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Possibilities of underground CO_2 storage in the Upper Silesian region

Introduction

The policy of the European Union obliges the Union's member states to counteract excessive carbon dioxide emissions into the atmosphere. Different actions are being undertaken in the field of implementation of clean coal technologies and geological carbon dioxide storage (among others Lubaś et al. 2003; Nagy 2010; Solik-Heliasz 2009; Stopa et al. 2006; Tarkowski et al. 2007; Uliasz-Misiak 2007). One of them is the task realised in 2007–2010 in the framework of the Technology Initiative I, entitled "Study of safe CO_2 storage basing at the example of the Silesian agglomeration", aiming at the determination of possibilities of CO_2 injection in this region. In the Silesian Voivodeship (Province) the highest CO_2 emissions in Poland are noted, originating from particularly onerous industrial plants (Ochrona środowiska... 2007). Additionally the Voivodeship (Province) is considerably urbanised what causes that the indication of a site for underground storage requires not only good recognition of geological structure parameters, but also the determination of the impact of CO_2 on existing and planned economic undertakings. On these factors will depend the effectiveness and safety CO_2 injection.

The performed investigations have pointed out that in the Upper Silesian region exists the possibility of carbon dioxide storage in water-bearing horizons and in selected workings of abandoned hard coal mines. The possibility of storage concerns also hard coal seams – however, it is a question of discussion if it will be economically justified. Incidentally, in relation to these problems arises the question: if in the future necessary will be the implementation of the rules of town and country planning with regard to the economic

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utilisation of underground rock structures? For some areas answering this question becomes urgent.

1. Possibilities of CO_2 storage in water-bearing horizons

It has been ascertained in the course of hydrogeological analysis of the region that for underground carbon dioxide storage are suitable the Miocene formations of the Dębowiec layers in the Skoczów-Zebrzydowice area and formations of the Lower Jurassic system in the Częstochowa region. Potentially possible is also CO_2 injection into the formations of the Cracow sandstone series in the Pszczyna-Ćwiklice area, however, the near neighbourhood of a big tectonic zone does not guarantee safe CO_2 storage.

1.1. Geological characteristics of proposed CO_2 storage sites and their storage potential

The water-bearing horizon of the Dębowiec layers is connected with weakly compact sandstones and conglomerates of the Miocene age. They fill the regional geological structure of the Pre-Carpathian depression. The overburden within the reach of the storage site is about 730–1040 m thick; it is formed by silty formations of the Skawina formation of the Miocene age and flysh formations of the Cretaceous-Older Tertiary age. In the floor of the deposit occur mainly Carboniferous formations of the mudstone series and locally Older Tertiary formations of the Zamarski member (Buła, Kotas 1994). For CO_2 storage the best area recognised as a result of hydrogeological and geophysical investigations, located between Skoczów and Zebrzydowice, was indicated (Fig. 1). In other areas (Bielsko-Biała, Kęty, Żywiec) the horizon is not sufficiently recognised; in connection with this it would be risky to indicate there sites for underground storage of industrial media (Dubiński, Solik-Heliasz 2007).

In the area of the proposed storage site the formations of Dębowiec layers point out fairly good values of hydrogeological and structural parameters (Table 1). Their horizontal variability has been ascertained, appearing in the fact that in the direction from south to north grow the permeability and porosity of formations, decreases the size of grains in the deposit and improves their sorting out and coating (Solik-Heliasz 1986 a, b). More advantageous values of reservoir parameters point out parts located in its northern part, i.e. in the Bzie-Jawiszowice fault area. The horizon contains relic waters of Na-Cl and Na-Cl-Ca type, with mineralisation up to 98 g/l, with dissolved methane. The temperature of the rock mass in the roof of Dębowiec layers amounts to 34–37°C and the water pressure related to the roof surface of layers reaches 7.3–8.5 MPa. These conditions allow to inject CO_2 in the supercritical state.

The proposed storage site is conveniently located. The initially defined effective storage capacity, determined from the relation presented by Bachu (Bachu et al. 2007), will allow to satisfy the needs of a medium-sized CO_2 emitter.

