Dating the polytypes of illite to decipher the successive hydrothermal events leading to the formation of ore deposits: example from uranium mineralization in the Athabasca basin, Canada.

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Résumé

Clays, and especially illite (K-rich clay), are ubiquitous minerals in hydrothermal ore deposits, and have been used to physico-chemically and timely constraint the formation of these systems. In the Athabasca basin located in Canada, high-grade uranium deposits are spatially associated with hydrothermalized structural trends that are likely the main conductor of hydrothermal fluids. The precise mineralogy and the timing of the alteration are not well defined, limiting our capability to identify the critical hydrothermal processes leading to the massive precipitation of uranium.
Because the clay fraction could contain multiple generations of minerals, the dating of illite is performed on separated size fraction using the K-Ar method. Assuming that the clay assemblage contains a mixture of only two illite populations, the set of individual dates can be extrapolated to determine two end-member dates reflecting the oldest and youngest geological events. This method requires the quantification of the proportion of the two populations of illite so to evaluate the dates at 0% and 100% of one population (100% and 0% of the other).

Assuming that the populations of illite differ in polytype, their quantification relies on XRD analyses performed on each clay fraction. In the proterozoic basin of the Athabasca, a unique mixture of only cv-1M and tv-1M authigenic polytypes is identified in hydrothermal zones in both basin and basement. Two innovating quantification methods are evaluated. The first relies on Rietveld modelling and the second on the comparison of the XRD diffractograms with patterns modeled by the Wildfire© software.

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Using this protocol, two distinct hydrothermal events are determined using the K-Ar and/or Ar-Ar method. The oldest age at 1333 ± 10 Ma is synchronous to the known U-Pb age for UO2 mineralization obtained on the same deposits, whereas the second ages at around 1100 Ma appears to be related to a hydrothermal event that disturbed the U-Pb isotopic system on UO2, without any contribution to the U resources. The two dates agree reasonably well with literature data on the timing of uranium mineralization and fluid circulation in the Athabasca basin, validating the quantification and dating method on the polytype of illite.

Mots-Clés: Argon dating, illite, XRD, uranium