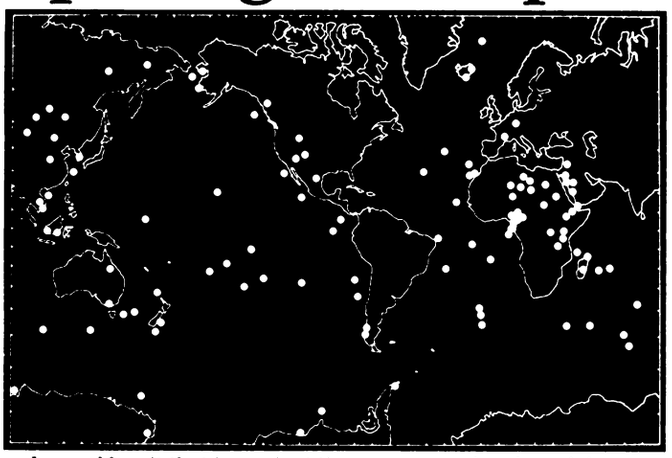
Spotting a Hot Spot



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

droplets of helium and the surrounding hydrogen, and that the effect would be detectable as a reduced percentage of helium, compared to Jupiter, in the top of Saturn's atmosphere. The trouble was that Pioneer 11's hydrogen-helium data, albeit imprecise, appeared to show no such reduction. Was some unknown process at work in Saturn? Was the excess-heat measurement—which had confirmed earlier ground-based studies — simply wrong? "One outrageous possibility," says Ingersoll, "was that Saturn is only 2 billion years old, and therefore had not lost the expected amount of heat. Such a possibility, if true, would shatter our understanding of solar-system formation, which is based on known physical principles and observation of star-formation elsewhere in the galaxy."

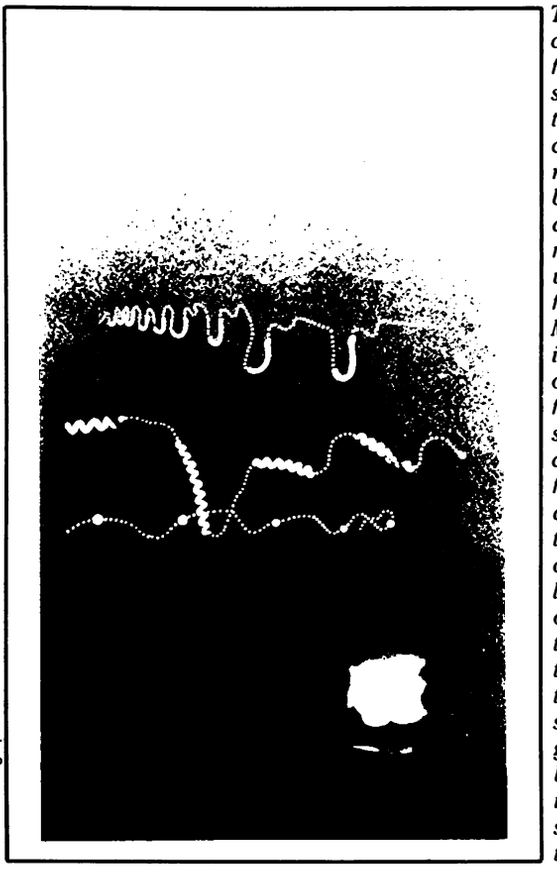
Last November, the far more sophisticated Voyager 1 spacecraft flew by for a better look at the planet. Its infrared sensor again confirmed the high heat excess, but it also seemed to show, at least at first look, a hydrogen-helium ratio the same as Jupiter's — 90 percent to 10. The puzzle (SN: 11/29/80, p. 343) loomed larger.

