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GEO ENeRGY

This issue is dedicated to coal-related research in Europe

The CARBOLAB Project

In the prospect of climate change mitigation, greenhouse gas emissions could be reduced by the geological storage of CO_2. One of the promising variants of this technique, the injection of CO_2 in deep unmineable coal seams, presents the most uncertainties and technical difficulties. The profit from methane recovery could cover part of the costs. European coal deposits, which differ from other potentially more attractive ones, have to date received little testing for this technique. The processes generated during and after CO_2 injection are not yet fully understood. Other questions remain unanswered, such as the precise percentage of CO_2 adsorbed, that stored in the coal's porosity, and that diffused in the strata immediately surrounding the coal seam. Such uncertainties make it difficult to demonstrate the feasibility of injecting CO_2 into coal seams and create a major drawback in terms of identifying the reliability and safety of this geological storage option.

Apart from RECOPOL, no other on-site project has been done to give better assessments far from the laboratory benches.

Therefore, there is a need for an in-situ injection study at an intermediate scale between that of field and laboratory, in order to test and upscale laboratory experiments (for example the CHARCO project) and before a pilot-size injection test. This is the aim of the CARBOLAB project, supported by the European Fund for Coal and Steel, involving partners from three European states: the leader HUNOSA, owner of the mine where the injection will take place, and AITEMIN from Spain, BRGM and INERIS from France, GIG from Poland, and the company TOTAL. Our aim is to inject a significant, though not pilot-related, quantity of CO_2 into a coal seam that will be pre-equipped for continuous data acquisition. Putting devices in the near vicinity of the CO_2 plume, only a few metres away, will allow data of much higher quality and density to be collected than in the case of injection from the surface, and to adapt the injected flow and the monitoring protocol depending on the evolution of the CO_2 plume.

The targeted coal seam, which lies at the bottom of the Montsacro mine in Asturias, Spain, was selected for its location, offering both easy access and being quite far from coal exploitation. Data acquisition will include geophysics (both active and passive seismic and electrical methods) and geochemistry (chemical and isotopic measurements). Work in the mine is complicated by dust, moisture and the firedamp environment. These and other methods will also provide an initial characterization of the coal seam and its surroundings. The acquisition phase will last one year, with several injections. The in-situ acquisition will be complemented by parallel laboratory experiments to provide intrinsic properties and characterisation of relationships between water, gas and coal, with and without mechanical stress. Afterwards, the data will be compared with results from simulations using existing analytical means as well as new developed ones. Three models will be built: hydro-thermo-mechanical at core scale, transport-chemistry at the same scale, and hydro-thermo-mechanical coupling at site scale. In addition to a better understanding of the physico-chemical mechanisms, this work, in conjunction with other long-term behaviour simulations, will provide a basis for the definition of safety criteria for undertaking enhanced coal bed methane projects associated with CO_2 injection. The overall aim is to make the impact on Man and the environment close to zero in the short, medium and long terms. However, site selection, risk analysis, storage security management, implementation and eventual remediation need to be studied.

The project started in 2009 and will end in 2013, giving us four years to achieve this programme.

