EARTH SCIENCES

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

Adding to the ocean crust mystery

Until Woods Hole Oceanographic Institution's *Alvin* took a closer look at the mid-Atlantic Ridge during the summer of 1978, oceanographers thought only one type of basalt — called pillow basalt because of its frothy appearance — was pushed out of the spreading ridges onto the ocean crust. But, says H. Paul Johnson of the University of Washington, *Alvin*'s deep-towed camera confirmed what earlier work on the Galapagos Rift suggested: that basalts also exist in thin horizontal sheets and in thick, massive units.

Johnson says the three types may represent different stages of ridge activity. The thick units may represent rapid outpourings of magma along very young, long fissures. The thin sheets may mark slower flows from narrowed channels and the pillows could result as the sources of magma close to a single point.

The pillow basalts — which have been extensively studied — were thought by some to account for the magnetic structure of the ocean crust alone, says Johnson. Now, he says, researchers will have to consider the magnetic properties of all three types. "They represent a third of the ocean crust we just didn't know was there," he says.

Solar magnetic field polarity: Part one

The polarity of the sun's magnetic field changes as it rotates. The point where it changes is called a sector boundary crossing. The irregular changes in polarity have been postulated to cause electrical changes in the earth's atmosphere which in turn may affect the weather (SN: 12/31/77, p. 423).

Last June, when researchers at Rice University decided to study the possible electrical changes before and after a boundary crossing, they found one small problem: They had no way to tell when a crossing would occur. Gary Heckman, chief of the National Oceanic and Atmospheric Administration's Space Environment Services Center in Boulder, Colo., came to their rescue. At the meeting, he described the first attempt — and a successful one — to predict a boundary crossing.

A telescope at Stanford University's Institute for Plasma Research measures the mean magnetic field of the sun — the sum of the polarities of the regions of the sun facing earth. A ground-based magnetometer at Thule, Greenland, allows researchers to infer the direction of the sun's magnetic field and thus mark the date of polarity changes after they occur.

Having monitored the mean magnetic field and the sector boundary crossings, Heckman and his group knew that the crossings typically are registered on earth three-and-a-half to four-and-a-half days after the mean field, as measured from Stanford, nears zero. When the Rice researchers contacted Heckman at the last minute from their launch site in Point Barrow, Alaska, the NOAA group came up with two dates which they predicted would just straddle the crossing. They picked the exact crossing date within one day. Real-time data, from the ISEE-C satellite for example, could pinpoint the crossings even more precisely, says Heckman.

Solar magnetic field polarity: Part two

Andrew J. Weinheimer of Rice University was there to complete the story. The boundary crossing studies marked the first two flights of a balloon-borne instrument called BEEPS (Balloon Electrical Environment Profiling System). While other similar instruments hang below the balloon as it carries them aloft, BEEPS sits inside. In addition, the aluminum-coated surface of the four-meter-diameter balloon is actually part of the instrument; the static electricity created by the plastic balloons of other systems often interferes with measurements. Taking continuous readings up to 14 kilometers, the system measures the electric field intensity and direction, the ability of the air to conduct electricity and the air-to-earth current.

Based on their preliminary data, Weinheimer said the atmospheric electrical property most affected by the change in solar magnetic field polarity seems to be conductivity. The positive ion conductivity — the ability of positive ions to carry conductivity — appears to have been greater before the polarity change than after it, he said. The Rice team hopes to have BEEPS monitor the same properties daily for an entire 27-day solar rotation.

Measuring continent growth

James R. Lawrence of Lamont-Doherty Geological Observatory has calculated that the continents may have grown a minimum of five percent and a maximum of 40 percent during the past three billion years. If, as some researchers believe, the uppermost ocean sediments riding atop the ocean plates are scraped off as the plates move under the continents, the continents have grown by five percent, Lawrence says. Based on measured fluctuations of O^{18} in deep ocean sediment cores, Lawrence says additional material from the volcanic layer of the ocean crust — called layer two — may have increased the continents another 35 percent.

The concentration of O^{18} depends on the type of reaction that occurs between the ocean crust and seawater. Low temperature reactions between ocean basalts and seawater use up O^{18} and create hydrous material.

Because of its high water content, such material is not likely to descend into the mantle without further alteration. High temperature reactions, on the other hand, produce O^{18} and easily subducted material. Because the ratio of O^{18} to O^{16} in the ocean crust has remained constant over geologic time, Lawrence observed that either more high temperature reactions must occur or the O^{18}-depleting hydrous rock must be removed in order to preserve the ratio. The measurements of O^{18} fluctuations indicate that not enough high temperature alteration occurs for that process alone to be responsible for maintaining the oxygen isotope ratio. However, Lawrence says, five to 15 percent of the volcanic layer is hydrous. The addition of this material to the continents, which would increase their sizes by as much as 35 percent, could preserve the proper isotope ratio.

Interpreting seismic wave decay

Seismologists have long been able to use changes in the speed of seismic waves to determine the thickness of the crust and the size of the earth's core. However, they have not known how to interpret the varying rates at which seismic waves decay or die away. Don L. Anderson of California Institute of Technology described a theory based in materials science that may allow scientists to quantify the physical conditions reflected by changing decay rates.

Imperfections in crystals determine how they respond to different physical conditions. Laboratory tests of stress and temperature on crystals show that they absorb more energy under higher stress and at higher temperature. Anderson and coworker J. B. Minster postulate that the same mechanisms operate in the mantle: Where the mantle temperature is high, the energy of seismic waves will be absorbed quickly and the waves will decay very rapidly. Likewise, areas of high stress will absorb energy quickly and seismic waves will not propagate far. Laboratory-determined calibrations will allow scientists to infer temperature distribution in the earth's mantle and to track stress buildup, Anderson says.

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