A plan to probe into the continent

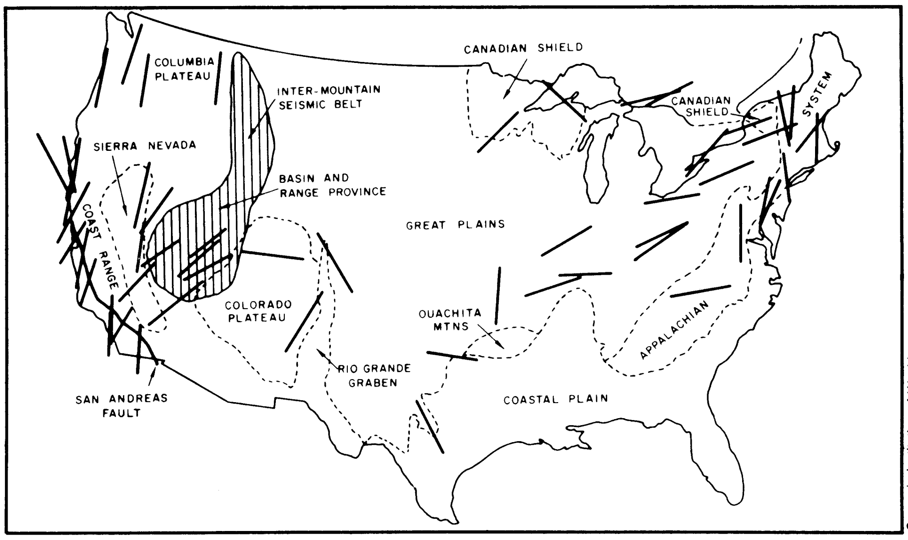
Geophysics, being the science it is, has gotten much of its information out of holes in the ground. The record goes back at least to the silver miners of ancient Greece, who observed that the deeper they went the hotter it got. From the silver mines of Laurion in Attica to the petroleum wells of Oklahoma's Anadarko Basin, the information for dry-land geophysics has usually come from holes drilled for commercial purposes. Now a group of distinguished American geophysicists, whose deliberations of the subject were financed by the Carnegie Institution of Washington, proposes a change: deep dry-land holes specifically for geophysics.

The proposed Continental Drilling Project is a conscious imitation of the highly successful scientific program of undersea deep drilling that has been going on for the past seven years. If dry-land geophysics piggybacked on mineral exploitation, the reverse has been true under water. There the successes of the scientific program have stimulated commercial interest.

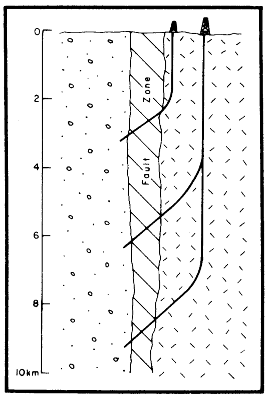
The holes proposed would be the deepest ever yet drilled, though not spectacularly deeper than the deepest now existing. Nine kilometers is the maximum for the proposed holes, compared to seven or eight in the Anadarko Basin and the Kola Peninsula in the Soviet Union. The drilling would thus be within the capabilities of present techniques except for some proposed hot-rock drilling that might require the new melting and boring techniques under development at the Los Alamos Scientific Laboratory.

The scientific objectives are several, basic and specific. They encompass the nature of earthquake mechanisms and possible avenues to their control or mitigation, investigations of geothermal deposits and possible penetration of a molten magma chamber, study of lateral stresses in the North American continental plate in an attempt to elucidate details of the forces that move it, and probes of the basement rock—the deepest part of the crust, what might be called the foundation garment of the continental plate.

The San Andreas is North America's best known earthquake fault and probably its most dangerous with regard to activity and location near population centers, and it is the target of the earthquake probing. The technique is to drill a hole alongside the fault zone and to "whipstock," bore off laterally, through the fault zone. The object is to study the relationship of lubrication to the release of stress (see p. 402) and why different portions of the fault release stress at different rates. It may turn out that artificial interference can promote gradual release in place of catastrophic quakes. The location would probably be the Bear Valley about 100 miles south of San Francisco.



Carnegie Institution of Washington



Map of lateral stress trajectories shows large data gap in the high plains region. "Whipstocking" is the technique proposed for probing the San Andreas fault (left).

The geothermal questions involve the differences between the two kinds of geothermal wells, those that spew mostly hot water and those concerned with dry steam and where the water comes from. The flow rate indicates there must be water sources deep underground not connected with the surface water cycle. Another objective is to obtain a sample of the molten magma that serves as a heat source.

