Quake prediction: Magnetic signals?

Earth scientists last week announced they have observed a long-sought phenomenon: magnetic signals generated by an earthquake. For decades, researchers have been exploring the possibility of using these kinds of effects as short-term predictors of an impending seismic event. But while the recent results demonstrate that the phenomenon does indeed occur, it appears that hopes are fading for using magnetic signals to predict earthquakes.

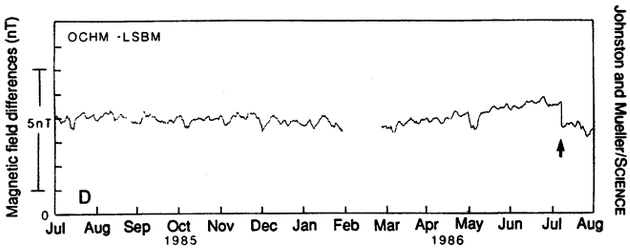
These results and conclusions are emerging from a report in the Sept. 4 SCIENCE by Malcolm Johnston and Robert Mueller of the U.S. Geological Survey (USGS) in Menlo Park, Calif. Since 1974, Johnston and Mueller have operated a network of magnetometers, or magnetic field sensors, along California's San Andreas fault.

Interest in the link between earthquakes and magnetics dates back to the 1800s, when European scientists often reported changes in the earth's magnetic field resulting from earthquakes. However, scientists in the 1950s dismissed earlier measurements as resulting entirely from the mechanical vibration of instruments.

Since the development of "vibration-free" magnetometers in the 1960s, many researchers in the United States, the Soviet Union and China have succeeded in documenting magnetic shifts *preceding* earthquakes, which are called tectonomagnetic effects. However, because scientists cannot link these events to seismic activity, they cannot be sure of their cause, Johnston told SCIENCE NEWS. "The magnetic effect that you expect to see most clearly is the one that occurs when the earthquake occurs, because you know there is a stress release when the earthquake occurs," he says. These events, termed seismomagnetic effects, had previously not been observed, says Johnston, mainly because the instruments had not been close enough to large earthquakes.

However, when a magnitude 5.9 (Richter scale) earthquake hit North Palm Springs, Calif., on July 8, 1986, two of the nearby USGS magnetometers recorded drops in the magnetic field strength. The meters also showed that in the five months preceding the earthquake, the magnetic field in the area had slowly started to rise, indicating an increase in stress along the fault.

These results prove that seismic activity can produce a magnetic signal, says Johnston. However, the magnetic shifts were on the order of 1 nanotesla – a minute change that almost blends in with the natural variations in the earth's field. "Even though I think we've demonstrated that the physics do work," says Johnston, "the usefulness of this and also many other techniques, I think, is limited because of the smaller [than expected] stress changes that appear to be occurring with earthquakes."



The subtle increase of field strength between March 1986 and the quake (arrow) is visible in the magnetic record, but it may be indistinguishable from background noise.

Earthquakes release the stress that accumulates when rocks on either side of a fault line lock together instead of sliding past each other. Ten years ago, scientists believed that stress levels drop by 100 bars when rocks finally give way during an earthquake. But it now appears that stress levels change by only 10 bars, and the corresponding magnetic changes are similarly smaller than earlier theories had predicted, says Johnston.

Stress and magnetics are linked through a process called the piezomagnetic effect, whereby stress can reorganize the magnetic structure inherent in certain minerals such as magnetite.

Atoms of magnetite have unpaired electrons whose spin causes a small magnetic field. In magnetite crystals, these fields line up in similar directions, making the crystal like a tiny bar magnet. On an even larger scale, bits of magnetite are organized into domains, which contain families of crystals with similar magnetic fields. Neighboring domains might point in wildly different directions, but the net field from a piece of magnetite is the sum of all the domains. When stress is applied – as happens along a locked fault – certain domains grow at the expense of others in order to minimize the total energy, and this alters the magnetic field of a rock that contains magnetite.

In the future, the USGS researchers hope to repeat their results by measuring the magnetic changes caused by other earthquakes. If they can establish that certain noticeable patterns of magnetic signals precede quakes, then magnetometers might prove to be useful tools for predicting an earthquake months to days ahead of time. However, while other countries are actively researching this field, most U.S. researchers, including Johnston, remain cautious about these prediction methods.

Randolph Ware, a seismologist at the University of Colorado at Boulder, told SCIENCE NEWS: "We went out and observed for over a decade, and we saw this one unequivocal signal that came from this phenomenon. But in retrospect . . . maybe there are better methods around."

– R. Monastersky

States race SSC site-proposal deadline

Sept. 2, the deadline for states to submit site proposals for the Superconducting Super Collider (SSC), has come and gone with 25 states submitting 43 proposals. The SSC, which will be the most energetic accelerator of subatomic particles ever built, will require a ring tunnel 53 miles in circumference. Many people thought it would not be easy to find appropriate sites, but half the states did, and some have offerred more than one – for example, Texas proposed seven, New York four and Utah three. The proposals will be evaluated by a committee chosen by the National Academy of Sciences and National Academy of Engineering, which will select a number of finalists for consideration by the Department of Energy (DOE).

There was both amusement and melodrama at DOE headquarters as the 2 p.m. cutoff time approached. The Texas submission, which came by truck, was estimated to weigh tons. Paul Sweet, a University of California lobbyist, paced up and down in front of the building, waiting for word from home. The night before, the California legislature had failed to pass an appropriation for the state's expenses in site preparation, deadlocked over how much of the SSC money would be set aside for minority contractors. However, on Sept. 2, in a meeting in Gov. George Deukmejian's office, legislative leaders arranged a compromise. As the agreement impended in Sacramento, word was passed to Sweet, and he made the submission with minutes to spare.

Meanwhile in Congress, support for the SSC seemed to be building. As Congress returned Sept. 9 from its August recess, it had before it a special appropriations bill for the SSC sponsored by 200 House members led by the chairman of the House Committee on Science, Space and Technology, Robert A. Roe (D-N.J.) and its ranking Republican member, Manuel Lujan Jr. (R-N.M.). Such a special bill is a rare mark of congressional favor. According to a DOE spokesman, the SSC is the first DOE project to have such a bill.

– D.E. Thomsen