

Geological Sequestration -CO₂-

Japan emitted about 1.2 billion tons of CO₂ artificially in 1995, already 8% larger than the 1990 level. Japan would barely be able to reduce future greenhouse gas emission to the 1990 level with the best efforts at conservation of energy, development of new energy sources, and the maximum boost in nuclear power generation. For significant reduction of greenhouse gas emission below the 1990 level, the only possible and quickly effective greenhouse gas mitigation option is the geological sequestration of CO₂ (Fig.1). Geological sequestration of CO₂ is more favorable than ocean sequestration of large amounts of CO₂ due to the sensitivity of the ocean environment. A systematic fundamental drilling survey of geological structures for oil and gas exploration in and around Japan by the Ministry of International Trade and Industry (MITI) - Japan National Oil Corporation, found empty anticlinal structures that could store 1.5 billion tons of CO₂, that is, enough capacity to accommodate 77 million tons of CO₂ annually over 20 years. Also, oil and natural gas reservoirs could contain 2 billion tons of CO₂.

Underground injection of 70 million tons of CO₂ reduces a net 68 million tons of CO₂ emissions in the air, this matches the 6% reduction goal of artificial CO₂ emission of the 1990 level in Japan as set by the 1997 Kyoto protocol. A preliminary cost estimation suggests that to achieve this goal, geological sequestration would cost 424 billion yen for the capture, transportation, and underground injection of CO₂. If the expenses for geological sequestration of CO₂ are paid by a carbon tax,

a reasonable rate of 1,200 yen per 1 ton of carbon would be sufficient.

The world-wide storage capacity of aquifers in sedimentary basins is estimated to surpass 3 trillion tons-CO₂. Zero emission fossil-fueled power plants with geological sequestration of CO₂ are a feasible option for the reduction of greenhouse gas emissions.

Autogenous sealing of CO₂ storage in aquifers

Natural gas-hydrate-filled layers are often found under the deep sea floor due to high pressure and low temperature.

Natural gas tends to accumulate under the gas-hydrate-filled layers as well as under permafrost layers, because the layers are a virtually perfect insulator of gas. It is feared that global warming may be accelerated by the emission of trapped methane due to the dissolution of permafrost layers and hydrate layers by warming. Injection of CO₂ under permafrost and methane hydrate caps with the counter extraction of trapped methane could prevent the acceleration of global warming. The injections of CO₂ strengthens permafrost and methane hydrate caps with CO₂ hydrate that is stable at a higher temperature than ice at high pressure and more stable than methane hydrate (Fig. 2). CO₂ injection under gas-hydrate layers and under permafrost layers realizes greenhouse gas mitigation and recovery of unused natural gas at the same

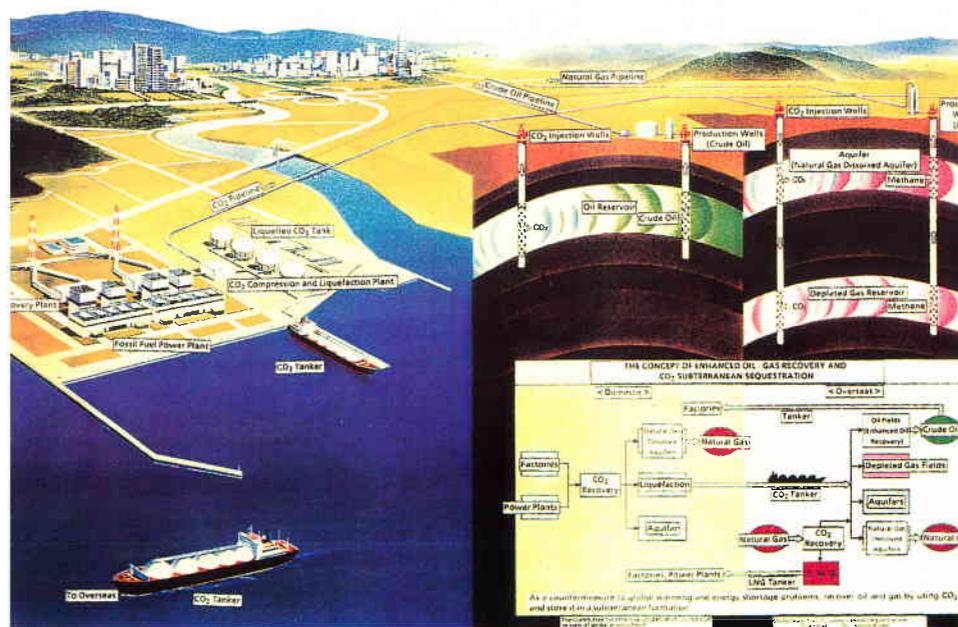


Figure 1. Geological sequestration of CO₂ captured from flue gas of fossil fuel power plants.

time.

