

**Development of an Integrated Natural Barrier Database System for Site Evaluation of a Deep Geologic Repository in Korea – 13527**

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**ABSTRACT**

Korea Radioactive-waste Management Corporation (KRMC) established in 2009 has started a new project to collect information on long-term stability of deep geological environments on the Korean Peninsula. The information has been built up in the integrated natural barrier database system available on web ([www.deepgeodisposal.kr](http://www.deepgeodisposal.kr)). The database system also includes socially and economically important information, such as land use, mining area, natural conservation area, population density, and industrial complex, because some of this information is used as exclusionary criteria during the site selection process for a deep geological repository for safe and secure containment and isolation of spent nuclear fuel and other long-lived radioactive waste in Korea. Although the official site selection process has not been started yet in Korea, current integrated natural barrier database system and socio-economic database is believed that the database system will be effectively utilized to narrow down the number of sites where future investigation is most promising in the site selection process for a deep geological repository and to enhance public acceptance by providing readily-available relevant scientific information on deep geological environments in Korea.

**INTRODUCTION**

Twenty-three nuclear power plants are under operation in 2012, and they provide nearly 40% of total electric generation in Korea (<http://www.khnp.co.kr/>). Korea government plans to increase nuclear power plants in near future. However, the management of spent nuclear fuels (SNF) waste is becoming a severe problem in Korea, as more nuclear power plants are built.

Korea Radioactive-waste Management Corporation (KRMC) was established in 2009 based on new radioactive waste management law. KRMC is legally responsible for the management of all kinds of radioactive wastes including SNF in Korea. At present, KRMC is ready to start a national debate to establish the national program on the management of SNF including permanent disposal.

Deep geological disposal has been recognized world-widely as one of the safest methods in the light of isolating SNF permanently from humans and environments. Accordingly, it is necessary not only to understand the geological phenomena of geotectonic movements but also to perform its long-term prediction at least more than 100,000 years for the purpose of safe SNF disposal. Therefore, it is strongly required to understand and to assess the inherent geological environments in the Korean Peninsula. KRMC has launched a new project to achieve the quantitative geological environmental assessment of the Korean Peninsula establishing the database (DB) of existing disposal environments.

The project aims are to:

- 1) Quantify long-term geological stability factors including uplift/subsidence, geological formation, volcanic activity, seismic activity, lineament, erosion and fault activity;
- 2) Understand geotectonic-hydrogeologic-geochemistry-bedrock mechanisms in deep geological environments; and
- 3) Develop natural barrier evaluation criteria.

Finally, an integrated natural barrier DB system is developed. It will be applied at the site evaluation of a deep geological repository.

## **APPROACH**

### **Long-Term Geological Stability Factor**

Geological formations were reviewed to characterize representative rock types using 1:250,000 scale geologic maps. Regional lineaments were also identified with normalized density in lengths and numbers. Seismic moments were computed through seismic inversion in the frequency domain. This technique was applied to the seismic moments of the earthquakes that occurred between 1995 and 2010 in Korea. Fault activities were evaluated using satellite images and aerial photographs, and then the ages of the fault movement were determined by morphologic-tectonic analysis and trench investigation.

### **Interpretation of Geotectonic-Hydrogeologic-Bedrock Mechanism**

Deep groundwater chemistry was quantified by the statistical analyses of hydrochemical data (355 hydrothermal data, 320 bedrock groundwater data, 158 alluvial groundwater data, 222 mineral water data, and rural groundwater data). Statistical analyses were performed using artificial neural network, multivariate analysis, and geostatistical technique. Hydrochemical patterns were characterized according to the deep geo-environment and water-rock interaction.

### **Development of Natural Barrier Evaluation Criteria**

The integrated natural barrier DB system was developed using natural environment properties and specific data obtained in this study. The integrated natural barrier DB system combines all the information related with long-term stability, deep geological environments, and natural barrier evaluation methodology based on web site ([www.deepgeodisposal.kr](http://www.deepgeodisposal.kr)).

## **RESULTS AND DISCUSSIONS**

### **Long-Term Geological Stability Factor**

A total of 6,400 lineaments were identified in the southern part of the Korean peninsula ([Fig. 1](#)). The lineaments with less than 8 km length occupy ~90% with dominant orientations of NNE-SSW, NE-SW, and WNW-ENE. Relatively stable areas are more widely distribute in Gyeonggi massif and Okcheon zone than the others in the southern half of the Korean peninsula determined by the mean density 1. The uplift and subsidence rates are measuring on coastal terraces. The uplift rate of 33 study sites ranges from 0.1 to 0.4 m/ka with an average of 0.29 m/ka. However, the uplift rate estimated may be changed by more data collection, especially in

areas besides the eastern coast, the Han River, Imjin River, and Geum River. Seismic moment sare computed through seismic inversion in the frequency domain. This technique was applied to the seismic moments of the earthquakes occurred between 1995 and 2010 in Korea. Fault activities are evaluated using satellite images and aerial photographs, and then the ages of the fault movement determined through morphologic-tectonic analysis and trench investigation.

