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Preliminary basin scale assessment of CO_2 geological storage potential in Santos Basin, Southeastern Brazil: Merluza Field study case

Avaliação preliminar do potencial para armazenamento geológico de CO_2 da Bacia de Santos, sudeste do Brasil: estudo de caso do Campo de Merluza

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ABSTRACT
The global community has authorized, through the Paris Agreement, the choice of an ambitious goal of reducing greenhouse gas emissions during the 21st century. The high world dependence on fossil fuels indicates that a quick energy transition—based on the use of renewable fuels or even considering the reduction of total energy consumption—will not be possible without structural changes in the neoliberal way of production and consumption. Thus, carbon capture and storage technologies emerge as a relevant tool for emergency action to meet the Paris Agreement goals. The search for adequate reservoirs is a relevant part of the CO_2 storage endeavor and the Santos Basin has a privileged location, being close to oil producing and consuming centers. This work culminated in the study of the Merluza Field zone. Geochemical data and compiled lithological descriptions suggest a possible use of Jureia Formation and Itajaí-Açu Formation. A storage capacity estimation study is also presented. This favorability is not only geological: the presence of infrastructure installed in the Merluza zone as a fixed platform and an exclusive gas pipeline suggests greater economy and less environmental damage from the adaptation of depleted fields for use as a geological reservoir of CO_2.

Keywords: CCS, Storage Capacity, Santos Basin, Depleted Oil and Gas Field

RESUMO
A comunidade global autorizou, através do Acordo de Paris, a escolha de um objetivo ambicioso para reduzir as emissões de gases de efeito estufa durante o século XXI. A alta dependência mundial de combustíveis fósseis indica que uma rápida transição energética — baseada no uso de combustíveis renováveis ou mesmo considerando a redução do consumo total de energia — não será possível sem mudanças estruturais na maneira neoliberal de produção e consumo. Assim, as tecnologias de captura e armazenamento de carbono emergem como uma ferramenta relevante para ações emergenciais para atender essas metas. A busca por reservatórios adequados é parte relevante do empreendimento de armazenamento de CO_2 e a Bacia de Santos possui localização privilegiada, próxima a centros produtores e consumidores de petróleo. Este trabalho culminou no estudo da zona do campo de Merluza. Dados geoquímicos e descrições litológicas compiladas sugerem um possível uso da Formação Jureia e Formação Itajaí-Açu. Um estudo de estimativa de capacidade de armazenamento também é apresentado. Essa favorabilidade não é apenas geológica: a presença de infraestrutura em Merluza como plataforma fixa e um gasoduto exclusivo sugere maior economia e menos danos ambientais pela adaptação de campos esgotados para uso como reservatório geológico de CO_2.

Palavras-chave: CCS, Armazenamento de CO_2, Bacia de Santos, Campos Depletados.

1 INTRODUCTION

The global community authorized, through the Paris Agreement, the choice of an ambitious emission reduction target during the second half of the 21st century (IEA, 2016). Participating countries agree to keep the global average temperature rise below 2 °C above pre-industrial levels and to make efforts to limit the temperature rise to 1.5 °C above pre-industrial levels. This path, however, requires the rapid and extensive development of low carbon technologies, including carbon capture and storage (CCS). In this context, the energy sector has an important role in this paradigm shift, since it accounts for 72% of the total greenhouse gas emissions in the world (WRI, 2019).

The high global dependence on fossil fuels indicates that a rapid energy transition—based on the use of renewable fuels or considering, also, the reduction of total energy consumption—will not be possible without structural changes in the neoliberal logic of production and consumption. In this way, CCS technologies emerge as a relevant tool for emergency action, a harm reduction technique to be used to achieve the goals of the Paris Agreement.

In the Brazilian context, the development of CCS technologies takes on a relevant space due to the performance of oil companies in the country as well as for the development of technologies that respond positively to the trends contemplated worldwide. It is evident that the offshore gas and oil production process results in the emission of greenhouse gases. Data provided by the Ministry of Science, Technology, Innovation and Communication of Brazil on greenhouse gas emissions from the extraction and transportation of oil and natural gas in Brazil show an increase from 6 201 Gg CO_2 in 1990 to 15 782 Gg CO_2 (fugitive emissions) in 2015 (MCTIC, 2015). When considering total emissions (gas turbines, turbochargers and fugitive emissions), this total value can reach 534 674.4 tons of CO_2 per year (MCTIC, 2015). The high values reiterate the need to relocate these emissions, putting CCS in focus again.

