European Mineralogical Conference
Vol. 1, EMC2012-632, 2012
European Mineralogical Conference 2012

Pressure and temperature-induced trapping of radionuclides in natrolite: A case study for europium and iodine

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Selective ion-exchange is one of the fundamental properties of zeolites enabling in various environmental and industrial applications such as the remediation of radionuclides. Our previous work has been successful in preparing potassium-exchanged natrolite (K16Al16Si24O80, 16H_2O) which exhibits outstanding ion-exchange properties towards other monovalent and divalent cation. Exchange for trivalent cations, however, seemed not to be feasible through conventional ion-exchange method but can be induced under high-pressure and temperature conditions utilizing auxetic expansion behavior of the natrolite framework. This work is to develop the most desirable conditions for trapping trivalent cations into natrolite. Trivalent europium cation was chosen to simulate trapping radionuclides into potassium-natrolite (K-NAT). High pressure and temperature experiments were performed in two-folds. First, diamond-anvil cell (DAC) experiments were performed for in-situ acquisition of X-ray powder diffraction data. Second, ex-situ experiments were conducted using a large-volume press (LVP) to produce recovered samples in suitable quantities for further elemental analyses. Accordingly, we have demonstrated that, using pressure and temperature, trivalent europium cations can be immobilized in K-NAT, and the sample exchanged at 3.0 GPa and 250 [U+2103] contains about 4.7 europium cations per unit cell, which is equivalent to potassium exchange by over 90%. Our preliminary results of iodine trapping using silver-exchanged natrolite (Ag-NAT) will also be discussed.