CHINA'S DEEP GEOLOGICAL DISPOSAL PROGRAM FOR HIGH LEVEL RADIOACTIVE WASTE, BACKGROUND AND STATUS 1998

JU WANG, GUOQING XU, YONGHAI GUO
Beijing Research Institute of Uranium Geology,
China National Nuclear Corporation,
Beijing, China

Abstract

This paper presents the background and progress made in the study of China's high level radioactive waste, including site screening, site evaluation, the study on radionuclide migration, bentonite, natural analogue studies, and performance assessment, etc. The study on Beishan area, the potential area for China's geological repository, is also presented in this paper.

1. INTRODUCTION

China is now facing the challenge of how to safely dispose of nuclear waste. The low and intermediate level waste will be isolated by near surface disposal method or underground disposal method, but the spent fuel in China will be reprocessed first, followed by vitrification and final geological disposal.

On the Chinese mainland, there are 2 nuclear power plants (NPPs) in operation: the Qinshan NPP in east China's Zhejiang province and the Daya Bay NPP in south China's Guangdong province, with a total capacity of 2100 MW(e). In the next 5 years 4 more NPPs will be built, their estimated capacity will be 6600 MW(e). According to Chinese plan, the total electricity capacity produced by NPPs will reach up to 20 000 MW(e) by the year of 2010.

It is deduced from the Chinese nuclear power plan that the accumulated spent fuel will be 1000 tons by 2010, while 2000 tons by 2015. Later than 2020, about 1000 tons of spent fuel will be produced each year.

In China, the work related to radioactive waste disposal is managed by the China National Nuclear Corporation (CNNC), which is responsible for the transport of high level waste (HLW) and spent fuels, reprocessing of spent fuels, vitrification and final disposal of liquid HLW. The Everclean Environment Engineering Corporation, attached to CNNC, is responsible for site selection and evaluation, construction, operation, closure and monitoring of repositories for low and intermediate level and high level radioactive waste.

A coordination expert group was organized for the geological disposal of HLW in 1986. The group is composed of experts from Beijing Research Institute of Uranium Geology (BRIUG), Beijing Institute of Nuclear Engineering (BINE), China Institute of Atomic Energy (CIAE) and China Institute for Radiation Protection (CIRP). The group is responsible for R & D program, research work related to site selection, site characterization, repository design, environmental assessment, safety analysis and performance assessment.

2. THE DEEP GEOLOGICAL DISPOSAL PROGRAM FOR HIGH LEVEL WASTE

In 1985, CNNC proposed an R&D program called DGD program for the Deep Geological Disposal of HLW (Yang, 1992). The Program is divided into 4 phases: 1) technical preparation phase; 2) geological study phase; 3) in situ test phase; and 4) repository construction phase. The objective of the program is to build a granite-hosted national geological repository in 2040, which can dispose of vitrified waste, transuranic waste and a small amount of CANDU spent fuel.

During the technical preparation phase (1986–1995), the main activities include planning, site screening, feasibility study and R&D. The goal of this phase is to select candidate areas and to prepare technical basis for final disposal. A preliminary pre-feasibility report was planned to be completed at the end of this stage.

During the geological study phase (1996–2010), systematic studies of site screening, site characterization, performance assessment of disposal system, methodology of environmental impact assessment, models development and buffer/backfill materials will be conducted. The goal of this phase is to determine the final disposal area for high level waste and to provide technical basis for the disposal.

During the in situ test phase (2011–2025), an underground research laboratory will be built, and detailed site evaluation, in situ heater test, tracer test and demonstration of disposal technology will be carried out. Combining with the experiences in western countries, the Chinese deep geological disposal technology will be much improved then. At the end of this stage, performance assessment of the total disposal system and feasibility study report will be completed. Licensing application for the construction of a HLW repository will be submitted to the National Nuclear Safety Administration.

In the repository construction phase (2025–2040), the designing and construction of the repository will be conducted. The goal of this stage is to have the repository operated.

The DGD program is a preliminary one, it will be revised with the development of China's Nuclear Power Industry. It is believed that the investment in radioactive waste disposal will be increased to ensure the safe disposal of the waste.

