the National Institute of Neurological and Communicative Disorders and Stroke. This study, the results of which are still under wraps, is also testing the effects of vitamin E on the rate of neurodegeneration.

"For a long time it was not clear that DATATOP would get funded, so we decided to continue with our much smaller trial," says Langston. In many ways the design of Shoulson's larger trial benefited from the early experience of the San Jose study. "Our trial has turned out to be something of a pilot study for DATATOP. We look forward to seeing if our results are confirmed." Although Shoulson declines comment on the outcome of DATATOP, rumors are that it echoes the San Jose study.

So what do these results imply? On a practical level, they mean a cost saving of about $340 million a year in the United States: for every extra week that Parkinson's patients can remain functional enough to work, $10 million are saved in the balance of taxes and disability payments. On the more academic level of understanding the disease, there are still many possibilities.

"Bill Langston would like to think that these results imply the existence of some kind of environmental toxin—something like MPTP—that causes neurodegeneration in Parkinson's disease," comments Roger Duvoisin, of Rutgers Medical School. "I doubt that this is important in the etiology." Duvoisin is in the middle of a reexamination of some twins studies that, he says, indicates a substantial genetic component in the cause of Parkinson's. By contrast, the University of British Columbia's Donald Calne, who is also involved with the twins studies, speculates that the genetic component is small—"perhaps 25%."

What really excites Calne, however, is that the results of the San Jose trial might be pointing to a rather general mechanism in neurodegenerative diseases, including Alzheimer's disease and amyotrophic lateral sclerosis. "The etiology of all these diseases might involve aberrant free-radical formation," says Calne. "Deprenyl treatment is one way of halting or slowing down radical formation, but there are other agents that could be tried as well."

If Deprenyl is so effective, why didn't it halt neurodegeneration completely? "One possibility is that the etiology involves several factors, with free-radical formation being only one of them," suggests Langston. "Another is that we didn't use high enough doses of Deprenyl. Our plan now is to rerun the trial using different dose levels, some lower, some higher. Whatever happens in these new studies, we've achieved more here than we could have hoped for in the beginning." ■ ROGER LEWIN

Deep Holes Yielding Geoscience Surprises

Sinking scientific boreholes in the continents is testing geology and geophysics with unexpected, sometimes disturbing, results

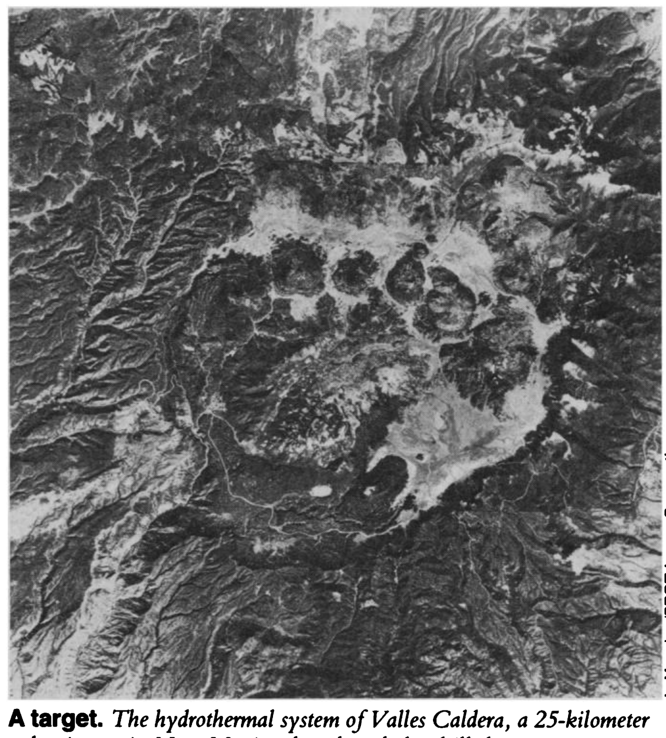
WHEN WEST GERMAN GEOSCIENTISTS came to the Oberpfälz Forest, they were not interested in the Bavarian scenery or the Wagnerian music festivals at nearby Bayreuth. They were there to drill the deepest hole in the world—one to 14 kilometers. The scientific rationale for this heroic venture was the testing of ideas about the crustal suture where an ancient collision fused two segments of the European continent.

