UNDERGROUND MINING ENGINEERING 21 (2012) 161-168 UDK 62
FACULTY OF MINING AND GEOLOGY, BELGRADE YU ISSN 03542904

Review paper

POSSIBILITIES OF GEOLOGICAL CO_2 STORAGE IN DEPLETED/PARTIALLY DEPLETED LAYERS OF HYDROCARBONS IN NORTH EAST SLOVENIA

Kraljić Marijan[1]

Abstract: The quantities of produced CO_2 in industrial processes in the world as well as in Slovenia are increasing yearly. Releasing CO_2 into the atmosphere has negative impact on the climate as CO_2 is one of the most important greenhouse gases. One possibility of reducing CO_2 emissions into the atmosphere is by capturing CO_2 in industrial processes, transporting and injecting it into suitable underground geological structure or geological storage. The most appropriate area in Slovenia for geological CO_2 storage is in Northeast Slovenia where potentially suitable layers for storing CO_2 can be found, namely the depleted or partially depleted oil and gas layers, saline aquifers and coal layers. The depleted or partially depleted layers of oil and gas from the oil and gas layers Petišovci are proposed as test layers for storing CO_2 mainly because of extensive geological, geophysical, well and surface infrastructure data and especially because in the process of storing gas, additional large quantities of oil could be produced (EOR).

Key words: geological CO_2 storage, depleted layers, partially depleted layers, Enhanced Oil Recovery (EOR), CO_2 storage capacity, saline aquifers, oil-gas field Petišovci

1. INTRODUCTION

Human activities generate only about 20% of the produced CO_2 but CO_2 can be found as an additional source in the atmosphere, which is significantly marked after the year 1950. CO_2 is one of the most important greenhouse gases and the question arises how to prevent its emissions into the atmosphere. One possibility is to store CO_2 in deep geological formations, namely the saline aquifers, depleted layers of hydrocarbons and coal layers.

At the same time the storage of CO_2 in oil and gas layers can stimulate or increase the production of oil and natural gas.

CO_2 emissions in Slovenia were around 9 t/capita/year or about 19 million t/years and are expected to increase. For this reason it will be necessary to find ways of reducing its emissions into the atmosphere.

Geological storage of CO_2 in depleted or partially depleted hydrocarbon layers in NE Slovenia is definitely one of the real possibilities to potentially reduce the release of CO_2 into the atmosphere and at the same time enhance hydrocarbon recovery (EHR).

[1] Nafta-Geoterm d.o.o., Mlinska ul. 5, 9220 Lendava, Slovenia, e-mail: marijan.kraljic@nafta-geoterm.si

2. POSSIBILITIES OF GEOLOGICAL CO_2 STORAGE

Essentially there are three possibilities of geological CO_2 storage as follows:

- storage in partially depleted or depleted layers of natural gas and oil;
- storage in saline aquifers;
- storage in coal layers (one of the possibilities for the future, when the problem of how to store large quantities of CO_2 in low permeability coal layers is finally solved).

The mentioned possibilities of storage are shown in Figure 1.

