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Analysis of crush leach solutions from hydrothermal ore deposits by combining ion chromatography (IC) and total reflection X-ray fluorescence spectroscopy (TXRF)

S. Ladenburger, M. Marks, and G. Markl

Fachbereich Geowissenschaften, Eberhard Karls Universität, Tübingen, Germany
(sara.ladenburger@student.uni-tuebingen.de)

Fluid inclusions are the only direct source of information on the chemical composition of mineral forming fluids and can be used to reconstruct the formation conditions of ore deposits (Shepherd 1985). The analysis of fluid inclusions by the crush-leach method has been widely used (Bottrell & Yardley 1988; Banks et al. 2000). This technique represents a bulk method where the average composition of the fluid inclusions present in a specific sample is determined. Therefore, a detailed characterization in terms of fluid petrography and microthermometry is mandatory before analysis, in order to identify suitable samples, which contain ideally only one type of fluid inclusions.

We present here a combination of IC and TXRF for analyzing the major, minor and trace elements in hydrothermal ore-forming fluids. To date, TXRF is still barely used in geosciences, although it combines the advantages of low to very low detection limits (ppb to sub-ppb range), small sample amount needed (μl-range) and a relatively fast and inexpensive analytical procedure. The combination of these two methods was applied to quartz samples from hydrothermal veins of the Schwarzwald ore district, SW Germany. Quartz was preferred over fluorite because of its high purity and low solubility, minimizing potential contamination effects during the analytical procedure.

Based on microthermometric characterization we are able to distinguish between three distinct fluid types: a low salinity ($\leq$ 10 wt. % $NaCl_{eqv.}$), an intermediate (10 – 20 wt. % $NaCl_{eqv.}$) and a high salinity (20 – 25 wt. % NaCl + $CaCl_2$) type. Major cations in the analyzed fluids are Na, K and Ca, with Cl being the dominant anion. Cl/Br rations vary between 60 and 430.

Based on our IC and TXRF data, minor and trace metals include Li ($\leq$ 1300 ppm), Rb ($\leq$ 70 ppm), Sr ($\leq$ 1500 ppm), Ba ($\leq$ 7000 ppm), Fe ($\leq$ 2500 ppm), Mn ($\leq$ 400 ppm), Ni ($\leq$ 200 ppm), Cu ($\leq$ 800 ppm), Zn ($\leq$ 10000 ppm), Pb ($\leq$ 2000 ppm), and As ($\leq$ 300 ppm).

Our data provide detailed insights into the chemical composition of upper crustal ore-forming fluids. The combination of IC and TXRF allows for the simultaneous quantification of a large number of major, minor and trace elements in hydrothermal fluids out from one bulk solution.

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