2.1. Progress in R&D of geological disposal

Since 1985, the following work related with high level radioactive waste disposal has been conducted:

- Site screening and site characterization for HLW repository;
- Site screening and prefeasibility study of underground research laboratory site;
- Laboratory experiment on radionuclide migration;
- Study on natural analogies;
- Study on buffer /backfill materials;
- Study on speciation of transuranic elements in solutions;
- Study on models for safety and environmental assessments;
- Study on methodology of performance assessment.

In the past two years, the R&D of high level radioactive waste disposal in China are concentrated in the following fields: preliminary site screening and siting evaluation, radionuclide migration study, buffer/backfill material study, natural analog study and performance assessment of geological disposal system.

Site screening and site evaluation has been the key activity of China's HLW disposal. On the basis of previous nationwide screening, the Beishan area, located in northwest China's Gansu province, is considered as the most potential candidate area for China's geological repository. With rare inhabitants, barren low hills, little precipitation and large evaporation, the Gobi desert Beishan area is of no economic development prospect. The candidate rock is granite in which a geological repository will be built at a depth about 500--1000 meters. The potential granite bodies include Jiujin, Xingchang and Qianhongquan et al. Geological mapping (1: 200 000 scale) and hydrogeological investigation are carrying out in the area. Preliminary results show that the Beishan area is of stable crust structure without active faults, and the groundwater system of the area is of low permeability and low velocity. Satellite image processing, Geographical Information System (GIS) technology and ground geophysical surveys are also used to evaluate the suitability of the Beishan area. The candidate host rock investigation in China reveals that granite is the most suitable rock for China's geological repository. In the period of 1999–2000, an International Atomic Energy Agency's Technical Cooperation Project entitled “Siting and site characterization study for China’s high level radioactive waste” will be carried out, 1:50 000 scale surface geological, geophysical and hrdrogeological investigation will be conducted, and 2 deep boreholes (600 meters deep for each) will be drilled in order to understand the deep geological environment in the saturated zone.

Radionuclide migration studies will help us understand how the nuclides transport through engineering barriers (waste canister and buffer materials) and natural barriers (geological formation such as granite and shale). The absorption and dispersion experiments of ^{239}Pu, ^{241}Am, ^{99}Tc and ^{90}Sr on bentonite and the Beishan granite samples are going on. A low oxygen glove box has been installed, and it can provide low oxygen environment (with oxygen concentration less than 5 ppm) for experiment. Experiments under repository conditions have been given particular attention. An installation, named as RADMIG, simulating the repository conditions has been constructed, in which experiment under T= °C, P=5 MPa, Eh< -200mV can be carried out. Actinide geochemistry and colloidal-actinide reactions are also studied.

Bentonite is considered as the best buffer and backfill material for deep geological repositories, while China is rich in bentonite resources. After a nationwide investigation and screening of bentonite deposits in China, the Gaomiaozi bentonite deposits in Xinhe county, Inner Mongolia Autonomous Region is considered as the best deposit which can provide enough high quality bentonite for the potential repository. The Gaomiaozi deposit has a bentonite reserve of 127 million tons, the montmorillonite content can reach as much as 63.77% to 80.92%. A systematic test on the bentonite is under way, including mineralogy, physical and mechanical properties, thermal properties, geochemical properties and radiation stability.

A hydrothermal granite-type uranium deposit in south China's Hunan province is used for natural analogue studies. Chemical composition, stable isotopes and uranium-series radionuclides of groundwater samples were analyzed. The results indicated that the diffusion of uranium, thorium and rare earth elements resulting from water-rock interaction is very limited.

Performance assessment (PA) of geological disposal system is at a very beginning stage. Only some western literature about performance assessment has been investigated and a plan for Chinese PA is under discussion.

