Site characterization of carbonate reservoir rock for the purpose of CO_2 storage in the Lorestan area of Iran

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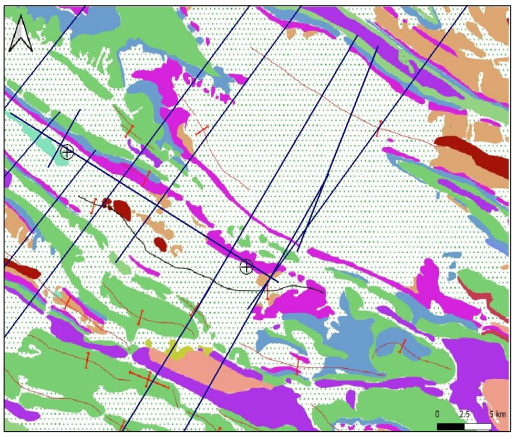
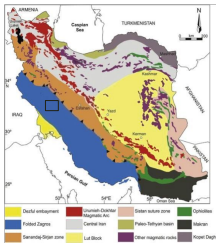
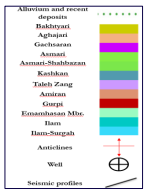
1. Introduction

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. Despite the substantial storage capacity offered by carbonate reservoirs, the majority of active and proposed CCS (carbon capture and storage) initiatives focus on sandstone reservoirs. To fully utilize the storage capabilities and existing infrastructures in depleted carbonate reservoirs nearing abandonment, further research is needed to develop and refine technologies suitable for carbonate rock utilization.

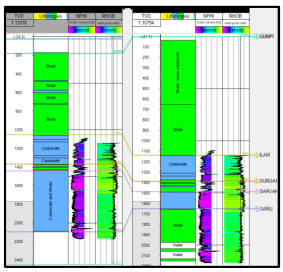


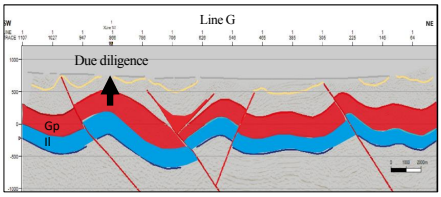


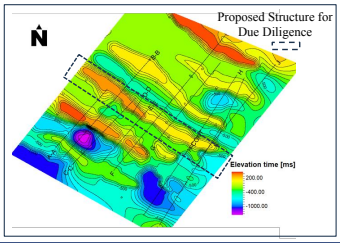


2. Site characterization

In this work, data has been collected from 2 wells located in the area 18 km distant from each other. All structures in the studied area are oriented from southeast to northwest. We have extensively investigated seven distinct geological structures. In particular, seismic cross-section G reveals three delineated structures running from southwest to northeast. We observed variations in the thickness of formations from southeast to northwest. For example, the Gurpi formation ranges from 800 meters in the southeast to 1000-1100 meters in the central and northwestern regions.







Caprock

Gurpi Formation (Campanian-Maastrichtian)

Lithology ➡ marls and clay, and in some parts shale

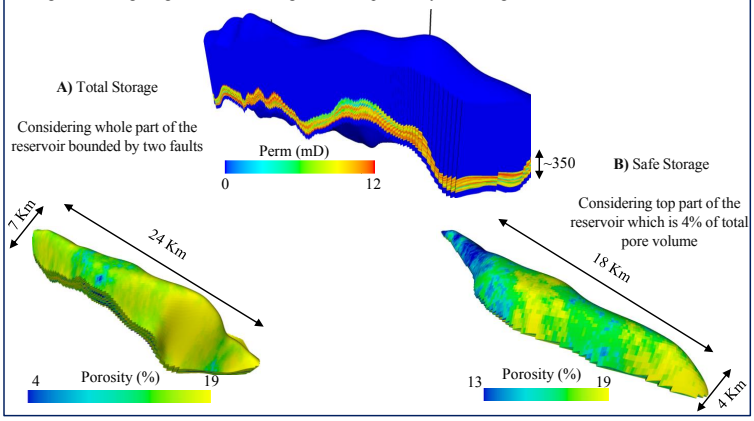
Reservoir

Ilam Formation (Santonian- Campanian)

Lithology ➡ shallow marine limestone

3. Geological model

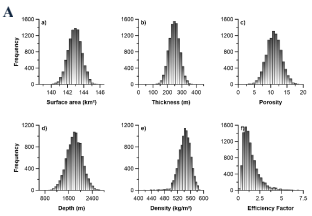
The assessment of two distinct storage scenarios was undertaken in this project. The existence of a spill point, along with other geological nuances, brought forth the possibility of treating this structure as two distinct entities.

