



POSSIBILITY OF CO₂ SEQUESTRATION INTO COAL SEAMS IN JAPAN

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Abstract

CO₂ sequestration into coal seams is one of the favored options for reducing atmospheric CO₂ emissions from power and industrial plants. The authors reanalyzed data of 1956 MITI nationwide systematic survey of coal reserves. CO₂ sequestration capacities of coalfields in Japan were estimated from old geological and experimental data. Remaining coal seams in old coal mines are estimated to be able to adsorb about 600 Mtons of CO₂ in Japan.

Explored but untapped coal seams are suitable for early application of CO₂ storage. A preliminary field test on CO₂-ECBM is made for untapped coal seams in the coalbed methane-rich Ishikari coalfield in Hokkaido. Major untapped coalfields in Japan may store 380 Mtons of CO₂ and may produce 84 Gm³ of coalbed methane in total. All major conventional coalfields in Japan may sequester about 1 Gtons of CO₂ and may produce 240 Gm³ of coalbed methane in remaining coals in old coal mines and in untapped coalfields, combined. Nearshore coalfields in the Kyushu district can provide cost-effective storage for CO₂.

Recent systematic exploration of oil and natural gas revealed that huge volumes of coal seams lie deep in Paleogene sedimentary basins along the Japanese islands. Deep coal and coaly shale are noticed as source rocks of natural gas and oil. In the central Hokkaido, unmineable coal seams deeper than -1,200m and shallower than -3000m are found to reach as much as 100 Gtons that may store 3.5 Gtons of CO₂ and contain nearly 900Gm³ of coalbed methane. Coal-bearing Paleogene sedimentary basins spread widely offshore of the Honshu and Kyusyu islands.

CO₂ sequestration potential of deep unmineable coal seams in Japan would reach well past 10 Gtons. Huge volumes of deep unmineable coal seams may not only provide potential sinks for CO₂, but also unseen enormous energy resources.

Introduction

CO₂ sequestration into coal seams is one of the favored options for reducing atmospheric CO₂ emissions from power and industrial plants. Since 2002, the Ministry of Economy, Trade and Industry (METI) implemented a national research and development project of CO₂ sequestration in coal seams in Japan [1]. The main contractor of the national R&D project of CO₂ sequestration in coal seams in Japan is Kansai Environmental Engineering Center Co., Ltd. (KANSO). The research group includes Japan Coal Energy Center (JCOAL), Research Institute of Innovative Technology for the Earth (RITE), Kansai Electric Power Co. Inc., Mitsubishi Heavy Industries, Ltd. and Non Profit Organization (NPO) Think-tank Kyoto Institute of Natural History among others. Our research team in the Waseda University participated in the national R&D project to estimate CO₂ sequestration potential of coal seams in Japan.

CO₂ sequestration potential into remaining coal in old coal mines in Japan

The research team in the Waseda University reanalyzed data of 1956 MITI nationwide systematic survey of coal reserves in Japan [1], when many coal mines were still flourish in Japan. As all coal mines except only one mine have been closed now in Japan, it is difficult to get coal specimens now for measurement of gas adsorption capacity. Fortunately, one of the authors measured methane gas adsorption capacity of coals of many coal mines when the

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mines were still active. CO₂ sequestration potential of coalfields in Japan was estimated from old geological and experimental data with rough estimate of pressure and temperature for depth intervals. Almost 18 Gtons of remaining coal seams in old coal mines are estimated to be able to produce about 158 Gm³ of coal mine methane and to sequester about 600 Mtons of CO₂ in Japan (Table 1). This estimate does not include very shallow coal seams above groundwater level, coal in very small mines, low-grade lignite or peat. Neogene sedimentary basins in Japan contain large volume of lignite and peat that could be useful for CO₂ sequestration. However, we have not yet reliable data of volume of neither lignite nor peat. As only very shallow low-grade lignite and peat were mined by small scale of mines, neither low-grade lignite nor peat beneath ground water level were not surveyed well.

Table 1. CO₂ sequestration potential into remaining coal in old coal mines in Japan

Coalfields Districts	CO ₂ sequestration potential into coal from 0m to - 300m	CO ₂ sequestration potential into coal from -300m to - 600m	CO ₂ sequestration potential into coal from -600m to - 1,200m	CO ₂ sequestration potential into coal from 0m to - 1,200m (in total)
Ishikari	32.36 Mtons	86.81 Mtons	190.24 Mtons	309.41 Mtons
Tenpoku	4.04 Mtons	3.53 Mtons	0 Mtons	7.57 Mtons
Tomamae-Rumoi	0.97 Mtons	1.89 Mtons	2.90 Mtons	5.76 Mtons
Kushiro	4.94 Mtons	9.23 Mtons	15.67 Mtons	29.84 Mtons
Hokkaido (in total)	42.31 Mtons	101.46 Mtons	208.81 Mtons	352.58 Mtons
Joban	1.35 Mtons	4.78 Mtons	4.57 Mtons	10.70 Mtons
Ube	3.87 Mtons	0 Mtons	0 Mtons	3.87 Mtons
Honshu (in total)	5.22 Mtons	4.78 Mtons	4.57 Mtons	14.57 Mtons
Chikuho	12.86 Mtons	16.60 Mtons	15.97 Mtons	45.43 Mtons
Fukuoka	1.35 Mtons	1.20 Mtons	0.55 Mtons	3.10 Mtons
Miike	3.67 Mtons	30.84 Mtons	43.92 Mtons	78.43 Mtons
Karatsu	1.84 Mtons	8.49 Mtons	5.66 Mtons	15.99 Mtons
Sakito-Matsushima	6.36 Mtons	9.89 Mtons	35.62 Mtons	51.87 Mtons
Takashima	1.89 Mtons	7.88 Mtons	29.47 Mtons	39.24 Mtons
Kyushu (in total)	27.97 Mtons	74.90 Mtons	131.19 Mtons	234.06 Mtons
Japan (in total)	75.50 Mtons	181.14 Mtons	344.57 Mtons	601.21 Mtons