By choosing the Oberpfälz site, the German researchers thought they would avoid dangerously hot rock. The fear of too much heat had scared them off other sites because it would bring the drilling venture to a premature end. But now, after drilling a 3.5-kilometer pilot hole, they have found that they are going to hit the very problem they so carefully planned to avoid.

Instead of the expected 80°C at the bottom of the hole, it is 118°C, outside the range predicted. As a result, plans for the record-breaking hole have been scrapped. The target depth of the so-called KTB hole has been scaled back to a more modest 10 kilometers—assuming, of course, that the new temperature predictions are better than the first ones.

This chastening experience is just one example of the many discomforting surprises geoscientists around the world are encountering as they test hypotheses about the earth's crust through drilling. "Every time we drill a hole," says Mark Zoback of Stanford University, "we find the unexpected. That's exciting but disturbing."

Scientific surprises are inevitable, even desirable, as geoscientists venture into unknown territory by drilling ever deeper into the crust. But, as in the Oberpfälz, big surprises—or too many little ones—can mean less science than promised at the same or even higher costs. That is no argument to quit drilling. Quite to the contrary, it is becoming increasingly apparent that drilling provides a necessary calibration of geoscience tools against reality as much as it directly tests ideas about how the crust behaves. It is just that now older but wiser geologists and geophysicists will be working to reduce the number of surprises by honing the tools that predict what lies below the surface.



L. Younker/SPOT Image Corporation

A target. *The hydrothermal system of Valles Caldera, a 25-kilometer volcanic scar in New Mexico, has three holes drilled.*

Too late though, for French researchers. A team under the Deep Geology of France Program came up against a piece of unpleasant reality that they reported at last month's International Geological Congress in Washington. Contrary to their expectations, they failed to find a magnetized body of rock at the bottom of their recently completed Sancerre-Couy borehole 150 kilometers south of Paris.

The French researchers had assumed that the hypothesized body of rock created the roughly north-south band of anomalously strong magnetic field crossing the Paris Basin. The phenomenon has puzzled scientists for 100 years. Electromagnetic surveys made from the surface seemed to place the top of the body at a depth of 3 kilometers. So, among other goals, the French drillers expected that the Sancerre-Couy borehole would test that interpretation by penetrating and identifying the magnetized body of rock before the hole bottomed out at 3.5 kilometers.

"That was not the case," said Christian Weber of the Bureau de Recherches Géologiques et Minères in Orleans. None of the rock recovered from the hole could account for the observed magnetic anomaly. On the basis of new geophysical measurements within the 3.5-kilometer hole, "the real magnetic body is located at 7 kilometers and deeper," said Weber.

Soviet drillers must have had a similar sinking feeling when their hole, now down to 12 kilometers, failed to find a major crustal boundary predicted to lie at 5 kilometers. When the Kola Peninsula hole was started in 1970, the interpretation of surface rocks and geophysical experiments placed the boundary at about 5 kilometers between the granitic upper crust and the more basaltic, iron-rich lower crust. The layers had been identified on the basis of the varying velocities of man-made seismic waves passed along the layers in seismic refraction surveys.

"The basaltic layer is not at 5 kilometers but 25 kilometers," reported V. I. Kazansky of the Academy of Sciences in Moscow, eliciting gentle laughter from the congress audience as he put the resolution of the question beyond the reach of the drill. The official line seems to be that the nature of the 5-kilometer boundary remains uncertain, but the metamorphic changes wrought by heat and pressure are thought to be the most likely explanation and not a fundamental division based on chemical composition.

The German KTB drillers are also having trouble finding a major subterranean boundary presumably located beneath the Oberpfälz site. They expected to drill through both crustal blocks that are sutured together just to the north of their drill site. That is possible because a thin sheet of the southern block was presumably shoved by the collision over the northern block, like the waters of a shallow sea lapping onto the shore. But from the surface geology and geophysical surveys, researchers predicted that the gently inclined boundary would appear at 3 kilometers; Rolf Emmermann of the University of Giessen and the KTB team reported that at 3.5 kilometers "there is no

Drilling Has Its Rewards

Testing geological hypotheses with continental drilling can have its frustrations, but the growing movement toward drilling is yielding some pleasant surprises as well. The following is a selection of U.S. shallow and intermediate drilling results as reported at last month's International Geological Congress in Washington, D.C.

