

The Moon: Still a Puzzle

by Jonathan Eberhart

► THE GEMINI program is all but over. The past year has seen the most concentrated push since the U.S. space program began. Since the last Project Mercury flight in May 1963, a dozen Gemini spacecraft, 10 of them manned, together with assorted Rangers, Surveyors, Orbiters and miscellaneous helpers have been paving the way for a single Apollo flight, now optimistically placed as early as 1967.

Gemini was by no means a total success. One of the main goals of the program—docking practice for future Apollo maneuvers—fell far short of the planned number of hours. Yet the reams of medical, astrophysical and even geological data produced as spin-off will probably not be fully analyzed even by the time the first astronauts set foot on the moon.

Many of the areas investigated by Gemini turned out the reverse of expectations. Notably, walking and working in space were found to be harder, rather than easier, than the same activities on earth. To remedy the situation, special tools, super-flexible spacesuits and other items are being developed for Apollo astronauts. Another example was the stress of spaceflight. After the first few astronauts turned in high pulse and respiration rates at launch time, their followers showed surprisingly few such effects.

Between now and a moon landing are at least five more Surveyors and three Lunar Orbiters. But they will be no substitute for the first-hand knowledge of man on the moon.

Apart from the fanfare, both the Gemini and Lunar Orbiter shots that dominated last week's space headlines promise scientific payoff. Landing on the moon, besides being an engineering feat, will help answer questions for

which theories have been offered since man first looked up at the sky.

Almost every time a noted scientist opens his mouth to discuss the moon's origin, out comes a new theory or variation. Most, however, can be divided into three types: the "offspring" theory, which holds that the moon was ripped from the earth in some primordial upheaval; the "twins" theory, whose adherents believe that earth and the moon originated together as a double planet; and the "capture" theory, in which the moon was formed separately and trapped by earth's gravitational field.

The offspring idea was first suggested by Sir George Darwin, son of naturalist Charles Darwin. He maintained that when the earth-moon mass was still fluid, solar tides wrenched the moon free and hurled it into its presently expanding orbit.

According to other adherents, at first a huge bulge appeared on the spinning, unsolidified earth. Finally the rotational stresses became too great and a vast chunk tore loose, only to be pummeled by meteorites and wracked by volcanic eruptions which left whole regions buried beneath miles of dust. (The dust has long since packed itself firm, apparently, and poses no hazard to space vehicles.)

Some "offspringers" have said that the moon was indeed ejected from earth, but not until the original mass had cooled enough to have a thin crust. The resulting scar in the crust is now the bed of the Pacific Ocean. The Pacific is only a few miles deep, however, and generally regarded as an unlikely source for so huge an object as the moon. Moreover, some mathematicians claim that such a large mass could not have been whirled off into space without going to pieces.

Though the moon did not come from the earth, one noted authority believes, both originated from the same source. Dr. Gerard P. Kuiper of the Yerkes and McDonald observatories has described a huge "proto-planet," a nebulous mass moving around through the fringes of the sun while the sun was still shrinking to its present size and intense brightness. When the proto-planet, one of many, separated from the rest of the solar nebula, it was intensely cold, according to Dr. Kuiper, perhaps as cold as 40 degrees above absolute zero. As the sun reached its full brightness, the gaseous "envelope" which had shrouded the earth and moon dissipated, leaving the two bodies perhaps as little as 2,500 to 5,000 miles apart, but gradually separating.

The opposition to both theories is awesome and international. Nobel laureate Dr. Harold Urey, leading British astronomer Dr. Patrick Moore, chief physicist at the Swedish Royal Institute of Technology Dr. Hannes Alfvén and others all believe that the moon was formed separately and was snagged by earth's gravity on the fly.

