CO_2 Storage project in Italy : The Sulcis Coal Basin, Italy

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Introduction

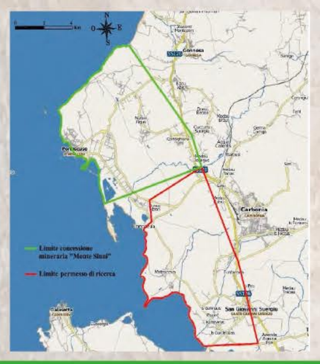
The CO_2 geological storage is considered as a suitable technique to reduce the anthropogenic greenhouse gasses in the atmosphere. Fractured carbonate rocks can be considered as potential geological reservoir; however it requires a detailed characterization of reservoir properties to assess the true CO_2 storage capacity and to guarantee an efficient and successful storage.

The Sulcis Project - Site description

The Sulcis Project has the aims to collect experimental data and information to design and construct a geological storage pilot test site, located in the Sulcis area, SW of the Sardinia Island in Italy. The project consists of a complex 10 years program of activities, starting from site characterization to operation (including the development of carbon capture technologies). The occurrence of over fourty years of coal mining activity has already provided lot of detailed information on the geology of the area.

Coal Mine (present day)

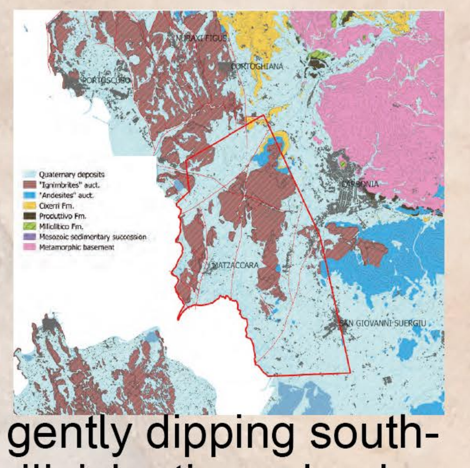
Capture Pilot Platform

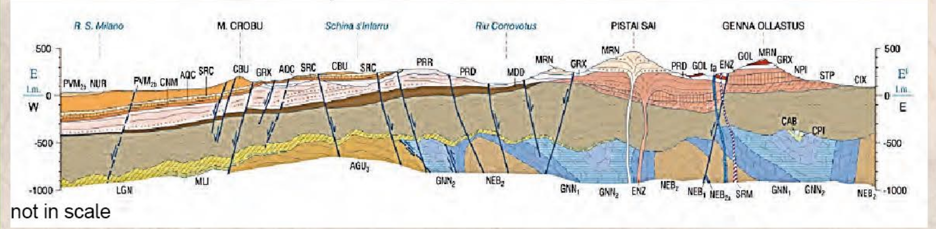


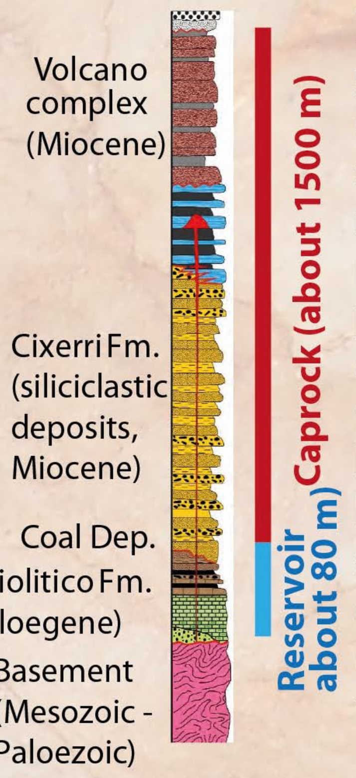
Sotacarbo Licence

Coal Mine (ancient photo 60' years)

In the Sulcis area the Paleogene a transgressive-regressive sedimentary cycle (F. Miliolitico and Coal deposits) covers in unconformity a basement made of metamorphic Meso-Paleozoic rocks. This sequence that gently dipping southwestward, is covered by siliciclastic and volcanic Miocene deposits.