Two next CO_2 storage sites are located in the northern frontiers of the Silesian Voivodeship (Province) in the Częstochowa region, between Włoszczowa and Radomsko (Fig. 2). The water-bearing formations are bounded with Lower Jurassic sandstones. The roof of the water-bearing horizon occurs at the –800 – –1350 m ordinate. Above occur weakly permeable clays and marls, 350–650 m in thickness, and in the floor weakly permeable Upper Triassic deposits. These storage sites are advantageously located in relation

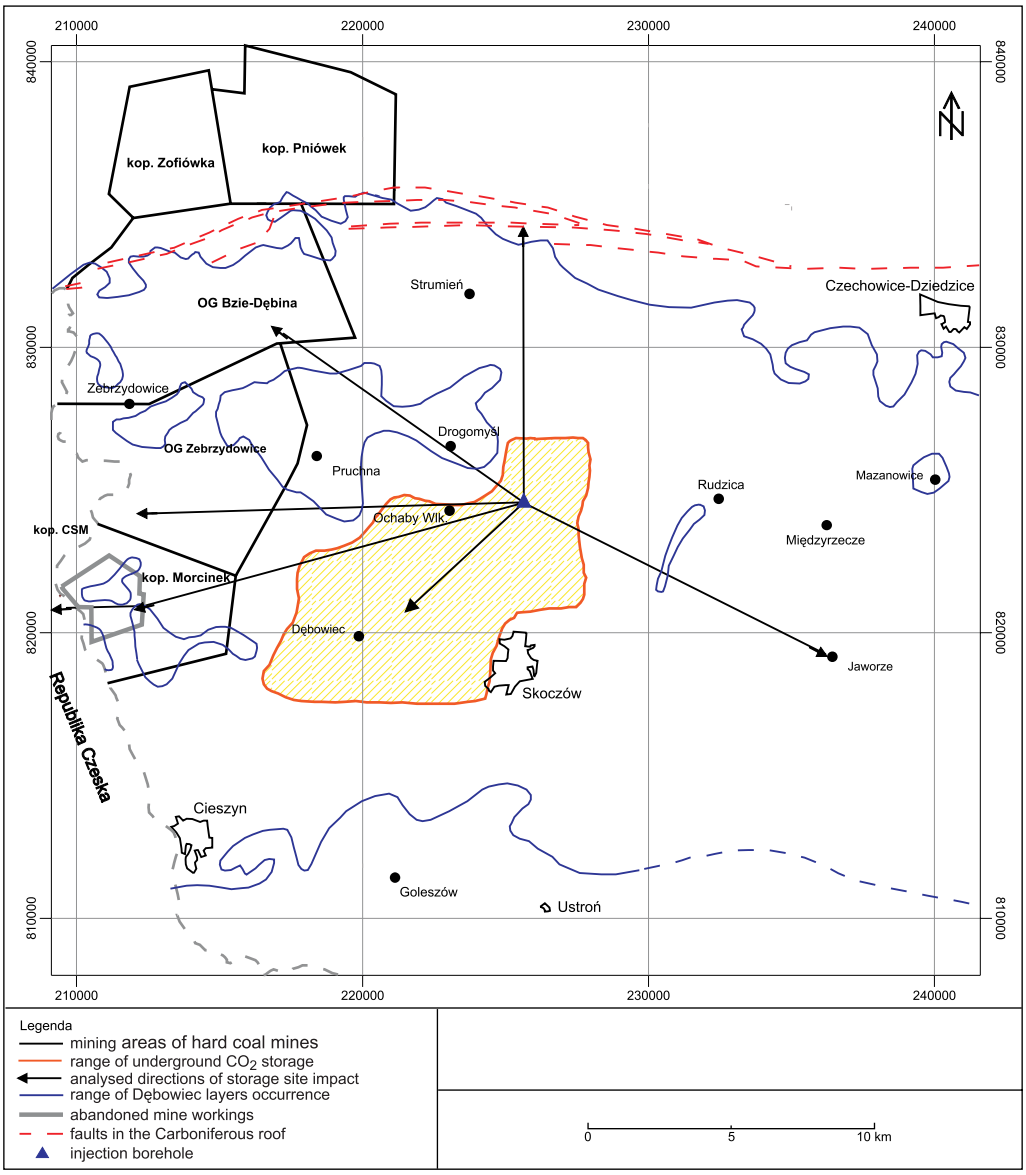

Fig. 1. Location of the Skoczów-Zebrzydowice storage site

Rys. 1. Lokalizacja składowiska Skoczów-Zebrzydowice

TABLE 1

Values of selected parameters of potential CO_2 storage sites in the Upper Silesian region (according to Solik-Heliasz)

TABELA 1

Wartości wybranych parametrów potencjalnych składowisk CO_2 w regionie górnośląskim (według Solik-Heliasz)

Parameters of reservoir rocks	Skoczów-Zebrzydowice area	Częstochowa area
Porosity [%]	8–15	8–22
Permeability [mD]	13–103	16–1 478
Thickness of the water-bearing horizon [m]	70–250	30–102
Total thickness of isolation formations in the roof [m]	720–1 030	350–650
Effective storage capacity [$Mg \cdot 10^6$]	24.1	43.9

