field could influence the volume and intensity of cosmic rays coming into the atmosphere. A strong field would keep more out while a weak one would let more in.

A minor factor is the burning of fossil fuels which puts more carbon 12 into the air, thus altering the ratios during the past 100 years. Another factor is the climatological changes that have occurred. An ice age, for example, would change the carbon content of the atmosphere by altering ocean temperature.

The nature of the radiocarbon dating aberrations is mostly upward, which makes dates more recent than they would actually be. A time profile of the discrepancies obtained so far shows deviations in radiocarbon levels from 1500 to 1700 A.D., followed by a leveling off until 500 B.C., when there is another period of discrepancy, followed by an apparent trend toward leveling off until 5150 B.C. At that point the skein of information runs out, and scientists are just not sure what happened before. There are also gaps in the profile from 4100 to 3600 and 4850 to 4400 B.C.

One of the purposes of the research at the University of Pennsylvania is to determine if indeed the fluctuations are as cyclic as they seem to be. Also the investigators would like to know the size and duration of the fluctuations.

In their experiments, the researchers, led by Elizabeth K. Ralph, will be making measurements of known-age samples of bristlecone pines. Longer lived than the sequoia tree samples, the pine samples will be dated by the carbon 14 method and the resulting ages compared.

Another tool the investigators will be calling on is thermoluminescent dating (SN: 11/30, p. 552). This method is based on the fact that electrons in a material subjected to radioactive bombardment become excited and emit light upon heating. The intensity of light emitted depends on the accumulated amount of radiation damage, which in turn depends on exposure time. Thus, by measuring the intensity of emitted light, an indication of the time that has elapsed can be obtained.

The Pennsylvania scientists will corroborate the half-life of carbon 14 with this technique. They will take phosphors susceptible to radiation damage and expose them to carbon 14. The phosphors will be heated and the light emitted measured.

The problem still facing the researchers is to figure some way to calibrate the emitted light to get a disintegration rate for carbon 14. Once the specific disintegration rate for a calibrated amount of light is known, it is the same as knowing the half-life of the substance. Since the technique is not a highly accurate one, the team hopes to come up with a "ballpark figure" for the true half-life of carbon 14.

The people most affected by the discrepancies are those who try to relate radiocarbon ages to calendar time. "It would affect the archaeologist the most," says geochemist James E. Mielke of the Smithsonian Institution in Washington, D.C. "He has to interpret the number the laboratory turns out."

But there is no thought of discarding the method. "It's serious but we're learning more about it," says Pennsylvania's Elizabeth Ralph. "As we obtain more information, we will obtain correction factors." ◇

UNDIFFERENTIATED ROCK

Ancient moon samples exhilarate selenologists

Scientists studying the earth to learn about its ancient past face much the same problems as sleuths trying to unravel a crime in which the criminal has carefully destroyed much of the evidence, shuffled the rest and smudged his fingerprints.

To a geologist, this tampering with the evidence is largely known as differentiation: the separation of rocks, minerals and elements into light and heavy components, due to heating, gravitational attraction and other forces. Differentiation has the effect of obliterating forever the original distribution of materials with which a planet was formed, and added to it are the planet's internal stresses which keep mixing and remixing the materials many times over.

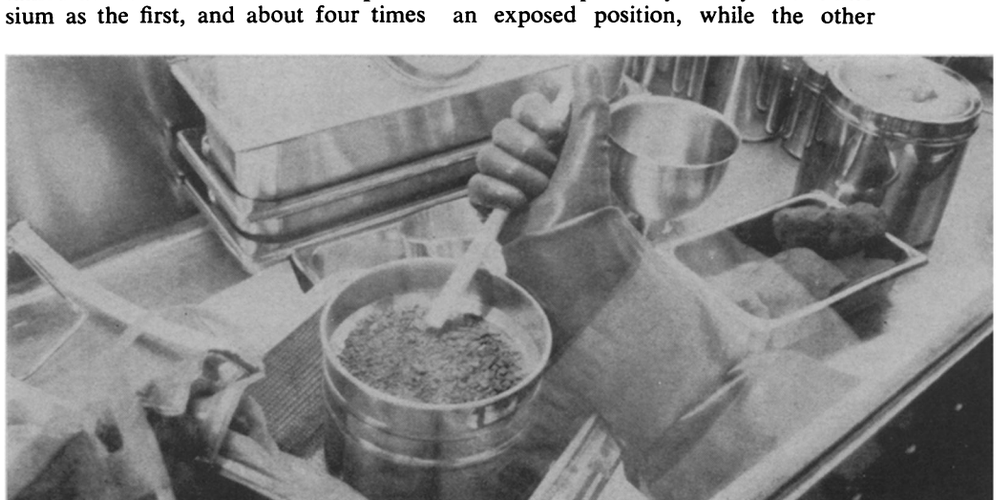
On earth, all this rock-shuffling has meant that reconstruction of the planet's early days involves a lot of guesswork, intuition and going out on limbs. There has also been evidence that the moon has undergone the same stirrings and churnings—the apparently volcanic nature of the Apollo 11 samples, for example—which could mean that the same difficulties are in store for lunar researchers.

