on Apollo 15, SIM is literally a high-flying laboratory: it contains eight different scientific instruments, including a tiny (78.5 lbs.) subsatellite, two spectrometers and two special lunar mapping cameras.

Once the spacecraft was inserted into lunar orbit, the taciturn threesome began to perk up. Gazing at the bleak moonscape, Scott compared it to a great desert. "This is absolutely mind-boggling," he said. The scenery was apparently even more mind-boggling after the spacecraft descended to a lower orbit of only ten by 67 miles. Crossing over the towering Apennines, Scott said: "Why, it's just unreal . . . the mountains jut out of the 'ocean.' They appear smooth and rounded. There aren't any jagged peaks that we can see."

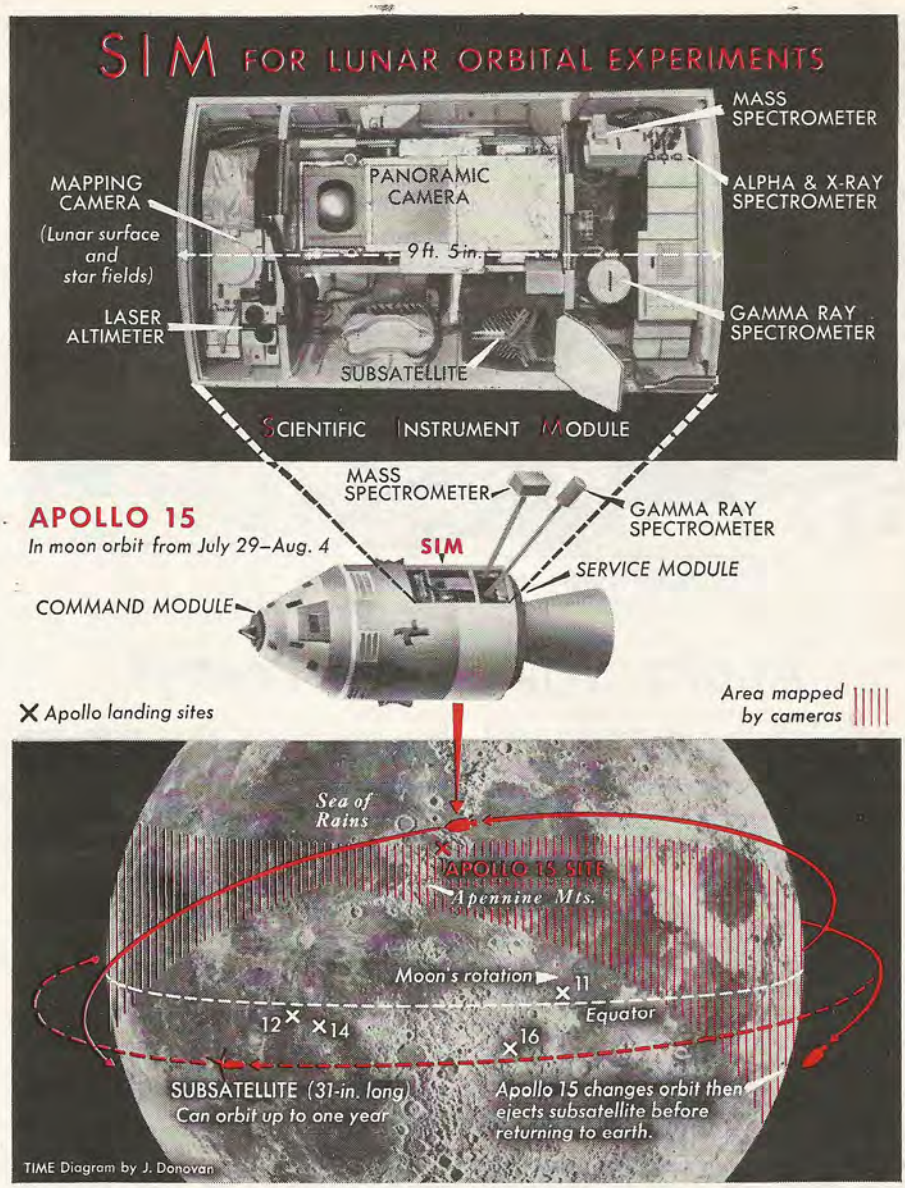
A short time later Scott and Irwin crawled into *Falcon,* preparing to cast off from the mother ship—and encountered another momentary scare. As they emerged from the back side of the moon, Scott reported: "Houston, we did not get a separation." *Falcon* and *Endeavour* were still tightly latched together. Again the wizards in Mission Control solved the problem: telemetry showed that two electrical plugs had not properly connected, and therefore separation could not be accomplished. Worden closed the circuit, and *Falcon* at last was free to fly on its own.

