Heat Flow Studies Made of Ocean Floor

September 18, 1963

An American and a Japanese scientist have joined forces to draw a new feature on the map of the globe.

Using delicate measurements taken on the miles-deep ocean floor they have traced two puzzlingly parallel tracks of high heat flow beneath the lonely seas south of the equator and east of Tahiti.

The scientists are Richard P. von Herzen, Assistant Research Geophysicist at the University of California's Scripps Institution of Oceanography, and Seiya Uyeda of the Earthquake Research Institute of Tokyo University, Japan.

Writing in a recent issue of The Journal of Geophysical Research, von Herzen and Uyeda report on the results of 194 new measurements of heat flow in the Pacific Ocean. Most of these were made in 1962 on a Scripps expedition, Risepac, which von Herzen led.

That the amounts of heat flowing through the earth's surface are higher in some parts of the eastern Pacific than in most other parts of the world has been known for several years.

New is the fact that there are relatively narrow (30 miles) "belts of fire" that parallel each other some 60 miles apart over several degrees of latitude. They have been traced by Scripps ships a distance that almost equals that between San Diego and San Francisco.

In terms of actual heat warming the bottom waters, the flow is not great. Per square yard of surface area, in most parts of the ocean it equals about one five hundredth of the energy coming from a lighted 25-watt bulb. It occasionally reaches six to eight times that amount in areas such as that studied.

However, it interests geophysicists because of the clues it offers to processes taking place in the inaccessible inner reaches of the earth.

Measurements of heat flow through the ocean floor were unknown until about ten years ago. Since then they have been made in all the world's oceans. Some of the first Scripps measurements were made on Capricorn Expedition, 1952-53, in which von Herzen participated as a graduate student from Scripps. He has gone on to win his Ph.D. in geophysics at Scripps and to become- one of the world's experts on heat flow through the ocean floor.

The first measurements suggested a rather surprising fact. It was found that the average amount of heat coming through the ocean floor in most places differed hardly at all from that coming through the continents.

What made this surprising was the fact that the earth's crust beneath the ocean is much thinner than that of the continents and is made up of different materials.

Why measurements on continents and in the sea should agree is still a matter of scientific dispute.

Even in the early studies, it was learned that unusually high values of heat flow appeared in some parts of the ocean. As research continued and oceanographic expeditions multiplied, it became possible to outline areas where the heat flow was consistently above average and where it was consistently below.

High values have been rather consistently found beneath ocean ridges and rises. One such region where the values were above average was the crest of the great East Pacific Rise.

The East Pacific Rise is a bulge in the earth's crust that sweeps in a sickle-shaped curve from the edges of the Antarctic Ocean to the coast of North America. In some places, it is very smooth, without the steep hills and valleys that characterize other oceanic rises.

Risepac Expedition crossed the crest of the Rise several times, making closely spaced heat-flow measurements. It is from these studies that von Herzen and Uyeda have been able to trace lines of maximum heat flow along the crest of the Rise.

Some scientists have suggested that the heat sources that cause the flow may lie hundreds of miles beneath the earth's surface. But von Herzen and Uyeda think differently. They suspect that the narrow belts of heat, at least, are caused by heat sources that lie only a few miles beneath the earth's surface.

One of the theories scientists use to explain high heat-flow values says that the stuff of the mantle is rising upward there, lifting the crust. Theory indicates that the material would have to be flowing upward at a rate of two inches a year to produce the observed heat-flow values. (This is rapid movement, on the time scale of millions of years that is used in such studies.)

The existence of the two parallel lines might be explained, say von Herzen and Uyeda, if the ascending material separated, as a jet of water does, into two streams near its top.

To the east and west of the crest of the Rise, low heat-flow areas have been found. These are enormously large, covering millions of square miles of the ocean floor. There the values are considerably below the oceanic averages. Under the convection theory, it is assumed that these are regions where the material of the mantle is descending.

Heat flow is measured with a six-foot long steel probe. It carries thermistors that measure the temperature differentials between the top and bottom of the probe when it has pierced the ocean floor. Samples of the bottom are taken to see how readily they conduct heat. Then the actual flow of heat can be calculated.

The heat-flow studies have received support from the National Science Foundation and the Office of Naval Research.