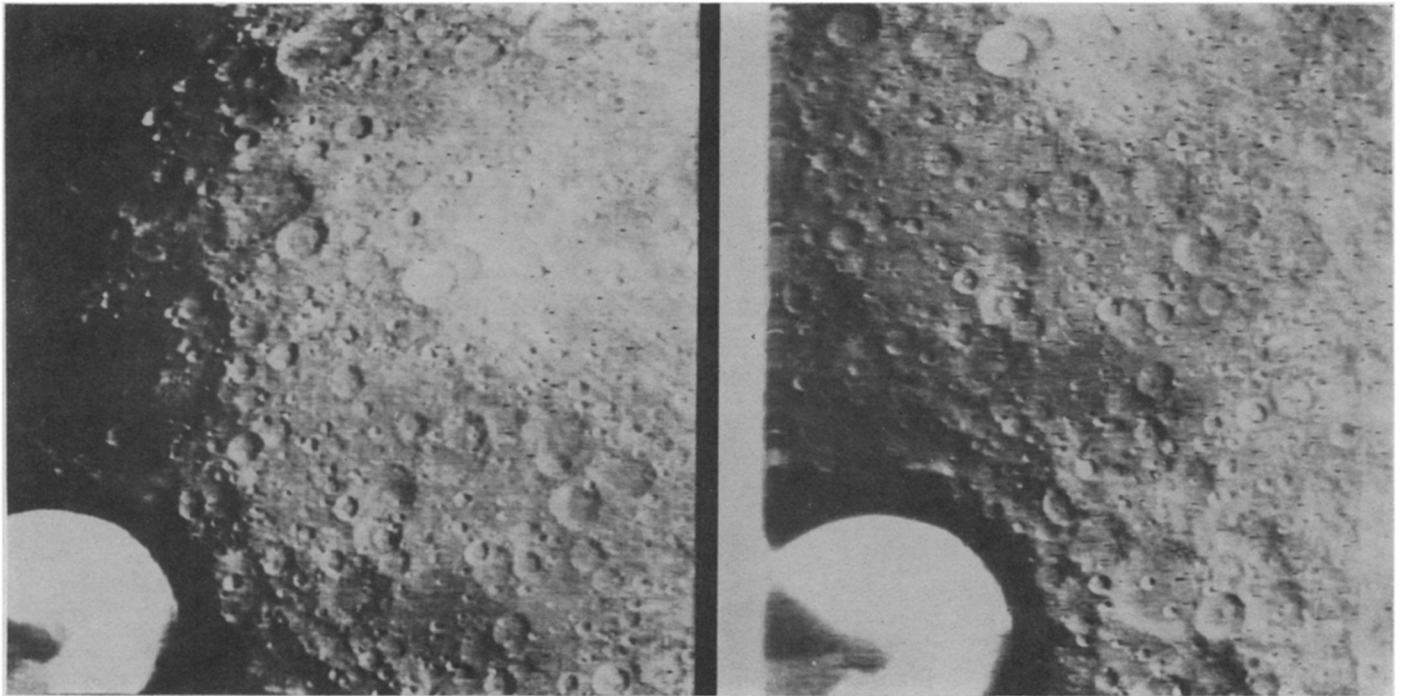
For one thing, says Dr. Urey, the differing ratios of the elements on the two bodies indicate that the moon could not have been part of the earth, or it would have been made of the same "mix." Furthermore, he adds, the moon is probably older than the earth, perhaps by as much as 100 million years. Originally the solar system was full of moon-sized bodies that hurtled around in space, colliding with each other, combining and dispersing, Dr. Urey believes. This would account for the puzzling fact that the moon is only three-fifths as dense as the earth.

"The moon is not earth's child," agrees Dr. Moore. In fact, he believes the earth-moon system should be considered as a double planet instead of a planet and satellite, "since the moon is much too large to be ranked as an inferior body."

Lunar origin theories cover the full circle: exactly opposite to the offspring idea is that of Dr. Alfvén, who believes