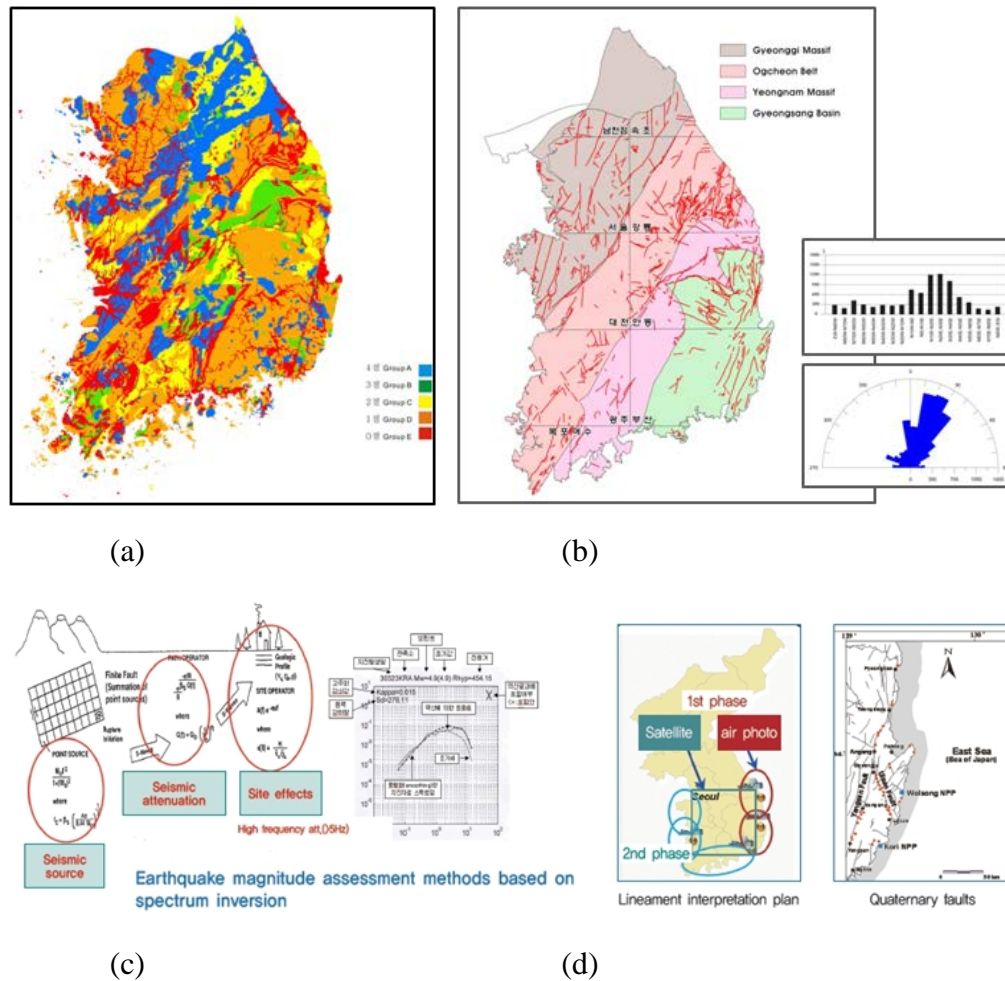


Fig. 1. Long-term geological stability factors - (a): geological formation, (b): regional lineaments, (c): earthquake moments, (d): active fault.

### Interpretation of Geotectonic-Hydrogeologic-Bedrock Mechanism

Groundwater flow simulation was performed to obtain groundwater flow data in a safety assessment for a geological disposal assumed to be located in a given bedrock site. A regional scale modeling of the groundwater flow system was carried out to make boundary conditions for a local scale modeling. The modeling methods used are available to prepare the data of groundwater flow in a safety assessment for a geological repository. The shallow groundwater showed Ca-HCO<sub>3</sub> type, whereas deep groundwater indicated Na-HCO<sub>3</sub> type. This difference indicates the mixing effect between shallow and deep groundwater. And statistical analysis supports the analytical result, quantitatively as shown in Fig. 2.

