Hot Brines in the Red Sea

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At the north end of the Red Sea there's a trench, 160 kilometers long, 12 meters deep and 55 meters wide, that connects its waters to the Mediterranean. This trench, the Suez Canal, is either stunning as an engineering artifact or, from the globe's perspective, a puny, shallow scratch across an isthmus. At the south end of the Red Sea, at Bab el Mandeb, a sill, 120 meters below the surface, separates the sea from the Gulf of Aden and the Indian Ocean. Between its northern and southern extremes the sea is a rather narrow but deep passage, containing some of the world's saltiest and hottest water.

This sea has been traversed many times, in the pursuit of commerce, the word of God, plain wonder and, more recently, knowledge of what brews under its surface. In September of 1964 the research vessel *Atlantis II*, operated by the Woods Hole Oceanographic Institution, was proceeding down the Red Sea to join an Indian Ocean expedition. Its scientists could not resist a stop, not far from Mecca and Medina, not far from where U. S. Navy ships were to launch bombers and cruise missiles toward Iraq 27 years later.

The attraction was a pool of water (but what water!) 2,000 meters down, found by the appropriately named British ship *Discovery* a few months earlier. About a mile across, and about 300 meters deeper than the rest of the sea bottom, lay a steep-sided body of water at 44.6 degrees Celsius, the temperature of a good hot bath, and 10 times as salty as the sea at its surface.

Trying to find the *Discovery* Deep, as the pool of water came to be called, was not that easy—a sailor can testify to the problems of getting a bearing in the middle of the sea. Drifting just a few miles away from the *Discovery* Deep, *Atlantis II* anchored and sent down bottles to collect water. All was quite normal, water temperatures were near the Red Sea average of 22 degrees Celsius. But as the bottom was approached, the temperature went off the scale of the thermometers. (It was eventually measured as 56 degrees Celsius.) On board that day, J. C Swallow describes the quality of the bottles' contents: "When water was being drawn from bottles that had been near the bottom it seemed to run out more slowly than usual, and any that got spilt on the deck immediately dried up leaving a thick white patch of crystals." (1)

Sediment cores were retrieved—hot, full of a black, greasy-looking material. E. T. Degens, in a later description, writes: "Rumor spread that oil had been struck; for its appearance was more like sludge from an automobile repair shop rather than the deep sea cores the crew were accustomed to." (2)

The Queen of Sheba had surely sailed by this spot, thinking of the hard questions she would ask King Solomon. Questions, no end of questions were on the minds of the crew of the *Atlantis II*. What was this sludge? What was in this water?

"Though a research vessel may represent a floating machine shop, ship chandlery and electronics supply house, inevitably there comes a time of reckoning when something is not to be had." (3) What C. D. Densmore, one of the expedition's scientists, describes as lacking on this vessel was not the expensive instrumentation, not the packaged tests designed for the routine—the laboratory equivalent of a cake mix—but the chemicals needed for that hoary, smelly laboratory indoctrination rite, the qualitative analysis. It's what Primo Levi describes as "...a method, a toilsome, age-old plan for systematic research, a kind of combined steam roller and fine-toothed comb which nothing (in theory) could escape...." (4)

There were metals in that sludge and in that brine. But which metals? Densmore continues:

> When R. Pocklington and E. Degens set about a qualitative analysis of this peculiar water they found the laboratory sadly wanting in certain essentials; no H_2S, no $PbNO_3$, no magnesium standard. The only conventional chemicals available: some hydrochloric acid, ammonia and nitric acid.
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> As so often before, necessity mothered invention, with the aid of memory of first year chemistry courses, sulphur was produced (amidst horrid smells) from thiosulphate—darkroom hypo—and hydrochloric acid. This, in turn, was fused with aluminum foil from the galley to give Al_2S_3, and the addition of water delivered the H_2S that was wanted.
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> Lead was no problem; the decks were littered with hydro-weights. A few shavings, nitric acid, and presto! $PbNO_3$.
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> Doc Willis' sickbay provided hydrogen peroxide, and later Epsom salts to be used as the magnesium standard in the flame photometer. Foot powder was considered for a borax bead test, but rejected as having too many additives.
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> When an acid solution of the core sample proved to contain both ferrous and ferric iron the need arose of testing for ferrous-ferric oxide, or magnetite. The little

