Poster # 3982

Seal assessment and estimated storage capacities of a targeted CO_2 reservoir based on new displacement pressures in SW Wyoming, U.S.A.

Lynsey Spaeth (lspaeth@uwyo.edu), Erin Campbell-Stone, Ranie Lynds, Carol Frost, J. Fred McLaughlin
University of Wyoming, Department of Geology and Geophysics

Introduction

A stratigraphic test well was drilled on the Rock Springs Uplift (RSU) in southwestern Wyoming, USA to characterize the site for CO_2 sequestration. Seal analysis for this location includes detailed lithologic characterization, regional mapping to determine extent and lateral variation, and mechanical analysis. Using mercury injection capillary pressure data, column heights were calculated for the RSU using converted pressures for brine/CO_2 systems, the interfacial tensions of CO_2, water, and substrate, as well as the densities of CO_2 and brine.

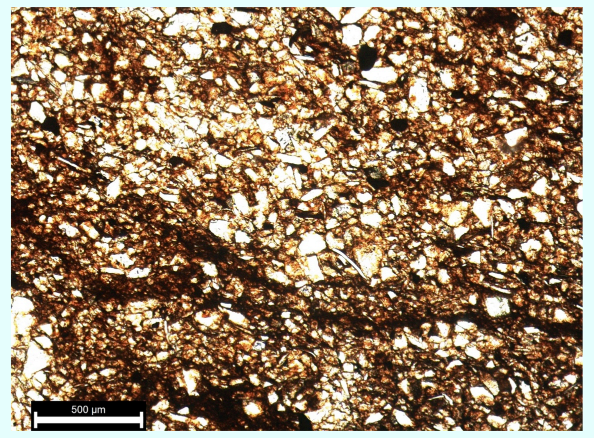


Fig. 1. Photomicrograph of a quartz-rich portion of the Dinwoody Formation (ppl)

Location and stratigraphy

Fig. 2. Location map of the stratigraphic test well, RSU #1, in southwestern Wyoming.

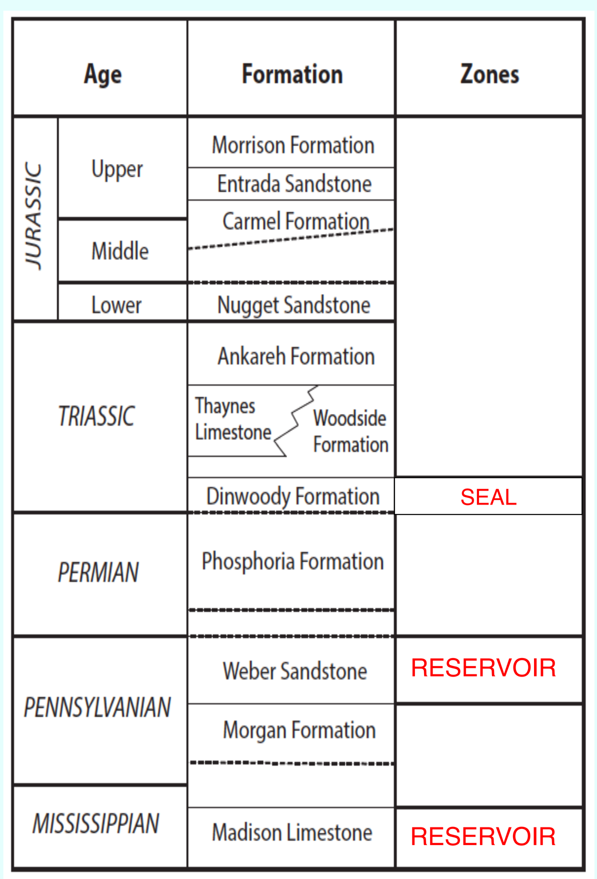


Fig. 3. Simplified stratigraphic column showing proposed reservoir and seal units for CO_2 sequestration on the RSU.

Acknowledgments

We thank the Carbon Management Institute at the University of Wyoming. Funding for this project was provided by the U.S. Department of Energy, University of Wyoming School of Energy Resources, and the American Association of Petroleum Geologists.

