

Interaction between sedimentary rock and underground water at uranium deposits

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1. Introduction

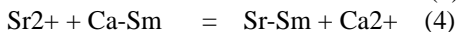
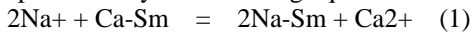
The clay minerals in uranium mine may play a role of reservoir in condensation of heavy metals, including uranium, by interaction with formation waters. In recent years, Iwatsuki et al. (1995) experimentally reacted the groundwater of the Tono uranium mine with a sedimentary rock around the mine, and indicated that the chemical composition (Na, Ca, HCO₃) of the ground water is possibly influenced by cation exchangeability of clay minerals and solubility of calcite. The purpose of this study is to investigate theoretically the interaction between sedimentary rock and formation water at Tono uranium mine by chemical modeling.

2. Experimental

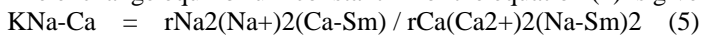
Major exchangeable-cations and heavy metals in the sedimentary rocks collected at the Toki lignite-bearing, the Oidawara and the Akeyo formations of the Tono uranium mine were extracted and analyzed. The extraction was carried out by batch-method, and the analysis was by AA(atomic absorption spectrophotometry), ICP and ICP-MS. The mineral compositions of the rocks were determined by XRD, SEM, and EPMA. The major components of the ground waters collected at the Tono mine (location 6) were determined by AA, IEC and ICP-MS.

3. Chemical equilibrium model

The ion-exchange equilibriums for major cations (Na⁺, Ca²⁺, K⁺, Mg²⁺ and Sr²⁺) between smectite and formation water are presented by the following equations:



The exchange equilibrium constant K for the equation (1) is given by:



By the equilibrium constants for the equations (1)-(4), the mass balance and by the amounts of exchangeable cations in rocks, the concentrations of cations in the formation water can be calculated as a function of total ion concentration (i.e., salinity).

4. Results

The amounts of major exchangeable-cations in the sedimentary rocks of the Toki lignite-bearing formation and the Akeyo formation are in the order of Ca²⁺, Na⁺, K⁺, Mg²⁺, Sr²⁺. The sedimentary rock of the Akeyo formation is characterized by a high K⁺ content compared with those of the Toki lignite-bearing formation. On the other hand, the sedimentary rock of the Oidawara formation is characterized by a low Na⁺ content and a high Mg²⁺ content, and its amounts of exchangeable cations are in the order of Ca²⁺, K⁺, Mg²⁺, Na⁺, Sr²⁺. The model calculation using these data showed that low-salinity waters equilibrated with the sedimentary rocks are comparatively high in Na⁺ concentration, while with increasing salinity Ca²⁺ concentration increases sharply. A comparison of the chemical model with the analytical data of the groundwater suggests that the clay minerals of sedimentary formation strongly influence the chemical composition of the formation waters. Such chemical modeling is applicable to understand the stability of sedimentary formation.

* Iwatsuki,T., Sato,K., Seo,T. and Hama,K. (1995) Mat.Res.Soc.Symp.Proc.Vol.353, 1251-1257. MRS, Pittsburgh, USA.