Aurélien Leynet, BRGM

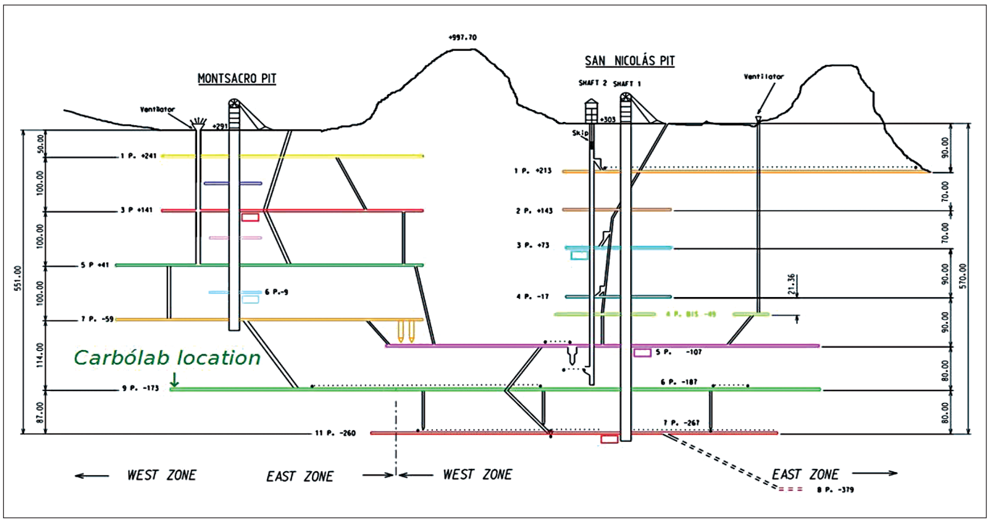

Fig. 1. Sketch of the Montsacro and San Nicolás mines. The position of the CARBOLAB injection and monitoring area is marked.

The use of Activated Greek Brown Coals for Mitigating and Alleviating Environmental Problems

Preliminary research has been carried out on activated Greek brown coals by the Greek Institute of Geology and Mineral Exploration (IGME) in conjunction with the Departments of Mineral Resources Engineering and Environmental Engineering, Technical University of Crete, Greece, and the Department of Geology, University of Patras, Greece. The findings have shown that upon activation of the coals, their surface area increases substantially from about 4 m^2/g to 270 m^2/g. These values are similar to commercially available active coal. Some Greek brown coals (xylites) show even larger surface areas, reaching values of 400 m^2/g.

This property of large surface area renders the coals suitable for use in mitigating and/or alleviating environmental problems, such as the adsorption of noxious gases (light hydrocarbons, NO, SO_2), cleaning industrial wastes such as adsorbing phenols from olive oil mil wastewater and decreasing the chemical oxygen demand (COD) of the effluent liquid, as well as decreasing the COD and adsorbing large amounts of nitrogen and phosphorus from a solution that simulates city waste disposals.

Fig. 2. Map of Greek coal-bearing basins included in the study (grey areas)

These initial findings could open the door for the economic exploitation of small-to-medium-size coal deposits in Greece, the occurrence of which is widespread. Such an undertaking would generate major financial benefits since the average cost of non-activated Greek brown coal destined for power generation is 30 €/ton, whereas that of activated coal is 800 €/ton.

The aim of this project was also to evaluate the suitability of certain lignite and peat deposits for the production of soil amendments and humic fertilizers, displaying better characteristics than the inorganic fertilizers regarding the gradual release of nutrients and, more importantly, their environmentally friendly behavior. A preliminary feasibility approach revealed that the agricultural areas in Greece suffer from severe soil degradation due to intense cultivation and the arid and warm climate. Thus, the demand for soil amendments and humic fertilizers is expected to increase in the future. The domestic consumption of inorganic fertilizers reaches up to 1,400,000 t, whereas the production of humic fertilizers from various vegetative and vital raw materials does not exceed 10,000 t. It is evident, therefore, that there is an opening for the development of such products and a market demand.

Cassiani Papanikolaou, IGME

DFG–GACR Project on Sorptive Storage Capacity of Coal

Methane gases are associated with bituminous coal seams worldwide. They represent an unconventional energy source when extracted efficiently, but cause a major hazard during and after coal mining when uncontrollably emitted to the subsurface atmosphere. An increased CO_2 content has been observed in certain coal bed methane and coal seam gases. The CO_2 from power plants is planned to be stored in coal seams. Consequently, there is growing demand from the industry for a better understanding and predictive tools for coal-methane and coal-carbon dioxide interactions.

This was the major motivation behind the collaborative research project of the Czech Geological Survey and the RWTH Aachen University entitled *Thermal and microbial gas generation, accumulation and dissipation in coal basins: role of sorptive storage capacity evolution*, financed by the German Research Foundation (DFG) and the Grant Agency of the Czech Republic (GACR).

