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Temporal Evolution of superhot hydrothermal Fluids in the young post-eruptive hydrothermal System at 5˚S, Mid-Atlantic Ridge

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Processes taking place in a hydrothermal circulation cell depend on depth/pressure and temperature conditions, with the pressure of 298 bar and the temperature of 407ºC being the so-called critical point, representing the threshold between subcritical and supercritical conditions in seawater (CP). Here we present temperature and chemistry data from the first hydrothermal system, in which the sampled fluids fall directly onto and above the p-T conditions of the critical point.

The vent system discovered at 5º S on the Mid-Atlantic Ridge (MAR) in 2005 represents a diverse active area with various fluid emanations at water depths around 3000 m. Fluids were sampled in 2005, 2006, and 2008. Vigorous gas bubbling, stable emanation of super-hot fluid at 407ºC and decreased salinity indicate phase separation under supercritical conditions at one site. The measured maximum temperature of 464ºC during a 20 sec interval at another site is by far the hottest ever measured on the seafloor and falls into the single-phase supercritical region of seawater. A third hot vent field emanates non-phase-separated fluids with 349˚C and can be used as a reference site.

The chemical data from the two extremely hot vent fluids show some unique features. The chlorinity-depleted fluids of the superhot vents are characterized by very high Fe concentrations, up to 4.2 mM. The increased Fe mobility in the supercritical region can be explained by the nearly complete formation of Fe-chloride complexes close to the CP. Cu is highly variable in different fluid samples (between 9 and 280 μM). We interpret this as the result of Cu being present in the extremely hot single-phase fluid in a different chemical form with different solubility than in lower temperature fluids, as Cu complexation is highly sensitive to temperature. The different solution properties of fluids below and above the CP, and the different speciation of metals under the respective p-T conditions, will have decisive influences on mineral-formation processes, and possibly also on biogeochemical interactions in the mixing zone of the rising plume.

Stable temperatures and fluid data at the 5º S sites were collected in 2005 and 2006 after the assumed trigger eruption in 2002. Hence, the high-temperature fluids appear to vent over unusually long durations compared to high-temperature sites in the Pacific. This has important implications for heat-flow models of hydrothermal systems. New data from the cruise in 2008 will be included in the presentation. As supercritical phase separation might be more common than previously thought, the 5˚S field can serve as a model system to investigate processes that likely operate within many other hydrothermal systems occurring at great water depth, but in which the processes become overprinted by cooling and/or dilution before the fluids reach the seafloor.