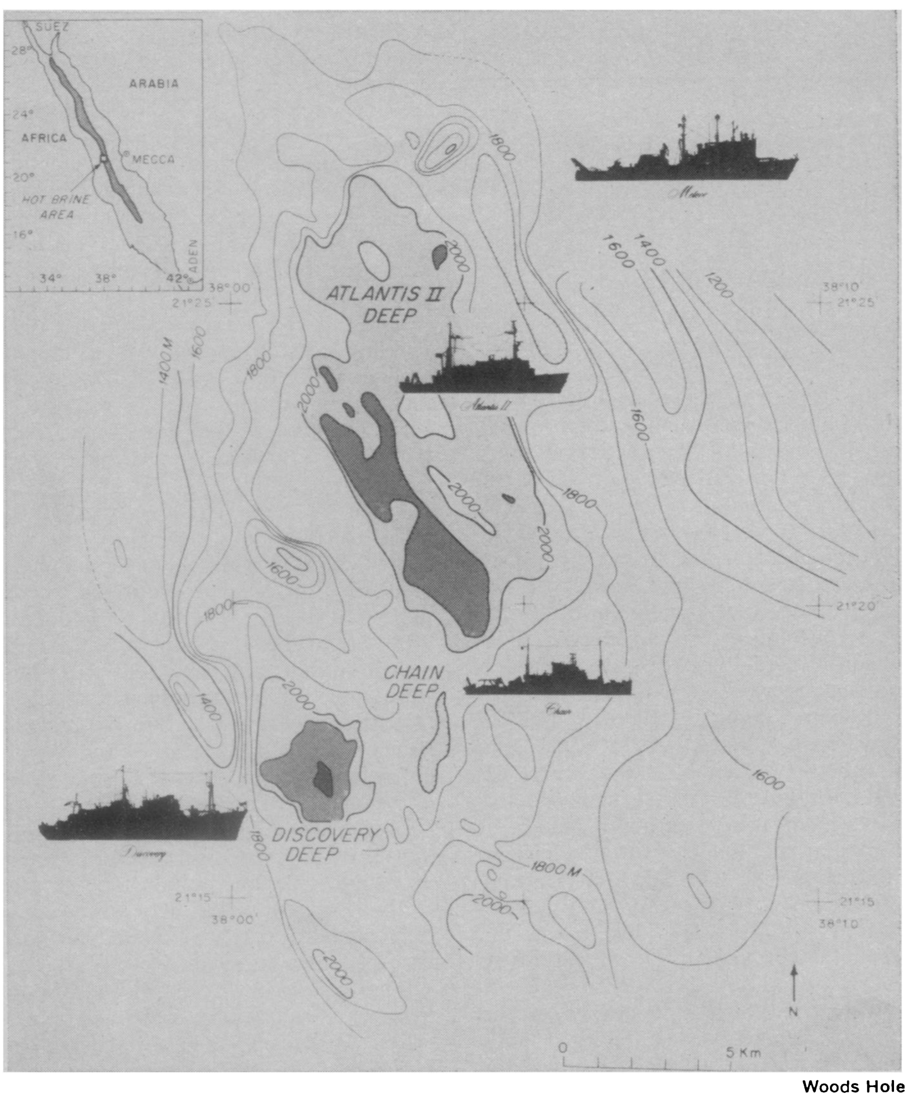
Hot spots in the Red Sea

A recent exploration of the Red Sea's hot brine pools shows that one of them is growing still hotter

by Louise Purrett



Woods Hole

A series of investigations has attempted to shed light on a deepening mystery.

In a small area of the Red Sea near Mecca, there are three deep pools with bottom layers of extraordinarily hot, salty water. These Red Sea brines have temperatures as high as 59 degrees C. (138 degrees F.) and salinity levels as high as 300 parts per thousand.

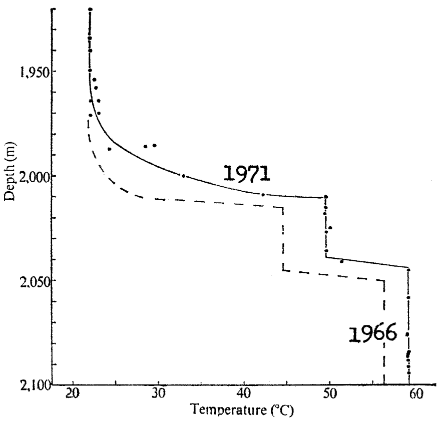
Normally, the temperature of seawater decreases with depth, since the oceans absorb most of their heat from sunlight. At depths of several thousand meters, temperatures normally approach the freezing point of water. The level of salinity of the oceans is, except for local variations, fairly uniform at about 35 parts per thousand. The range in the open oceans is usually between 33 parts per thousand for polar regions, where melting ice adds fresh water, and 37 parts per thousand for subtropical zones with high evaporation rates.

