Geologic CO, Storage in Kentucky: Interim Results of the Kentucky Consortium for Carbon Storage Tests

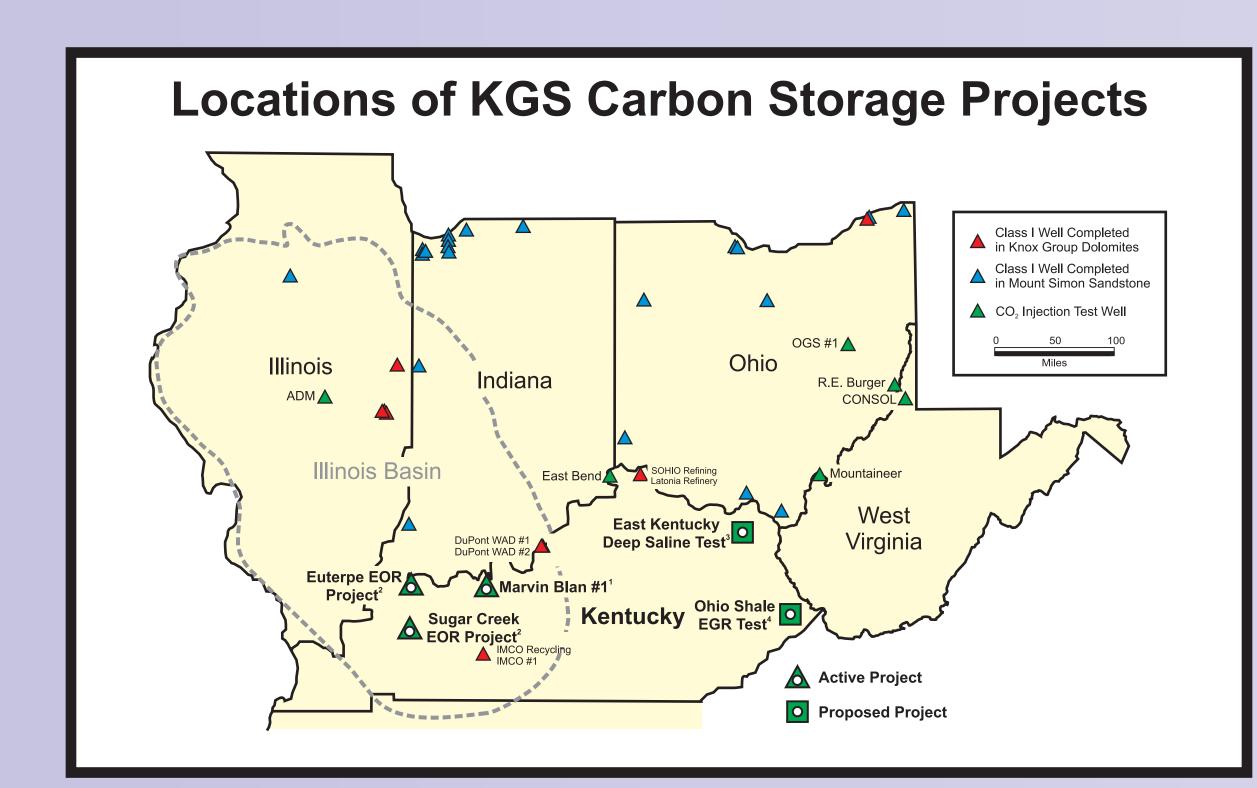
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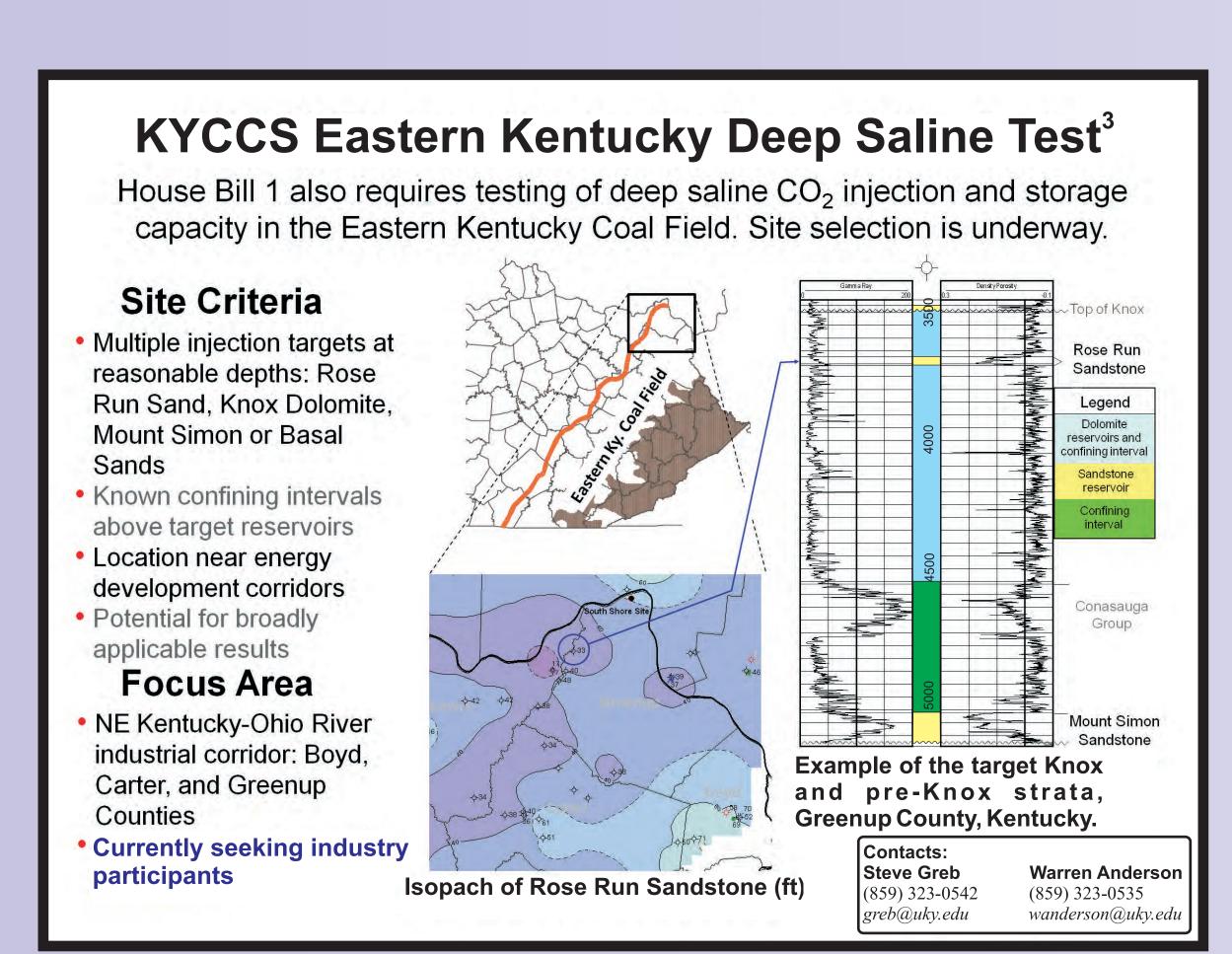
Halfway through a 4-year research and demonstration program, KYCCS participates in two CO₂ enhanced oil recovery pilot projects, and will begin injection tests in 2010 in the Ohio Shale in eastern Kentucky. Progress continues toward locating and funding an eastern Kentucky deep saline test.

