Evaluation of Fe-rich Silicates as the Reducing Agents in the Formation of Unconformity-related Uranium Deposits: Insights from Reactive Mass Transport Modeling

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Abstract

The understanding of the mechanisms leading to the formation of unconformity-related uranium (URU) deposits is a major scientific challenge. In this study, Fe-rich silicates are evaluated as the reducing agents in the precipitation of URU deposits using reactive mass transport model. The results show that Fe^{2+}, released by the destruction of Fe-rich silicates, can reduce the oxidized uranium present in the solution; and it can be considered as a viable mechanism in the deposition of uraninite. Uraninite co-precipitates with hematite in the basement away from the fault zone as a result of the redox process. The grade of the precipitated uraninite is higher than the grade of some URU deposits in Canada and Australia, and comparable with that of the Rabbit Lake uranium deposit in the Athabasca basin. Favorable physiochemical conditions such as pressure, temperature, oxygen fugacity, and pH are required for the formation of uranium deposits in relatively short periods of time of about 0.1–1 million years. Uraninite starts to precipitate in the areas experiencing reduction of oxygen fugacity and having temperature of 180-200 °C and a pH range of 2.5-4.5. Alteration halos developed around the deposit include hematite, Mg-chlorite, and muscovite as well as minor amounts of pyrite and K-feldspar alteration.