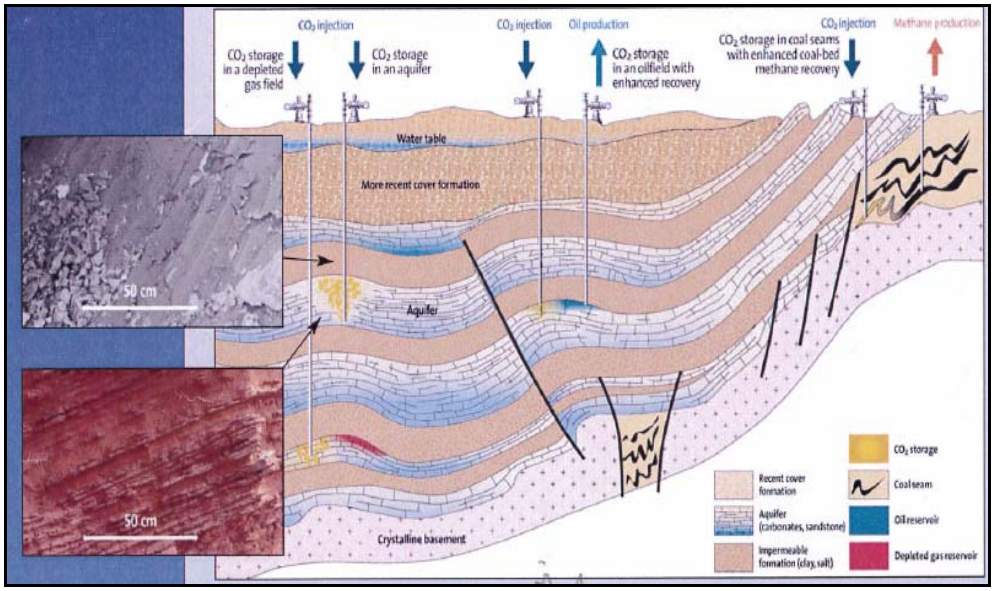

Figure 1 - CO_2 injected into porous and permeable layers, 1) Depleted layers of hydrocarbons, 2) Saline aquifers, 3) Coal layers (Arts et al. 2008)

Potentially suitable layers for the storage of CO_2 must meet a number of conditions or must have the following:

- sufficient porosity, permeability and large dimension;
- impermeable cover layer (clay, marl, …), which prevent the CO_2 from migrating towards the surface;
- structural and non structural traps which prevent the migration of CO_2 within the layers and prevent hydrodynamic connection with the above layers or surface;
- the layers must be at a depth greater than 800 m and less than 2,500 m and where the pressure and temperature are large enough in the liquid phase, large amounts of CO_2 can be stored. (Figure 2);
- lack the presence of fresh water layers, because CO_2 is not allowed to be injected into fresh water.

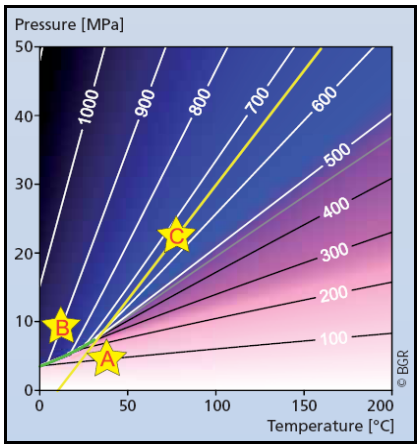

Figure 2 - Density of pure CO_2 in kg/m^3 dependent on pressure and temperature (Arts et al. 2008)

Sedimentary basins suitable for CO_2 storage in Europe are shown in the following geological map of Europe (Figure 3).

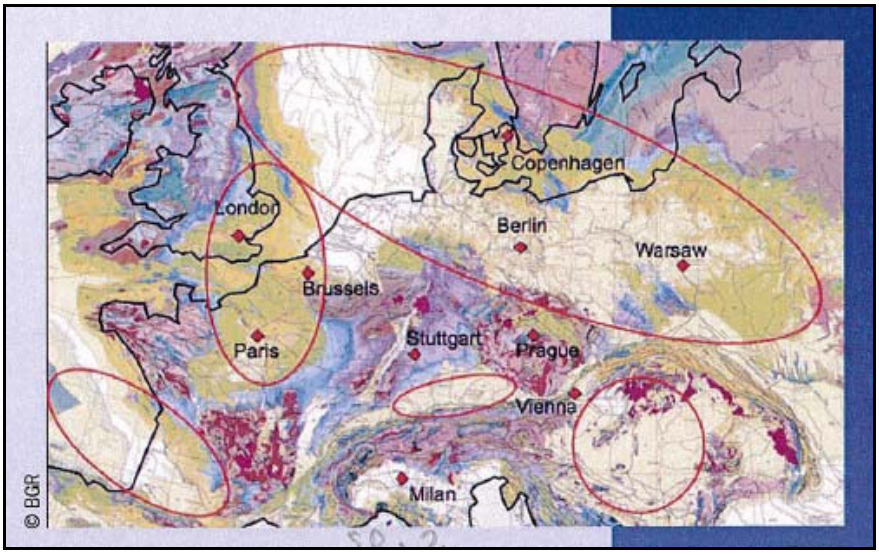

Figure 3 - Geological map of Europe, marked with the largest sedimentary basins (areas marked in red) potentially suitable for geological CO_2 storage. (Arts et al. 2008)

The map above shows that the best area in Slovenia for geological CO_2 storage is the NE part of Slovenia.

