means of energy delivery. For best results the energy must be delivered to the shallowest possible layer of the surface of the pellet in the quickest possible time. Light has the problems of penetrating the pellet and of being reflected by it. Much effort is going into the proper sizing and shaping of pellets to minimize these effects and to concentrate the light. Light also has a preheating effect on the pellet surface that lessens the desired explosive effect of the ablation when it comes. Electrons also penetrate, and there is an effort to coat pellets with substances that will absorb electrons efficiently. Ions tend to give up their energy in the outermost atomic layers of the pellet, and there is no preheat problem.

The major outstanding problem, Yonas points out, is getting the ion beam from the diode to the target. It will be necessary to transport it at least several centimeters. A beam of this kind cannot be run through a vacuum tube like the beams of the usual particle accelerators. The beam is too dense with particles of the same electric charge. Their collective repulsive effect on each other, called the space charge effect, will destroy the coherence of the beam. In some cases, according to one commentator, it can even stop and reverse the motion of the beam.

The solution to the problem seems to be to run the ion beams, and the electron beams, which are under experimentation in the same places, through a background gas. The background gas could be electrically neutral or it could be ionized. Its purpose is to dilute the space charge effect. But it is also an obstacle, which is why it is removed in ordinary accelerators, in which space charge is not so serious a problem. The ion or electron beam must be guided through the background gas by a magnetic pathway, which can be formed by external magnets or by electrically dissociating the background gas. Experiments on these problems are underway at Sandia and at the Naval Research Laboratory and elsewhere in the world, especially the Soviet Union. Yonas was questioned about the Angara machine, now being built in Leningrad, which is more or less the Soviet counterpart of EBFA. According to his present information, Angara is expected to be operating at the megajoule energy level by 1985. At Sandia they are now beginning the design work to raise EBFA from its present 30 kilojoule design to the megajoule level.

Work of this kind can also have applications to so-called particle-beam weapons. A part of the excitement and of the interest in Soviet work may stem from that.

The work on the production of light ion beams that has so far been done has concentrated on protons, which are the lightest possible ions. But where protons operate, nuclei of other light elements can usually be made to follow, and ultimately, perhaps with some difficulty, even fairly heavy ions may be made to go the route. ☐

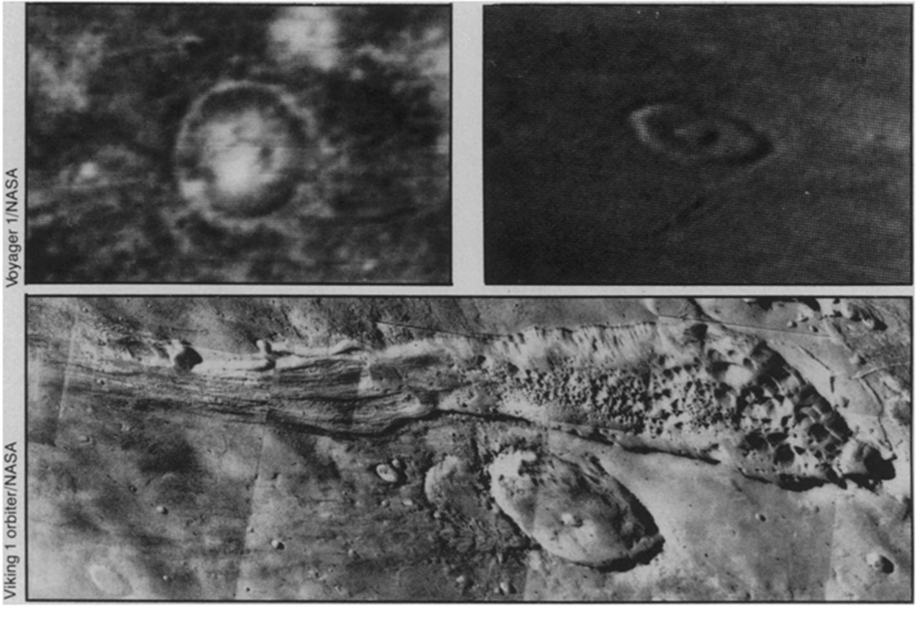
Rockfest 10: Comparing and competing

When the first Lunar Science Conference was held at NASA's Manned Spacecraft Center (now Johnson Space Center) in Houston in January of 1970, the more than 800 scientists attending it were focused on a single subject: the first study results on the Apollo 11 moonrocks, brought to earth just six months before. This year's gathering, held last week at JSC, was the tenth such affair, but the subject matter has expanded to include at least that many solar system objects — the moon, the planets from Mercury through Jupiter and Jupiter's four Galilean satellites, as well as meteorites, tektites, asteroids, comets and space dust. Last year the event was renamed the Lunar *and Planetary* Science Conference, and this year's nearly 700 participants showed why.

