lunar sciences

Gathered at the Apollo 11 Lunar Science Conference in Houston last week

RADIONUCLIDE STUDIES

Different geochemical history on moon

The concentrations of potassium, uranium and thorium in the lunar materials have been found to be considerably different from those observed in meteorites and in major kinds of earth rocks.

This uniqueness in the moon's primordial radionuclide composition is one of the many examples indicating the moon has gone through a substantially different geochemical history than have those earth and extraterrestrial materials that are known.

Dr. Richard W. Perkins and four colleagues from the Pacific Northwest Laboratories of the Battelle Memorial Institute performed one of the studies. They found that the concentration of uranium and thorium in lunar samples was ten times as high as in stony meteorites and a fourth as high as the earth's average crustal composition. The concentration of potassium on the moon ranges up to five times as high as in the meteorites and a tenth of that in the earth's crust.

BIOGENIC COMPOUNDS

No life and not much potential

The lack of life on the moon, or even of biological compounds that might under some circumstance lead to it, had been expected long before Apollo 11 went there. The first lunar rock samples have clamped the lid more tightly.

Several research teams have been hunting signs of life or favorable conditions for it. Dr. Cyril A. Ponnamperuma, head of an 18-man group of investigators at the space agency's Ames Research Center in California, reports what turns out to be the consensus of the other teams as well: "the total absence of any structure that could be interpreted as biological in origin."

Another Ames team, headed by Dr. Vance I. Oyama, found similar results even after testing its sample in 300 different temperature, pressure and atmospheric environments. A few organic compounds were found but they appear to be contamination from the exhaust of the Apollo lunar module's descent engine (SN: 5/17, p. 486).

The closest thing to an exception comes from Dr. John Oro of the University of Houston, who reports that at least the elements necessary for synthesis of organic compounds are present in some lunar rock types, but conditions on the moon leave them far removed from the compounds themselves.

THERMAL PROPERTIES

Low surface conductivity

Direct analysis of the thermal properties of the lunar samples indicates that the mean conductivity for the lunar-surface layer is somewhat lower than had been deduced from earth-based infrared observations. The new value is 2.5×10^{-6} calories per centimeter per second per degree K.

The results, when combined with other known information, imply that at depths of about 10 meters the crust is still likely to be fragmented and porous.

The thermal studies, conducted by Drs. P. E. Clegg and J. A. Bastin of Queen Mary College, London University, also suggest that a considerable fraction of heat transfer takes place by radiation rather than by conduction. Conduction remains the dominant process, however.

MICROPALEONTOLOGY

No evidence of fossils

A search for any possible fossil evidence of biological activity from any time in the moon's past proved negative.

Several different investigating teams carried out independent searches, and the summary comment by Dr. Elso S. Barghoorn of Harvard University and his two colleagues was perhaps typical: "It can be inferred that the lunar regolith has never possessed life and is inimical to life." The regolith is the layer of loose rock and dust covering the bedrock.

All the teams doing micropaleontological investigations commented on the many tiny glass spheroids and ovoids similar in shape to many algal and bacterial unicells, producing rather impressive pseudomicrofossils.

"This is not to propose that there are or were solid glass protozoa on the moon," said Dr. Preston Cloud of the University of California at Santa Barbara. But he wanted "to add one more warning to the many that have already been given about a too-ready interpretation of exotic objects as of vital origin based on gross morphology alone. The warning deserves emphasis; elsewhere on the lunar or Martian surface may be lifelike artifacts that will be harder to discriminate from the real thing."

TRAPPED GASES

Carbon monoxide in glass bubbles

Carbon monoxide gas has been found trapped in bubbles within particles of lunar material.

A sign of the gas was noted by Dr. Edwin Roedder of the U.S. Geological Survey. While investigating immiscible silicate liquids, he noted the presence of "up to billions of molecules of noncondensable gases," though he did not analyze their chemical composition.

A research team from the University of California at Berkeley, however, identified the gas when it was found as a result of following up a mysterious discrepancy in some general data on organic compounds.

Heating a sample of lunar fine material, says Dr. Melvin Calvin, the team's principal investigator, produced 168 parts per million of CO; chemical extraction, however, showed only 119. When some of the researchers noticed that some spherical features trapped in the material appeared to resemble bursting gas bubbles, a liquid helium trap was employed to catch any gas being freed. The result was an additional 66

65-66

parts per million of CO for a total of 185, more compatible with the previous result.