Commercial holes have given a good deal of information about lateral stresses in the continental plate. The technique is to pump in high-pressure liquids and to observe in what direction the surrounding rocks crack. But commercial holes are drilled only where there is hope of oil or gas so there are no data for a large part of the middle of the continent.

The basement rock comes to the surface in northern Canada, but it is buried through most of the United States. The questions include how far out to sea it extends and whether it undergirds the whole of the dry land (in the Pacific Northwest it may not), and its general structure and composition.

Each of the principal projects would take between four and seven years. Each would take \$20 million to \$30 million, bringing the total to upwards of \$150 million. The different projects could be done separately. The geophysicists envision funding from various government agencies that ought to be interested.

To justify support there is a promise of practical results. Earthquake control could conceivably save thousands of lives and billions of dollars, says Eugene F. Shoemaker, of the California Institute of Technology, one of the two conveners of the panel. "If we don't do something about the earthquake danger in California, we're headed for a major disaster." Energy-crisis types should be interested in the geothermal phenomena. And then there is always the gnomic serendipity of digging into the earth. E. F. Osborn of the U.S. Bureau of Mines relates that the Polish government, prospecting for gas to decrease its dependence on Russia for fluid hydrocarbons, hit a deposit of high-grade copper. Poland has gone from being a copper importer to a copper exporter as a result of the one discovery. □

The argon on Mars: Portents, puzzles

On March 12, 1974, a Soviet spacecraft called Mars 6 reached the surface of its namesake planet. Apparently it crashed—its transmissions ceased just as it was to have touched down—but one of its instruments, a mass spectrometer intended to measure the gases in the Martian atmosphere, managed to get out a brief signal. It didn't measure anything; it just signaled that it was getting ready to go. But that short message has stirred new and old concerns ranging from improved chances of life on Mars to a reappraisal of the genesis of earth.

The signal came from the spectrometer's ion pump, a device which was to clear gases out of the instrument. It showed that the current in the pump seemed to be sporadically rising, a possible indication that the pump was having to work harder than expected. One interpretation of the rising current is that a

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to Science News. www.jstor.org

substantial amount of some inert gas was present in the pump, and an Izvestia report shortly after the landing estimated "several dozen percent. . . . The gas," said the report, "is most probably argon." By December, Soviet researchers had calculated that the Martian atmosphere contains from 25 to 45 percent argon.

Since then, U.S. scientists have been speculating on the possible portent for their own studies, both in theory and in technique.

Last week, Gerald A. Soffen of the National Aeronautics and Space Administration, chairman of the Science Steering Group for the Viking spacecraft that will land on Mars next summer, said he was "very apprehensive" about the danger to Viking's own ion pump, which could be overloaded by too much argon. Viking researchers, in fact, are tentatively planning to change the sequence of Martian surface experiments, using the instrument containing the pump first for an organic soil analysis, then for atmospheric studies, in case argon-rich air should spell the end of the device.

Argon was also in the wind this week at the annual meeting of the American Geophysical Union in Washington. Nearly 40 sessions in the four-day extravaganza were devoted to space research, yet only two were devoted to a single planet each. One of these focused on the Martian atmosphere, and every speaker mentioned the ubiquitous argon.

The quasi-circumstantial evidence from the Soviet Mars probe is not the only evidence of abundant argon on the planet. Joel Levine of the NASA Langley Research Center, who chaired the AGU session, argues by analogy: While the cosmic abundance of argon consists entirely of naturally occurring isotopes argon 36 and argon 38, 99.6 percent of earth's supply is argon 40, a radioactive decay product of potassium 40. Since earth and Mars formed from the same primordial mixture of elements, including potassium 40, the column density of argon on earth can be "scaled" to the mass-to-surface-area ratio of Mars. According to Levine and Guenter R. Riegler of Bendix Aerospace Systems Division in Michigan, this calculation yields 28 percent argon in the Martian atmosphere.

It is virtually impossible to detect Martian argon directly from earth-based observations because its spectral lines are in the far ultraviolet bands masked by earth's atmosphere. Lewis D. Kaplan of the University of Chicago, however, used spectra taken with the 200-inch telescope on Mt. Palomar to derive the total surface pressure of the Martian atmosphere and the partial pressure of carbon dioxide, its major component. Subtracting the carbon dioxide partial pressure from the total should have left nearly zero if only trace constituents remained. Instead, there was a discrepancy of nearly 30 percent. "Since all other reasonable alternatives can be excluded on the basis of spectroscopic evidence and cosmic abundance considerations," he says, "the residual component is presumably argon 40, formed by decay of potassium 40 and outgassed at a rate comparable to that of earth."

