

Multiple hydrothermal fluid flow in the NW Rhenohercynian

J. SCHNEIDER¹, M. CHATZILIADOU², S. SINDERN²,
CH. HILGERS² AND U. KRAMM²

¹Department of Geology and Centre for Archaeological Sciences, K.U.Leuven, Celestijnenlaan 200E, B-3001 Leuven, Belgium (jens.schneider@geo.kuleuven.be)

²Institut für Mineralogie und Lagerstättenlehre, RWTH Aachen, Wüllnerstr. 2, D-52062 Aachen, Germany (sindern@rwth-aachen.de)

The NW Rhenohercynian belt of the Central European Variscan orogen, studied in the northern Eifel area, was affected by several pre-, syn- and postorogenic hydrothermal events.

Investigation of core material from the RWTH-1 drill hole in Aachen revealed mineralogical, geochemical and structural evidence of intense Variscan hydrothermal activity. Recently published temperatures of up to 370 °C (Lögering *et al.* 2006) but low illite 'crystallinites' can only be explained by a short duration (< 10000 a) of this hydrothermal event, which was initiated by dewatering of sedimentary rocks during Variscan compressional tectonics. This synorogenic fluid flow did not result in significant large-scale element transfer, except for nitrogen which was incorporated into clay minerals as ammonium.

Important postorogenic, sandstone-hosted Pb-Zn deposits in the northern Eifel have been dated at 170 ± 4 Ma (Schneider *et al.* 1999). This Jurassic event caused large-scale element mobilisation in the Palaeozoic sedimentary rocks, as indicated by the homogeneous Pb isotope signatures of the sulfide ores. However, new geochronological data give evidence for at least one Cretaceous hydrothermal remobilisation event in the NW Rhenohercynian. Direct Rb-Sr-dating of non-economic vein sphalerites from the Sandgewand fault (Hastenrath near Stolberg) yields an age of 134 ± 2 Ma, while the Pb isotope signatures of these ores are identical to the Jurassic ones.

Thermal spring waters in Aachen represent the youngest stage of hydrothermal events in the NW Rhenohercynian. They are characterized by high concentrations of particle-bound Zn. Isotope ratios of Pb and Sr determined directly on water and sinter samples indicate several metal sources, such as postorogenic base metal ores but also evolved Devonian-Carboniferous sediments and a yet unidentified source characterized by unradiogenic Pb isotope signatures.

References

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The Cr isotope label of the solid Earth and hydrothermal pathways

R. SCHOENBERG, S. ZINK, M. STAUBWASSER AND
F. VON BLANCKENBURG¹

Institute for Mineralogy, Leibniz University of Hannover, Callinstrasse 3, D-30167 Hannover, Germany

The Cr isotope compositions of Earth's major silicate rock reservoirs and Cr-bearing minerals of metamorphic and high-temperature hydrothermal origin were obtained by high-precision double-spike MC-ICP-MS Cr measurements.

The principle igneous reservoirs of the Earth share a common stable Cr isotope composition. Within the 95% confidence interval, Student's *t*-tests do not allow to distinguish the Cr isotope compositions of seven mantle lherzolites ($\delta^{53/52}\text{Cr}_{\text{SRM979}} = -0.104 \pm 0.110\text{‰}$; 2 SD), ten ultramafic cumulate rocks ($-0.119 \pm 0.113\text{‰}$) and six continental and oceanic basalts that represent partial mantle melts ($-0.151 \pm 0.050\text{‰}$). Thus, unlike suggested for Fe isotopes [1], partial mantle melting does not appear to fractionate Cr isotopes. The average $\delta^{53/52}\text{Cr}_{\text{SRM979}}$ value of $-0.082 \pm 0.058\text{‰}$ for 12 different chromitite seams from the Bushveld and Great Dyke layered igneous intrusions is identical to that of the silicate igneous Earth reservoirs. This again supports the notion that Cr isotopes do not fractionate during partial mantle melting, since chromites crystallize from Cr-rich partial mantle melts that enter an overlying magma chamber containing an evolved Cr-depleted liquid. The Cr isotope compositions of Cr(III)-bearing uvarovite and fuchsite minerals from amphibolite-facies metamorphic terranes are also equal to those of igneous rock reservoirs. Since partial mantle melting and metamorphism do not involve redox-changes for Cr and differences in the Cr-ligands of solids and melt, high-temperature isotope fractionation appears to be too small to be detectable.

However, crocoite (PbCr(VI)O_4), a mineral that forms in oxidizing zones of high-temperature hydrothermal systems, shows $\delta^{53/52}\text{Cr}_{\text{SRM979}}$ values from +0.640 to +1.037‰. Precipitation experiments of crocoite from Cr(VI) solutions reveal (equilibrium) isotope fractionation with $\Delta^{53/52}\text{Cr}_{\text{crocoite-Cr(VI)aq}} \approx 0.1$ to 0.2‰. This is too small to explain the heavy Cr isotope compositions of crocoite. One possible explanation is that oxidation of dissolved hydrothermal Cr(III) to Cr(VI) is accompanied by isotope fractionation. Alternatively, Cr behaves like its chemical twin Se that only fractionates during reduction [2]. Partial Cr(VI) reduction [3] may explain the heavy compositions of the crocoites, which in turn allowed quantification of redox-changes along the hydrothermal pathway.

References

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