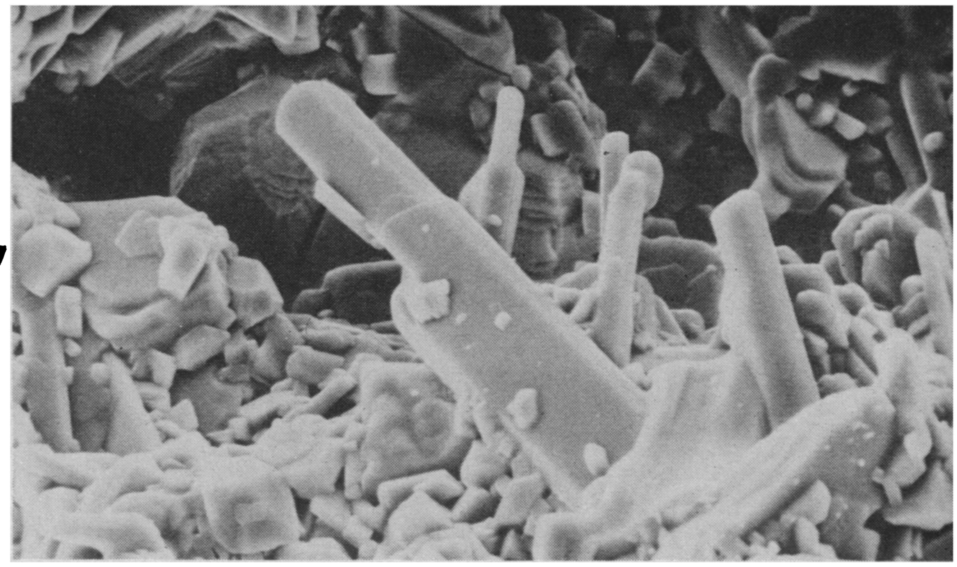
The moon: Many facts, many interpretations

The third lunar science conference settled few major issues about the moon



NASA

Crystals that grew from a hot vapor in the cavity of a moon rock.

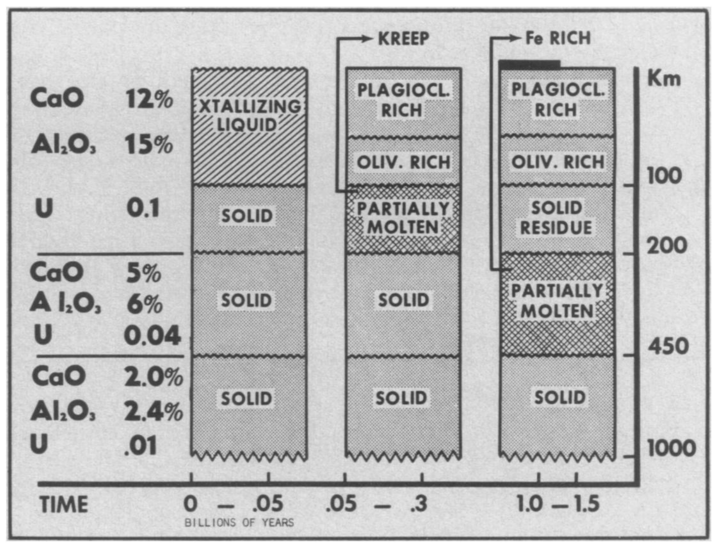
"Speculation [about the moon] is more restrained because there are many more facts, and people are not willing to stick their necks out as far as they did in [the] Apollo 11 [Lunar Science Conference]." Paul W. Gast

Some things about the moon are perfectly clear. It either had a molten core early in its history or it didn't; it accreted either rapidly or very slowly; it either has 4.6 billion-year-old rocks preserved somewhere on its surface or they've been obliterated. Beyond these points there is little consensus.

Although the total picture of the moon's origin and history is still not understood, the present stage of the lunar story is really not all this bleak. Last week more facts emerged at the Third Lunar Science Conference in Houston, but not enough to settle the major issues.