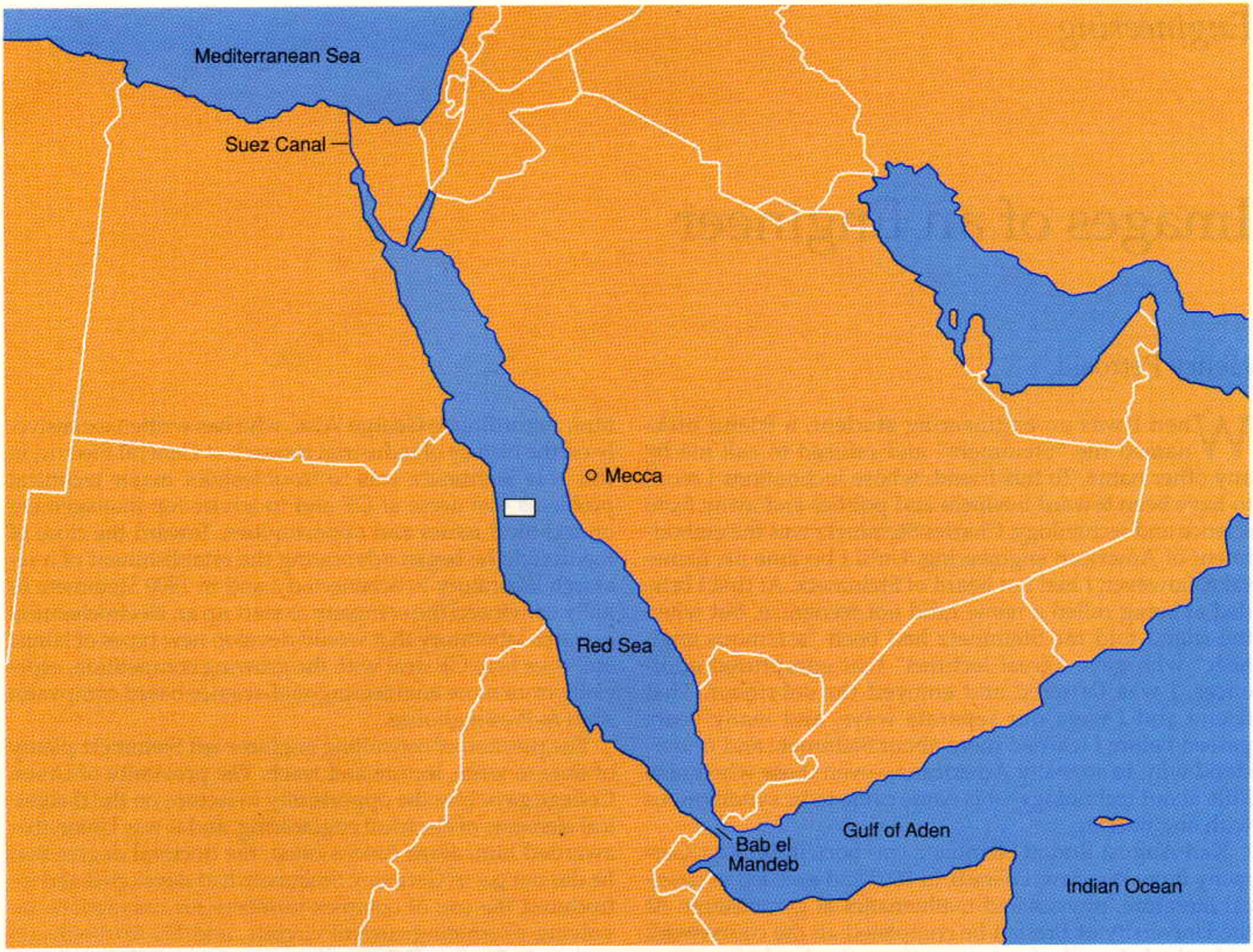

Figure 1. Deep waters in the Red Sea reach extraordinarily high temperatures (near 56 degrees Celsius), high salinity (10 times the ocean norm) and concentrations of heavy metals (iron, manganese, copper and zinc) a thousand times their ordinary ocean abundance. The hot brines—called the *Atlantis* and *Discovery* Deeps, after two of the research ships that were involved in their discovery—are located west of Mecca (*rectangle*), about 2,000 meters below the surface of the sea.

magnetic clips from the notice board didn't quite have the steam, but a fine magnet was acquired by pulling apart a loudspeaker. But—alas—the sediment was [not] magnetic. (3)

The brines were duly analyzed. They are enriched in heavy metals, iron, manganese, copper and zinc, concentrated about a thousand times over their ordinary ocean abundances. The water is acidic (pH 5.5 to 6.2) and depleted in sulfate. An analysis of the sulfur isotopes points to a geological rather than biological origin of the brines. The sediments contain many metals present as sulfides—marcasite, marmatite or sphalerite, chalcopyrites, pyrite. And as oxides. One sediment sample consisted of about 6.2 percent zinc in the form of zinc oxide.

The dispersion of the minerals is what one would expect from a hot, metal-rich solution welling up from igneous rocks. Presumably there are vents in the Red Sea, like the "black smokers" found elsewhere in geologically active sea-bottom regions. The metals in the brine pools are concentrated to a degree that makes speculation about their commercial use possible. Quoted in 1967, the value of the top 10 meters of the *Atlantis II* Deep sediments has been estimated at $2.5 billion (5).

Much careful research, artfully cutting across classical scientific disciplines, went into establishing the presence and nature of these hot salty waters. The science has been duly reported, in the way science is, in the proper journals, with lengthy tables, methodical analyses, x-ray diffractometer traces, isotope ratios, the full armament of several sciences. The account is impressive, authoritative, thorough.

And lacking in the drama of the discovery. Where does one find the quotations that I cite, the excitement of people improvising as they plumb the unknown? Not in the scientific articles but in *Oceanus*, the informal publication of the remarkable Woods Hole Oceanographic Institution (6). When will we learn... when will we ever learn?

References

1. J. C. Swallow, 1965, *Oceanus* 11(3):3.
2. E. T. Degens, 1989, *Perspectives on Biogeochemistry*; Berlin: Springer-Verlag, p. 137.
3. C. D. Densmore, 1965, *Oceanus* 11(3):6.
4. P. Levi, 1984, *The Periodic Table*; New York: Schocken Books, p. 39.
5. K. O. Emery, J. M. Hunt, E. E. Hays, 1969, in *Hot Brines and Recent Heavy Metal Deposits in the Red Sea*, ed. E. T. Degens, D. A. Ross; Berlin: Springer-Verlag, p. 557. See also A. R. Miller, et al., 1966, *Geochimica et Cosmochimica Acta* 30:341.
6. And in the highly original book of E. T. Degens, Reference 2.