■ **Inyo domes.** John Eichelberger of Sandia National Laboratories and his colleagues came to this string of young volcanoes east of Yosemite National Park to find out more about how magma rises to the surface and erupts. By drilling four holes no deeper than 0.9 kilometer, some at an angle, they retrieved samples from the buried roots of some of the volcanoes. Usually, volcanoes are studied by one group of geologists, and conduits that fed volcanoes now eroded away are studied by others. The Inyo drilling showed that getting at the shallow parts of a single system can yield quite a different picture of how volcanoes behave than when separate parts are studied. For example, samples retrieved by drilling beneath a giant volcanic puddle of glassy obsidian lava revealed that that lava rose toward the surface as a gassy foam, not in its final bubble-free form as had been presumed. The gas must have escaped during the day or so that it rose the last 500 meters, refuting the idea that ascending magma is a closed system. From this finding, Eichelberger and his colleagues conclude that volcanoes like Mount St. Helens do not alternate between explosive eruptions and quiet, oozing eruptions because the amount of gas in the original magma changes. Instead, they say, a solid, impermeable conduit forces the gas in the foaming magma to blow the magma into bits of ash while a conduit filled with porous rubble left from an explosive eruption allows the gas to escape quietly.

■ **Cajon Pass.** Is the San Andreas a weak or a strong fault? Mark Zoback of Stanford University and his colleagues thought drilling could answer this question after decades of debate. Laboratory experiments had shown that two blocks of rock pushed past each other form a strong "fault" between them and build up high stresses before slippage—an "earthquake"—releases part of the stress and generates heat through friction. But no one could ever find the excess heat near the surface that the San Andreas was supposedly generating, which implied that stresses are low and the fault weak. So Zoback and company drilled at Cajon Pass, reaching a depth of 3.5 kilometers just 4 kilometers from the fault. Still the measured stress and heat flow were low. "Every bit of data—and we have a lot of it—is consistent with the weak fault hypothesis," Zoback told the congress.

■ **Salton Sea.** Miners bore and dig into ore deposits, revealing much about how they form to scientists. But those are long-dead, fossilized deposits. Much more might be learned from an active, living process depositing ore today. With that in mind, Wilfred Elders of the University of California at Riverside and his colleagues drilled 3.2 kilometers into the sediments just south of southern California's Salton Sea. This is where spreading and rifting of the crust has drawn magma near the surface and created a heat source that supplies commercial geothermal wells. The scientific hole showed that the heat drives a system that is laying down copper, lead, and zinc minerals at the boundary between highly saline, reducing brine and less saline, oxygenated brine floating above it. The hot, reducing brine leaches those and other metals from the sediment, carries them in the form of chloride complexes to the interface between the two brines, and deposits the metals there as sulfides when mixing of the two brines reduces the salinity and increases oxygenation. Given 500,000 more years of this, the mining of minerals might replace the mining of heat.

■ **Quimby.** A cornfield in Iowa may not be as sexy a place for continental scientific drilling as the San Andreas fault or the geothermal fields of the Salton Sea, but a borehole near Quimby, Iowa, shows how modest drilling ambitions can still yield good science. Randall Van Schmus of the University of Kansas and his colleagues drilled a narrow 609-meter hole to test a hypothesis about how the continent was put together. The hole hit its target, an intrusion of granite whose presence had been inferred, but not proven, from a magnetic anomaly. The existence of the intrusion, its age, and its isotopic composition confirmed that lower crustal rock melted about 1.4 billion years ago and rose into a block of the crust about 1.8 billion years old that had collided with the existing continent to the north. The drilling also supported a magnetically defined boundary about 70 kilometers to the north of the hole as the location of the old continental edge. ■ **R.A.K.**

R. Andrews

The Soviet ultradeep hole. *This drill rig enclosure stands over the 12-kilometer-deep hole on the Kola Peninsula.*

indication we are close to it."

What the Germans did find was a series of nearly vertical folds that failed to show up on seismic reflection profiles, the radar-like geophysical surveys in which man-made seismic waves are bounced off subsurface features such as layered rock. Compression and folding after the collision may have spoiled the classic picture of a suture, said Emmermann, or "perhaps we may have to think about our model."