Paul W. Gast of NASA's Manned Spacecraft Center presented a model for the thermal history of the moon that fits many scientists' own peculiar biases. This model requires heating of the moon from the exterior downward that stops abruptly about 3 billion years ago. This fits in neatly with age dating results determined by Gerald J. Wasserburg of the California Institute of Technology that points to a moon that "shut itself off" thermally about 3.3 billion years ago—or, as he calls it—"a half baked moon." In the Gast model the moon accreted of material already partially differentiated, making the original moon heterogeneous. If the radioactive elements, for example, are concentrated near or on the surface of the moon, the unusual flow of heat measured at the Apollo 15 site would be explained. This flow—one-half the heat flow of the earth—could be a local anomaly, says Marcus G. Langseth of the Lamont-Doherty Geological Observatory.

Thermal models for three different times in the moon's history.



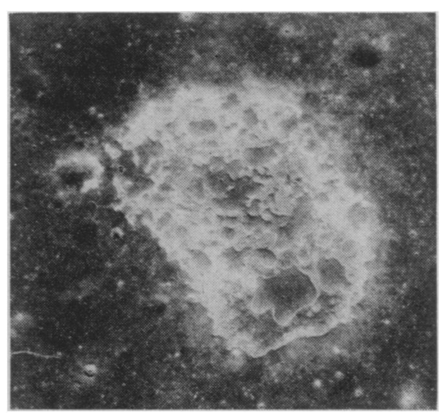
Paul Gast

According to the Gast model, the center of the moon never had to be molten to account for the moon seen today. But Gast readily admits that he cannot explain the remnant magnetism found in the lunar rocks—with or without his model.

The Gast model does support data from two orbital instruments of Apollo 15 interpreted by James R. Arnold of the University of California at San Diego and Isidore Adler of NASA's Goddard Space Flight Center.

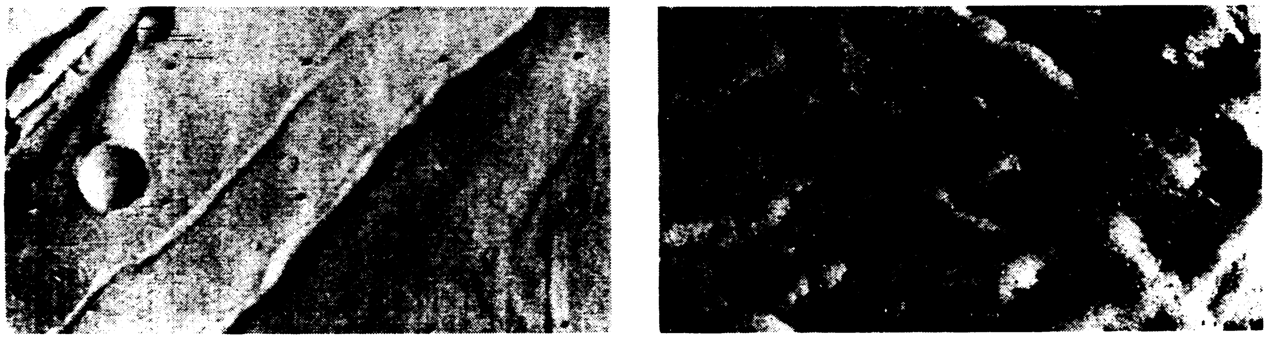
The X-ray spectrometer mapped the presence on the surface of three elements important chemically to lunar history—magnesium, aluminum and silicon. The results show that the highlands are indeed different in composition from the mare areas. They are richer in aluminum (SN: 8/21/71, p. 122).

Arnold's gamma-ray spectrometer found concentrations of radioactive uranium, thorium and potassium in the Mare Imbrium region and Oceanus Procellarum and some on the far side



El-Baz's D-shaped structure.

of the moon. These concentrations correspond to those in the KREEP or noritic material found at the Apollo 12 and 14 sites. The orbital instruments detected three major components on the moon's surface—anorthosites (calcium aluminum silicates) found in the highlands, iron-rich basalts found in the eastern maria, and the KREEP basalts or KREEP-



NASA

Cracks and canyons: Mariner's camera shows immense rilles (left) and canyonlands on Mars.

Beneath Mars' settling dust

After days of keeping up a dusty front for its earth visitors, Mars has begun yielding a little in the past week or so. The view the Mariner 9 cameras are transmitting to earth is causing quite scientific stir.

