16th International Conference on Greenhouse Gas Control Technologies, GHGT-16

23rd -27th October 2022, Lyon, France

Static modelling of geological structures for carbon sequestration purposes in the Lorestan area of Iran

Pegah Soleimani Dinani[a]*, Sabina Bigi[a], Fabio Trippetta[a], Seyed Ali Moallemi[b], Alessia Conti[c], Giampaolo Proietti[a] and Valentina Romano[a]

[a]*La Sapienza University, Department of Earth Sciences, Piazzale Aldo Moro 5, Rome, Italy*

[b] *Research Institute of Petroleum Industry (RIPI), Tehran, Iran*

[c]*Research Council of Italy, Institute of Environmental Geology and Geoengineering (CNR-IGAG), Piazzale Aldo Moro 5, Rome, Italy*

Abstract

One of the most important methods aimed at climate mitigation technology is carbon geological sequestration. During the process of site selection and characterization required for evaluation of capacity storage potential of a given region, geological static modelling plays an essential role by providing a better understanding of the structure in terms of petrophysical and geological characteristics. This work presents the 3D geological model of several anticlines in the Lorestan area (northwestern Zagros), to evaluate their carbon storage capacity potential. The 3D geological model is based on seismic data and well-log data from 2 wells drilled in the area, kindly provided by the National Iranian Oil company (NIOC). Preliminary well logs analysis allowed to identify potential target formations by considering pivotal criteria of CO_2 storage such as depth, porosity, and other petrophysical characteristics. The 3D model will be followed by the construction of a geocellular model that will be populated by petrophysical data obtained from well logs. The reconstructed volume will be then used for injection simulations to obtain an evaluation of the volume available for storage. The dynamic simulation will also provide and support the evaluation of other important aspects such as the injection strategies and efficiency coefficient, comparing the observed theoretical and effective capacity.

Keywords: Mitigation technologies; Carbon Sequestration; CCS; Iran; Lorestan area

1. Introduction

The concept of carbon sequestration has been raised for long-term storage of CO_2 without reproducing energy from a stored gas to stop the cycle of greenhouse gas emissions. The primary stage in the carbon capture storage (CCS) scenario is finding a suitable geological structure that has the possibility to maintain the gas in depth for a long period of time. This step is always accompanied by challenges due to the unexpected behavior of host formation as a response

* Corresponding author. Email *address:* Pegah.soleimanidinani@uniroma1.it

to the injection of gas. Following that, evaluation, and screening of potential reservoirs aimed at carbon storage are needed.

Iran as a country with 0.72 GT of carbon dioxide emission in 2020 and more importantly as a country that is the 4th and 2nd largest reserve holder of oil and natural gas respectively, needs to be studied on a regional scale.[1] For this reason and due to its potential, we are focusing on data obtained from the Zagros area. The continuous subsidence history of Zagros through multiple unconformities differentiates this zone from other Iranian basins. This young, active orogen which has been formed by the north-south collision of the Arabian and Eurasian plates encompasses the most important oil and gas reservoirs of Iran [2]. The asymmetrical structural pattern of Zagros led to thickness alteration of sedimentary cover and facies variability; since the sedimentary cover overlying basement showed various responses to compressional stresses, Zagros is subdivided from east to west in four structural zones, namely, Fars, Izeh, Dezful Embayment, and Lorestan [3].

The Lorestan region is demarcated to the north and northeast by thrust faults, and to the south by the Balarud flexure [4]. Even though variations in depositional facies and diagenesis have resulted in permeability variation, the presence of porous structures and more importantly, the existence of several seal layers encouraged us to evaluate the potentiality of this zone in a more specific and local manner.

