CO_2-EOR POSSIBILITIES IN ROMANIA: A FIRST SCREENING FOR THE IMPLEMENTATION OF CO2-EOR TECHNOLOGY IN ROMANIA

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Abstract. Romania is committed to reduce CO_2 emissions and efforts are made to speed up the implementation of Carbon Capture, Utilization, and Storage (CCUS) technology in our country. CCUS involves capturing CO_2 at coal-or gas-fired power stations and industrial facilities (steel mills, cement plants, refineries), and transporting it by pipelines or tanks to an oil field where it can be injected into a suitable geological formation via wells into the reservoir to increase oil recovery (CO_2-EOR) combined with long-term storage. The underground storage of CO_2 is feasible as it is demonstrated by naturally occurring CO_2 reservoirs which exist for thousands to millions of years like a series of eight natural CO_2 reservoirs in south-eastern France.

Key words: Carbon capture, utilization and storage; oil fields; CO_2 emission sources; enhanced oil recovery

INTRODUCTION

CO_2-EOR (Enhanced Oil Recovery) is a technology that involves injection of CO_2 into an oil reservoir to enhance oil recovery, which is being deployed since the mid-seventies in the hydrocarbon industry as an improved recovery method. In the past two decades, this method began to be associated with CO_2 geological storage. Although much of the CO_2 is recycled and reinjected for hydrocarbon production, a significant quantity of CO_2 is permanently stored in the reservoir.

The most famous CO_2-EOR project is Weyburn – Midale CO_2 Project in Saskatchewan (Canada). Although the primary objective of this project is oil recovery, a lot of experience is very instructive for the purpose of CO_2 storage. The CO_2 injection within the Weyburn – Midale CO_2 Project began in October 2000 as part of an ongoing enhanced oil recovery activity combined with the recycling of CO_2 (the CO_2 that returns to surface together with the recovered oil is re-captured at the surface facilities and re-injected). By June 2010, more than 16 million tons of CO_2 have been stored in the Weyburn reservoir, at a current injection rate over 250 mmscf/day, which is equivalent to about 13,000 tonnes/day or 4,7 Giga tonnes/Year) (Rostron and Whittaker, 2011). It is estimated that by the end of productive life of the field, 40 million tones will be stored (Zaluski *et al.*, 2016), as the injection continues today. After 10 years of CO_2 injection, oil production in this 50 year old field has been increased by 60%. About 155 million barrels of incremental oil are expected to be recovered and will extend the life of the field by more than 30 years. Similarly, in the adjacent Midale Oil Field, full field CO_2 injection began by Apache Canada in September 2005 with a forecast of the extension of its lifetime with 30 to 40 years and 60 million barrels of incremental production. At Midale, pilot tests of CO_2 flooding were carried out by the operator, Shell Canada at that time from 1984-1989, which progressed into a demonstration project from 1992-1999. CO_2 injection into geological reservoirs in southeastern Saskatchewan, therefore, has been occurring in some measure for more than a quarter century (Whittaker et al, 2011).

Taking into account the success of these projects and the need for providing a business case to the CCS technology, global efforts are made to implement large scale CO_2-EOR optimized for CO_2 storage. Enhancing oil production through CO_2 injection at a large scale requires large volumes of CO_2 that can only be supplied by capturing CO_2 from industrial installations (IEA, 2015). Thus, Combining CCS and EOR technologies can ensure the economic viability of CCS and the necessary CO_2 volumes for the development of CO_2 EOR projects as shown by the Weyburn – Midale CO_2 Project.

CO_2-EOR ACTIVITIES IN ROMANIA

In Romania, CO_2 injection experiments were designed for several oil fields as mentioned in Table 1 (Trasca-Chirita and Baciu, 2010; 2012; Trasca-Chirita *et al.*, 2017).

