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Off-axis Submarine Massive Sulfide accumulation at the fault-controlled Logatchev 1 hydrothermal field, Mid-Atlantic Ridge

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The largest Submarine Massive Sulfide (SMS) deposits in Mid-ocean ridge settings are found along slow-spreading ridges, where tectonic processes dominate and long-lived faults control the circulation of hydrothermal fluids through the oceanic crust.

Here we combine results from 2D fluid flow simulations of the off-axis (8km), fault-controlled, high-T Logatchev 1 hydrothermal field (LHF1) at the Mid-Atlantic Ridge with data on vent fluid chemistry and the associated SMS deposit, which give insights about its accumulation history. Modeled high vent temperatures of 360°C, as measured at the active LHF1, result in a total integrated mass-flow rate through the seafloor of ~36 kg/sec scaled to 28 vent orifices of 10x10cm, located in the 7 known high-T sites at the LHF1. About 42% of the vent fluids are hotter than 350°C, the minimum temperature required for efficient metal transport, with a mass-flow rate of 13 kg/sec. This corresponds to ~400 kilotons of potentially SMS-forming hydrothermal fluids leaving the vent field per year. Combined with a total H2S-SiO_2-metal (Zn+Cu+Fe) concentration of 732 ppm, measured in the LHF1 vent fluids, this makes a flux of ~300 t of hydrothermal precipitates per year. The SMS deposit at LHF1 has been dated to 58.200 years and has an estimated tonnage of 135 kilotons. Applying the above modeled annual discharge rate over the dated time period, results in an SMS accumulation efficiency of ~0.8% for the SMS deposit at the Logatchev 1 field, which fits the range of estimated global average for MORs between <0.3% and 3%.

Our predicted depositional efficiency is based on numerical modeling, which simulates continuous and ideal venting. Realistically, venting at LHF1 might well have been fluctuating, including periods of low temperature discharge, where metal transport is insufficient or periods of inactivity, compensated by periods with a higher depositional efficiency than 0.8%. Such fluctuations could have been caused by variations in permeability and structure of the active tectonic fault zone, which have a strong influence on fluid temperature and mass-flux (Andersen et al., (2015)).