CO_2 storage capacity estimation of fractured reservoirs in Adriatic Basin

General objective

Estimation of the CO_2 storage capacity of the potential structures of the Adriatic and Periadriatic Basin.

Specific objective

Estimation of the effective CO_2 storage capacity of potential structural and stratigraphic traps selected in the onshore and offshore of the Apennine chain, through the application of the main existing rating methods based on seismic interpretation, 3D modeling and evaluation of the petrophysical parameters of the formations involved. The latter will be obtained by analyzing well data, sampling on outcropping analogues and modeling on fracture systems.

State of art

In the field of the mitigation action to a low-carbon energetic system, the CCS (Carbon Capture and Storage) technology can give a great contribution, quantified around the 14% of the total emissions. This process consists in the capture, the compression and the transport of CO_2, generated by the large power plants, and the injection in deep geological formations able to host it (IEA, 2004; IPCC, 2005). Therefore, at the base of any CCS project there is the potential sites research and the calculation of the CO_2 volume that can be hosted. There were many institutions working on projects aimed at characterizing sites and estimating CO_2 storage potential in Europe and the world (Carbon Storage Atlas, NACSA 2012, CSA of the US and Canada, Queensland Storage Atlas, Norwegian Sea CO_2 Storage Atlas, Brazilian Atlas of CO_2 Capture). To identify a good storage site, it is necessary to identify suitable geological formations, i.e. suitable reservoir rocks, with satisfying volumetric and injective capacity and a caprock, which has the petrophysical characteristics suitable for confinement. Once a geological setting has been defined, different equations allow to estimate the exploitable volumes, as they combine the area, thickness and porosity of the reservoirs with the N / G ratio of the rock and the density of the CO_2 to be injected. On this base several different capacity values can be defined: theoretical, effective, practical and matched (Bachu et al., 2007; Bradshaw et al., 2007; Kopp et al., 2009). The domain of the external Apennines and the Adriatic Sea have already been identified by several projects as potential areas for storage (Buttinelli et al., 2011; Donda et al., 2011; Bigi et al., 2013; Civile et al., 2013; Volpi et al., 2015). These researches identified two potential reservoirs, such as calcareous and sandy formations, both very widespread in Italy onshore and offshore, but just a total amount of capacity volume has been defined, without a more specific analysis focused on each structure.

The **I Year** activities were articulated with two main goal:

1) The site characterization involves the analysis and interpretation of seismic data in the Adriatic Sea and the construction of 3D models of the representative chosen structures (with the use of *QGis, DecisionSpace, Petrel* software)

2) The analysis of petrophysical parameters, that implied the determination of coefficients linked to the specific lithologies defined as reservoir in the area, focusing on fracturing of the pelagic carbonates ("Scaglia Fm." – Burano Anticline)

The **II Year** will be dedicated to the implementation of 3D models of the chosen structures as representative. These models will allow to have good volumetric estimation and to integrate simple 3D volumes with fracturing data for detailed structural models. Part of this period will be spent at the *Zagreb University - Faculty of Mining, Geology and Petroleum Engineering*, where the group of Prof. Bruno Saftić deals with similar research having object the eastern side of the Adriatic Basin. In the second part of the year, I will focus on the characterization and the determination of the storage related coefficients through the utilization of the software *DFNWorks*, that allows to generate 3D fracture networks and to simulate fluid injection in fracture systems. Through this tool I will be able to determine the influence of the distribution of fracture systems on the fluids circulation, permeability variation and, therefore, the amount of CO_2 that can be hosted by the fracture system volume.
Fracture networks exist at a wide range of scale in the earth crust and strongly influence the hydraulic behaviour of rocks, providing either pathways or barriers for fluid flow. Many oil, gas, geothermal and water supply reservoirs form in fractured rocks.
The main challenge is the development of numerical models that describe adequately the fracture networks and the constitutive equations governing the physical processes in fractured reservoir.
The hydraulic properties of fracture networks, derived from Discrete Fracture Network (DFN), models are commonly used to populate continuum equivalent models at reservoir scale, to reduce the computational cost and the numerical complexity. However, the efficiency of fracture networks to fluid flow is strongly tied to their connectivity and spatial distribution, that continuum models are not able to capture explicitly.
In my project I used field data and synthetic models to introduce a new parameter to evaluate the efficiency of fracture networks to fluid flow, reflecting a range of variability in fracture network characteristics (e.g. P32, number of fractures, stress field).
The simulation of fluid circulation will be then performed on the synthetic DFN models, measuring the behaviour of fracture network with respect to the total amount of injected / flowed gas through the model. This will allow to obtain a curve of different efficiency of several fracture network for different values of the P32 (the volumetric fracture density, expressed as the area of fractures per unit volume). In this way it will be possible to parameterize the efficiency (with a parameter ranging from 0 to 1), and to apply it in the volume calculation for potential reservoirs with the same characteristics.
The parameters obtained from the synthetic models will be used to estimate the efficiency of the real DFN, calculated for the offshore anticlines using field data measured on the Burano anticline during the first year. The modelling of the fluid flow in the anticline will be performed to validate the obtained parameter.
This alternative method allows to model fractured systems at reservoir scale, in a variety of geological settings, using exclusively a DFN approach.
In the last part of the II year I will apply the same approach to the analysis of the distribution of fracturing, to the characterization of the petrophysical parameters and to the determination of the storage parameters in the formation of the "Calcare Massiccio", the representative formation of numerous reservoirs composed by carbonate platform facies.

