# The CARBMAP Project: $CO_2$ source-sink matching and opportunities for carbon sequestration in Brazil


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## 1. Summary of the CARBMAP Project


The CARBMAP Project aims to match stationary $CO_2$ sources and geological sinks in Brazil to identify appropriate sites for long term $CO_2$ storage in petroleum fields, saline aquifers and coal seams. It also aims to calculate Brazil's $CO_2$ storage capacity, as well as to maximize and identify opportunities for enhanced oil/gas recovery (EOR) and enhanced coal bed methane recovery (ECBM) combined with $CO_2$ storage. Here we present the preliminary results and conclusions of the first phase of project, which focus on storage in petroleum fields.

The main anthropogenic, landlocked $CO_2$ sources are described in terms of location, emission and sector of activity. The database used is from the International Energy Agency Report (IEA GHG, 2002). According to this report, total $CO_2$ emission in Brazil consists of ca. 200 Mt/year. $CO_2$ sources-sink matching consists of the identification of the possible geological sinks in sedimentary basins located at distances <300 km, and in the CO2 supply quantity and rates, and separation, transport, and injection cost estimation. The $CO_2$ source-sink matching will result in more realistic storage capacity calculation and site selection for storage.

$CO_2$ sinks considered in this work consist of petroleum fields, saline aquifers, and deep (> 300m) coal seam in Brazilian sedimentary basins. Data on petroleum and coal reserves are from the National Petroleum Agency (ANP, 2005) and the National Department of Mineral Production (DNPM, 2005), respectively. $CO_2$ source-sink matching indicate that the majority of $CO_2$ emissions are associated with the Paraná, Santos, São Francisco, and Campos basins. The Paraná Basin (intracratonic sag, Palaeozoic to Mesozoic) contains mainly saline aquifers and coal seams as sinks, in addition to minor sub-commercial gas fields. The Santos Basin (South Atlantic rift-drift basin, Mesozoic to Cenozoic) contains important petroleum fields (particularly gas fields) and saline aquifers that could be used for $CO_2$ storage. There are no known petroleum fields and coal deposits in the São Francisco Basin (intracratonic, Proterozoic). Appropriate saline aquifers may exist in the latter basin, but reservoir quality is probably poor. The Campos Basin (South Atlantic rift-drift basin, Mesozoic to Cenozoic) contains ca. 88% of Brazil's petroleum reserves and saline aquifers that could be used for $CO_2$ storage. There are few important $CO_2$ sources related to the Recôncavo Basin (intracratonic rift, Mesozoic), but ongoing and planned EOR activities makes this an important candidate for $CO_2$ storage in mature oil fields and saline aquifers.



**Acknowledgements:**
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**References:**
ANP(2005)- Agência Nacional do Petróleo (Brazil's National Petroleum Agency) Reservas Nacionais de Petróleo Ano 2005 (National Petroleum Reserves 2005) (www.anp.gov.br).
DNPM(2005) Departamento Nacional da Produção Mineral (Brazilian Mineral Yearbook) 2005, 143 p.
IEA GHG (2002) International Energy Agency Greenhouse Gas R&D Program, Building the cost curves for $CO_2$ storage, part 1: sources of $CO_2$. IEA Report Number PH4/9 on $CO_2$, July 2002.


## 2. Location map and main pipeline network


## 3. Stationary $CO_2$ sources in Brazil

Emissions from large, anthropogenic, stationary $CO_2$ sources in Brazil consist of 200 Mt/year, and are related to biomass, electricity generation, cement factories, iron and steel industries, refineries, and chemical plants (Fig. 3.1). Most of carbon dioxide sources are located in the south and southeastern part of the country, with important isolated occurrences in the northeastern part (Fig. 3.2). Storage programs will have to consider the distance from source to sink, but also the quantity and supply rate of $CO_2$ to evaluate injectivity rates and costs. It is of great importance, therefore, a detailed mapping of the emissions by sector of activity (Fig. 3.3).

Fig. 3.1 Origin of $CO_2$ emissions (total ca. 200 Mt/year)

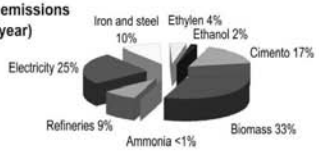



Fig. 3.2 Emission map (mass of $CO_2$)

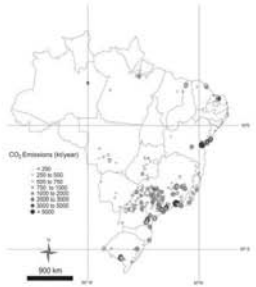



Fig. 3.3 Emission map of $CO_2$ by sector


## 4. Potential geological $CO_2$ sinks in Brazil

Geological sinks in Brazil are widely distributed in the country, and consists of sedimentary basins formed in different geotectonic settings (rift, intracratonic sag, drifting of passive margin), and ages (Proterozoic to Cenozoic; Figs. 4.1 and 4.2). Oil and gas reserves are significant (ca. 11 billion barrels and 300 billion $m^3$, respectively) and mainly located in the South Atlantic basins (Fig. 4.3). Know deep (> 300m) coal reserves occur only in the Paraná Basin, and consist of ca. 8 billion tons (Fig. 4.3).

