Characterization of fractured rocks as potential CO\textsubscript{2} storage: the case of Sulcis Coal Basin, Italy

Tartarello Maria Chiara\textsuperscript{1}, Bigi Sabina\textsuperscript{1}, Colucci Francesca\textsuperscript{2}, Civile Dario\textsuperscript{4}, Giustiniani Michela\textsuperscript{4}, Accaino Flavio\textsuperscript{4}, Moia Fabio\textsuperscript{2}, Plaisant Alberto\textsuperscript{1}, Maggio Enrico\textsuperscript{3}, Pettinau Alberto\textsuperscript{3}, Conti Alessia\textsuperscript{1}, Ruggiero Livio\textsuperscript{1}

\textsuperscript{1}Sapienza University of Rome - Department of Earth Sciences, CERI, P.le A. Moro 5, 00185 Rome, Italy
\textsuperscript{2}Ricerca sul Sistema Energetico – RSE S.p.A., Via R. Rubattino 54, 20134 Milan, Italy
\textsuperscript{3}Sotacarbo S.p.A., c/o Grande Miniera di Serbariu, 09013 Carbonia, Italy
\textsuperscript{4}OGS – Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Borgo Grotta Gigante 42/C, 34010 Sgonico, Italy

Abstract

The naturally fractured carbonates have a great potential for Carbon Capture and Storage (CCS) purpose because they could offer the possibility for CO\textsubscript{2} storage in areas where no suitable sandy reservoirs are available, as for example in the Mediterranean area, where most of the stratigraphic succession is composed by carbonate rocks. The characterization of this kind of reservoir is complex, as it is needed to well define both primary and secondary porosity and permeability. The formers are petrophysical properties of the rock, mainly due to the sedimentary processes, grain size and early diagenesis, while the latter are the results of diagenesis and tectonic events, that modify the primary structure, increasing or decreasing the porosity and permeability of the rocks.

Although the evaluation of the storage capacity is one of the key objective of a site characterization, the existence of a thick and impermeable caprock is essential to consider the site suitable for CCS purpose. With this aim, it is required to calculate primary and secondary porosity and permeability, and identify main faults and fractures that could act as leakage pathways.

In Italy, one of these potential sites is located in Sardinia, in the sub-region named Sulcis. The Sulcis coal basin, located in South-West Sardinia, is the only region of Italy where the exploitation of coal is active since the last century. Thanks to data available from several national and international project, as well as from the mining activities, it has been possible to recognize a potential reservoir-caprock system, suitable for CCS purpose. Here, the “Miliolitico Fm.” has been identified as a potential reservoir; this Formation consists of well bedded, about 50 m thick, mudstones and grainstones with Miliolidae, with a very low primary porosity and permeability (5\% and <0.1 mD), deposited in a lagoon environment during the Early Eocene. At the top of this carbonate, there is a rhythmic succession of siliciastic to carbonate deposits with interbedded lignite (Produttivo complex), that could be considered as a secondary reservoir. The caprock is represented by a thick succession of siltstones, sandstones and conglomerates (Cixerri Fm) and up to 900 m of Oligo-Miocene volcanic rock, ranging from basaltic to rhyolitic composition.

In this work we built a tridimensional model of the Southern part of the Sulcis coal basin at a regional scale, using geophysical and geologic data (reflection seismic profiles, high resolution seismic lines; geological maps, borehole data, geological survey, etc.), consisting of the main faults and horizons.
In order to study the geometry and the parameters of fracture network, we performed also a detailed fracture analysis at the outcrop, using scan lines and scan areas techniques. We measured the fractures spacing, aperture, length and connectivity both linearly and on surface. The same approach was also utilized in the Nuraxi Figus coal mine, where the Miliolitico crops out at a depth of -480 m b.s.l., in more confined pressure condition. The measured linear parameters were used to build several Discrete Fracture Model (DFN) both of reservoir and caprock formations, using the software Petrel (Schlumberger). In particular, DFN were constructed varying length and aperture values to evaluate their influence on the total secondary porosity. The results show a variability in the porosity/permeability distribution in the rock succession, with higher values in the carbonate reservoir. More in details, the Cixerri Fm. seems to be the less permeable rock in the succession, with a low porosity, due to the small length of fractures and low frequency in fracture spacing. On the other hand, the volcanic complex shows a very constant spacing, mainly due to cooling; in the DFNs these characteristics are represented by a quite homogenous distribution of petrophysical properties. Moreover, most of the secondary permeability and porosity increase in correspondence of faults, through which fluids circulate.