Earth Sciences

Strange new seafloor features

The more scientists tinker with data collected by the oceanographic satellite SEASAT during the 70 days it functioned in 1978, the more detail they are able to see in seafloor topography (SN: 12/4/82, p. 364). Some familiar but uncharted features, such as ridges and fracture zones, are apparent, especially in regions that have been poorly surveyed. More surprising is the discovery of new kinds of seafloor structures that have not been revealed by standard survey methods used by surface ships.

William Haxby of Lamont Doherty Geological Observatory in Palisades, N.Y., describes puzzling signals in the seafloor of the south Indian Ocean where relatively few ship tracks have been taken. The satellite data indicate what Haxby calls "harmonic rolls," regular, parallel undulations in the earth's gravity, reflected in the seafloor. The signals are as long as 1,000 kilometers, he says, and may occur at intervals of 200 km to 250 km for as many as four or five repetitions. They are observed in several locations, but only in the middle of the world's fastest moving crustal plates. Haxby tentatively suggests two possible explanations for the harmonic rolls. Compression in the plate may cause the lithosphere (the crust and topmost portion of the mantle) to undulate, but that would not explain why the signals appear with such regularity. Or the features may be caused by the rapid movement of the plates over the part of the mantle just below, resulting in interaction between mantle and the lithosphere material. Scientists are compiling maps of the ocean floors based on data collected by SEASAT's altimeter, an instrument that measured the distance between the satellite and the ocean surface with an accuracy of 10 centimeters. The shape of the ocean surface reveals the presence of seafloor features because the sea undulates — up over areas of low gravity, down over areas of higher gravity.

Logging earthquakes under the sea

Researchers are on their way to a remote area of the South Pacific about 1,000 miles southwest of Tahiti to retrieve the first data from a monitoring system that was inserted this winter 500 feet into the ocean floor. The computer-controlled system, 35 feet long and eight inches in diameter, includes four seismometers, and other sensors. It records earthquake activity from its snug position in a borehole drilled into the seafloor three and a half miles below the ocean surface by the drillship *Glomar Challenger.* The monitors will provide long-desired information about earthquakes beneath the oceans, and should reveal some information about the earth's structure. The researchers also will retrieve six seismometers that were left behind on the ocean bottom. But the borehole package will stay in place — the first permanent seismic station on the ocean floor.

That was the quake that was

By counting individual atoms, scientists now find they are able to measure quickly ratios of carbon-14 to carbon-12, a widely used method of dating ancient materials. Usually the dating process takes weeks if the decay of carbon isotopes is measured as it occurs. The new method, which uses high energy mass spectrometry, can be performed in days, and on the tiniest of samples. Allen B. Tucker of San Jose State University in California and colleagues from the Laboratory for Nuclear Physics in Zurich, Switzerland, report in the March 18 SCIENCE that the method enables them to learn the ages of tiny flecks of charcoal — sometimes the only carbon sources identified with rocks known to have been displaced by earthquake activity. By dating charcoal flecks found at rupture sites in the Wasatch fault in Utah, the scientists found that the carbon ages correspond to ages of 7,800, 8,800 and 9,000 years, with uncertainties of 600 years.

Space Sciences

Martian meteorites: Signs in the air

"Personally," says Robert O. Pepin of the University of Minnesota, "as soon as I saw Bogard's gas data, I was convinced." The question is whether certain meteorites have come to earth from Mars, suggested (inconclusively) by petrologic and other studies but defying some dynamicists' contention that an impact capable of knocking a fragment free of the red planet's gravity would destroy the result. Late last year, Donald D. Bogard of NASA's Johnson Space Center in Houston reported that one of the candidate Marsrocks bore traces of rare-gas isotopes in ratios that resembled Viking lander measurements of the Martian atmosphere (SN: 11/27/82, p. 341). And though Pepin may thereby have been "convinced," he and U. of Minn. colleague Richard H. Becker have added to the case by telling the recent Lunar and Planetary Science Conference of similarly provocative nitrogen-isotope ratios from the same meteorite.

The rock in question is known as EETA 79001, recovered in 1979 from Antarctica's Elephant Moraine. It is considered part of a small meteorite group known as Shergottites, whose rock was apparently formed 1.3 billion years ago and subjected to a shock (as though by the impact that would have knocked some fragments into space) 180 million years ago. The Elephant Moraine sample is unusual even among Shergottites (only four are known) in that it contains bits of shock-caused glass, in which the measurable quantities of rare (noble) gases were preserved.

The ratio of argon 40 to argon 36, says Bogard, is above 2000, about seven times the terrestrial ratio and representing some 400 times as much ^{40}Ar as could have been produced by the natural decay of potassium 40 since the shock (as well as 40 times more than such decay would have caused in the whole age of the rock). The Martian atmosphere, however, he notes, was found by Viking to have a $^{40}Ar/^{36}Ar$ ratio of about 2700 ± 500.

Similarly, Bogard's meteorite analysis revealed just over twice as much xenon 129 as xenon 132, comparable to the Viking measurement of $2.5^{+2.0}_{-1.0}$ and far below the ratio in earth's atmosphere (about 128). In addition, the relative abundances of neon, argon, krypton and xenon are similar to Viking's findings, while quite different (as are the argon and xenon isotope ratios) from those believed to exist in differentiated asteroids of the type suggested as the source of many meteorites. "I don't *know* Elephant Moraine is from Mars," Bogard says, "but there is a lot of strong geochemical evidence."

Now along come Becker and Pepin with nitrogen analyses of samples from the same object. The ratio of nitrogen 15 to nitrogen 14, they report, is about 13 percent greater than that of earth's atmosphere. The solar wind shows an excess of about 12 percent, and one known meteorite shows 17 percent, but both have $^{14}N/^{36}Ar$ ratios nothing like that of the "air" of Mars, which the Elephant Moraine sample resembles to within a factor of three. All other meteorites, says Pepin, have $^{15}N/^{14}N$ ratios of 4 percent or less, making EETA 79001 the only measured rock whose nitrogen-isotope ratio even approaches the Martian atmosphere.

But the Martian atmosphere's ratio is far richer still—about 62 percent. Why, asks Pepin, with the rare-gas isotopes matching Viking's Mars data so well, should the nitrogen ratio fall short? If the meteorite did *not* come from Mars, he says, it might be possible to produce the measured isotope ratio of each rare gas by combining input from several sources, such as the meteorite's "parent body" and the object that struck it. But that would require the rock to have undergone a different such mixing scenario for each element, a combination that the researchers maintain would have to be a rare, virtually "custom-tailored" event. Far more plausible, they suggest, would be if the shock of the object's birth left it with a mixture of nitrogen both from the Martian atmosphere (with the 62 percent in $^{15}N/^{14}N$ enrichment) and from the non-enriched Martian crust, as indicated by analysis of nitrogen in the sample's non-glassy component.