The main area of mapping interest still lies in an area bordered by Nix Olympica to the west and a great trough to the east. In between lies one of the highest areas on the planet and the three "dark spots" that appear to be summit craters running north to south (SN: 12/11/71, p. 387). These parallel the great trough. To the east of the dark spots is a high plateau and the great "canyonlands."

"The canyonlands are a real puzzler," says Harold Masursky of the U.S. Geological Survey. "We know these are partially controlled by tectonic breakage [causing faulting], but something else has gone on there. What this something is is the biggest mystery at the moment."

Scientists also obtained their first good look at rilles, or cracks, in the Martian crust. They are part of a system of parallel fissures extending more than 1,800 kilometers along the surface—some as wide as 1.6 kilometers.

Although ground-based telescopes show Mars to be clear of dust, the Mariner cameras show dust still in the atmosphere. The northern hemisphere remains hazier than the southern. "It may be that the dust will remain in the atmosphere," says Masursky. In fact, scientists looking back now on the 1964 and 1969 Mariner data believe the atmosphere almost certainly had dust then.

"Contrary to recent reports, the atmosphere of Mars has not become crystal clear," says Bradford Smith of New Mexico State University. "This may require a reevaluation of what represents a normal Martian atmosphere." □

rich regolith from the highlands.

Farouk El-Baz of Bellcomm, Inc. in Washington found an unusual D-shaped formation on the moon in the orbital photographs. "We just have not seen anything like it before. The whole basin, or crater, is a depression about two miles across and within it are very funny features that we have not seen elsewhere that look like blisters. They are very smooth, perhaps volcanic domes within the larger caldera." Most of the lunar scientists, except Thomas Gold of Cornell University, believe this is one more piece of evidence of extensive volcanism in the moon's history.

One major fly in the ointment turned out to be new evidence to support an old theory—that the moon had a molten core at one time. This idea does not sit too well with many lunar scientists and even those who privately wish the moon had had a molten core cannot explain how the interior could be so cool now (an estimated 800 to 900 degrees C.).

The paper presented by S. Keith Runcorn of the University of Newcastle upon Tyne, England, and others working with remnant magnetism in lunar rocks point to the fact that sometime during the first billion and a half years of the moon's history, the moon was exposed to a magnetic field. Scientists believe planetary magnetic fields are produced by the flow of electric current in an electric conducting ore—in the case of the earth, an iron core. But lunar scientists think they have a fairly good handle on the total mass and the distribution of the mass (moment of inertia) of the moon, and the moon doesn't behave as a planet that has a lot of mass in the center—like an iron core. Runcorn explains why the moon no longer has a magnetic field (its field is 1×10^{-4} of the earth's field) by saying that when the core cooled and solidified, the magnetic field was lost. Runcorn also believes that the moon could have a core one-fifth its radius—a size that would not be incompatible with the known error margin for the moon's moment of inertia. If the moon did not have its own magnetic field, it would have had to get it from the sun or from the earth—and even Runcorn finds these possibilities far out.

Although some scientists disagreed with the interpretation that Leon T. Silver of Caltech gave to uranium-lead ages of lunar rocks (SN: 1/1/72, p. 12), the volatilization mechanism by which metals move around on the lunar surface was not disputed. David McKay of NASA found crystals of iron, for example, that had grown from hot vapor in the cavity of a brecciated rock.

Several papers relieved most scientists by providing some partial answers rather than raising more questions.

C. M. Hohenberg presented evidence for the early existence of now extinct plutonium 244 in Apollo 14 material, which would place the lunar crust among the older objects of the solar system. Most scientists believe that plutonium 244 is produced by galactic processes that would have swept it into the solar system early in the solar system's history. Since the half-life of plutonium is only 84 million years, any plutonium would have decayed into xenon very soon after entering the solar system and would no longer be present.

Johannes Geiss of the University of Bern, Switzerland, settled a 30-year-old debate about the ratios of deuterium to hydrogen in the early solar nebula. Deuterium burns to helium 3 and by measuring the helium 3 in the solar wind, Geiss has determined that the deuterium-to-hydrogen ratio on earth and in meteorites has been enriched by a factor of four compared with the deuterium present originally in the solar nebula. "This is an extremely profound observation," says Wasserburg of the Geiss data. "It's one that has very far-reaching consequences, and means that every time that we think about making planets, particularly in the solar system, that processes took place that we have tended to either ignore or desired to bury." □