CO₂ injection into deep aquifers may form CO₂ hydrate-filled layers under about a 300m water column and under deep and cool sea floors. Autogenous sealing of CO₂ in deep and cool aquifers assures virtually complete and practically unlimited subsurface containment of CO₂. Autogenous sealing is very safe since every crack will be automatically filled, even gaps in cap rocks from earthquakes. Virtually complete isolation of huge amounts of CO₂ is possible by deep sub-seabed disposal. Liquid CO₂ in a heavy suspension intrudes laterally under light unconsolidated sediments at sea floors deeper than about 3700m. This lateral intrusion technique for the super-deep sub-seabed disposal of CO₂ can protect the ecology of the sea floor.

Microbial rejuvenation of methane deposits in aquifer storage of CO₂

Dissolved natural gas deposits are not usually economically exploitable and methane dissolved in groundwater is found in most sedimentary basins. The underground injection of CO₂ and counter extraction of groundwater can realize the recovery of methane dissolved in fossil groundwater for use as a low grade natural gas resource. Extremely light isotopic

compositions of carbon in CH₄ suggest that methanogens formed some of the dissolved methane deposits. Accumulations of methane-rich natural gas of bacterial origin have been found in many sedimentary basins around the world.

Anaerobic chemoautotrophic methanogens, that belong to Archaea, gain energy by forming CH₄ from CO₂ and H₂. Bacterial methanogenesis takes place without the help of sunlight. Methanogens are also blamed for greenhouse gas emission as they produce methane in the bowels of cows and termites and in rice paddies since they are abundant in these anoxic habitats. If CO₂ is injected into aquifers and dissolved into groundwater in which methanogens are active, methanogens reduce CO₂ into CH₄. Where the aquifer has a geological trapping structure, methane tends to accumulate at the top of reservoir under cap rock and revive natural gas deposits.

Chemoautotrophs fix carbon dioxide in deep aquifers even without sun light. Methanogens can convert the carbon dioxide into methane in deep anoxic aquifers. Biogenetic restoration of subsurface hydrocarbon deposits is expected in CO₂-injected aquifers after tens or hundreds of years. Microbiological recycling of carbon dioxide in aquifers is an attractive future technology for energy-short countries such as Japan.

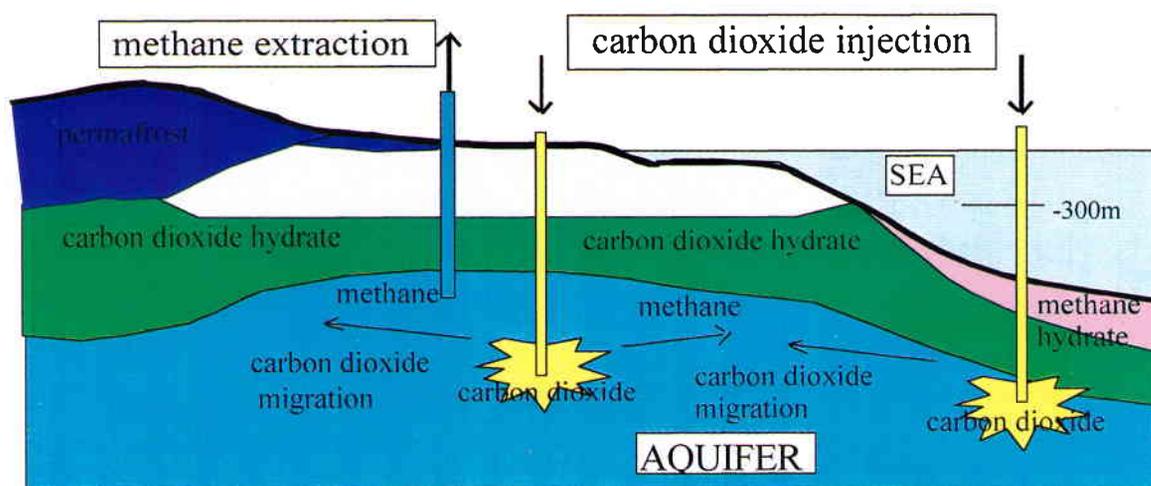


Figure 2. Trapping of CO₂ in sub-seabed and cool aquifers and methane extraction.

For more information contact:

Hitoshi KOIDE
Environmental Geology Department
Geological Survey of Japan
1-1-3 Higashi, Tsukuba, Ibaraki, 305-8567 Japan
phone: +81-298-54-3801
fax: +81-298-54-3801
e-mail: MXE02263@nifty.ne.jp
web site: <http://www.aist.go.jp/GSJ/>



Geological Survey of Japan

*Agency of Industrial Science and Technology (AIST)
Ministry of International Trade and Industry (MITI)*