Dr. Calvin theorizes that much of the CO is probably in other than free gaseous form in the bubbles as they exist on the moon. For that much CO to be in gaseous form, he says, it would have to be at about 10,000 times the pressure of the earth's atmosphere, probably more than the lunar material could stand.

LUNAR SOIL

Dark of the moon from solar wind

One of the unusual findings by the automatic Surveyor spacecraft was that the lunar surface material seemed to be dark on its uppermost face but light where it was turned over, such as by the spacecraft's scoop. Analysis of Apollo 11 samples by researchers from Cornell University suggests that the darker top layer might come from solar wind effects on certain elements in the soil.

The scientific team, headed by Dr. George H. Morrison, detected the presence of significant amounts of oxides of titanium and calcium. "This suggests," Dr. Morrison says, "that the dark color may be due to reduction by solar-wind proton bombardment, producing black, oxygen-deficient compounds."

The theory is that solar-wind protons knock some of the oxygen atoms loose from their oxides, causing the titanium and calcium compounds to darken as they become closer to pure metals.

PHYSICS

Still no magnetic monopoles

For several years physicists have been hunting for particles that would interact with magnetic fields just as electric charges interact with electric fields (SN: 2/22, p. 187). According to a recent theory of the physicist Dr. Julian Schwinger of Harvard University, these magnetic monopoles would be the most fundamental particles.

Because of its long exposure to cosmic rays, the lunar surface was considered to be the most likely trap and hiding place for monopoles. And a group led by Dr. Luis W. Alvarez of the University of California at Berkeley undertook a search for them in the returned lunar samples. No monopole was found.

The result sets upper limits on the presence of monopoles both in the primary cosmic rays and in the proton-nucleon interactions.

MINERALOGY

Lunar highlands material

One of the findings to come out of the study of the moon material is that rock fragments seem to be transported about quite a bit over the lunar surface. Specifically, good evidence was reported that some of the samples from Tranquility Base derived from the lunar highlands, which begin only 42 kilometers south of the Apollo 11 landing site.

Dr. J. A. Wood and his associates at the Smithsonian Astrophysical Observatory, for instance, found that about 3.6 percent of the fragments they studied consisted of light-gray or white rocks called anorthosites, which differ markedly in appearance and composition from the dark, titanium-rich basalts composing a majority of the samples.

The light-reflecting power of the moon's surface at the elevation of the highlands leads them to suspect that any fragments from them would be lighter in color and lower in density than the mare basalts. The anorthosites, the Smithsonian group concludes, are the most obvious candidates. They feel confident that the anorthosites are highlands material, thrown into Tranquility Base by cratering events.

TRACE ELEMENTS

Sometime mercury atmosphere

An extremely thin, on-again off-again atmosphere of mercury vapor may exist on sunlit areas of the moon, suggests a research team from Argonne National Laboratory in Illinois.

Mercury in the lunar samples, says Dr. George W. Reed Jr., evaporated at about 110 degrees C. "Since during full sunlight the surface of the moon is above this temperature," Dr. Reed says, "our results seem to show that sunlit lunar areas may have a thin atmosphere of mercury vapor."

When the samples were then heated to 150 degrees C., about the temperature of sunlit parts of the moon, a burst of additional mercury was given off, totaling as much as 80 percent of the total released even at much higher temperatures.

When the temperature was reduced, analogous to part of the moon passing into shadow, the mercury was absorbed back onto the lunar material.

The amount of mercury given off by the samples, he reports, was considerably higher than that given off by terrestrial rock samples or meteorites.

HELIUM

Solar wind origin likely

Traces of helium in the lunar material were apparently first incorporated in the outer layers of the mineral grains in which it is found, and later transferred into the interior of the grains by diffusion.

This conclusion, which points to the solar wind as the source of the moon's helium, is based on microprobe analysis by three researchers at the Max Planck Institute of Nuclear Physics in Germany. It was also found, according to Dr. F. Steinbrunn, that helium concentrations in different materials vary by as much as 10 times, including, in descending order: ilmenite, glassy titanium-rich conglomerates, glass spherules, pyroxene and plagioclase. Other rare gas analyses, Dr. Steinbrunn says, show similar relationships.