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

J. CARNEIRO[1], A. A. ARAÚJO[1], P. MOITA[2], J. PEDRO[1], P. SOUSA[3], M. BELTRANE[2], E. BERREZUETA[4], A. CORREIA[1], C. GALACHO[2], J. L. LOPES[1], F. MARQUES[3], C. MIGUEL[2], J. MIRÃO[2], A. CHAMBEL PEDRO[1], C. RIBEIRO[1], C. PINHO[1]

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

InCarbon

In situ carbonation for reduction of CO_2 emissions from Power and Industrial sources in Alentejo - Portugal

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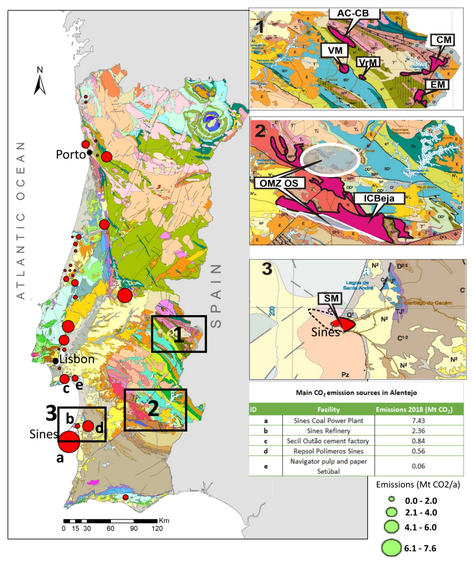
1. the problem

In Portugal, the Sines industrial area is the largest CO_2 emitting cluster in Portugal, with a coal power plant, a refinery and petrochemical facilities. in 2018 were responsible for more than 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 CO_2 [1]. If CCS is to be implemented, CO_2 must be transported to other regions or alternative storage options need to be found.

2. the opportunity

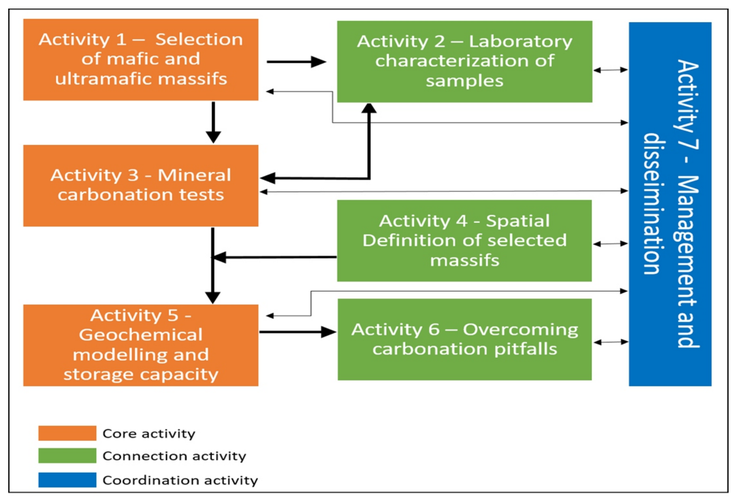
In situ mineral carbonation in mafic and ultramafic rocks has been proved a valid alternative for permanent sequestration of CO_2, with pilot injection sites in Iceland and the USA, particularly if resorting to CO_2 dissolution in water during injection, which reduces the time scale for carbonation to months and years, discards the need for extensive cap-rocks and allows for shallower injection depths, down to 200 m to 300 m[2].

Main CO_2 emission clusters in Portugal and mafic and ultramafic rock massifs to be studied:



VM - *Vale Maceira*, VrM - *Veiros,* CM – *Campo Maior*, EM – *Elvas,* AC-CV- *Alter do Chão-Cabeço de Vide*, ICBeja – *Igneous Complex of Beja*, OMZ OS – *Ophiolite Sequences*, SM – *Sines.*

3. the Incarbon project



The project InCarbon intends 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.

Research is focused, 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.

Other mafic formations occurring in Southern Portugal, such as the olivine-gabbros, 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 criteria.

