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**NURTURE OF HUMAN RESOURCES FOR GEOLOGICAL REPOSITORY PROGRAM**

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**Abstract.** The Japanese geological repository program entered the implementing stage in 2002. At the implementing stage of the program, different sectors need various human resources to conduct their functions. This paper discusses a suitable framework of nurture of the human resources to progress the geological repository program. The discussion is based on considering of specific characters involved in the program and of the multidisciplinary knowledge related to geological disposal. Considering the specific characters of the project, two types of the human resources need to be nurtured. First type is the core persons with the highest knowledge on geological disposal. They are expected to communicate with the various stakeholders and pass down the whole knowledge of the project to the next generation. Another is to conduct the project as the managers, the engineers and the workers. The former human resources can be developed through the broad practice and experience in each sector. The latter human resources can be effectively developed by training of the fundamental knowledge on geological disposal at training centers as well as by conventional on-the-job training. The sectors involved in the program need to take their own roles in the nurture of these human resources.

### 1. Background

The site selection process for a high level radioactive waste (HLW) repository in Japan consists of three steps as specified in the "Specified Radioactive Waste Final Disposal Act of 2000" (the Final Disposal Act□; the selection of the Preliminary Investigation Areas, the selection of the Detailed Investigation Areas and the selection of the Site for a repository construction. On 19 December 2002, an implementing body (the Nuclear Waste Management Organization of Japan: NUMO) has launched an open invitation for volunteer municipality for the Preliminary Investigation Areas. This means that the geological repository program of Japan entered the implementing stage from the research and development stage. At the research and development stage, a lot of the human resources have been nurtured in research organizations such as Japan Nuclear Cycle Development Institutes (JNC). These scientific and technical experts have been transferred to NUMO as principal members.

An advisory committee organized in the Japanese Atomic Energy Commissions (AEC) referred to nurture of the human resources for the geological repository project. They pointed out that one of the essential issues for the geological repository program is nurture and secure of the human resources. This concern comes from very long time span of the program from site selection phases to construction, operation, and closure phases. The Cabinet Decision "the Basic plan of Japanese final disposal program" (29 September, 2000) according to the Final Disposal Act also stated that nurture and secure of the human resources is one of the important commitments of the government for the program.

This paper discusses a suitable framework of the nurture of human resources to advance the Japanese geological repository program. The discussion is conducted with consideration of the specific characters involved in the program, such as time span and knowledge required.

## 2. Specific characters of the nurture of the human resources for the geological repository program

The geological repository program has specific characters as compared with other nuclear technology areas.

These are:

- The program has very long time span from site selection to repository closure. Over several decades might be required to complete the project. This causes alternation of the generations of the human resources. Consequently, the knowledge of the program needs to be passed down from the active generation to the next generation. Even within one generation, the knowledge should be up-to-dated continuously.
- To advance the program, close communication with various stakeholders is essential. The human resources should acquire communication ability as well as technical ability.
- The program involves multiple realms. The human resources who can cover multi areas are required.
- The program may not progress on planned schedule. A framework of the nurture needs to be adaptable to this uncertainty
- The public reliability will come mainly from the technical reliability of the regulatory authority as well as that of the implementing body (NUMO). The human resources having the sufficient knowledge on safety of geological repository should be nurtured and secured in the regulatory authority from the early stage of the program.

## 3. Type of the human resources for the geological repository program

In the fulfillment of the geological repository program, different sectors require human resources having various abilities to perform their own functions. These functions are categorized into: policymaking, safety regulation, oversight, implementation and research.

These sectors require two types of the human resources. We define the first type as having the broad and profound knowledge on geological disposal (the knowledge base of geological disposal). They will be the core of the geological repository program and thus act as the key persons in each sector. They are expected to pass the whole knowledge on the geological repository project down to the next generation.