Characteristics of the seal

- Typically greenish-gray in outcrop, the Dinwoody Formation varies from 15 m thick near type locality in Wyoming to 273 m thick in Colorado (**Fig. 4.**)

Fig. 4. Dinwoody Formation outcrop southwest of the RSU

- 27 m of core recovered and described from test well on RSU
- Comprised mainly of sandy siltstone with minor to moderate amounts of primary and secondary anhydrite and minor amounts of mica
- Thin sections demonstrate variability of grain size throughout seal (**Fig. 5.**)

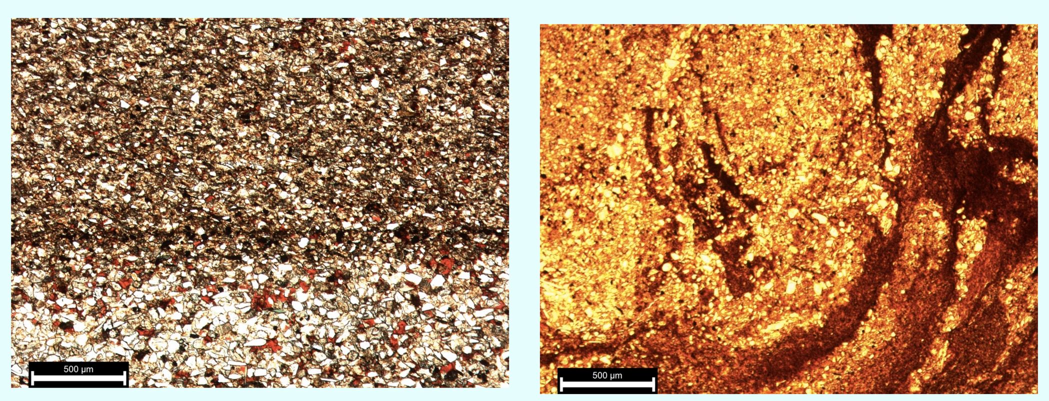


Fig. 5. Grain size variation in samples (images in ppl)

- Secondary anhydrite growth is recorded (**Fig. 6.**)

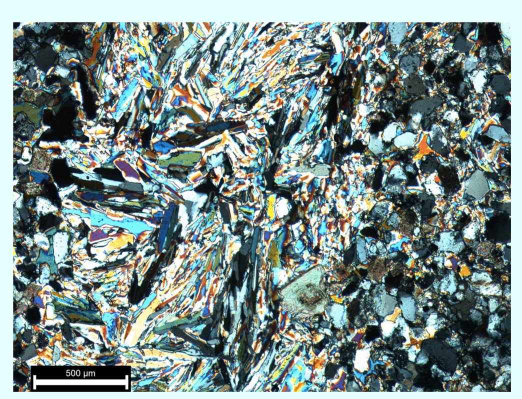


Fig. 6. Secondary anhydrite growth (xpl)

- Interpreted as shallow marine deposit

Capillary pressure data and interpretation

Data

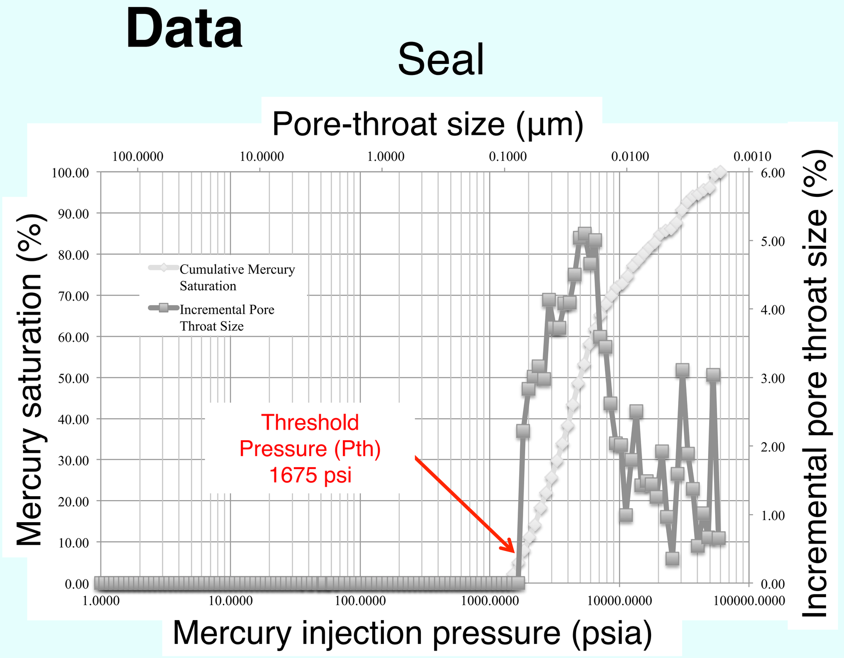


Fig. 7(a). Mercury injection capillary pressure analysis of Dinwoody Formation, seal.

