

# **JAPANESE R&D PROJECT FOR CO<sub>2</sub> GEOLOGICAL SEQUESTRATION**

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## **ABSTRACT**

The Japanese government is conducting an R&D program for the fixation and utilization of emitted carbon dioxide (CO<sub>2</sub>). This paper deals with an outline of the “R&D project for CO<sub>2</sub> geological sequestration”, which is one of the major items in this program, starting in 2000. RITE is undertaking this project in co-operation with Engineering Advancement Association of Japan (ENAA). The purpose of this project is to study the feasibility of CO<sub>2</sub> geological sequestration in Japan, including public acceptance as well as environmental impact assessment. This 5-year project consists of three major research themes, that are “Fundamental research” including laboratory tests on rock cores and the development of long-term reservoir simulator, “CO<sub>2</sub> injection and monitoring” at an actual field, and “Geological investigation” on methodology of technical site evaluation.

The research results of RITE in-house laboratory tests under this project are reported in separate presentations.

## **INTRODUCTION**

The distributions of oil and gas fields in Japan are quite limited, and the scale of each field is relatively small. However, there are aquifers that may become suitable reservoirs for CO<sub>2</sub> geological sequestration. A preliminary study on CO<sub>2</sub> geological sequestration (Tanaka et al., 1995) estimated the possible capacity at 8.8 billion tons in the offshore areas surrounding the Japanese Islands. This amount provides an incentive for progressing this project.

In terms of technical feasibility, there is a great deal of information available from the experiences of the enhanced oil recovery (EOR), and this is in part due to the similarity between EOR and geological sequestration. Additional aspects may be taken into account because of the injection into an aquifer (not into

oil and gas reservoir); for example, geochemical reactions and underground stress changes induced by injection. Furthermore, various geological conditions will require an appropriate method of site evaluation, such as long-term stability of geologic structures and integrity of cap rock against the leakage of CO<sub>2</sub>, in terms of safety. On the other hand, methodology for public acceptance and economic analysis are also important in enabling future implementation of CO<sub>2</sub> geological sequestration.

This project deals with both technical and social aspects of CO<sub>2</sub> geological sequestration, and is divided into three major subjects (one of them is subdivided into four). The following provides descriptions of each subject:

## **FUNDAMENTAL RESEARCH**

### ***Laboratory tests***

Basic experiments have been conducted at the laboratory level to collect data such as the solubility of CO<sub>2</sub> in aquifers and the interaction between CO<sub>2</sub>, formation water, and rocks. These data are to be used in evaluating the long-term stability and safety of CO<sub>2</sub> injection. A series of experimental studies on seismic wave velocity monitoring of CO<sub>2</sub> flooding in porous sandstone was carried out to demonstrate the usefulness of seismic survey for mapping the movement of CO<sub>2</sub> sequestered in the underground. Measurements of wave velocity change while injecting CO<sub>2</sub> showed that seismic survey might be applicable for monitoring the migration of CO<sub>2</sub> in the subsurface. Additionally, the newly developed phase-shift interferometer, which detects surface configuration changes of mineral crystal on nanometer scale, showed a potential to measure rock dissolution rates in the CO<sub>2</sub>-saturated water.

### ***Monitoring methods***

Monitoring methods have been investigated in order to study monitoring technologies that might be applicable in the future. These methods will be applied to the quantitative evaluation results of the environmental impact and safety of applying the underground storage technology for CO<sub>2</sub> in Japan. In FY2001, investigations were focused on the feasibility of those methods for monitoring behaviors and impacts of CO<sub>2</sub> injected in aquifer, in comparison with similar cases so far.

### ***Long-term reservoir simulator***

The long-term simulator is intended to develop a tool for an environmental impact assessment (EIA) by means of the prediction of the long-term behavior of CO<sub>2</sub> sequestered in the underground. A simulator for the underground storage of natural gas (named as GEM-UGS) has been selected for the core code. This simulator can deal with more natural phenomenon, compared to other simulators.

From the viewpoint of the long-term behavior of CO<sub>2</sub>, it is necessary to incorporate some additional element modules to the core simulator, such as geochemical reaction, mechanical deformation of strata, character changes of groundwater and CO<sub>2</sub> movement along a geological discontinuity.

Up to FY2001, modules of geochemical reaction, deformation of strata have been completed.

## ***System analysis study***

A system analysis study has been conducted with two objectives: to identify the environmental impact and safety levels for the cases of possible combinations among locations of large-scale CO<sub>2</sub> sources, means of recovery and transportation, and storage points by using multi-dimensional, quantitative evaluation indices, and to elucidate the significance of the underground storage technology in terms of costs, safety, social acceptance, and other factors among a variety of optional countermeasure against global warming. In FY2001, we reviewed the following items:

- To construct an integrated cost evaluation model for the selection of storage site and for the analysis of cost effectiveness
- To analyse the life cycle cost of the whole system from emission sources to storage site
- To investigate the over-sea case of natural gas storage operation and to assess the risks in extreme case
- To investigate the legal aspect of the operation, environmental assessment, and public outreach processes

## **CO<sub>2</sub> INJECTION AND MONITORING**

The injection experiments will be conducted in order to obtain various types of information and data on the actual behavior of carbon dioxide underground, and to reflect them in a short-term prediction by means of the simulator (black oil model). In FY2000, the first injection site was selected in Nagaoka, Niigata prefecture, from the standpoint of continuity and sealing capacity of the cap rock and reservoir. After this, an injection well was drilled, the core sample was obtained, and its geophysical character was analysed. From these results, the injection amount of CO<sub>2</sub> and the most suitable configuration of 3 observation wells were decided. The following were carried out in FY2001:

- Drilling of the observation wells and investigation.

Two observation wells were drilled at the Minami-Nagaoka natural gas field, with a depth of 1,319m and 1,270m respectively. The results of well logging showed that the thickness of the sandstone layer is almost uniform. CO<sub>2</sub> will be injected into this layer because of its higher porosity and permeability.

- Simulation study

Data obtained from the core tests and the well logging were used in the simulation study of carbon dioxide behavior underground.

The schedule of the injection test is as follows.

The construction of injection facilities started in November 2002 and experimental injection and monitoring of CO<sub>2</sub> will be performed from FY2003 for one and half years. The total amount of injected CO<sub>2</sub> will be 7,000-10,000 metric tons. CO<sub>2</sub> behavior underground will be researched using logging and cross-well seismic tomography.

## **GEOLOGICAL INVESTIGATION**

The geological site survey aims to establish the procedures of the investigation, analysis and evaluation, focusing on CO<sub>2</sub> geological sequestration.

In FY2001, investigations were carried out as follows:

- literature search on existing geological information around Pacific offshore region
- reviewing closer structures from the collected reports and evaluating the geological structure
- recompiling the existing seismic exploration data
- creating a GIS data base to support CO<sub>2</sub> geological sequestration

## CONCLUSIONS

Japan took the first step towards the implementation of CO<sub>2</sub> geological sequestration. Soon, we will gain the data concerning safety assurance of CO<sub>2</sub> sequestration. As many authors such as Holloway (1997) pointed out, the major barrier to implementation of CO<sub>2</sub> sequestration is cost. Besides cost, public acceptance is the key issue. Therefore, we will have to co-operate on a worldwide basis in order to gain public acceptance for this technology.

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