

## The varied faces of the moon

Less titanium, fewer breccias and larger crystals than indicated by Apollo 11 suggest a surprisingly varied moon



Photos: NASA

*Experience from Apollo 11 paid off on Apollo 12 walk.*

Alien and little-understood as the moon is, it nonetheless seems to be much more homogeneous than the earth. Without the constant change that would be produced by the presence of life, or even water and an atmosphere, the moon presents a relatively uniform face, its major difference being between the flat maria and the rougher highlands.

As the lunar samples brought back by two Apollo flights are revealing, however, even the presumably similar areas of the moon have essential differences between them.

From an eastern mare, the Sea of Tranquility, the Apollo 11 astronauts brought back material that consisted predominantly of breccias, mixtures of several minerals combined in a substrate of another mineral. The material was also extraordinarily high in titanium content, much more so than any earthly rock. Finally, any crystals that the moon rocks contained were small ones, only fractions of an inch across.

**The rocks** and dust returned by Apollo 12 (SN: 11/22, p. 470) came from another mare, the Ocean of Storms, and might reasonably have been expected to closely resemble those from Apollo 11. Since scientists in the Lunar Receiving Laboratory began to open the rock boxes and bags last week, however, they have been finding striking differences in all these characteristics.

Most conspicuous is the almost total absence of breccias. While the Apollo 11 rocks were almost 60 percent breccia, the Apollo 12 crop has yielded only one or two out of some 50 rocks.

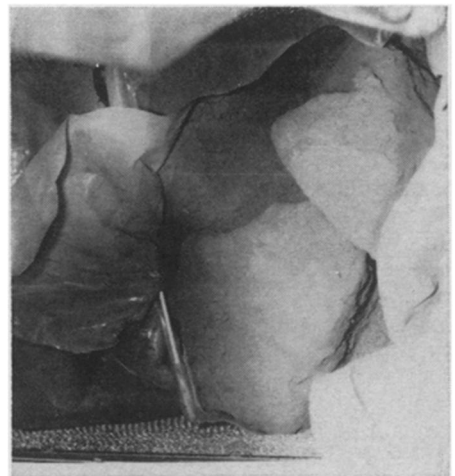
It is too early to formulate any definite theories, says geologist and LRL associate curator Jeff Warner, but there are possibilities. Most researchers, he says, assumed the Apollo 11 breccias

to be the result of the shock of meteor impacts. It could turn out that the Apollo 12 breccias were not caused by impacts at all, but instead are so-called tuffs, consisting of fine volcanic particles welded together on or under the ground by their own heat.

This in turn might mean that the Apollo 11 breccias also are actually tuffs instead of impact formations. On the other hand, Warner suggests, it may be that the breccias result from meteor impacts, but only from large ones. The Apollo 12 site is quite near the large Lansberg crater. Lansberg is old; any breccias created in the impact that formed it would have had time to be either broken up by eons of micrometeoroid bombardment or covered by dust from the more recent formation of Copernicus crater.

**The difference** in titanium concentration is even more of a puzzle. The Apollo 11 samples contained almost 10 percent titanium, compared to less than 1 percent in the most titanium-rich rocks on earth. As far as the Apollo 12 analysis had gone early this week, the latest moon rocks seemed to contain from 2.5 to 3 percent titanium. Though theories are in short supply, researchers such as Warner and NASA's Dr. John O'Keefe agree that the Apollo 11 findings were far enough from anyone's expectations to give the Apollo 12 rocks the edge as being more representative of the moon.

The other surprising difference has been the presence, in the Apollo 12 samples, of large crystals, some of them apparently almost four inches long. Here again, the mechanism that produced them remains to be discovered. There are so many ways that large crystals can be produced on earth, Warner says, that more data are necessary to pin down the ones at work on the moon. They might simply



*Apollo 12 brought biggest rocks yet.*

have grown, surrounded by minerals of lesser surface tension, or they could have precipitated out of some ancient, still-molten magma. There are other possibilities.

Meanwhile, scientists were working this week on some of Apollo 12's prize findings, core samples taken from as deep as 32 inches below the lunar surface. In that brief length could be represented more than a billion years of lunar history. Initial observations of the opened cores confirmed several of the Apollo 11 findings: the lack of weathering, the presence of glass spherules and a distinct layering, with smaller particles on the top which indicate more direct exposure to micrometeoroid bombardment.

**One blow** to the research going on in the Lunar Receiving Laboratory this week was a tiny, half-inch tear in one of the gloves used to handle the moon rocks without exposing them to the air. The gloves, installed in sealed holes in the sides of a series of vacuum cabinets, have been perhaps the most

troublesome item in the LRL's specialized equipment roster.

During the analysis of the samples delivered by Apollo 11 in July, the gloves were so badly slashed in the line of duty that they had to be replaced, a procedure that consumed most of a valuable day. In the Apollo 12 rock study, however, a single tear has caused more serious damage.

As part of precautions against possible lunar pathogens, an LRL ground rule is that anyone exposed to lunar material must thereafter be quarantined with the astronauts until their release around Dec. 10. In the room with the glove cabinet on Dec. 1 when

the glove tore, unfortunately, were seven of the moon lab's top scientists: Drs. Clifford Frondel of Harvard, Ed Chao and Robert Smith of the U.S. Geological Survey, Robin Brett of NASA, Joseph Zahringer of the Max Planck Institute, Raymond Davis of Brookhaven National Laboratory and assistant LRL curator Russ Harmon.

