CO_2 GEOLOGICAL STORAGE POSSIBILITIES IN HISTRIA DEPRESSION - BLACK SEA (ROMANIA)

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Abstract. The Histria Depression (Black Sea) is an important unit for hydrocarbon exploration and exploitation. The existence of good reservoirs and good seal formations, discovered during hydrocarbon exploration, lead to its selection as the first unit from Romanian continental plateau to be assessed for CO_2 storage potential in deep saline aquifers. The assessment revealed the potential reservoir and seal formations for CO_2 storage and three potential CO_2 storage sites, *Iris*, *Lotus* and *Tomis*, located on the southern flank of the depression.

Key words: Carbon capture and storage; site selection; reservoir characterization; well correlation; geology

INTRODUCTION

The Carbon capture and storage (CCS) is an important method to obtain a rapid and drastic reduction of CO_2 from industrial installations. The main CO_2 geological storage solutions are: deep saline aquifers, depleted hydrocarbon fields, deep unminable coal seams and use in enhanced hydrocarbon recovery (EHR), and enhanced methane recovery (ECBM).

Assessing the potential of Romanian Black Sea shelf for CO_2 geological storage is very important for accelerating the implementation of CCS technology in Romania. It is well known and studied that offshore storage is more likely to be accepted by the public due to the fact that the storage locations are further away from the populated areas than in the case of onshore storage. Till present, only onshore storage possibilities were identified and assessed for Romania, taking into account that Black Sea is far from the main CO_2 sources and the transport by pipeline on large distances is very expensive. Recent studies concluded that water transport is the cheapest transport solution and, as a consequence, storage into the Black Sea structures has become accessible. Thus, the CO_2 could be captured from onshore installations, transported by pipeline on small distances and then transported by ship along the Danube River to the Black Sea.

For a first assessment of CO_2 storage potential of western Black Sea (Romanian continental plateau), we have chosen the unit of Histria Depression (location in Fig. 1), an unit intensely explored and exploited for hydrocarbons. This unit comprises the most important hydrocarbon fields discovered till present on the Romanian Black Sea shelf, namely *Pescarus*, *East Lebada*, *West Lebada*, *Sinoe* and *Portita* (Morosanu, 2012). Furthermore, during the oil and gas exploration, several structures have been identified and mapped, with no hydrocarbon indication, structures that could be used for CO_2 storage. It is necessary to mention that the CO_2 geological storage assessment for Histria Depression presented in the present paper was done solely for storage in deep saline aquifers. The hydrocarbon fields present in the investigated area are not depleted and there are no plans for enhanced hydrocarbon recovery.

GEOLOGICAL SETTING

The Histria Depression is a post-tectonic cover superposed over the North Dobrogea Orogen (Fig. 1) which has formed by extension, starting with Aptian – Albian and continued till Eocene, followed by flexural and thermal subsidence. The depression limits are represented by Heraclea fault

