thoroughly referenced; with full titles included and citations as recent as the summer of 1995, the references actually occupy a quarter of the text. In summary, this new edition lives up to the high standards of the first and should quickly become a standard reference for experts while providing a logical starting point for newcomers to the field.

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Oceanic Vents

Seafloor Hydrothermal Systems. Physical, Chemical, Biological, and Geological Interactions. SUSAN E. HUMPHRIS, ROBERT A. ZIERENBERG, LAUREN S. MULLINEAUX, and RICHARD E. THOMSON, Eds. American Geophysical Union, Washington, DC, 1995. xiv, 466 pp., illus. $65; to AGU members, $45.50; to AGU student members, $42.25. Geophysical Monograph 91.

Hydrothermal activity in the deep sea was first observed directly on the Galápagos Spreading Center in 1977 after the accumulation of much indirect evidence that it had to exist. This initial discovery has been gradually followed up with the identification of vent fields at numerous other locations on oceanic and back-arc spreading ridges and on submarine hot-spot volcanoes. Emplacement of a magmatic heat source into permeable, water-saturated oceanic crust induces convection; the operating fluid is seawater. The scale of this phenomenon is such that a volume of seawater equivalent to the entire ocean is cycled through these high-temperature convection cells in about eight million years. This much had been guessed at prior to the actual discovery. What had not been anticipated was that reduced gases in the venting fluids, principally H_2S, derived from the seawater-basalt reactions could support a unique fauna of chemosynthetic macro-organisms, that the fluid compositions produced by the hydrothermal process could be extremely diverse despite the quite constant composition of the initial reactants, and that these compositions could be stable on decadal time-scales. In addition, the vent fluids were found to feed the accumulation of ore bodies, massive Fe-Cu-Zn sulfides, identical to those exploited in ophiolite bodies and ancient greenstone belts on land. Thus the discovery has led to a revolution in marine biology and geochemistry and in economic geology and has spawned an entirely new branch of the oceanographic sciences. The work reviewed here contains a series of surveys of the current state of play by some of the leading participants in this revolution.

The collection leads off with an excellent discussion of the tectonic and volcanic controls on hydrothermal activity at open ocean ridge axes, replete with maps and diagrams of the best-explored sites. The second paper, on the hydrothermal plumes that ascend for hundreds of meters over the vent fields, seems out of sequence since, though interesting, these are secondary phenomena and their understanding depends on knowledge of the primary fluid compositions at the vent orifices. This is followed by a very brief discussion of the vent organisms accompanied by some remarkably good color plates of the biota. Discussion then turns to the sub-seafloor processes that control the vent fluid compositions. Despite heroic efforts, it has not yet proved feasible to drill directly into the reaction zone. Processes there have to be reconstructed from fossil systems preserved in the geologic record either at off-axis locations on the ridge flanks or in ophiolites, fragments of seafloor often of uncertain provenance that have been obducted on land during tectonic collisions. The synthesis of this information suggests a continuum of processes extending from magmatic temperatures to those of the ambient oceanic water column. This discussion is then continued with a survey of the known actively forming ore deposits and the factors influencing their relatively broad range in size, morphology, and composition. This chapter is largely based on systematic observations of mineralogy and is followed by an excellent review of the thermodynamic modeling of deposit growth and evolution. Then the question is addressed of the interaction of the biota with all this. Certainly organisms are intimately associated with the growing deposits, living on and in them. Whether they actively influence growth and morphology is unresolved, but healthy speculation abounds.

"The Rose Garden vent on the Galápagos Rise in 1979. Vestimentiferan tube worms and mussels dominate. Bresliid shrimp and archaeogastropod limpets walk on them." [From R. R. Hessler and V. A. Kaharl's chapter in *Seafloor Hydrothermal Systems*]

About halfway through the book we finally get explicit information on vent fluid compositions, specifically the range in stable isotope values. In principle these give insights into the origins of the various components and the reaction mechanisms that introduce them to the fluids and, eventually, to the precipitates. This discussion is continued with a systematic presentation of the chemical features of the known active vents; this is a very useful data compilation and synthesis and leads naturally into a presentation of the bacterial processes that sustain the macro-organisms. These are then discussed from the point of view of their physiological ecology.

The succeeding section is composed of a series of papers on the hydrothermal plumes, their distribution, dynamics, propagation, and eventual dispersal. The mysterious problem of sustaining the vent populations, dependent as they are on transient habitats, is then addressed. How do larvae "find" and colonize new vent fields? What controls the basin-scale faunal boundaries as evidenced by the differences between the biota of the East Pacific Rise and the ridges of the Northeast Pacific and the North Atlantic? We appear to be a long way from satisfactory answers.

The final two papers attempt estimates of the global hydrothermal flux. The first utilizes conductive heat flow data and runs into the thorny problem of axial versus off-axis heat transport. The second uses the chemical flux approach. As usual the values obtained are irreconcilable: heat budgets give relatively low hydrothermal fluxes, and the integral chemical effects require high ones.

One is left with a good appreciation of the present understanding of hydrothermal activity in the deep sea. We still have three persistent problems: larval dispersal and colonization and faunal distributions, the mechanisms controlling the temporal compositional stability of the fluid compositions, and the true magnitude of the chemical fluxes. Much remains to be done.

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