So many new results were described from planetary missions such as Voyager, Pioneer Venus and Viking that some researchers felt that the moon was in danger of being lost in the shuffle. Indeed, a proposed Lunar Polar Orbiter satellite, designed to make global lunar studies to expand the limited Apollo and Soviet Luna data, has been on a far back burner at NASA, in large part because of competing proposals for Venus, Mars and comets. Even the existing moonrocks, most of which have not yet been touched, had their study funds cut last year from $5.7 million to a single million (pending a new division of the effort between NASA and the National Science Foundation), although the space agency hopes to reallocate enough money to get the amount back up to about $3.7 million. The cut is particularly ironic in view of discoveries still being made, such as last week's announcement of a new low-potassium, high-rare-earth basalt type found in the decade-old Apollo 11 samples. "The politics of pure science," says moon-veteran astronaut John Young, "is one of the toughest politics there is."

Through it all, David R. Criswell of the Lunar and Planetary Institute managed to sound confident as he introduced a somewhat blue-sky session on proposed ideas for future lunar exploration. "I'm personally convinced," he told his audience, "that we will return to the moon. Six years, maybe the next century, but we *will* return." In the session, topics ranged from an Exxon engineer's evaluation of drilling tens of kilometers into the lunar crust, to a description by Jack B. Hartung of the State University of New York at Stony Brook of a huge mat of "light-pipes" that could reveal meteorite impacts to a distant monitor by flashes of light, to a talk by Alan Binder of the New University at Kiel, Germany, about an envisioned unmanned lunar program involving 16 landing craft in a seismic and heat-flow network plus 18 robot vehicles to bring back new samples.

There are certainly regions from which scientists wish they had such samples — a young crater floor (bearing signs of the moon's later evolution), the lunar farside (which may retain more of its original surface), the polar regions (which have been suggested by some researchers to serve as a "cold sink" for a still-present reservoir of frozen water). In learning about the formation of the solar system's planets, according to the University of Maryland's C. G. Andre, "the moon may no longer be the most fashionable body in the sky, but it is our greatest hope." So saying, she proceeded to cite orbital X-ray data indicating the apparent presence of early, magnesium-rich basalts in all five of the lunar basins for which the data exist — yet they


Voyager 1/NASA

Viking 1 orbiter/NASA

Competing with the moon for attention: Central-pit craters on Ganymede (top) and Mars (bottom) may indicate their formation in icy surfaces or subsurface permafrost.

are largely buried by more recent, lower-magnesium basalt flows that followed. Such material is vital to an understanding of the lunar interior, but, she says, "if we're correct in our interpretation, the surface basalts are a misleading sample."

Charting such uncertainties is often cited as a reason for the U.S. Lunar Polar Orbiter, which is not exactly waiting in the wings. A Soviet version was asserted to be due "within five years" by a Soviet official at last year's "rockfest," but the prevailing opinion among U.S. scientists at last week's meeting was that it is no likelier to fly. The best hope seems to lie with POLO, a Polar-Orbiting Lunar Observatory now being studied by the European Space Agency as a joint project for its member nations. POLO is no shoo-in either, however, and European scientists at a special session during the rockfest discussed with some concern the possibilities of getting the proposal past the preliminary scientific assessment that has been done.

One of POLO's problems, like the LPO's, is that it is competing with possible missions to less-visited parts of the solar system (such as a multiple asteroid "fly-by"). A factor in such competition is the diversity of planetary surface types revealed by recent missions to non-lunar targets. Given the parched nature of the moon, Mercury and probably Venus, a particularly tempting category is those surfaces either made of, or strongly influenced by, water. The presumably ice-rich crusts of Ganymede and Callisto and the variety of possibly water-formed features on Mars showed signs at the conference of drawing a widening range of interest.

Studies of impacts into ice, says Mark J. Cintala of Brown University, suggest, for example, that craters made on icy bodies may often be characterized by "pits" at their centers rather than by the central peaks seen in many craters on, say, the moon. The rebound splash of the impact that hardens into a peak on a rocky world may just fly apart, leaving a hole, when the rebounding surface is as weak as ice, Cintala says, and such central-pit craters seem to show in Voyager 1's photos of Ganymede and Callisto. If the difference is really due to ice, the presence of similar features in Viking's Mars images may now be additional evidence of the presence of permafrost on that planet. Except that they also exist on the moon. Still, certain ridges seen on Mars resemble ridges thrust up through ice in Iceland, and, according to Charles Simonds of Northrop Services, Inc., of Houston, a Martian water reservoir vaporized and redistributed around the planet by impacts might help account for the clay-like nature of the surface material inferred from Viking data. Some Martian geologic features such as table mountains, in fact, says C. C. Allen of the University of Arizona, seem to suggest water-related formation processes requiring nearly 10 times the water invoked by current atmospheric history models. □

SYNROC—a better way to store rad wastes?