Virgin Surface

As *Falcon* plunged toward the Apennines' 12,000-ft. peaks in a trajectory steeper (25°) than any moon lander before, Scott and Irwin barely displayed a trace of emotion. By the time they were 50 ft. from the surface, the dust kicked up by *Falcon's* engine was so thick that Scott could not see the landing site. Relying on instruments, Irwin counted: "Ten feet . . . eight feet . . ." Then Scott cut in: "Contact." On *Falcon's* instrument panel, a blue light flashed. Said Scott: "The *Falcon* is on the plain at Hadley."

Scott had set down the spacecraft about 400 ft. northeast of the target. An hour and a half later, Scott donned his suit and poked his head out of *Falcon's* top hatch. "Oh, boy, what a view," he shouted, and he proceeded to name the features he had so carefully studied on earth. Scott's descriptions were so detailed that NASA Geophysicist Robin Brett said he performed as well as a professional geologist.

The Apollo 15 crew was reported to be the best trained in geology of any of the moon explorers. And indeed they should have been. For Apollo 15 was the first of the new "J" missions, a flight category primarily concerned with science rather than engineering. The



dangerous, 12-day, seven-hour journey of Apollo 15 had one overriding goal: to learn more about the most prominent heavenly body in the nighttime sky and thus more about the mysterious universe. Loved, feared, worshiped, the moon has figured in the mythology of most ancient people and has awed man since the beginning of human experience. The Greeks, who personified the moon in the form of the goddess Selene, were the first to study the lunar disk scientifically. They realized that their goddess was not luminous herself but shone only in the reflected light of the sun. They determined that the moon had mountains and valleys and that it always kept the same face turned toward earth. By the 3rd century B.C., the Greek philosopher Aristarchus and others had used geometry to make surprisingly accurate estimates of the moon's size, its orbit, its distance from earth. They even guessed that it was the cause of tides.

Yet the real beginning of lunar science had to await the invention of the telescope in the 17th century. Peering through their primitive instruments, Galileo and other early astronomers discovered a whole new world: great craters, deep canyons, sprawling dark plains (which they mistakenly identified as maria, or seas). In the wake of their findings, scientific interest in the moon began to grow. Long before Neil Armstrong set foot on the moon, two years ago, scientists had determined much of its basic nature. They knew that the moon is untouched by wind and rain and that it is lifeless: a virgin surface still much the same as it was billions of years ago. The moon's surface in effect is a surviving specimen of the early years of the solar system, which can provide a cornucopia of celestial information.

Fundamental Questions

Regardless how shrewd the detective work by earthbound scientists, however, many fundamental questions remained unanswered: How and where was the moon formed? Was it ripped from the earth while the planet was spinning more rapidly through space than it is today, or did it coalesce separately out of the

"Apollo, we've been going over the figures—we don't have the money to bring you back!"

Apollo: Where Is Its Poetry?

NOT since the tragic fire that killed three astronauts on the launch pad in 1967 has NASA's morale been so low or its future so bleak. The signs are all too apparent: shops are shuttered in Florida's once-booming Brevard County, the home of Cape Kennedy. Thousands of engineers and technicians are out of work in Southern California and other aerospace centers. Last week, even as Apollo 15 streaked to the moon, Congress sent the White House a compromise $3.27 billion NASA appropriations bill—$1.9 billion below the allocations of the space agency's heyday.

The Russians meanwhile are moving steadily ahead. Despite the disastrous end of Soyuz 11, they are launching payloads of all kinds at almost three times the U.S. rate. It almost seems, says Norman Mailer, who chronicled the first lunar landing in his book *Of a Fire on the Moon*, as if Americans no longer find any poetry in the quest to reach the stars.

Two years after Neil Armstrong's "giant leap for mankind," many Americans have become blasé about moon voyages. The technical argot of the astronauts has turned off some early enthusiasts, while the rigorous attention the moon walkers must pay to their inflexible schedules has made them seem like robots. Beyond that, the U.S. has become concerned with other pressing priorities: urban decay and pollution, poverty and racial inequality.

