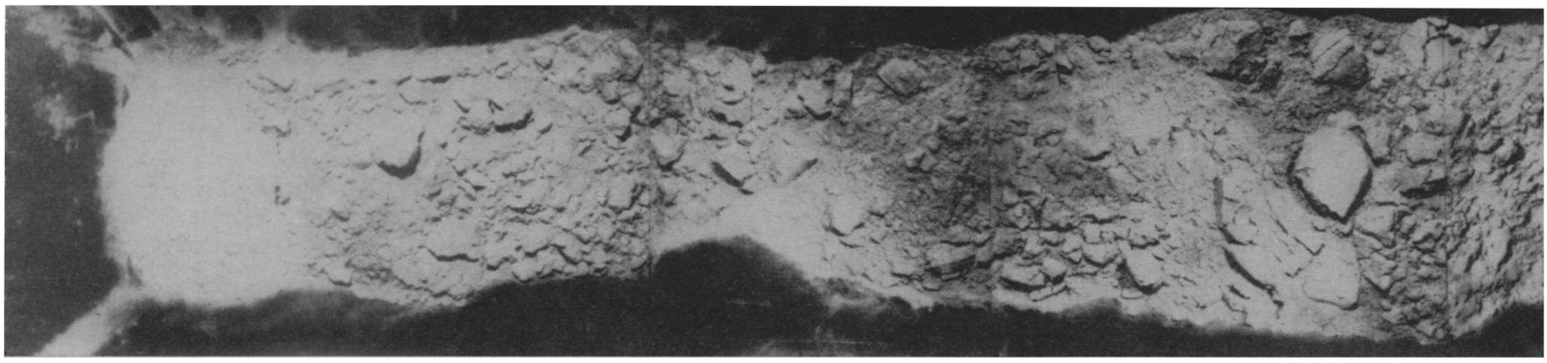
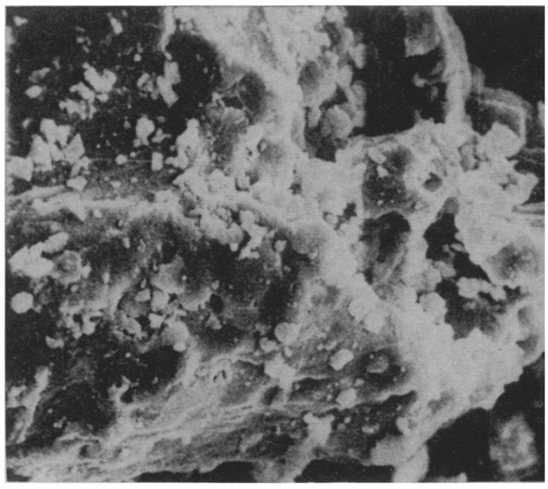


A. P. Vinogradov

Analysis of the core of soil extracted from the Sea of Fertility by Russia's Luna 16 supports Apollo findings.

At the moon conference: Consensus and conflict

Lunar scientists find as many questions as answers in their studies of samples from three sites



A. P. Vinogradov

Regolith particles in Soviet sample.

As more than 700 scientists the world over continue to produce data from microscopic analyses of lunar soil grains (some as small as one-thousandth of a millimeter) and detailed volumes of information continue to mount about the moon, both present and past, the reaction is often, "But, Professor, what does all of this mean?"

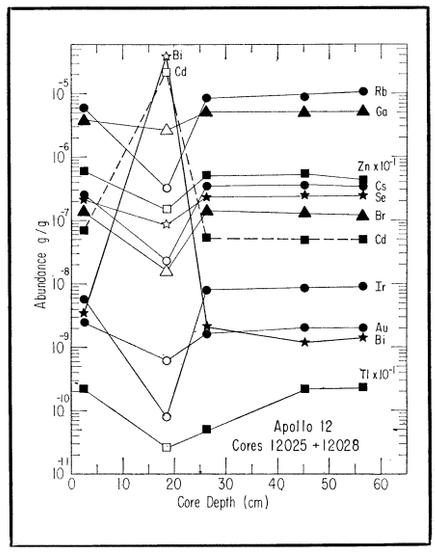
The answer is often more complex than the data, since new facts lead to deductions that often contradict well protected theories of the past. This was evident last week at the 2nd Lunar Science Conference in Houston (SN: 1/16, p. 43), as one scientist after another submitted models of the moon with the qualification that they were subject to change without notice. What in fact the recent Apollo 12 data deluge may ultimately mean is not clear. It is evident, however, that diverse processes are at work in the multidisciplinary effort to understand the moon.