Most of the investigations were carried out in the SW Upper Silesian Basin, Czech Republic, in cooperation with Green Gas DPB a.s. The gas content of the fresh coal samples from the exploration boreholes and mining faces was measured using standard desorption canisters in the Green Gas DPB laboratories. The contribution of the thermogenic and microbial methane was estimated based on the chemical and isotopic composition of the desorbed gas. Then the coal type and thermal maturity (coal rank) was characterized by the proximate and ultimate analysis (volatile matter, moisture, etc.), microscopic measurements of vitrinite reflectance, and Rock-Eval pyrolysis.

The burial and thermal history and thickness of the eroded sedimentary units was restored and simulated using the PetroMod®11 (Schlumberger ®) software. The most up-to-date method was used to quantify the high-pressure excess sorption isotherms of methane and CO_2 on coal samples (P. Weniger and B.M. Krooss, RWTH Aachen University) at laboratory conditions and close to geological temperatures (45°C, see Fig. 3). All the measured parameters made it possible to improve the model of gas generation in the seams, saturation, gas loss, and the amount of replenished gas during the course of the geological history.

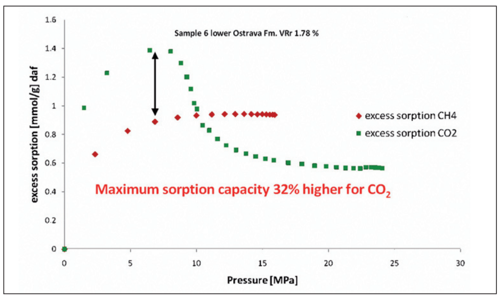

Fig. 3. CO_2 and CH_4 sorption isotherms at 45 °C (as received)

The results of the project are planned to help:

- Improve estimations of the gas potential of partial sub-basins of the Upper Silesian Coal Basin;
- Calculate methane, oxygen, and CO_2 budgets in the subsurface;
- Identify gas sources in different geological settings;
- Estimate the contribution of microbial consortia to the total gas content in coal seams and adjacent aquifers;
- Improve predictions of gas production from different horizons and settings;
- Evaluate CO_2 storage capacity in the unmined part of the Upper Silesian Coal Basin.

Juraj Francu, Czech Geological Survey

Coal-related research in Poland

Poland has the highest percentage of coal combustion in electricity generation in Europe (92%). Total resources of hard coal in the country are estimated at 43 billion tonnes, with reserves accounting for at least 10% of this figure, equivalent to 150 years at the current production rate. The resources are mostly located in the Upper Silesian Coal Basin in southern Poland. In the case of brown coal/lignite, resources are as high as 13.5 billion tonnes and reserves are also estimated as at least 10% of resources, which is sufficient for 25 years at the current production rate. The Polish Geological Institute (PGI), which is the National Research Institute and also the national geological survey, is in charge of the assessment of the country's mineral resources, including coal, and has been since 1919.

Because of the importance of coal for the national economy, research in this topic is a high priority, and several leading national institutes are worth citing. The AGH University of Science and Technology (formerly University of Mining and Metallurgy) in Cracow has the longest history of educating coal mining engineers and carrying out coal-related research, active in these domains since 1913. The Central Mining Institute (CMI) in Katowice, Upper Silesia, is the key R&D institute for the coal and mining industry, and has been involved in applied research since 1945. Together with the Institute for Chemical Processing of Coal and the Institute of Chemical Engineering of the Polish Academy of Sciences, also located in Upper Silesia, CMI is the key research centre in Clean Coal Technologies (CCT) in Poland. Regarding research on Carbon Dioxide Capture and Storage (CCS), CMI participated in the EC FP-funded projects RECOPOL and MOVECBM (coordinator – TNO, NL), which involved the first European CO_2 injection into coal beds at the Kaniów site in Upper Silesia and then a comprehensive post-injection monitoring programme.

In the case of CCT research topics, Underground Coal Gasification (UCG) should be taken into consideration as it is closely related to the use of the subsurface. UCG is an industrial process that enables coal to be converted into product gas. It is an *in-situ* gasification process carried out in unmined coal seams and consists in the injection of oxidants and bringing the product gas (syngas) to the surface through injection and production wells drilled from the surface. The product – gas (syngas) can be used as a chemical feedstock or as fuel for power generation. In the latest case, the CO_2 obtained from fuel combustion could be re-injected into 'burned-out' seams. Compared to traditional coal mining and gasification, UCG has a lesser environmental and social impact, but the application of such a technology in densely populated areas is still debatable.

