Study on the 3D Site-descriptive Model for the HLW Disposal Site Characteristics Evaluation

Soo-Gin Kim, Jae-Yeol Cheong, Jeong-Hwan Lee, and Jeong-Hyoun Yoon*
Korea Radioactive Waste Agency, Deajeon 34129, Republic of Korea
*jhyoon@korad.or.kr

1. Introduction

Despite the growing number of voices wanting to stop the nuclear power generation after the Fukushima nuclear accident, nuclear power has continued to rise in many countries, and an increasing number of energy demands and efforts to reduce greenhouse gas emissions have taken place. One of the important issues to be addressed for the sustainable development of nuclear power is to present a solution for the safe management of spent nuclear fuel. Since the 1950s, various high-level radioactive waste (HLW) management methods have been proposed, including ocean disposal, space disposal, and glacier disposal. One of them, the deep geological disposal, is a direct disposal of HLW that emits high heat and radiation to the bedrock, which is located deep in the underground for completely isolating it from the ecosystem. The International Atomic Energy Agency (IAEA) recommends deep geological disposal as long-term solution for HLW disposal when considering economic and safety considerations. The most important factor of the deep geological disposal is to select an optimal site and implement a disposal system that meets safety, technical and environmental requirements. The system may slightly depend on the geological conditions and the type of waste in each country, but the ultimate goal is to secure long-term safety. Thus, it is very important to understand the characteristics of the site, before designing to maintain the performance of the disposal system for a long time.

This study analyzes the case of site-descriptive modelling (SDM) in Sweden and Finland for future HLW disposal projects in Korea.

2. Domestic and overseas case

2.1 Definition of Site-descriptive modelling (SDM)

The Olkiluoto (crystalline rock) region of Finland is the world's first deep geological repository (DGR) site and is now in the construction phase. Following, Sweden and France selected Forsmark (crystalline rock) and Bure (sedimentary rock) for disposal sites. Germany and the US selected Goreleben (rock salt) and Yucca Mountain (volcanic rock) as disposal sites, but now they are reviewing the project. Thus, depending on the geological characteristics of each country, the preference for disposal sites is different. The role of the geological formation is to provide stable mechanical conditions, favorable hydro-geochemical conditions, low movement of groundwater and effective retention of radionuclides, if released from the disposal site [1]. These site characteristics affect the performance of the disposal system, so it must be understood before engineering barrier design. SDM is a detailed description to help understanding of the site characteristics based on the interpretation of the quality assurance databases generated by the site investigation. The geo-scientific disciplines forming the base for the SDM models included geology, thermal properties, rock mechanics, bedrock hydrogeology, bedrock transport properties and surface ecology [1]. These are related to each other by the feedback based on the geological model, which is an essential element of the SDM (Fig. 1.). Therefore, the SDM should be performed with multidisciplinary project.

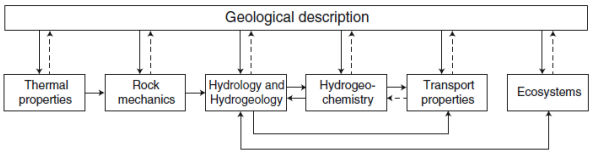

Fig. 1. The framework of SDM.

2.2 Comparison of SDM for Olkiluoto and Forsmark

Finland and Sweden are countries on the Baltic coast which share broadly similar geological histories and geography. However, there are obvious differences between the two such as hydrogeochemistry, hydrogeology, and rock

mechanics. Considering also that site safety is a composite of multiple barrier functions, the impact of these differences, in terms of overall site suitability, is difficult to judge without a full safety assessment of each site that includes an analysis of how these differences and associated uncertainties may influence safety [2].

2.3 Domestic case

In Korea, a low and intermediate-level radioactive waste (LILW) repository, comprising a total size of 800,000 drums, are under development. The 1st phase of the construction, which is an underground silo-type, was completed in 2014. The 2nd phase for a surface-type is under construction. The safety analysis report (SAR), which is a document related to licensing, provides a description of site characteristics. In this report, the results of the site investigation are shown with a diagram and a picture with explanations.

2.4 3D geological modeling

The key process in the SDM is the visualization of the site. When displaying natural phenomena with tools such as maps, it is helpful to improve understanding by expressing them as images, rather than just writing them. In particular, the 3D geology model is very similar to the actual view of the natural landscape. It also helps to simulate and interpret invisible underground space. In fact, Posiva and SKB estimated the deep structure and volume through SDM geological modeling.

The commercial software used for building a 3D geological model is SKUA-GOCAD from Paradigm, Leapfrog from ARANZ Geo, etc. SKB developed a unique system called Rock Visualization System (RVS) to perform 3D geological modeling (Fig. 2.).

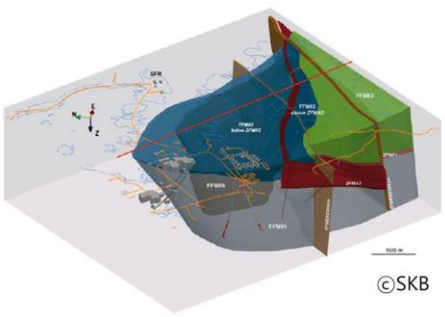

Fig. 2. 3D model (fracture domains and their relation).

3. Conclusion and future work

This study analyzed the necessity and method of SDM to improve the understanding of disposal site characteristics based on site investigation data in the case of Finland and Sweden. These countries are in the stage of construction or construction license permit reviewing by demonstrating the performance of DGR through site investigation and safety assessments over a decade. The center of SDM is a geological model, so it is recommended that they build a 3D structure. Korea Radioactive Waste Agency has carried out preliminary 3D geological modeling based on geological survey data, compiled in the SAR, of Gyeongju LILW repository [3]. The model is currently being complemented by reflecting the results of the second stage site investigation. In order to enhance the understanding of site characteristics, SDM will be constructed by integrating modeling results of groundwater flow, fault and geochemistry. The building process and the results of the models will be useful to evaluate HLW disposal site characteristics in the future.

Acknowledgement

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