

The chemistry of seawater-like fluids reacted with gabbro at conditions below and above the critical point of seawater

O. Beermann (1), D. Garbe-Schönberg (1), A. Holzheid (1), C. Kusebauch (2,1)

(1) IFG, Institut für Geowissenschaften, CAU Kiel, Germany (ob@min.uni-kiel.de), (2) Institut für Mineralogie, Westfälische Wilhelms-Universität Münster, Germany

Hydrothermal systems in water depths >3000 m can run at extreme pressure (p) and temperature (T) conditions above the critical point of seawater (CP_{SW} ~ 298 bar and 407 °C [1]), if enough heat from magma injections is provided. Exactly this type of submarine hydrothermalism has recently been discovered [2]: a high-pressure system in 3000 m water depth at 5°S on the Mid Atlantic Ridge (MAR) emanating extremely hot fluids (>400°C), which contain high to very high concentrations of transition metals (e.g., Cu, Fe) and exhibit an unique rare earth element (REE) chemistry with LREE and HREE depletion and no Eu-anomaly ('special REE-signature') [3]. Current hypotheses explain the chemical composition of the high p-T MAR 5°S fluids by either re-dissolution of anhydrite previously formed in the sub-seafloor, or deriving from a 'reaction zone fluid' leaching the oceanic crust at p-T conditions above the critical point of seawater [2, 3].

There is a large deficiency in experiments studying the REE distribution in fluids reacting with original rocks from the oceanic crust, e.g. MOR basalt and gabbro, in particular at p-T-conditions typical for deep water slow-spreading ridges. We experimentally investigated the effect of major mineral gabbro composition on the fluid chemistry using cold seal pressure vessels (CSPV) at 400 bar and at 375 and 425 °C – conditions below and above CP_{SW} . Mixtures of plagioclase (plag) and clinopyroxene (cpx) grains sized 125-500 μ m reacted in gold capsules with 3.2 wt.% $NaCl_{(aq)}$ fluid (similar to seawater salinity) containing in addition ~ 4 ppm Ca and ~ 14 ppm Mg at a fluid/rock ratio of ~ 10 and at a run duration of 3, 10 and 30 d. The reacted fluids were extracted after quenching, and analysed by ICP-OES and ICP-MS. Significant chemical changes in the reacted fluid composition were observed for the major elements Mg, Na, and K varying systematically with starting mineral composition, run duration, and temperature. Only in cpx bearing systems Mg fluid concentration decreased, and Ca increased with both T and run duration. This suggests fluid-solid Mg-Ca exchange reactions during cpx alteration. Fluids reacting with plag are depleted in K, being independent on T or run duration and pointing towards K-Na exchange reactions. In all reacted fluids the concentrations of Rb, Sr, and Ba increased with decreasing Mg content resulting from cpx alteration. The concentration of REE- and transition metals were mainly below or close to the detection limit in fluids containing Cl but no sulfate.

First water-rock interaction experiments below and above CP_{SW} using natural sulfate bearing seawater (containing ~ 900 ppm S) indicate that sulfur enforces gabbro alteration and enhances the REE and transition metal concentrations of reacted fluids accompanied by the formation of a 'special REE- fluid signature'. However, because of possible precipitation of REE- and transition metal bearing phases during/after quenching [4] more data are needed by *in situ* sampling of fluid phases, e.g. single phase fluid as well as coexisting liquid and vapor- or brine and vapor phases. Those experiments are in preparation by using a large volume hydrothermal reactor (PARR®) equipped with a flexible Au reaction cell system and two individual sampling tubes allowing *in situ* sampling of both, single or two phase fluids below or above CP_{SW} .

References:

- [1] Bischoff J. L. and Pitzer K. S. (1985) *EPSL* **25**, 385–397
- [2] Koschinsky A., Garbe-Schönberg D., Sander S., Schmidt K., Gennerich H.-H., and Strauss H. (2008) *Geology* **36**, 615–618
- [3] Schmidt K., Garbe-Schönberg D., Bau M., and Koschinsky A. (2010) *GCA* **74**, 4058–4077
- [4] Seewald J. S. and Seyfried [Jr.] W. E. (1990) *EPSL* **101**, 388–403