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Silicified brecciated fault rocks from an oceanic detachment fault at 13°20'N, Mid-Atlantic Ridge: which fluid sources and pathways?

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Studied oceanic detachments (e.g. at Atlantis Massif or MAR 15°45'N) are mainly composed of hydrated ultramafics ± gabbros, supposed to derive from footwall material which localized deformation. In contrast, the MAR 13°20'N corrugated detachment fault, sampled in situ by ROV during the ODEMAR cruise, is composed of pervasively silicified mafic cataclastic breccias that obviously record overplating of hangingwall diabases. What are the sources of fluids responsible for such a silicification (up to 90%)? To reconstruct the scheme of fluid circulations that occurred in this detachment fault, we coupled a fluid inclusion study (microthermometry, Raman spectroscopy) to whole rock and chlorite chemistry.

Major Na-Ca-Al loss and Fe gain in mafic clasts suggests that syntectonic silicification is due to important influx of silica-iron-rich fluids able to leach alkalis and calcium. Co-crystallization of quartz±pyrite+Fe-rich-chlorite with a composition similar to that in stockwork zones points to a highly evolved, mafic rock-derived fluid. Fluid trapped in quartz inclusions shows important salinity variations (2.1-10 wt.% NaCl eq.), indicating supercritical phase separation. Fluid inclusions also contain minor amounts of H_2±CO_2±CH_4±H_2S, with high H_2/CO_2 and H_2/H_2S ratios, signatures typical of ultramafic-hosted vent fluids. We propose that seawater infiltrated the hangingwall upper crust at the axis adjacent to the active detachment, reaching a reaction zone at the dyke complex base (~2 km). At >500°C, fluids become Si-rich during diabase alteration (amphibolite-facies alteration in clasts), and undergo phase-separation. Brines, preferentially released in the nearby detachment fault during diabase brecciation, mix with footwall serpentinite-derived fluids bearing H_2 and CH_4. Cooling during detachment deformation and fluid upward migration triggers silica precipitation at greenschist-facies conditions. Important variations in fluid inclusion salinity and gas composition at both sample and grain scales record heterogeneous fluid circulation at small spatial and short temporal scales. This heterogeneous fluid circulation operating at <2 km depth, extending both along-axis and over time, is inconsistent with models of fluids channeled along detachments from heat sources at the base of the crust at the fault root. Present-day venting at detachment footwall, including Irinovskoe, is instead likely underlain by fluid circulation within the footwall, with outflow crossing the inactive detachment fault near-surface.