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Activation of a Ca-bentonite as buffer material

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Swelling behavior is an important criterion in achieving the low-permeability sealing function of buffer material. A potential buffer material may be used for radioactive waste repository in Taiwan is a locally available clayey material known as Zhisin clay, which has been identified as a Ca-bentonite. Due to its Ca-based origin, Zhisin was found to exhibit swelling capacity much lower than that of Na-bentonite. To enhance the swelling potential of Zhisin clay, a cation exchange process by addition of $Na2CO_3$ powder was introduced in this paper. The addition of $Na2CO_3$ reagent to Zhisin clay, in a liquid phase, caused the precipitation of $CaCO_3$ and thereby induced a replacement of Ca2+ ions by Na+ ions on the surface of bentonite.

Characterization test conducted on Zhisin clay includes chemical analysis, cation exchange capacity, X-ray diffraction, and thermogravimetry (TG). Free-swelling test apparatus was developed according to International Society of Rock Mechanics recommendations. A series of free-swelling tests were conducted on untreated and activated specimens to characterize the effect of activation on the swelling capacity of Zhisin clay. Efforts were made to determine an optimum dosage for the activation, and to evaluate the aging effect. Also, the activated material was evaluated for its stability in various hydrothermal conditions for potential applications as buffer material in a repository.

Experimental results show that $Na2CO_3$-activated Zhisin clay is superior in swelling potential to untreated Zhisin clay. Also, there exists an optimum amount of activator in terms of improvements in the swelling capacity. A distinct time-swell relationship was discovered for activated Zhisin clay. The corresponding mechanism refers to exchange of cations and breakdown of quasi-crystal, which results in ion exchange hysteresis of Ca-bentonite. Due to the ion exchange hysteresis, activated bentonite shows a post-rise time-swell relationship different than the sigmoid-shaped time-swell curves of typical bentonites. That is, a greater part of swelling strain develops after the completion of primary swelling strain.

At an optimal amount of 1% $Na2CO_3$ in weight, the maximum swelling strain was found to be 3 times as much as that of untreated Zhisin clay. Furthermore, the $Na2CO_3$-activated Zhisin clay exhibited improved resistance to thermal environments and behaved similar to Na-type bentonites under various hydrothermal temperatures.