The quarantined scientists diminished the number of qualified mineralogists and petrologists by one-third, says Anthony J. Calio, director of science and applications at the Manned Spacecraft Center, and left a total of 20 researchers in the LRL Preliminary Examination Team.

## WATER POLLUTION

### A vote for the middle-sized stick

Philosophically, the mechanisms by which industrial water pollution may be controlled vacillate between the carrot and the stick: inducements like tax relief to encourage pollution control, and rigorous regulatory policies backed by fines, charges or penalties for failure to comply.

Both approaches have been debated in Washington for several years; neither has been given much of a workout.

Congress still concentrates on the appropriation of funds, largely for the construction of sewage treatment plants. And this week, for the first time, it took a step toward disbursement of funds at authorized levels when House and Senate conferees compromised on an \$800 million appropriation. This is still below the authorized \$1 billion, but almost four times the current year's spending level which President Nixon sought to maintain (SN: 10/18, p. 350). This still leaves open, however, the question of stimulating individual pollution control activities.

To fill the vacuum, a version of the stick approach—charges to effluent-discharging industrial plants—is being resurrected by Sen. William Proxmire (D-Wis.), who last week proposed a bill empowering the Secretary of the Interior to levy such charges.

Under Proxmire's plan, the effluent charges against a plant would be based on the amount of waste discharged, its strength and its toxicity.

The theory is that the polluters will prefer to stop or at least reduce their polluting activities rather than pay the charges. Even if they don't desist completely, the revenue from the charges would help pay for new treatment plants or improve old ones to clean up the remainder of the effluents.

Nevertheless, the proposal is regarded as both too strong and too mild.

The fact that the charges would be moderate troubles Leon Billings, a staff member of the Senate Subcommittee on Air and Water Pollution. Billings points out that to be successful, "The program administrators would have to decide to set a charge which would be sufficient to close down a plant unless the plant moved to eliminate or radically reduce pollution. I question if a fee of such magnitude would be assessed."

And William Driver, president of the Manufacturing Chemists Association, says, "Such a program, I fear, would not result in cleaning up pollution. It would merely set a price for polluting."

Despite such misgivings, Proxmire claims a host of backers for the effluent charge principle, including the Council of Economic Advisers, the Environmental Pollution Panel of the President's Science Advisory Committee and the Federal Water Pollution Control Administration.

Says Robert Barlow on the staff of the President's Science Adviser Dr. Lee A. DuBridge, "The principle is regarded in the Office of Science and Technology as a very appealing idea."

But David Dominick, FWPCA Commissioner, denies having taken a stand. "It's my personal opinion that the pollution problem is much more complex than it is being viewed, and its solutions will be much more complex than the Proxmire bill," he says. "It's a neat concept theoretically, but we're not in a position to administer it because of the variety of the discharges."

Although these agencies do not change bills into laws, the testimony of their various representatives at hearings on the bill sometime in the spring will influence the final form of the bill. This form will be determined by Sen. Edmund S. Muskie (D-Me.) and his pollution subcommittee, for which Billings works. □

## SONMY

### Analyzing the inexplicable

On the morning of March 16, 1968, a company of American troops entered Mylai 4, a Vietnamese hamlet in the village of Sonmy, known to the Americans as Pinkville. The official army communique for that day described the ensuing events as "a bloody day-long battle" resulting in the death of "128 Communists" and the capture of three weapons.

Now, more than a year later, some of the soldiers who were present are describing the action at Pinkville as a massacre involving the deliberate slaughter of as many as 500 unarmed Vietnamese civilians, mostly women and children. The Army has charged one soldier, First Lt. William Calley, Jr., with the "premeditated murder of 109 Oriental human beings," and is investigating at least 25 other soldiers for possible incrimination connected with the Pinkville killings.

The precise details of what happened at Mylai, and the legal guilt or innocence of the American soldiers involved, will not be decided for some time. Yet the public outrage surrounding the incident stems from the more general recognition that Americans, as well as the enemies of Americans, seem to be capable of atrocities in wartime.

Dr. Erik Erikson, professor of human development at Harvard University, suggests that Americans are especially horrified by such a recognition "because of the outrage we felt about the Nazis during the Second World War."

The official American policy in Vietnam obviously is not comparable to official Germany policy in World War II. On the other hand, it is increasingly difficult to dismiss situations like the alleged Pinkville killings as the individual aberrations of deranged soldiers.

Dr. John Spiegel, a social psychiatrist at the Lemberg Center for the Study of Violence at Brandeis University, says that a mentally average soldier is capable of committing atrocities under the pressure of two factors which occasionally come together in battlefield conditions:

The first factor, he says, is the "impersonality of the military bureaucracy." Under the military system a soldier is under great pressure to carry out orders mechanically, and the enemy is regarded as an object rather than a person. An unpublished survey of the lower-echelon Germans who operated the death camps in World War II revealed no special pathology among these functionaries, Dr. Spiegel reports. "The military system is dehumanizing,