The hot Red Sea brines have therefore aroused considerable excitement among oceanographers. They were first noticed as early as 1957, when researchers on Woods Hole Oceanographic Institution's research ketch Atlantis discovered high salinity values in the Red Sea. A 1964 voyage led by Dr. John Swallow of the British National Institute of Oceanography aboard the British research vessel Discovery investigated the area in greater detail. They recorded a water temperature of 44 degrees C. with a salt concentration eight times normal. The German ship Meteor made a later voyage to the same area, now called the Discovery Deep, and confirmed these findings.

In 1965, a scientific team led by Dr. Arthur A. Miller of Woods Hole aboard the Atlantis II discovered another, larger hot brine area, since named the Atlantis II Deep. The Atlantis II crew recorded a temperature of 55.92 degrees C., and a later trip by the Woods Hole ship Chain in 1966 revealed readings of 56.48 degrees.

A third deep, the Chain Deep, was discovered in autumn of 1966 by the Chain. A maximum temperature of 34 degrees was recorded at a depth of 2,042 meters. Normal temperatures for this depth are about 20 degrees in the Red Sea and as low as three or four degrees in most other oceans. Water samples had a maximum salinity of 74.2 parts per thousand. In all three pools the increase in temperature is accompanied by a marked decrease in oxygen.

The three brine areas are located in deep basins. The Chain Deep is separated from the Discovery Deep by a sill at a water depth of 1,980 meters. Since the sill is higher than the top of the hot brine layer, it would prevent an exchange of hot water between the two deeps. The shallowest area observed between the Chain and Atlantis II Deeps, on the other hand, is 2,009 meters.



Nature

Atlantis II Deep: Hotter and bigger.

This would permit an exchange of water, but the temperature profiles from the three deeps show distinct differences which suggest to the Chain researchers that the hot waters of the three holes are not in direct communication. There may be a shallow barrier that has not yet been observed, they conclude.

The Chain team concluded that though the holes are not now in direct communication, the hot water in them probably had a similar origin—either from the same ultimate source, or by mixing of water between the holes at some time in the recent past.

During February of this year the Chain revisited the brine area. In the May 7 NATURE, the researchers, led by Dr. Peter G. Brewer, reported findings that, instead of clarifying the mystery, have deepened it. The temperature of the Atlantis II brine had risen 2.7 degrees, from 56.5 to 59.2, since the last published observation in 1966. In addition, the upper boundary of the hottest layer appears to have risen by about six meters since 1966, increasing the volume of the brine by 12 percent. An intermediate brine layer lying above the bottom layer but less dense and warm, has also increased in temperature by 5.4 degrees, from 44.3 degrees to 49.7 degrees.

The implication is that the hot brine area is undergoing active geological formulation, receiving hydrothermal discharges from deeper in the earth below the floor of the Red Sea. The brine areas are located above the central rift zone of the Red Sea, where Africa and Arabia are splitting apart and new ocean crust is being formed. The magnitude of the increase was startling, says Dr. Brewer. "A temperature rise of this size means that instead of the heat coming through the sediment by conduction, it is probably coming in through an input of its own hot salty brine."

Previous investigations had revealed a long, narrow depression to the northeast of the Atlantis II Deep. The Woods Hole scientists found this depression to contain hot brine. The maximum temperature recorded was 56.69 degrees C., with salinity of 318 parts per thousand. This brine may have come from the Atlantis II Deep, they suggest, but the presence of a sill between the deeps makes this explanation by no means certain. The smaller deep could be a new active source.

Observations in the Discovery Deep revealed no changes in brine temperature or salinity since 1966. It has generally been assumed that this brine is renewed by overspill from the Atlantis II Deep. The researchers conclude that the recent activity in the Atlantis II Deep has not yet caused such an overflow.

The researchers calculated the minimum original temperature of the input brine as 113 degrees C. The actual temperature of this new water, they explain, was probably higher, as there must have been some heat loss to the surrounding sediments and the Red Sea bottom water.

The concept of active formulation is supported, the researchers point out, by a steady increase in iron and manganese that has occurred simultaneously with the temperature increase. These elements remain in solution in the lowest brine layer until they are removed by oxidation and precipitation. The process is the principal mechanism of formation of the mineral-rich sediments of the basin. The observed increase in dissolved iron and manganese therefore indicates that over the period of observation the rate of input of these elements in dissolved form in the water has exceeded the rate of deposition. This means that the system is one in which ore formation is now occurring, the researchers say. The process may be the same by which other ore deposits have formed in the past.

Dr. David Ross, who led the geological and geophysical investigation on the same voyage, confirmed these findings. "We have seen the Red Sea brine area as being a dynamic, active process continuing on up to the present moment. In fact, if we returned to the area in a few years, we'd probably find conditions had changed again."

The sediments on the floor of the Red Sea are thus rich in numerous heavy minerals, with a potential value estimated at more than two billion dollars. But, concludes Dr. Ross, "the value of these deposits on the sea floor, although high, is not the most important aspect here. It is that we have found a process occurring from which we can learn more about the formation of mineral deposits on land and the origin of the ocean basins." □