

## Distribution of solutes between coexisting steam and water: Test of the new equation of state

N.N. AKINFIEV

Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry RAS, Moscow, Russia  
(akinfiiev@igem.ru)

Boiling of hydrothermal fluid that brings to appearance of coexisting dense (liquid) and vapour phases is usually considered as a typical reason of ore deposition during natural fluids evolution. Thus the theoretical modelling of such processes is of great geochemical interest. Nevertheless it is to state that while description of equilibria in the dense fluids is rather reliable (Tanger and Helgeson, 1988), the low density fluids are bereft of an approach that takes into account the hydration of solute in the vapour phase.

The goal of this study is to apply the recently proposed equation of state (Akinfiiev and Diamond, 2003) for the description of liquid-vapour partitioning of various solutes to the critical temperature of water.

The master equation for the partitioning constant between vapour and liquid  $K \equiv m_{\text{vap}}/m_{\text{liq}}$  at given temperature  $T$  yields

$$\ln K = - \left[ \xi \ln \frac{\rho_{\text{vap}}}{\rho_{\text{liq}}} + \left( a + b \left( \frac{10^3}{T} \right)^{0.5} \right) \right] (\rho_{\text{vap}} - \rho_{\text{liq}})$$

and uses only three empirical parameters  $\xi$ ,  $a$  and  $b$  that can be estimated from the low temperature data. Here  $\rho_{\text{vap}}$  and  $\rho_{\text{liq}}$  stand for density of pure solvent (H<sub>2</sub>O) in coexisting vapour and liquid phases respectively.

This equation was successfully employed to describe partitioning of both volatile nonreactive solutes (H<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub> etc), and reactive solutes which undergo protolytic equilibria in water (CO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>S, B(OH)<sub>3</sub>, and even HCl) in the temperature range from 0 to 370°C. Some preliminary estimation for description of vapour-liquid partitioning of NaCl as a characteristic example of strong electrolyte was also implemented. The study was supported by grants RFBR 05-05-64139 and NSERC CRO.

### References

- Tanger IV J.C. and Helgeson H.C. (1988). *Amer. J. Sci.* **288**, 19-98.  
Akinfiiev N.N. and Diamond L.W. (2003) *Geochim. Cosmochim. Acta* **67**, 613-627.

## Fluid inclusion evidence for extreme element partitioning during subcritical phase separation

V. LÜDERS<sup>1</sup>, K. RICKERS<sup>1,2</sup>, D.A. BANKS<sup>3</sup>  
AND L. MESTON<sup>3</sup>

<sup>1</sup>GeoForschungsZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany (volue@gfz-potsdam.de)

<sup>2</sup>HASYLAB at DESY, Notkestrasse 85, 22603 Hamburg, Germany (karen.rickers@desy.de)

<sup>3</sup>School of Earth Sciences, University of Leeds, Leeds, LS2 9JT, UK (banks@earth.leeds.ac.uk)

Fluid phase separation (boiling) can be the primary cause of major variations in fluid composition in many land-based and marine hydrothermal systems. Such major variations commonly lead to extreme enrichments of important metals and to ore deposits. Subcritical boiling produces a vapour phase and a brine that can be chemically very different from each other and from their parent fluid. Under the best circumstances, fluid inclusions trapped in hydrothermal minerals can provide a direct link to the fluids that formed them. Therefore the study of fluid inclusions in minerals from boiling systems using Laser-ablation ICP-MS (LA ICP-MS) and Synchrotron radiation X-ray fluorescence (SR XRF) have revealed new insights on the partitioning of elements between the liquid and vapour phase.

SR XRF has the advantage of being non-destructive but is limited to higher Z elements ( $Z > 16$ ). LA-ICP-MS can detect all elements but is destructive and limited to 10 or less elements per ablation to achieve optimal results.

The fluids studied here are trapped as inclusions in quartz from cavities hosted by granitic rocks of the Torres del Paine complex, Chile. Primary boiling assemblages of vapour-rich and highly-saline (>30 eq. wt% NaCl) inclusions have been analyzed by LA-ICP-MS and SR XRF.

Qualitative results from SR XRF analysis reveal extreme element partitioning between the vapour and liquid phase. The brines are typically enriched in Mn, Fe, Ni, Zn, As, Br, Rb, Mo, Cd, Sn, Sb, Cs, Pb, W, Ce, Pr, Nd, and minor amounts of Ag, but Cu could not be detected. In contrast, most of the vapour-rich inclusions show strong signals for Cu and Fe, Zn, As, Sn, Pb, ±Mn, Rb, and Br.

LA-ICP-MS analysis shows that Cu and La are preferentially enriched in the vapour, Mn, Zn, Fe, Pb, Na and K are enriched in the high salinity brine, while Ca, Mg, Ni Li and Ti do not show clear partitioning into either phase. For example Cu concentrations in the vapour phase are c. 1000 ppm and c. 80 ppm in the brine. Zn concentrations in the vapour phase are c. 1200 ppm and c. 7500 ppm in the brine.