Use of carbon dioxide in underground natural gas storage processes

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Používanie CO_2 pri procesoch uskladövania plynu v podzemí

The possibility of use of carbon dioxide in gas storage processes is presented. The model of mixing process between CO_2 and methane in porous media is given. The process of injection of carbon dioxide into a lower part of storage near the water –gas contact is modeled. The example of changes in the mixing zone is presented and discussed.

Key words*: carbon dioxide, gas storage processes, porous media, near the water*

Introduction

The research project related to the"Use of carbon dioxide in underground natural gas storage processes" is executed in two phases. In the first stage, the study of diffusive and dispersive mixing processes (CO_2/stored natural gas) in classic gas storages and the study of adsorption-diffusive processes in coal bed layers in selected abandoned hard coal mines is given. The second stage is related to a numerical study of mixing processes.

Carbon dioxide designated to be used in storage processes could be obtained in separation processes from flue gases that come from sources of a CO_2 emission point (power plants, thermal-electric power stations, chemical factories, steel mills, etc.). Following technologies are available for the capture of carbon dioxide: chemical absorption, cryogenic process, physical absorption, membrane technologies.

Basically, four methods of CO_2 storage in geological structures could be distinguished:

1. storing in oil depleted reservoirs and exploited gas storages
2. storing in aquifer structures
3. storing in coal beds linked with an enhancement of methane exploitation (ECBM) or construction of a storage in abandoned hard coal mines
4. storing in depleted and exploited oil reservoirs

CO_2 in storage processes

The easiest process, using CO_2 in a natural gas storage process in the depleted natural gas reservoirs, is the exchange of classic gas cushion (buffer volume) for another cushion which partly involves CO_2. Such using of carbon dioxide could be economically justified: the costs of separation, transport, compression and the injection of CO_2 could be diminished by the possibility of natural gas reception from the top parts of storage. Besides obvious ecologic and economic benefits, the uncertainty of the composition of the natural gas exploited from an underground storage should also be considered. This issue will be the first point of the research project. The matter of storing in coal beds linked with the enhancement of exploitation (ECBM) or the erection of a storage in abandoned hard coal mines is the second basic problem in the research project.

ECBM-CO_2 in the upper silesian basin of Poland (RECOPOL)

The RECOPOL project is an EC-funded research and demonstration project to investigate the technical and economic feasibility of storing CO_2 permanently in subsurface coal seams (Pagnier et al., 2004). The main aim of the project was to demonstrate that the CO_2 injection in coal under European conditions is feasible and that the CO_2 storage is a safe and permanent solution. This is the first field demonstration experiment of its kind in Europe. The development of the pilot site in the Upper Silesian Basin (Fig. 1) in Poland began in summer 2003.

One of the existing coal bed methane wells was cleaned up, repaired and put back into production (Fig. 9). A new injection well was drilled at 150 m from the production well. After the completion of the well with casing, cementing and perforations, the perforated zones were tested. A baseline cross borehole seismic

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survey was carried out for monitoring purposes in September 2003. Activities in autumn 2003 included the finalizing of the injection facilities. The production has started in the first half of June 2004, to establish a baseline production. First injection tests took place in the first week of July. Once the injection is stabilized, both injection and production is continuing. During the injection period the process will be monitored directly and indirectly to assess any potential, although unlikely, of a leakage of CO_2 to the surface. Along with the field tests, an extensive laboratory program is carried out.

