A Study on Thermodynamics of Swelling Stress of Bentonite: Acquisition of Thermodynamic Data of Interlayer Water of K-Montmorillonite in Consideration of Alteration

*Misato Endo[1], Haruo Sato[1]

1. Okayama University

In the geological disposal of high-level radioactive waste, vitrified waste, which is a high-level radioactive waste, is buried in the geological formation deeper than 300m with engineered barrier. The engineered barrier is composed of vitrified waste, overpack (metal container) and buffer material from inside, and the outside is rock mass. Compacted bentonite in which bentonite and silica sand were mixed and compacted is used as a buffer material. The buffer material swells by contacted with groundwater, and seals space with rock mass and fractures in rock mass. The buffer material has a function of mechanical buffer with rock pressure, and swelling stress is important in this case. The alteration of bentonite may occur due to the replacement of cations (Na^+ ions initially) in the interlayer with K^+ ions upon contact with groundwater. In designing buffer material, it is necessary to consider the effect of cation exchange on the properties of the buffer material, but there are no studies on the swelling stress of K-bentonite. In this study, the authors prepared samples in which all cations in the interlayer of montmorillonite, the main component of bentonite, were replaced by K^+ ions, and obtained thermodynamic data of interlayer water as a function of water content using a relative humidity method. The activity and the relative partial molar Gibbs free energy of water were obtained as thermodynamic data. The activity and the relative partial molar Gibbs free energy of water decreased with decreasing water content in the region below approximately 15%. This behavior significantly differs from that of other ions such as Na. The swelling stress of bentonite was analyzed based on a thermodynamic model developed in earlier studies and thermodynamic data obtained in this study, and compared with measured data. The calculated results of swelling stress of bentonite occurred in the region of high density of 1.9Mg/m^3 with montmorillonite partial density. This indicates that K-bentonite scarcely swells under realistic design conditions.

Keywords: swelling stress, K-montmorillonite, thermodynamic data, interlayer water, relative humidity method