UCG was first developed in the 1930s in the Soviet Union. It was used for decades after WWII, but has not been used in Russia at industrial scale since the 1990s because of the abundance of natural gas. Since the 1970s, several UCG test plants were built in the US & Canada (1986–88) and Spain (1992–99) and then, in 1999–2003, a UCG pilot plant was developed in Chinchilla, Australia. Recently, many R&D programmes on UCG have been conducted all over the world.

In Poland, the first UCG tests were carried out in 1950 in the laboratory followed by underground experiments in 1953 in the Mars coal mine in the Polish Silesian Coal Basin. Further experiments were then stopped until the 1980s when R&D programmes restarted, firstly with simulations of UCG processes.

Under the RFCS-EU programme (Research Fund for Coal and Steel), the international project HUGE (Hydrogen Oriented Underground Coal Gasification for Europe) launched in 2007 has been working on the selection of optimal UCG sites in the Polish Silesian Coal Basin. The Polish partner CMI has been working on the testing of a coal gasification reactor. As a result of HUGE, an integrated large-scale pilot UCG plant is planned in the Polish Silesian Coal Basin. The plant concept is based on the Super Daisy Shaft System (see Fig. 4) where syngas, hydrogen and electric energy is to be produced.

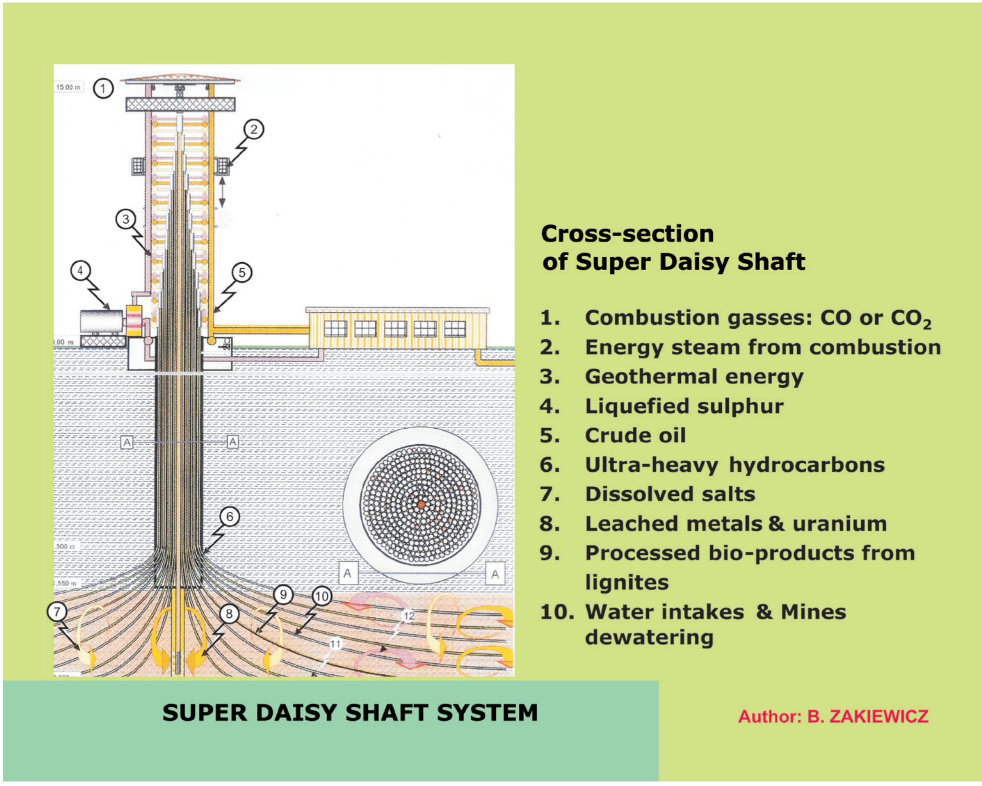

Fig. 4. Sketch of the Super Daisy Shaft System

Adam Wojcicki, PGI

ENeRG – European Network for Research in Geo-Energy

ENeRG – European Network for Research in Geo-Energy – is an informal contact network open to all European organisations with a primary mission and objective to conduct basic and applied research and technological activities related to the exploration and production of energy sources derived from the Earth's crust.

