Feasibility of CO_2 Geological Sequestration near Large-Scale Emission Sources in Japan

Background

CO_2 Geological Sequestration (Fig.1) is the subject to great expectation as a technology, which can reduce the amount of CO_2 emission to the atmosphere. Although the sites appropriate for sequestration are identified in the government project based on the results of resource surveys, many of those places are far from the major large-scale CO_2 emission sources, for example thermal power stations, steel plants, cement plants, etc. In order to examine the role of CO_2 Geological Sequestration in the reduction of CO_2 emission, it is important and realistic to investigate existence of geological settings suitable for CO_2 sequestration in the vicinity of individual large-scale emission sources.

Objectives

To survey geological distribution of sites for CO_2 Geological Sequestration, to clarify the possibility of the sequestration near typical large-scale CO_2 emission sources in Japan, to examine current levels of technology about sequestration, and to extract tasks concerning that.

Principal Results

1. Distribution of geology suitable for CO_2 Geological Sequestration near large-scale emission sources

The possibility of geological sequestration near 36 sites of typical large-scale CO_2 emission sources in Japan was evaluated (Fig.2). The sedimentary rocks and pyroclastic rocks (like a green tuff) from Paleogene to Pleistocene (whose porosity and permeability are comparatively high) below 800m depth (where CO_2 will become supercritical state [*1]) were selected as the geological settings appropriate for CO_2 sequestration: candidate of reservoir (Fig.1). The suitable strata were distributed within a 5km (distance in which press fit by an Extended Reach Drilling well is possible: Fig.1) radius of 16 sites, and within a 20km (distance with the rational transportation by a pipeline; Fig.1) radius of 20 sites (Table 1). Distribution of physical trap structure like large-scale anticline is limited near the large-scale emission sources. In many cases, strata around the seashore where many of the large-scale emission sources are distributed inclines on the ocean side, the Pleistocene to the Paleogene below 800m depth therefore are usually thicker in the ocean area than on the landside. The coast to ocean area in the Sea of Japan side is the area where the Neogene has accumulated on very thickly, and can be expected to have especially large capacity for sequestration.

2. Evaluation of potential capacity of CO_2 sequestration

When a stratum that shows 28% porosity (average value of common reservoirs) and 50m of effective thickness below 800m depth, the expected potential capacity of CO_2 sequestration is about 3,500,000tons [*2] /1km^2 (Table 2)

3. Technical reliability and issues of CO_2 Geological Sequestration near large-scale emission sources

Since distributions of the stratum that show anticline near the CO_2 emission sources are limited, improvement in reliability of the sequestration mechanism based on the dissolution trap or residual gas trap [*3] as CO_2 trap mechanism is the key issue. Moreover, since it is necessary to understand the long-term subterranean behavior of stored CO_2 after the injection, simple and reliable monitoring technique needs to be developed.

Future Developments

In order to enable detailed evaluation of storage capacity, we aim at establishment of the evaluation technology of CO_2 behavior in consideration of the residual gas trap mechanism. In industrialization, we propose an appraisal method of storage capacity, and will develop economical and reliable monitoring technique.

Main Researcher: Shiro Tanaka, Ph. D.,
Research Geologist, Geosphere Science Sector, Civil Engineering Laboratory

Reference

T. Ohsumi et al., 2007, "Feasibility of carbon dioxide storage near large-scale emission sources in Japan", CRIEPI Report N06035 (in Japanese)

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*1 : CO_2 will be in the supercritical state on the conditions of 31 degrees C or more and 7.4MPa or more. Supercritical CO_2 shows high density like a liquid and diffusibility like gas, therefore the method of pressing CO_2 fit into a stratum by the supercritical state is considered in the geological sequestration.

*2 : When CO_2 in the flue gas from a coal-fired power station of 1 million kW output is captured 90% or more, the amount of collected CO_2 is about 20,000tons/day.

*3 : The trap mechanism by which CO_2 fluid phase remains in pores when CO_2 moves through the porous media in a stratum.

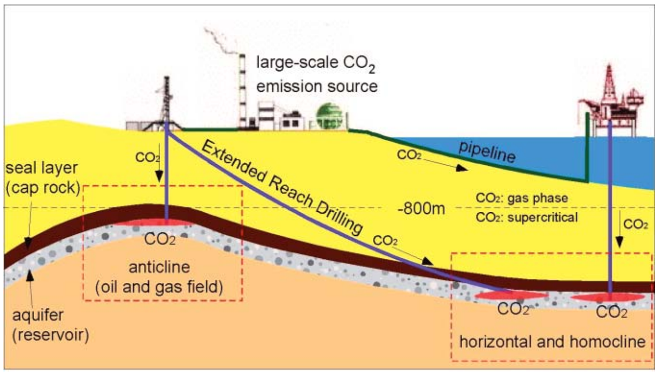

Fig.1 Basic concept of CO_2 transportation and injection near the large-scale emission sources

Supercritical CO_2 will be injected into the aquifer below 800m depth. To transportation of CO_2 to a storage site, pipeline transportation and Extended Reach Drilling well transportation are realistic (modified from RITE (2006)).