And the second type is defined as having some specialty required to conduct the program, such as civil engineering, mechanical engineering, nuclear engineering, and geology. They perform various practical tasks in the program. In addition to their specialty, they need to have the fundamental knowledge of geological disposal.

## 4. Numbers of the human resources required for the program

It is hard to estimate the exact quantities of the human resources required in various sectors involved in the program at this moment.

But we consider that the number of the core persons should be kept constantly in each sector, regardless of the progress of the geological disposal program. This is because their roles are to communicate with various stakeholders and to pass the whole knowledge including philosophy of the program. The number of these human resources required is between 10 and 20 as total in Japan.

The quantities of the human resources to conduct the program are to increase or decrease with the progress of the program. As a starting base to plan the nurture, we tried a preliminary estimation of the numbers of the human resources for the implementing body (the inside and

the outside of the body) on the working category. The working categories, as defined below, are the manager class, the engineer class, and the worker class.

- Manager class: manage assigned tasks and conduct more sophisticated tasks
- Engineer class: conduct assigned tasks by themselves or by employing workers under instruction of managers
- Worker class: conduct works under instruction of engineers

For the selection of the Preliminary Investigation Areas, 30 of the managers and 90 of the engineers are estimated and for the selection of the Detailed Investigation Areas, if five sites are investigated, 30 and 300 are estimated respectively. Table 1 summarizes the qualities and the quantities of the human resources for Japanese geological repository program.

*Table 1 Type and numbers of the human resources for the Japanese geological repository program*

Type	Expected Function	Working Class	Estimated Numbers Needed (men/year)
Cores for the program	Pass down whole knowledge on geological disposal to next generation Communicate with stakeholders and public on geological disposal	Superior to Manager class	10□20 (Total of Japan)
For the practice of the program	Practice various tasks and jobs (including research and development)	Manager class	30 <sup>*1</sup>
		Engineer class	90 <sup>*1 *2</sup> 300 <sup>*1 *3</sup>
		Worker class	□ <sup>*4</sup>

\*1 numbers for the implementing body only (inside and outside)

\*2 for the selection of the Preliminary Investigation Areas

\*3 for the selection of the Detailed Investigation Areas (five sites to investigate are assumed)

\*4 not estimated

#### 5. Fundamental knowledge on geological disposal

The goal of the human resource development for the geological disposal program is to provide or improve the knowledge on geological disposal to fill the gap between requested level and actual level by appropriate methods.

We suggest the multidisciplinary fundamental knowledge related to geological disposal as follows:

- Generation of waste
- Policy of final disposal
- Ethics of geological disposal
- Safety concept and way to secure safety
- Institution of geological disposal
- Performance assessment and safety assessment
- System of safety regulation of geological disposal
- Site investigation and site characterization
- Design and construction of repository

- Institutional control of geological disposal
- Social communication
- Natural analogue
- Safety case

#### 6. Level of the knowledge on geological disposal

To consider methods and means for developing the human resources, we grade the levels of the knowledge on geological disposal from 3+ to 0. Each level is defined as:

3+: the highest level and broad knowledge backed up considerable practice and experience

3: high level and broad knowledge

2: broad knowledge, but partially insufficient

1: partial knowledge

0: some specialty, but with little knowledge on geological disposal

#### 7. Nurture of the core human resources

The core human resources are expected to pass the whole knowledge of the geological disposal program down to the next generation and also broadly communicate about geological disposal. They need to acquire not only the high-level knowledge but also sufficient ability to dialogue with the various stakeholders including nationwide and local public.

The level of the knowledge for these persons should be the highest Level 3+. To achieve this level, they need abundant experience and practice in each sector. Moreover they should acquire multidisciplinary knowledge and new knowledge through international conferences and meetings on geological disposal. Now this type of the human resources is not sufficient in Japan. A systematic framework to nurture these core persons is urgent to establish in each sector.

