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The thermal structure of mid-ocean ridges and the dynamics of hydrothermal circulations

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The thermal structure of segments along mid-ocean ridges is likely to be a key parameter controlling the distribution, dynamics and geometry of hydrothermal systems. It is usually considered that the depth of penetration of hydrothermal fluids at the ridge axis is a function of the depth to the brittle-ductile transition. At fast spreading axis, this horizon is flat and lies in the transition zone between the magma lens and the dyke complex. At slow-spreading axis, it is likely that this depth varies both along- and across-axis, with a deepening of several kilometers from the segment center towards its ends. This geometry is a consequence of focused melt supply to the segment center, resulting in the episodic and localized injection of magma bodies in the crust, as observed at the Lucky Strike segment of the Mid-Atlantic ridge.

In order to study the effect of such slopes of the basal temperature on the dynamics of mid-ocean ridge hydrothermal systems, we ran a series of two-dimensional numerical models of hydrothermal convection. As a first approximation and following previous studies [e.g., Rabinowicz et al., 1999], we assume that these systems can be represented as rectangular and inclined permeable layers. The models are single-phase and incorporate realistic fluid properties and permeabilities. We have explored the cases of slopes ranging from 0 to 15˚, aspect ratios from 1 to 6, and permeabilities up to 10^{-14}m^2.

The basal slope controls the number of convective cells. As the slope increases, the ratio of the size of the dowflow and upflow areas increases. Above a critical slope the circulation is uni-cellular and composed of a broad recharge zone and a focused discharge zone, and encompassing the whole length of the system. We will present the implications of our models for the distribution, size, heat and mass fluxes of vent sites along mid-ocean ridge segments.