Thus, the scope of this project is the search for possible geological reservoirs for CO_2 in the Santos Sedimentary Basin. This basin has a privileged location, being close to centers producing and consuming oil products. In addition, the presence of local companies that are willing to develop this type of technology is a relevant factor. The work ended up directing the focus of the study preferentially to the geological formations associated with the oil and gas reservoirs, looking mainly for the depleted or depleting oil and/or gas field.

2 DATA SELECTION AND METHODOLOGY

Three fundamental steps were established in the working methodology of this research:

- an initial collection of all geological data available about the stratigraphic units of the Santos basin to compare with the specifications necessary for a geological formation to be considered as a safe reservoir for CO_2 storage, as well as the main characteristics of the geological CO_2 reservoirs around world, possible associated environmental issues and selection criteria;
- after selecting the best geological units to store, specific data collection on the most promising formations were developed;
- preliminary estimate of CO_2 storage capacity of the selected reservoir.

The selection of the most appropriate geological units for CO_2 storage was based on all the criteria raised during the literature review.

3 RESULTS AND DISCUSSION

Before the geological characterization of the stratigraphic units of the Santos Basin, it is necessary to identify key selection criteria that allow to say whether the chosen reservoir is environmentally safe, economically adequate and geologically viable (AMINU et al., 2017). The criteria that must be considered when choosing a geological reservoir for CO_2 are diverse, but they can be divided into three main categories (BCHU, 2000; LLAMAS et al., 2014; TOMIĆ; SCHNEIDER, 2018) as follows: geological; physical, thermodynamic and hydrodynamic; techno-economic, social and regulatory.

The availability of geological information allows the studied rocks to be classified according to the effective possibility of use for CO_2 storage. Among these parameters, it is possible to mention: type of basin, tectonic stability, lithology, reservoir volume, porosity, permeability, depth, thickness, permeability of the sealing rock, seismic data, faults and fractures as partially described in Tomić and Schneider (2018). The chemical and mineralogical compositions of the rock are relevant factors as well.

The CO_2 is injected into the reservoirs in a supercritical state, reached by compressing and heating the gas until it exceeds the critical point, represented by pressures above 7.38 MPa and temperatures above 31.1 ºC. Thus, the analysis of thermodynamic criteria includes the study of temperature and pressure gradients. In the aforementioned conditions, CO_2 exhibits gas and liquid properties simultaneously, showing density of a liquid and viscosity of a gas (TOMIĆ; SCHNEIDER, 2018). When considering the conditions of temperature and pressure existing on Earth, the minimum depth of CO_2 injection to remain in the supercritical state must be about 800 m.

With the increase in depth, there is a significant reduction in the volume of injected carbon dioxide (AMINU et al., 2017).

Thermodynamic and geothermal conditions are not constant across all basins, being distinct even in different portions of the same basin. In this sense, the limiting factors for the geothermal regime in a basin can include: type of basin, age and tectonism; basement heat flow; thermal conductivity and heat production in the sedimentary succession; temperature at the top of the sedimentary succession (AMINU et al., 2017).

Knowledge of the hydrodynamic regime of the water present in the formations is essential for CO_2 storage, especially in the case of injection into depleted oil and gas reservoirs, that are very important in the Santos Basin context. Hydrocarbon reservoirs are the result of secondary hydrocarbon migration through aquifers and trapping. As a result, the vast majority of hydrocarbons are in constant contact with the underlying water formation. The $CO_{2,}$ injection affects the pressure, flow regime and salinity of the water and there is a clear link between the type of sedimentary basin and the flow of water contained (BACHU, 2000).

Among these criteria, one can mention the pre-storage costs, costs related to the storage location and monitoring costs (TOMIĆ; SCHNEIDER, 2018). The costs related to the steps prior to storage include expenses with capture and transportation, as well as feasibility studies for the proper characterization of a storage location. Capital costs, on the other hand, include infrastructure for carbon dioxide capture, transportation, injection costs and field equipment, depending on the choice of storage location. The costs of monitoring the enterprise, in turn, depend on local regulation. The great variation found in the cost estimation is due to methodological differences and by the variation of available scenarios as well (TOMIĆ; SCHNEIDER, 2018).

