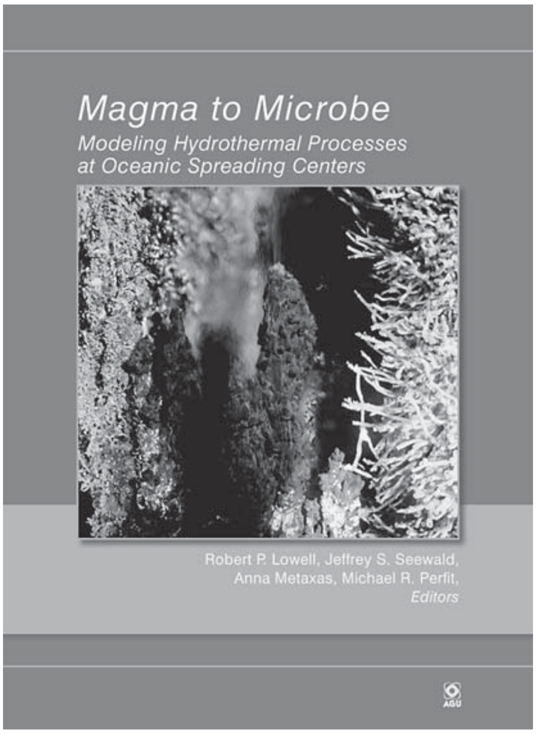
Magma to microbe − Modeling hydrothermal processes at ocean spreading centers, edited by Robert P. Lowell, Jeffrey S. Seewald, Anna Metaxas & Michael R. Perfit, 2008. Geophysical Monograph Series 178. American Geophysical Union, 2000 Florida Avenue N.W., Washington, DC 20009, U.S.A. Hardcover, 285 pages. Price USD 86.80. ISBN: 978-0-87590-443-6.



Seafloor hydrothermal systems play a major role in energy and mass transfer between lithosphere, biosphere and ocean. The chemical species transported by hydrothermal fluids support extraordinary chemosynthetic ecosystems, and their discovery has led to a new awareness of life in extreme environments on Earth, as well as to suggestions of possible life elsewhere in the solar system. Hydrothermal processes at oceanic spreading centres are characterized by a complex interplay among magmatic, tectonic, hydrogeological and biogeochemical transport processes. Our knowledge of them is mainly based on observational and experimental studies and is synthesized in 5 excellent books of the same series (Humphris et al., 1995; Buck et al., 1998; Wilcock et al., 2004; German et al., 2004; Christie et al., 2006). Modelling works (mathematical and numerical) which allow integration of these various processes into a quantitative framework are scattered in the literature. Most numerical models of the seafloor hydrothermal systems that have been created to date have focused on either the physical or the chemical aspects of the hydrothermal activity, while greatly simplifying the other aspects or neglecting them altogether. In order to design realistic models, coupling of physical, chemical and biological processes is essential. This implies that fluid flow, heat flow, solute transport, chemical reactions and biological processes will have to be integrated into single models. These models can then be used to describe how these processes are linked, interact, and evolve through space and time. In general, conceptual models are a necessary prerequisite for the interpretation of field observations and lab-experiment data. Such models serve as starting points for the development of quantitative models that elucidate the importance of various processes and guide the interpretation of data in appropriate physical, chemical, biological and geological contexts. The development of integrated, quantitative numerical models of hydrothermal circulation is thus an important goal of ocean-ridge investigations.

In order to understand the state of development of mathematical and numerical modeling of hydrothermal processes at oceanic spreading centres and to encourage the development of integrated, whole system models, RIDGE 2000 organized a Ridge Theoretical Institute (Mammoth Lakes, California, June 25–30, 2006), and the present book is a spin-off of that event. The book provides an overview of recent attempts to model oceanic hydrothermal systems and illustrate the salient features and possibilities of such models. It contains 13 papers which address a number of interconnected processes ranging from magmatic to biogeochemical processes. These papers might be thematically divided into 5 groups.

(1) Six papers address and model magma transport and evolution of the oceanic crust. Lowell et al. suggest that heat transfer from a stationary convecting and crystallizing magma chamber is not sufficient to maintain stable hydrothermal heat output on decadal time scales. Maclennan discusses the difficulties in determining the heat supplied to ridges by magmatism without full knowledge of melt composition, depth of crystallization and phase proportions during crystallization. His calculations indicate that most of the heat supplied to mid-oceanic ridges (MOR) is from the latent heat of crystallization, specific heat and subsolidus cooling. Pester et al. and Cruse et al. show the importance of rock composition and temperature on the evolution of vent fluid chemistry from two very different MOR environments. Alt Epping & Diamond review the current state of seawater/basalt reactive transport modelling.

(2) Four papers present geochemical models for the origin and evolution of hydrothermal fluids. Spatially focused studies examining equilibrium processes in high temperature reaction zones as well as mixing environments associated with hydrothermal upflow and the formation of sulphide chimneys are investigated. The development of more complex whole-system models faces some important limitations when applied to submarine hydrothermal systems. The composition of vent ecosystems may reflect the availability of organic and inorganic carbon sources that are influenced by cycling of organic matter in shallow regions of the crust and carbon fluxes from depth.

(3) At present, mathematical models of biological processes within the microbial biosphere (Huber & Holden and Schrenk et al.) including carbon cycling (McCollom, and in macrofaunal communities (Shea et al.) are in their infancy. Although mostly unexplored, mathematical models can be developed to better understand mechanisms of dispersal, growth of both individuals and populations of species, and community succession. It is suggested that mathematical models originally developed for terrestrial or other marine systems can be adapted to seafloor-vent communities, guide further data collection, and enable a mechanistic understanding of the processes regulating these communities.

(4) The three basic approaches to modelling hydrothermal circulation at oceanic spreading centres (single-pass models, cellular convection models, and downward crack-propagation models) had been all in place before the first seafloor hydrothermal systems were discovered. The discovery of hydrothermal activity at the spreading centres brought a new era in model development. Quantitative modelling of hydrothermal circulation at oceanic spreading centres is now entering a stage that emphasizes linkages among complex phenomena and the development of integrated models of specific hydrothermal systems. Ramondenc et al. investigate the hydrothermal response to earthquakes, Alt Epping & Diamond review the state of the art in reactive transport modelling, and Lowell et al. discuss recent advances in the study of multiphase, multi-component processes (phase separation, magma hydrothermal processes, biogenic floc production).

(5) Although this set of papers is focused on models that highlight the relations among hydrothermal, magmatic, tectonic, geochemical and biological processes at modern oceanic spreading centres, the impact of hydrothermal processes on the global ocean over geologic time has received considerable attention (Kump). His comprehensive review implies that improved models of ocean chemistry over geologic time may be expected in coming years.

Although the current models are still capable of simulating all facets of seafloor hydrothermal systems, they may provide a solid basis for developing new, more comprehensive models. This monograph will definitely provide a more integrated understanding of the complex interdisciplinary seafloor processes, leading in turn to innovative field and laboratory experiments that will verify the accuracy of models. The book is aimed at M.Sc. and Ph.D. students, post doctoral and experienced researchers in the fields of marine geology, marine geochemistry, biological oceanography, petrology and numerical modelling. Overall, I found this an excellent book and I highly recommend it.

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