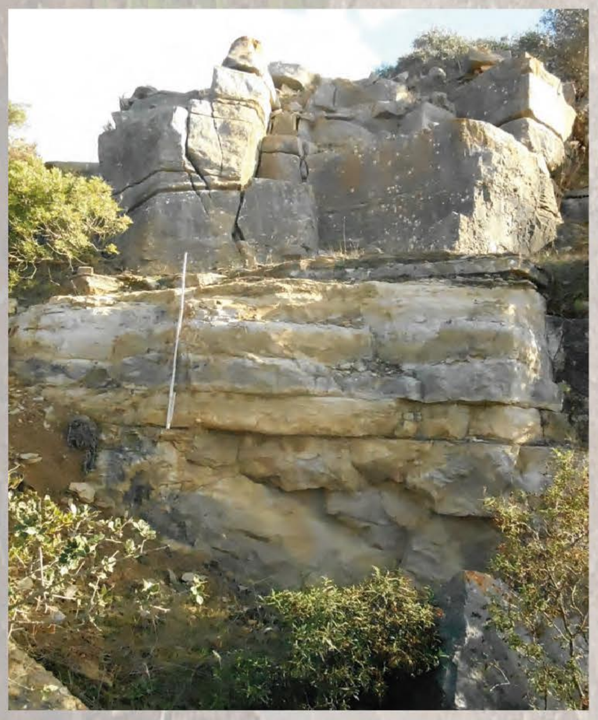




In terms of geological storage, the described succession provides two main groups of deposits that can be potentially considered as the reservoir (fractured carbonate and coal, hosting an aquifer) and the overburden sequence (siliciclastic and volcanic rocks)

The potential reservoir: the Miliolitico Formation

The "Miliolitico Formation" can be considered as potential fractured carbonate reservoir, having a low primary permeability and a discrete density of fractutures and faults. As the storage potential strongly depends on the fracture network properties, a detailed structural analysis has been carried out on the outcrops analogue of these rocks. Quantitative analysis includes fractures detection and measurements, with the aims to define thier main characters, such as density, aperture and lenght to provide all the useful parameters to generate a DFN (discrete fracture network) and populate the geological model. The field data were collected using the scanline and scanarea techniques, followed by a statistical elaboration of the data. Measurements of fractures were also performed at the depth of about 500 m under the surface in the coal mine, in order to compare data from surface and depth. Moreover, in the evaluation of porosity, the occurrence of fossil karstic cavities has been taken into account.



Miliolitico F.m outcrop whith the boundary between the lower dolomitic portion and the upper limestones

Scan area on the fractured limestones of the Miliolitico Fm.

The Miliolitico Fm (Eocene), has a total thickness of about 50 m, which can be distinguished into a lower part, mainly dolomites, and an upper part, composed by limestone and wackestone in strata of about 100-300 mm thick. Thickness and facies lateral variation are frequent and in some cases seems to be controlled by synsedimentary extensional small faults; also karstic cavities are present in depth as observed in the coal mine sites.

