SITE SCREENING FOR *IN SITU* MINERAL CARBONATION OPTIONS IN SOUTHERN PORTUGAL

Júlio Carneiro[1], António A. Araújo[1], Patrícia Moita[2], Jorge Pedro[1], Pedro Sousa[3], Massimo Beltrane[2], Edgar Berrezueta[4], António Correia[1], Cristina Galacho[2], Luís Lopes[1], Fábio Marques[3], Catarina Miguel[2], José Mirão[2], António Chambel[1], Carlos Ribeiro[1]

[1] Universidade de Évora, Instituto de Ciências da Terra, Évora, Portugal
[2] Universidade de Évora, Laboratório HERCULES, Évora, Portugal
[3] Laboratório Nacional de Energia e Geologia, Aljustrel, Portugal
[4] Instituto Geológico y Minero de España, Oviedo, Spain

Corresponding author's e-mail address: jcarneiro@uevora.pt

Keywords: Site screening, mineral carbonation, laboratory experiments

ABSTRACT

The Sines industrial area is the largest CO_2 emitting cluster in Portugal, with a coal power plant, a refinery and petrochemical facilities that can be responsible for almost a third of the national emissions from stationary sources. This cluster is seen as an early opportunity to deploy CO_2 Capture and Storage (CCS) in Portugal, but the nearby offshore sedimentary formations do not provide economic conditions for storage of the CO2 [1]. If CCS is to be implemented, CO_2 must be transported to other regions or alternative storage options need to be found.

In-situ mineral carbonation in mafic and ultramafic rocks has been proved to be a valid alternative for permanent storage of CO_2 at Carbfix (Iceland) and Wallula (USA) pilot injection sites. Furthermore, Carbfix demonstrated that CO_2 dissolution in water during injection reduces the time scale for mineral carbonation to months and years, discards the need for extensive cap-rocks and allows for shallower injection depths, down to 200 m to 300 m [2]. These characteristics prompted project INCARBON to conduct a site screening process for mafic and ultramafic rocks in southern Portugal that can provide a mineral carbonation opportunity for the Sines cluster. Ongoing phases address the geological characterization and laboratory experiments.

Research focus, first and foremost, in the Sines sub-volcanic massif, located immediately adjacent to the CO_2 sources, outcropping along 300 km^2 onshore and offshore and mostly composed of gabbro's and diorites (Fig. 1). Other mafic formations occurring in Southern Portugal, such as the olivine-gabbro's, peridotites and pyroxenites rocks of the Beja, Alter do Chão, Campo Maior, Elvas, Veiros and Vale Maceira massifs, will also be ranked according to a uniform set of geological and socio-economic criteria (Table 1).

Table 1 – ranking criteria for site screening

Geological criteria	**Socio-economic criteria**
Quantity of mafic minerals (reactivity with CO_2)	Distance to CO_2 sources
Volume of the massif	Current use of groundwater resources
Degree of fracturing (secondary permeability)	Existence of environmental protected areas
Geological structure and geometry	Proximity to urbanized areas

Given their low secondary porosity and permeability, this kind of plutonic mafic rocks, although enriched in Ca^{2+}, Fe^{2+} and Mg^{2+}, have seldom been considered for mineral carbonation [3]. To study the kinetics of the carbonation in this rock types, laboratory experiments are being conducted in a constrained hyperbaric chamber, under pressure and temperature conditions simulating a hypothetical injection. Cubic-shaped samples (each 27 cm^3) from the three most promising massif are exposed to a CO_2 saturated brine for 1-day, 4-days, 16-days and 64-days periods.

The textural–mineralogical and petrophysical changes in the rock samples imposed from the rock-CO_2-brine interaction are addressed through a range of techniques applied to the same samples *ante*- and *post*-carbonation experiments, including conventional optical microscopy (OM), X-ray diffraction (XRD), thermogravimetric analysis (TGA), by scanning electron microscopy coupled with X-ray spectrometer (EDS-SEM), fourier transformed infrared spectroscopy (FTIR) and high resolution X-ray computed tomography (CT-scan).