2.2. BEISHAN AREA, GANSU PROVINCE, NW CHINA--The potential area for China’s geological repository

The Beishan area, Gansu province, is the preselected area for China's high level radioactive waste repository, and is located in the Erdaojin-Hongqishan compound anticline of the Tianshan-Beishan folded belt in western China. The candidate host rock for the repository is granite. The regional brittle faults, including Erduanjinnan Fault, Zhongqiujin-Jinmiaogou Fault and Erdaojin-Hongqisham Fault, are nearly EW-striking, shallow and non-active faults. The crust in the area is of block structure, with the crust thickness of 47 through 50 km. The depth contour of the crust is nearly EW striking, with very little variation. The gravity anomaly is $-150\times10^{-5} m/s^2 - 225\times10^{-5} m/s^2$. The gravity gradient is less than 0.6 mGal/km. On the gravity anomaly map, the gravity anomaly contour is distributed very sparse without obvious step zones, indicating that there are no great faults extending to the depth of the crust. The seismic intensity of the area is less than 6, and no earthquakes with Ms>4 ¾ have occurred. The land form of the area is characterized by flatter Gobi and small hills with elevations above sea level ranging between 1000m and 2000m. The height deviation is usually several ten meters. Since Tertiary it is a slowly uplifting area without obvious differential movement. The uplifting velocity of the crust in the area is about 0.6 mm/a-8 mm/a, much lower than that of the Qilian region (1.5 mm/a-1.8 mm/a). Comprehensive analysis of structural deformation of the Cenozoic faults and folds indicate that the area is undergone horizontal compression at present, and the principal compression stress is between 30° and 60°. The data provided by the mechanism at the source of earthquakes show that the direction of the principal compress stress is about 40°, and the superimposed fault angles, suggesting that the main faults be stable and will not have strike-slip displacement. The geological characteristics of the Beishan area shows that the crust in the area is stable, and it has a great potential for the construction of a high level radioactive waste repository.

The geological work on the Beishan area is at a very early stage, and the above mentioned are only preliminary results. In the future, a systematic site characterization work will be conducted year by year, to see the suitability of the Beishan area and to select the final site for the HLW repository.

The safe disposal of high level radioactive waste is a worldwide challenging task. Although China has made some progress in this field, there is still a long way to go. For example, a policy act related to nuclear waste disposal should be established, a more effective organization should be formed to promote the related work, and a way should be explored to raise enough money for the safe disposal of nuclear waste.

Information exchange is very important for the disposal of radwaste. China is willing to learn the successful experiences of other countries and to strengthen international cooperation. China is also willing to share its own experiences and achievements with other countries, for the purpose of protecting the living environment of the human beings and protecting the Earth.

REFERENCES

[1] L..YANG., " Progress in DGD program for high-level waste deep geological disposal in China (1986–1991)" , Selected Works on the Study of Deep Geological Disposal of HLW in China, ed. by Sci. & Tech. Bureau, China National Nuclear Corporation, (Dec. 1992) 1–5 (in Chinese).

[2] G. XU.," Investigation on site preselection of HLW repository in China" , Selected Works on the Study of Deep Geological Disposal of HLW in China, ed. by Sci & Tech. Bureau, China National Nuclear Corporation (Dec. 1992) 11–15 (in Chinese).

[3] S. LUO., et al., Radioactive Waste Management, Atomic Energy Press, Beijing (1995) 1–9 (in Chinese).

[4] X. LI., et al., Radioactive Waste Management, Atomic Energy Press, Beijing (1995) 62–66.(in Chinese).

[5] X.WU., The Future Development for China's Nuclear Power Plants, China Nuclear Industry Newspaper (Nov. 1, 1995).

[6] X. LI., et al., Research Theory and Method of Regional Crust Stability, Geological Press, Beijing, (1987).

[7] CHINA NATIONAL SEISMOLOGICAL BUREAU, The Geophysical Exploration Achievement of the Crust and Upper Mantle in China, Seismological Press, Beijing (1986).

[8] CHINA NATIONAL SEISMOLOGICAL BUREAU, Atlas of Seismic Activity in China, China Science and Technology Press, Beijing (1991).

[9] GEOLOGICAL BUREAU OF GANSU PROVINCE, The Geological Map and its Explanation of Yumenzhen Quadrangle(1:200 000) (1972).

[10] GEOLOGICAL BUREAU OF GANSU PROVINCE, The Geological Map and its Explanation of Houhongquan Quadrangle (1:200 000) (1969).