Social criteria consider public perception, which consists of understanding whether the population directly and indirectly affected understands carbon capture and storage technologies as a benefit or a problem. This issue also involves the direct surroundings of the enterprise and the populations that are directly affected by possible changes in their quality of life (TOMIĆ; SCHNEIDER, 2018).

Regulatory issues are also significant and involve the development and adoption of appropriate regulatory acts for CO_2 storage and the creation of a legal apparatus for political agents and international treaties adopted around CCS technologies. An example of this type of development was the creation of a European commission that elected the CCS as a technology with special participation in order to achieve the CO_2 emission mitigation goals provided for in various treaties (EUROPEAN COMMISSION, 2011).

The Santos Basin has an area of approximately 352 260 km^2, which extends between 150 760 km² from the coastline to the 400 m bathymetric elevation, 20 750 km^2 located between the 400 and 1 000 m and 180 quotas 750 km^2 between the 1 000 and 3 000 m elevations (FREITAS et al., 2006). Geographically, the basin faces the states of Rio de Janeiro, Santa Catarina, São Paulo and Paraná. It is limited to the north by Alto do Cabo Frio (bordering the Campos Basin), to the south by Alto de Florianópolis (in relation to the Pelotas Basin). To the east, the basin extends to approximately the limit between the continental crust and the oceanic crust, and to the west it is limited by the Santos Fault (FREITAS et al., 2006).

The origin of the Santos Basin is associated with the South Atlantic Ocean open processes. Its tectonic and stratigraphic framework comprises three mega-sequences: synrift, transitional and post-rift (MOHRIAK, 2003). The synrift megassequence (Neocomian / Barremian age) presents coarse siliciclastic sediments (Guaratiba Formation) that sit in discordant contact with volcanic rocks of the Camboriú Formation (MOHRIAK, 2003). The transitional mega-sequence, in turn, presents the deposition of aptian and siliciclastic evaporites, which are above the break-up disagreement. This mega-sequence presents characteristics of a restricted marine environment, with carbonates, anhydrite and halite (in the Ariri Formation). Finally, the post-rift mega-sequence, corresponding to the third tectonic phase, is associated with thermal subsidence during continental drift processes (MOHRIAK, 2003).

In relation to oil exploration, the main oil generators are associated with the shales of the Guaratiba Formation (aged corresponding to Aptian / Barremian / Hauterivian) and the shales of the Itajaí-Açu Formation (aged Cenomian–Turonian). The oil reservoir rocks are the carbonatic sandstones of the Guarujá Formation and the sandstones of the Florianópolis Formation. The siliciclastic reservoirs of the Upper Cretaceous, represented by the platform sandstones of the Jureia Formation and turbidites of the Itajaí-Açu Formation are also important. Tertiary turbidites from the Marambaia Formation (Eocene–Paleocene) also occur (HASUI, 2012). The sealing rocks, in turn, correspond to those that prevent oil (and gases) from moving through the different layers of rock. In the case of the Santos Basin, these rocks are represented by shales, marl and calcilutites acting on carbonate and siliciclastic accumulations. The oil in carbonates from the pre-salt sequence have gained much prominence recently. In these cases, the salt layer acts as a sealant for oil trapped in high rift phase structures, which mark large positive features in the basin, on a regional scale (MOHRIAK et al., 2008).

In this research a bibliographical review about Santos Basin made it possible to verify the main geological characteristics of the stratigraphic units, which are summarized in the table 1.

Table 1 - Geological units at Santos Basin and its main features.

