An Improved Approach for Sandstone Reservoir Characterization

D. Ross-Coss, W. Ampomah, R.S. Balch, M. Cather, P. Mozley, L. Rasmussen, New Mexico Institute of Mining and Technology

Abstract:

The Farnsworth Unit (FWU), is located in the northeast Texas Panhandle. Characterization is undertaken as part of a Phase III project conducted by the Southwest Regional Partnership on Carbon Sequestration (SWP). Extensive data acquired from FWU was used to improve previously constructed static and dynamic models.

The Morrow B reservoir is the target for interval for injection and production at FWU. It was deposited as fluvial low-stand to transgressive clastic fill within an incised valley. However, It was shown that primary depositional fabrics have less effect than post depositional diagenetic features do on reservoir performance. In order to characterize the heterogeneous porosity and permeability relationships the, Winland LogR35 method was used.

The method involves grouping porosity and permeability measurements into intervals with similar sized pore throats. It was successfully used to identify 8 distinct Hydraulic Flow Units (HFU) within the reservoir. There was a strong relationship between HFU and depositional and digenetic trends such as Calcite cementation at the bottom of the reservoir and Siderite cementation at the top. The HFU then became the basis for a facies model subsequently used to propagate porosity and permeability as a function of HFU.

This method of using core calibrated Hydraulic flow units for petrophysical modeling was able to accurately quantify reservoir heterogeneity within FWU. The approach illustrated presents an improved methodology in characterizing heterogeneous and complex reservoirs that can be applied to reservoirs with similar geological features.

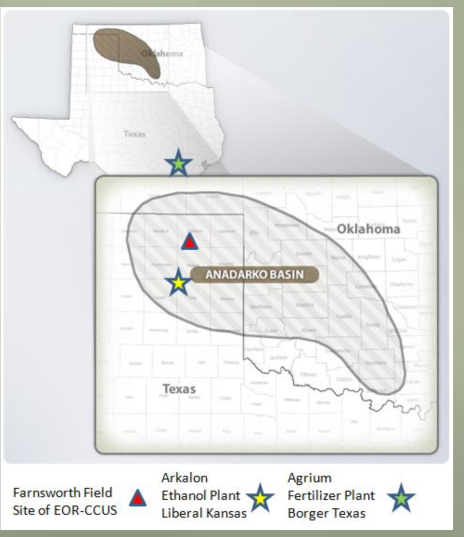


Figure 1. Site location of SWP's CCUS project. Modified from Grigg and McPherson, (2012).

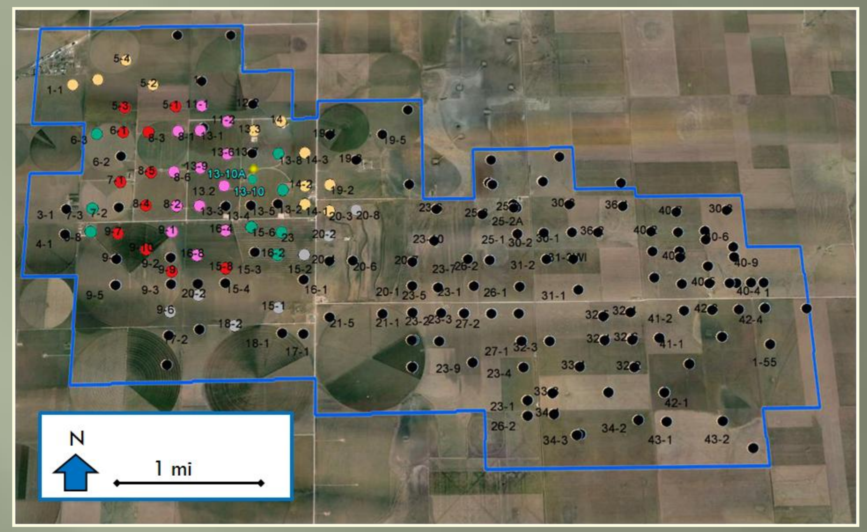


Figure 2. Field map and well locations. Active injection and production on west side of field