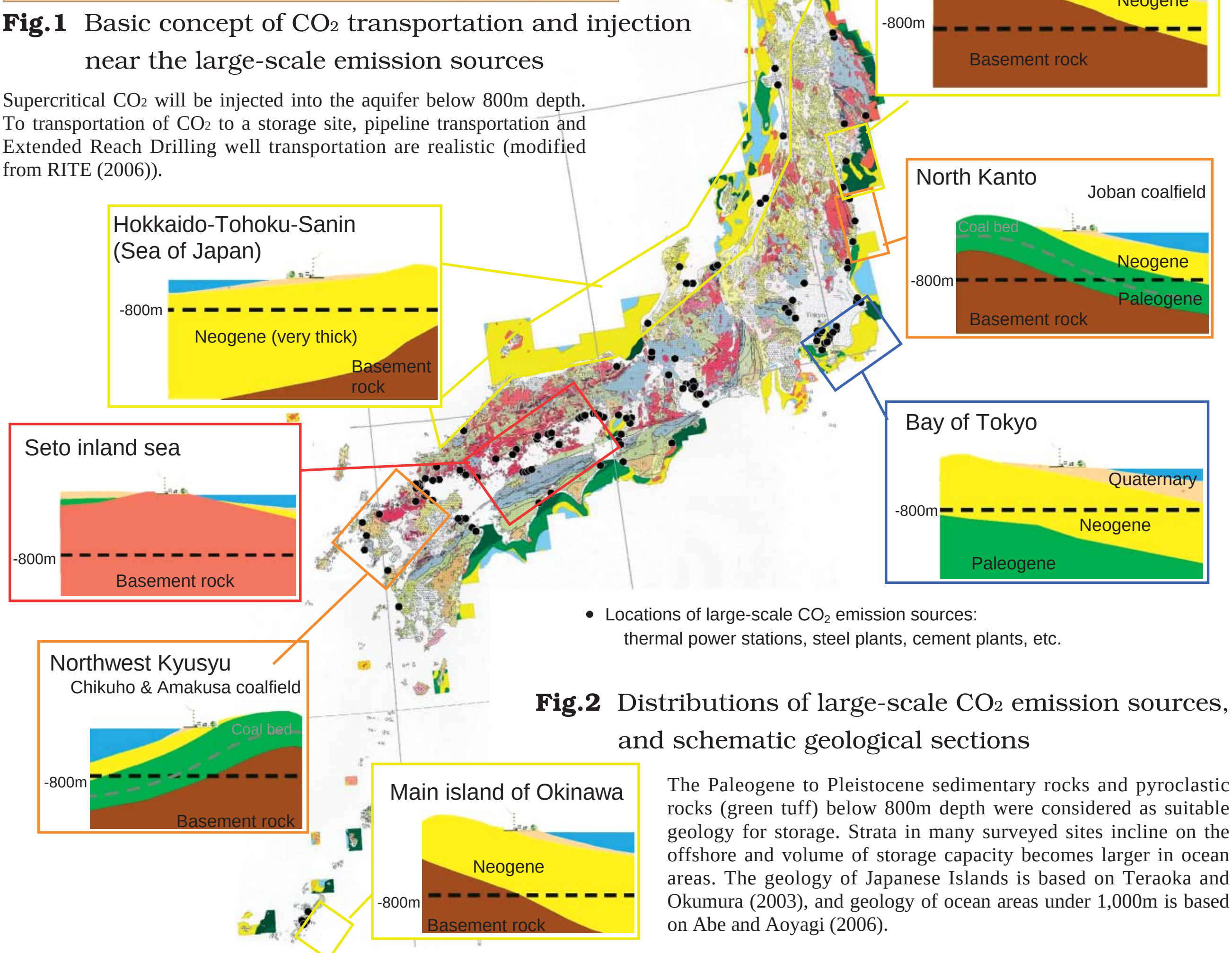

Fig.2 Distributions of large-scale CO_2 emission sources, and schematic geological sections

The Paleogene to Pleistocene sedimentary rocks and pyroclastic rocks (green tuff) below 800m depth were considered as suitable geology for storage. Strata in many surveyed sites incline on the offshore and volume of storage capacity becomes larger in ocean areas. The geology of Japanese Islands is based on Teraoka and Okumura (2003), and geology of ocean areas under 1,000m is based on Abe and Aoyagi (2006).

Table 1 Possibility of Geological Sequestration near the large-scale CO_2 emission sources

Depth of reservoir	Distance from the large-scale CO_2 emission source	
	~ 5 km	~ 20 km
below -800m	16 Neogene: 9 Paleogene: 7	20 Neogene 12 Paleagene 8
none or above -800m	20	16

At the large-scale CO_2 emission sources more than a half, geology for sequestration (reservoir) may exist in less than 20km.

Table 2 Trial calculation of the storage capacity per $1km^2$ in consideration of the residual gas trap mechanism

	Symbol [unit]	Adopted value
Thickness of reservoir	d [m]	50
Average porosity of reservoir	ϕ	0.28
Spatial efficiency of storage	F	0.5
	Equation [unit]	Result
Volume which CO_2 occupies	$V=d\phi F$ [m^3]	7×10^6
Average density of CO_2	ρ [tm^{-3}]	0.5
Capacity of CO_2 storage	ρV [t]	3.5×10^6

Storage capacity mainly depends on the volume and porosity of the aquifer. General porosity of the Neogene is higher than that of the Paleogene. The Neogene is expected to have larger capacity per unit volume.