Elemental partitioning in liquid-vapour fluid inclusion assemblages during sub-critical phase separation

K. RICKERS[1,2] V. LÜDERS[2] AND P. BLEUET[3]

[1] HASYLAB, D- 22603 Hamburg; karen.rickers@desy.de
[2] GFZ Potsdam, D-14473 Potsdam; volue@gfz.de
[3] ESRF, BP 220, F-38043 Grenoble; pierre.bleuet@esrf.fr

Fluid phase separation (boiling) can be the primary cause for major variations in fluid composition in many hydrothermal systems. Such variations commonly lead to extreme enrichments of important metals and to the formation of ore deposits. Boiling produces a vapour phase and a brine which can chemically be very different from each other and from their parent fluid. Ideally, fluid inclusions can provide a direct link between hydrothermal minerals and the fluids that formed them. Analyses of fluid inclusions from boiling systems using Synchrotron radiation induced X-ray fluorescence (SR-XRF), therefore can reveal new insights into the partitioning of elements between the liquid and vapour phase.

The fluids studied here are hosted in quartz in miarolic cavities of the Torres del Paine complex (Chile). The granitic magma intruded into sedimentary host rocks and formed apophyses and cavities 12 Ma ago. The formation temperatures of hydrothermal quartz in vugs range between 280°C and 340°C. Fluid inclusion boiling assemblages are preserved in hydrothermal quartz.

Scanning and single point SR-XRF on fluid inclusions were performed at beamline L at HASYLAB using polychromatic excitation conditions to enable multi-element analysis of trace elements (Z = 20 – 92). To enhance better spatial resolution and lower limits of detection, additional experiments were performed at ID22 at the ESRF. Experimental conditions were optimised for the detection of lighter elements (Z = 15 – 42) using small beam sizes (3 x 4 μm^2). These parameters are optimal for the analysis of microscopic fluid inclusion (5 – 70 µm diameter) and minimum daughter crystal sizes (few µm). In addition, high spatial resolution 3D imaging of coexisting brine type and vapour-rich inclusions was performed at ID22 using fluorescence tomography. SR-XRF analysis display an extreme elemental partitioning during boiling processes: brines contain Mn, Fe, Ni, Zn, Br, Rb, Sr, Mo, Nb, Ag, Cd, Sn, Sb, Cs, W and Pb. In vapour-rich inclusions Mn, Fe, Ni, Cu, Zn, Rb, Sn, Sb and Pb were detected. Copper is always strongly enriched in the vapour phase. In some inclusions considerable concentrations of As, Fe, Mn, Zn and Pb were detected in the vapour phase as well. All other elements got concentrated in the liquid phase during phase separation. Elemental distribution maps and 3D tomography allowed daughter crystals to be analysed within individual inclusions thus contributing to their identification.