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Basic plutonic rocks: an unconventional solution for CO_2 storage through mineral carbonation?

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Abstract. CO_2 capture and geological storage (CCS) is recognized as an essential technology to achieve carbon neutrality and the Paris Agreement targets. The success of *in-situ* mineral carbonation of CO_2 in basalts accomplished in the Carbfix project, opened up the prospect for considering other igneous rocks as viable targets for CO_2 storage. The InCarbon project embraced the challenge to test the potential for mineral carbonation in basic plutonic rocks, with a chemical composition similar to basalts, but with much more challenging textural and petrophysical conditions

Samples from basic intrusions in south Portugal were tested for mineral carbonation potential under laboratory conditions, by promoting reaction with an aqueous solution with varying degrees of saturation in supercritical CO_2. To ensure realistic conditions, and unlike previous laboratory studies, the liquid phase was a very saline brine or sea water, and the experimental design mimicked the reservoir conditions (80 bar and 40°C). Four experiments were conducted with a duration of up to 120 days each. A multi-analytical methodology was applied to monitor the chemical variations of the brine and the textural, mineralogical and chemical variations of the rock specimens. The experiments were followed by geochemical modeling with Crunch Flow@.

The results show that brine supersaturated with CO_2 promotes the increase of roughness on specimens' surface due to the dissolution of silicates and results in an increase in silica, alumina and some other major elements (e.g. calcium, magnesium and iron) in solution. For longer experimental times (120 days), a decrease in silica and aluminum concentrations is associated with crystallization of zeolite and clays. The rate of dissolution of Ca, Fe, Mg decreases and coincides with crystallization of trace magnesite and dolomite carbonates.

The modelling results globally supports the obtained experimental data. Moreover, the experimental conditions, not catalyzed by any additive, and in particular by using sea water, point to a viable solution for CO_2 storage. Although these rock types present low porosity, essentially provided by the fracture network, the favorable mineralogy and the large volume associated to mafic intrusions may be promising for the use of this CCS technique for small-scale sources of CO_2.

Keywords: carbon capture and storage, carbonation, mafic plutonic, supercritical CO2, geochemical experiments.