

## Calcium & iron carbonates from Erzberg - New insights from stable, radiogenic & clumped isotope data

*Boch, Ronny (Graz University of Technology, Institute of Applied Geosciences, Graz, AUT); Kluge, Tobias (University of Heidelberg, Institute of Environmental Physics, Heidelberg, GER); Wang, Xianfeng (Nanyang Technological University, Earth Observatory of Singapore, Singapore, SGP); Leis, Albrecht (JR-AquaConSol GmbH, Graz, AUT); Lin, Ke (Nanyang Technological University, Earth Observatory of Singapore, Singapore, SGP); Pluch, Hannes (VA Erzberg GmbH, Eisenerz, AUT); Melcher, Frank (Montanuniversität Leoben, Chair of Geology & Economic Geology, Leoben, AUT); Dietzel, Martin (Graz University of Technology, Institute of Applied Geosciences, Graz, AUT)*

The iron ore deposit Erzberg represents one of Austria's most prominent geo-sites due to its historic and economic value. It is mainly composed of various carbonates including the dominant minerals siderite, ankerite, (Fe-)dolomite and calcite, as well as scarce and often laminated aragonite-calcite veins ("erzbergite") which precipitated in major vertical fractures. During several sampling campaigns, typical Fe- and Ca-(Mg)-carbonate host rocks and erzbergite veins, as well as modern waters distributed on-site were recovered. Stable, radiogenic and multiply-substituted (clumped) isotope measurements were conducted in order to better understand distinct aspects of genetic, diagenetic and metamorphic origin, and the hydrochemical evolution of modern and past water flowing through the fissured carbonate aquifer at Erzberg.

Radiometric  $^{234}\text{U}$ - $^{230}\text{Th}$  age determination based on the constant decay of  $^{238}\text{U}$  incorporated into  $\text{CaCO}_3$  yielded absolute ages from  $285.1 \pm 3.9$  to  $1.03 \pm 0.04$  kyr BP for different erzbergite samples ( $n=20$ ). The vast majority of samples were dated with high precision, i.e. typical age uncertainties ( $2\sigma$ ) from 0.5 to 1 % (decades to few hundred years). Unexpectedly, all vein samples collected from fractures on-site are younger than the last glacial maximum ( $< \sim 20$  kyr BP). Thus, considering the erzbergite formation mechanisms (Boch et al., 2018), the fractures themselves seem of young age too. Clumped isotope measurements of erzbergite aragonite ( $n=7$ ) revealed cool to near-freezing (water) temperatures of  $\sim 0$  to  $10 (\pm 5)$  °C, i.e. a rare case of aragonite crystallization at low temperature. This temperature range is i) in line with a higher elevation alpine meteoric setting restricted by recurrent freezing (and dryness) during cool climate intervals and ii) corroborated by meteoric paleo-fluid  $\delta^{18}\text{O}$  isotope compositions ( $-11.8$  to  $-8.7$  ‰ VSMOW) inferred from the aragonite  $\Delta_{47}$  and  $\delta^{18}\text{O}$  analyses, as well as by similar  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  isotope signatures of small water flows encountered in fractures today. The stable H and O isotopes of modern waters further support distinct local differences regarding the water infiltration areas and hydrochemical evolution at Erzberg. The latter includes processes such as sulfide oxidation and prior  $\text{CaCO}_3$  precipitation in the aquifer. A broad range of stable C versus O isotopic compositions of siderite, ankerite, calcite and aragonite supports lime-/dolostones as the principal source rock for erzbergite formation. First clumped isotope data of the iron ore host rocks siderite and ankerite will be presented.