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Current status of Domestic Natural Analogues Study Database System

H. S. Im*, D. W. Jeong, M. H. Baik, J. H. Ryu
Korea Atomic Energy Research Institute, 111, Daedeok-Daero 989Beon-Gil, Yuseong-Gu, Daejeon, Korea, 34057
**Corresponding author: ihs95@kaeri.re.kr*

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1. Introduction

Safety assessments of disposal systems heavily rely on modeling techniques that are based on the evolution of disposal sites and scenarios involving radionuclide release. However, the uncertainties surrounding the spatio-temporal behavior of disposal sites over long periods necessitate efforts to enhance the reliability of disposal safety case. Recently, safety case has emphasized the acquisition of broader and more diverse safety proof[1]. As part of these efforts, Natural Analogues(NA) Study has been initiated to explore natural systems resembling the environment around radioactive waste disposal sites, serving as supplementary safety proof to improve understanding long-term behavior and to validate deep-geological disposal safety programs. Consequently, there is a need to develop database system to utilize the complicated results of NA studies over the world effectively.

2. Developing a Domestic NA Information System

2.1 Purpose and Necessity

Firstly, there is a need to collect geological, hydraulic, and mineralogical data obtained through field drilling and literature and to categorize them systematically with disposal system components(engineering barrier and natural barrier), and to manage them step by step. Secondly, domestic environmental input data are required for use in the safety assessment of the Korean disposal system. Thirdly, from a long-term evolutionary perspective, it is necessary to consider the possibility of extreme environments beyond Korea's geological and climatic environments, requiring the construction of global NA information data. Lastly, NA information database can suggest the natural evidences and the understanding the concept of disposal system and the safety, enhancing non-professional public confidence.

2.2 Structure of the NA database System and the Current Status of Domestic NA Study

Classification criteria for the domestic NA information database (DB) system have been formulated [2]. Table 1 illustrates the component elements for the Engineered Barrier System (EBS) and Natural Barrier system(NBS) considered within the natural analogue database.

Table 1: classification of NA database[2]

EBS		NBS	
silicate glass	Devitrification	Elemental solubility and speciation	Elemental solubility
	Radiation induced effects		Speciation
	Dissolution and alteration	Elemental retardation	Transport and retardation within fractured crystalline rocks
	Radionuclide retardation by secondary alteration products		Transport and retardation within argillaceous rock
Spent nuclear fuel	Dissolution and radionuclide release		Transport and retardation within volcanic ash deposit
	Radionuclide retardation by secondary alteration products		Transport and retardation within evaporites
	Etc.		Transport and retardation at the geosphere-biosphere interface
Metal	Durability and longevity of iron and steel		Measurement of in situ distribution coefficient
	Durability and longevity of copper	Matrix diffusion	Depth and volume of interconnected porosity
	Radionuclide retardation by secondary alteration products		Bulk rock chemical buffering capacity
Bentonite	Longevity of bentonite and the rate of alteration		Extent of matrix diffusion in sedimentary formation
	Physico-chemical changes due to heating		Estimation of diffusion coefficient
	Canister sinking	Radiolysis	Process involved in radiolysis of groundwater
	Interaction with other repository materials		Radiolysis in nature(how common is radiolysis in nature)
	Hydraulic barrier and colloid filter functions		Potential buffering capacity of reduced iron corrosion phases from corroding engineered barriers
Concretes and cements	Durability of cement	Redox Front	Redox front formation and behaviour in crystalline rocks
	Cement-rock-groundwater interactions		Redox front formation and behaviour in argillaceous rocks
	Radionuclide sorption		Radionuclide migration at a redox front
	Colloid production and filtration	Colloids	Populations of colloids in natural systems
	Gas and water permeability		Stability of colloids in natural systems
	Bonding properties of cement and concrete		Radionuclide uptake and transport by colloids in natural system
Bitumen	Durability and longevity		Colloid in anthropogenic systems
	Groundwater leaching		Biocolloids
	Microbial degradation	Microbial activity	Microbial populations at depth in natural systems
	Radiation induced degradation		Tolerance to hyperalkaline conditions
	Interaction with saline water		Nutrient and Energy availability
Organic materials	Cellulose degradation	Gas generation and migration	Gas production rates
	Cellulose degradation products		Gas migration and reaction with the geosphere
	Natural resins		Gas migration effects on solute transport

Domestic NA study has been conducted through a combination of on-site field drilling and laboratory experiments with three domains: uranium nuclide transport, buffer material, and disposal container material. Accordingly, NA database is gathered regarding uranium deposits as analogous to radioactive waste, copper/iron deposits as analogous to disposal containers, and clay bentonite deposits as analogous to buffer materials.