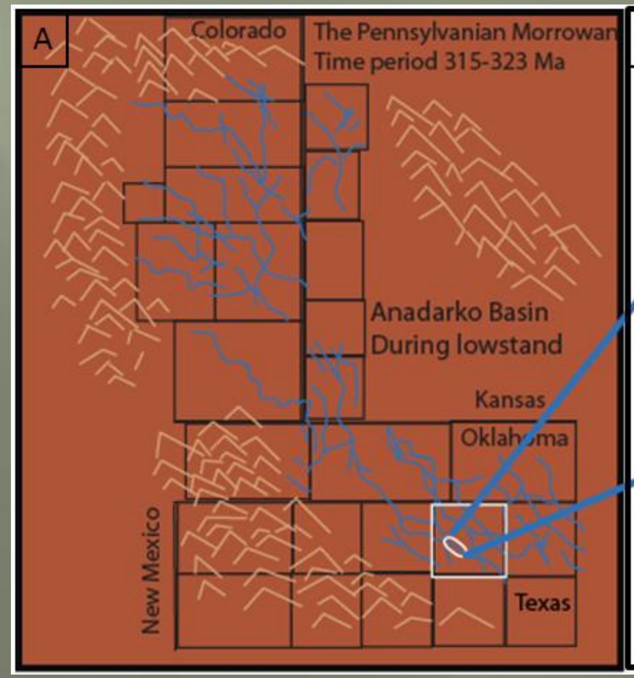


Figure 3. Paleogeography of Anadarko basin during a late-Pennsylvanian. Image depicts fluvial systems that deposited Morrowan incised valley reservoirs. Modified from Puckette et al. 2008

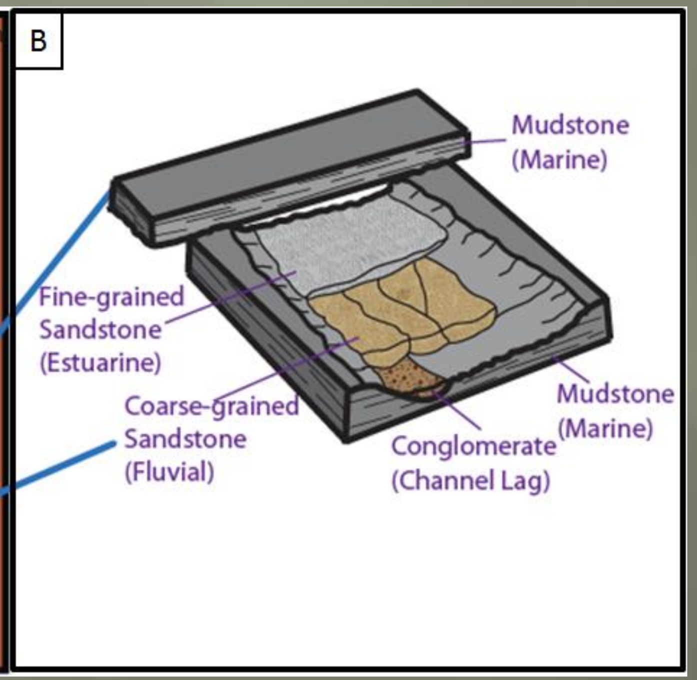


Figure 4. Incised valley depositional sequence. Injection and production occur within the coarse grained sandstone. The overlying mudstones serve as caprock or sealing lithologies. Modified from Puckette et al. 2008

