MULTIMODAL TRANSPORT OF CO_2 FOR IMPLEMENTING CCUS IN ROMANIA

Constantin Stefan SAVA[1], **Alexandra DUDU**[1], **Sorin ANGHEL**[1], **Corneliu DINU**[2], **Romeo SOARE**[2], **Andreea BURLACU**[2], **Iolanda ALEXE**[3], **Mihai CHIRAN**[3]

[1]National Institute of Marine Geology and Geo-Ecology (GeoEcoMar), 23-25 Dimitrie Onciul St., 024053 Bucharest, Romania
e-mail: savac@geoecomar.ro; alexandra.dudu@geoecomar.ro; soanghel@geoecomar.ro
[2]CO_2 Club
e-mail: codinu@gmail.com; romeo.soare@afdj.ro; andreea.lorelay@gmail.com
[3]SC PICOIL INFO CONSULT SRL - Str. Ion Cîmpineanu nr. 21, Câmpina, jud. Prahova
e-mail: iolanda.alexe@pic-oil.ro; mchiran@pic-oil.ro

Abstract. Romania is committed to reduce CO_2 emissions and efforts are made to speed up the implementation of CCS technology in our country. While the situation of capture and storage possibilities is well known and studied, CO_2 transport is less considered. European projects designed a transport infrastructure based solely on pipelines; the design included the territory of Romania with a high degree of uncertainty. The existence of Danube and the opening to the Black Sea, where good storage reservoirs have been discovered, lead to the idea of implementing a multimodal transport solution for southern part of Romania, involving onshore pipelines and river transport by vessels.

Key words: Major CO_2 emission sources, CO_2 transport, CO_2 geological storage, Enhanced Oil and Gas Recovery, Danube, Black Sea

INTRODUCTION

Efforts are made to implement CO_2 capture and storage technology across the world, as an important measure to reduce CO_2 emissions and limit global warming well below 2 degrees, as indicated by IPCC (2014) and by the Paris Agreement (2015). The large-scale implementation of CCS requires a viable business case, which can be achieved by commercial utilisation of CO_2 and the establishment of a transport infrastructure framework.

While the United States of America has an impressive CO_2 pipeline network and uses CO_2 for extensive EOR operations, Europe struggles to design a CO_2 transport infrastructure and to encourage CO_2-EOR projects. According to the scenario developed within the European Energy Roadmap 2050 (EC, 2011), at least 11000 km of CO_2 pipelines will be needed by 2035 (ZEP, 2013). Important European research projects (e.g. COCATE, COMET) concluded that CCS clusters, where transport and storage infrastructures serve multiple CO_2 sources, offer significant opportunities for CCS development. As for developing a common European CO_2 transport infrastructure, two options were analysed so far, designing a pipeline network (JRC and EUROPIPE models) (Morbee *et al.*, 2010; Neele *et al.*, 2011) and creating CO_2 hubs (*e.g.* Rotterdam harbour).

Romania is committed to reduce CO_2 emissions. CCS technology is mentioned in the national environmental and energy strategies as an important measure to reduce CO_2 emissions, especially from the energy production sector (The Ministry of Energy, 2016). This sector depends still on coal which is a "pillar of national energy security" (The Ministry of Energy, 2016). CCS related activities were performed in Romania for a decade, starting with the estimation of national CO_2 geological storage capacity and culminating with the preparation of a CCS demonstration project, GETICA CCS (currently cancelled for lack of financing). Although initially only onshore CO_2 geological storage options were taken into consideration for Romania, recent research revealed suitable storage options in the Histria Depression, which is located in the western Black Sea Basin. These options refer to deep saline aquifers (Dudu *et al.*, 2017) and CO_2-EOR prospects. So far in Romania, the transport part of the CCS chain was analysed just for the Oltenia region in the context of the GETICA CCS feasibility study. In this study a 40 km onshore pipeline was designed from the Turceni power plant (CO_2 source) to the proposed storage sites (Global CCS Institute, 2013).

MAJOR CO2 EMISSION SOURCES FROM SOUTHERN ROMANIA

The emissions from the southern part of Romania totalized to 29.82 Mt of CO_2 in 2014 (the last published verified emissions from stationary sources). Most of the emissions come from the energy production sector, as can be seen from the distribution of emissions by sector (Figure 1). The largest quantity of CO_2 was emitted in 2014 by the Turceni plant, followed by Rovinari and Arcellor Mittal from the cement production sector.

