Getting to the bottom of the San Andreas

Last month, scientists began drilling a 5-kilometer-deep hole in California, which they expect will get to the bottom of a long-standing paradox about the stresses and heat generated in the nearby San Andreas fault.

The hole, located within the fault zone, 3.5 kilometers from the fault itself, is in the Cajon Pass, northeast of Los Angeles. It will be the deepest hole ever drilled in the United States solely for research, according to Mark Zoback, a geophysicist at Stanford University and chief scientist on the project. By using the hole to study fundamental properties of the earth's crust as well as to monitor the San Andreas over the next few decades, scientists hope to improve their earthquake prediction abilities considerably.

Earthquakes are generated along the San Andreas as the Pacific plate to the west of the fault grinds northward past the North American plate. In the Cajon Pass area, the Pacific plate moves at a rate of a few centimeters per year. This motion is resisted by friction in the fault. Scientists, using laboratory studies of the strength of rocks, calculate that the frictional stress shearing the fault should be high, about 1,000 bars. Indeed, measurements at shallow levels reveal a strong stress gradient, suggesting that high stresses are present at lower depths.

But with such high frictional stress, scientists have also expected that the San Andreas would be generating much heat as the rocks grind past one another. And there is the rub, because essentially none of the more than 100 shallow heat-flow measurements made during the last 20 years has detected any anomalous heat coming from the San Andreas; the heat levels near the fault are no greater than those 10 kilometers away. These heat-flow measurements are consistent with shear stresses in the fault that are 5 to 10 times lower than the 1,000 bars predicted by the laboratory and theoretical studies.

Because the heat and stress studies have been made near the surface, where all kinds of factors can complicate the measurements, scientists are cautious about extrapolating their results to deeper levels of the fault. That's why Zoback and others have wanted to drill a deep hole near the San Andreas. "It's been our inability to address the [stress-heat] question with anything but direct observations that has been the primary motivation for this project," says Zoback.

The National Science Foundation agrees. It is providing most of the $8 million required for the Cajon Pass project. In addition to studies relating to the stress-heat paradox, 30 researchers from a dozen institutions plan to do a wide variety of experiments to investigate everything from regional geologic questions to geophysical properties of the crust. According to Zoback, the hole should be completed by March 1988.

While drilling has just begun, project scientists concerned about the stress-heat paradox already have given much thought to what they may find. One scenario is that at depths greater than about 2 kilometers, they may measure both high stresses and the "missing" anomalous heat. If so, then it's possible that the flow of groundwater, or some other mechanism, is carrying the heat away at shallow levels.

Alternatively, they may find that the shear stresses and heat levels are low at greater depths. This would mean that the fault is much weaker than previously supposed, says Zoback. "The implications of this would be quite dramatic," he says, since scientists have assumed that frictional stress on the fault is an important force controlling the movement of the earth's tectonic plates.

In support of a weak fault, Zoback and his wife, Mary Lou Zoback of the U.S.. Geological Survey in Menlo Park, Calif., have recently found that compressional stresses in California's crust point about 70° away from the trend of the fault. This orientation, they say, would tend to move the San Andreas, rather than other faults in the area, only if the San Andreas were weak enough to be susceptible to such a stress.

If the Cajon Pass study also suggests that the fault is weak, then scientists will probably want to drill other holes in the fault zone to find out why. One possibility is that fluids trapped in the pores of fault rocks and clays are exerting a strong pressure, jacking the rocks apart and nearly nullifying the frictional stresses.

The Cajon Pass hole probably won't answer all the questions scientists have about fault mechanics, but Zoback says it may help them to move beyond the realm of describing plate motion, and toward an understanding of the physics behind plate tectonics. *— S. Weisburd*

Copper: What a difference sex makes

Over the past decade, nutrition scientists have found they can induce all the symptoms of coronary heart disease in animals merely by feeding them a low-copper diet (SN: 6/8/85, p.357). Last year, a different research group reported that those coronary effects of copper deficiency were magnified dramatically when an animal was allowed to indulge its sweet tooth on a diet high in fructose, the sugar in fruits and honey (SN: 5/3/86, p.279). Their latest findings now indicate that sex may affect the susceptibility to this effect.