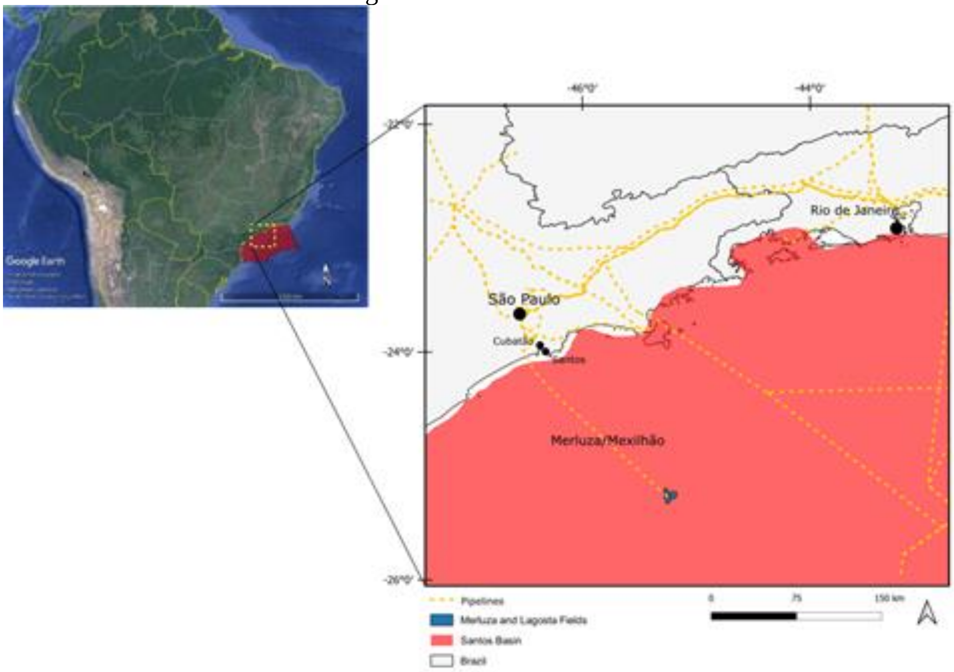
Geological unit	**Main features**
Camboriú Formation	Basaltic spills below the sedimentary section for almost the entire length of the basin.
Guaratiba Formation	Pack of clastic and carbonate rocks located above the Camboriú Formation and below the evaporites of the Ariri Formation, with both discordant contacts.
Ariri Formation	Composed of thick packages of halite and white anhydrite, calcilutites, shales and marl.
Florianópolis Formation	Fine to coarse, red sandstones with clayey matrix, shale and micromicaceous red siltstones
Guarujá Formation	Bioclastic oolitic calcarenites that appear varying laterally for cream-grayish / brownish-gray calcilutites and gray marl.
Itanhaém Formation	Pelitic package that occurs between the clastics of the Itajaí-Açu Formation and the carbonates of the Guarujá Formation.
Santos Formation	Clusters and reddish lithic sandstones that occur interspersed with gray shales and red clays.
Itajaí-Açú Formation	Pelitic package sotoposto and interdigitated with the clastics of the Jureia and Santos formations. It is composed of a thick section of fine clastics and the predominant lithology is dark gray shale.
Jureia Formation	Dark gray to greenish and reddish-brown shales, dark gray siltstones, fine and very fine sandstones and light cream calcilutites.
Iguape Formation	Bioclastic calcarenites and calcirruditesthat occur interspersed with greenish-gray clay, siltstone, marl and conglomerates.
Marambaia Formation	Thick section of shale and light gray marl intersecting with fine turbiditic sandstones.

The selection of the most suitable geological units for the CO_2 reservoirs, however, was not only based on geological criteria. The combination of the use of depleted reservoirs conditioned the search for formations associated with these reservoirs. This restriction was due to cost reductions, fewer accidents and environmental and greater technical knowledge associated with depleted fields. Other possibilities (such as the use of salt and mineralization caves) are not ruled out by geological criteria.

The choice of the most suitable formations for CO_2 storage is based on two main criteria: initially, those that meet the geological criteria necessary to be suitable for to be a safe geological reservoir; secondly, the aim is to find these units in depleted or depleting oil and gas fields, that was considered a situation more suitable for application in the Santos Basin.

When considering the use of depleted fields, it is important to emphasize that the exploratory use and oil and gas production of the Santos Basin is recent and few fields currently fits into this scenario and within this framework the Merluza Gas Field (figure 1) seems to be the best option, because its gas production is decreasing, which brings to the fore a decommissioning not too distant, or, still, the possibility of its conversion to a CO_2 storage project.

Figure 1 - Merluza Field location.