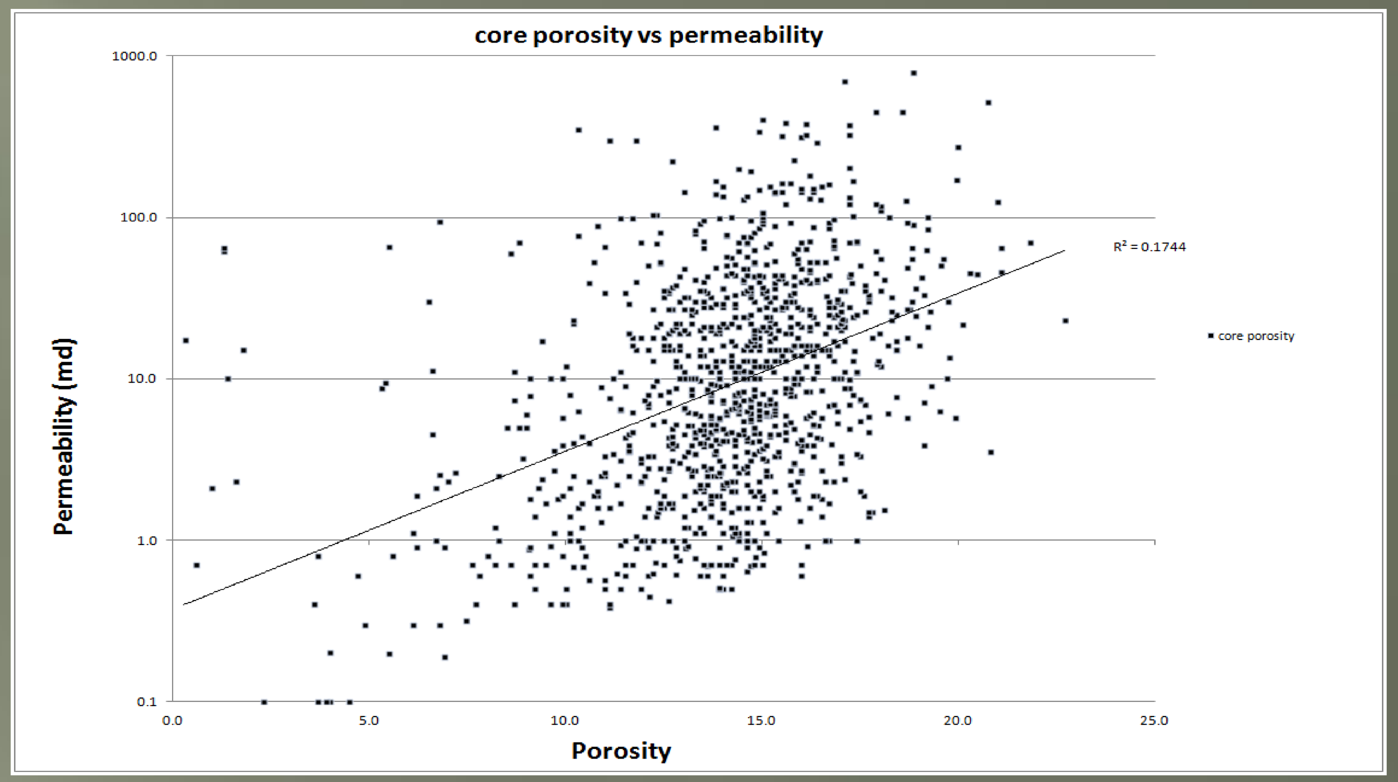
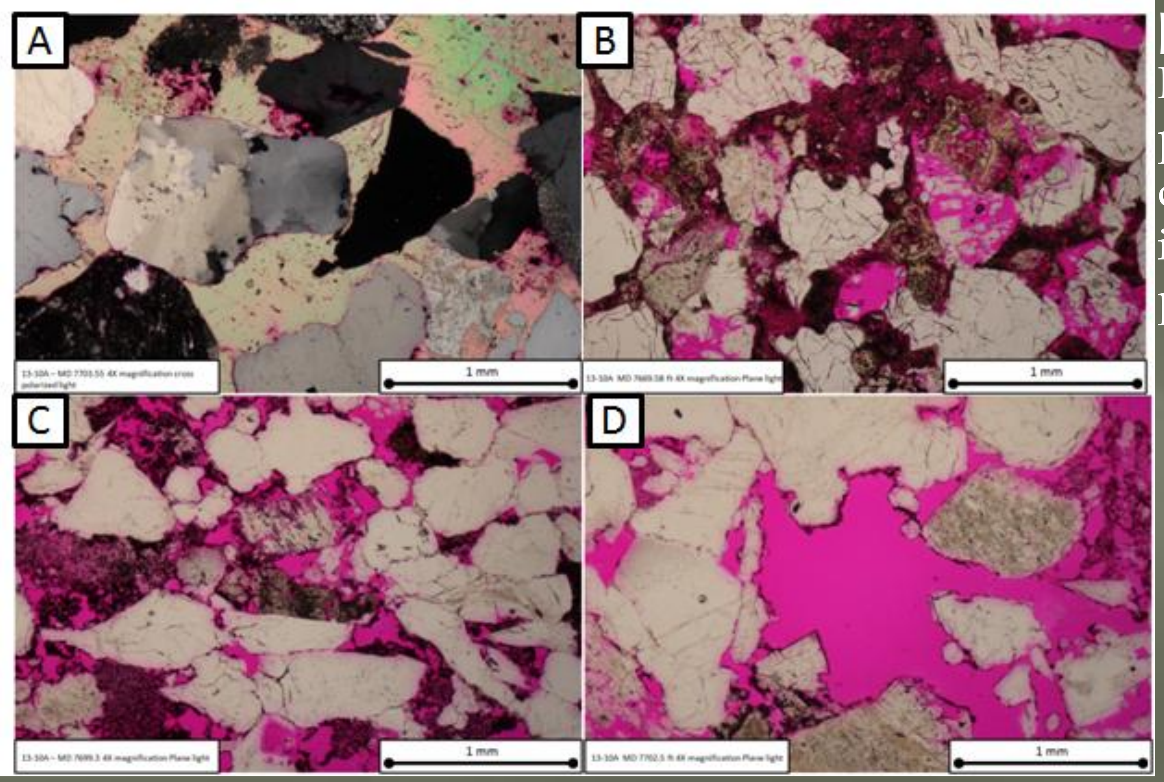