3. CO_2 STORAGE CAPACITY

CO_2 storage capacity is usually first determined based on the projected volume of the layers. In the next phase if we have sufficient data (porosity, permeability, and saturation with reservoir fluids) the assessment of storage capacities can be realistic. Therefore, we distinguish three different storage capacities (Figure 4) as follows:

- volumetric capacity (determined on the basis of the projected volume in the layers);
- real capacity (determined on the basis of the volume of the pores, which can be filled with CO_2);
- viable capacity (determined by taking into account also the socio-economic conditions of entire region).

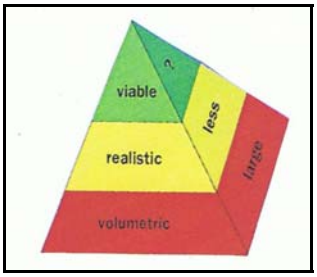

Figure 4 - CO_2 Storage Capacity (Arts et al. 2008)

4. HOW WE TRANSPORT AND INJECT CO_2 INTO GEOLOGICAL CO_2 STORAGE

When CO_2 is captured in industrial processes, it is prepared for transport and is transported (either with appropriate tanks, ships or by pipelines) to the injection station where it is being injected into the underground layer through one or more wells (Figure 5).

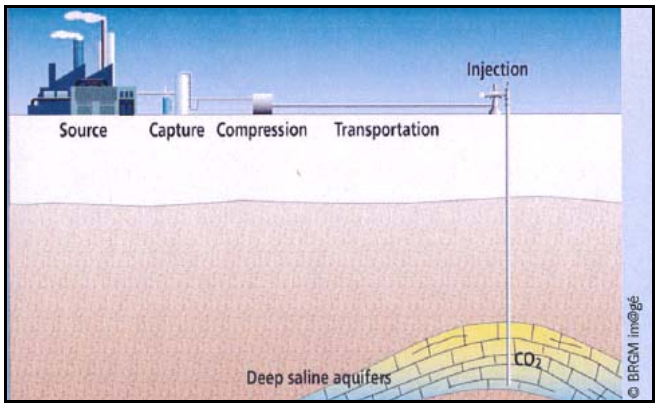

Figure 5 - Necessary activities of geological storage of CO_2: Capture, compression, transportation and injection. (Arts et al. 2008)

With injection the density of CO_2 is increasing (reducing the volume) until it reaches the supercritical state (Figure 6).

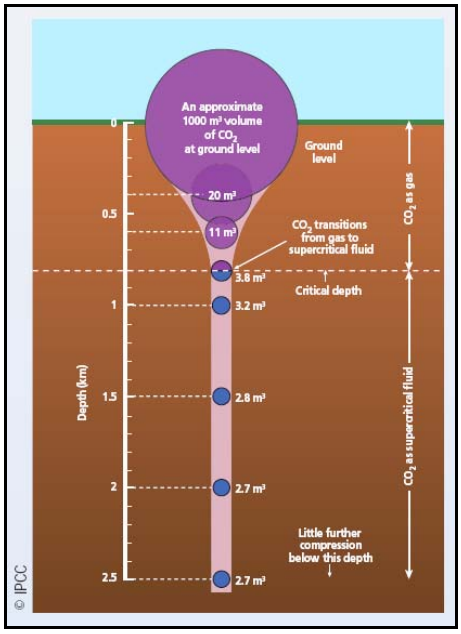

Figure 6 - With injection the density of CO_2 is increasing (reducing the volume) until it reaches the supercritical state. (Arts et al. 2008)

5. POSSIBILITIES OF GEOLOGIAL CO_2 STORAGE IN NE SLOVENIA

In northeastern Slovenia, there are possibilities for geological storage of CO_2 in depleted or partially depleted hydrocarbon beds, saline aquifers and coal layers.