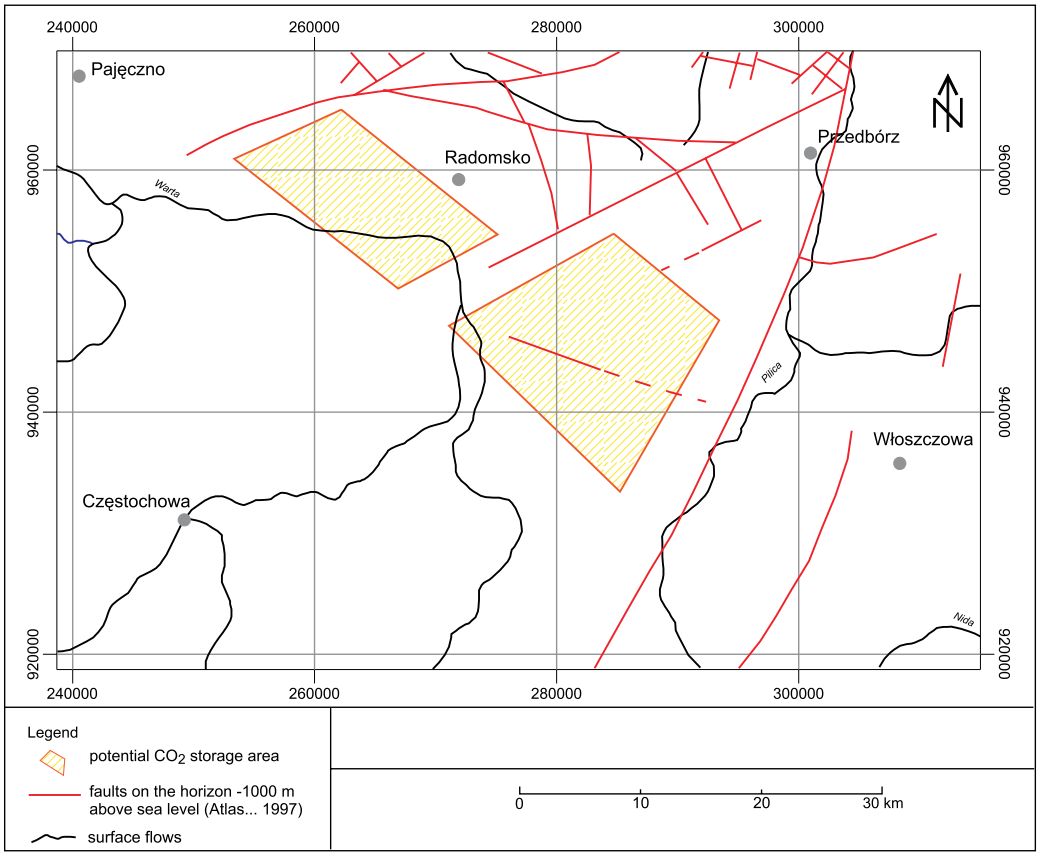

Fig. 2. Location of the Częstochowa storage site

Rys. 2. Lokalizacja składowiska Częstochowa

to environmental elements. However, the series contains waters with mineralisation up to 3 g/l, which can be potentially useful for utilisation objectives. This factor is not too advantageous from the viewpoint of underground industrial gases disposal (Chadwick et al. 2008). The CO_2 disposal capacity is considerable and it would allow to inject carbon dioxide originating from neighbouring industrial plants.

1.2. The problem of CO_2 storage site tightness

The Skoczów-Zebrzydowice storage site is tight from the side of formations occurring in the roof and floor. The relic waters ascertained in the horizon of the Dębowiec layers confirm the lack of its feeding from the terrain's surface – though possible is the contact of the horizon with other horizons of Dębowiec layers occurring in the roof, containing waters of paleoinfiltrative character. However, one should take into consideration that this state concerns current hydrodynamic conditions. When injecting carbon dioxide under pressure higher than the current hydrostatic pressure (even pressure equal to 12 MPa is considered), we cannot exclude partial clearing of the rock mass. This is all the more possible that the Dębowiec layer formations and deposits occurring in their roof and floor point out lower values of strength and engineering parameters; the compressive strength of the Dębowiec layer formations amounts to 4–56 MPa, and the tensile strength up to 4 MPa. In these conditions CO_2 injection can lead to the fracturing of both reservoir and surrounding formations; thus appropriate injection pressure selection will be required. This hazard could concern chiefly formations occurring in the area of the big, regional tectonic zone Bzie-Jawiszowice, running to the north of the storage site, with thrust amounting to 400–600 m. Taking into account the potential hazard, the storage site's boundary was delimited at a fairly large distance from the fault, amounting to 7–10 km.

A hazard can also create boreholes drilled into the Dębowiec gas deposit and deeper boreholes drilled into the Carboniferous roof. The gas deposit occurs in roof parts of the Newer Tertiary rock mass, above the CO_2 storage site's roof. The boreholes must be eliminated using special tightening mixtures, resistant against high pressures. However, some of them can be used for observation of the carbon dioxide injection process, after the confirmation of their satisfactory technical condition.