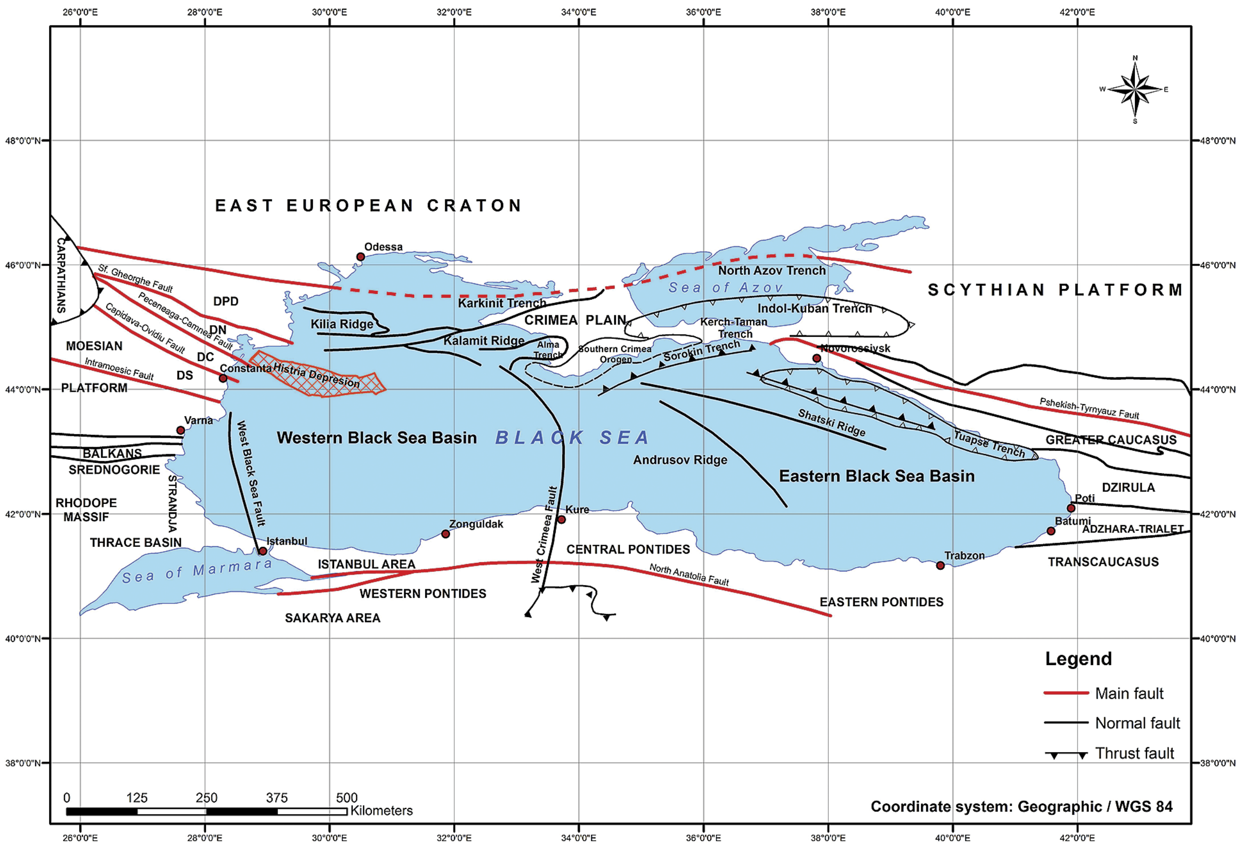

Fig. 1. Location of Histria Depression. Black Sea tectonic map (modified after Dinu *et al.*, 2005)

to the North and Peceneaga - Camena fault to the South (Dinu *et al.*, 2005; Tambrea, 2007; Morosanu, 2004, 2007).

The seismic lines acquired on the Romanian shelf and also in the Histria Depression put into evidence two seismic megasequences with different characteristics, separated by an unconformity (a major discordance) (Post-Eocene – Pre-Oligocene (Konerding, 2005; Moroșanu, 2007).

The lower megasequence includes Pre-Oligocene formations and can be subdivided into three sequences (Moroșanu., 2007): (1) The Pre-Triassic sequence (Paleozoic formation); (2) The Pre-Albian sequence (The Triassic, Jurassic and Neoecomian formations); (3) The Pre-Oligocene sequence (Aptian-Albian – Upper Cretaceous – Eocene formations).

The upper megasequence consists of Oligocene - Quaternary formations (Konerding, 2005; Moroșanu, 2004, 2007). This megasequence includes four seismic sequences (Moroșanu, 2004, 2007), corresponding to: (1) The Oligocene formation; (2) The Badenian-Sarmatian formation; (3) Pontian formation and (4) Dacian-Romanian-Quaternary formations.

From a structural point of view, the configuration of the depression is dominated by a NW-SE fault system (Dinu *et al.*, 2005; Morosanu, 2007). The two flanks of the basin show significant structural differences determined by the extensional processes from Aptian – Albian and continued till Eocene, which allow its formation. The Southern flank has an extensional character, with block descending on lystric faults to the centre of depression, while the Northern flank presents an inversion character.

POTENTIAL RESERVOIR AND SEAL FORMATIONS FOR CO_2 GEOLOGICAL STORAGE

The reservoir formations suitable for CO_2 geological storage in Histria Depression, as well as their potential seal formations, were identified based on the delimitation of reservoir levels on the litostratigraphic column of the area and also on the analogy with the hydrocarbon reservoirs exploited on its Northern flank. We focused only on reservoirs located at depths greater than 800 m below sea bottom, a depth that guarantees maintaining of CO_2 in supercritical state and allows storing large quantities of CO_2 at smaller plume volumes.