Now, however, there is reason to believe that the moon may be in a much better preserved state than was previously thought, with remnants of its early composition readily accessible to researchers. At the Lunar Receiving Laboratory in Houston, scientists have discovered that the Apollo 11 samples, simply picked up on the surface by the astronauts, contain rocks more than three billion years old.

The rocks were dated by measuring the degree to which radioactive potassium 40 had decayed into stable argon 40, a process which takes place with a fixed half-life of 1.3 billion years. The more argon present in the rock, the older it is. The abundances of the two elements were measured twice, in a pair of samples each weighing only a few milligrams. The second sample contained about four times as much potassium as the first, and about four times as much argon, says Dr. Oliver Schaeffer of the State University of New York at Stony Brook, meaning that the ratio in the second sample verified the conclusion from the first.

The conclusion: It has been at least 3.1 billion years since the two rock chips were subjected to any significant heating, such as the volcanic activity, which might have given them their initial charge of potassium 40.

One of the samples, says Dr. Schaeffer, was probably deposited on the surface about 50 million years ago, when a meteor impact may have jarred it into an exposed position, while the other



NASA

Ancient moonchips may mean that the moon's old face can still be seen.

reached the surface about 100 million years before that. Most significant for the study of the moon, however, is the fact that both rocks may have come from as little as six feet below the original surface of Mare Tranquilitatis, which could mean that unaltered relics of the moon's earliest days are within easy reach of astronauts equipped with simple digging tools.

Many scientists have hoped to find the moon in a well-preserved state, at least in part because it would reveal much about the evolution of earth if the two bodies turn out to be related. Most of them, however, have regretfully predicted that it would turn out to be well mixed and differentiated, with all of earth's decoding problems.

Crater counts and other evidence have caused some researchers, such as Dr. Eugene Shoemaker of California Institute of Technology, to believe that the lunar maria may be as little as 500 million years old. The new evidence, Dr. Schaeffer suggests, may force researchers to consider the possibility that the rate of meteor impacts on the moon—heretofore the most common method of dating parts of the lunar surface—may not have been uniform.

Instead, meteor bombardment may have been heavier during the early days of the solar system. If the rate did indeed drop off sharply, perhaps several billion years ago, the maria could date all the way back to the drop-off point and still appear relatively young by a crater-count standard.

If the moon's ancient self is actually within a few feet of the surface, upcoming Apollo missions, possibly as early as Apollo 13 next March, could be particularly interesting. Apollo 13 is tentatively scheduled to bring back the first samples from the lunar highlands, which many scientists including Drs. Schaeffer and Shoemaker feel are older than the maria.

It is within the realm of possibility, therefore, that an Apollo mission could present scientists with an incredibly exciting prize: rocks almost as old as the moon itself, perhaps still bearing traces of the throes of its formation.

Another possibility suggested by the ancient rocks is that the moon is even drier than the arid wasteland it had been supposed to be. This, according to Dr. John O'Keefe of the National Aeronautics and Space Administration's Goddard Space Flight Center in Greenbelt, Md., is likely if the basaltic glass found in the samples (SN: 8/2, p. 95), which apparently still retains its glassy structure, is also billions of years old.

On earth, says Dr. O'Keefe, such glass would long since have reverted to the crystalline structure from which it was formed. The fact that the lunar glass stayed glassy, he believes, means either that the moon is radically different from the earth or that the rocks contain very little water trapped within their molecular structure.

