# Dating of mineralisation and ore formation by U-Pb small scale isochrons

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Various radiogenic isotope systems are used for dating crystallization and re-crystallization of mineral assemblages in earth crust. Whereas in general these methods are very successful to date magmatic and metamorphic events, there are rocks and processes that often cannot be dated as appropriate accessory minerals are absent and temperatures were below the closure temperature of common thermo-chronometers. Many mineralisation of economic interest occur as a consequence of uplift and erosion at relatively shallow crustal levels, e.g. from hydrothermal vein systems. Although many aspects of their formation is well constrained the timing with multiphase (re-)crystallisation, especially during their exhumation, is poorly understood. So far radiometric methods fail to unravel the complex evolution of mineralisation and ore formation.

The application of the U-Pb method for dating low-U minerals, such as carbonates, was until very recently hampered by its heterogeneity in the cm-scale. Minerals often crystallize episodically and are intergrown with each other. Isotopic equilibration is reached only at a small scale as the initial Pb composition is a mixture of Pb from the fluid and dissolved minerals at the site of crystallization. While Pb isotopes equilibrate the U/Pb is variable at the µm-scale. Both of it is required for dating by the U/Pb isochron method but it requires sampling of the analysed material at high spatial resolution. Thus, the LA-SF-ICPMS appears to be the method of choice for dating carbonates and other minerals - theoretically as young as ca. 0.4 Ma- despite of the relative low U (<5 ppm) content. As this has to be applied usually at a scale of <1cm the method is best described as U/Pb small scale isochron (SSI) ages.

The potential of the method for dating different types of mineralisation will be demonstrated using various examples, e.g. from the Black Forest, the Alps, the Upper Rhine Graben valley, and the Mountains pass mine. These example show that it allows unrevealing complex histories, where minerals formed episodically during short distinct periods.