Lower Cretaceous presents very good reservoirs for CO_2 geological storage. Thus, a first suitable reservoir for CO_2 could be the clastic sequence (sands and sandstones) from Neocomian (base of Lower Cretaceous). This stratigraphic term is well represented on the area of Histria Depresion and it is composed from detritical rocks such as shales, marls, sandstones, microconglomerates and conglomerates (Tam-

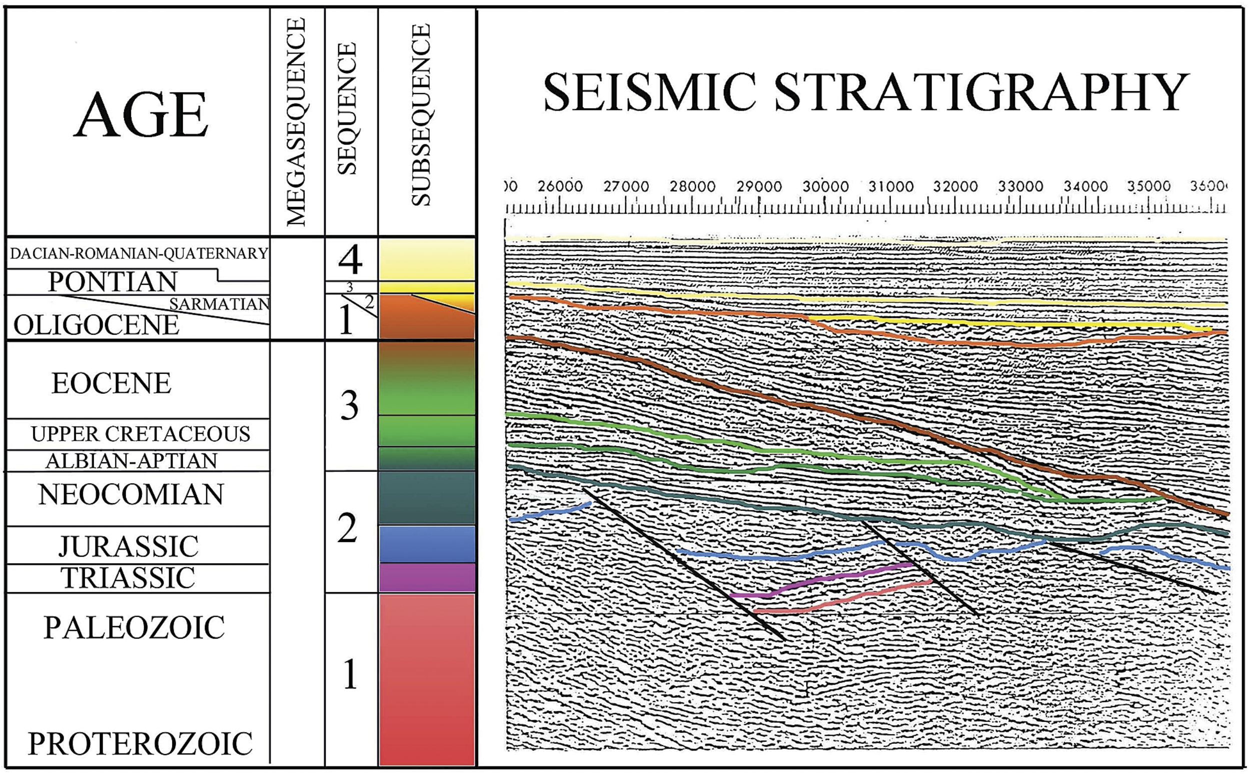

Fig. 2. Seismic megasequences (Morosanu, 2004, 2007)

brea, 2007). An upper reservoir consists of Barremian – Aptian sequence, characterised from a lithological point of view by the presence of calcareous sandstones, argillaceous limestones and siltstones. An important potential reservoir could be also Albian formation which mainly comprises clastic rocks with a wide dimensional variety and small thin intercalations of carbonates. This formation constitutes a very good hydrocarbon reservoir for the Lebada and Pescarus oil fields (Morosanu, 2007).