Figure 5. Porosity versus permeability for 51 cored wells.

- A hydraulic flow unit is a representative unit of rock where the geological and petrophysical properties that control fluid flow are internally consistent but predictably different (Amaefule, et al., 1993, Svirsky, et al., 2004)
- R35 refers to the pore throat aperture radius when core samples are 35 % saturated during a mercury porosimetry test (Gunter, et al., 2014).
- **log R35 = 0.732 + 0.588(logKair) – 0.864(logϕcore)**

[A] HU1 Porosity occluded by calcite cement

[C] HU5 Lack of inter grain cementation enables better flow paths



[B] HU3 Intra-granular porosity dominant, lacks interconnected pore networks

[D] HU8 abundant macro-pores creates great flow paths

Figure 6. Petrographic relationship to HFU.

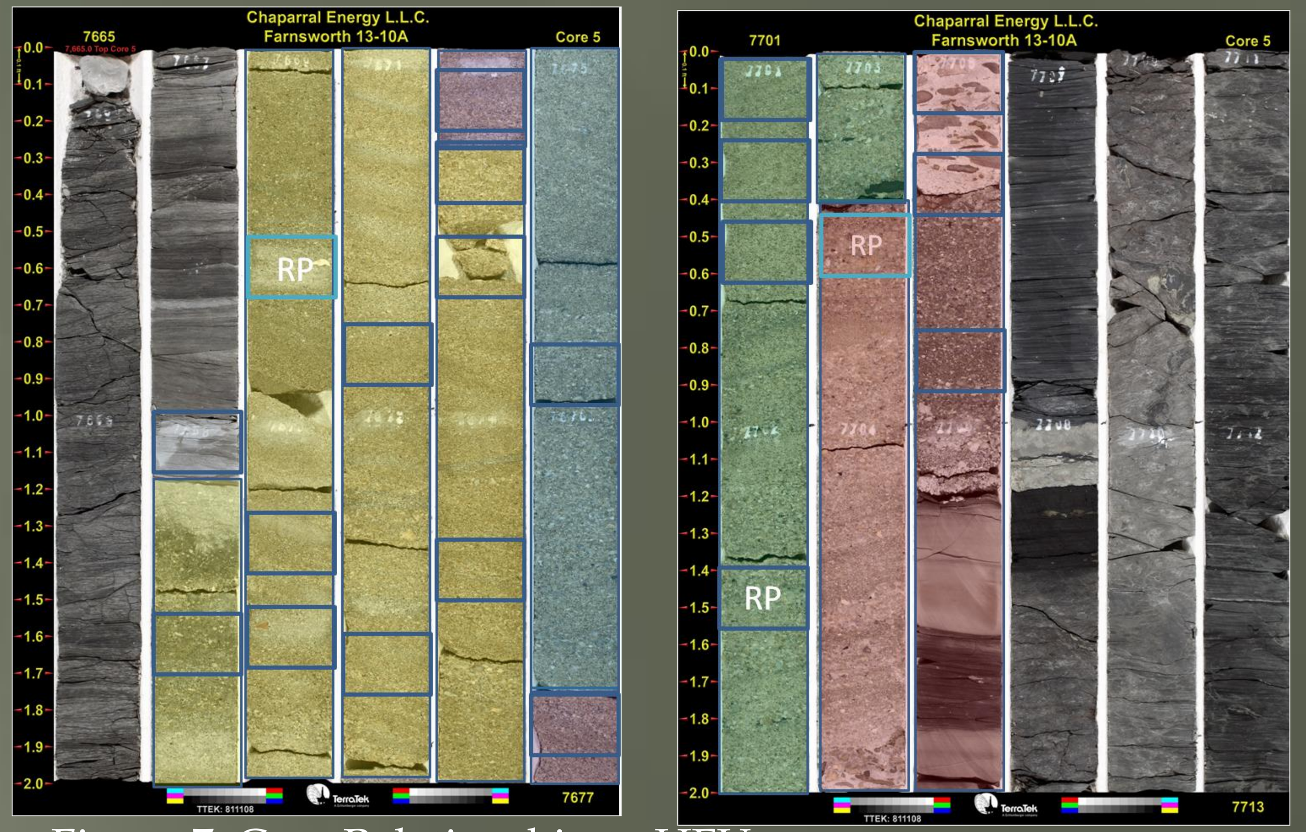


