Spatial Variations in Vent Chemistry at the Lucky Strike Hydrothermal Field, Mid Atlantic Ridge (37°N)

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This study aims at characterizing the subseafloor architecture of the Lucky Strike hydrothermal field (LSHF) based on an extensive chemical database of the various vents. Our analysis is motivated by the discovery in 2013 of a new active high-temperature site, named Capelinhos, approximately 1.5 km east of the LSHF. Capelinhos fluids display particular chemical features with chloride and metals (Fe, Mn) concentrations two times lower and four times higher, respectively, compared to other vent sites. Trace element partitioning over the entire chlorinity range indicates a single deep fluid source feeding all the venting sites. Applying the Si-Cl geothermobarometer at Capelinhos, we find phase separation conditions at 435–440°C, and 370-390 bars (2500–2800 m below seafloor (mbsf)) consistent with former estimates for the LSHF, while temperatures of fluid-rock last equilibrium are estimated at ~400°C for Capelinhos and 350-375°C for the other sites based on the Fe-Mn geothermometer. We interpret these discrepancies in thermodynamic conditions beneath the sites in terms of crustal residence time which are likely related to permeability variations across the hydrothermal upflow zone. We propose that conductive cooling of the up flowing fluids from the phase separation zone to the seafloor, beneath the main field vent sites, lowers the T conditions of last fluid-rock equilibrium, enabling ~65% of Fe mobilized in the reaction zone to be stored. In comparison, Capelinhos fluids are transported more rapidly from the reaction zone to the seafloor along a high-angle fracture system. The fluids venting at Capelinhos are more representative of the deeper part of the hydrothermal reaction zone.