A separate problem constitutes the tightness of the isolating layer occurring between the roof of the Dębowiec layers and Dębowiec deposit floor. They are composed mainly of clays and mudstones from 275 m to more than 1000 m in thickness. We assess that in principle this is a sufficient isolation, however we cannot entirely exclude small CO_2 migration into hydrocarbon deposits. The particular location of the Dębowiec structure has caused that its use was considered as: 1/ safety buffer for the Skoczów-Zebrzydowice storage site; 2/ for the application of CO_2/CH_4 gases conversion (EOR method) and methane output intensification from the gas deposit; 3/ as separate CO_2 storage site, however, with lower pressure than at the storage site in the Dębowiec layers. Currently, on account of too poor experience in the field of underground CO_2 storage the first solution is preferred.

With reference to the storage sites located between Włoszczowa and Radomsko, the main hazard results from the possible carbon dioxide migration in the direction of the terrain's surface. At the distance of minimum 25 km from the storage site's boundary exists the probable feeding zone of the water-bearing horizon of the Lower Jurassic system from shallow, water-bearing horizons. At present we have too few data in order to carry out the simulation of the feeding process of this horizon. Thus in spite of advantageous values of hydrogeological parameters, the storage sites in this area were classified as reserve ones for underground CO_2 injection.

1.3. Impact of CO_2 storage sites on existing and planned economic undertakings

Beyond the area of the Skoczów-Zebrzydowice storage site conducting of various economic activities is anticipated. At the distance of up to 10 kilometres from the CO_2 storage site boundary:

— exploitation since the year 2017 of the hard coal deposit at the new Bzie mine along with drainage of the water-bearing level in the Dębowiec layers is planned;
— the possibility of exploitation of thermal waters in Jaworze near Bielsko-Biała from the Miocene and Devonian horizons is considered;
— moreover, in the area of the abandoned Morcinek mine exist mine workings – at present being flooded – as well as a depression crater formed in the horizon of the Dębowiec layers, comprising the mining areas of the Morcinek and ČSM (Czech Republic) mines – Fig. 1.

The results of a detailed analysis have pointed out that the planned CO_2 storage site will be beyond the range of impact both of planned and finished economic actions. This concerns first of all the present and predicted range of the depression crater in the water-bearing horizon of the Dębowiec layers. All the same, during the exploitation of the storage site the CO_2 injection process should be accurately monitored in such a manner that the carbon dioxide "cloud" should not appear in an uncontrolled way within the range of the overburden of workings of the mines mentioned above.

It is anticipated that the process of carbon dioxide injection can be accompanied by arising of the overpressure cone. It may appear mainly in the horizon of the Dębowiec layers and as a result of hydraulic bonds, in Carboniferous horizons in the area of mine workings of the Morcinek mine, and may be, ČSM mine. These calculations carried out using the *Theis* formula (Rogoż 2007) have pointed out that after 5 years of CO_2 injection, within the range of the overpressure front in the Dębowiec layers will appear the eastern boundary of the mining area of the Bzie mine, fault zone Bzie-Jawiszowice and the geothermal water intake in Jaworze, and after 10 years the workings of the Morcinek mine and the State's border.

At present it is difficult to assess the physical effects of pressure increase of the water-gas medium within the range of the overpressure cone; this medium will compose water, methane and carbon dioxide. According to the opinion of the authoress, the following phenomena can

be anticipated: 1/ increase of the water flow speed in the Dębowiec layers, 2/ pressure increase of the medium in flooded workings of the Morcinek mine and 3/ fracturing of formations in the case of exceeding of the permissible injection pressure. The pressure increase caused by CO_2 injection can theoretically also influence the boundary pillar determined in Carboniferous formations between the Morcinek mine and ČSM mine. On account of the potential water-gas hazard, an analysis of stability of the existing pillar was performed. At present the boundary pillar has a width equal to 100 m and it is foreseen for hydrostatic pressure amounting to 7.2 MPa (Frolik et al. 2003). Using the *Slesariev's* formula (Frolik 1998) it has been ascertained that the pillar's width will be sufficient even in the case of pressure increase in gobs, by 50% in relation to the current pressure, i.e. up to the value of 10.8 MPa. However, an additional effect will be the growth of intensity of water filtration through the boundary pillar. We access that the filtration of waters through the pillar, determined on the basis of the *Darcy's* formula (Rogoż 2007), will increase from the current value of 9.1 l/min to maximally 13.6 l/min.

