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Conditions for high-temperature off-axis venting at the Logatchev 1 hydrothermal field

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The off-axis Logatchev hydrothermal field at 14°45'N at the Mid Atlantic Ridge consists of several vent sites in an ultramafic environment. Here we focus on the Logatchev 1 site, which is located 7km off-axis. Hydrothermal fluids are discharging at 300-360°C (Petersen et al., 2009) and a recent seismic study revealed intense off-axis seismic activity along fault planes dipping towards the ridge axis. But how can high-temperature venting be sustained several kilometers off-axis and what is the heat source driving hydrothermal flow?

We have conducted a numerical modeling study of the Logatchev 1 hydrothermal field to answer these questions. We use a 2D FE-FV model, which resolves for hydrothermal flow of pure water. The model is instructed by geophysical data (bathymetry, fault location, depth of the heat source) and a basal heat flux boundary condition according to the total heat input of slow-spreading ridges. During systematic model runs we have varied the position of the heat source as well as fault and background permeability.

Only a narrow range of model parameters is consistent with observations. In order to get off-axis hydrothermal venting the driving heat-source cannot be located on-axis. It has to be located between the region affected by faulting and the vent field. Under these conditions, hydrothermal fluids will ascent towards the seafloor along the fault planes. Vent temperatures can be used as proxy for permeability. Driesner (2010) pointed out that there is an inverse correlation between matrix permeability and vent temperature. For Logatchev 1 we need a low background permeability in order to heat pore fluids to temperatures higher than 300°C and a higher fault permeability in order to rapidly transport them to the seafloor. We find that 2x10-16 m2 as background and 1x10-14 m2 as fault permeability yields the best results.

In summary, we find that the combination of geophysical data with numerical modeling can help understanding sub-surface flow pattern beneath the Logatchev 1 hydrothermal field. Only a narrow range of off-axis heat source locations are consistent with venting at Logatchev 1. The discharge system is controlled by faults, while recharge occurs either through faults or over a wider area.