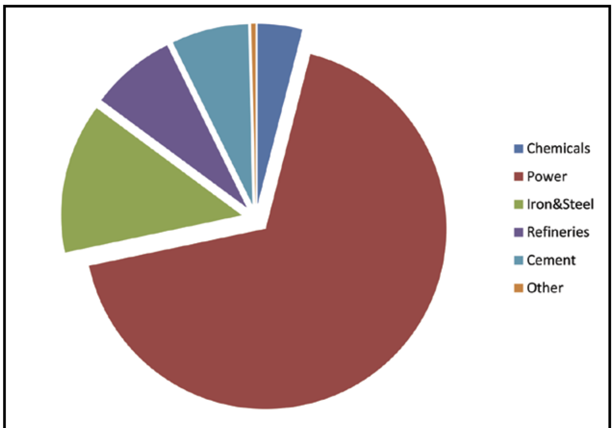

Fig. 1. Distribution of major CO_2 emissions by sector from the southern part of Romania (based on the list of verified CO2 emissions for 2014 published by the Ministry of Environment, Water and Forest in 2015)

As it can be seen from Figure 2, the major CO_2 sources have a relatively uniform distribution and at least half of them are close to the Danube. There are three sources located practically on the Danube and near major Danube harbours, namely Arcellor Mittal and SE Galati in the area of Galati harbour and S.C. Alum S.A. in close vicinity of Tulcea harbour. Constanta, the main Romanian harbour at the Black Sea, is very close to CET Palas Constanta. Lafarge Medgidia is located near Medgidia harbour on the Danube Black Sea Canal. Another observation that can be made from the map is that the emission sources could be grouped into clusters, smaller clusters (e.g. Bucharest, Ploiesti, Constanta, Galati) and regional clusters (e.g. Oltenia cluster).

CO2 STORAGE AND UTILISATION POSSIBILITIES IN THE WESTERN BLACK SEA BASIN

At the current knowledge level, the most favourable region for CO_2 geological storage is Histria Depression. This depresssion comprises five hydrocarbon fields (discovered so far) located on a NW-SE alignment on its northern flank. These fields are:

- Lebada Est, discovered in 1980, with oil in Albian and Upper Cretaceous rocks and gases in Eocene deposits;
- Lebada Vest, discovered in 1984, with oil in Albian, Upper Cretaceous and Eocene reservoirs;
- Sinoe, discovered in 1988, with oil in Albian reservoirs;
- Delta, discovered in 2007, with oil in Albian reservoirs;
- Pescarus, discovered in 1999, with oil in Upper Cretaceous (Cenomanian) reservoir.

The location of the fields can be seen in Figure 2 and partly in Figure 3. From these fields, only Lebada East and Lebada West can be used for CO_2-EOR operations and CO_2 storage purposes. These fields already have injection wells which are used for enhanced recovery operations (not involving CO_2).

Another option for CO_2 storage in the Histria Depression would be storage in deep saline aquifers. Hydrocarbon exploration revealed very good reservoirs in Albian, Upper Cretaceous and Eocene strata which host oil and gas on the northern flank of the depression, but were found with no indication of hydrocarbon on the southern flank. Recent research (Dudu *et al.*, 2017) revealed the existence of good structures for CO_2 storage named Iris, Tomis and Lotus (locations in Figure 3).

PROMOTING THE CONCEPT OF MULTIMODAL TRANSPORT

While the analyses of CO_2 emissions and of CO_2 geological storage and use possibilities in the western Black Sea basin (Romanian continental shelf) are at a relatively advanced level, the problem of CO_2 transport in Romania is just starting to be taken into consideration. The first feasibility study for transport was done in the context of GETICA CCS project, as mentioned before; it included transport by pipeline over a small distance (40 km) from the Turceni power plant to the storage sites identified in the Sarmatian deposits of the Getic Depression in the Oltenia region.

We have analysed the results of some important European projects, which have led to the design of CO_2 transport pipelines, gradually expanding throughout Europe, with time horizons of 2050 and 2100 (CO_2 Europipe or Trans-European CO_2 Transport Network), but also the results of projects promoting water transport (Rotterdam CINTRA Project). The latter project studies shipping over the river Rhine. This transport mode provides access to the North Sea where deep under the seabed geological reservoirs are present with prolific storage capacity and prospects for EOR and EGR.