Table 1. Designed CO_2 injection experiments in Romania

Name of oil field	Age of reservoir rock
Bradu - Albota	Meotian
Silistea	Sarmatian
Satchinez	Pannonian
Calacea	Miocene
Bradesti	Triassic
Turnu	Pannonian
Moreni	Meotian
Cerdac	Oligocene

Also, operations to stimulate the production of oil were applied by short-term injection of CO_2 into many wells (Trasca-Chirita and Baciu, 2010; 2012; Trasca-Chirita *et al.*, 2017). The short CO_2 injection experiments were applied to wells in the following oil reservoirs: Bodrog, Turnu, Urziceni, Ghimpati and Bradesti. The results were positive, except well I1 Ghimpati which couldn't be restarted into production for technical reasons. The best result was obtained at well 137 Bodrog, where 24 tonnes of CO_2 was injected at 20 to 60 bar. The well was shut down for 4 days and after that was returned into production with a flow rate of 17 tonne/day; the flow rate before the operation was about 1 tonne/day. The long term injection of CO_2 was applied only to the Meotian – Bradu Albota deposit, where, although the oil recovery was successful, the recovered oil quantity was less than estimated (Trasca-Chirita and Baciu, 2010; Trasca-Chirita *et al.*, 2017).

CO_2-EOR POSSIBILITIES IN ROMANIA

In terms of economic efficiency of the enhanced production from oil fields, the most favourable ones for operation by injection of CO_2 are located near sources of CO_2 because the transport costs are relatively low. Oil fields near industrial sources of CO_2 are the most appropriate because in the first stage, the injection of CO_2 can be used to increase oil exploration and increase recovery and the second stage the the operation can switch to CO_2 injection for long-term storage.

The most suitable reservoirs for CO_2-EOR are the ones which are in the final exploitation phase (location in Figure 1), which are hydrodynamically sealed or in other words do not communicate with other layers around the reservoir, have at least one well which can be used for injection and at least 3-4 reaction (production) wells, is at a depth of more than 800m and a reservoir rock which is preferably homogeneous.

The oil fields from the western part of Romania are appropriate because they have the same structure, or very close, to natural CO_2 reservoirs or free gas reservoirs with high CO_2 (40 - 80%). Such deposits are the structures Turnu, Biled, Varias, Lovrin, Bodrog, Peregu, Viisoara and others.

From a list of more than 130 oil fields with CO_2-EOR potential (see location in Figure 1), we selected several fields and clusters of fields as most suited for the application of this technology by coupling them with major emissions sources (Table 2).

Table 2. Most suited oil fields for application of CO_2-EOR and their potential emission sources

Name of oil fields	Emission source	Type of emission sources
Abramut, Viisoara - Marghita	SC Holchim SA – Cement Alesd	Cement factory
Bradesti, Corbii Mari, Racari	Isalnita and Craiova	Power plants
Balteni, Coltesti-Hurezani	Rovinari and Turceni	Power plants
Liscoteanca, Balta Alba	Arcelor Mittal Galati	Cement factory
	"Societatea Electrocentrale Galati SA"	Power plant
Aninoasa	Carpatcement Holding SA Fieni	Cement factory
Lipanescu, Malu Rosu	SC Petrotel-Lukoil SA	Refinery
	Petrobrazi	Refinery
	Dalkia Termo Prahova	Power plant
Calinesti - Oarja - Bradu – Albota	SC Carmeuse Holding SRL - Valea Mare	Chemical plant
Silistea Ciresu	SC CET Govora SA	Power plant
	CIECH Soda Romania (formerly: Uzinele Sodice Govora)	Chemical plant
Moreni	Dalkia Termo Prahova	Power plant
	Petrobrazi	Refinery
Balaceanca, Jilava, Berceni, Novaci-Dumitrana	"SC Electrocentrale Bucuresti SA" (CET Bucuresti Sud, CET Grozavesti, and CET Progresu).	Power plants