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For years, NASA was little bothered by such problems. To fulfill President Kennedy's mandate to land men on the moon within the decade, it frequently made space sound like a celestial Grand Prix with one purpose above all others: to beat the Russians. NASA became bloated by success and aloof from normal budgetary restraints. Engineers and jet pilots ruled Houston's Manned Spacecraft Center and NASA became the symbol of an older, less troubled America. While there may have been some minority members toiling in the back rooms, the men out front—the astronauts—have been white, middle class, and, it seemed all too often, unimaginative or insensitive. Mailer touched a raw nerve when he called Al Shepard's lunar golfing an "incredible vulgarity." Said Mailer: "Golf is insulting enough to people who live in ghettos, but when we start doing it on the moon, there is something obscene in it." While that judgment may be too harsh, it does point up the difficulties NASA faces in trying to rewin public support. Critics damn the astronauts for their taciturnity but condemn them when the space voyagers display any hint of exuberant fun.

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There still are both poetry and purpose in space. The world is already reaping the benefits of the space program. Improved weather forecasting by earth satellites, for example, has saved millions of dollars in property damage and an untold number of lives by warning of dangerous storms. Other benefits are less visible: technological spin-offs from space research, which include everything from improved kitchen appliances to navigational aids with pinpoint accuracy. NASA has helped the economy directly. At its peak in 1966, NASA employed or provided jobs through its major industrial contractors for almost half a million people. Less tangible but no less significant has been the spiritual uplift provided by the spectacle of man overcoming the danger and complexities of travel beyond his own world.

Still, NASA seems unable effectively to rebut its critics. Because of the budget cuts, NASA will be able to send up only two more moon missions; originally there were to be another five. Plans to land an unmanned probe on Mars have been set back to 1975. The launching of Skylab, the first U.S. orbital space station, is unlikely to occur before 1973. Cape Kennedy's director, Kurt Debus, explained NASA's problem on the eve of Apollo 15's launch: Space is enormously important to the future well-being of the U.S., he said, but we have not yet found the way to convince the American public of that.

same primordial dust cloud? Was it captured, spider-like, when it strayed too close to the earth's gravitational web, or was it built up out of small asteroids that may have once orbited the primitive earth? Were its craters formed by meteor impacts or volcanic eruptions? What made its maria? And its sinuous, canyon-like rilles? If earth and moon were created out of the same cloud at the same time, why is the moon's density so low (only .6% that of earth's)? Why is its mass so large in comparison to earth's (approximately one-eightieth the mass) when no other moon in the solar system is greater than one ten-thousandth the mass of its host planet? Does the moon's interior have layering of differentiated minerals like earth or is it just one big chunk of rock?

Such questions are far from academic. Scientists are quite certain that uncovering the moon's secrets will lead to the solution of many terrestrial problems. By reconstructing the moon's early geological history, for example, they should be able to chronicle similar events on the young earth that have been obliterated by wind and water erosion and mountain building: no rock older than about 3.4 billion years has been found on earth. Discovering how the earth evolved should provide clues to how minerals have been distributed in the earth's crust and how abundant they are. Such knowledge would help scientists accurately predict how long certain substances like uranium can be used until their reserves are exhausted.

Before the first Apollo landing, scientists suggested so many answers to these questions that their debates sometimes sounded like barroom brawls. "Some people said, 'You've got water on the moon,' " recalls Caltech's Gerald Wasserburg. "Others said, 'You've got rivers on the moon,' or 'You've got part of the Pacific Ocean on the moon, even elves on the moon.' " Perhaps the most hotly debated question of all by selenologists was about the composition of the moon's interior. Was it hot or cold? The answer could well help solve such astronomical puzzles as how the planets were formed, how the universe evolved and how some day our solar system will die.

Leading champion of the cold-moon cause is Nobel Laureate Harold Urey, who has vigorously argued for more

than two decades that the moon began its life with a cool interior. If any heating occurred, said Chemist Urey, it was mostly on the moon's surface, caused by the searing impact of large planetoids. Not so, replied the hot-moon theorists. Led by men like the U.S. Geological Survey's Harold Masursky, they insisted that the moon's interior was —and perhaps still is—hot and molten. Despite the moon landings, the debate is unresolved; the contending theorists' arguments still often generate more heat than light.

In their enthusiasm for answers, many scientists on the eve of the first moon landing optimistically described the moon as a Rosetta stone of the solar system. At least one scientist said that just a single moon sample would solve the major lunar riddles. That prediction proved as insubstantial as a moonbeam. If the 218 lbs. of lunar dust and rocks gathered so far have proved anything at all, it is that the moon is far more complex than anyone expected. Certainly none of the major questions about its origin have been answered. Instead each landing adds to the number of questions. "We could go a million times to the moon," said one scientist after the first moon rocks were examined, "and never have all the answers."