2. Possibility of CO_2 storage in mine workings and hard coal seams

The results of investigations carried out hitherto have pointed out the possibility of industrial gases storage in mine workings of abandoned hard coal mines in the Upper Silesian Coal Basin – GZW (Underground disposal sites... 2006). These investigations concerned indeed methane and liquid fuels, however, according to the opinion of the authoress, the results can be also related to carbon dioxide. The possibilities of creation of underground storage sites concern abandoned mines, isolated from other mines, with suitably thick overburden of isolation formations with low water inflows into mine workings (Frolik et al. 2006). Such conditions were ascertained in the Krupiński, Silesia and Brzeszcze mines. It is important that the creation of the underground reservoir coincided with the mine closure stage in such a way that flooding of workings through waters originating from the natural inflow should be avoided. On account of the probability of rock mass cracking as result of performed mining exploitation, as optimum the formation of low-pressure reservoirs is considered, with pressure 0.25–0.6 MPa, comprising all mine workings of the given mine. There exists also the possibility to create high-pressure reservoirs for pressures above 1 MPa, which can be created in selected sealed workings after their adaptation and tightening.

In low-pressure reservoirs the storage surface will form all free spaces, i.e.: post--extraction gobs, roadway workings, cross-cuts, shafts, fractures and drained rock mass as a result of mining activity. The storage volume will be also connected with coal remainders left in pillars, safety berms, seams and extra-balance parts. The volume determined for methane is considerable (Chećko et al. 2006), and for carbon dioxide higher, what results among others from the coal ability to CO_2 sorption which was adopted for calculations as two times higher than for CH_4 (Ceglarska-Stefańska et al. 2008). The Table 2 presents the results of initial calculations concerning the expected potential of CO_2 storage in mine workings and

TABLE 2

CO_2 storage capacity in mine workings and coal remainders in the Silesia and Krupiński mines (according to Solik-Heliasz)

TABELA 2

Pojemność składowania CO_2 w wyrobiskach górniczych i resztkach węglowych w kopalniach Silesia i Krupiński (według Solik-Heliasz)

Parameters	Silesia mine	Krupiński mine
Volume of mine workings [$m^3 \cdot 10^6$]	25.08	5.80
Mass of left coal [$Mg \cdot 10^6$]	78.75	43.56
CO_2 quantity possible for storage in mine workings and coal remainders [$Mg \cdot 10^6$]	2.9–6.7	0.9–1.9

coal remainders in the Krupiński and Silesia mines. They were estimated for pressure of 0.6 MPa and temperature equal to 25°C.

From the above mentioned estimates it results that the CO_2 storage sites created in abandoned hard coal mines will be characterised by a fairly low or, at the outmost, medium storage capacity in comparison with water-bearing horizons. However, they could be used for local CO_2 storage sites for not very large industrial emitters.

There remains the problem of tightness of CO_2 storage sites in mine workings. One should mention the example of the existing methane storage site created in workings of abandoned hard coal mines in the Anderlue-Charleroi area in Belgium. This storage site is exploited since more than 20 years and it is tight – in spite of the fact that the cover of isolation formations in the gob roof is not too large and amounts minimally to 15 m (on the basis of own information of the authoress). It should be supposed that in similar conditions tight will be also the CO_2 storage site – in particular because the affinity of CO_2 to coal is higher than CH_4. In the case of mine workings, tightening will require old boreholes, drifts, shafts and parts behind the shaft lining and surrounding it cracked rock mass. In relation to Polish mines the condition of safe CO_2 storage in workings will be also the lack of impact of operating mines; their effect could be terrain subsidence or rock mass tremors, what could be the reason of CO_2 escapes. Furthermore, one should take into consideration that in some mines (among others Krupiński, Silesia) CO_2 injection will be accompanied by methane expulsion. Methane can be recovered and used for economic purposes. Carbon dioxide storage in workings of selected mines is a chance for the utilisation of a part of CO_2 emissions and as a method it should be implemented into practice and verified considering its effectiveness and safety for the environment.

The results of *in situ* investigations realised hitherto have pointed out also the possibility of CO_2 injection into hard coal seams. It should be mentioned, however, that the scale of experiences carried out hitherto is limited. In Poland investigations of this type were performed in the years 2004–2005 in the framework of the European Union's RECOPOL project (Bruining et al. 2004). Carbon dioxide was injected at the Silesia mine into three coal

seams occurring at the depth of about 1000 m. During 11 months in total 760 t of CO_2 were injected and on the principle of conversion more than 16000 m^3 of methane were obtained. It should be mentioned that the in general weak absorptiveness of the coal matrix did not increase under the injection pressure growth, whereas radically it improved after performing the fracturing of seams. Then the quantity of injected CO_2 increased from more than 100 t to 760 t in total. At present it is difficult to assess whether CO_2 storage in hard coal seams will be a method for gas utilisation at an industrial scale. According to the opinion of the authoress the storage capacity in seams occurring at the depth of 1000–2000 m estimated in the framework of the Sixth Framework Programme GeoCapacity (Wójcicki 2009) can be lower, because the safety in it of the industrial infrastructure and inhabitants was not taken into account. Moreover, it is quite probable that in the conditions of the Upper Silesian Coal Basin the majority of seams will require fracturing, what will influence the costs of the entire undertaking connected with injection. However, the investigations and applications should be continued – especially in relation to seams of weak quality, occurring in strongly tectonically affected areas and flooded, beyond the range of operating mines and towns.

