# Measurements of Thermodynamic Data of Water in Ca-Bentonite by Relative Humidity Method

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Buffer material (compacted bentonite), one of the engineered barrier elements in the geological disposal of a high-level radioactive waste, develops swelling stress due to groundwater penetration from the surrounding rock mass. Montmorillonite is the major clay mineral component of bentonite. Even previous studies provide few mechanical data on Ca-montmorillonite. Furthermore, there is almost no thermodynamic data on Ca-montmorillonite. In this study, thermodynamic data on Ca-montmorillonite were obtained by measuring relative humidity (RH) and temperature. The activities of water and the Gibbs free energies of water were determined from the experimental results, and the swelling stress of bentonite was calculated using the thermodynamic model. Ca-montmorillonite was obtained by replacing all interlayer cations (mainly Na) of Kunipia-F (99% Na-montmorillonite content, Kunimine Industries Co. Ltd.) with Ca and removing soluble salts beforehand. After the bentonite powder was dried, 2.00 g of each was placed in a weighing bottle and slowly absorbed water vapor in a polycarbonate vacuum chamber while at the same time a sensor was inserted to measure RH and temperature. The pressure in the vacuum chamber was -95 kPa below atmospheric pressure. RH, temperature, and mass were measured every about 24 hours.
The Ca-montmorillonite dehydration experiment was conducted as a function of water content after the Ca-montmorillonite was moisturized, as described above. The experiment was performed in a thermostatic chamber at 25˚C with a closed container in which an RH sensor, a temperature sensor and a weighing bottle with bentonite were inserted. Every about 24 hours, RH and temperature in the closed container were measured and the weight of the weighing bottle was measured to obtain water content. This operation was repeated every about 24hours.
The activities of water and the relative partial molar Gibbs free energies decreased with decreasing water content in water contents lower than about 25%. This trend was similar to that of Na-montmorillonite. The swelling stress calculated based on the thermodynamic model was approximately 17MPa at a montmorillonite partial density of 1.5Mg/m$^3$, and similar level as that of Na-montmorillonite.

Keywords: Radioactive waste disposal, Buffer material, Ca-montmorillonite, Bentonite