Figure 7. Core Relationship to HFU

HFU 1-3 | HFU 3-4 | HFU 4-5 | HFU 6-7 | HFU 7-8

Core sampling location | RP Relative permeability

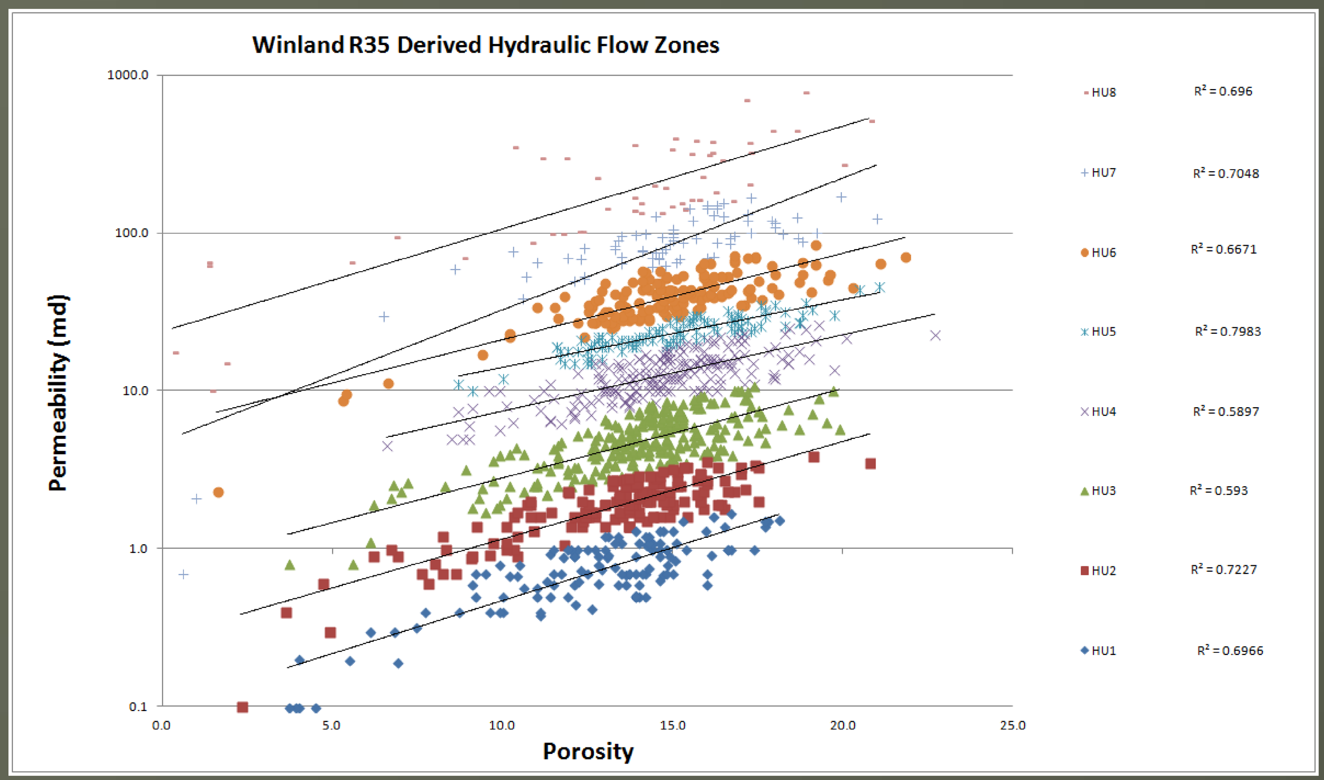


Figure 8. Porosity versus permeability for 51 cored wells separated by pore throat size into Hydraulic Flow Units.

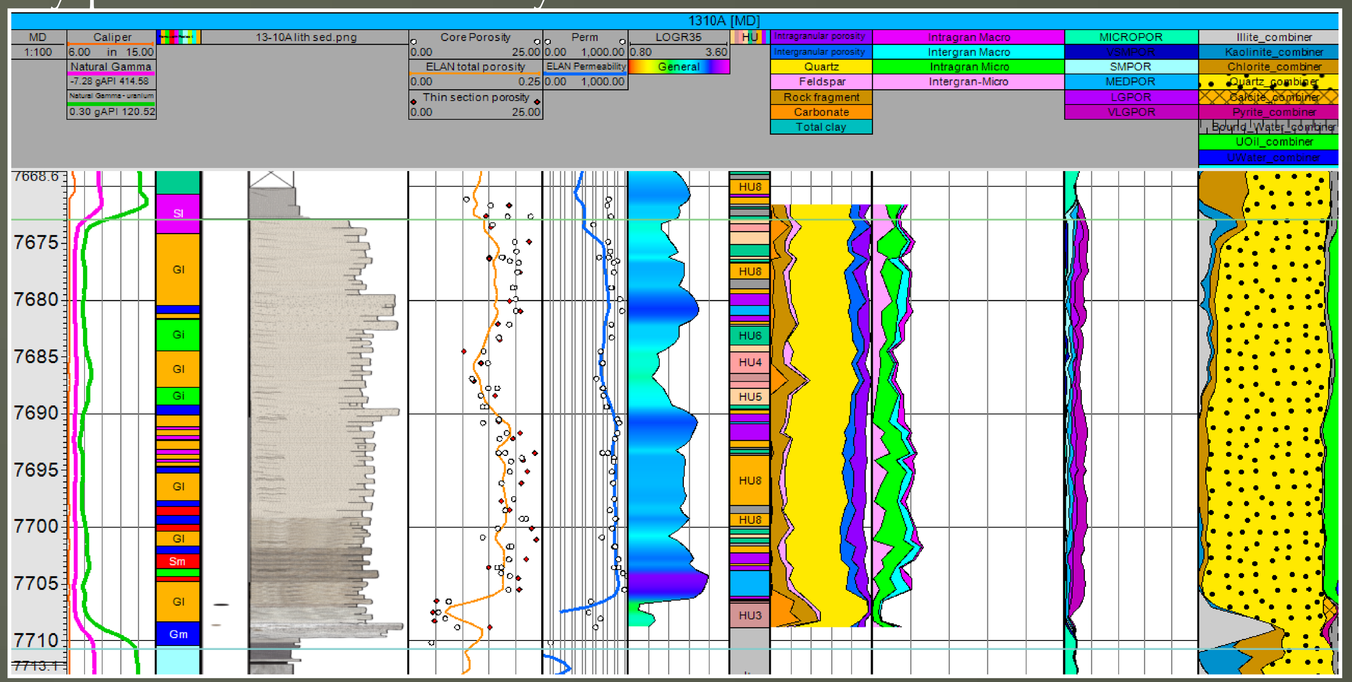


Figure 9. HFU compared to Core, Petrography and Petrophysics.