Although it is possible to explore other fields thinking about a future situation, this work focuses on the Merluza field. In this sense, the lithological units selected for the study were the turbidity sandstones of the Jureia Formation and of the Itajaí-Açu Formation–Ilhabela Member which will be focused as a potential CO_2 geological reservoir.

3.1 MERLUZA FIELD DATA AND SELECTED FORMATIONS

The selected rock formations were not the only ones possible for the application of a CO_2 storage project. There are possibilities such as storage by mineralization and use of salt caves. In the case of this work, only the formations associated with depleted reservoirs were considered, as this scenario presents lower costs and lower environmental and leakage risks.

The largest available source of geological data on the Merluza Field is the work of Sombra et al. (1990). The Merluza platform (PMLZ-1) has been in operation since 1993 and produces the Merluza and Lagosta natural gas fields. Geographically, it is located about 180 km from the coast of the city of Praia Grande (São Paulo), being a platform fixed in a water depth of about 131 m (PETROBRAS, 2019).

The Merluza field has two gas reservoirs of Santonian age (Upper Cretaceous period between 86.3 million and 83.6 million years ago): the turbidity sandstones of the Jureia Formation, which were deposited on a shallow platform, and the turbidite sandstones of the Itajaí-Açu Formation–Ilhabela Member, deposited in the region of the oceans that corresponds to the relief of the continental shelf and the water layer without influence of the tides presenting an average porosity of 16% and permeability of 12 mD.

The reservoirs at the base of the Jureia Formation and the Ilhabela Member have different lithological and faciological associations. The deposition conditions of the Jureia reservoir can be understood as a shallow platform while the sandstones of the Ilhabela Member were deposited by currents and turbidity (SOMBRA et al., 1990). In both cases, the presence of variable granulometry of very fine and coarse sand is remarkable, presenting rare conglomeratic levels. The main lithofacies present in the reservoir at the base of the Jureia Formation are fine to medium sandstones, moderately selected, with small sigmoidal cross-stratifications; medium sandstone, moderately to well selected, with low angle cross-stratifications; coarse, apparently massive, bioclastic sandstone; conglomerate rich in pelitic intraclasts, with baseline erosional contact and gradual breastfeeding; finally, very fine, intensely bioturbated clayey sandstone with excavations of vertical microorganisms up to 10 cm. Thus, the set of lithofacies described above is found in shallow platform deposits, possibly corresponding to a barrier island complex (SOMBRA et al., 1990).

In the Ilhabela Member, lithofacies predominate from solid, fine to coarse sandstone, moderately to poorly selected, often with gradation of coarse tail (submerged coarse sand fraction and floating in fine sand decreasing in granulometry from the base to the top). Clay intraclasts are rare. This lithofacies probably corresponds to deposits of high-density turbidity streams. Secondarily, the presence of laminated sandstones with incomplete Bouma sequences is observed at the base of the cores from well 1-SPS-20. Shales can be seen at the base of the Ilhabela Member and have planktonic foraminifera and rare radiolarians. This association of lithofacies corresponds to deposits of channeled wolves commonly found in the Campos Basin (SOMBRA et al., 1990)

The sandstones at the base of the Jureia Formation and those of the Ilhabela Member are predominantly made up of quartz (~ 60%) and feldspars (20–25%) and, to a lesser extent, lithoclasts of volcanic rocks (10%). Thus, they can be classified as arcos or lithos in the corresponding classification of Folk (1968). The bioclasts present at the base of the Jureia Formation are found only in the lithofacies of bioclastic sandstone, which can make up to 20% of the total volume of the rock and are compositionally marked by the presence of shells of bivalve molluscs. Regarding volcanic rock fragments, there is a predominance of intermediate and acidic composition and, secondarily, fragments of basic volcanic rocks. Clay intraclasts correspond to a few levels, making up 4% of the total content (SOMBRA et al., 1990)

The data collected in Merluza from the local geology and infrastructure allows the generation of the table 2 that compiles data favorable to the application of a local CO_2 storage project.

Table 2 - Favorable criteria for the use of the Merluza Field for geological CO_2 storage.