2. Area of study

The Lorestan area located in the northwest of Zagros has a long history of hydrocarbon exploration and production but relatively few wells drilled here have been successful [4]. This region is part of the massive sedimentary basin of the Zagros mountains, which extended with a length of approximately 1,400 km. In this area, we considered the structure Lur_A, approximately 20 km wide, as represented in Fig. 1. Drilled wells in this structure in the stage of exploration are labeled as abandoned oil and gas wells, due to the absence of hydrocarbons or for the relative low amount of the resource. Although most studies focus on abandoned oil and gas fields or on depleted reservoirs for sequestration, the suspension of exploration in this area contributes to having a less complete dataset and increases the complexity of the screening process.

The geological area of Lorestan includes the deep part of the sedimentary basin, mainly composed of Pelagic limestones and shales [5]. The stratigraphic column of the studied area (Fig. 2) highlights the occurrence of several potential reservoirs mainly belonging to the Mesozoic (Cretaceous) limestones, e.g. the Bangestan Group and mostly Ilam Formation, according to the optimum depth criteria for storage of Carbon Dioxide [6]. Since in our study area Quaternary deposits and Asmari Formation outcrop have the most exposure, the latter cannot be considered a reservoir in this area.

Bangestan group (Ilam, Surgah, and Sarvak Fms.) represent carbonate deposits considered the most important exploration target in this zone, and since it is overlaid by the low permeability layer of Gurpi Formation, it can be considered a suitable candidate for storage. There are a lot of elements such as spatial distribution of depositional facies, secondary alterations (diagenetic events), and depositional cycles controlling carbonate reservoir quality and architecture [7]. In a carbonate reservoir, primary porosity and permeability are controlled mostly by the sedimentary facies, but also secondary porosity controlled by fractures plays a major role [8]. In our case, all defined potential candidates consist of carbonate rocks, so reservoir characterization will require fracture modelling to be integrated into the calculation of porosity and permeability. In particular, our attention is focused on the Ilam Formation (Santonian-Campanian) consisting of shallow marine limestone, and on the Sarvak Formation (Albian-Turonian), characterized by pelagic facies. Gurpi Formation (Campanian-Maastrichtian) consists of marls and clay, and in some parts shale which can be a proper candidate for our seal layer (Fig. 2(a))