Upper Cretaceous presents good reservoir levels in Cenomanian and Senonian and is a hydrocarbon producing interval for Lebada and Portita oil fields (Morosanu, 2007). The Cenomanian formation is developed in the Histria Depression area in four different facieses: non-stratified sandstones and limestones (*West Lebada*); marls alternating with fine sandstones (Unirea); marls, fine sandstones and frequent intercalations of medium sandstones and conglomerates (*East Lebada*, *Pescarus*, *Razelm*) and fine sandstones, marls and limestones (*Poseidon*, *Iris*, *East Lebada* and Lotus) (Tambrea, 2007). The Senonian formation is well represented in Histria Depression for the Coniacian – Santonian interval, which could be suited for CO_2 geological storage, as, apart from small intercalations of limestones, is mainly composed of sands and sandstones.

The last potential reservoir is Middle Eocene formation, characterised at the base part by a detritical facies and by a carbonate facies at the top.

As for the seal formations identified, these could be represented by shale sequences from Lower and Upper Cretaceous and by the Oligocene formation. This last formation could be a primary seal for Eocene reservoir, but also an important secondary seal for the Cretaceous reservoirs. The Oligocene covers as a thick blanket the entire continental platform of the Black Sea, thus implicitly the entire area of Histria Depression. The Oligocene formation consists of shales with rare occurrences of siderithic dolomites and very rare occurrences of sandstones (Tambrea, 2007). The thickness of the formation increases from West to East.

SELECTION OF POTENTIAL STRUCTURES FOR CO_2 GEOLOGICAL STORAGE

Analysing the available seismic sections, gravimetric and magnetic data, well data from hydrocarbon exploration, we have identified several structures which have the potential for becoming CO_2 geological storage sites, namely *Iris*, *Lotus* and *Tomis* (location in Fig. 3). These structures are located on the Southern flank of Histria Depression.

The selection of the structures was made on several criteria:

- Wildcats drilled on these structures (16 *Iris*, 18 *Lotus* and 10 *Tomis*) had no hydrocarbon indication;
- The structures are located at shallow water (70-80 m maximum water depth) and their eventual exploitation for CO_2 storage would be much easier and would require less investment than for structures offshore;

