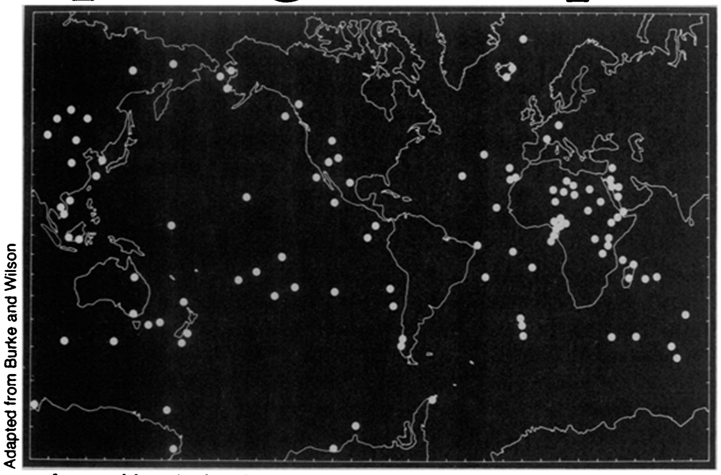
Spotting a Hot Spot



Adapted from Burke and Wilson

The "maximum list" suggests 120 hot spots. The "minimum list" suggests only 33.

Legend has it that in ancient times warriors from the island of Ponape, part of the Caroline chain in the west Pacific, set sail toward the southeast but turned homeward when fire appeared in the sea. This tale, recounted in an 1899 manuscript, is among the evidence used by geoscientists at the Hawaii Institute of Geophysics to pinpoint a previously unknown hot spot in the Pacific Ocean. They reported their find last week in Baltimore at the American Geophysical Union's spring meeting.

A hot spot is a source of hot rock that may come from the mantle, explains Barbara H. Keating, assistant professor of marine geology and paleomagnetics. This hot rock melts through oceanic crust to form a chain of submarine volcanoes and volcanic islands. Hot spots clue scientists to convection within the mantle and to movements of continental and oceanic plates (SN: 9/22/79, p. 202). The fire in the sea seen by Ponape warriors was probably an erupting submarine volcano formed by the Caroline Islands hot spot, Keating believes. Although hot spot traces are common — the Hawaiian Emperor Seamount Chain is perhaps the best known—the hot spot in the Caroline Islands is the first one geoscientists have seen that exhibits evidence of dying, says Keating.

Key to diagnosing the presence of a hot spot is a string of volcanics whose ages progress, without deviation, from oldest to youngest. Keating and colleagues found that three of the major islands in the Carolines follow this pattern. The westernmost island, Truk, was formed 12 to 14 million years ago, the geophysicists estimate, followed by Ponape (8 million years ago) and then by Kusaie (4 million years ago). Geochemical studies show that the islands probably were formed by the same source, although the exact makeup of each is slightly different, indicating some change in the magma as the islands formed.

The Carolines are unusual, however, because the volume of the oldest island is twice that of the youngest. (In Hawaii, the youngest island has the greatest volume.) This indicates that the hot spot that formed the Caroline volcanic chain produced less material over time and perhaps was dying as Truk, Ponape, and Kusaie were being formed, Keating concludes. She predicts that the hot spot is located at 4.8° North, 165.7° East.

Supporting her theory is seismic information collected by Dan Walker of the University of Hawaii. He found evidence for seismic activity in the presumed hot spot region. In addition, bathymetric records indicate the presence of a seamount, or submarine volcano, that rises 1,300 meters from the seafloor slightly north of the predicted hot spot location. What's more, predicting the location using paleomagnetic data results in a position 2° from that predicted by Keating.

Taken together, the seismic data, bathymetric information, geochemical studies, radiometric dating, paleomagnetics and local legend point to a waning hot spot in the Caroline Islands. Says Keating, "It's one of the few times in science when things fall together nicely." □

Another theory of earth formation

If you were to stroll on the moon's surface, you could pick up a rock nearly as old as the moon itself. But the pickings are slimmer, or at least younger, on earth: The oldest rock was formed almost one billion years after the earth. A new theory of the evolution of earth structure explains this difference.

An ocean of molten rock, or magma, 500 kilometers deep blanketed the ancient earth, according to Don L. Anderson, professor of geophysics and director of the seismological laboratory at the California Institute of Technology. Earth's early crust, with original or "genesis rocks" heavier than the magma, sank into the boiling cauldron. Anderson says his theory is a radical departure from previous ones that say that the earth formed with a largely pristine interior, with only modest amounts of melting to supply the molten material shot from volcanoes or oozing from within the mantle at ocean ridges.

Temperatures on primordial earth should have been high enough to produce a magma ocean, Anderson told fellow scientists last week at the AGU meeting. "At the higher pressures on earth, the first forming crystals would have been denser than the melt, and they therefore would sink instead of float." By contrast, present theory purports that the oldest lunar rocks were formed of crystals that floated on the moon's cooler magma ocean.

Anderson says his magma ocean explains why magmas emerging at oceanic islands and within continents differ from those coming up from greater depths at mid-ocean ridges. For one thing, the magmas have different concentrations of potassium, uranium, thorium, barium, rubidium and other trace elements. Concentrations of these elements in one magma type complement those of other magma types, Anderson explains. "When mixed together in the proper proportions, they approximate the average composition of the earth," he says.

Furthermore, seismological data show that major discontinuities occur in the mantle at depths of about 220 and 670 kilometers. Anderson says, "These are probably the boundaries of the two ancient layers formed as the earth was cooling down from its initially high temperatures." □

Solving Saturn's simmer

Jupiter is a hot world, at least down deep, giving off about 1.8 times as much heat as it receives from the sun. And scientists have taken the imbalance in stride. "It was just the amount calculated," says Andrew P. Ingersoll of Caltech, "for a body of that size left to cool for 4.5 billion years [the estimated age of the solar system] at that distance from the sun." A check on such a calculation is the ratio between the amounts of hydrogen and helium that comprise most of the planet's mass, and Pioneer and Voyager spacecraft measurements showed that the ratio "came out exactly equal to the value deduced for the sun, the stars, and even the universe as a whole." Fine.

Saturn, however, began to look trickier when Pioneer 11 data showed it to have a still larger excess, emitting as much as 2.5 to 3 times the heat of its solar input. Researchers suggested that the extra heat might be caused by the gravitational separation of the two elements, producing "viscous friction" between descending