Fig. 4.1 Location map of sedimentary basins


Fig. 4.2 Geological sections of representative basins

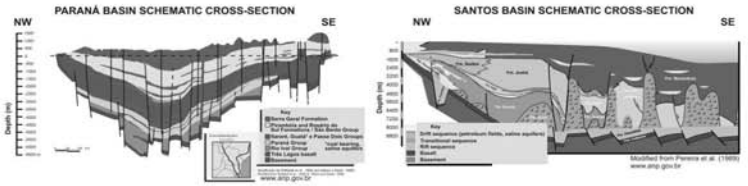
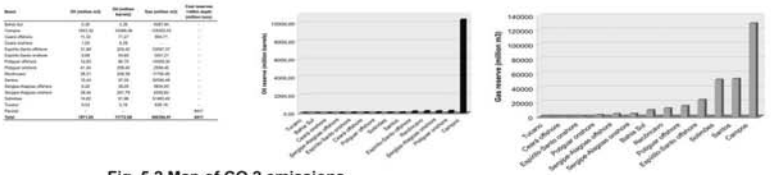



Fig. 4.3 Diagrams showing oil and gas proven reserves in Brazil (per basin)



## 5. $CO_2$ source-sink matching

The first step of the source-sink matching work is to identify sources that are in the vicinity (<300 km) of geological sinks (Fig. 5.1). After that, a direct association of sources and sinks is possible, allowing the identification of the amount of CO 2 available per sink (Figs. 5.2 and 5.3). Figure 5.4 shows the theoretical CO 2 storage capacity in petroleum fields of prolific basins (Details of the capacity estimations can be found at APEC – Asia Pacific Economic Cooperation, 2005. CO 2 storage prospectivity of selected sedimentary basins in the region of China and South East Asia. APEC Energy Working Group EWG Project 06/2003, 227 p.). More realistic storage capacity estimations can be made based on hydrocarbon production data, such as the one presented for the Campos Basin (Fig. 5.5).

Fig. 5.1 Map of $CO_2$ sources with 300km nodes

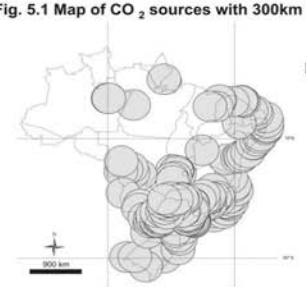



Fig. 5.2 Map of CO 2 emissions associated with sedimentary basins (< 300km from sources)

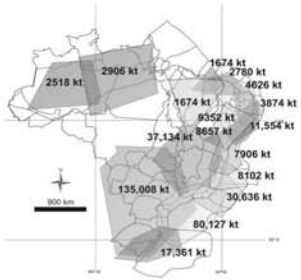



Fig. 5.3 Diagram showing $CO_2$ emissions associated with sedimentary basins (< 300km from sources)

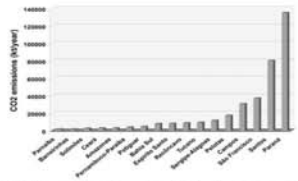



Fig. 5.4 Diagram showing $CO_2$ storage capacity in oil and gas fields of prolific basins

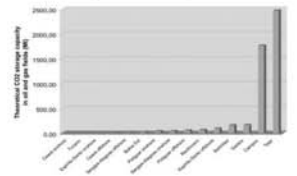
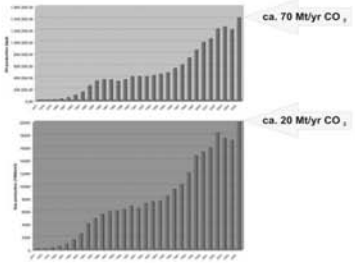


Fig. 5.5 Diagram showing oil and gas production in the Campos Basin and related present-day $CO_2$ storage capacity per year




## 6. Conclusions

1. Distribution of lanlidocked $CO_2$ sources is concentrated in south and southeastern regions, where most of hydrocarbon production occurs.
2. The majority of emissions are associated with the non-prolific Paraná Basin, and few emissions are associated with large basins such as Amazonas and Solimões.
3. Theoretical storage capacity of the Campos Basin is 1700 Mt of $CO_2$, but only 90 Mt can be stored per year based on production data.
4. The Campos Basin can store ca. three times the associated emissions in oil and gas fields, i.e., 90 Mt/year.
5. Next step of CARBMAP project is to estimate storage capacity in saline aquifers and coal seams, and detail $CO_2$ sources for precise