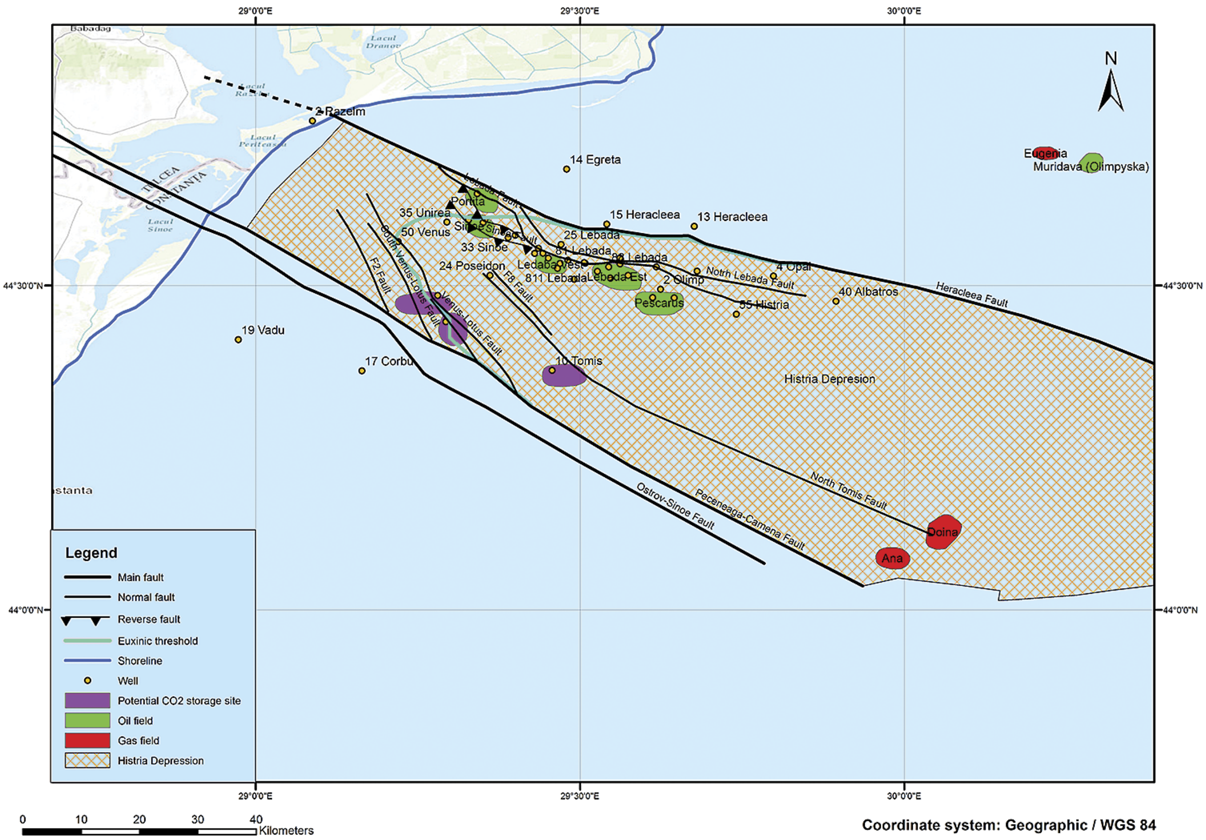

Fig. 3. Location of potential storage sites and hydrocarbon resevoirs from Histria Depression (compiled after Tambrea, 2007; Morosanu, 2012)

- The existence of good Cretaceous reservoirs and of compact seal formations at depths greater than 800 m (the minimum acceptable depth for CO_2 storage) below sea bottom.

In order to select the most suitable structure for CO_2 geological storage, we have analysed all the available data and we also did a well correlation (Fig. 4) between the three wells drilled on the structures.

A first observation related to the well correlation is that 18 *Lotus* intercepts the basement rise highlighted on the gravimetric maps through a maximum local anomaly (Sava *et al.*, 1996).

The only potential CO_2 geological storage reservoir that can be correlated on the three wells is the Albian reservoir represented through grey sandstones with limestone cement, on the depth interval 2700 m – 2844 m in 10 *Tomis*, quartz sandstones with limestone cement developed on the interval 1821 – 1835 m in 18 *Lotus* and quartz sandstones with limestone cement on the interval 2600 – 2615 m in 16 *Iris*. It has been noticed that the thickness of this reservoir reaches a maximum in the East on the 10 *Tomis* well. The petrophysical properties of this reservoir were estimated based on the analogy with the hydrocarbon deposits from the Northern flank of depression and refer to a porosity of up to 30 % and permeability up to 200 mD (Ionescu *et al.*, 2002).

The seal formation for this reservoir is represented by the thick stack of compact black marls in 10 *Tomis* well, by compact black shales in 18 *Lotus* and, probably, by a thin layer of shales in 16 *Iris*.

Another reservoir, correlated only on 18 *Lotus* and 16 *Iris* wells, is the Cenomanian reservoir. This reservoir is represented through a calcareous sandstone with thin layers of silthic shales (Morosanu, 2007), developed on the depth interval of 1523 - 1658 m in 18 *Lotus* and through a grey fine sandstone with limestone cement on the interval 2235 - 2250 m in 16 *Iris*. The seal formation for this reservoir could be represented on both structures by Oligocene shales.

On *Tomis* structure there are two additional possible reservoirs in Neocomian and Senonian. The Neocomian reservoir is well represented and consists of an alternation of conglomerates, calcareous or quartz grey sandstones, fine layers of limestones and possibly altered basalts. This reservoir is developed at 2937 – 3200 m depth. The Senonian reservoir is composed of friable limestones with thicknesses up to 100 m. The Upper Cretaceous reservoirs have porosities of 17 % and permeabilities of 48 mD (Ionescu *et al.*, 2002).

