Contribution ID: **563** Type: **Poster Presentation**

Towards the prediction of caprock porosity and permeability for CO2 storage seal integrity assessment

Thursday, 25 May 2023 10:45 (1h 30m)

Carbon capture and storage (CCS) requires sealing caprocks to ensure the stored CO2 is contained in the reservoir and not leaking towards the surface. Many caprocks are composed of mudrocks, a siliciclastic sedimentary rock with a high clay content. We here analyse such a caprock from the Field S which is a potential CO2 storage site in the Sarawak Basin, East Malaysia. The determination of important caprock properties, like porosity and permeability, is often difficult and requires fresh core material that is adequately stored for lab testing. When such core material is not available, drill cuttings might be used as alternatives to predict formation properties if suitable empirical relationships are available which is the objective of this study.

Therefore, we performed a petrophysical characterisation of core and cutting samples using mercury intrusion porosimetry (MIP), unsteady state pulse decay permeameter, nuclear magnetic resonance and helium pycnometry measurements. Because of shape limitations, only MIP and helium pycnometry are suitable to determine porosity and permeability on drill cuttings, while plug samples can be used for permeability tests under subsurface stress conditions. In addition, we performed a full characterisation of the sample to obtain mineralogy, pore size distribution and grain sizes. Finally, the lab data has been correlated with well log data to further understand the porosity and permeability trend for prediction purposes.

Sedimentologically, we find that the caprock in Field S is divided into two facies (Seal A and Seal B) with varying clay contents of ~20 and ~40% respectively. In term of grain size distribution, this field is mostly dominated by fine silt (2.0 to 6.3 microns), with a higher fine silt content in the deeper Seal B. However, laboratory determined porosity and permeability do not vary significantly between these two facies, even though seal B has higher clay contents. This might be because Seal B is significantly over-pressured compared to Seal A, potentially resulting in porosity preservation during compaction and therefore increased permeability. This is consistent with the time-to-depth conversion from seismic data, where Seal B is identified as being undercompacted in comparison to Seal A. Porosity from MIP is generally lower than porosity from helium pycnometry, for both core samples and drill cuttings. This is because mercury invasion is restricted to pores >3 nm and therefore underestimates the total porosity. Additionally, porosity and permeability values determined on unconfined drill cuttings are always higher than the values measured on confined plug samples.

Here, we will present our workflow in predicting porosity and permeability of caprocks based on a petrophysical and mineralogical database developed for Seal A and B. We will discuss issues with this approach and its potential and highlight the difficulties in determining permeability from confined plug or unconfined cutting samples.

Participation

In-Person

References

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Session Classification: Poster

Track Classification: (MS01) Porous Media for a Green World: Energy & Climate