Buffer Retardation Experiment for Radionuclides Under the Elevated Temperature Conditions: Strategy and Methodology Development for the Korean Bentonite

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1. Introduction

To validate the performance of buffer materials for the high-level radioactive waste disposal in Korea, understanding the properties of domestic buffer materials is a prerequisite. Bentonites are to be used as buffer materials in a geological repository designed to host high-level radioactive wastes. Under the repository conditions, the long-term behavior of bentonites in the engineered barrier system is of crucial importance in the geological timescale safety assessment as well as safety cases. KAERI has been investigating the long-term behaviors of the bentonite under the Korean granite environments.

The spent nuclear fuels generate decay heats for a very long time. Thus, the thermal criteria for the hosting buffer materials must be set for the disposal repository. In most countries, it is set to below 100°C, due to the possible transformation of the smectite to illite which will result in the loss of their requested properties including the swelling capacity. Recently, some efforts (*e.g.*, Grimsel Test Site (GTS) HotBENT Project) have been started to reconsider the thermal criteria for the buffer, because if the maximum temperature allowed for the disposal repository increases, the disposal density decreases dramatically [1]. This will help certain nation with a high population density, especially from a viewpoint of the national economy, site availability, and public acceptance. However, the database for the buffer retardation at the elevated temperature conditions (e.g., T > 150°C) are still lacking.

Here, we have developed a strategy and methodology for the Korean bentonite retardation experiments to rationally address the issues related to the thermal criteria. First, we have illustrated a scienario for the Korean bentonite in the disposal repository with time. Second, the alteration of the Korean bentonite in the absence and/or presence of the groundwater at the elevated temperatures must be investigated due to the buffer saturation period, which will likely take several-hundred years up to one thousand years. Lastly, we need to construct the database for the Korean bentonite retardation at the elevated temperature conditions for the radionuclides.

2. Conditions for the Korean buffer system with time

The condition for the Korean bentonite changes with time. In general, it is expected that the early stage of the SF disposal, the buffer system will be exposed to the elevated temperatures. Then, the system will be cooled down to the 'normal' temperatures. From the viewpoint of the wettability of the Korean bentonite, the bentonite will be dry at the early stage of the disposal, and then become wet. We have illustrated a condition for the Korean bentonite in the disposal repository with time (Fig. 1). This allows us to apply appropriate experimental methods to understand the phenomena related.

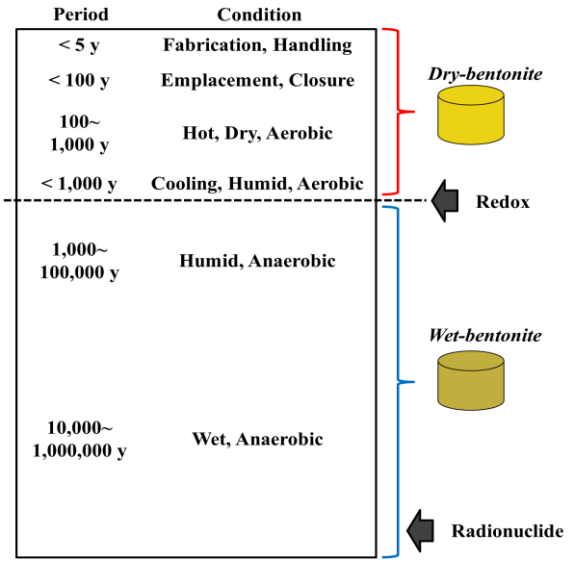

Fig. 1. Illustration of the conditions for the Korean buffer system with time (modified from Peter Keech's work).

3. Korean bentonite at the elevated temperatures

Prior to verify the retardation performances of the buffer for the radionuclides at the elevated temperature conditions, the performances associated with the buffer itself must be understood. Thus, the thermal properties, especially the thermal conductivity and specific heat, and related properties (e.g., density, etc.) for the Korean bentonite must be investigated at the elevated temperatures. In addition, the bentonite properties must be studied in the absence and/or presence of the groundwater at the elevated temperatures due to the buffer saturation periods, which will likely take several-hundred years up to one thousand years [2]. Furthermore, the most crucial factor for the bentonite alteration will be the mineral phase transformation, thus the mineralogical properties associated with the Korean bentonite scienario (Fig. 1) for the disposal is of crucial importance.

4. Database for the Korean bentonite retardation at the elevated temperature conditions

To verify the retardation performances of the buffer for the radionuclides, we need to construct the database for the Korean bentonite retardation at the elevated temperature conditions. We suggest two approaches on the methodologies related. One is to expose the bentonite to the target temperatures (e.g., 90, 120, 150^{o}C, and higher), then followed by the radionuclides sorption experiments. The other is to see any phenomena related to the bentonite-radionuclides interactions at the elevated temperatures simultaneously. Furthermore, the properties from the bentonite blocks as well powders must be equally and importantly considered, because some conditions are almost impossible to realize in the laboratory. For example, once the bentonite blocks are fully saturated, they become difficult to deal with for further experiments.

For the bentonite powders, sorption experiments can be suggested using autoclaves and other similar containers to apply bentonite solid, groundwater, and the heat (e.g., 90, 120, and 150^{o}C). However, for the bentonite blocks, a sorption test equipment to saturate and obtain the distribution coefficient is developed and designed.

5. Conclusion

The strategy and methodology for the Korean bentonite retardation experiments for the radionuclides are developed and suggested to verify the performance of buffer materials at the elevated temperature conditions. A scienario for the Korean bentonite in the disposal repository with time is suggested. At the elevated temperatures, the thermal and mineralogical properties of the Korean bentonite, as a powder as well as a block, in the absence and/or presence of the groundwater need to be investigated. The database construction suggested for the Korean bentonite retardation at the elevated temperature conditions for the radionuclides will further pursue and help in providing useful information on the scientific and technological reasoning behind the decision making for the disposal repository.

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