#### 8. Nurture of the human resources to practice the program

For implementing practical tasks in the geological repository program, the engineer class is the most important. The engineers having some specialty required to conduct the practice tasks in the program need to learn the fundamental knowledge of geological disposal. In addition, since the practice of the program involves various different realms, they are desired to acquire multi specialties to cover multi areas, for example, geology and computer simulation.

The managers can be developed from the engineers by providing higher level of the knowledge on geological disposal and ability of communication with public and society.

At present human resources are trained mainly through on-the-job training with combination of some off-the-job training, such as practical experience at domestic or foreign institutes. These methods will also take important roles in developing the human resources in future. However training at training centers should be considered as complementary methods. For the engineers and the workers at Level 0 to Level 2 of the fundamental knowledge on geological disposal, a proper training course will be more useful for improving their ability for the program.

The methods for training the human resources are varied with their professional carriers and the level of the knowledge that they have. The methods for advancing the levels are briefed as follows:

Level 2→Level 3 : wide practice and supplemental advanced training

Level 1→Level 2 : training targeted on higher-level special knowledge

Level 0→Level 1 : training on basic knowledge

For more effective training at the training centers, the training contents should be allocated between a domestic raining center and an international training center. At international training centers, such as the International Training Centre School of Underground Waste Storage and Disposal (Switzerland), the world wide common knowledge should be lectured.

On the other hand, at domestic training centers, domestically specific issues, for example in Japan, fault, earthquake, and volcanoes should be provided.

#### 9. Nurture of persons to outreach the program

Opinion leaders and local advisers will take important roles in outreach of the geological repository program as a third party. They are expected to communicate with local public and improve their understanding of the program. Professors of local universities or colleges are potentially these human resources. To nurture them, a training course that combines their specialties with the fundamental knowledge on geological disposal should be prepared at the early stage of the program.

#### 10. Role and responsibility to develop the human resources

In principle, each sector should be responsible of the nurture and secure of necessary human resources. But the geological repository program contains disadvantages to nurture the human resources, such as very long time span and uncertain market. Therefore, especially the private sectors involved in the program are not likely to nurture and secure their own human resources at their own cost. This may cause shortage of the human resources required to conduct the program practically. Under these conditions, various sectors should cooperate in the nature of the human resources for the geological program and establish a suitable and stable framework (organization and financial support) from early stage of the program. We suggest roles and responsibilities to develop the human resources as follows:

- The research sectors can develop technical human resources through research activities and can supply them to the implementing body.
- The implementing body can develop their own human resources by conducting the repository program. Moreover they can also develop human resources in private sectors through the on-the-job training.
- The government can contribute to human resource development through funding research and development activities of related organizations and sectors. The government could do some part to develop the human resources in private sectors by providing financial support to training of engineers.
- The role of universities is to supply next generation. They can provide graduates having basic specialties, such as geology, radiology, and earth science essential for the geological repository program but declining in education field. Universities are also expected to train new type graduates who acquire multidisciplinary knowledge that will be directly useful for the geological repository project.

In addition, the progress of the repository project for low level wastes could contribute to developing the human resources through on-the-job training.

#### 11. Ending remarks

The shortage of the human resources for the geological repository program was noticed before the starting of the implementing stage of the program. A definite framework to develop and secure the human resources is not established yet. The geological repository program has unique characters in time span and the knowledge required. Thus, the human resources should be developed to accommodate to these characters. Two types of the human resources are required. The core persons are expected to pass the knowledge of the whole project from the active generation to the next generation and communicate about the program with broad stakeholders. They should be nurtured in various sectors to act as the key persons. On the other hand, the engineers and the managers can be developed by appropriate training at training centres as well as the conventional on-the-job training. The secure of the human resources is another important issue. The progress of the geological repository program is the most effective to secure the human resources. Besides this, continuous funded research and

development to advance the technology for geological disposal will take an equally important role.

The framework to nurture and secure the human resource for the geological repository program could be established by cooperation of various sectors. And this would be required not only to implement the program stably but also to improve reliability of the public to the program.

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