In their study with rats, researchers at the Agriculture Department's Human Nutrition Research Center in Beltsville, Md., observed that males began dying from ruptured hearts after five weeks on a low-copper, high-fructose diet. By the eighth week, 40 percent were dead, and the rest were dying of heart disease — with severely enlarged hearts, anemia and high cholesterol levels. Meanwhile, except for having high serum-cholesterol levels, the females were healthy and disease free.

"I couldn't believe it," says biochemist Meira Fields. "By the eleventh week my rats were either alive or dead — there was nothing [illness-related] in between." And the only factor differentiating them was their sex.

What this means, she says, is that "an animal was protected against death just by being female." In her search for reasons, Fields is focusing on the possible role of sex hormones in making males more vulnerable or females less so.

It also prompts speculation, Fields says, that a sex-related difference in susceptibility to heart disease may help explain why U.S. women experience less heart disease than men (SN: 11/2/85, p.279). Nutrition researchers have estimated that, at least in the United States, as much as 70 percent of the population may be copper deficient. And fructose is becoming an increasingly larger part of the average diet as processed-food and soft-drink manufacturers increase their reliance on this inexpensive natural sweetener.

Fields says it's unlikely that the dramatic sex-differentiated effects seen in her low-copper, high-fructose experiments are unique to copper. Many trace metals have similar effects on the body. So she suspects that if there is a sex-linked vulnerability to copper deficiency's effects, there may be a similar one for zinc, manganese, vanadium or nickel.

She points out, however, that probably half of all human nutritional studies involve only males. While male-only experiments avoid the complicating variable of widely fluctuating sex-hormone levels in premenopausal women, Fields says they also risk ignoring significantly different nutritional needs of women, or effects of diet on them.

"It appears that [Fields] is on to a nutritional factor that could be very important," says Edward J. Calabrese at the University of Massachusetts in Amherst, author of a textbook on sex differences in toxic susceptibility. His research indicates that "probably less than 30 percent of the time" are both sexes used in toxicological studies. However, he says, "we found well over 150 to 200 or more examples of significant sex differences in mice and rats." Moreover, he says, the few human studies looking

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for possible sex-linked effects have demonstrated "significant differences do exist in susceptibility to 17 different [toxic] agents."

Both Fields and Calabrese worry that too many unisexual research data are being extrapolated to include the untested sex. And the implications can be enormous, they believe. For example, in today's workplace, most women "are being 'protected' by standards that were developed principally from industrial hygiene data with men," Calabrese says. Since there is the potential for at least 200 to 500 percent differences in susceptibility to toxicants, he says, with females sometimes showing the greater susceptibility, "there's got to be some question about the extent to which current [occupational health] standards are effective in protecting women." *– J. Raloff*

Clean water bill sent back to Reagan

Though the House and Senate unanimously passed a $20 billion bill to reauthorize the Clean Water Act in the closing hours of the 99th Congress (SN: 10/25/86, p.264), the long-awaited legislation died from a pocket veto by the President. On the first day of the 100th Congress, however, it was born again as HR-1, the first bill introduced in the House. Following swift passage by both the House and Senate, the Clean Water bill was back on President Reagan's desk by Jan. 21. Congressional support for the bill is so strong that its passage into law – if necessary, by a veto override – is all but assured.

The bill would commit $18 billion over nine years to new sewage treatment plants – far more than the $12 billion called for in the President's alternative bill. It also provides money to begin a program to control "nonpoint" pollution, which runs off nonindustrial lands such as farms, city streets and construction sites; to help clean lakes and major estuaries; and to enable the Environmental Protection Agency and the states to further restrict allowable pollutant discharges where several heavy industrial polluters already reside.

The clean water program stagnated for four years while Congress formulated the controversial measures embodied in the new bill, according to Sharon Newsome of the National Wildlife Federation in Washington, D.C. She says, "Now it's up to President Reagan to reinvigorate the program by signing the legislation before him." Adds Sen. Robert W. Kasten (R-Wis.), "If the President doesn't approve this, not only will his veto be soundly overriden, but he will have been saddled with a major political defeat in his first skirmish with the 100th Congress."