Lunatic Asylum

Perhaps. But the successful moon landings have already added considerably to man's fund of lunar knowledge. Some of the findings have been expected, such as the absence of any trace of life or life-building amino acids in the lunar rocks. Others produced surprises. The lunar specimens bear many similarities to volcanic rock found on earth, but there are distinct differences: the lunar rocks contain a smaller percentage of metals such as nickel and gold but are considerably richer in titanium. One result of such unique mineral composition is that it makes less likely the theory that the moon was formed out of the earth, or in the same area of the early solar system. That at least is the prevailing speculation today; new data could quickly change things.

Another surprise has been the varying age of moon rocks. Before Apollo 11, many scientists thought it would be a rather simple matter to pick up a rock dating back to the origin of the solar system nearly 5 billion years ago. But radioactive clock measurements at Geophysicist Wasserburg's puckishly named "lunatic asylum" at Caltech and other laboratories have reported a variety of ages ranging from 3.3 billion years to 4.4 billion years.* The findings produced speculation that the moon may have undergone two or more great periods of surface melting that stretched out for more than a billion years. According to one theory, the first cataclysm occurred shortly after the moon was formed, and was caused by a bombardment of huge meteors that filled the sky during earth's infancy. The second upheaval occurred when heat produced by radioactive materials in the moon's interior finally brought the moon's crust to the melting point.

Yet another unexpected finding was the strength of the moon's magnetic field; pre-Apollo scientists were sure that there was no significant lunar magnetic field. But there is, though its strength is puny compared with earth's. Does that mean that the moon once had a molten iron core? Perhaps. Urey offers an alternate explanation. He maintains that the moon picked up its magnetism early in its history while it was closer to earth. And the arguments go on.

Even before the first Apollo flight, lunar scientists had made a startling discovery. They found that the unmanned lunar orbiters were being thrown unexpectedly off course as they passed over certain lunar seas. Careful calculation showed that this extra gravitational tug was apparently due to concentrations of denser material under the moon's surface. These "mascons," as they were dubbed, still defy explanation, although theories abound: one says that they are heavy material that crystallized early in the moon's history; another claims they are the compacted residue of meteors. To complicate matters, careful tracking of the Apollo 12 and 14 spacecraft has shown that there are also areas of less gravitational pull on the moon; this effect has been attributed to so-called "minicons," which may be areas of lower density.

Perhaps the biggest surprise of all came from the seismometers left behind on the moon by Apollo 12 and 14 astronauts. The sensitive instruments have registered moonquakes every month when moon and earth come closest together, detected meteor impacts and shown that the moon's interior is indeed unique: it "rings like a bell" when hit by a meteor. In contrast, the earth barely vibrates when it is struck. To Seismologist Gary Latham, the moon's resonance means that the upper 60 miles of the moon are composed of fragmented and jumbled rock. In addition, Apollo instruments have detected flows of electrically charged gases on the moon's surface. Could these vapors have been trapped inside the moon and released by the quakes? Such emissions may indicate that there is a measure of volcanic activity on the moon. The gases could also explain the occasional orange glows that earthbound astronomers have spotted.

Significant Adventure

If Apollo 15 clears up only a few of the moon's puzzles, the perilous mission will be worth the enormous risks. On their homeward journey, the astronauts were scheduled to continue their scientific investigations. Shortly before *Endeavour*, carrying all three crewmen again, fires itself out of lunar orbit, the ship is to leave behind another memento of Apollo 15's visit. With the press of a button, the small, instrument-packed subsatellite will be automatically injected into an orbit around the moon. The tiny package should swing around the moon for more than a year, radioing vital data about the lunar environment. Then Worden was scheduled to climb outside the spacecraft, edge his way back to SIM and retrieve his valuable film in history's first "walk" in deep space 200,000 miles from earth. Finally, twelve days after the start of their journey from Cape Kennedy, the astronauts will splash down in the Pacific, ending man's most significant scientific adventure on the moon.

ARNOLD H. DRAPKIN

SPECTATORS AT CAPE KENNEDY WATCH APOLLO 15 SOARING TOWARD THE MOON
The first truly scientific adventure.

* Only one older rock has been found: the now-famous Rock 13 from the Apollo 12 collection, which was dated at 4.6 billion years, and is suspected of being a precious fragment of the moon's original crust.