The **III Year** will be dedicated to get 3D models combining structural features and rock property values. At the end of this phase, I will have all the necessary parameters to create highly detailed 3D petrophysical and fracturing models. These models will allow to estimate the storage capacity in each representative structure and consequently estimate for all the reservoirs of the same group, maintaining constant the parameters related to storage and changing only the variables of formation volume and density of the CO2 to be injected (linked to the depth of the reservoir). The last step will be the validation of derived storage coefficients through the dynamic injection simulation (*Eclipse* Software).

Publications

- ✓ Billi A., Cuffaro M., Beranzoli L., Bigi S., Bosman A., Caruso C., Conti A., Corbo A., Costanza A., D'Anna G., De Caro M., Carlo Doglioni C., Embriaco D., Fertitta G., Frugoni F., Gasperini L., Italiano F., Lazzaro G., Ligi M., Martorelli E., Monna S., Montuori C., Nigrelli A., Passafiume G, Petracchini L., Petricca P., Polonia A., **Proietti G**., Ruggiero L., Sgroi T., and Tartarello M.C. *The SEISMOFAULTS Project: first surveys and preliminary results for the Ionian Sea area, southern Italy.* Annals of Geophysics.

- ✓ **Proietti G**., Conti A., Cuffaro M., Esestime P. & Bigi S. *Subduction related faults and sedimentary basins: The Western Ionian Sea case.* SUBMITTED

- ✓ **Proietti G,** Conti A. & Bigi S. *Potential structures for CO_2 storage in Adriatic Basin.* IN PREPARATION

Conferences

- ✓ **Proietti G**., Bigi S., Conti A., Cuffaro M. & Esestime P. *Structural setting and sedimentary basins in the Western Margin of the Calabrian Arc*. Geophysical Research Abstracts, EGU General Assembly 2019. (Wien 7-12 April 2019)

Courses

- ✓ December 2018 - Università di Perugia - "Geoscience in the Energy Industry" (Reservoir characterization and modeling), Elena Morettini (YPF)
- ✓ December 2018 - Using databases in Earth Sciences, Roberto Basili
- ✓ December 2018 - Schlumberger Technical Service, La Defense (Paris) - "Petrel Reservoir Engineering" Course
- ✓ January 2019 - Università di Roma La Sapienza - "Paleoenvironmental and paleoclimatic reconstructions", Marco Brandano
- ✓ January 2019 - Università di Roma La Sapienza - "Carbonate seismic interpretation and sequence stratigraphy applied to hydrocarbon exploration", Marcello Badalì (Stratigraphy and Sedimentology Group, Exploration Technical Services, Repsol)
- ✓ January - February 2019 - Università di Roma La Sapienza - "GIS Applications", Marta della Seta

- ✓ February 2019 - Università di Roma La Sapienza - “Geomagnetism”, Angelo de Santis (INGV, Roma)

Collaborations

- ✓ “Seismofault project”.
  Researcher onboard the Mobile Scientific laboratory, Oceanographic Vessel “Minerva Uno” for acquisition, processing and interpretation of geophysical and seismic data.

- ✓ University proposal research project,- Santantonio M., Fabbi S., Cipriani A., Innamorati G., Proietti G. – Evoluzione tettonica Giurassica e ambienti sedimentari e geodinamici a confronto in aree-campione ai margini di tre placche: Europea (Sila Greca), Africana (Sicilia occidentale) e Apula (Appennino centro-settentrionale). WAITING FOR APPROVAL.