Having put geology and geophysics to the test with these and other holes, geoscientists are finding all those high-tech geophysical tools such as seismic reflection profiling, which in recent years have filled in subsurface details for geologists, to be sorely wanting. "Geophysics is great," says one geophysicist, with just a touch of exaggeration. "You can devise all these models, and no one even tests them, except in sedimentary rocks. But, invariably, when somebody drills, it messes it all up."

Among geophysical techniques, seismic reflection takes much of the criticism. It was developed by the oil industry and adapted for study of the continental crust in the early 1970s. "It's ridiculous," says Karl Fuchs of the University of Karlsruhe. "We have these thousands of kilometers of reflection profiles, and we don't know what they show."

Thanks to drilling of seismic reflectors, researchers are beginning to find out, though. At the Siljan hole in Sweden, which was drilled in search of commercial quantities of methane seeping up from the mantle, one possible interpretation of four horizontal reflectors was that impermeable seals had formed in place and trapped gas in more porous rock beneath them. The three reflectors drilled so far turned out to be rock injected into horizontal sills as magma with no porosity beneath them. The prominent reflector penetrated by the German pilot hole seems to be created by fluid-filled fractures, something unexpected after drilling through 3.4 kilometers of dry rock. And at the French Sancerre-Couy hole, "we were expecting more or less horizontal layers," said Weber. "That interpretation is absolutely contradictory to the cores themselves, so we reinterpreted the seismic data."

The problem with seismic reflection profiling is that, although of all geophysical techniques it provides the most detailed picture of the crust, it was developed and tested by the oil industry in rock quite unlike the crystalline crust. The sedimentary rock of interest to industry is laid down in horizontal or nearly horizontal layers that reflect seismic waves at their boundaries due to the contrast between types of rock. The crystalline crust being probed by scientific drilling is a good deal messier. It was formed from lava flows and magma intrusions of every size and shape. It has been distorted, altered by heat and pressure, and fractured. Near-vertical boundaries, which must be common, tend to be invisible in seismic reflection, and researchers are only beginning to figure out how to determine the true nature of individual reflectors, short of drilling.

The rash of reflector misidentifications "just represents naiveté on our part," says geophysicist Robert Hamilton of the U.S. Geological Survey in Reston, Virginia. "We're going to need 10 years to recalibrate ourselves." Drilling to recalibrate seismic reflection and probably other techniques inevitably means more surprises. Drilling programs, from the Soviet and German ultradeep projects to the most modest kilometer-deep holes, are moving ahead in the face of such surprises. The difference is that researchers are approaching drilling, especially deeper holes, with a bit more humility.

■ RICHARD A. KERR

Circumcision May Protect Against the AIDS Virus

African studies suggest that uncircumcised men may be five to eight times more likely to get AIDS during heterosexual intercourse than men who have been circumcised

ALTHOUGH RESEARCHERS HAVE LEARNED a great deal about how the AIDS virus spreads, they are still wrestling with some extremely important puzzles: why, for example, are the patterns of AIDS virus infectivity so very different in Africa and North America? In Africa, almost all of the cases occur in heterosexuals, affecting men and women equally; in North America, the disease primarily strikes male homosexuals, who account for about 75% of the total cases.

A series of recent studies may now be helping to explain the apparent readiness with which the AIDS virus is transmitted among heterosexuals in Africa. The studies indicate that uncircumcised men run a greater risk of becoming infected by the AIDS virus during sexual intercourse than do circumcised men, although other factors, such as the presence of genital ulcers, also facilitate AIDS tranmission among heterosexuals.

"The results clearly point to a very important sociological aspect that may play a role in [AIDS virus] transmission," says Thomas Quinn, an epidemiologist with the National Institute of Allergy and Infectious Diseases who has been tracking the AIDS epidemic in Africa and other developing countries for several years. Quinn notes that he and other epidemiologists are adding circumcision status to the list of variables they are examining in the studies they are now conducting around the world.

And the discovery may also have implications for preventing AIDS, especially in developing countries where condoms—the first line of defense against AIDS infection—may not always be available or used. In Africa, prostitutes, especially those in the larger cities, have been identified as a major reservoir for spreading the AIDS virus. Quinn notes that in some areas 50 to 80% of the prostitutes are infected, putting their customers at great risk if they have unprotected sex.

And as many African men have left their