EARTH SCIENCES

Susan West reports from the meeting in San Francisco of the American Geophysical Union

Magnetic salmon

Birds do it, bees do it, even bacteria and dolphins apparently do it—use the earth's magnetic field to guide them (SN:4/28/79, p. 278; 4/28/80, p. 267; 6/14/80, p. 376). Now, researchers at the University of Washington have evidence that some salmon may also have a magnetic guidance system.

Unlike other salmon that migrate immediately to the ocean from their river spawning beds, sockeye salmon fry spend at least their first year in a fresh water lake through which they move in a specific direction that differs from lake to lake. Earlier studies showed that salmon navigate by smell in rivers and in the ocean and some researchers suspect the fish use a magnetic sense in their ocean migrations, but no studies had been done on the navigation abilities of lake-dwelling salmon.

Fisheries biologist Thomas Quinn isolated sockeye fry from three different lakes in water tanks and found that they still moved in the same direction as they had in their lake. Moreover, when the magnetic field around the tank was shifted using an electromagnet, the fish changed heading accordingly. Quinn and co-workers Ronald Merrill and Ernest Brannon also noted that those salmon populations that migrate through a lake during the day were not much affected by the shifted magnetic field unless the tank was covered, indicating that their magnetic sense takes a back seat to their solar navigation ability.

Preliminary studies have found no magnetic particles in the sockeye — unlike the bits of magnetite found in pigeons and bacteria — and it remains unclear exactly how the fish know which way is north. Nevertheless, says Merrill, the experiments indicate that magnetic sensing is, along with chemical and visual clues, an important navigational device in salmon.

Harmonic tremor on the ocean floor

Since the discovery in 1979 of mineral-rich hot-water vents on the Pacific ocean bottom (SN: 1/12/80, p. 28), researchers have been trying to figure out exactly what they mean — why they occur some places and not others and what their relationship is to volcanic activity on the seafloor. To do just that, Ken Macdonald of the University of California at Santa Barbara and co-workers placed seven seismometers on the ocean bottom near the hot water vents at 21° N on the East Pacific Rise. Just as researchers on land use seismic data to determine a geyser's stage of activity and the structure of the rock and magma chamber beneath it, Macdonald and co-workers hoped to find the location and depth of the magma chamber responsible for the seafloor geysers. They found that and more.

The researchers recorded three different kinds of earthquakes. The first, "typical" shallow quakes associated with faulting, yielded focal depths of about 2½ kilometers. This depth, Macdonald said, probably marks the upper boundary of the magma chamber that drives the hydrothermal circulation. In addition, the researchers recorded high frequency, short-duration quakes — up to 100 events per hour — and — less expected — low-frequency, long-duration events that closely resemble the harmonic tremor known to precede the eruption of land volcanoes. In fact, said Macdonald, "If you saw these signals at Mt. St. Helens, they would lead you to evacuate the area."

Using a theory that suggests that harmonic tremors are created by the flow of magma through cracks toward the surface with the collapse of the chamber left behind, the researchers calculated the depth of those cracks and got 2½ km — which agrees well with the focal depth data, notes Macdonald. Between the seafloor harmonic tremor and the large number of high-frequency quakes, says Macdonald, it looks as if 21°N is about to enter an active volcanic phase—the eruption of magma to form new ocean crust.

Tangshan quake autopsy

For a country as bent on predicting earthquakes as China, even the misses are important, because what they reveal may lead to a hit next time. Now an intensive study of one of the most disastrous misses — the magnitude 7.8 Tangshan quake on July 26, 1976, that killed several hundred thousand people — reveals previously undetected precursors.

From March to July 1980, Francis T. Wu of the State University of New York in Binghamton and Han Da Yu of the State Seismological Bureau in Beijing re-examined a variety of data looking for precursors to the quake. The researchers found definite precursors, but, notes Wu, most were extremely subtle, detectable only in certain areas and did not have the same pattern or timing as precursors to successfully predicted quakes.

The researchers found, for example, that rapid changes occurred in surveys of leveling lines during a one-and-a-half-year period before the quake. The changes were not noticeable, however, until the effects of rainfall and temperature on the instruments were subtracted from the data. Wu and Han also found subtle changes in the water levels in regional wells a few days before the quake and "very rapid changes" a few hours before. Odd animal behavior also was noted the day before the quake.

What confused observers in part, says Wu, was that most of these changes occurred near branch faults away from the main fault in the region. In fact, he says, the main fault was not responsible for the quake, and the responsible fault was so buried under thick sediments and had been inactive so long that its existence was still questioned after the quake. In addition, he notes that prior to other predicted events, such as the 1975 Haicheng quake, foreshocks had been detected and other precursory signs—such as animal behavior and well water changes—occurred several days, instead of hours, before the quake. He adds that the reporting network faced a problem familiar to our technology-tied society—poor telephone service.

Getting to the source of precursors

The strength of the Chinese program in earthquake prediction has always been the number of observations gathered by field workers, all of which are employed as possible earthquake precursors. Much emphasis has been placed on geochemical observations, such as increased emissions of the radioactive gas radon from the ground, or changes in the chemistry of groundwater. And now Chinese researchers are trying to find mechanisms for those empirical observations.

Jiang Fong-liang and Li Gui-ru, visiting scientists at the California Institute of Technology from the State Seismological Bureau in Beijing, reported that Chinese scientists recently have begun controlled laboratory and field experiments to determine such mechanisms. These experiments include measurements of gas emissions from a variety of rock samples subjected to stress, simulation of earthquakes using explosives, examination of geochemical changes due to the mixing of different aquifers and examination of the chemical effects of stress on rocks.

So far, according to Jiang, the researchers have found that the timing of the geochemical anomalies appears to be related to the stage of stress build-up: Long-term anomalies correspond to the elastic — or impermanent — stage of deformation of the rock, short-term anomalies to the plastic — or permanent — stage of deformation and "spike-like" anomalies to shear movement of the rock. In addition, Jiang said, the studies indicate that rock fracturing at depth may open pathways for the movement of fluids and gases that change the chemical composition of groundwater and soil gas, and increasing stress on rock in the region surrounding the eventual epicenter may result in chemical changes in groundwater.