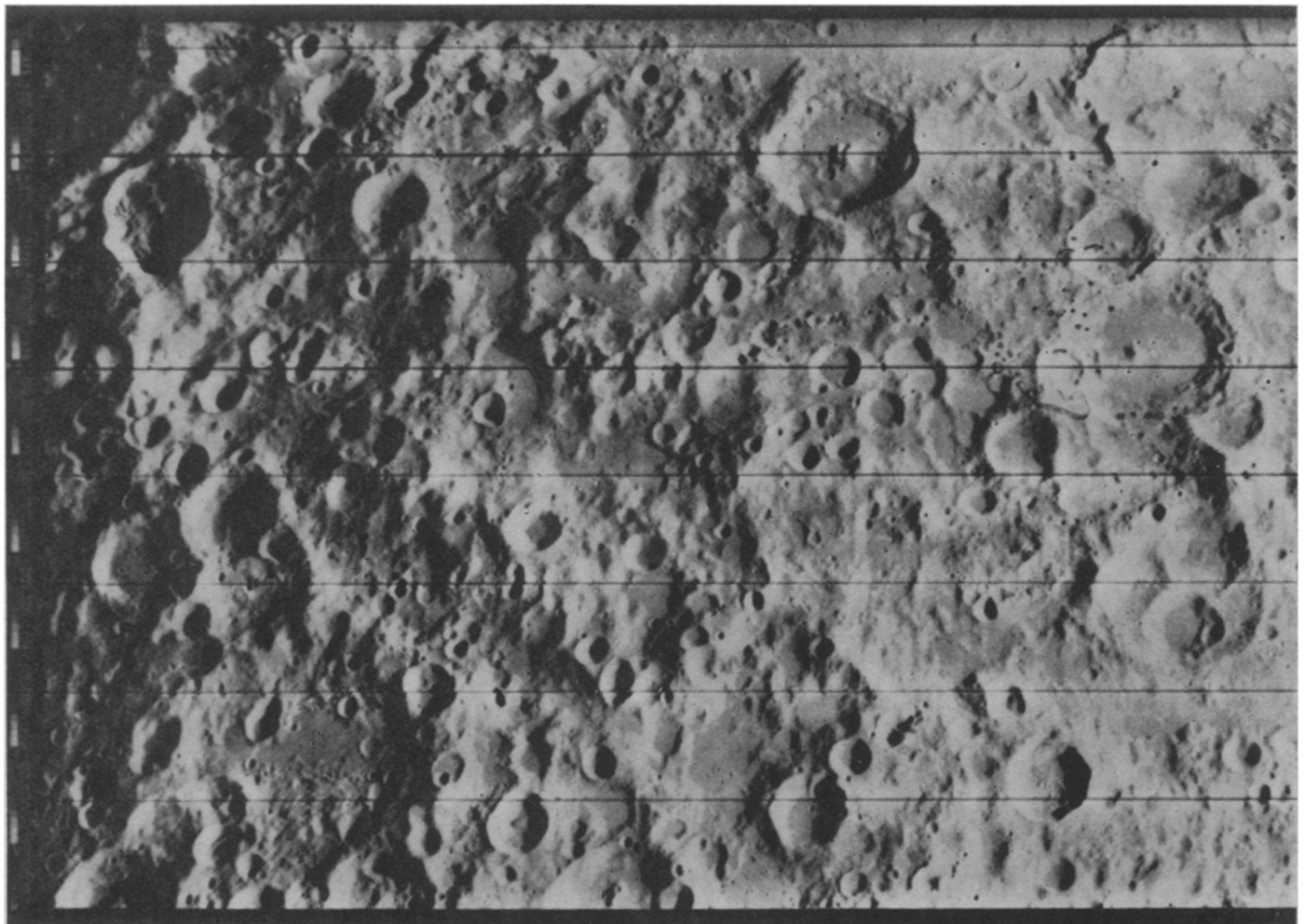
8 YEARS OF MOON SHOTS

Able 1	8/17/58	failed; 1st stage LOX pump stopped	Lunik 4	4/ 2/63	passed within 5,281 miles; believed soft landing attempt
Pioneer 1	10/11/58	failed; 3rd stage thrust insufficient	Ranger 6	1/30/64	impacted; photographic equipment failed
Pioneer 2	11/ 8/58	failed; 3rd stage did not ignite	Ranger 7	7/28/64	impacted; took 4,316 photos
Pioneer 3	12/ 6/58	failed; 1st stage cut-off prematurely	Ranger 8	2/17/65	impacted; took 7,137 photos
Lunik 1	1/ 2/59	passed within 4,660 miles of moon	Ranger 9	3/21/65	impacted; took 5,814 photos
Pioneer 4	3/ 3/59	passed within 37,300 miles; should have been 20,000	Lunik 5	5/ 9/65	impacted; soft-landing failed
Lunik 2	9/12/59	impacted; detected ionosphere, but no magnetic field	Lunik 6	6/ 8/65	failed; midcourse error
Lunik 3	10/ 4/59	photographed back side	Zond 3	7/18/65	lunar flyby; now in solar orbit
Atlas-Able 4	11/26/59	failed; payload shroud came loose	Luna 9	1/31/66	soft-landing; took pictures for 3 days
Atlas-Able 5A	9/25/60	failed; 2nd stage oxidizer malfunctioned	Cosmos 111	3/ 1/66	suspected lunar probe failure
Atlas-Able 5B	12/15/60	failed; exploded 70 seconds after liftoff	Luna 10	3/31/66	in lunar orbit
Ranger 3	1/26/62	failed; missed by 22,862 miles	Surveyor 1	5/30/66	soft-landing; took 11,150 photos
Ranger 4	4/23/62	impacted; experiments inoperative—timer failed	Lun. Orb. 1	8/10/66	orbited successfully
Ranger 5	10/18/62	failed; missed by 450 miles	Luna 11	8/24/66	in orbit
no name (USSR)	1/ 4/63	probably lunar probe failure	Surveyor 2	9/20/66	impacted; soft-landing failed
			Luna 12	10/22/66	in orbit
			Lun. Orb. 2	11/ 7/66	in orbit



NOVOSTI

THE BACK of the moon (below) seen by Lunar Orbiter 1, and (above) snapped by the Soviet, Zond 3, Novosti reports.



NASA

that not only was the moon *not* ever a part of the earth, but indeed that most of earth's continents were once part of the moon. Starting with a virtually ignored paper published in 1955 by an obscure German girls' school teacher, Dr. Alfven paints a pretty lively picture of primordial earth.