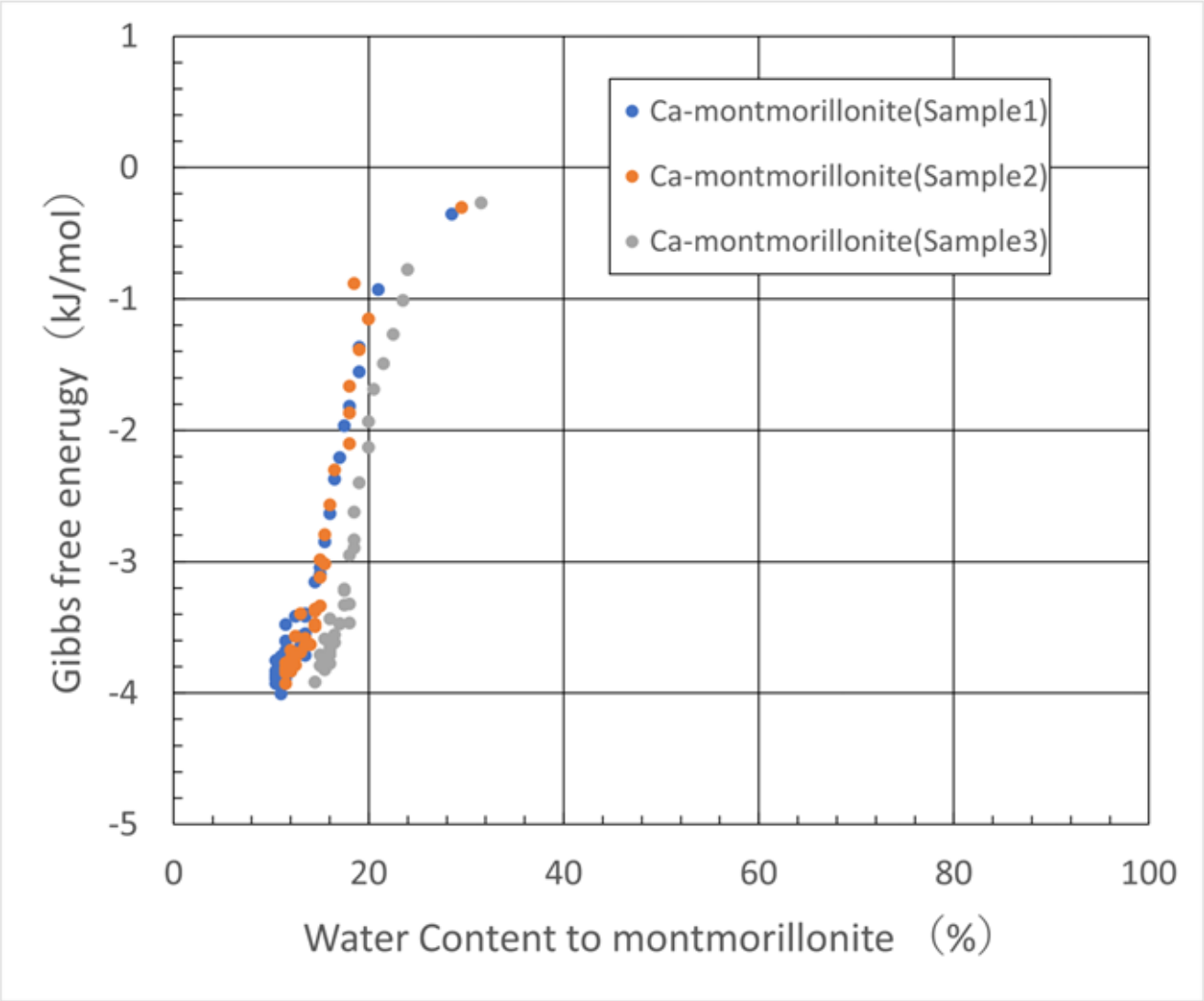


**Fig. Relation between Water Content to Ca-montmorillonite and relative partial molar Gibbs free energy for Ca-montmorillonite**

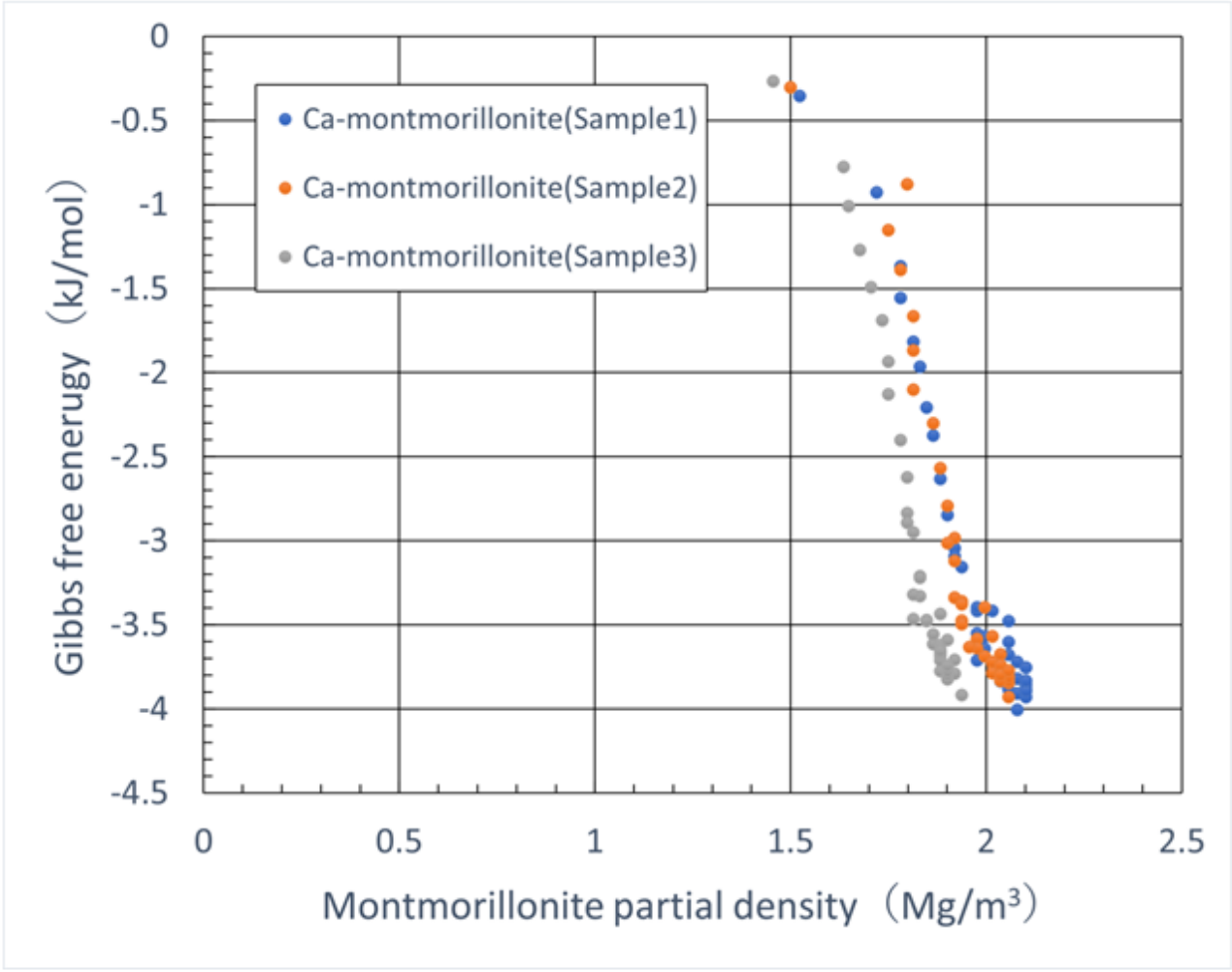


**Fig. Relation between Montmorillonite partial density and relative partial molar Gibbs free energy for Ca-montmorillonite**