One of the most obvious is the piecing together of the moon itself—micrograin by micrograin. More subtle but perhaps more important is the evolution of a new age of science.

The arrival of tangible samples from the moon, says Dr. Geoffrey Eglinton of the University of Bristol, "has had an effect very similar to [that of] a wartime effort. It causes a catalytic time-dependent effort which is quite remarkable." Not only can the coordinated effort be compared to the almost superhuman responses of war, says Dr. Gerald J. Wasserburg of the California Institute of Technology, but the results of this era may also be similar. "At the end of the bomb business," he says, "after the academics got out of it, there was a literature produced that was not just a pile of papers. It was a new science and a new technology."

Whether or not the current cross-disciplinary study of the moon produces a renaissance, it has produced a pile of papers, over 200 of which were presented at the Apollo 12 conference. Much of the information presented was happily compatible and similar to other independent studies. Some was unique, and therefore controversial. The remaining details may take years to integrate into any current model of the moon.

Although the meetings were rife with debate, there was some consensus. The emerging picture is of a complex moon, originating somehow about 4.6 billion years ago, and partially melting somehow one billion years later. During this melting, which could have been caused either by an internal mechanism such as volcanism or by surface melting from catastrophic events (there is little agreement at this point), it is believed that some of the maria were formed—at least the Ocean of Storms and the Sea



E. Anders

Apollo core shows distinct layering.

of Tranquility. That there were several events and not just one would account for the 200-million-year difference in ages of these seas. The Apollo 12 samples from the Ocean of Storms were not only younger but also more varied than those from Apollo 11. The composition was different, but the chemistry was the same—a first cousin relationship.

Adding to the scientists' confidence in the integrity of their geochemical

finds was the preliminary report of the core samples returned to earth by Luna 16 from the Sea of Fertility (see p. 65). Academician Alexander P. Vinogradov, vice president of the Soviet Academy of Sciences, told a hushed audience of some 600 scientists that the three ounces of Fertility soil was similar in composition and age (4.6 billion years old) to that brought back by Apollos 11 and 12. From this he infers a common origin for the seas. Dr. Vinogradov also concludes from the much greater coarseness of the grains in comparison with the Apollo core samples and from the fact that the Luna 16 drill hit a solid object (which he says could have been bedrock) that the Sea of Fertility's regolith was thinner than that at the Apollo 11 and 12 sites.

Another Apollo 12 find of general agreement was that of an exotic component called KREEP by some—for high content of potassium, rare earth elements and phosphorus—found in rock 13 and in other material dated about 4.5 billion years old. Although the scientists could not agree whether it came from the highlands or a crater such as Copernicus, it is believed that it could be part of the ancient crust and perhaps be the mysterious component that causes the soil to be dated 4.6 billion years old while the rocks are usually a billion years younger.

Beyond this there was little agreement.

Differences of interpretation exist about the findings from an 18-centimeter Apollo 12 core tube sample. The sample has definite striation; each layer differs in color, chemistry and grain size. "Less than one part in 1,000 or 10,000," says Dr. Edward Anders of the University of Chicago, "moved to the top." Another study revealed that the top layer of bismuth and cadmium remained at the surface for 15 million years. If the lunar soil is constantly being dug up by many small impacts, more mixing should have occurred. One explanation is that, at least in that area of the moon, the impacts are larger and less frequent. Another theory, held almost singularly by Thomas Gold of Cornell University, is of an electrostatic process on the moon which gently moves surface materials and fills holes. Some of the greatest controversy arose over data from studies of the moon's physical properties. It is generally believed that the moon was formed by accretion, although there is yet little evidence for this. It is also generally accepted that the moon is highly fractionated. And results show it is depleted in volatile elements. But there is still lively debate about whether the moon once had a hot core, where the moon's mantle begins and of what material it is composed.