Although the storage capacity in depleted/partially depleted hydrocarbon beds is relatively small (1.8 to 5.3 million tones of CO_2 - the real storage capacity), at the beginning it is proposed for the storage of CO_2 in those beds mainly for the following reasons:

- the availability of a large amount of geological, geophysical and well data;
- the availability of large number of exploration/production oil-gas wells;
- the possibility of enhanced hydrocarbon recovery (EHR);
- the available surface infrastructure, which can be at least partially applicable.

5.1. Potentially suitable oil-gas fields and layers for CO_2 storage

For CO_2 storage both discovered oil-gas field in NE Slovenia are conditionally suitable. This is:

- oil-gas field Petišovci and
- oil-gas field Dolina.

On the oil-gas field Petišovci (Figure 7) the following layers are suitable for CO_2 injection:

- oil layers Petišovci;
- gas layers Lovaszi;
- oil-gas layers Ratka (Lower, Middle and Upper Ratka);
- oil-gas layers Paka.

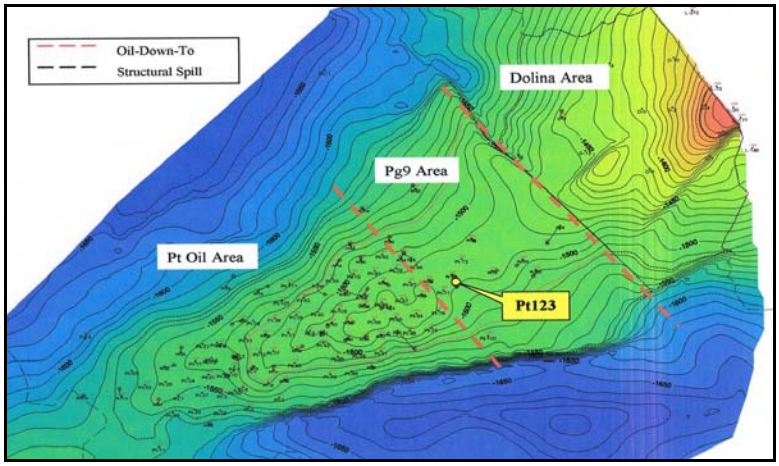

Figure 7 - Anticlinal structures of fields Petišovci and Dolina

On the gas field Dolina the same layers are potentially suitable for CO_2 injection as in Petišovci. It should be emphasized that the gas field Dolina is actually part of the large Hungarian oil-gas field Lovaszi (Figure 8) and that all activities related to CO_2 injection should be carried out in coordination with the Hungarian managers of oil-gas field Lovaszi.

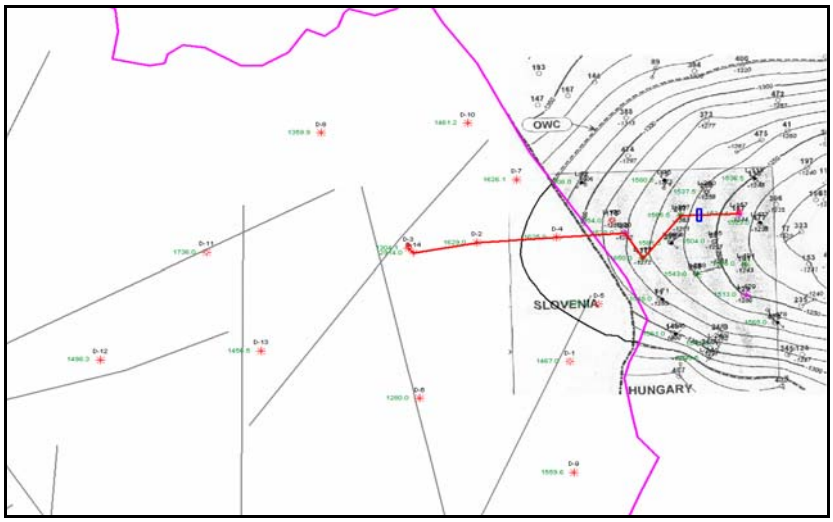

Figure 8 - Part of the Anticline Structure Lovaszi - Dolina

5.2. Possibilities of further production of hydrocarbons with CO_2 injection (secondary/tertiary methods of productions)

CO_2 injection into oil layers in Petišovci can enhance the oil recovery (EOR) from 10 to 15%. The additional yield of oil with CO_2 injection falls into the so-called secondary or tertiary methods of production (recovery) of oil (EOR – Enhanced Oil Recovery).