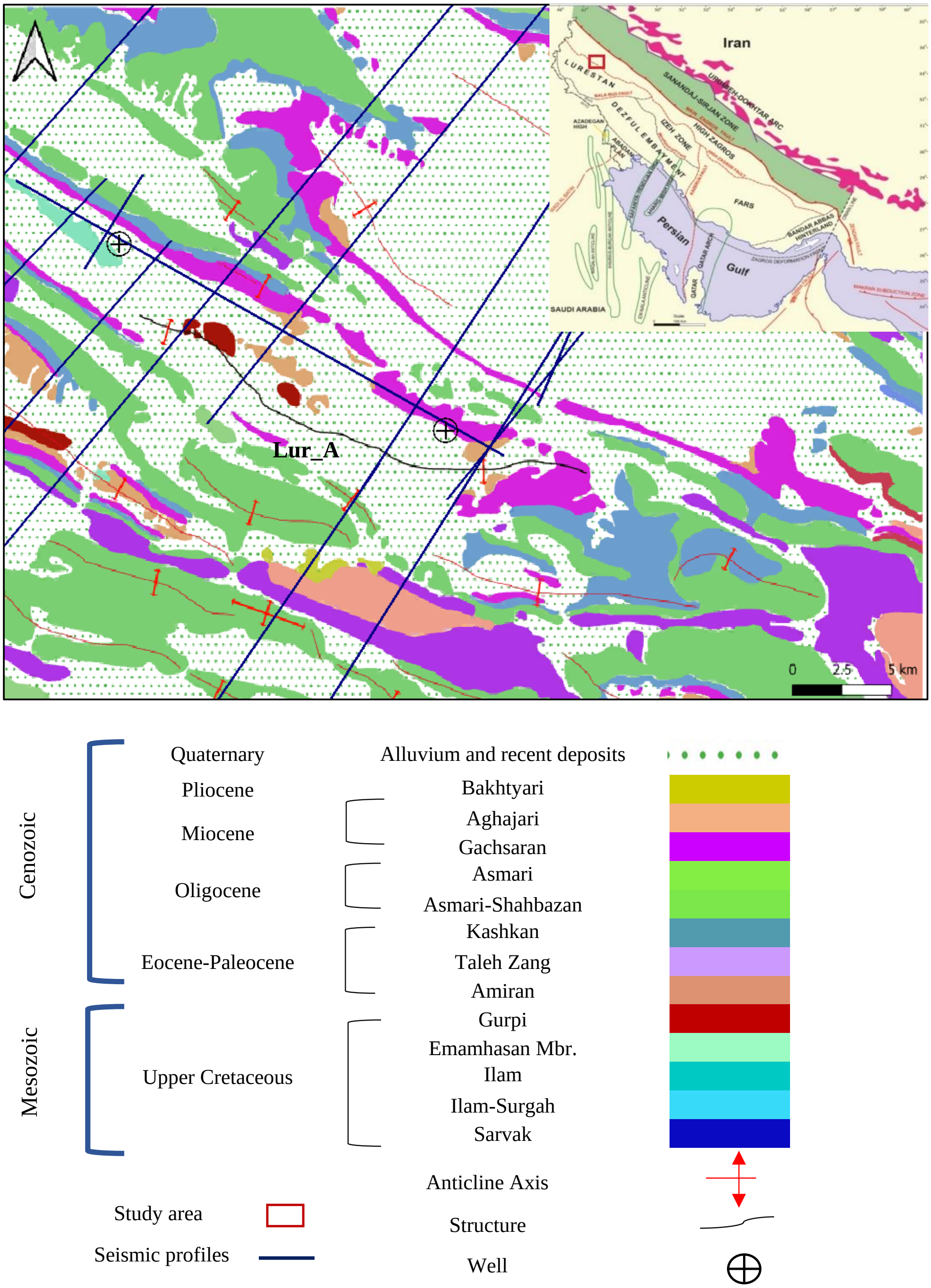

Fig. 1. Geological map of study area showing outcrop terrains, boreholes and the proposed structure of study. (Modified from NIOC geological map of Ilam-Kuhdasht [9,10,11].

3. Materials and methodology

In this work, data has been collected from 2 wells located in the area (fig. 1), 18 km distant from each other, and seismic data shown in fig. 2(b). The first challenge faced during geological modelling is a conversion of the interpreted horizons from time to depth to have an accurate 3D view of the structure. There are different methods for converting seismic interpretation from time to depth based on budget, time, complexity, and availability of data. In this work, the interpretation was constrained by well top markers, followed by the depth conversion based on a velocity model reconstructed using time-depth relationships mostly derived from sonic logs. The summarized workflow for time-to-depth conversion has been illustrated in fig. 3. The picking of the two horizons, corresponding to the top of Ilam and Sarvak Fms. has been carried out on all the seismic profiles (Fig. 2(a)), creating a model of the reservoir in time. Once the process of interpretation has been completed, according to the relationship between parameters, namely, time, depth, and velocity shown in figure 3, the velocity model is constructed. The velocity values assigned to our simplified velocity model are summarized in Fig. 2(a).