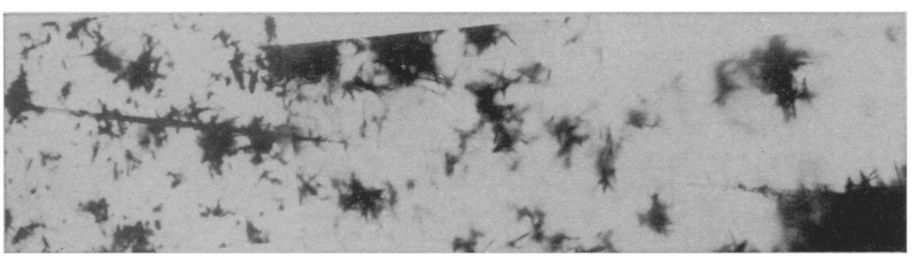
"The magnetism results from Apollo 12," says Dr. Michael Yates of Bellcomm, Inc., Washington, D.C., "seems to be supplanting the seismic results in importance since the magnetism relates to the moon as a whole." The interpretation given to the magnetic results by Dr. C. P. Sonett of the National Aeronautics and Space Administration's Ames Research Center, Moffett Field, Calif., "gives answers in direct contradiction to everyone else's," Yates says. The magnetic field in the solar wind sets up currents as it strikes the moon. From the induced currents Dr. Sonett determines something of the electrical conductivity of the moon as a function of depth. A spike or a peak in this conductivity occurs, says Dr. Sonett, at a depth of 200 kilometers. He believes that the temperature increases to that depth, and then decreases again. From this he concludes that the moon's core is relatively cool—800 to 1,000 degrees C., well below the melting point of most solids. A core that is cool now almost precludes the moon's ever having a hot core, as the cooling mechanism is impossible to explain.

"If Dr. Sonett's findings are confirmed," says Dr. Nowell Hinners, also of Bellcomm, "it is spectacular." But Dr. Sonett's cool moon contradicts other data that lead scientists to believe that the moon once had a magnetic field and thus a molten core. The spike, say the hot-mooners, could be caused by a change in material.

A tantalizing mystery was suggested from independent studies of cosmic-ray tracks found in the Apollo 12 samples. Scientists believe that the spontaneous fission of a uranium atom would leave a track about 14 microns in length. But Dr. Narenda Bhandari of the Tata Institute of Fundamental Research in Bombay, India, found a track about 18 microns in length, which he concluded was proof for the existence of transuranium elements.

Adding to the superheavy element excitement was a find by Dr. P. Buford Price of the University of California at Berkeley of a track 50 times as long as that reported by the Indians. This track, he believes, may contain the first real evidence of the hypothesized magnetic monopoles (SN: 8/29/70, p. 183). "If they do exist," says Dr. Price, "the moon's surface, which has been exposed for billions of years, would be a logical place to find one."

What does all this mean? "The speculation this year is more restrained than last year," says Dr. Robin Brett of NASA's Manned Spacecraft Center in Houston. "This is a sign we are zeroing in; we are starting to do real science." □



P. Buford Price

Long particle track is claimed to be possible evidence of a magnetic monopole.

POLYWATER POOH-POOHED

By the sweat of their brow

Polywater, or anomalous water, has provoked a continuing controversy among chemists. It is hard enough to believe that water can assume a form as viscous as molasses and have an atomic weight several times that of an ordinary molecule of water. Straining credibility even more are the facts that the anomalous water appears only in capillary tubes of a few microns diameter and that the largest samples obtained are measured in micrograms.

Nevertheless when Dr. Boris V. Deryagin, director of the Institute for Surface Chemistry of the Soviet Academy of Sciences, announced the discovery of the substance by one of his colleagues, N. N. Fedyakin, specialists in colloid and surface chemistry paid attention (SN: 12/21/68, p. 615). For awhile those who believed in anomalous water had the floor, and studies based on infrared and Raman spectroscopy indicated that anomalous water had the structure of a polymer made of water molecules (SN: 3/21/70, p. 287).

From the beginning, however, there were doubters, and as proponents of polywater failed more and more to agree on the structure of the substance and in their attempts to produce convincingly large quantities of it, the doubters began to have their innings. In the Soviet Union doubts were loudly expressed at a confrontation that the Soviet Academy of Sciences arranged between Dr. Deryagin and other interested academicians (SN: 10/3/70, p. 286).

In the West a more or less negative attitude appeared at the 44th National Colloid Symposium at Bethlehem, Pa., last June (SN: 7/4/70, p. 6). Lately a series of reports in three different journals fires a few more salvos from the negative side. Whether these will finally sink polywater will probably depend on the faith of proponents; from the