Criteria	**Note**
Average porosity	Ilhabela Member - 21% a 4 700 m Ilhabela Member - 16% a 4 900 m Jureia Formation - 12% a 4 450 m
Porosity (qualitative comments)	In both reservoirs the macroporosity is almost entirely intergranular, of primary origin. Volcanic feldspars and lithoclasts appear poorly dissolved. Higher levels of calcite in the Ilhabela Member occur close to the shales, indicating that the acidic fluids originated in the shales were ineffective in dissolving the reservoir constituents.
Permeability	Ilhabela Member (1-SPS-20) - 10 a 100 mD Ilhabela Member (1-SPS-25) - 1 a 5 mD Jureia Formation (1-SPS-25) - 10 a 100 mD
Tectonic stability	Tectonically stable environment in general.
Reservoir characteristics	Both reservoirs are constituted by lithic arcosios / arcosios without great variations in their detrital compositions. Predominant lithoclasts: intermediate and acidic volcanic rocks, and in lesser basic volcanic quantities.
Clay minerals	Ilhabela Member - presence of chlorite fringes.
Degree of exploitation	High exploratory knowledge.
Infrastructure	Fixed platform; exclusive pipeline.

3.2. ESTIMATED CO_2 STORAGE CAPACITY

The collection of the aforementioned data allows an estimate of the CO_2 storage capacity at Campo de Merluza to be made. For that, the methodology proposed by Bachu et al. (2007) and adapted for the Brazilian scenario by Rockett (2010) and Rockett et al. (2013). The methodology proposed by Bachu et al. (2007) for depleted fields allows for three interpretative paths: a calculation for gas fields (which would be ideal for the case of Merluza), a case for oil fields and an equation that makes it possible to calculate through well geometry. Both the calculation by the gas field methodology and the geometry of the well would be possible for the estimate in Merluza, but the absence of data for this prevents the procedure. Therefore, this estimate considers the Merluza field according to the following equation:

Where MCO_2 corresponds to the theoretical CO_2 storage capacity in metric tons, $\rho CO_{2}r$ is the density of CO_2 in the reservoir conditions in kg/m^3, R_f is the recovery factor, $OOIP$ is the oil estimate on site, B_f is the formation volume, V_{iw} is the injected volume of water and V_{pw} is the volume of water produced.

The capacity estimate calculated by the methodology proposed by Bachu et al. (2007) considers that the volume previously occupied by hydrocarbons (whether already produced or to be produced) will be made available to store CO_2. Therefore, the methodology considers a simple replacement, which disregards that the integrity of the reservoir can be affected by the procedures performed in production. However, this assumption tends to result in values very close to the actual for depleted reservoirs that are not in hydrodynamic contact with an aquifer or that are not flooded by secondary or tertiary oil recovery. Another relevant assumption is that the gas will be injected into the depleted field until the original reservoir pressure values are reached (BACHU et al., 2007).

To estimate the CO_2 density under the reservoir conditions, the geochemical model proposed by Duan et al. (1992) is considered, inserting the desired pressure and temperature. The use of the basin's geothermal gradient is also necessary, and in the absence of available data, the same mechanism as Rockett (2010) with the Campos Basin gradient is used. Thus, based on the depth h and the geothermal gradient of the Campos Basin of 23.36 ºC/km (JAHNERT, 1987), the average temperature in the Campo de Merluza can be calculated based on the following equation:

The 4 ºC added corresponds to the temperature of the seabed (MILLER; KOWSMANN, 2009). The pressure, in turn, is assumed according to the depth, assuming a hydrostatic pressure of 100 bar/km (ROCKETT, 2010). For the calculation, the average depth of the Merluza reservoir of 4 850 m is used, as it is between 4 600 and 5 100 m. Therefore, T_r = 117.2 ºC and P = 500 bar.

The recovery factor is defined as the ratio between the planned oil production and the estimated oil on site. Rockett (2010) used reserve values for this calculation due to the unavailability of published data for the Campos Basin. In the case of Campo de Merluza, the total volume in place and the accumulated production are added together in order to approximate this value. So that there is not much discrepancy in relation to the volume of gas, the ratio of 1 million m^3 of natural gas liquid is used, equivalent to approximately 600 million m^3 of gas (PORTAL NAVAL, 2009). Thus, 88.48 million m^3 are obtained (ANP, 2015).