4. site screening criteria

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

5. the lab research

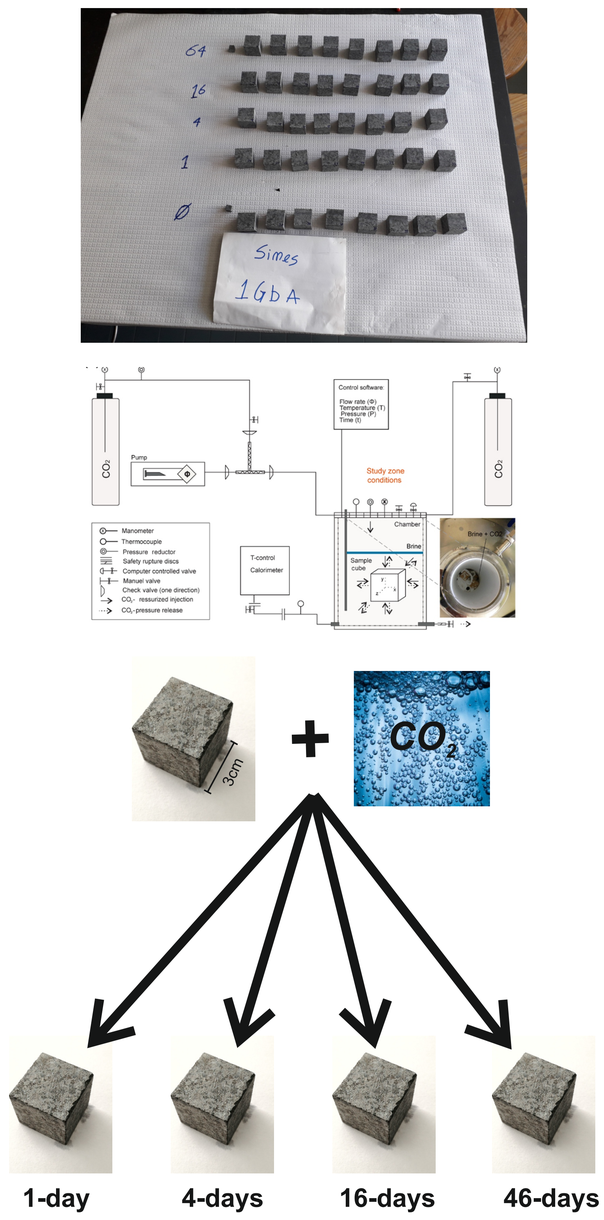
Given their low secondary porosity, this kind of plutonic mafic rocks, although enriched in Ca^{2+}, Fe^{2+} and Mg^{2+} cations, have seldom been characterized for mineral carbonation [3]. To study the kinetics of the carbonation in this rock types, laboratory experiments are being conducted in a constrained 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 (P - 80Bar; T - 40º C; pH - 6.85) for 1-day, 4-days, 16-days and 64-days periods at IGME Lab.

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);
- X-ray fluorescence (FRX);
- Inductively coupled plasma mass spectrometry (ICP-MS);
- Thermogravimetric analysis (TGA);
- Scanning electron microscopy coupled with X-ray spectrometry (EDS-SEM);
- Fourier transformed infrared spectroscopy (FTIR); and
- High resolution X-ray computed tomography (CT-scan).

Scheme of laboratory experiments of samples exposed to a CO_2 saturated brine in a hyperbaric chamber:



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

6. the expectations ...

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

references

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UNIVERSIDADE DE ÉVORA
ESCOLA DE CIÊNCIAS E TECNOLOGIA
DEPARTAMENTO DE GEOCIÊNCIAS

ICT
Instituto de Ciências da Terra
Institute of Earth Sciences

CENTRO HERCULES
HERANÇA CULTURAL, ESTUDOS E SALVAGUARDA

LNEG
Laboratório Nacional de Energia e Geologia, I. P.

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Instituto Geológico y Minero de España

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