As the moon sped by from spaces unknown, he says, earth's gravity caught it and swung it into a retrograde orbit, moving around earth in the opposite direction than it does now. Then, as gravity tried to get the two bodies into a balanced relationship, the moon moved up over the poles instead of more nearly over the equator. Tides were five miles high, and rolled around the earth in six hours, "polishing" the globe. The moon, looking twice as big as it does now, dominated the heavens.

Then, says Dr. Alfven, came the most dramatic event in the history of the earth: the moon reached what is called the Roche limit and broke apart. More than half of the moon may have plunged to the earth, Dr. Alfven believes, an event which could explain why the earth's crust is considerably less dense than its core.

But where did the moon come from? The same place as Mars. The moon was once a planet, Dr. Alfven says, and condensed out of the same "cloud" as Mars, while the Earth, Venus and Mercury form another "genetic group."

If, as Dr. Urey and others believe, the moon is older than the earth's estimated 4.5 billion years, the riddle of its birth may hold the key to even bigger questions, such as the origin of the solar system.

What's It Made Of?

It may not be exactly a goldmine, but silver, platinum, diamonds and a host of other materials have all been indicated on the moon by one study or another. Depending on whether or not there have been volcanic eruptions on the moon, other possibilities include metals such as iron, nickel, cobalt, copper, aluminum, magnesium, titanium, mercury and zinc; other elements such as phosphorous, carbon, sodium, potassium, sulfur, iodine and chlorine; and even water.

Water is a special case. The moon could hold twice the world's riches and water would still be more important to anyone on it. Volcanic rocks often have up to 10 times the water found in other basic rocks (in part because the time during their formation when water could have escaped is shorter). Astronauts will thus be in luck if there turns out to have been volcanic activity in the geologically recent past.

Arguments over what the moon is made of, however, can't hold a candle to the pet theories that clash on just what the surface looks like. Despite painstaking analysis of thousands of

lunar photos, scientists still vie with one another as strongly as before.

