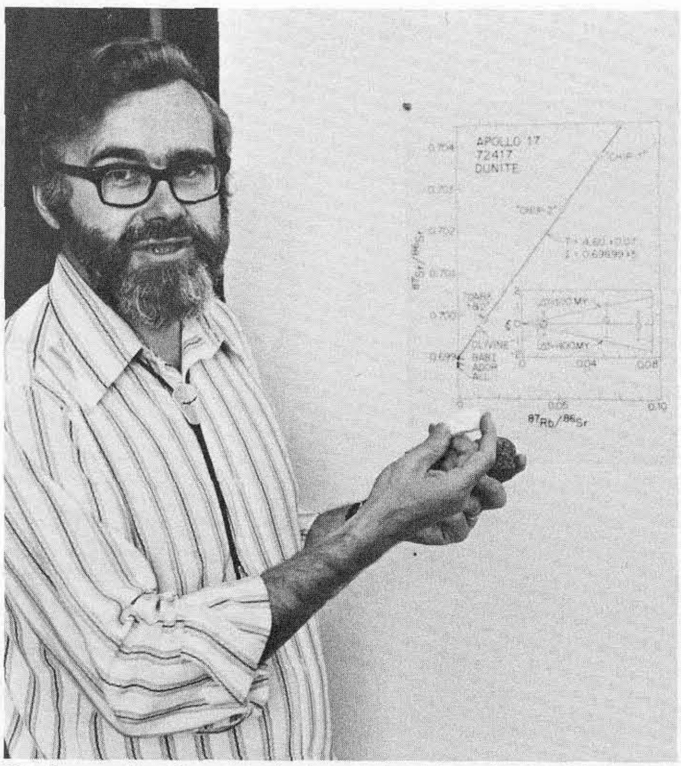
Rocks of Ages

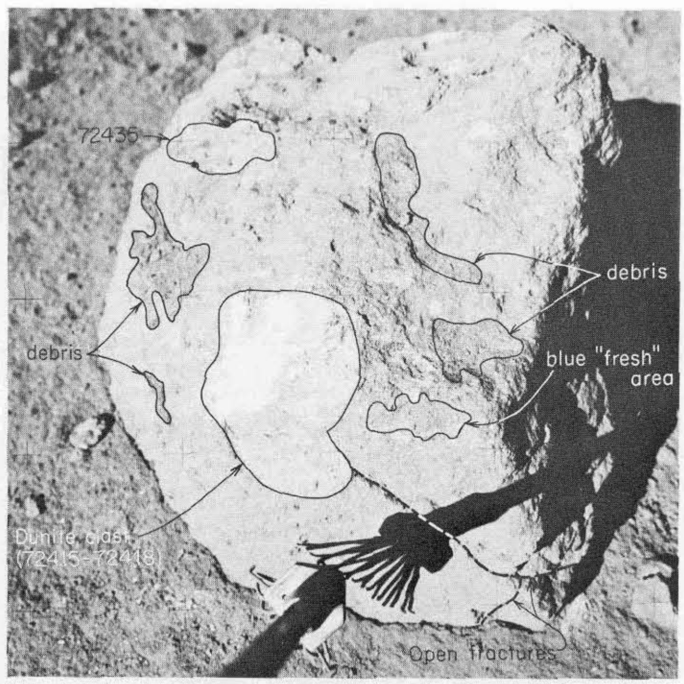
A major goal of the exploration of the moon was to find rocks as old as the solar system and thus to improve our understanding of how the earth, the moon, and the other planets were formed—about 4.6 billion years ago. The oldest terrestrial rock is only 3.7 billion years old, because erosion, mountain building, weather, and the atmosphere have erased the very early history of the earth. So, the moon, where those forces have not acted, was a logical place to look for older rock samples.

Most of the rocks returned by the early lunar missions were between 3.1 and 3.9 billion years old, with the oldest recorded at 4.2 b.y. There is a hint of older ages in feldspar crystals taken out of lunar highland breccias. But with the Apollo 17 samples, the age-dating program seems to have hit a primordial jackpot. Several of its rocks have been dated at between 4.2 and 4.5 b.y., and one tiny fragment checks out at 4.6 b.y.—which was almost immediately after the formation of the solar system.