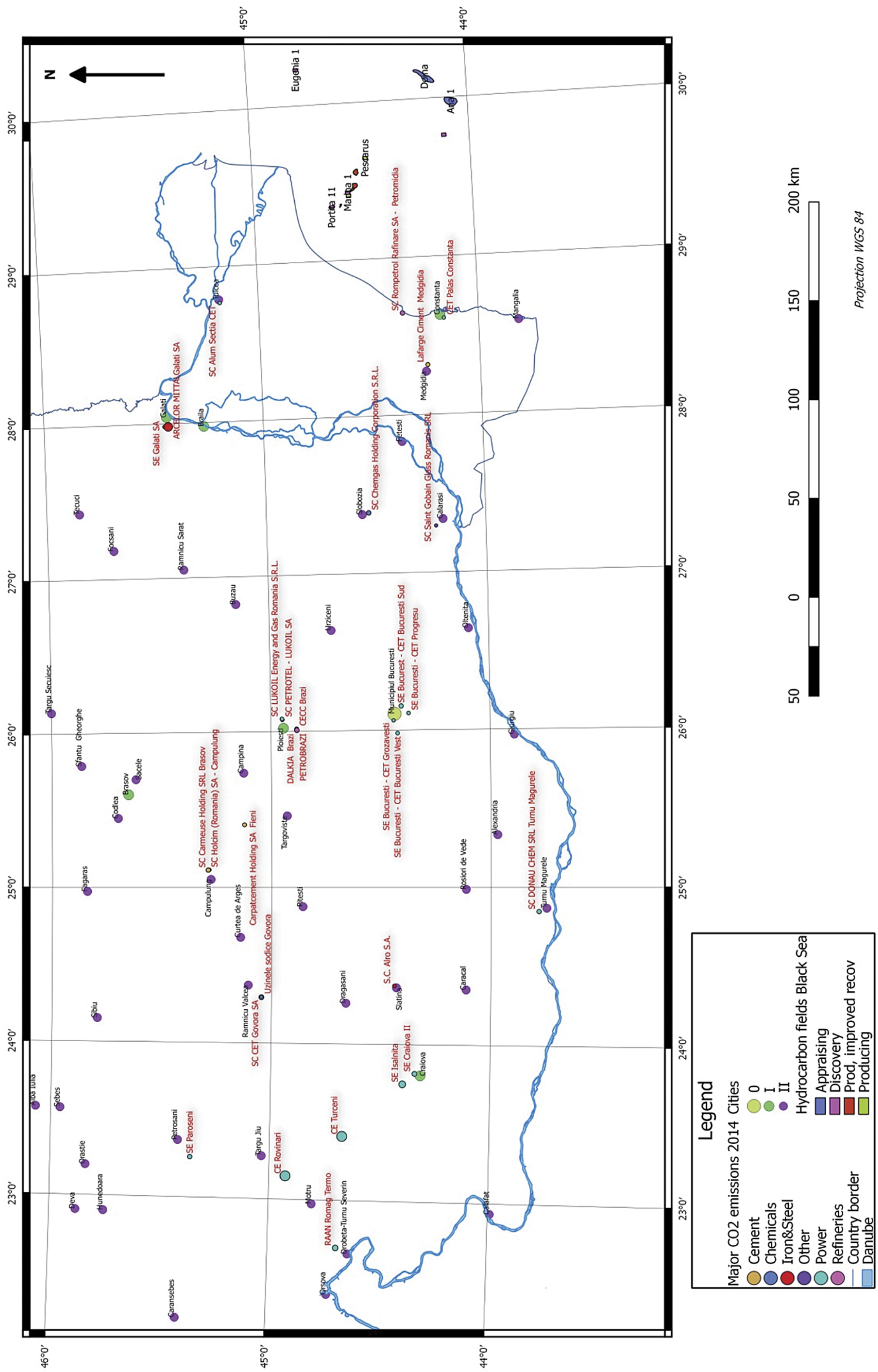

Fig. 2. Map of the southern part of Romania illustrating the areal distribution of major CO_2 sources and the hydrocarbon fields in the Black Sea