But analysis of data from Voyager's infrared instrument is a time-consuming process, and refined results appear to have resolved the quandary. The infrared team, headed by Rudolf Hanel of the NASA Goddard Space Flight Center, has revised their quick-look estimate of the helium abundance downward to 4 percent—just what would be expected if gravitational separation has indeed been taking place. "The net result," Ingersoll says, "is that both Saturn and Jupiter have the right ages, the right amount of internal heat, and the right hydrogen-to-helium ratio."

The relevant difference between the two giant worlds is merely that Jupiter is more massive, and has thus held onto enough of the original heat from its formation to prevent the helium from condensing into droplets that would sink into the Jovian depths. Even at Saturn the separation process probably did not start with the planet's birth. Some researchers have estimated that Saturn did not get cool enough for the helium to condense until about 2 billion years ago, and that Jupiter may just be reaching the point at which condensation will start there too. This does not mean that Jupiter will start to get warmer, Ingersoll points out, merely that its cooling rate will slow down.

Saturn, meanwhile, has plenty of other questions that still need answering, some of which may be directly related to the amount of heat rising from within it. Why, for instance, do its equatorial winds whip past at four times the speed of Jupiter's? It is possible, but far from certain, that a major mechanism is the transfer of energy from huge eddies of the sort that are much more prominent on Jupiter. Voyager 2, which will fly by Saturn in August, may provide some of the answers. It will certainly provide more questions. □

Light treachery among fireflies



National Geographic

The visual Morse code of fireflies can be used for deceit as well as for honest communication, says a scientist who has studied more than 100 species of the luminescent beetles during 18 years of research. James E. Lloyd of the University of Florida finds that in at least 12 species females can mimic the courtship response of up to five other species, to lure foreign males, which they devour. Male fireflies strive to get an edge in the mating game by imitating other species, by interjecting flashes in another male's courtship dialog, by flashing in synchrony with a rival male to confuse the female and by mimicking a female to throw a rival off the track. Competition is intense because, at least in a Florida grasslands firefly, most females take only six minutes to emerge from their burrows and mate. Males typically need more than a week to find a partner. The glowing silhouette of a firefly was photographed in Southeast Asia. The beaded trails above it illustrate illuminated flight paths of four species as they might appear in a time exposure photograph.

Strong reprimand to gene-splicer

In July 1980 a Los Angeles scientist violated federal regulations for protection of human subjects and also the guidelines for use of recombinant DNA. This conclusion, reported May 26 by the director of the National Institutes of Health, is the result of an investigation by an NIH committee appointed last October (SN: 10/18/80, p. 245).

In controversial experiments Martin J. Cline of the University of California at Los Angeles injected recombinant DNA into bone marrow cells, and returned the altered cells to each of two young women patients, one in Israel and the other in Italy. The experiments attempted to provide a missing gene to the women, both of whom have a fatal blood disease called beta-thalassemia. A proposal for similar experiments was under consideration, and subsequently rejected, by the UCLA Human Subject Protection Committee.

The several punitive measures now being taken against Cline comprise the most severe penalty ever imposed by the NIH. During the next three years Cline must receive prior NIH approval for any research with human subjects and any research using recombinant DNA. Each of the four NIH institutes currently funding Cline's research has been instructed to consider before next October whether its grant should be withdrawn. In addition, the just released NIH report on Cline's conduct will be considered during the review of applications for future research funds from NIH.

"My examination of the report of the committee and of the larger record upon which its decision was based leads me inexorably to agreement with the conclusion that Dr. Cline has violated both the letter and the spirit of proper safeguards to biomedical research," says Donald S. Fredrickson, director of NIH.

A strong factor leading to Cline's reprimand is a decision he made unilaterally before operating on the Israeli patient. A proposal approved by the Israeli hospital's human subject protection committee described use of purified human genes, not attached to genetic material from any other organism. The committee contacted the NIH to ascertain that such genes are not considered recombinant DNA under the guidelines. But on the morning of the operation Cline says he decided to inject the human gene linked to other genetic material, as well as pure genes. A similar procedure was later performed on a 16-year-old girl in Italy.

Cline told the NIH committee, "I decided