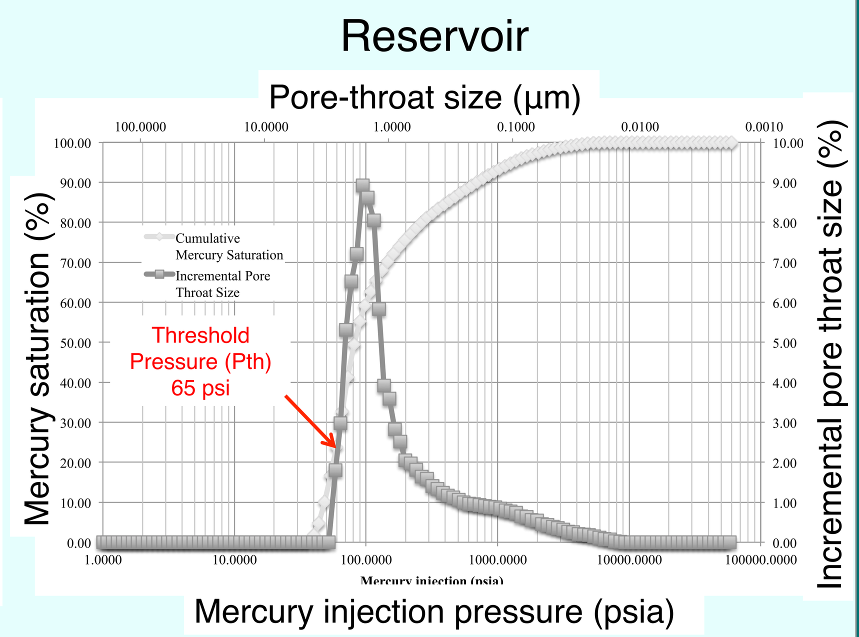


Fig. 7(b). Mercury injection capillary pressure analysis of Weber Formation, reservoir.

Interpretation

The data from the mercury injection were converted to estimates for the brine-CO_2 system. A range of variables were used in converting data from the air/mercury system to the brine-CO_2 system, including:

- Interfacial tension of air/mercury ($\sigma_{a/m}$): 485 mN/m
- Contact angle of air/mercury ($\theta_{a/m}$): 130°
- Interfacial tensions of brine/CO_2 ($\sigma_{b/CO2}$): 25.2 – 26.4 mN/m
- Contact angles of brine/CO_2($\theta_{b/CO2}$): 0° – 80°
- Brine density (ρ_b): 1.01 g/cc
- CO_2 densities (ρ_{CO2}): 0.688 and 0.86 g/cc

Mercury injection pressure data ($P_{a/m}$) was first converted to subsurface CO_2-water system pressures ($P_{b/CO2}$) using the equation:

$$P_{b/CO_2} = P_{a/m}\frac{(\sigma_{b/CO_2}\cos\theta_{b/CO_2})}{(\sigma_{a/m}\cos\theta_{a/m})}$$

Height above free water level (h) was calculated utilizing the converted pressure data using:

$$P_{c\,b/CO_2} = h(\rho_b - \rho_{CO_2})0.433$$

Maximum column heights (h_{max}) were calculated using:

$$h_{max} = (P_{ths} - P_{thr}) \div (\rho_b - \rho_{CO_2})0.433$$

Table 1. Example seal capacities for Dinwoody Formation using an estimated CO_2 density of 0.688 g/cc and an interfacial tension of 25.8 mN/m for the brine-CO_2 system. CA = contact angle

Formation and Sample number	CO_2 Column Height (m) at CA 0°	CO_2 Column Height (m) at CA 20°	CO_2 Column Height (m) at CA 40°	CO_2 Column Height (m) at CA 60°
Dinwoody - 1	194	182	148	96
Dinwoody - 4	263	247	189	131
Dinwoody - 16	584	549	447	292
Dinwoody - 18	291	273	222	145