Fracture systems at the outcrop

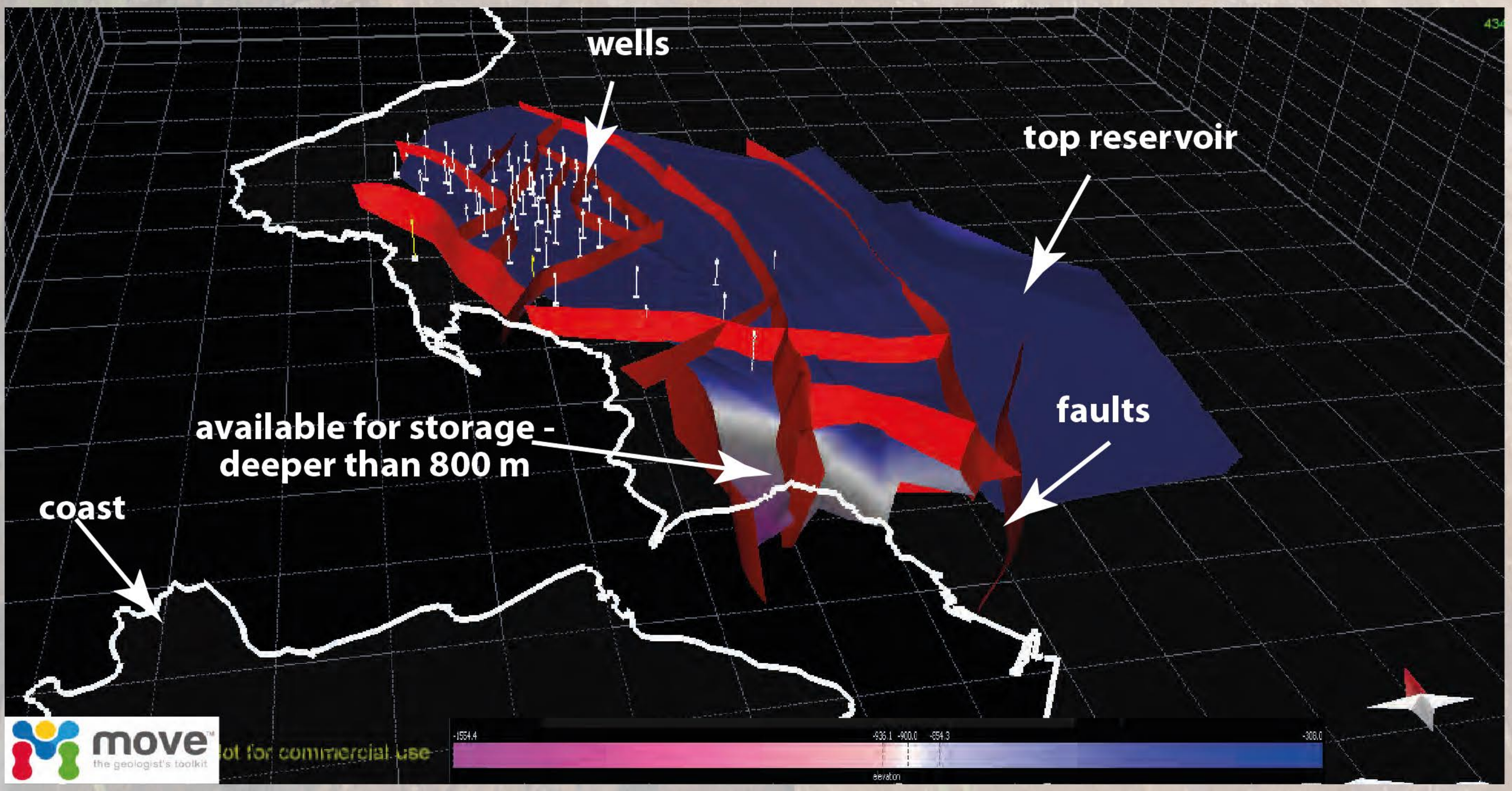
Brittle deformation is characterized by extensional fractures, oriented at high angles with the bed, often constitutes by systematic joints with very regular parallel planes. Veins are also very frequent: they appear as mainly extensional (fibres area normal to the fracture walls) and small (millimetres of aperture). Usually they appear with a regular spacing and

no constraint by bedding. The main fracture directions are consistent with the main fault plane systems of the area: N-S, E-W and NW-SE, and have variable densities in the different measure sites.

