



## **Control of fault geometry and permeability contrast on fault-related hydrothermal fluid flow**

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High-temperature black smoker systems along slow-spreading ridges such as the Mid-Atlantic Ridge (MAR) are frequently related to tectonic fault zones and therefore are commonly found off axis. While preferential flow of hot fluids along highly permeable, fractured rocks seems intuitive, such efficient flow leads to the entrainment of cold ambient seawater resulting in a drastic decrease in vent temperatures. This temperature drop is difficult to reconcile with high-temperature black smoker activity observed at outcropping fault zones. In our recent study we aim to resolve this apparent contradiction by combining newly acquired seismological data (Grevemeyer et al., 2013) from the high-temperature, off-axis Logatchev 1 hydrothermal field (LHF1) along the MAR with 2D hydrothermal flow modeling. The seismic data shows intense off-axis seismicity with focal mechanisms suggesting a fault zone dipping from LHF1 toward the ridge axis.

In order to explain fault-related high-temperature hydrothermal discharge as observed at LHF1, our simulations predict that fault zones need to be just permeable and wide enough to capture and redirect hydrothermal plumes rising from depth but, because they are not isolated conduits, must not be too wide or permeable in order to prevent cooling through mixing with ambient colder fluids. The two controlling parameters fault width and permeability contrast between fault and surrounding rock can be expressed as a single term, the relative transmissibility of the fault zone, which is defined by the product of the two. Low relative fault transmissibility leads to plumes that cross the fault and vent above the heat source rather than at the fault termination at the seafloor. High relative fault transmissibility leads to significantly lower vent exit temperatures than those observed at black smoker systems. Our findings further illustrate the intrinsic relationship between permeability, mass flux and upflow temperature: the higher the permeability, the higher the mass flux and the lower the vent temperature. The common occurrence of fault-linked high-temperature vent fields strongly points at a not-yet-quantified self-adjusting permeability that depends on pore space-clogging reactions between hydrothermal and ambient cold fluids.

Furthermore, the temperature drop associated with any high permeability zone in heterogeneous crust may well explain the sparse high-temperature vent fields along the MAR and why the heterogeneous crust of the Atlantic, with its strong permeability contrasts, is predominantly cooled by lower-temperature fluid flow.