6.1 AI-BASED INTEGRATION OF GEOSCINCE AND OTHER DATA FOR CARBON SEQUESTRATION AND ENHANCED OIL RECOVERY

F. Aminzadeh[1,2*]

[1]*Co-founder, Energy Transition International, Houston, TX USA*
[2]*President, FACT, Santa Barbara, USA*
**Corresponding author e-mail: famin@fact-corp.com*

ABSTRACT

CO_2 sequstration and monitoring its injection into carbon storage sites (often times old oil fields) is becoming an important issues. This is done to address enviromental issues. In addition, when CO_2 is injected into and old oil resrvoir for the additional objective of extracting the oil "behind the pipe" and to extend its life, it has the potential to make the entire process more cost effective. We will refer to this procrss as carbon sequestration-EOR or CS-EOR. This paper highlights everal new ideas on how to use artificail intelligences (AI) to intgrate different types of geosceince data (seismic, micro-seismic, electromagnetics, petrophysics and rock physics) with other data types for an effective CS-EOR. One of the reasons to use AI is the difficulty in data integration due to what we call: SURE challenge. By SURE challenge we mean the fundemental diffeernces in Scale, Uncertainty, Reseolution and the Environment associated with diffeernt data types. Finally, a dynamic updating procedure is introduced for real time monitoring of potential induced seimicity due to the CO_2 injection process. Although in this abstrcat we focus on carbon sequestration, similar techniques could be ustilized for other energy transition applications, including geothrmal exploration and production.

KEY WORDS : GeoScience Data Integration, Artificial Intelligence, Carbon Sequestration, Enhanced Oil Recovery, Dynamic model updating, Energy Transition

INTRODUCTION

This paper focuses on the increasingly important topic of reducing the amount of CO_2 emmission by its sequstration in carbon storage sites (usually in old and abandoned oil fields). Of course when CO_2 is injected into an old oil resrvoir with the additional objective of extracting the residual oil, it offers the opportunity to extend the life of field, resulting in economic benefits and postponment of encouring the field abandonment cost. We will refer to this process as carbon sequestration with enhanced oil recovery or CS-EOR. Given the limited capital budget in most CS-EOR projects cost effectiveness of the employed methods is an important factor. The proposed AI- Based methods take this factor into consideration. Naturally, an effective CS-EOR operation requires reservoir (site) charcaterization through integration of different geoscinces and other data types. Furthermore, to monitor the effetiveness of carbon sequestration and EOR we need to monitor changes in the reservoir parametes as the CO_2 plumes moves in the reservoir.

METHOD and APPLICATION

From many issues associated with CS-EOR we will highlight two key elements in this paper. They include data intergration and dynamic reservoir updating. It should be emphasized that other energy transition problems such as geothermal exploration and production can also benefit from proposed techniques with minor modifications.

Integration of Data with different Scales, Uncertainty, Resolution and Environment

Use of committee machines (modular neural networks) to integrate data from various sources with different Scale, Uncertainty, Resolution, and Environment will improve carbon storage site characterization as well as imaging and monitoring CO2 plumes. Committee neural networks can also quantify the incremental benefit of each data component on the results, both in the accuracy of the characterization and reduction in the level of uncertainty. Integration of data from different measurements, including conventional 3D seismic, micro-seismic, VSP, cross-well, electromagnetic, well log, and geochemistry data is an important goal. Different scale, uncertainty, data resolution and environments (e.g., lab-scale core-flooding data and CT imaging generated from the CO2 injection experiments to 4D seismic measurements at the field scale) are consistent with the "SURE" challenge (Figure 1).