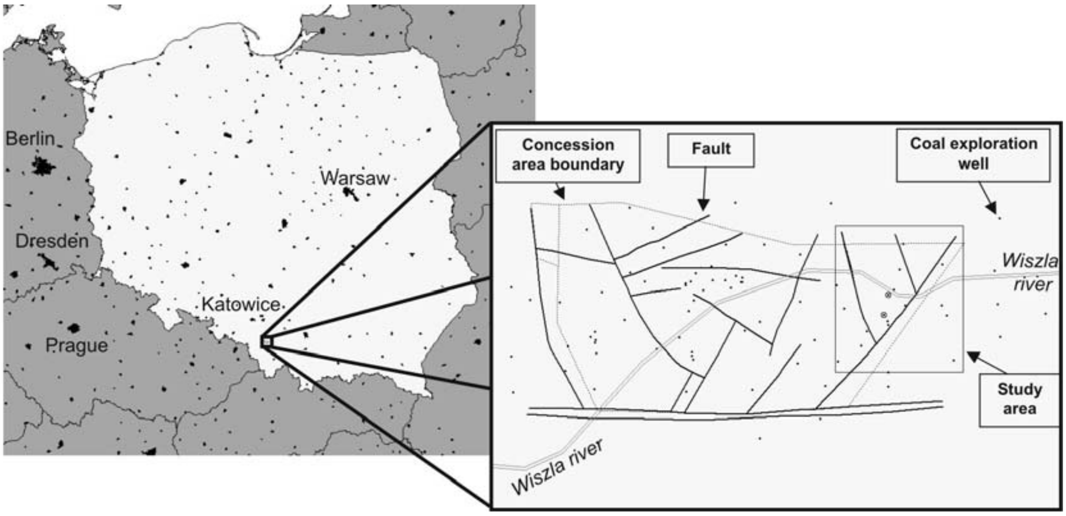

Fig. 1. Upper Silesian Coal Basin and the location of pilot wells (Pagnier et al. 2004).

Final Storage of CO_2 in Coal-bed Methane Layers

Besides of the methane production – the possibility of storage of CO2 may be considered. The advantage of the storage capacity at the pressure below 100 m is given in the Fig. 2 & 3 (Di Federico, Brandani, 2005). The process of ECBM-CO2 may be also important for a future – the final stage of storing of CO_2 in geologic sequestration process.

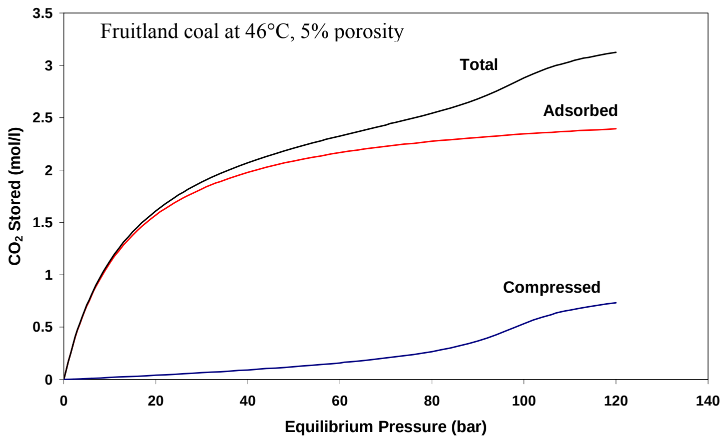

Fig. 2. Comparison of coal storage capacity (45 °C, 5 % of porosity) versus the equilibrium pressure (Di Federico, Brandani, 2005)

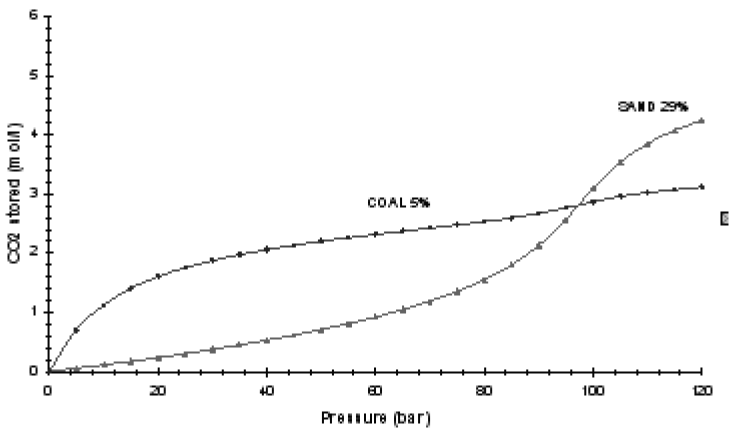

Fig. 3. Comparison of storage in coal bed layers with a high porosity of porous media (Di Federico, Brandani, 2005).