The volume factor of the formation converts the volume in oil under normal conditions to the *in-situ* conditions of the reservoir. The value of 1.2 used is the average value between the minimum and the maximum, 1.0 and 1.4 (APEC, 2005; ROCKETT, 2010). As for the values of volume of injected water and volume of water produced, these are assumed to be zero due to the lack of specific data for the field. Thus, $V_{iw} + V_{pw} = 0$ (ROCKETT, 2010).

The approaches mentioned above allow an estimate of the storage capacity of the Campo de Merluza, according to the methodology proposed by Bachu et al. (2007) and adaptations by Rockett (2010). Using the same methodology, Ketzer et al. (2007) proposed that the Santos Basin has a total storage capacity of 167 $MtCO_2$ in oil fields but did not discriminate the calculation field by field. The following data in table 3 were used for the calculation.

Table 3 - Data used to calculate the CO_2 storage capacity

Data	
$\rho CO_2 r$	678 kg/m^3
$R_f \times OOIP$	88.48 mi m^3
B_f	1.2
$V_{iw} + V_{pw}$	0

It is estimated that the CO_2 storage capacity at the Campo de Merluza is around 49.9 $MtCO_2$. Comparing to the values obtained by Rockett et al. (2013) for the Campos Basin, it is possible to see where Merluza is placed (Figure 2). Figure 3 makes it possible to compare the value obtained for the Merluza field with international examples.

Figure 2 - Merluza Field CO_2 storage capacity compared to Campos Basin fields. Campos Basin data collected from (ROCKETT et al., 2013).

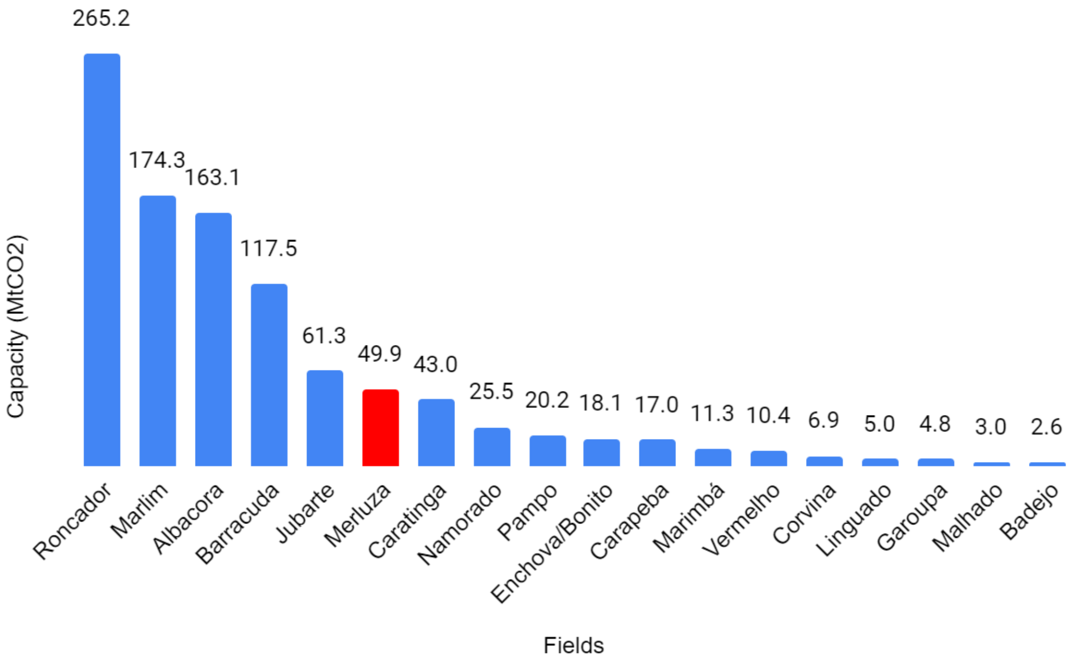
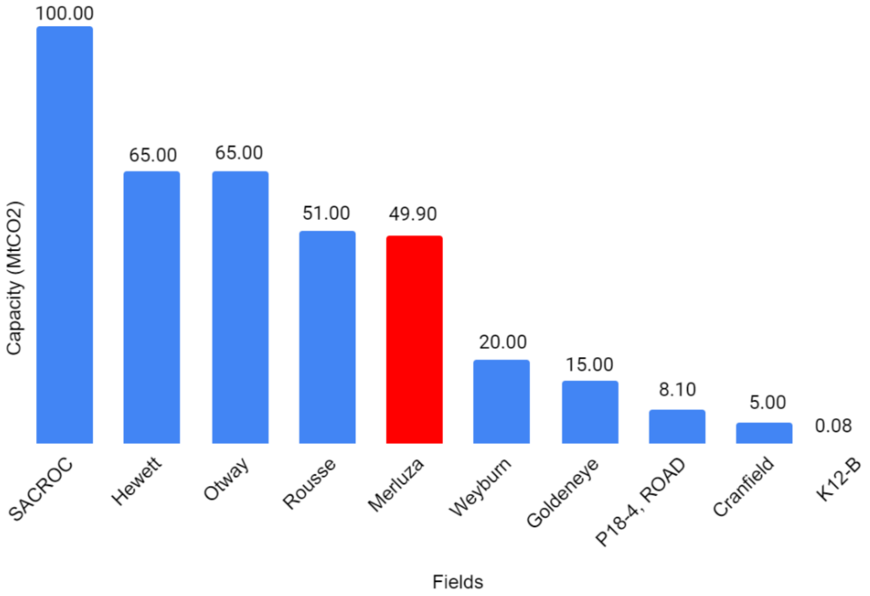