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Research and new exploration strategies for the use of Hungarian coal deposits in carbon dioxide geological storage and underground coal gasification

Hungary has nine distinct coal basins with coals ranging from lignite to low volatile bituminous in rank and from Mesozoic to Tertiary in age. Coal mining began in the 18th century in the Mecsek Hills on Jurassic hard coal and in the Transdanubian Range on Paleogene brown coals. Most exploration and research were carried out in the second half of the 20th century, but as soon as coal production declined and mines were closed, the interest in coal geology also decreased. In the last five years, however, carbon capture and geological storage has encouraged a new wave in coal sciences based on the use of coal seams as geological storage formations for industrially emitted CO_2. Eötvös Loránd Geophysical Institute of Hungary (ELGI) conducts research projects on the prediction of CO_2 storage capacity and has participated in three EU-financed projects over recent years, including EU GeoCapacity, where coalfields located at a depth greater than 1000 m were studied.

A scheme was developed for the selection of potentially accessible seams, different from the previously used conventional mining resource assessment methods, and based on various criteria. Coal seam thickness, reservoir properties (Gluskoter et al., 2002) and the sealing conditions of underlying and overlying sediments were considered to identify formations that are appropriate for the long-term geological storage with the lowest hazard risks.

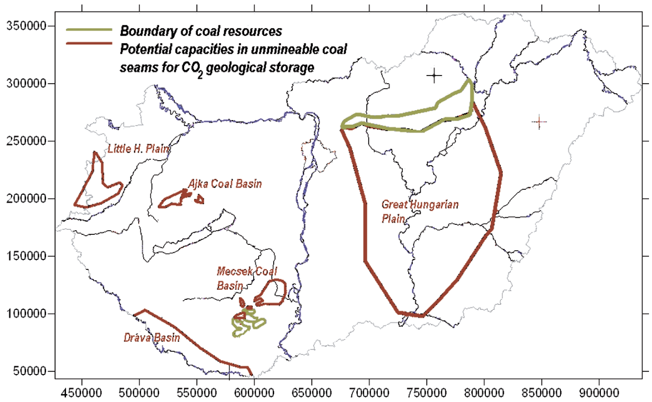

Fig. 5. Location and distribution of CO_2 storage capacities in unmineable coal seams in Hungary.

According to the geological conditions and physical property requirements, the most favourable coal basins for CO_2 storage appear to be the Upper Cretaceous Ajka Coal Formation and the Újfalu Formation in the deep basin of the Great Hungarian Plain and in the Dráva Basin (see Fig. 5). In the first instance, the Mecsek Coal Formation was also considered due to its high gas content (Fodor, 2007), but the low permeability and plasticity of the coal, together with the complex tectonic structure, raised the question of applicability.

The other new area for research and exploration is underground coal gasification (UCG), with a proposed operation depth between 300 and 1000 m. ELGI has been calculating estimations of coal resources for UCG since 2009. The continuity of coal seams over longer distances in tectonically complex areas is a main concern. ELGI supports the UCG exploration of the Wildhorse Energy Ltd. Project, with the establishment of a unified coal seam system of 46 seams in the Mecsek coal basin in the four prospection regions of Pécs, Hosszúhetény, Komló and Váralja, where regional marker horizons and facies changes helped the interpretation.

For the UCG technique, the in-seam coal quality can be lower, and intercalations between coal beds are allowed if the average ash content of the seam does not exceed 60% in total. The implementation of a new cut-off criterion also has an impact on the estimation of coal resources and broadens the possibilities of the utilization of formerly uneconomic occurrences.

Mária Hámor-Vidó, ELGI

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