This fragment—designated Apollo 17 No. 72417—is a greenish rock called dunite, composed largely of olivine, an iron magnesium silicate. It is so depleted in trace elements that it almost certainly must have formed during early lunar differentiation and associated gravitational settling. Apparently, at some later date, a large meteor



The fragments of lunar dunite brought back from Apollo 17's Boulder #3 are too valuable to be as casually displayed as Arden Albee seems to be doing. But, as a matter of fact, the white rock in his hand is only a scale model of the largest of the fragments.



After this boulder was photographed on the moon, astronaut Jack Schmitt chipped at it in two places with a hammer to break off samples that could be returned to earth. The largest area shown in outline is the place from which the fragments of ancient dunite were taken. Near the top of the boulder, the area labeled 72435 was sampled to secure an example of the matrix. The fringed shadow at the base of the boulder is cast by Schmitt's rake.

Scientists from the "Lunatic Asylum" report on the oldest lunar sample and the youngest meteorite

smashing into the moon gouged deeply into the interior, and propelled this bit of rock out onto the surface.

The basis for dating the origin of the solar system at 4.6 b.y. has been the study of the radioactive decay of meteorites that have crashed into the earth. Meteorites are believed to be debris left over from the formation of the planets, fated to wander aimlessly in space—unless or until they collide with another body. Most meteorites found on the earth are rated 4.6 billion years old, though one that landed in Sudan in 1942 is recorded at 3.5 b.y.

Age-dating of both moon rocks and meteorites is a project of the Caltech group working in the "Lunatic Asylum," headed by Gerald J. Wasserburg, professor of geology and geophysics. The group also includes Arden Albee, professor of geology; Dimitri Papanastassiou, senior research fellow in planetary science and physics; graduate students Robert Dymek, Alexander Gancarz, and Don Goldman; and senior spectroscopist Arthur Chodos.

Albee recently reported on the discovery of the 4.6 b.y. moon rock, and at the same time Papanastassiou announced that thanks to the generosity of Professor Clifford Frondel of Harvard University he had been able to study an unusual meteorite, called Nakhla, that fell on Egypt in 1911. Nakhla turns out to be a mere 1.3 b.y., and in addition it has a peculiar chemistry that shows it was molten sometime in the past—much later than the formation of the solar system.

Papanastassiou theorizes that Nakhla was once part of a small planet or minimoon that experienced melting about a billion years ago and then for some reason broke up and scattered pieces through the solar system. (The moon recorded its last major melting more than three billion years ago, and the earth still spews out molten lava.)

Scientists have generally assumed that the moon, with a radius of about 1,000 miles, is the smallest body in the solar system that was at one time active volcanically. But discovering the history of Nakhla suggests that there are probably numerous bodies around the solar system —perhaps with radii of only 150 to 200 miles—that have had a life of their own.

It has been so generally accepted that meteorites are close to primordial material that very few have been carefully age-dated. This preconception about the age

Dimitri Papanastassiou's cap, gown, and tweezers indicate some of the care used to prevent contamination of the rock samples analyzed in Caltech's "Lunatic Asylum." The rock is the Nakhla meteorite that Papanastassiou discovered was only 1.3 billion years old.

of meteorites and the time scale for the development of planetary objects has lasted 20 years. Nakhla's youth may change that, sending scientists back to their labs to check the age of whatever meteorite material is on hand.

This further research—and new information from it—could cause a revision of theories about the relationship between meteorites and the formation of the solar system. In fact, what the post-Apollo studies seem to show best is that we still don't understand the origin of the planets, their moons, or the meteorites. "Before Apollo," says Wasserburg, "there was one magic recipe in the solar nebula by which all planets, including the moon and earth, were formed. No one thinks that way any more. The Holy Grail is gone, and we're beginning to face the real problems of planetary formation for the first time." □