Challenges and considerations

- No experimental data to validate assumptions about interfacial tension and contact angle of CO_2
- Seal exhibits lateral and vertical variations in lithology
- Sealing formation is not in direct contact with reservoir unit
- Data are limited to one test well
- Threshold pressures are difficult to determine graphically for some capillary entry pressure tests (example: **Fig. 8.**)

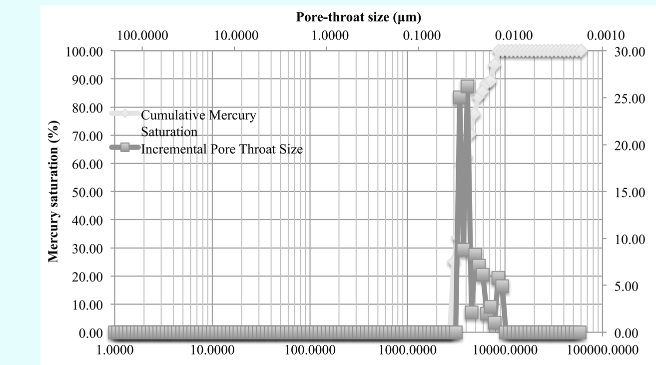
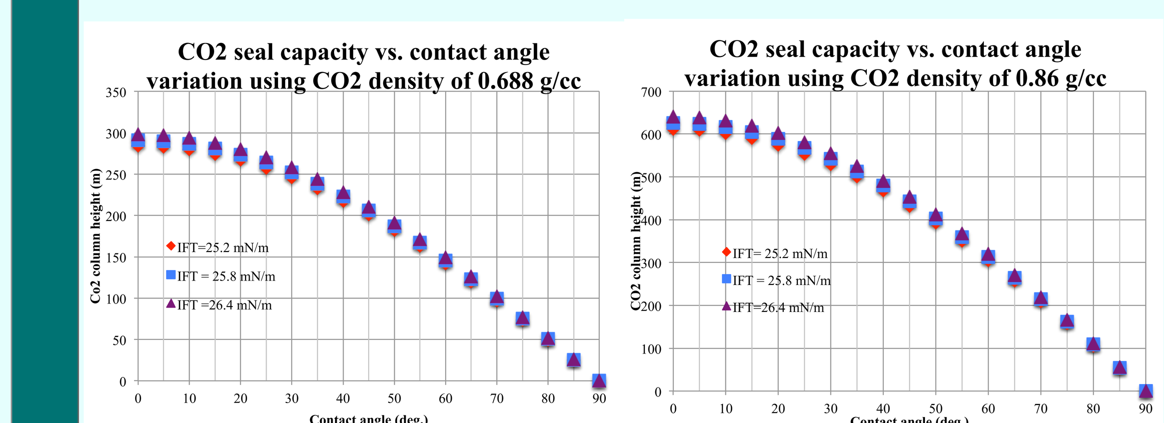


Fig. 8. Mercury injection capillary pressure analysis of seal with multiple threshold pressure possibilities

Conclusions

Lithology of the Dinwoody Formation suggests that this unit is a good potential seal. The plots below illustrate the sensitivity of the column height calculation with respect to three variables: interfacial tension of brine/CO_2 , contact angle of brine/CO_2 , and density of CO_2.



In order to determine whether this reservoir's capacity will be limited by the seal or by reservoir thickness, more certainty is needed from experimental data with respect to the contact angles of the brine/CO_2/substrate for this system and the density of CO_2 at depth of injection for the well.

Literature cited

Chiquet, P., and D. Broseta, 2005, Capillary alteration of shaly caprocks by carbon dioxide; Society of Petroleum Engineers Paper No. 94183, 10 p.

Daniel, R.F., and J.G. Kaldi, 2009, Evaluating seal capacity of cap rocks and intraformational barriers for CO2 containment, *in* M.Grobe, J.C., Pashin, and R.L. Dodge, eds., Carbon dioxide sequestration in geological media – State of the science: AAPG Studies in Geology 59, p. 355-345.

Schowalter, T.T., 1979, Mechanics of secondary hydrocarbon migration and entrapment: AAPG Bulletin, v. 63, p. 723-760.

Varva, C.L., J.G. Kaldi, and R.M. Sneider, 1992a, Capillary pressure, *in* D. Morton-Thompson and A.M. Woods, eds., Development geology reference manual: AAPG Methods in Exploration Series 10, p. 221-225.

University of Wyoming
School of Energy Resources