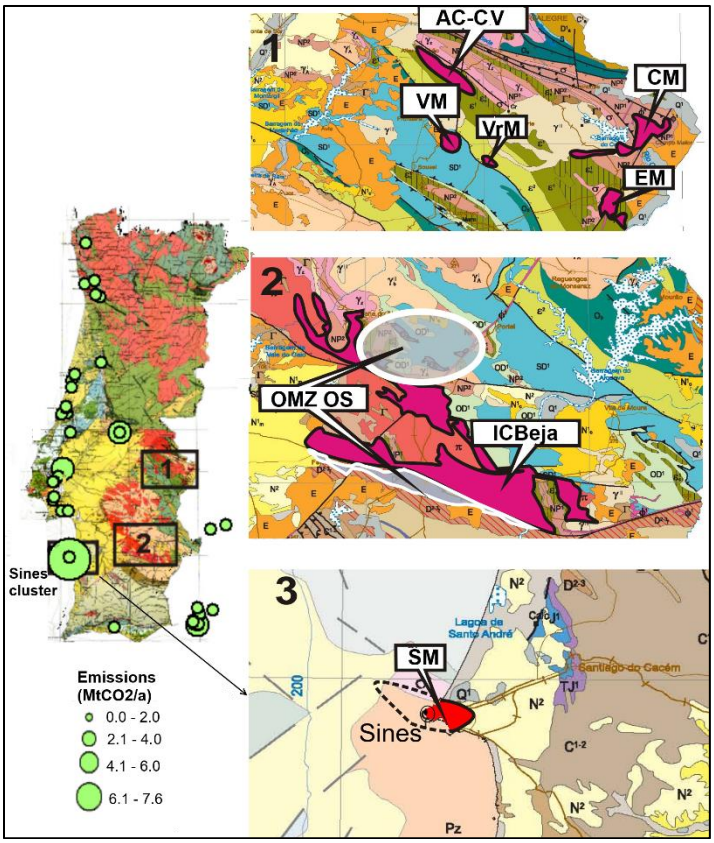

Fig. 1- Main CO_2 emission clusters in Portugal and mafic and ultramafic rock massifs to be studied: VM - Vale Maceira, VrM - Veiros, CM – Camo Maior, EM – Elvas, AC-CV- Alter do Chão-Cabeço de Vide, ICBeja – Igneous Complex of Beja, OMZ OS – Ophiolite Sequences, SM – Sines.

Subsequent phases will apply geochemical modelling to simulate the results of the carbonation tests and, in conjunction with geological and geophysical field studies to define the geometry of the rock massifs, to upscale in order to estimate the CO_2 storage capacity in the rock massif with the most suitable conditions.

If the storage capacity and injectivity is proved to exist, mineral carbonation would provide a feasible technology for the Sines industrial cluster to decouple its industrial activity from CO_2 emissions.

Acknowledgments

INCARBON is funded through national funds by the Portuguese *Fundação Para a Ciência e Tecnologia (FCT)* under contract PTDC/CTA-GEO/31853/2017.

References

[1] Seixas J, Fortes P, Dias L, Carneiro J, Boavida D, Aguiar R, et al. CO_2 capture and storage in Portugal: a bridge to a low carbon economy. Lisbon, Portugal: FCT-UNL; 2015.

[2] Snæbjörnsdóttir SO, Gislason SR. CO_2 Storage Potential of Basaltic Rocks Offshore Iceland. Energy Procedia. 2016;86:371-80.

[3] Romão IS, Gando-Ferreira LM, da Silva MMVG, Zevenhoven R. CO2 sequestration with serpentinite and metaperidotite from Northeast Portugal. Minerals Engineering. 2016;94:104-14.