The major significance of all this argon may be its implications for water on Mars, which bears on the chances for life as well as the vast erosion features photographed by Mariner 9 in 1971. If water, CO_2, nitrogen and argon 40 are "outgassed" from the interiors of Mars and earth in the same ratios, says Levine, there must be far more CO_2 on Mars than shows up in the atmosphere (frozen into the polar caps, says Cornell's Carl Sagan; adsorbed into the mantle regolith, says Jet Propulsion Laboratory's Fraser Fanale). In addition, Levine adds, the planet must have exuded enough water to cover the surface—if it were all in liquid form—2.4 kilometers deep.

Even Levine, however, admits that such quantities of water are "very difficult to reconcile" with current ideas of how much water can be tied up in permafrost or bound in the regolith. Besides, points out Tobias Owen of the State University of New York at Stony Brook, "we don't know the numbers for the earth that well." Furthermore, he says, the current in the Soviet probe's ion pump rose so erratically that argon calculations from it may be subject to "larger uncertainties than [Soviet researchers] are willing to admit."

Not even Kaplan's earth-based spectra are sacrosanct. In fact, he says some of the uncertainties involved are such that an error of a few percent could change the implication from 25 percent argon to none at all. This may be resolved in September when Levine and David S. McDougal of NASA Langley plan to use the Copernicus observatory satellite to take extreme UV spectra of Mars from above earth's atmosphere, some 10 months before the two Vikings arrive to settle the matter for good.

Meanwhile, Fanale argues that inferring so much water from argon comparisons with earth is a mistake. There is plenty of non-liquid water, he predicts, much of it frozen into vast "ice lenses" that begin less than 40 degrees of latitude away from the equator and thicken all the way to the poles—some 50 million cubic kilometers' worth. But the far greater quantities hypothesized by Levine, he says, are based on a misconception, namely that the earth got all of its liquid water from outgassing over a long period of time. Most of earth's water, he says, was formed during a short span while the planet was accreting from the primordial solar nebula, whereas the argon came from outgassing. Thus a large quantity of argon on Mars should not automatically imply the huge quantity of water that is visible on earth. □

Tiny diamonds found in Wyoming

The Government has announced that diamonds have been found in rare rocks in Wyoming. But don't get too excited. The crystals are tiny (smaller than the head of a pin), only a few have been discovered, and it's way too early to know whether the find has any economic significance.

Two geologists, Malcolm E. McCallum of Colorado State University and David H. Eggler of the Carnegie Institution of Washington, catalyzed the events leading to the discovery. They had been examining pipe-like intrusions of igneous rock called diatremes in the Rocky Mountains as part of basic studies of rocks deep within the earth. There are more than 20 diatremes known in Wyoming and north-central Colorado. Most of the pipe is composed of kimberlite, a basic igneous rock and the source of most diamonds found around the world. (In most cases, however, it contains no diamonds.)

McCallum and Eggler sent their diatreme specimens to the U.S. Geological Survey laboratories in Denver for routine analysis. The technicians had trouble making thin sections of the rock and then noticed deep scratches on a grinding plate they used. They found that the scratches were caused by a tiny white diamond crystal less than a millimeter across. Several additional crystals—even smaller—were subsequently found. The samples came from a diatreme west of Laramie, in south-central Wyoming.

They were in a fist-sized nodule of rock now composed of serpentine which was formed by alteration of pyroxene and olivine. Such nodules are regarded as fragments of the earth's upper mantle, torn from as much as 160 miles below the earth by violent volcanic activity, in this case perhaps 350 million years ago. Only a small fraction of the Wyoming pipe is made of nodules, and the USGS, which funded the field work with the National Science Foundation, says only a few may have the right composition to contain diamonds.

In general, North American diamonds have had little economic importance. The most important diamond locality in the United States is at Murfreesboro, Pike County, Ark., where a mine was operated early in the century until 1919. □

Death of Dawn

Only 17 days after its much ballyhooed birth, Dawn, the first whooping crane ever bred and born in captivity, died this week of a congenital disorder. The bird's birth (SN: 6/7/75, p. 367) was considered a major step in reestablishing the whooping crane as a viable species in the wild. That step will have to be taken again. □