

Micro-fracturing induced by radioactivity of minerals: what consequences on the permeability of rocks?

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ABSTRACT

Some rocks may contain radioactive (U-Th) minerals (zircon, monazite, titanite, allanite, euxenite, uraninite...) ranging from micrometric to centimetric sizes (Figure 1). These minerals are therefore submitted to intense self-irradiation (i.e. α -decay of U and Th chains) that can lead to amorphization and also modify their environment by irradiating the host minerals.

Here, we focus on two examples of the effect of radiation damage within minerals and rocks from different localities. The first example¹ concerns uranothorianite (UTh) from the Tranomaro granulitic skarns (SE-Madagascar). These structures consist of UTh grains surrounded by both aluminous diopside (Figure 1 left) and calcite crystals. The second one² concerns accessory minerals (zircon, euxenite, xenotime) in rare-metal-rich pegmatites from southern Norway (Kragerø, Iveland-Evje); some of these minerals are rich in U (e.g. up to 15wt % for euxenite). In both cases similar features were described: presence of radiating cracks around the radioactive minerals and evidence of intense fluid circulation and elements transport through the fractures propagating inside rock. The conclusions of these observations are that irradiation (self and out), destroys the crystal lattice (amorphization) promoting the alteration of more or less destroyed parts. Amorphization induces volume increase, leading to the formation of cracks which eventually connected into a network through the rock. This fracturing allows fluid circulation, and promotes alteration of source minerals and dispersion of elements (e.g. Pb, U and strategic metals like Nb, Ti, REE). These observations highlight the importance of understanding the impact of radiation damage on radioactive transport by fluids passing through such fractured rocks.

The next step is to determine the consequences of irradiation (amorphization, fracturing) of these radioactive minerals on key parameters (porosity, permeability, tortuosity) involved in the transport of elements (via fluid) within rock and also to determine how to take into account the transfer of scale to assess the significance of these effects at the macroscopic scale (Figure 1).

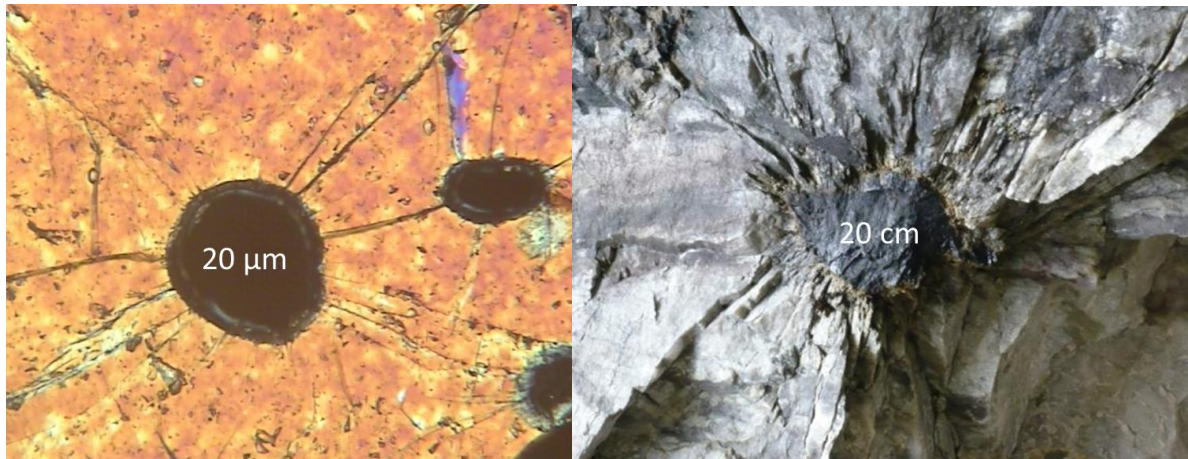


Figure1: U-Th-minerals micrometric (on the left urano-thorianite inside diopside) and centimetric (on the right allanite in pegmatite).

References

- 1-Seydoux-Guillaume A.M., et al. (2009). *Chem. Geol.* 261, 318-332.
- 2- Seydoux-Guillaume A.M., et al. (2015). *EPSL* 409, 43-48