A separate issue is the legitimacy of CO_2 disposal in hard coal seams. The creation of carbon dioxide storage sites in seams means irrevocable loss of the deposit. Within the range of CO_2 storage sites never coal could be extracted using mining methods nor seams could be gasified. Admittedly we can assume theoretically that storage sites will be created in extra-balance seams or occurring at great depths. However, in the practice never only extra-balance seams occur; those are in general groups of thinner and thicker seams. Thus even if the CO_2 injection technology in relation to coal seams turned out to be technically and economically justified, Poland, as a coal potentate, should have reserves of coal resources. The exploitation of reserves can be for the present unprofitable, however, in the next time profitability can increase as a result of development of new technologies. We should not to get rid of the chance to gain these technologies.

3. The problem of economic use of rock structures – a conflict of interests or coexistence (material for discussion)

The results of investigations realised hitherto indicate that in the area of CO_2 storage sites conducting of any economic activity will not be possible. However, in order to conduct other undertakings in their neighbourhood, necessary will be the determination of the range of their impact and exclusion of the interference phenomenon. With these problems the authoress came in contact when determining the storage site Skoczów-Zebrzydowice. An excellent example of this can be the exploitation of thermal waters and geological CO_2 storage. In Poland, including the Upper Silesian Coal Basin, areas that are suitable for the development of geothermal investments, in general are also suitable for carbon dioxide storage (Atlas... 2009). However, both activities entirely exclude each other. Hence appears the question related to the priority of individual economic initiatives. In some countries already goes on

the discussion regarding this subject (Sanner 2009). According to the opinion of the authoress, on account of the high environmental burdens, in the Upper Silesian Coal Basin priority should be given to investments relating to mining, tourism, balneotherapy etc. Privilege in favour of environmental investments, for example geothermal ones, is also postulated by EGEC (2009) and supported by the directive concerning CCS (Directive 2009). However, in some countries lasts the discussion regarding the preferences of individual initiatives (Sanner 2009).

There appears the question, if necessary will be the town and country planning with reference to the use of deeply located rock structures and water-bearing horizons? This is a too radical requirement. As in every economic activity, about the selection of investments will decide safety, expected ecological effects and conformity of the given activity with the local plans of region development.

Summary

The results of investigations have pointed out that in the Upper Silesian region exists the possibility of carbon dioxide storage in the water-bearing horizon of the Dębowiec layers in the Skoczów-Zebrzydowice region. A local storage site was determined, which is located apart from the range of impact of present and planned economic undertakings (in the field of underground mining and geothermal waters).

The results of investigations realised hitherto have also pointed out that mine workings of selected abandoned hard coal mines can be suitable for the creation of low-pressure CO_2 reservoirs (with pressure up to 0.6 MPa) and high-pressure reservoirs (with pressure more than 1 MPa) in selected, sealed workings. However, their storage capacity is lower in comparison with water-bearing horizons, what causes, that they can be used for the needs of local CO_2 emitters.

The storage possibility concerns also hard coal seams (Recopol Project). However, this means the irrevocable loss of the deposit – particularly with respect to the fact that the effectiveness of the process increases considerably after carrying out its fracturing. However, the investigations and applications should be continued with reference to deposits occurring at great depths, intensively tectonically affected and flooded, beyond the range of operating mines and towns.

On the basis of the problems mentioned above appeared the issue of the sequence of economic initiatives in the field of management of rock underground structures. It seams that the hitherto existing legal regulations give priority to environmental undertakings (geothermy, underground mining) over CCS. This is correct, taking into consideration that CO_2 storage sites make impossible to conduct any other underground activity within their range. In turn, activity in the neighbourhood of storage sites is possible, however it requires the elaboration of detailed hydrogeological analyses in order to supply documentary evidence for the range of impact and exclusion of the interference phenomenon.

REFERENCES

Atlas geologiczny Polski. Mapy ścięcia poziomego. 1:750 000. Red. Z. Kotański. Państwowy Instytut Geologiczny. Warszawa, 1997.

Atlas zasobów energii geotermalnej. Utwory neogenu, karbonu i dewonu. Red. E. Solik-Heliasz. Wyd. GIG, Katowice, 2009.

Bachu S., Bonijoly D., Bradshaw J., Burruss R., Holoway S., Christensen N., Mathiassen O., 2007 – CO_2 storage capacity estimation: Methodology and gaps. International Journal of Greenhouse Gas Control, 1 (4), October 2007.