CO_2 injection enhances the oil recovery mainly because of the mixing of CO_2 with hydrocarbons and with this process it reduces the viscosity of oil.

A rough estimation shows that with this method we could acquire 500,000 - 600,000 t of oil more (around 70% more oil than it was depleted altogether in Petišovci up until now).

5.3. Technical suitability of existing wells in the process of CO_2 storage

In the process of CO_2 storage into depleted or partially depleted layers of hydrocarbons it is necessary to have the following wells:

- injection wells;
- production wells;
- monitoring wells.

In all the mentioned wells, the layers which provide the storage of CO_2 must be drilled and the wells must be constructed in way so that there will be no hydrodynamic communication between the drilled layers (Figure 9).

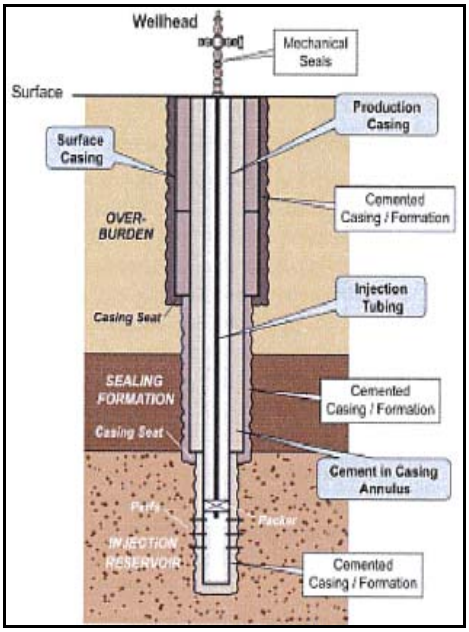

Figure 9 - A well with natural and engineered barriers to prevent the migration of CO_2 (Cooper and Phillips, 2009)

In order to achieve this it is necessary to install the appropriate depth equipment (pipes, casing, cement, gaskets) and all the work should be carried out in accordance with the highest standards for the construction of wells (cementation, perforations, installation of depth equipment).

On the oil-gas field Petišovci there is a large number of production and abandoned wells (about 110 wells), which can potentially be used in the project for CO_2 storage and for the EOR methods. It is necessary to pre-determine the technical condition of existing wells (corrosion, the cement quality for casing, the depth of perforated intervals in the well, …). This is possible with the implementation of modern logging measurements (CCL, CBL, GR, ...).

The experience indicates that wells despite their age of several decades are in good technical condition and that could be used as a production or monitoring wells. For CO_2 injection it may be necessary to drill new wells.

4. CONCLUSION

One of the potential geological CO_2 storages is the injection of CO_2 into depleted or partially depleted layers of oil and gas in Petišovci. Despite lower capacities of CO_2 storage, it is proposed that the CO_2 is stored in the mentioned layers mainly because of (the already constructed underground and surface infrastructure and the possibility of increasing the production of hydrocarbons in the process of the CO_2 storage (EOR).

In this process we could produce 500,000 – 600,000 t of crude oil more, which represents a larger potential for further development of the oil-gas industry in NE Slovenia.

REFERENCES

[1] ARTS, R. et al. (2008) *What does CO_2 Geological Storage really mean.* CO_2 GeoNet European Network of Excellence.

[2] COOPER, C. and PHILLIPS, C. (2009) *A Technical Basis for Carbon Dioxide Storage.* Members of the CO_2 Capture Project.

[3] Technical Documentation of Nafta-Geoterm, 1945-2012, Lendava.