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Modelling of hydrothermal fluid circulation in a heterogeneous medium: Application to the Rainbow Vent site (Mid-Atlantic-Ridge, 36°14N)

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Hydrothermal activity at the axis of mid-ocean ridges is a key driver for energy and matter transfer from the interior of the Earth to the ocean floor. At mid-ocean ridges, seawater penetrates through the permeable young crust, warms at depth and exchanges chemicals with the surrounding rocks. This hot fluid focuses and flows upwards, then is expelled from the crust at hydrothermal vent sites in the form of black or white smokers completed by diffusive emissions.
We developed a new numerical tool in the Cast3M software framework to model such hydrothermal circulations. Thermodynamic properties of one-phase pure water were calculated from the IAPWS formulation. This new numerical tool was validated on several test cases of convection in closed-top and open-top boxes. Simulations of hydrothermal circulation in a homogeneous-permeability porous medium also gave results in good agreement with already published simulations.
We used this new numerical tool to construct a geometric and physical model configuration of the Rainbow Vent site at 36°14'N on the Mid-Atlantic Ridge. In this presentation, several configurations will be discussed, showing that high temperatures and high mass fluxes measured at the Rainbow site cannot be modelled with hydrothermal circulation in a homogeneous-permeability porous medium. We will show that these high values require the presence of a fault or a preferential pathway right below the venting site. We will propose and discuss a 2-D one-path model that allows us to simulate both high temperatures and high mass fluxes. This modelling of the hydrothermal circulation at the Rainbow site constitutes a first but necessary step to understand the origin of high concentrations of hydrogen issued from this ultramafic-hosted vent field.