EDX analyses of U-rich microminerals both for geochronology and hydrogeology – examples from recent studies in Austria

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Introduction

Due to the radioactive decay of uranium, U-rich microminerals like uraninite, uranothorite or coffinite can be used to determine the age of geological processes. Under certain conditions, uranium is highly water soluble – therefore the investigation of U-rich microminerals is also of interest for hydrogeology.

Within the last years, the Geological Survey (since 1.1.2023 GeoSphere Austria) was involved in some projects investigating Uranium-bearing microminerals by means of scanning electron microscopy – both for hydrogeological and economical geology.

In several Austrian regions there appears groundwater with an uranium concentration over the national threshold value for drinking water which is 15 µg/l (Berka et al., 2014 and Schubert et al., 2018). The high uranium contents in groundwater appears mostly in orthogneisses of Alpine regions and in the dry basins in the East (eastern Molasse basin, Vienna basin and western margin of the Pannonian basin, fig. 1).

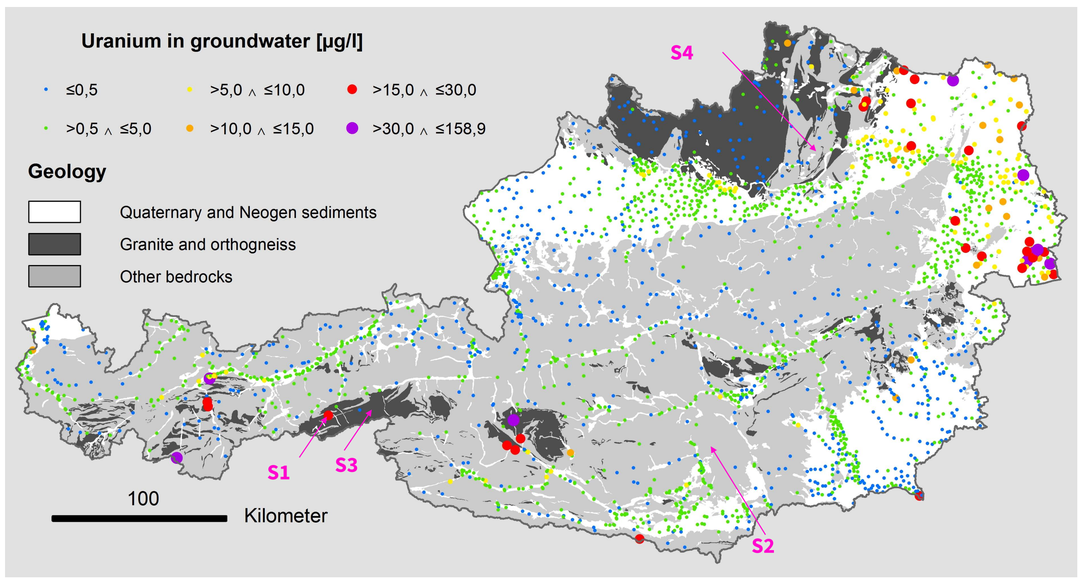


Fig. 1: Uranium in national groundwater observation wells and springs (Berka et al., 2014): the highest uranium content is mostly associated with orthogneisses in the Alps and with Neogene–Quaternary basins in NE Austria. Samples for the geochronological analyses were taken at the locations S1 to S4 (right side).

Recent studies

Within the DaFNE-project "uranium in groundwater", for the first time the mineralogy of aquifers was scanned by means of electron microscopy on the micro- and submicrometre scale (Humer et al., 2019). From 2016 to 2017 in the MRI-project "micro uranium minerals" the U-Th-Pb-analysis by electron microscope was improved and U-rich microminerals from the central Tauern window were dated chemically (Finger et al., 2017). Between 2018 and 2023 in the MRI-project DaMM ("dating of mineralisation processes by means of innovative micromineral analysis") such minerals were systematically used for the age dating of samples from Austrian ore deposits both in the Alps and in the Bohemian Massif (fig. 1 sample location S1 to S4). Furthermore, in both projects the influence of the U-rich microminerals to groundwater was taken under consideration.

Results hydrogeology

Concerning hydrogeology, it came out that in the crystalline regions a high uranium content in groundwater was always associated with abundant U-rich microminerals. This is not the case in the Neogene basins in the east of Austria. Here other sources should be taken under consideration (concentration of uranium by evaporation and redox reactions, uranium from phosphate fertiliser). It is also remarkable, that U-rich granites and orthogneisses are normally associated with high radon concentration in the groundwater whereas in the basins in the East the radon content is very low.

