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Alteration systems in the Shea Creek deposit (Athabasca Basin, Canada): contribution of radiation-induced defects in clay minerals for tracing past uranium migrations

elisa morichon (1,2), daniel beaufort (1), thierry allard (2), and jean-pierre milesi (3)

(1) Sciences Fondamentales et Appliquées, laboratoire HYDRASA, POITIERS, France (elisa.morichon@univ-poitiers.fr), (2) IMPMC, UMR 7590, 140 rue de Lourmel, 75015 Paris, France, (3) AREVA BU Mines, Tour Areva, 1, Place Jean Millier - 92084 Paris La Défense Cedex

The Athabasca Basin contains the uranium deposits with highest grade and highest tonnage in uranium actually known in the world, related to an unconformity between Mesoproterozoic sedimentary sandstones and Paleoproterozoic metamorphic basement rocks. These deposits are systematically surrounded by clay minerals in alteration halos, formed during the tectonic and hydrothermal events which instigated dissolution, transport and mineralization of uranium. Interactions between rocks and ionizing radiations naturally emitted by uranium and his daughters induce stable structural defects in clay minerals, which evidence the residence (ancient or recent) of radioelements near these minerals. These defects can be detected by electron paramagnetic spectrometry, and were studied in minerals such as quartz from Mesoproterozoic basins, and from kaolinite, dickite and dioctahedral smectites from recent environments (<50My).

In the Athabasca basin, the aim of the studies led since several years on radiation-induced defects in clay minerals is to trace the ancient pathways of uranium-rich fluids at several scales. Clay minerals are assumed to behave similarly under irradiation. At the global basin scale, radiation-induced defects are similar in nature, but their concentrations can widely vary over several orders of magnitude. The maximum fluctuations in defect concentrations are observed along the regional Paleoproterozoic unconformity between the lower sandstones and the basement rocks and close to crosscutting brittle structures. These discontinuities appear to be the main vectors of uranium-bearing fluids transfer in the basin. In the basement, some hudsonian faults connected to this unconformity also show high defect concentrations, attesting that uranium-bearing fluids may have circulated in the fractures network.

At the regional scale, the She114 drill-hole example (Shea Creek deposit), which intersects several mineralized orebodies in sandstones, at the unconformity and in the basement, consolidates the importance of the unconformity and the associated fractures network for the circulation of fluids. The defect concentration increases at proximity of the unconformity, as the light rare earth elements (LREE)-rich APS, contemporaneous of clay minerals. Moreover, the non-correlation between the defect concentration and the total dose rate confirms the existence of past migrations of radioelements, which occurred after the clays formation.