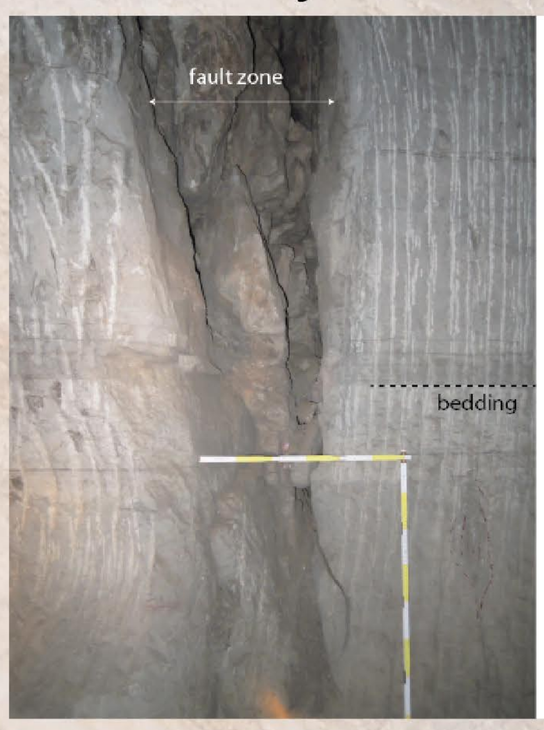
The Miliolitico Fm shows an average spacing varying from 20 to 50 mm in the outcrop and around 120 mm in the mine, indicating a generally high grade of fracturing at the surface; within the carbonate member, fracture spacing does not seem to be strongly controlled by bedding. The "Fracture Modelling" module of Move 2015 (Midland Valley, UK) has been used to calculate porosity, expressed as the ratio of two volumes, and permeability, producing a tensor based on the geometric method discussed in Oda, 1985, which in turn is based on Darcy's law. The porosity values obtained from DFN model generated from outcropping and mine data are comparable among each other, and indicate average porosity values from 3 to 5%.

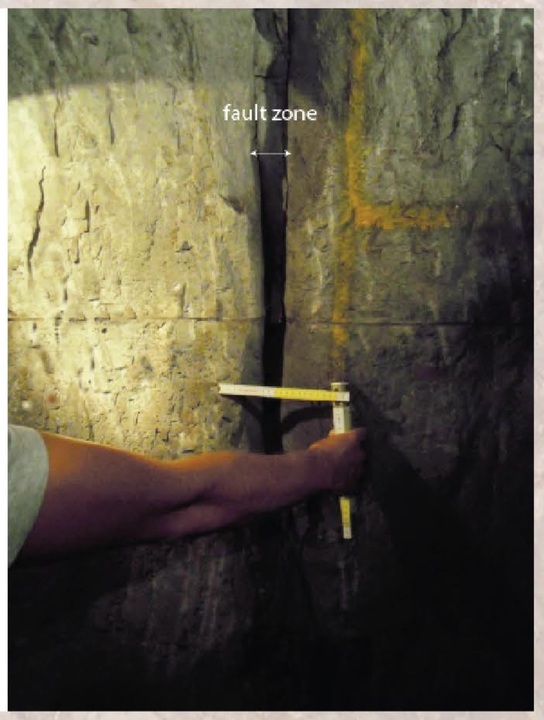
Geological model

A geological model was built to reconstruct the top of Miliolitico Fm. and the regional faults.



