LA-ICP-MS analysis of trace and rare earth elements in carbonate fracture fillings from Granitoid Rocks (Sweden)

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Trace elements (TE) and rare earth elements (REE) commonly coprecipitate in secondary carbonates and provide valuable information about the fluid chemistry and system parameters at the times of their formation. REE share similar chemical properties with trivalent actinides and are therefore used as analogues to estimate the retention potential of crystalline host rock fractures.

Here we apply high-resolution 2D element analysis (μXRF and LA-ICP-MS) to scan for the trace elements Na, Mn, Fe, Sr, Y, La, Ce, Yb, Pb, Th and U coprecipitated in low-temperature calcite fracture fillings originating from exploration drill cores from the sites Simpevarp, Laxemar and Forsmark (Sweden) [1]. The generated element maps highlight microstructures and growth zones within the fracture fillings. Conclusions on the palaeohydrological evolution of the fracture network can be drawn by them. Evidence of face dependent partitioning within the same concentric growth zones shows that sector related preferential coprecipitation of the measured trace elements occurs in three clusters with major enrichment in Mn-Fe-Sr, Y-Yb-U and Na-La-Ce-Pb-Th.

The calculation of the partition coefficient D_{TE} (Equation 1) is based on the trace and rare earth element assemblage of the most recent growth zone and associated formation waters. Compared to experimentally generated coefficients [2] (and references mentioned therein) and values derived from a 17-year precipitation experiment carried out at the Äspö Hard Rock Laboratory [3], D_{TE} ratios of the light REE La and Ce are relatively high, whereas for Sr and U D_{TE} ratios are remarkably low.

References

[1] Tullborg, Drake & Sandström (2008), *Applied Geochemistry* 23, 1881-1897.

[2] Curti (1999), *Applied Geochemistry* 14, 433–445.

[3] Drake, Mathurin, Zack, Schäfer, Roberts, Whitehouse et al. (2018), *Environmental Science & Technology* 52, 493–502.

$$D_{TE} = \frac{(TE/Ca^{2+})_{solid}}{(TE/Ca^{2+})_{liquid}} \qquad \text{Equation 1}$$