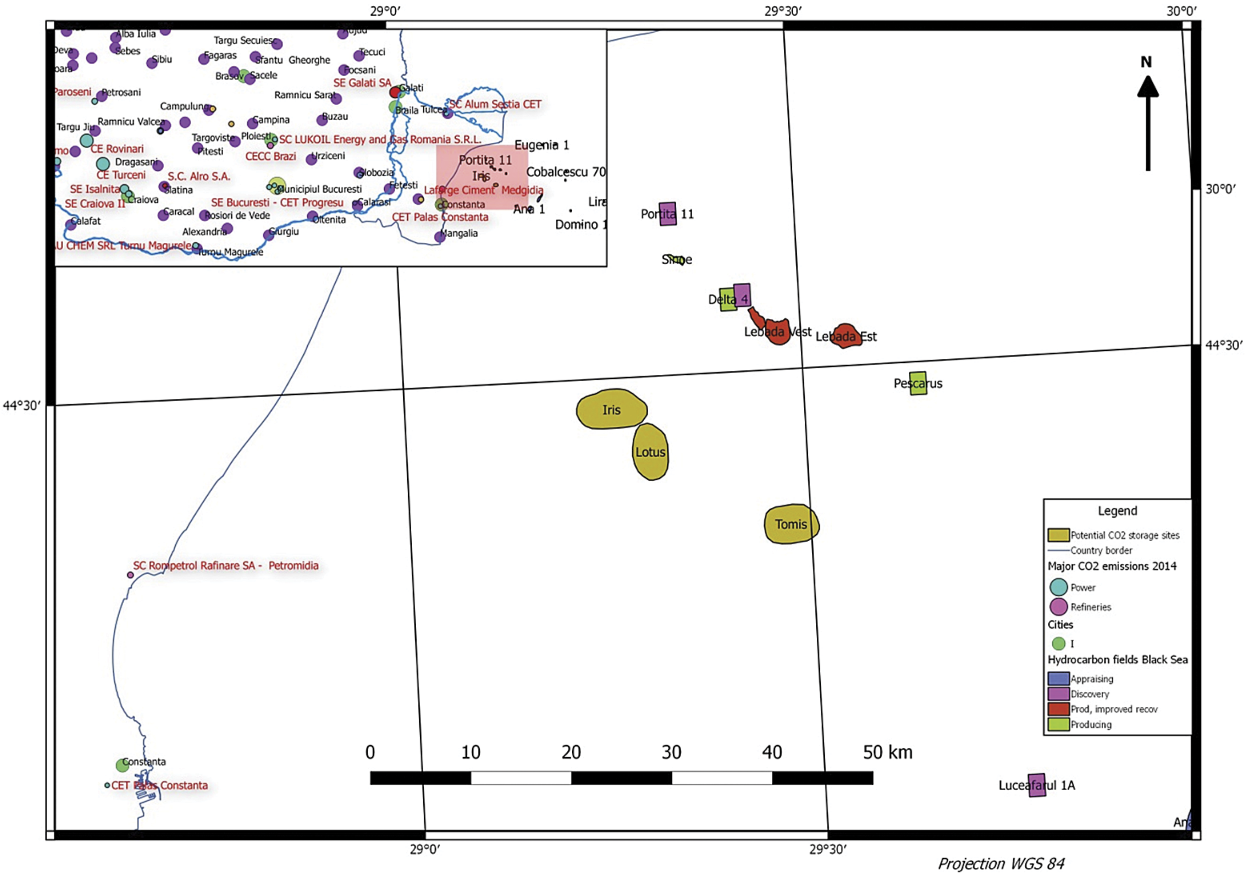

Fig. 3. Map illustrating the location of possible CO_2 storage structures in deep saline aquifers and the hydrocarbon fields in the Histria Depression

As the entire southern part of Romania is crossed by the Danube, this offers a great opportunity to promote the concept of „multimodal transport of CO_2 in Romania". Once we have identified both the major CO_2 industrial sources and geological structures favourable for the storage of CO_2, or even for the application of EOR and EGR, we can move on to designing segments of CO_2 transport pipelines to or from the closest Danube ports. Once a certain amount of CO_2 reaches its collection point in a Danube port, it can be transported by barges to another Danube port which is connected to a storage site. Similarly, the amount of CO_2 arriving at a Danube port can be transported through the Danube-Black Sea Channel to the Agigea Port. From here it can be transported with a sea-going ship or through offshore pipelines, to a storage site in the Black Sea. In this way CO_2 storage operations including EOR or EGR could develop in the Western Black Sea Basin, similar to the North Sea.

CONCLUSIONS AND DISCUSSION

The development of a CO_2 transport infrastructure is essential for speeding up the implementation of CO_2 capture and storage technologies in Romania and in Europe at large. This infrastructure does not necessarily rely on onshore pipelines only depending on the height of the capital costs for developing such an infrastructure versus the investments in ship transport. Furthermore, building new pipelines could face also public concern, as some social studies revealed in the last years. The best solution would be to combine transport by pipeline with transport by vessels. This is also an option for Romania, taking into account the existence of the Danube, of the Danube - Black Sea Canal and the opening to the Black Sea where good storage reservoirs have been identified. From the analysis of major CO_2 emission sources in the southern part of the country, we can conclude that these could be grouped into major or minor clusters for the purpose of CO_2 transport. In our vision, the best solution would be to design small segments of pipelines for the CO_2 transport from an individual source to a central or nodal point at which all the captured emissions from the industrial cluster are collected. The next segment of transport is also a pipeline, from the nodal point to a Danube harbour, at which the CO_2 will be transferred to a barge or vessel and transported by river to the offshore region where it will be injected for CO_2 EOR operations (e.g. in East Lebada and West Lebada fields) or for storage in deep saline aquifers (e.g. Iris, Tomis, Lotus structures).

Moreover, the Danube and the existence of the Rhine - Main - Danube European transport corridor, connecting the Black Sea with the North Sea, could play in important role in transboundary transport and subsequent usage and storage of carbon dioxide.

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