Bruining H., Bossie-Codreanu D., Busch A., Choi X., de Schmedt G., Frobel J., Gale J., Grabowski D., Hadro J., Hurtevent D., Jura B., Kretchmar H., Krooss B., Krzystolik P., Mazumder S., Muller G., Pagnier H., Reeves S., Skiba J., Stevens S., van Bergen F., van der Meer B., Wenting P., Winthaegen P., Wolf K., 2004 – Recopol – field experiment of ECBM-CO_2 in the Upper Silesian Basin of Poland. 7th International Conference on Greenhouse Gas Control Technologies, Vancouver Canada.

Buła Z., Kotas A., 1994 – Atlas geologiczny Górnośląskiego Zagłębia Węglowego. Warszawa.

Ceglarska-Stefańska G., Zarębska K., Wolszczak J., 2008 – Sorption of pure components and mixtures CO_2 and CH_4 on hard coals. Gospodarka Surowcami Mineralnymi, tom 24, z. 4/1.

Chadwick A., Arts R., Bernstone C., May F., Thibeau S., Zweigel P., 2008 – Best practice for the storage of CO_2 in saline aquifers. Observations and guidelines from the SACS and CO2STORE projects. Keyworth, Nottingham British Geological Survey.

Chećko J., Nagy S., Paliński A., Siemek J., 2006 – Ocena efektywności magazynowania gazu. [W:] Podziemne magazyny gazu w zaniechanych kopalniach węgla. Wyd. GIG Katowice.

Dubiński J., Solik-Heliasz E., 2007 – Uwarunkowania geologiczne dla składowania dwutlenku węgla. [W:] Uwarunkowania wdrożenia zero-emisyjnych technologii węglowych w energetyce. Wyd. Instytutu Chemicznej Przeróbki Węgla, Zabrze.

Dyrektywa Unii Europejskiej i Parlamentu Europejskiego dotycząca podziemnego składowania CO_2. 2009.

EGEC's Position on „Carbon Capture and Storage". Bruksela, 2009.

Frolik A., 1998 – Ocena szczelności przeciwwodnych filarów bezpieczeństwa. Prace GIG. VII Konferencja na temat „ Problemy geologii w ekologii i górnictwie podziemnym".

Frolik A., Solik-Heliasz E., 2003 – Analiza zagrożenia wodnego ze strony zlikwidowanej kopalni „Morcinek" dla projektowanych przez „ČSM" (Czechy) robót górniczych w rejonie filara granicznego. Dokumentacja GIG.

Frolik A., Kidybiński A., Marcak H., Nierobisz A., Rychlicki S., Solik-Heliasz E., 2006 – Metody oceny możliwości magazynowania węglowodorów w podziemnych wyrobiskach górniczych. [W:] Podziemne magazyny gazu w zaniechanych kopalniach węgla. Wyd. GIG, Katowice.

Lubaś J., Stopa J., 2003 – Doświadczenia i osiągnięcia górnictwa naftowego w zakresie zatłaczania gazów kwaśnych do stref złożowych. Polityka Energetyczna, t. 6, z. spec.

Nagy S., 2010 – Analiza możliwości wykorzystania istniejących struktur gazu ziemnego niżu polskiego do bezpiecznego składowania CO_2. Mat. V Konferencji: Ochrona Środowiska w Energetyce 2010. Jaworzno 11–12 luty 2010.

Ochrona środowiska. Informacje i opracowania statystyczne. GUS. Warszawa, 2008.

Podziemne magazyny gazu w zaniechanych kopalniach węgla. Red. A. Kidybiński, J. Siemek. Wyd. GIG, Katowice, 2006.

Rogoż M., 2007 – Dynamika wód podziemnych. Wyd. GIG, Katowice.

Sanner B., 2009 – CCS vs. Geothermal resources – some thoughts on recent experience in Germany. W: GTR-H Conference, Dublin.

Solik-Heliasz E., 1986a – Zmienności własności hydrogeologicznych warstw dębowieckich w południowo-zachodniej części GZW na tle ich cech strukturalnych. Praca doktorska, Arch. GIG, Katowice.

Solik-Heliasz E., 1986b – Warstwy dębowieckie jako źródło zagrożenia wodnego wyrobisk górniczych. Zeszyty Naukowe Politechniki Śląskiej nr 13. Materiały I Konferencji „Postęp naukowy i techniczny w geologii".

Solik-Heliasz E., 2009 – Uwarunkowania geologiczne i górnicze podziemnego składowania CO_2 w regionie górnośląskim. Mat. II Konferencji: Geologia, hydrogeologia i geofizyka w rozwiązywaniu problemów współczesnego górnictwa i energetyki. Prace Naukowe GIG. Górnictwo i Środowisko. Kwartalnik Nr 4/1.