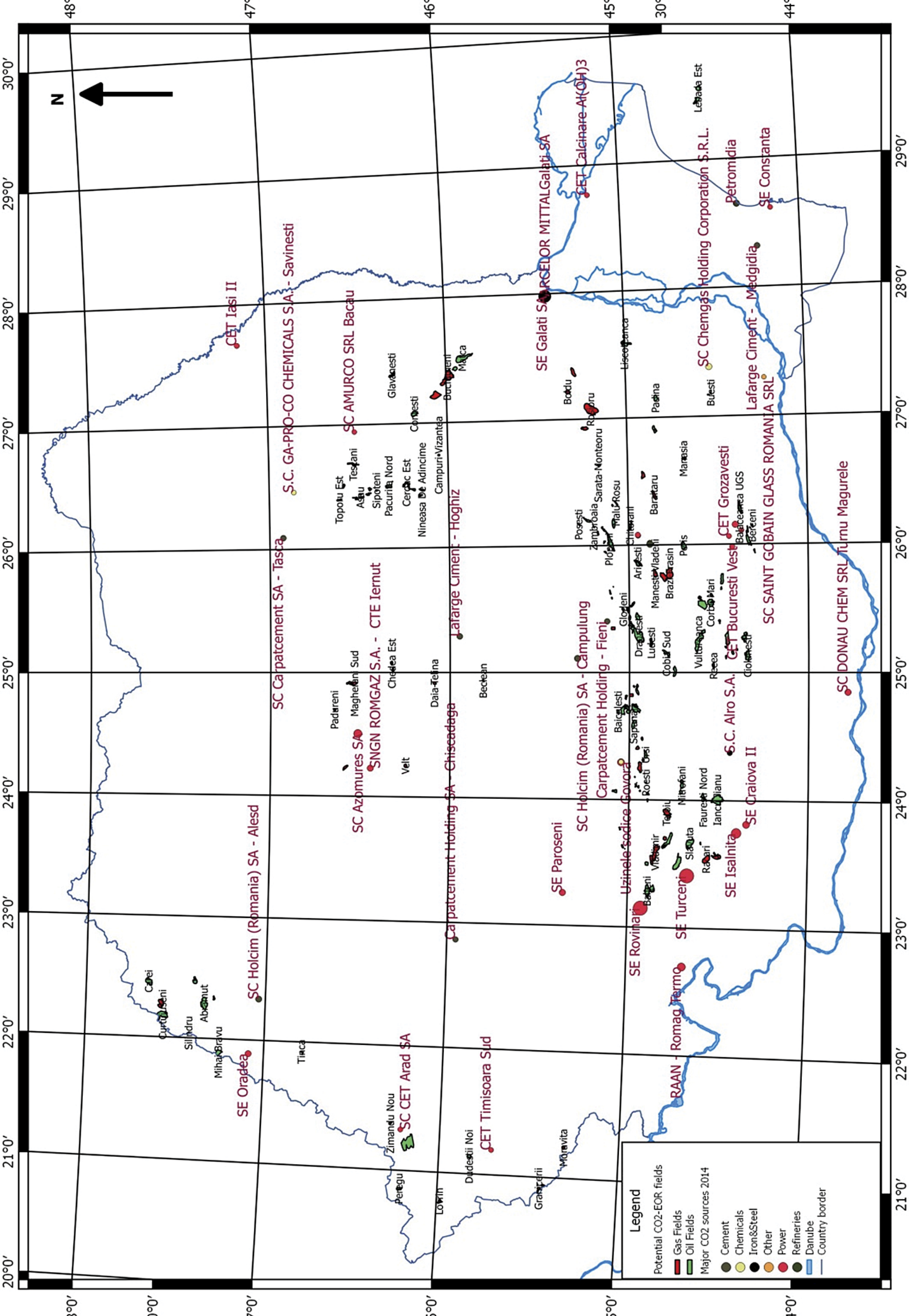

Fig. 1. Distribution of major CO_2 major emission sources for 2014 (the last published verified emissions) and of the potential CO_2-EOR oil fields

These combinations of reservoirs and sources can be considered as small regional industrial clusters on the whole CCUS chain can be implemented.

By applying the CO_2 injection into the above-mentioned fields, we can estimate that an extra production of 1 to 5 million tonnes of oil can be extracted per oil field over the next 20 years, so the increase in oil reserves could be 20 to 80 million tons.

CONCLUSIONS

Romania has a very large potential for using the CO_2 captured from industrial sources for injection in oil fields to simultaneously increase the oil recovery and store CO_2 for the long-term. The geological formations which are suitable for safe storage and are marked with a high degree of geological and physical knowledge, are widely distributed in the country.

To date CO_2 injection experiments were designed for the Romanian oil fields Bradu Albota - Meoțian, Siliştea - Sarmatian, Satchinez - Pannonian, Calacea - Miocene, Bradesti - Triassic, Turnu - Pannonian, Moreni - Meotian and Cerdac – Oligocene and operations to stimulate the production of oil were carried out.

From this wide range of deposits that Romania offers to inject CO_2 for the purpose of increasing oil recovery or long-term storage, we were able to achieve a plan in which we grouped these deposits with the closest sources.

All these have been designed to achieve a complete CCUS chain that involves the capture, transport, usage and storage of CO_2.

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