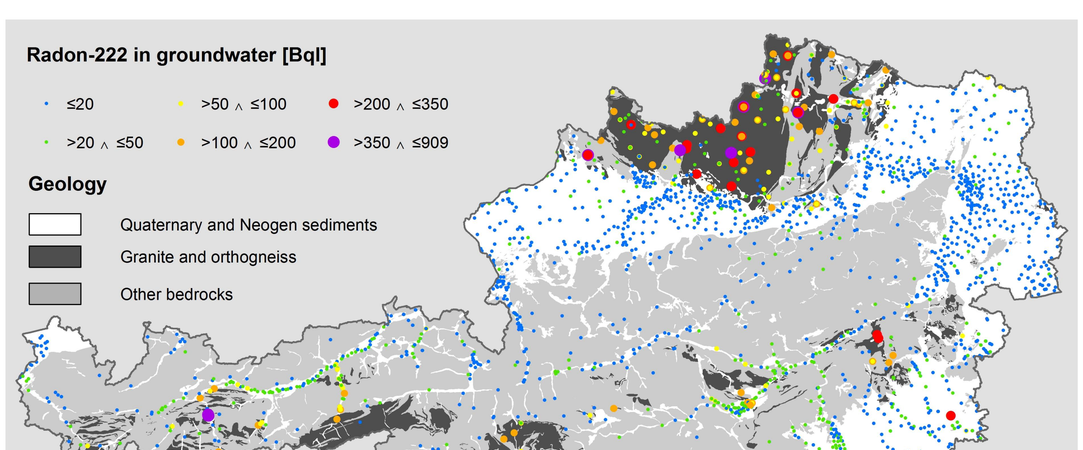
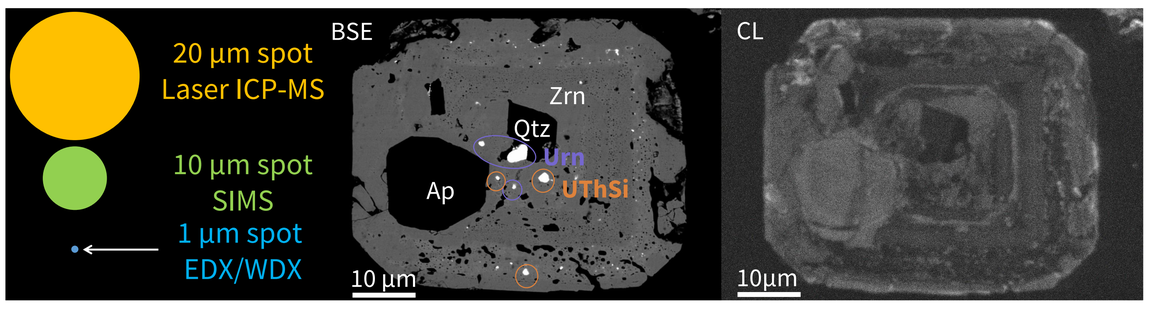


Fig. 2: ^{222}Radon in groundwater in wells end springs after Berka et al. (2014). The highest ^{222}Rn concentrations are associated with granites and orthogneisses which have a high uranium content. In spite of this, in the groundwater of the granites of the Bohemian Massif the uranium content of groundwater is normally low (fig. 1). The mineralogical reason for this is under investigation.

Results geochronology

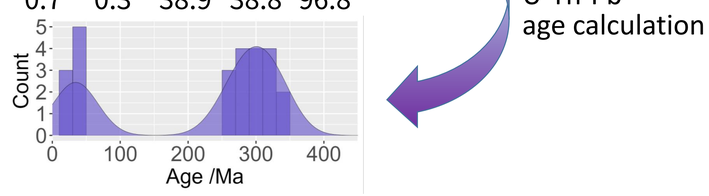
New energy dispersive X-ray (EDX) detectors have larger and more sensitive detector areas and better counting statistics. New electron microscopes have a better beam and current stability as well as current yield (Waitzinger 2018).
⇒ Spot size can be decreased to less 1 µm for accelerating voltages <= 15 kV

Ahorngneiss (S1)