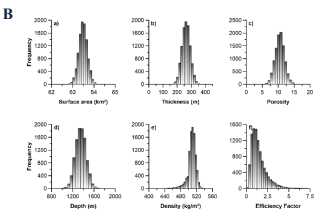


4. Static Capacity

Within the realm of CO_2 storage, various classification systems and methodologies are employed to estimate storage capacity. We presented a detailed outline of static estimation, both theoretical and effective storage, utilizing the volumetric method exclusively for the Ilam reservoir. To account for uncertainties in the final estimations, we applied a Monte Carlo simulation method.

$$M_{co2} = A \times h \times \phi \times E \times \rho_{co2(P,T)}$$





	Total Capacity (Mt)	Effective Capacity (Mt)
P10	1501.4	11.3
P50	2182.7	26.8
P90	2978.9	62

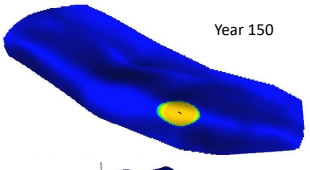
	Total Capacity (Mt)	Effective Capacity (Mt)
P10	688.1	4.9
P50	883.2	11
P90	1096.5	24.6

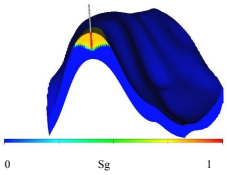
5.Simulation results

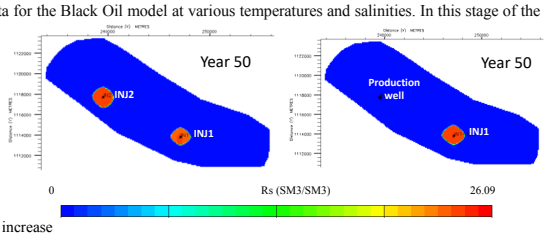
We utilize the Black Oil model (Eclipse Schlumberger), treating hydrocarbon gas as supercritical CO_2 and oil as brine. Hassanzadeh et al. (2008) introduced an algorithm to convert compositional data from an equation of state into Black Oil PVT data. This allows us to generate PVT data for the Black Oil model at various temperatures and salinities. In this stage of the work, we evaluated injectivity and plume distribution in a single porosity model.

50 years of Injection
100 years post injection

Parameter	Symbol/UNIT	Case A
Total Cells		415800
Resolution	m*m	100*100
Grid cells	nI*nJ*nK	220 *126*15
Pore Volume	m^3	3.84E+10
Reservoir Temperature	°C	65
Initial Field pressure	Bar	126
Injection rate	SM3/DAY	1,500,000
Max.Well Bottomhole pressure	Bar	262

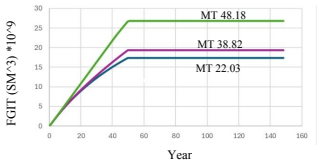






Comparing methods to increase injectivity

Injection well (drilled)
Two Injectoin well
Injection + Producing water



Conclusion

1. This project characterized a proposed CO_2 storage site in the northwest of Lorestan (Iran).

2. A 3D geological model of the proposed structure has been constructed using well data and seismic data.

3. The theoretical and effective static capacity of the Ilam formation using a volumetric approach, considering the probability for each input parameter has been calculated

4. The reservoir identified as an open aquifer from the northwest, connected to another structure by a spill point, and bounded from the top and bottom by the Gurpi and Surgah formations (seal layers).

5. Plume migration has been demonstrated, and a comparison of two methods for increasing injectivity has been conducted: 1. Simultaneous water production for CO_2 injection and 2. Using two injection wells for CO_2. This comparison shows that the latter method is more plausible and effective in our case

6. The impact of fractures will be evaluated in the next stage of the work

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