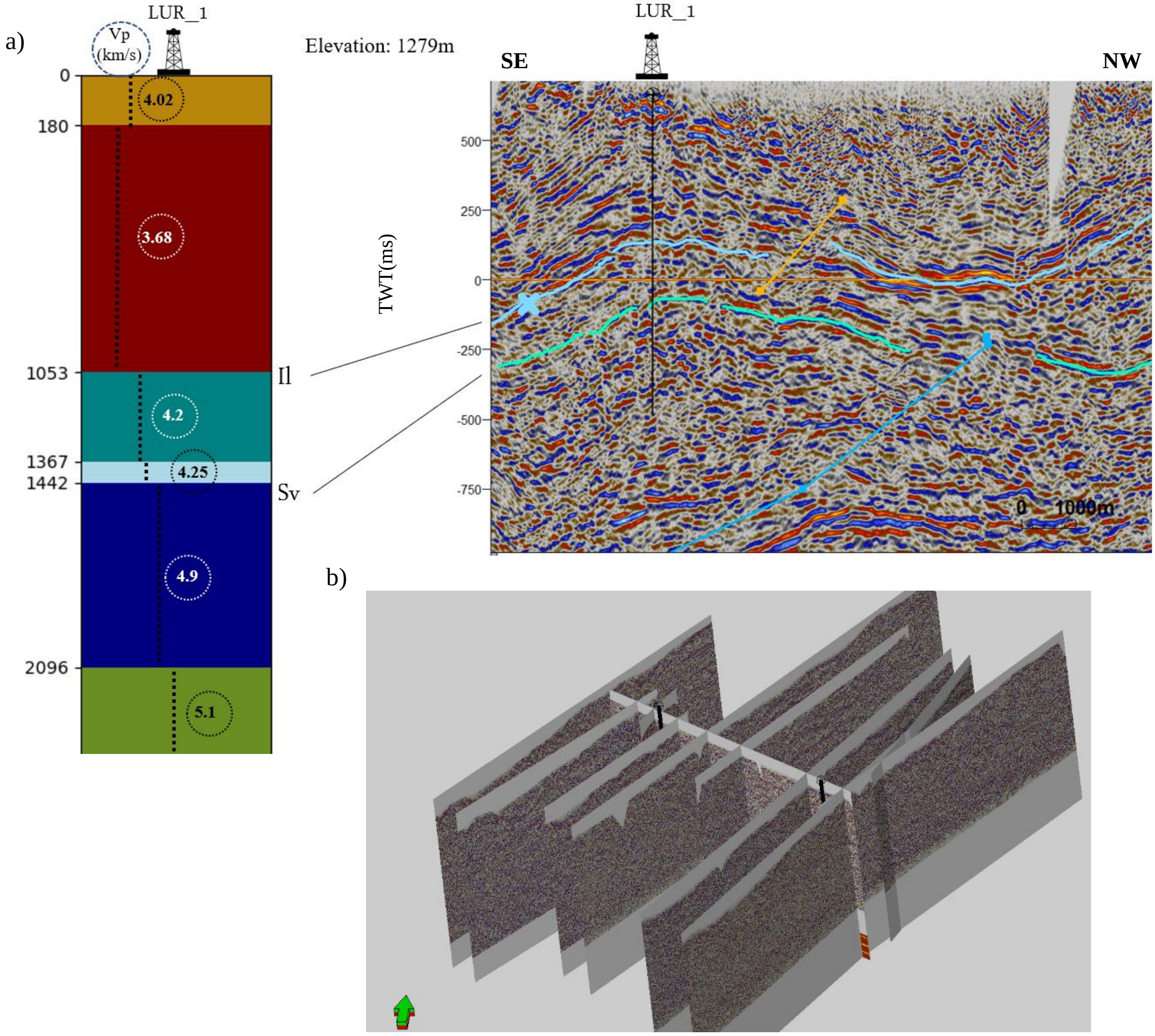

Fig. 2. (a) Seismic stratigraphy of the Lur_a calibrated with well Lur_1. Two highlighted reflectors refer to the top of two reservoirs Ilam and Sarvak Fms. P-wave seismic velocity of formations (Vp); (b) Seismic reflection profiles organized into a three-dimensional working project.

