DIPARTIMENTO
DI SCIENZE DELLA TERRA
SAPIENZA
UNIVERSITÀ DI ROMA

DOTTORATO DI RICERCA
IN SCIENZE DELLA TERRA

PhD Research Project in Earth Science - XXXVII cycle

"Evaluation of the hydrogen storage potential in Italy"

INTRODUCTION AND STATE OF THE ART

The 2015 Paris Agreement initiated a global commitment to reduce CO_2 emissions, with the aim of limiting the level of anthropogenic-induced climate change and to reach the net-zero emissions target no later than 2050.
In this transition, hydrogen can represent a new energy carrier, being sustainable, secure and storable. Hydrogen can be produced in many ways, characterized as "blue", if coming from biomass or hydrocarbons reforming, or "green", if produced from water electrolysis.

Of particular interest among potential renewable energy sources are solar and wind, widely in use all around the world. These power sources are intermittent and discontinuous, and thus technological advances are needed before they become a real alternative to fossil fuels. In fact, their production is independent of demand, generating a surplus of energy during some periods and deficit in others. The combination of hydrogen production processes and renewable sources could lead to a net-zero energy system, and the drawbacks of the intermittent supply could be overcome by storing the produced hydrogen in geological storage sites.
The Underground Hydrogen Storage (UHS) consists of the compression and injection of hydrogen in geological settings (like salt caverns, depleted hydrocarbon reservoirs, saline aquifers and hard rock cavities) that are capable of storing this gas and making it available for withdrawal when needed.

Hydrogen storage shares some similarities with other kinds of underground gas storage (UGS) methods, like methane and CO_2, from which it's possible to take advantage of

years of experience. There are 680 UGS sites worldwide, and even if depleted hydrocarbon reservoirs have been highly characterized during exploitation, every site needs further information to evaluate its chemical reactivity and long-term storage integrity in case of UHS. There are many databases about CO_2 capture, utilization and storage (CCUS) sites. UHS, instead, is an emerging technology and it lacks this kind of information, although it is essential for a fast and successful implementation of geological hydrogen storage. Therefore, the present research project will address this knowledge gap, creating a preliminary atlas of possible UHS sites in Italy.

Useful tools for this purpose have been proposed by Poland and the United States, that published the AHP (Analytic Hierarchy Process)[4] method and the H2GSM (Hydrogen Geologic Storage Model)[5] software respectively. The first allows to evaluate and compare different sites for a preliminary classification. The latter is a software that compares different geological settings to evaluate the feasibility of a UHS project, returning basic models from an economic and operative point of view.

RESEARCH OBJECTIVES

Hydrogen can be the key for a sustainable, secure and storable energy; however, the studies about this issue are still at the beginning. Among the uncertainties to resolve, there is the need to find sites for underground hydrogen storage (UHS) that are suitable for the specific properties imposed by this gas. Therefore, the general objective of this research is to create a preliminary atlas of UHS-capable sites in Italy, and the specific one is to carry out a deeper investigation on the most promising site.

WORK PLAN

In this project, a regional approach will be used to evaluate UHS potential in Italy, as done before for other gases, in order to obtain a better knowledge about various aspects and problems related to the geologic storage of hydrogen. Four areas will be analyzed, selected based on criteria used for UGS surveys of the past years: the Adriatic domain (onshore and offshore), the Bradanic domain (between the regions of Puglia and Basilicata), the southern Sicily and the south-western area of Sardinia. In these areas, favourable geological settings will be studied and classified based on the critical parameters for UHS: firstly, the geological characteristics; then properties like reservoir integrity and chemical reactivity of the local lithologies, with an evaluation of the optimal pressure that the sites can bear and the right mixture of H_2 and cushion gas needed for safety purposes.

That classification will be the result of three main tasks, to be carried on during the three years of PhD.

1. DEFINITION OF THE MAIN CRITERIA FOR EACH KIND OF RESERVOIR

A complete review of the criteria proposed in the international literature will be made, to define more suitable and pertinent parameters for the Italian geological settings. Information will be taken from national and international experiences in oil exploration to evaluate caprock-reservoir systems. From the field of UGS, the main parameters concerning UHS will be chosen (e.g., position, kind of storage, lithology, deepness of the aquifer, porosity, permeability, thickness of the rock formation, depths and pressures of the formations, salinity). In this phase, the calculation methods of the storage capacity will also be defined.

2. SECOND YEAR: DATA COLLECTION

To build the database needed for further evaluations, four main sources will be used:
- the public database ViDEPI for Italian oil exploration activities data;
- scientific literature database;
- industrial datasets;
- previous works of the TFC Lab of DST-Sapienza.

Moreover, a geomechanical and geochemical characterization of representative samples will be performed in the laboratories of "La Sapienza" University and during the abroad period in Scotland respectively. The gathered data will be organized using a spreadsheet software and a georeferenced database will be set up using a GIS software that will include geological layers and geophysical data.

3. THIRD YEAR: SITE CLASSIFICATION

The site ranking procedure will include definition of the classification parameters and evaluation of the chosen geological settings. For this purpose, a coefficient will be associated to each parameter to measure the weight that each one will have in the calculation procedure. In this phase, the first calculation of the storage capacity will be done, using the methods already published for each geological structure.

The most promising site, based on the chosen criteria, will be 3D-modelled, and the first dynamic injection simulation will be executed to validate the storage capacity calculation (this operation will be done during the stage in Eni S.p.A).