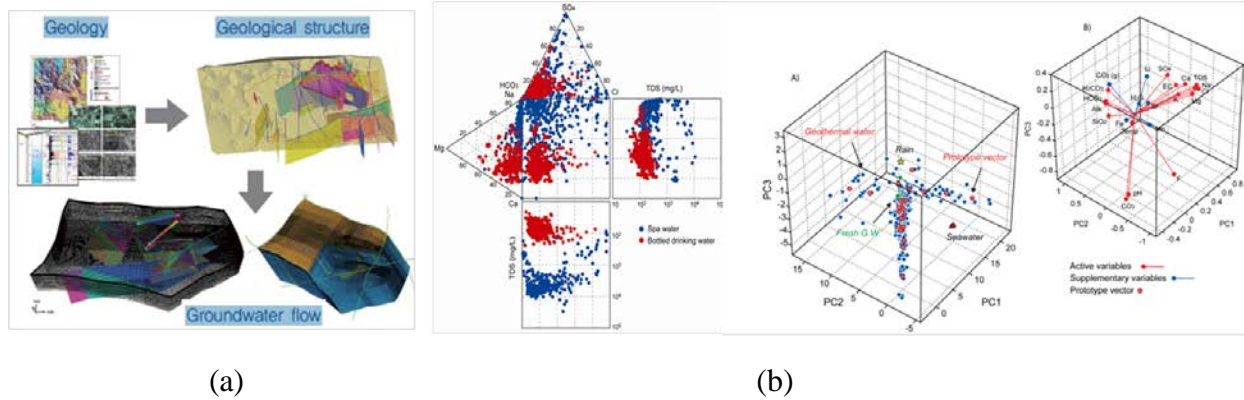


Fig. 2. Result of geotectonic-hydrogeologic-bedrock mechanism- (a): groundwater modeling, (b): hydrochemical properties.

### Development of Natural Barrier Evaluation Criteria

The evaluation standards of natural barrier were established by referencing the examples of the IAEA, Sweden, Finland, Switzerland, France, Germany, England, USA, and Japan. A combined DB system was built using natural environment properties and specific data obtained in this study. It was designed and constructed with geographic maps, geology maps (1:1,000,000; 1:250,000; and 1:50,000-scale), lineaments, active faults, hydrogeological maps, uplift/subsidence and etc as shown in Fig. 3. It also included socially and economically important information such as land use, mining area, conservation area, population density, and industrial complex, because some of this information is expected to be utilized as exclusionary criteria at the site selection process for a deep geological repository.

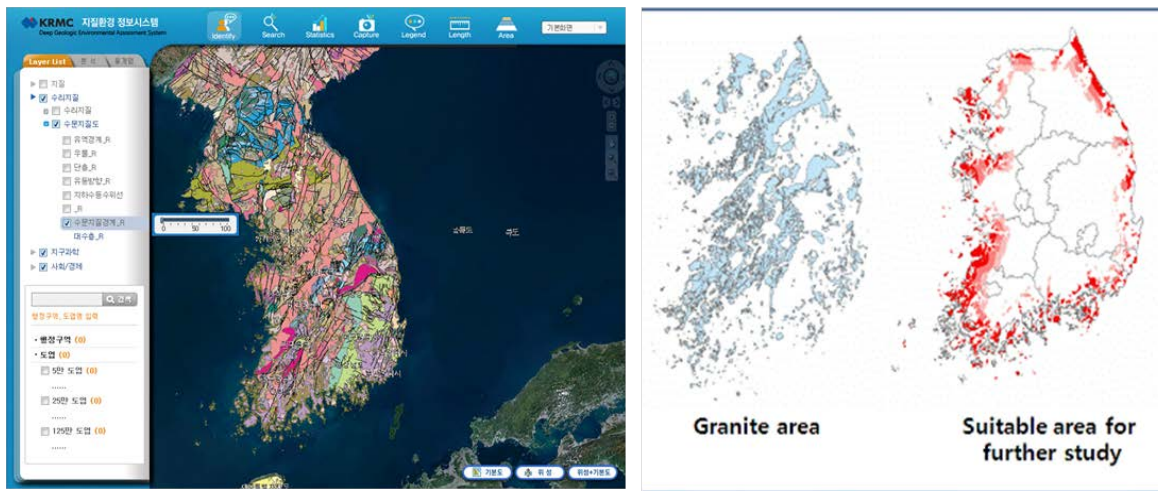


Fig. 3. Integrated natural barrier database system.

## **CONCLUSIONS**

The integrated natural barrier DB system was developed using all the currently available information on long-term stability, deep geological environments, and natural barrier evaluation methodology in the Korea Peninsula. It also includes socially and economically important information. It is believed that this integrated natural barrier and socio-economic DB system will be effectively utilized to narrow down the number of sites where future investigation is most promising in the site selection process of deep geological repository and to enhance public acceptance by providing readily-available ([www.deepgeodisposal.kr](http://www.deepgeodisposal.kr)) relevant scientific information on deep geological environments in Korea.

## **ACKNOWLEDGMENT**

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