The latter conclusion could in turn add weight to the theory that the moon was originally spun off from the earth, Dr. O'Keefe says. Such a process—one of the main ideas competing for advocates as the origin of the moon—would create a great deal of heat, which would drive off most volatile materials, including water.

The critical factor in such informed guesswork, of course, is that the dating of the apparently ancient rocks holds up under close scientific scrutiny. The best check, Dr. Schaeffer says, is rubidium-strontium dating, which involves the ratio of rubidium 87 to its decay product, strontium 87. This is the most common form of dating for extremely old earth rocks, and will be tried on lunar samples, once they leave the LRL in mid-September, by Dr. Gerald J. Wasserburg of California Institute of Technology.

CANCER THERAPY

Titillating but inconclusive

Not long ago, leukemia killed within months. Now, with the judicious use of a combination of anticancer drugs, sometimes coupled with radiation treatments to destroy leukemia cells, physicians induce remissions of the disease, giving patients a temporary stay from death (SN: 12/21, p. 626). At the hands of a skilled physician, abreast of the newest gains in cancer research, a leukemia patient can now hope to live for three to five years. But the stay is still only temporary. Researchers continue to fight for total victory.

Perhaps the most promising new line of attack is an immunological approach to cancer, based on the fact that the disease is inevitably associated with a weakening of the body's protective immune system (SN: 5/10, p. 457). For some unknown reason, the immune system fails to recognize and fight the wildly proliferating cancer cells that will ultimately destroy the body. Or, in any case, it fails to marshall a sufficiently strong army of lymphocytes to destroy these abnormal cells completely. In view of this, investigators seek ways of enhancing immune activity.

One new approach to the therapy that has growing support limits the use of known anticancer drugs. It reduces doses to the lowest acceptable level because these agents, while killing cancer cells, also suppress the immune system. And that takes away what natural defense a patient may have.

A second approach is to stimulate a sluggish immune system by introducing foreign cells, in the hope of inducing a rejection process like that which occurs when the heart or liver of one man is transplated to another.

Russian scientists, reporting in the Aug. 2 NATURE, declare they have achieved success with this second approach by injecting the leukemic cells of one patient into another victim. Foreign cells are used because an individual's own leukemia cells stimulate no strong immune response.

Leukemia cells from another person, the Russians say, do the job as any antigen does. Dr. S. V. Skurkovich of the Central Institute of Hematology and Blood Transfusion in Moscow, with Drs. N. S. Kisljak, L. A. Machonova and S. A. Begunenko of the Second Moscow Medical Institute, experimentally treated 12 children, separated into six pairs, with marked success.

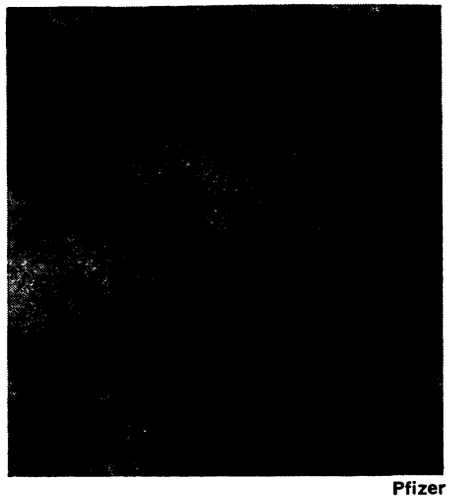
Aged 3 to 10 years, the children had various forms of leukemia. In each pair, live leukemia cells from one child were used to immunize the other and vice versa. The Russians report that after receiving injections of these foreign leukemic cells the patients' immune systems responded.

In 8 of the 12 patients, the number of leukemic cells in the blood decreased by two to three times within a week, continuing to drop more gradually thereafter until the total percent of leukemic cells in the body was reduced from initial levels of between 40 and 89 percent to levels of between zero and 10 percent.

U.S. scientists are skeptical; they find the article lacks convincing data.

"I can understand what they say they did," observes a West Coast immunologist, "but they have not proved to me that they got remissions by using live leukemic cells. Their patients had also been taking drugs that quite routinely induce remissions."

Other observers in the United States



Pfizer

Leukemia viruses emerge from cell.