CO₂ sequestration potential into major untapped coalfields in Japan

Explored but untapped coal seams are most suitable for early application of CO₂ storage (Table 2). A preliminary field test on CO₂-ECBM is made for untapped coal seams in the coalbed methane-rich Ishikari coalfield in Hokkaido for the national R&D project of CO₂ sequestration in coal seams in Japan.

We estimated that the 6 undeveloped areas of the Ishikari coalfield in Hokkaido may store 178 Mtons of CO₂ and may produce 41 Gm³ of coalbed methane. The Kushiro-oki offshore coalfield, Hokkaido, may sequester 67 Mtons of CO₂ and may produce 17 Gm³ of coalbed methane. The Ariake inland sea coalfield in Kyushu may store 32 Mtons of CO₂. The Nisi-Sonogi offshore coalfield in northwestern Kyushu may sequester about 103 Mtons of CO₂ and may produce 26 Gm³ of coalbed methane.

Major untapped coalfields in Japan may store 380 Mtons of CO₂ and may produce 84 Gm³ of coalbed methane in total. All major conventional coalfields in Japan, that is the sum of remaining coals in old coal mines and untapped coal seams, may sequester about 1 Gtons of CO₂ and may produce 240 Gm³ of coalbed methane. Power and industrial plants as CO₂ source locate near some of coalfields in the Kyushu district. The cost of transportation is a significant factor in the economics of CO₂ sequestration. Nearshore coalfields in the Kyushu district can provide cost-effective storage for CO₂.

Table 2. CO₂ sequestration potential into major untapped coalfields in Japan

Coalfield	Estimated coal reserve	Coalbed methane	CO ₂ sequestration potential
6 untapped areas in Ishikari coalfields	3.3 Gtons	41 Gm³	178 Mtons
Kushiro-oki offshore	2.8 Gtons	17 Gm³	67 Mtons
Ariake inland sea	0.9 Gtons	-	32 Mtons
Nishi-Sonogi offshore	2.0 Gtons	26 Gm³	103 Mtons
Total	9.0 Gtons	84 Gm³	380 Mtons

CO₂ sequestration potential into deep unmineable coal seams in Japan

Recent systematic exploration of oil and natural gas by MITI (Ministry of International Trade and Industry: now METI) and private oil companies revealed that huge volumes of coal seams lie deep in Paleogene and late Cretaceous sedimentary basins which extend through central Hokkaido and along the Pacific coast of northeastern Honshu [2]. Deep exploratory wells often encounter deep coal and coaly shale layers that attract geologists' attention as source rocks of natural gas and oil, although conventional coal exploration neglected coal seams deeper than -1,200m as unmineable coal. However, deep unmineable coal seams and coaly shale layers may provide possible sink for CO₂ sequestration and source for coalbed methane.

The authors estimated CO₂ sequestration potential of deep unmineable coal seams in the central Hokkaido area by exploration data for oil and natural gas (Table 3). Unmineable coal seams deeper than -1,200m and shallower than -3,000m are found to reach as much as about 100 Gtons that may store 3.5 Gtons of CO₂ and produce nearly 900 Gm³ of coalbed methane in the central Hokkaido area. Very deep unmineable coal seams deeper than -3,000m may exceed 440 Gtons in the central Hokkaido area, only. Very deep unmineable coal seams may be used for CO₂

sequestration in future. However, CO₂ sequestration potential of very deep coal seams has not been calculated, due to lack of experimental basis.

Coal-bearing Paleogene sedimentary basins extend southward to Sanriku-Oki and Joban-Oki offshore areas east of the northeastern Honshu [3]. Coal-bearing sedimentary basins are expected to contain huge volume of deep unmineable coal also in northeast Kyushu [4]. CO₂ sequestration potential of deep coal seams in Honshu and Kyushu is to be estimated in the future.

Preliminary estimation suggests that CO₂ sequestration potential of deep unmineable coal seams in Japan would reach well past 10 Gtons, if major offshore coal-bearing sedimentary basins are surveyed and counted. Huge volumes of deep unmineable coal seams may not only provide potential sinks for CO₂, but also unseen enormous energy resources.

Table 3. CO₂ sequestration potential into deep unmineable coal seams in central Hokkaido

(Depth interval: from -1,200m to -3,000m)

Area	Estimated coal reserve	Coalbed methane	CO ₂ sequestration potential
Tenpoku onshore	21 Gtons	210 Gm ³	828 Mtons
Tenpoku offshore	9 Gtons	71 Gm ³	277 Mtons
Enbetsu onshore	15 Gtons	83 Gm ³	329 Mtons
Enbetsu offshore	7 Gtons	42 Gm ³	167 Mtons
Tomamae onshore	34 Gtons	338 Gm ³	1,336 Mtons
Tomamae offshore	8 Gtons	83 Gm ³	330 Mtons
Ishikari Plain	5 Gtons	56 Gm ³	223 Mtons
Total	99 Gtons	883 Gm³	3,490 Mtons

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