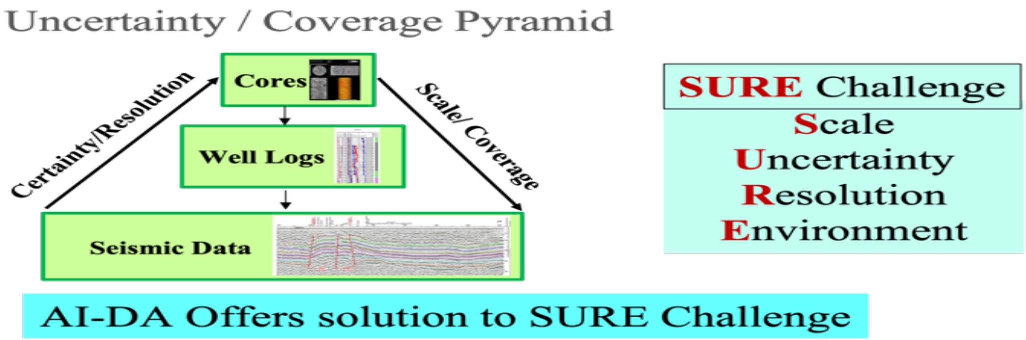

Figure5 SURE Challenge to be addressed by FACT Proprietary AI-DA Based Technology, Adopted from Aminzadeh (2021)

Dynamic updating of the reservoir parameters and potential risk factors during the CO2 injection and monitoring is very important. The real time or near real time requirements for assessing the dynamic changes in. To reduce the cost and time for updating of the subsurface model and evolution of the fracture system, we have implemented a fast recursive updating technique borrowed from control theory.

The concept is illustrated the Figure 2 (right). The Feedback loop schematically demonstrates how the recursive updating uses the old model, the new input data and the feedback parameter to calculate the new model. The process involves (1) collecting data (D_{old}), (2) creating preliminary model of the "system" S, relating the input data D_{old} to the "output" or model parameters (M_{old}), based on D_{old} and system (3) measure new data (D_{new}), and (4) update the model by tweaking the original model M_{old} through the "innovation process: (adaptive control), using D_{new}, to create the updated model (M_{new}).

An example of application of this approach for updating the fracture system from microseismic data before and after different intervals of CO_2 injection process is shown in Figure 2 (left). In this case, the slope of the fracture grouping at the top of “stage 1” of injection is changed at the second stage of injection, indicating changes in the “b” value which may indicate increased risk associated with induced seismicity because of the new injection.

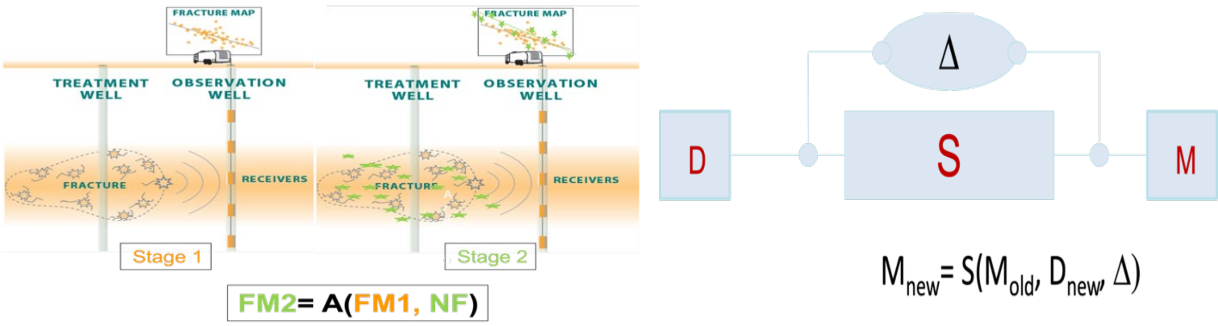

Figure2 Model updating (FM2) as a function of the old model and new fracture (MEQ) Data (left), A- FAST Recursive model updating for fracture mapping in CS-EOR (right) (Aminzadeh 2019)

DISCUSSION and RESULTS

The results shown in Figures 1 and 2 shows the benefits of using AI based method to address the SURE challenge associated with the data integration problem caused by vast differences in Scale, Uncertaintly level, data reasultion and the enviornment of different data types for reservoir charcatrization required for effective CS-EOR. It also show the power of dynamic recursive model updating for rela time monitoring of CS-EOR that reduces cost and speeds up the process.

CONCLUSION

Data integration is an important part of any site charcaterization for CS-EOR. The asscocited chanlleges can be overcome by employing AI-Based methods. Furthemore for fast and cost effective model updating, recursive model updating borroed from control theory can be useful. These tools can be more valuable as move towards interdisciplinary collaboration as we attempt to address more challenging problems.

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