There is no evidence of "moon dust" or that the moon is honeycombed with caverns, as some scientists have suggested, says Dr. Eugene Shoemaker, a geologist. "Absolute nonsense," says Cornell's noted Dr. Thomas Gold, who firmly believes that there is a definite dust layer, fluffed up into myriad "fairy castles" by the continual impact of micrometeoroids. Miles beneath the lunar crust there may be a layer of ice and dirt, Dr. Gold believes, which may have implications for life on the moon.

NASA's Dr. John O'Keefe thinks the moon is largely covered with ash flows, while Soviet expert B.J. Levin believes they are lava flows. Dr. Evan Walker of the University of Miami has described a layer of granular particles ranging from 65 to 500 feet deep. Dr. Urey calls the surface "soft and spongy," while Dr. Kuiper calls it "crunchy." Or it may be "fuzzy" (Dr. Charles Warren, U.S. Geological Survey). Or hard, or pebbly, or gritty, or bouldery, or silt-like (miscellaneous scientists).

Millions of dollars and hundreds of scientific minds have devoted more than half a decade to discovering the moon's secrets. But it will take a lot more asking to satisfy anyone of the answers.

End of an Era

SEVERAL THOUSAND engineers, scientists and technicians at Cape Kennedy noted the closing of an era last week as they watched Gemini 12, the last of its kind, poised above launch complex 14. At the same time, the second U.S. Lunar Orbiter was nestling in toward its picture-taking orbit around the moon, and somewhere below it the amazing Surveyor 1 was again talking back to its mentors on earth.

Surveyor, to everybody's surprise, continued to respond to commands from earth and to deliver data, even long after it was no longer able to deliver pictures.

Unlike its predecessor, Lunar Orbiter 2 would not be looking out for Surveyor's landing spot. It would, however, have more than a dozen areas to look at, possibly including the one where Ranger 8 crashed 21 months before. In addition, changes in its orbit would provide information about the moon's gravitational field, which is "sufficiently non-uniform" to affect the path of any lunar satellite.

Surveyor 3 (No. 2 failed—see chart p. 420) is due to be launched in mid February and may be the first of several equipped with drills, probes or scrapers that will reach down into the lunar surface and retrieve samples. A robot chemical laboratory called a mass spectrometer will analyze the samples and transmit the results to earth

AERONAUTICS

Bug-Eyed Airplane Bugs Pilots

A BUG-EYED jet fighter is being flown by pilots who have no way to see out except through a periscope.

Obviously such indirect viewing has its disadvantages—one periscope-peering test pilot misjudged his speed so badly that he almost attempted a full 180-degree turn while taxiing across the runway at 150 miles per hour—but he may have to learn to like it for the supersonic transports and space rescue missions of the future.

Huge space-going gliders called lifting bodies, now being designed for rescue or as earth-to-orbit ferries, will build up too much heat from re-entry to use ordinary windshields.

A current test model, which goes nowhere near orbit, needs three layers of inch-thick glass filled with a continuous flow of cooling gas to withstand the heat. In a space-going version, windshield weight would be prohibitive.

To test a possible substitute, an F-104 Starfighter was fitted with a binocular periscope ending outside the cockpit in two bulbous "eyes."

The half-dozen NASA pilots who flew it were "pretty apprehensive" about the periscope before they tried it, said William H. Dana, co-director of the project, who doubles as a testpilot himself. After a few flights they unanimously decided it could be gotten used to, but there are problems.

Biggest complaint has been the need to look away from the eyepieces in order to check instrument readings.

The exaggerated stereo effect of the periscope has caused pilots to "consistently" level off too high in landings.

Vibration on the ground caused "severe loss of vision," and the system was virtually useless at night. Lack of side vision hampered all circular approaches to the runway, and the need to stay glued to the eyepieces drew complaints.

To improve visibility and side vision, the researchers are now outfitting a second plane, a C-47 "Gooney Bird," with a system using ground-glass viewing screens instead of eyepieces. This will allow pilots to move their heads normally, and consult instruments with minimal eye movement. The wrap-around screens will stretch as much as 100 degrees to the side.

The system has also been suggested as a possible aid to supersonic transport aircraft. Both SST designs currently in competition have pivoted "droop-snoots," which swing down so pilots can see over the plane's long nose.