	Experiment title: Multi-element analysis of fluid inclusions of extreme boiling systems	**Experiment number**: EC45
Beamline: ID18F	**Date of experiment**: from: 15.6.2006 to: 20.6.2006	**Date of report**: 31.8.2007
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Report:

Samples

Fluid inclusions in minerals are small blebs of liquid which are trapped in the Earth's crust during the growth of minerals. The included liquid is a remnant of fluid phases present in the Earth's crust where those liquids are responsible for rock and mineral formation. Thus, inclusions in minerals enable to study element transport and enrichment processes in otherwise inaccessible areas. Phase separation processes are believed to be responsible for chemical changes in fluids and for element enrichment processes finally resulting in the formation of ore deposits. The samples investigated here are from a natural system (Torres del Paine granite complex, Chile) where boiling assemblages with formation temperatures of 460 – 330°C are preserved in hydrothermal quartz formed between 340 and 280 °C. These samples allow to have an insight on element redistribution during boiling.

Experimental method

Doubly polished chips of quartz hosting liquid and vapour inclusions have been mounted on a standard sample holder at ID18F. The inclusions of interest have been identified previously by microscopy and were measured during the experiment by micro fluorescence mapping. The incident energy was set to 21 keV in order to achieve simultaneous detection of elements with atomic numbers between 17 (Cl) and 42 (Mo). The beam was focussed with CRL optics to a spot size of 1.7 μm (vertical) x 4.5 μm (horizontal). This spot size was well suited for detection of elemental distributions within the single fluid inclusions as well as to measure rather small inclusions of a diameter of below 10 μm. Area scans were performed on different generations and types of fluids.

Results

SR XRF maps on more than 20 single fluid inclusions revealed the elemental distribution within the inclusions and allowed a relevant interpretation on the behaviour of trace elements during sub-critical phase separation. The elements Mn, Fe, Ni, Zn, Br, Rb and Pb were recognized to be omnipresent in liquid inclusions while Cl, Ge, Ga, Sr, Mo, Nb, Ag, Cd, Sn, Sb, Cs and W could only be detected occasionally. Vapour-rich inclusions are composed of the trace elements Mn, Fe, Cu, Zn, Rb, ± Sn, Sb and Pb. The comparison of compositions of coexisting liquid and vapour rich inclusions formed during sub-critical phase separation showed that for most studied pairs of liquid and vapour inclusions, Cu gets concentrated in the vapour phase. Most other elements get enriched in the brines (liquid phase) during boiling (Figure 1). In rare cases, Mo got also extracted into the vapour.
The results of this study are thus is agreement with the interpretation that in the Earth's crust Cu and Mo may get transported together in the vapour phase and that they may become deposited from the vapour during ore deposit formation. Therefore, the boiling process may be an effective process fractionating Mo and Cu from the liquid and also for fomation of ore deposits.

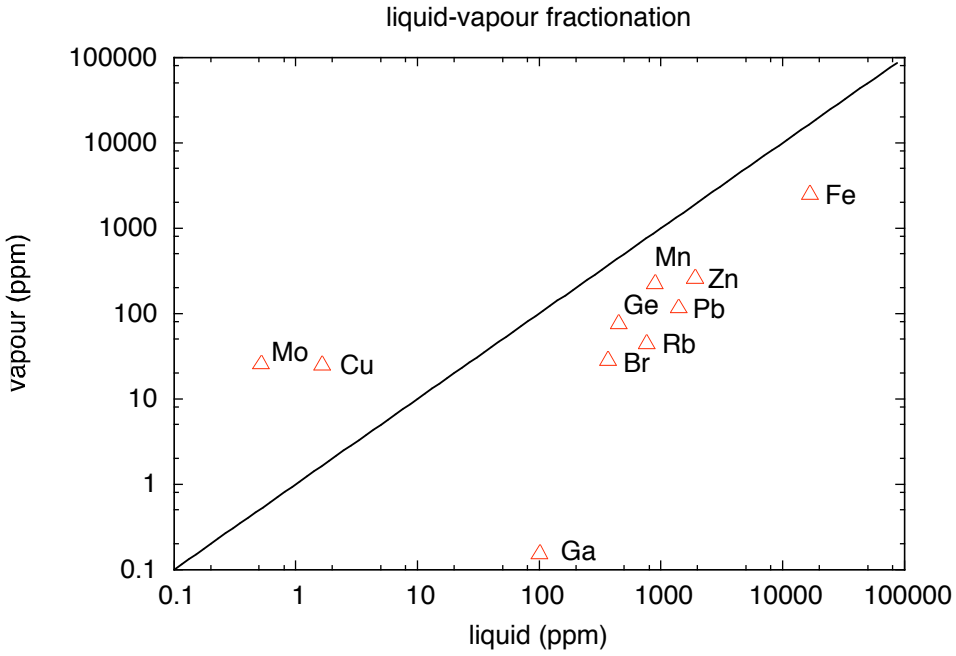

Figure 1: Example of element partitioning during vapour and brine during sub-critical phase separation.

Reference resulting from this experiment

Rickers, Karen, Bleuet, Pierre, Cauzid, Jean, and Lüders, Volker (2007) Elemental partitioning during sub-critical phase separation: evidence from SR XRF, fluotomography and X-ray absorption techniques of liquid-vapour fluid inclusion assemblages from the granitic Torres del Paine Complex, Patagonia, European Current Research on fluid inclusions (ECROFI XIX) University of Bern, Switzerland, 17th - 20th July 2007, Abstract Volume 60.

Related references from experiment performed at ESRF

Rickers, K., Cauzid, J., Hazemann, J.-L., Proux, O., and Lüders, V. (2007) Speciation of Cu and Zn in natural hydrothermal boiling systems: Evidence from fluid inclusion studies by X-ray absorption techniques, Goldschmidt 2007, 19th - 24th August, Cologne, Germany, Abstract Volume, 840.

Rickers, K., Lüders, V. and Bleuet, P. (2006) Elemental partitioning in liquid-vapour fluid inclusion assemblages during sub-critical phase separation, 16th Annual VM Goldschmidt Conference, Melbourne, Australia, 27.8. – 1.9.2006.