Figure 3 - Merluza Field CO_2 storage capacity compared to international examples. International data collected from Hannis et al (2017).



The value found for Campo de Merluza should be considered a primary estimate of storage capacity. Merluza, represented by the color red, presents intermediate values of CO_2 storage capacity when compared to the values obtained by Rockett et al. (2013) for the Santos Basin oil fields. In comparison, Merluza is located between Jubarte and Caratinga with 61.3 $MtCO_2$ and 43 $MtCO_2$ respectively.

Estimating storage capacity allows you to study the feasibility of planning a storage project. It is possible, for example, to consider the emissions of a given plant located on the coast of the Santos Basin and to examine whether the chosen field has the capacity to store the emissions emitted in industrial processes.

In order to discuss which are the main environmental (and social) issues that hinder the implementation of a carbon storage project in the Merluza Field area, an issue is fundamental: the environment in question is offshore. This information alone already facilitates several criteria that should be considered when installing a project of this scale in an onshore location that could directly affect human populations. This does not diminish the need for an adequate environmental analysis, it only considers that the target audience for this study will be other types of animals, in this case the local marine fauna.

4 CONCLUSIONS

The search for geological reservoirs for CO_2 storage is a logical path in a worldwide context of measures to reduce greenhouse gas emissions. As one of the signatories to The Paris Agreement, Brazil needs to make decisions that result in the reduction of greenhouse gas emissions (SCHETTINI et al., 2020). The Santos Basin is in a strategic location, close to the Southeast Region, a pole of GHG emissions in the country, which justifies the search for reservoirs in that location. On the other hand, the productive rise of the basin itself poses a question of a possible destination for local emissions. Searching for geological reservoirs in the Santos Basin, therefore, appears as a logical path in the construction of a CO_2 capture and storage portfolio in the country.

The information obtained in this project about the peculiar characteristics of Merluza are strong indications that this location can be used as a geological CO_2 reservoir. Thus, the Itajaí-Açu Formation–Ilhabela Member and Jureia Formations, in the Merluza Field region, have potential for CO_2 storage, and the Ilhabela Member seems to contain more adequate characteristics (porosity above most Brazilian reservoirs, permeability with consistent values, generally stable tectonic environment, adequate depths for gas injected in a supercritical state). It is evident that further studies are necessary for this to be said: the modeling can try to elucidate how the CO_2 would behave injected into a reservoir chosen more specifically.

The proximity of the Merluza Field to its final exploration phase suggests that an adaptation of the use of local infrastructure (exclusive fixed platform and gas pipeline) for a pilot CO_2 storage project seems an adequate possibility in the face of the usual decommissioning, and that it responds to current demands industry due to the need to commit to reducing CO_2 emissions, which is increasingly required internationally.

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