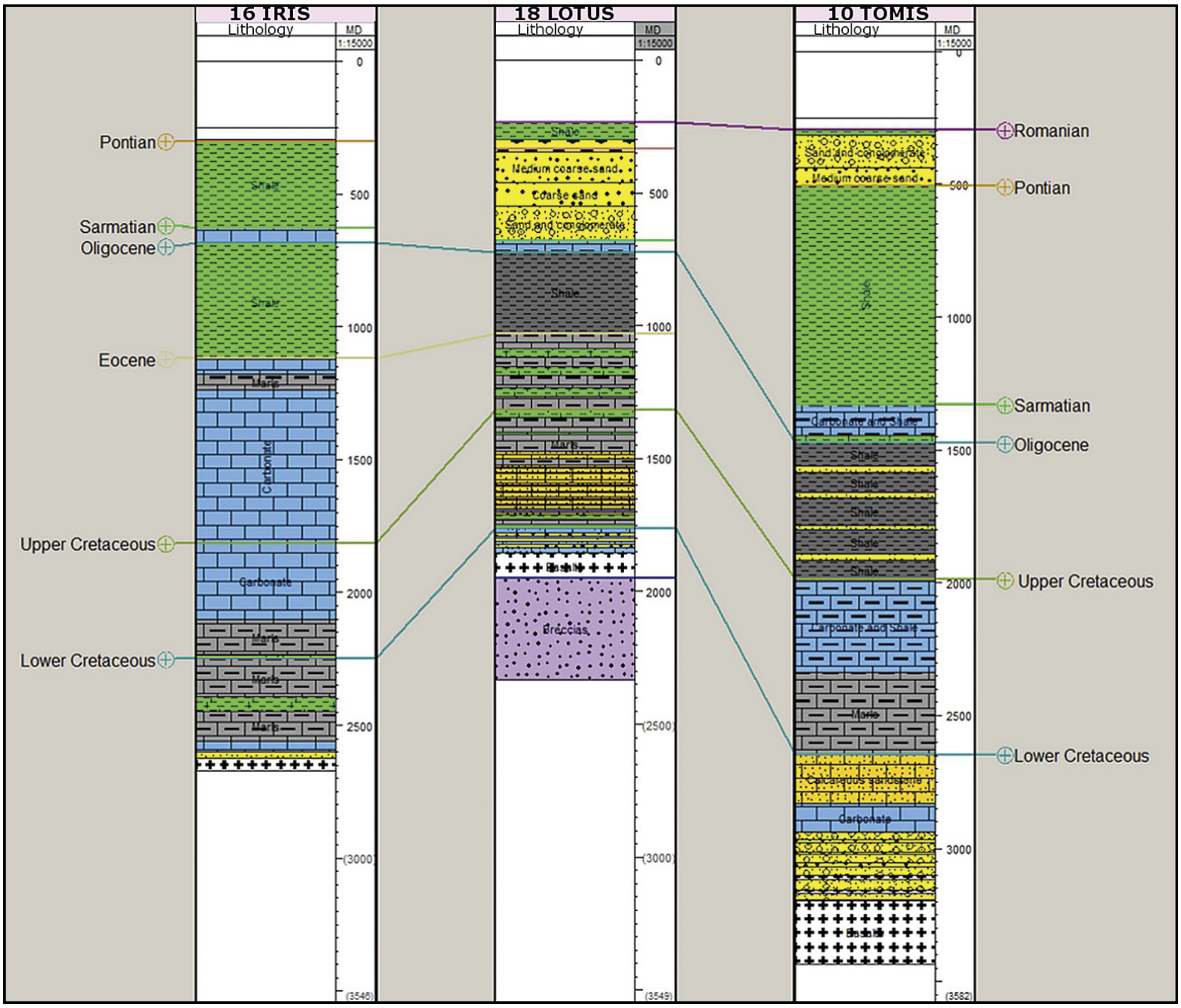

Fig. 4. Litostratigraphic corelation for 16 *Iris*, 18 *Lotus* and 10 *Tomis* wells

CONCLUSIONS

From the analysis of litostratigraphic particularities of Histria Depression and considering the mandatory characteristics of suitable storage formations (minimum depth of 800 m below sea bottom), we have identified good reservoir formations in Albian, Lower and Upper Cretaceous and Middle Eocene. These reservoirs are sealed primarily by shale sequences on top and secondary by the Oligocene shale formation.

Furthermore, the analysis of available geological and geophysical data, has materialized in the selection of three structures, suitable for CO_2 storage, *Iris*, *Tomis* and *Lotus*. This structures present good reservoir levels, according to well data, and did not present hydrocarbon indications. These structures must be further investigated in terms of site closure, continuity of seal formations, possible migration pathways and storage capacity. It is also necessary to correlate the wells using seismic lines in order to see the variations of the reservoir thicknesses.

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