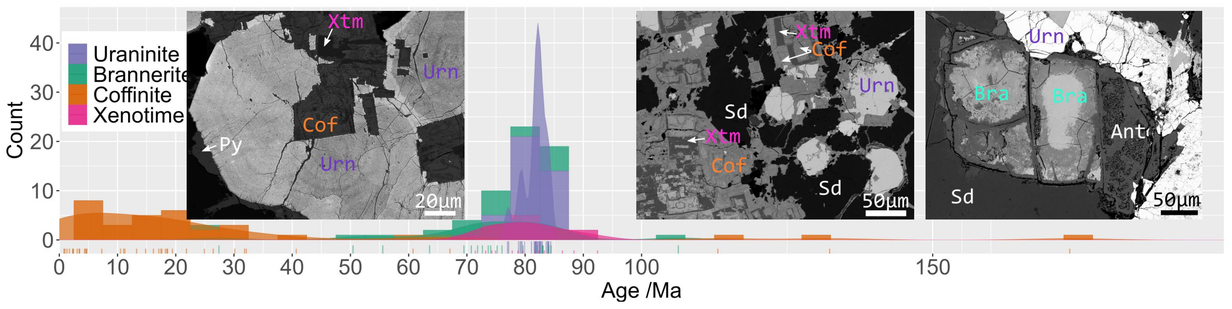
EDX

Name	Mineral	SiO_2	SO_3	Y_2O_3	PbO	ThO_2	UO_2	Total
Urn	Uraninite	0.5	-	4.0	3.9	7.8	82.2	98.4
Urn	Uraninite	0.4	-	0.9	3.8	9.7	81.3	96.1
UThSi	Thorite	18.1	-	0.7	0.3	38.9	38.8	96.8



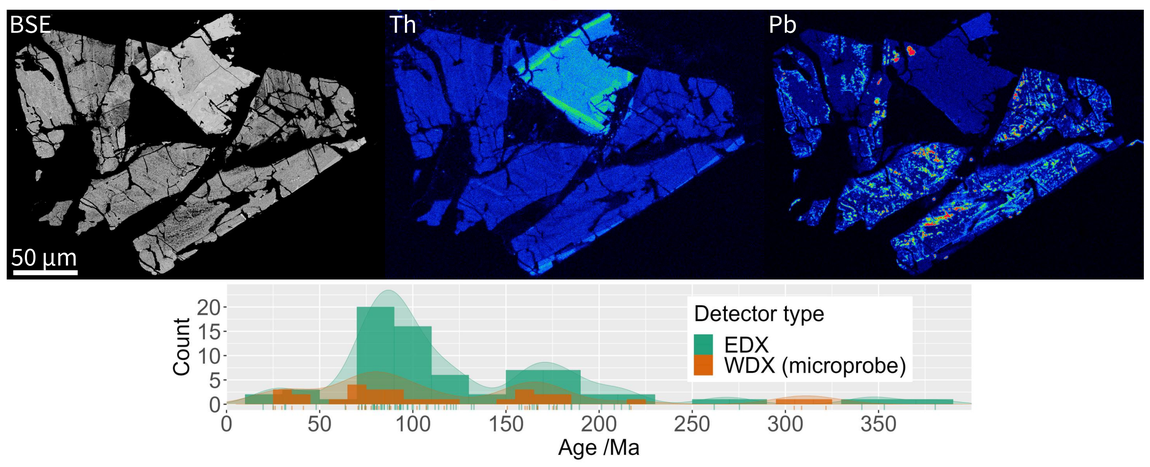
Uraninites (re)crystallised between the Permian and Variscan event, coffinite/thorite at the Alpine event.

Hüttenberg siderite deposit (S2)



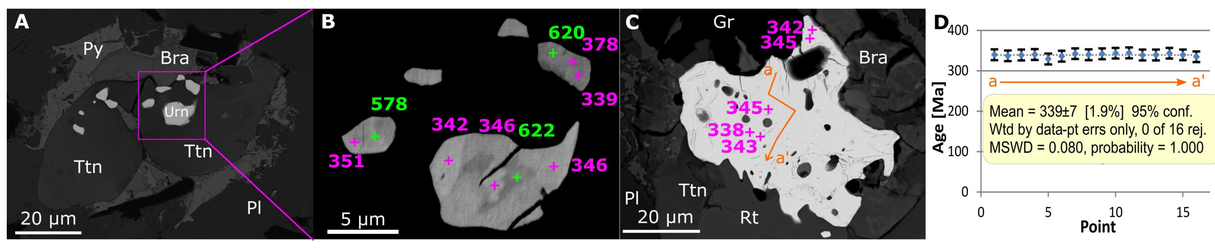
Crystallisation ages for uraninite, brannerite and xenotime are about 80 Ma. Brannerite and coffinite loose Pb (Waitzinger 2020).

Molybdenum-bearing Aplite gneiss from Reichenspitze (S3)



Both EDX and WDX show that calculated ages of the uraninites range from the Variscan to the Alpine orogeny.

Graphite mineralisations in the Bohemian Massif (S4)



Uraninites were formed during the Cadomian as well as the Variscan orogeny.

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