In studies pertaining to the natural behavior of nuclides using domestic uranium mines, various analyses have been conducted to acquire fundamental characteristics of groundwater and rock formations at two research sites: the Boeun Hoenam-myeon Research Site and the Geumsan Suyeong-ri Research Site, along with the KAERI KURT (Underground Research Turnel).

In the bentonite study, geological, mineralogical, physicochemical, and microbiological characteristics are examined not only for the bentonite mineral of candidate sites but also for the surrounding environment encompassing rocks, groundwater, and microorganisms. Notably, Pohang Yeongil and Gyeongju Yangnam areas have been designated as candidate sites.

Regarding the NA study of disposal container materials, ancient artifacts constructed from copper and iron are investigated as natural counterparts to disposal containers. Investigations encompass the burial environment of the Korean Peninsula and the corrosion properties of iron/copper artifacts. Soil and metal artifacts retrieved from archaeological sites within the Seoul 15th-16th districts and the Sejong Smart Green General Industrial Complex construction project site have been subjected to analysis.

2.3 Utilization and Current Status

M. H. Baik et al. suggested that categorization of *NA* information could be categorized into five distinct groups based on application function in the safety case (Table 2)[2].

Table 2: Categories of the application of NA database[2]

	Categories	Code
Quantitative	Input for safety and Performance Assessments	ISP
	Model validation	MV
Qualitative	Scenario Development	SD
	Understanding Improvement	UI
	Demonstration and Education	DE

According to the criteria, all the collected NA information were analyzed and the distribution of the application of current NA database was depicted(Fig. 1).

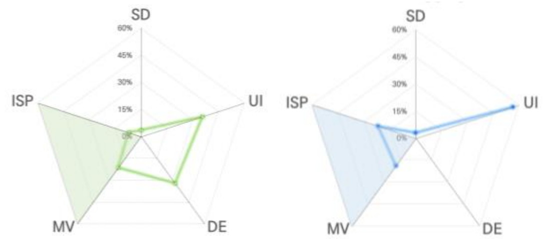

Fig. 1. Distribution of application domain of EBS database (left, green) and NBS database(right, blue)

As Fig. 1 shown, an analysis of the distribution of application reveals that the most significant applicability lies within the domain of UI for both EBS and NBS. Concerning the EBS(green), it is predicted that quantitative application fields (ISP, MV) would exhibit relatively lower utilization because the NA data from the natural environment have been generated by complex interaction, it would be improper to relatively simplified engineering barrier formula models. Conversely, at the qualitative explanation and education realm (DE) for deep geological disposal, it is expected that the visual presentation of information, capable of demonstrating the robustness of the EBS, would induce its full utilization.

On the other hand, the natural barrier system(NBS) shows minimal utilization at the DE domain. It is because the extensive evolutionary change process of NBS occurs over an extended period, surpassing human lifespans, and visual identification may be challenging like microbial domains.

3. Conclusions

To effectively utilize the collected NA information data, it is imperative to classify and systematize this information. In this study, various NA research results were collected and categorized to establish NADB system. The application of NA database was also predicted with 5 types. The better application of NA research results can be achieved by systematically classifying and reconstructing them in accordance with the purpose. And the distribution analysis for application domain made it effective to assess the current status of NA study and the results.

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REFERENCES

[1] IAEA, Natural analogues in performance assessments for the disposal of long lived radioactive wastes. IAEA Technical Repαts Series No. 304, 1989.
[2] M. H. Baik, T. J. Park, I. Y. Kim, J. T. Jeong, and K. W. Choi, Development of a natural analogue database to support the safety case of the Korean radioactive waste disposal program, Swiss J. Geosci., 108, pp. 139–146, 2015