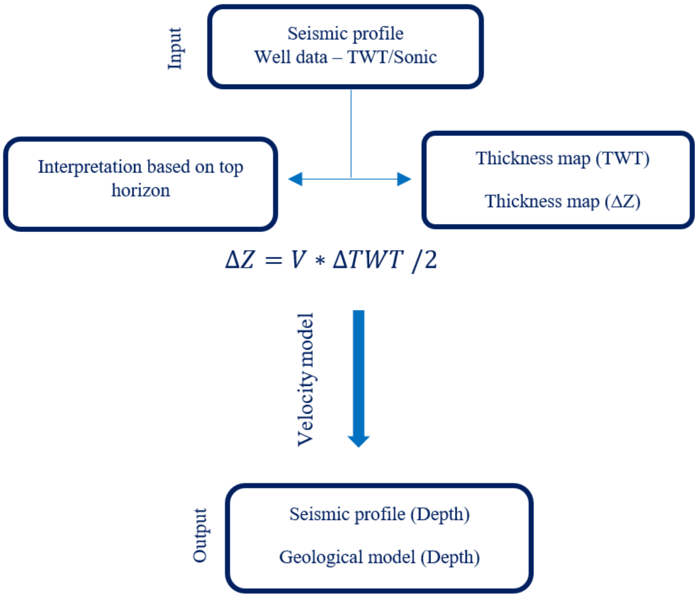

Fig. 3. Workflow of time to depth conversion

4. Conclusion and future work

This work presents the preliminary studies for the evaluation of storage capacity of several structures in the Lorestan area (Iran). By the first studies of the stratigraphy of the area, the Ilam Formation (fractured carbonate) has been considered as a potential host formation for the storage of CO_2. The top of the Ilam Formation has been reconstructed in the area, as a base for the geological model of the Lur-A anticline. Since doubts regarding the actual potentiality of this zone remain to be addressed, in the next step of our work by completing the static modelling of the reservoir, the theoretical capacity and injectivity of this structure will be studied.

References

[1] Mousavi, S. M., Dinan, N. M., Ansarifard, S., & Sonnentag, O. (2022). Analyzing spatio-temporal patterns in atmospheric carbon dioxide concentration across Iran from 2003 to 2020. Atmospheric Environment: X, 14, 100163.

[2] Alavi, M., 2007- Structures of the Zagros fold thrust belt in Iran. Am. J. Sci. 307, 1064–1095.

[3] Allen, M., Talebian, M., 2011- Structural variation along the Zagros and the nature of the Dezful Embayment. Geological Magazine 911-924.

[4] Farzipour‐Saein, A., Yassaghi, A., Sherkati, S., & Koyi, H. (2009). Basin evolution of the Lorestan region in the Zagros fold‐and‐thrust belt, Iran. Journal of Petroleum Geology, 32(1), 5-19..

[5] Homke, S., Vergés, J., Serra-Kiel, J., Bernaola, G., Sharp, I., Garcés, M., ... & Goodarzi, M. H. (2009). Late Cretaceous–Paleocene formation of the proto–Zagros foreland basin, Lorestan Province, SW Iran. Geological Society of America Bulletin, 121(7-8), 963-978..

[6] Tomić, Lola, et al. "Criteria for CO_2 storage in geological formations." Podzemni radovi 32 (2018): 61-74.

[7] Zohrabzadeh, M., Rahimpour-Bonab, H., & Aleali, M. (2019). Application of 3D-Seismic Data in Detecting Buried Karsts in Asmari Formation: An Example from Kupal Oil Field, Southwest Iran. *Geopersia*, *9*(1), 151-167.

[8] Ghorbani, M. (2021). The geology of Iran: tectonic, magmatism and metamorphism. Springer International Publishing..

[9] NIOC (1970) National Iranian Operating Oil Company, Geological and exploration division. 1/100000 Geological map of western Iran maps. Tehran, Iran

[10] NIOC (1974) National Iranian Operating Oil Company, Geological and exploration division. 1/250000 Geological map of Ilam-Kuhdasht. Tehran, Iran

[11] National Iranian Oil Company (NIOC). Internal report number Gs-PG-81