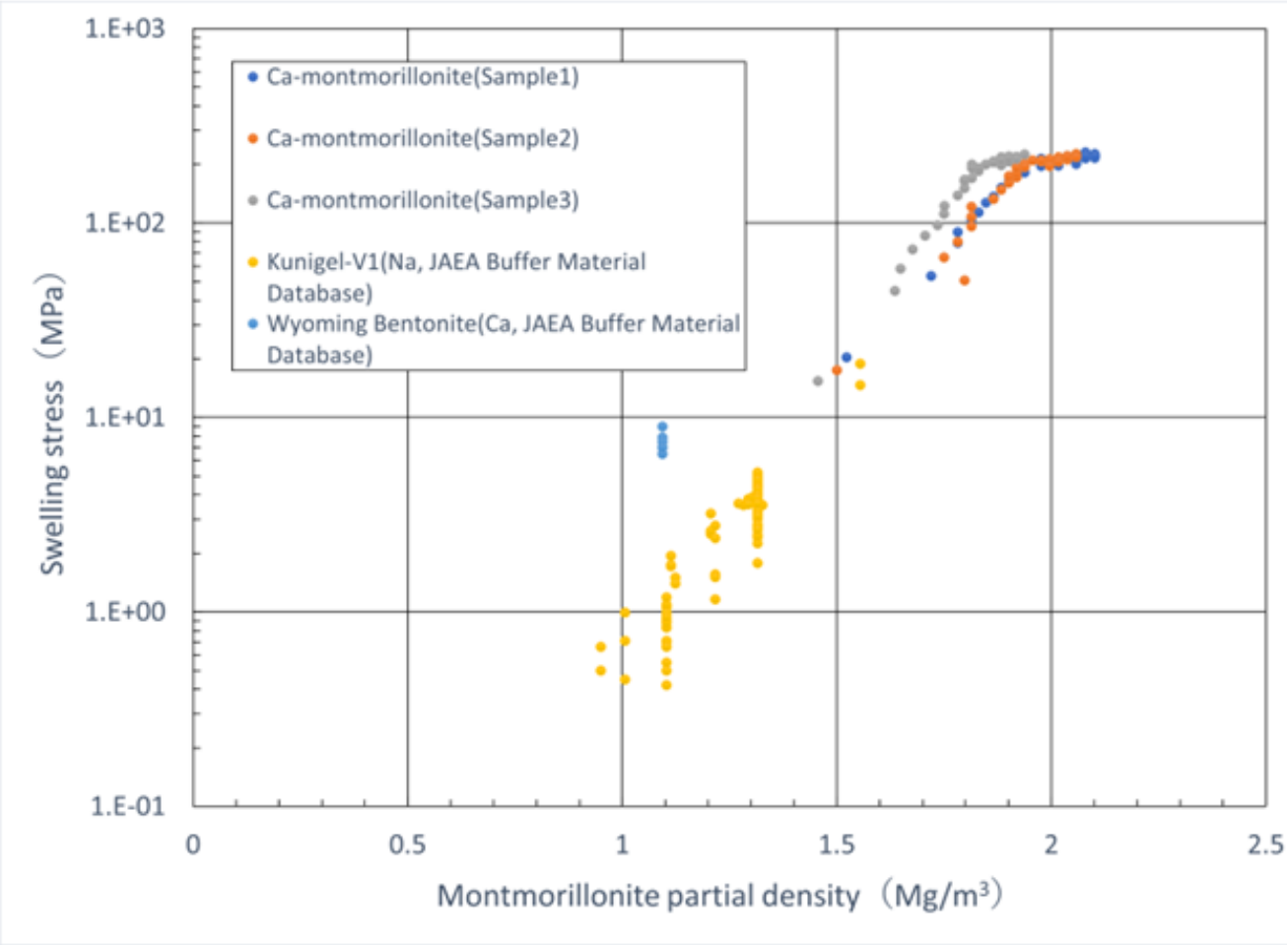


**Fig. Relation between Montmorillonite partial density and Ca-montmorillonite Swelling stress**