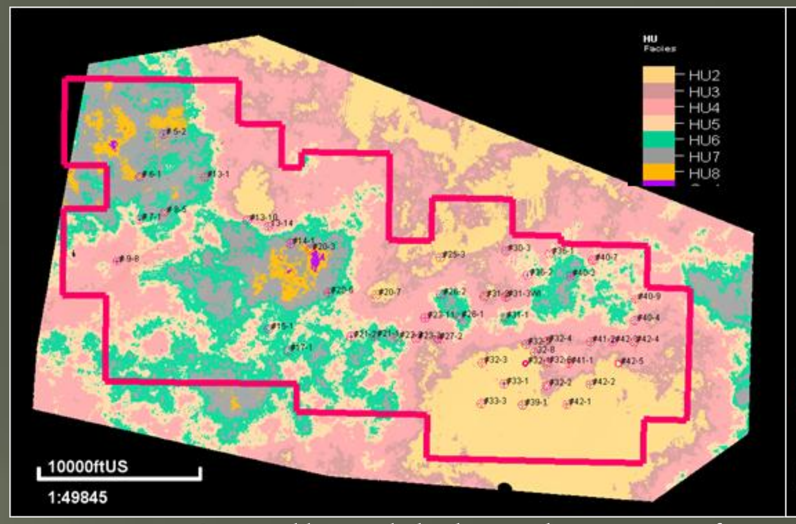


Figure 10. Full Field distribution of Hydraulic Flow Units binned using R35 values.

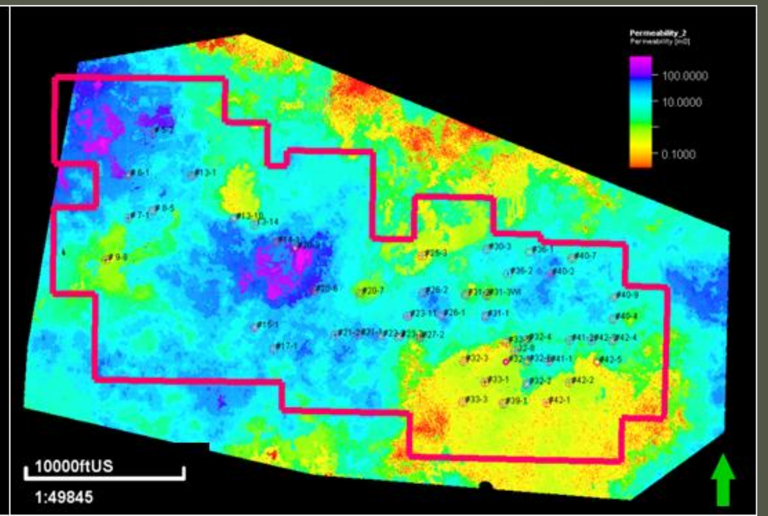


Figure 11. Full Field permeability distribution as a function of HFU.

Conclusions:

- Primary depositional fabrics were previously determined to have little effect on porosity and permeability trends. Diagenesis had a greater role in controlling flow paths.
- The R35 up-scaled log values captured reservoir heterogeneity and simplified porosity and permeability distinctions.
- Modeling porosity as a function of HFU ensured that the algorithms applied to porosity values were appropriate and that they adequately reflected the geological heterogeneity of the reservoir.

Acknowledgements:

Funding for this project is provided by the U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL through the Southwest Regional Partnership on Carbon Sequestration (SWP) under Award No. DE-FC26-05NT42591. Additional support has been provided by site operator Chaparral Energy, L.L.C. and Schlumberger Carbon Services.