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Fluid chemistry of metamorphic quartz vein systems, Rhenish Massif (Germany)

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Formation of metamorphic veins in fold-and-thrust belts is generally related to crustal fluid flow and fluid-rock interaction processes. Fluid inclusions in metamorphic veins record the chemical composition of metamorphic fluids and their evolution with time. This project investigates the fluid chemistry and mechanisms of mass transfer in metamorphic vein systems in the Rhenish Massif (Germany) by combination of field and fluid inclusion studies, isotope geochemistry and geochemical modeling. The project is part of the multidisciplinary research initiative FRACS (www.fracs.de) that aims at understanding the dynamics of vein formation processes at a fundamental level, and involves strongly linked collaboration between structural geologists, material scientists, hydrologists and geochemists.

Based on field documentation and structural mapping, the relative time sequence of deformation and vein forming events in the central part of the Rhenish Massif has been established. In particular, two main generations of metamorphic quartz veins were identified, which are (1) en-echelon vein sets in faults related to progressive compressional deformation, and (2) late stage extension veins with pronounced laterally extensive alteration zones. Following petrographic study, the fluid inclusion inventory of both vein types was characterized. Two main fluid inclusion types were identified, which are (1) aqueous two-phase inclusions with variable vapor bubble sizes (5-20 vol.%), which are present as pseudosecondary and secondary inclusions, and (2) aqueous two-phase inclusions with consistent small vapor bubble sizes (about 5 vol.%), which are present as secondary inclusions on late crosscutting trails.

Using a combination of microthermometry and LA-ICPMS analysis of individual inclusions, the chemical composition (major cation concentration, including Na, K, Ca, Mg, Fe etc.) will be determined. This analysis will provide the first consistent dataset of the solute inventory in low-grade metamorphic fluids. The measured fluid compositions will then be compared with those obtained from fluid-mineral equilibria modeling using a multicomponent-multiphase Gibbs energy minimization approach. This will address the question whether chemical equilibrium is attained during fluid-rock reactions in deep reservoirs and provide important constraints for reactive transport models.