– J. Raloff

Military funding: Does it add up?

"Being poor does not mean we should sell out," writes mathematician William P. Thurston of Princeton (N.J.) University. That statement appears in a letter in this month's NOTICES, published by the American Mathematical Society (AMS). It's one sign of a growing debate within the mathematical community on the effects of military funding on mathematics research at universities. Last week, that debate surfaced at an AMS meeting in San Antonio, Tex., where several resolutions on the matter were considered.

Just three years ago, a National Academy of Sciences report, citing how support for mathematics has lagged behind that for other sciences, recommended that the federal government double its funding of mathematics research (SN: 2/4/84, p.71; 6/23/84, p.392). Since then, largely through the efforts of the Joint Policy Board on Mathematics in Washington, D.C., funding for basic mathematical research has increased substantially, from $68.5 million in fiscal year '83 to $115 million in '87. In both years, the Department of Defense (DOD) provided about 40 percent of the funding.

A small group of mathematicians, including Thurston, became concerned about the funding situation more than a year ago. At that time, a new, $10 million mathematics program was established at the Defense Advanced Research Projects Agency (DARPA), which suddenly injected large sums into a few, narrowly defined fields of mathematics, such as dynamical systems and signal processing, which could have military applications. Initially, DARPA's move elicited complaints and criticisms from many mathematicians worried about a number of practices that DARPA instituted during the first year, including closed meetings, restrictions on publication and the lack of proper peer review of proposals. Later, DARPA agreed to correct many of those problems, but that experience forced mathematicians to look more closely at the consequences of depending on DOD funding.

One concern, at a time when many mathematicians are scrambling to get funds for computers and when the number of National Science Foundation (NSF) grants for individual investigators is decreasing, is that the trend within DOD seems to be toward research with specific applications or missions in mind. "That's a real mistake," says Robert Osserman of Stanford University. "It's shortsighted and clearly undesirable."

Irving Kaplansky of the Mathematical Sciences Research Institute in Berkeley, Calif., says that unless one can predict "what mathematics is going to be like in the future, [then] all good mathematics should be pursued. There are so many cases in the past where something abstract . . . has unexpectedly turned out to be just what was needed."

At the AMS business meeting, Michael Shub of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., introduced a resolution expressing concern about these trends and requesting that those representing the AMS direct their efforts toward increasing the fraction of non-military funding for mathematics research, as well as toward increasing total research support. The resolution had about 400 co-sponsors.

"We're not asking military organizations to stop funding mathematics research," says Morris W. Hirsch of the University of California at Berkeley. "We're not asking individuals to stop applying to military organizations for grants. It's a question of emphasis and degree."

On the other hand, Melvyn B. Nathanson of Lehman College in Bronx, N.Y., argues that even if NSF funding goes up, it's still appropriate for AMS to seek more funds from DOD and other mission-oriented agencies. "There's nothing unethical about accepting DOD funds," he says. "If you disagree, don't take the money."

Says Ettore Infante of the University of Minnesota in Minneapolis, "It seems to me that to try to divide into two the funding that comes to mathematics and to say that one is good and one is bad is a fundamental mistake on our part."

Nevertheless, suggests Hyman Bass of Columbia University in New York City, there seems to be "a broad consensus about at least a slow movement toward allocating a larger portion of the funding of mathematics to civilian agencies."

Supporters of the resolution succeeded in getting a vote on the issue put on the agenda for the next AMS meeting, which takes place in Salt Lake City in August. Meanwhile, the AMS council may decide to mail out a ballot so that the society's 20,000 members can vote on this resolution and several others.

Earlier, the council itself passed an alternative resolution simply recommending that more should be done to strengthen "traditional basic research programs." A pair of resolutions directing AMS not to "encourage or actively facilitate" the participation of mathematicians in Strategic Defense Initiative research programs was also considered and is likely to show up on the ballot.

– I. Peterson