Underground Gas Storage in abandoned hard coal mines

Two storage facilities examined are locatedwithin underground coal mines abandoned processes (KWK Krupinski, KWK Silesia). The mine workings are overlain by a relatively impermeable and competent caprock. A fundamental question related to UGS in Cola Mine is the tightness of UGS. The tightness of UGS may be technical (production, injection wells, shaft, etc) and geological (type of structure, mining activity). The requirements for the geological tightness are presented in Fig. 4, where the migration time into the upper confining layer with the permeability 0.01 md and 0.001 is shown. The calculation of the migration time was obtained using the migration model based upon the following data: Bagrodia & Katz, 1977, Domenico & Schwartz, 1996, Krooss 1986, O'Sullivan & Smith., 1970, Civan & Rasmussen, 2001.

The possibility to build two underground gas storage inside of abandoned mine may be considered in future as en example of local gas storage for the Upper Silesia area. The existing three cases of UGS in coal mines in the world (EPA 1998, Kidybinski, Siemek, 2006) show that it is technically and economically possible.

Below, in Table 1, the storage capacity for the low pressure storage of the KWK Silesia (Kidybinski & Siemek, 2006) is presented. The working capacity of 162 mln Sm^3 is relatively high. An analysis of the possibility of storage of gas in abandoned coal is difficult, So for every case a specific study may be necessary. Details related to the designing of UGS in a coal mine may be found in two monographs: Kidybiński & Siemek (2006) and EPA (1998).

Tab. 1. Example of storage capacity for the low pressure storage in the KWK Silesia (Kidybinski, Siemek, 2006).

P_{max}	P_{min}	Adsorption P_{max}	Adsorption P_{min}	Max capacity (total)	Buffer capacity (total)	Working capacity
bar	bar	mln Sm^3	mln Sm^3	mln Sm^3	mln Sm^3	mln Sm^3
7	2	68	33	244	82	162

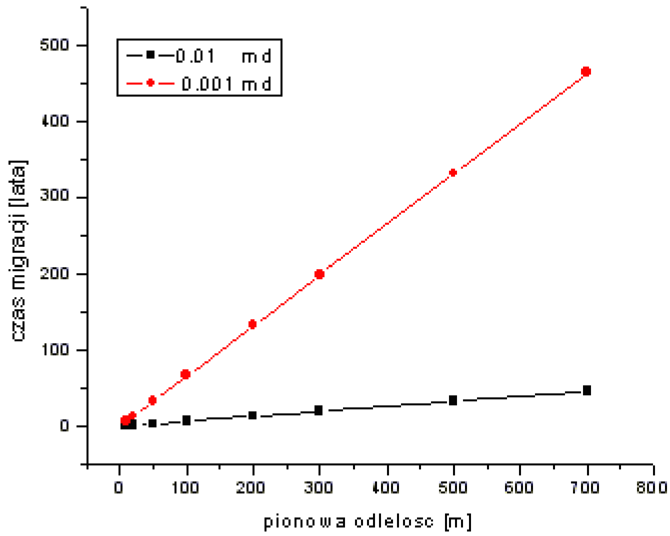

Fig. 4. Migration time into the upper confining layer with permeability 0.01 md and 0.001 (Kidybynski, Siemek 2006).

Conclusions

The lessons from Recopol can possibly help to overtake the start-up barriers of a future CO_2 sequestration project in Europe.

Besides of the methane production – the possibility of storage of CO_2 may be considered. The high advantage of storage capacity in the pressure below 100 bar in comparison to a high porosity porous media layer is evident

The possibility to build two underground gas storage (UGS) inside of an abandoned mine may be considered in future as en example of local gas storage for the Upper Silesia area. The requirements for the geological tightness are most important.

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