Structural analysis in the Nuraxi Figus Coal Mine

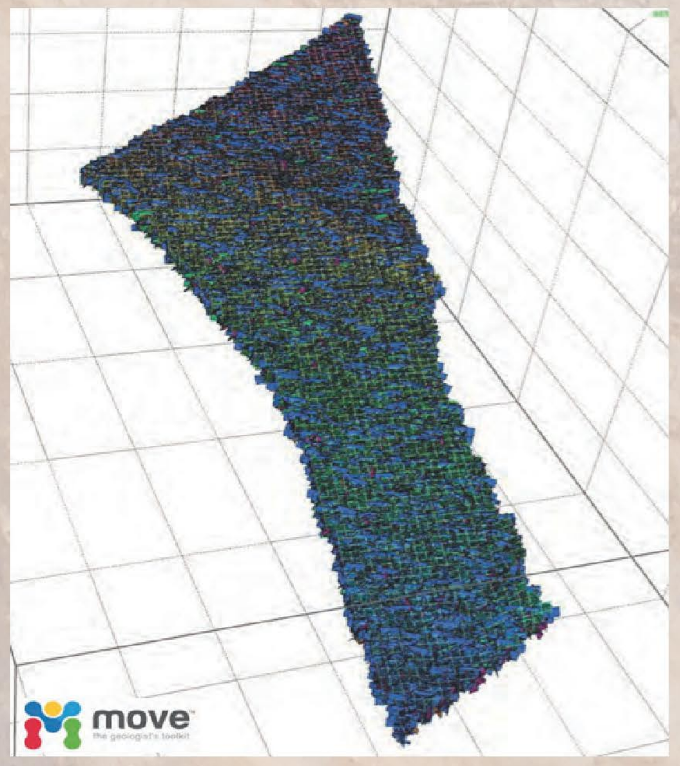




Thanks to the owner of the coal mine Carbosulcis S.p.A., we perform structural analysis at the depth of about 450m.

In the photos on the left, high angle strike slip faults in Miliolitico F.m in the Coal Mine of Nuraxi Figus, are shown. Note the notable aperture (about 5 to 10 cm) and the high angle to the bedding.

Fracture Modelling



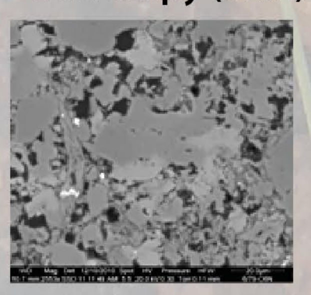
The data collected at the outcrop were used to model a DFN of the potential reservoir. Several DFN were calculated, using varying the lenght range and the aperture values of sets.

The average fracture porosity (volume of fracture/total volume) is 3.09% for a total volume of 0,49 Km³

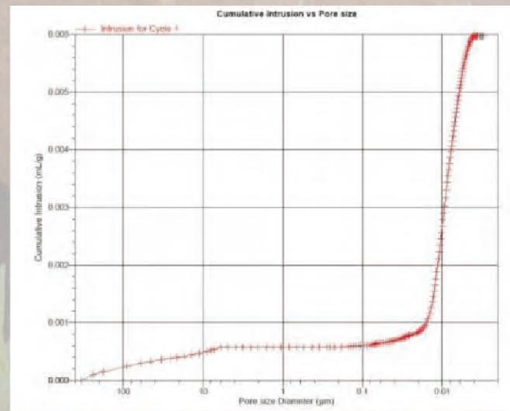
Core samples petrophysical analysis

The physical characteristics of Miliolitico Fm. have been analyzed in the light of their petrographical characteristics; mainly texure and porosity, which affects the permeability and the geomechanical properties of the rocks.

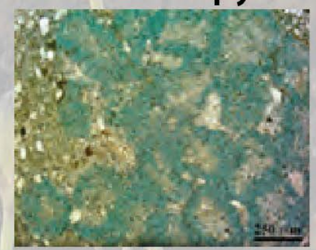
Scanning Electronic Microscpy (SEM)



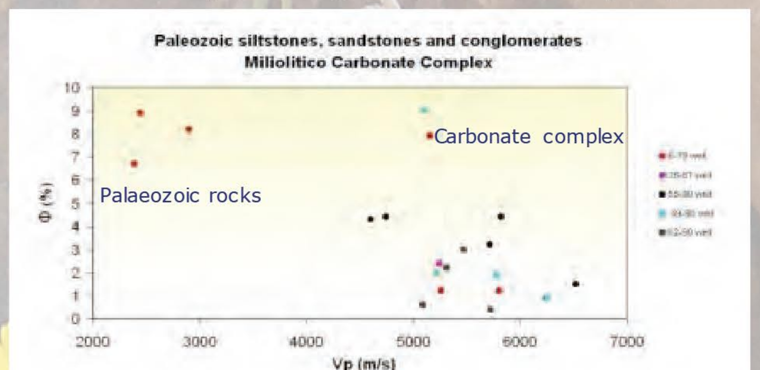
Mercury Intrusion Porosimetry



Optical microscopy



Porosity vs longitudinal velocity (Vp)



Petrophysical analysis preliminary results
- Porosity is generally low, in the range of 0.9 and 5%;
- These low porosity are associated with very low permeability values, that are influenced by tortuosity
- Significant porosity values were found in sample with evidence of dolomitization of calcite.

References

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