How to store high-level radioactive wastes safely and permanently is a thorny problem. Whether or not one buys the argument that nuclear power is both necessary and safe, there are already growing stores of radioactive wastes from power plants and nuclear-weapons plants that must be dealt with. Encapsulating wastes in borosilicate glass and burying them in geologically stable graves of rock or salt is one potential solution that appears to be gaining favor. A. E. Ringwood, a geochemist at the Australian National University's Institute of Advanced Studies in Canberra, offers another in the March 15 NATURE; he calls it SYNROC.

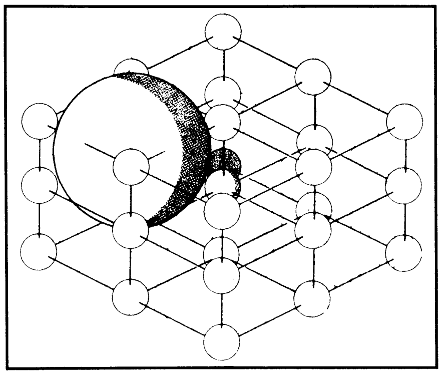
The idea is to bond atoms of the radioactive waste into the crystalline structure of a stable, synthetic host rock composed primarily of three minerals: perovskite, hollandite, and celsian — at least two of which are highly insoluble. The mixture of minerals and the radioactive wastes would be melted separately and then combined in a ratio of nine parts melted rock to one part waste. The igneous blend would then be poured into a thick-walled nickel canister and uniaxially cold-pressed to about 70 percent of its theoretical density. After being sealed with a thick copper and nickel lid, the entire assembly should be hot-pressed at 1,200° C to 1,300°C into a mechanically strong package "close to its theoretical density."

Ringwood and his ANU colleagues claim that aside from the benefits of simplicity, encapsulating and sealing wastes in a single process tend to reduce the loss of substantial amounts of cesium, ruthenium and other volatile elements that occurs in the production of borosilicate glasses, for instance.

More important, since the mineral components of SYNROC constitute 90 percent of the final product, they will determine its atomic structure and geochemical properties, Ringwood says. Atoms of the radioactive-waste elements simply substitute, in low concentrations, for the atoms that otherwise determine SYNROC's structure. This means chemists have a greater opportunity to predictably engineer the bonding—and as far as radioactive wastes are concerned, the immobilizing — structure of SYNROC, Ringwood claims.

In tests at high temperatures and pressures, SYNROC outperformed borosilicate glass for maintaining its integrity. It also degraded far less than glass when subjected to pure water.

The more dangerous and long-lived radioactive elements must be safely contained for thousands or millions of years. Ringwood feels SYNROC will be able to do this better than currently competing technologies; it should react less with the rock in which it's buried because it can be made to resemble the rock in which it's buried, he says. An account of Ringwood's work in the September 1978 SCIENTIFIC AUSTRALIAN describes a waste-storage scheme where bore holes drilled into granite to depths of 3,000 meters would be filled with nickel-covered SYNROC capsules to within 1,000 meters of the surface. Spaces between capsules and in the top 1,000 meters of each hole would be sealed with impermeable clay and mudstone. □



Scientific Australian

Model of how large, radioactive atoms fit into the spaces (lattice) of SYNROC.

Anticancer proteins

Protein complexes have been isolated from mouse blood that, when injected into other mice with tumors, killed their cancers quickly, sometimes within 24 hours. So reported Saul Green of New York's Memorial Sloan-Kettering Cancer Center at an American Cancer Society seminar in Daytona Beach, Fla.

The protein complexes can also sabotage human cancers, preliminary evidence from Green and his colleagues suggests. The complexes killed cancer cells taken from patients with cancer of the large intestine and skin, slowed the growth of a human tumor called a neuroblastoma and caused human melanoma tumors growing in mice to shrink. What's more, Green and his co-workers have isolated similar protein complexes from the blood of humans. These complexes are called "normal human globulins" (NHC's).

Both because of their apparent effectiveness against human tumors and because they are substances natural to the body (and therefore purportedly safe), the protein complexes might eventually be used to treat cancer patients. First, though, scientists must learn more about how they work against tumors and whether the human proteins are as effective as the animal ones. Then they must obtain enough proteins for widespread testing.

Green suspects that the proteins may constitute vital natural defenses against cancer, both among animals and humans. They may help explain, he conjectures, why three out of four persons do not get cancer. □