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A Thermomechanical Model for the Accretion of the Lower Oceanic Crust at Fast-spreading Mid-ocean ridges considering Multiple Intrusions and Off-axis Hydrothermal Cooling

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Thermal models obtained from seismic observations at the East Pacific Rise (EPR) has shown that the off-axis thermal structure of the axial magma chamber is incompatible with purely conductive cooling, suggesting that heat removal by hydrothermal circulation can be effective up to depth of 5-6 km. This interpretation is in good agreement with the bimodal distribution of the nucleation rate inferred from the quantitative textural study of gabbros from the Oman ophiolite and interpreted as the result of enhanced igneous cooling of gabbros $>$ 2 km above the Moho Transition Zone (MTZ).

To investigate the effect of deep off-axis hydrothermal convection on the thermal structure and accretion of the oceanic crust, we have constructed a new thermo-mechanical model of crustal flow beneath fast spreading ridges. Previous numerical models imposed injection of melt at the MTZ and/or an upper melt lens below the sheeted dyke complex by jumps in the external boundary conditions of the model. They also imposed the shape of the temperature field by setting arbitrary conditions at the top of axial magma chamber. To simulate a more realistic scenario, our numerical model takes into account boundary conditions in the center of the modeling box. Also, the temperature boundary condition at the top of the model is the sea bottom temperature and no assumptions are made on the initial temperature structure. In the center of the axial magma chamber the melt is injected with a 'needle' with adjustable porosity allowing the simulation of different configurations of melt injection (i.e. distributed or not throughout the magma chamber). The shape of the magma chamber is not longer imposed in our model, but computed from the steady state reached by the thermal field considering the heat diffusion and advection and the latent heat of crystallization. The motion equation is solved for a temperature and phase dependent viscosity. The thermal diffusivity is also dependent on temperature and depth, with a higher diffusivity in the upper plutonic crust to account for more efficient hydrothermal cooling at these crustal levels. Our preliminary results indicate that deep off-axis hydrothermal circulation highly influences the shape of the axial magma as well as the flow lines and the cooling rate of gabbros at different crustal levels. Only limited combinations of enhanced off-axis heat removal and melt injection modes in the axial magma chamber can reproduce satisfactorily the magmatic cooling rate observed in gabbros from the Oman ophiolite, as well as the thermal and melt distribution deduced from seismic studies at EPR.