Stopa J., Lubaś J., Rychlicki S., 2006 – Underground storage of acid gas in Poland – experiences and forecasts. [W:] 23 World gas conference, 5–9 June 2006 Amsterdam. International Gas Union, Denmark, IGU, 2006.

Tarkowski R., Uliasz-Misiak B., 2006 – Possibilities of CO_2 Sequestration by Storage in Geological Media of Major Deep Aquifers in Poland Chemical Engineering Research and Design. Vol 84, issue A9 Carbon Capture and Storage.

Uliasz-Misiak B., 2007 – Polish hydrocarbon deposits usable for underground CO_2 storage. Gospodarka Surowcami Mineralnymi 23 (4).

Wójcicki A., 2009 – Potencjał geologicznego składowania CO_2 w głębokich, nieeksploatowanych pokładach węgla Górnośląskiego Zagłębia Węglowego. Przegląd Geologiczny, t. 57, nr 2.

MOŻLIWOŚCI PODZIEMNEGO SKŁADOWANIA CO_2 W REGIONIE GÓRNOŚLĄSKIM

Słowa kluczowe

Składowanie CO_2, GZW, zatłaczanie CO_2 do pokładów węgla, CCS

Streszczenie

Wyniki dotychczasowych badań wskazują, że w regionie górnośląskim istnieje możliwość składowania dwutlenku węgla w strukturach geologicznych. Jednak ze względu na znaczny stopień zurbanizowania do składowania nadają się poziomy wodonośne i pokłady węgla kamiennego zlokalizowane na obrzeżu aglomeracji, natomiast nie kwalifikują się ze względów bezpieczeństwa obszary silnie zindustrializowane (miast, dużych obiektów przemysłowych i innych). Najlepsze warunki do zatłaczana CO_2 stwierdzono w poziomie warstw dębowieckich w rejonie Skoczów-Zebrzydowice. Wyznaczone składowisko ma pojemność wystarczającą na potrzeby lokalnego emitenta CO_2. Możliwość składowania dotyczy również wyrobisk górniczych wybranych zlikwidowanych kopalń węgla kamiennego. Wyniki wstępnych badań wykazały, że można rozważać utworzenie w nich zbiorników niskociśnieniowych (o ciśnieniu do 0,6 MPa) lub w wybranych, izolowanych wyrobiskach, zbiorników wysokociśnieniowych (na ciśnienie powyżej 1 MPa). Ich pojemność składowania będzie jednak mniejsza, niż w warstwach wodonośnych. Potencjalnie możliwości składowania są związane również z pokładami węgla kamiennego – zwłaszcza zalegającymi na dużej głębokości, w obszarach znacznie zaangażowanych tektonicznie i zawodnionych, poza zasięgiem czynnego górnictwa. Należy jednak mieć na uwadze, że ewentualne zatłaczanie CO_2 spowoduje, iż zasoby węgla w rejonie składowiska CO_2 nigdy nie będą mogły być eksploatowane metodami górniczymi lub poddane zgazowaniu, oraz że będzie można prowadzić innego typu działalność gospodarczą tylko w znacznej odległości, poza zasięgiem ich wzajemnego oddziaływania.

POSSIBILTIES OD UNDERGROUND CO_2 STORAGE IN THE UPPER SILESIAN REGION

Key words

CO_2 storage, Upper Silesian Coal Basin, CO_2 injection into coal seams, CCS

Abstract

The results of investigations hitherto performed indicate that in the Upper Silesian region exists the possibility of carbon dioxide storage in geological structures. However, taking into account the considerable urbanisation degree, for storage are suitable water-bearing horizons and hard coal seams located on the outskirts of the agglomeration, whereas because of safety reasons areas intensively industrialised are not suitable (towns, large industrial objects). The best conditions for CO_2 injection were ascertained in the horizon of Dębowiec layers in the Skoczów-Zebrzydowice area. The determined storage site has a sufficient capacity for the needs of a local CO_2 emitter. The storage possibility concerns also mine workings of selected abandoned hard coal mines. The results of initial investigations have pointed out that the creation in the workings of low-pressure reservoirs (with pressure up to 0.6 MPa) or high-pressure reservoirs in selected, isolated workings (for pressure exceeding 1 MPa) can be considered. However, their storage capacity will be lower than in the water-bearing layers. Potential storage possibilities are connected also with hard coal seams – particularly seams occurring at great depth, in areas considerably tectonically affected and flooded, beyond the range of operating mines. However, it should be taken into consideration that possible CO_2 injection will cause that coal resources in the CO_2 storage area never could be extracted using mining methods or be subject to gasification and that other type of economic activity could be conducted only at a considerable distance, beyond the range of their mutual influence.