Ph.D. THESIS DEFENSE ANNOUNCEMENT

Effect of Seismicity and Diking on Hydrothermal Circulation at Mid-Ocean Ridges

By

Pierre Ramondenc

Advisor: Dr. Leonid N. Germanovich (CEE)
Committee Members: Dr. Haiying Huang (CEE)
Dr. Robert P. Lowell (EAS)
Dr. Glenn J. Rix (CEE)
Dr. Wenyue Xu (EAS)

Date: Tuesday, September 4, 2007 at 3:30 p.m.
Location: Sustainable Education Building (SEB), Room 122

Abstract

Seafloor hydrothermal systems play a key role in Earth’s energy and geochemical budgets. They also support the existence and development of complex chemosynthetic biological ecosystems that use the mineral-laden fluids as a source of energy and nutrients. This dissertation focuses on three inter-related topics: (1) the heat output at mid-ocean ridge (MOR) hydrothermal sites, (2) the hydrothermal response to earthquakes at mid-ocean ridges, and (3) the effect of magma degassing on dike propagation at mid-ocean ridges.

The response of mid-ocean ridge hydrothermal systems to seismic and magmatic activity could provide a means of using seafloor observations to assess processes occurring at crustal depths. Three decades of study of the ocean floor have made clear that tectonic/volcanic perturbations and changes in the hydrothermal activity are correlated. Yet, this relationship is still highly misunderstood. In this dissertation, we developed a mathematical model of hydrothermal circulation affected by magmatic and/or tectonic events occurring at depth. We showed that the perturbations they generate need not propagate through the entire upflow zone, as previously suggested, but need only affect the movement of the boundary layers. In this case, the fluid residence time in the discharge zone is on the order of years.

The determination of heat output at MOR hydrothermal sites provides important constraints on the physics of these processes. Yet, such measurements are still very limited, available only for ~30 sites out of the ~10^3 estimated worldwide. This dissertation reports the first measurements of hydrothermal heat output at 9°50' N on the East Pacific Rise (EPR), which has been the most intensively studied site for the past 20 years (~10^2 expeditions). The values we obtained helped constraining the aforementioned mathematical model, which was tested based on the March 1995 microearthquake swarm near 9°50' N, EPR. Our results showed that the current interpretation based on a thermal cracking episode at the bottom of the upflow zone, may be incorrect. We argue that a diking scenario better explains the seismic and temperature data, while being consistent with the mechanics of inflation of the axial magma chamber in the 9°50' N, EPR area between two major eruptions, in 1991 and 2006.

The third and last topic of this dissertation concerns the influence of magma degassing on the propagation of dikes from magma chambers lying beneath hydrothermal fields. Dikes provide localized heat sources and the process of dike emplacement may generate crustal permeability to focus and/or enhance hydrothermal flow. In existing models of dike propagation, the effect of magma degassing has been ignored, and the compressibility of liquid magma is not sufficient to drive the dike all the way to the seafloor. The addition of volatiles to the magma dramatically increases magma compressibility, however, thus maintaining the pressure in the magma lens and enhancing dike propagation. We investigated this mechanism by incorporating the data on basaltic magma degassing as a function of pressure.