KYCCS and the Kentucky Carbon Storage Foundation completed initial testing in the 8,126-ft deep KGS No. 1 Blan well, Hancock County, southern Illinois Basin, in fractures. Conventional cores from the Knox had porosity averaging 6.1% in the upper Knox and 3.8% in a deeper section. Injection of 18,454 bbl brine and 323 tons of CO₂ (1,765 bbl), and pressure falloff tests, indicates good injectivity in the upper Knox. Additional testing is planned for 2010, but initial results suggest the Knox is a viable storage reservoir.

EOR projects include geochemical monitoring at the Midwest Geological Sequestration Consortium's pilot immiscible CO₂ flood in Sugar Creek Field, Hopkins County. Gas and brine analyses tracks movement of CO₂ during this 8,000-ton injection. A separate immiscible, cyclic CO₂ project in Euterpe Field is

KYCCS will test the sequestration potential of the organic-rich Ohio Shale in a Pike County well. This test will measure adsorptive storage capacity and injectivity of gas-bearing organic shales.

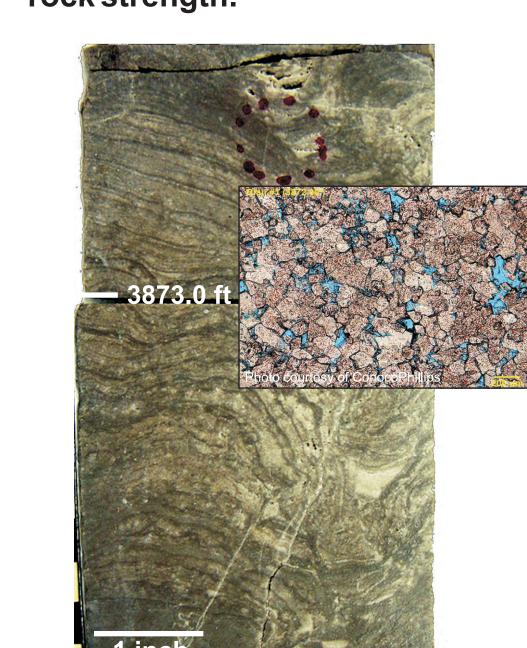




Evaluating CO₂ Storage in the Knox Dolomite Marvin Blan #1, Hancock County, Kentucky¹

Coring Program

Three whole diameter 4-inch cores totaling 243 ft were cut in the Knox Dolomite to test





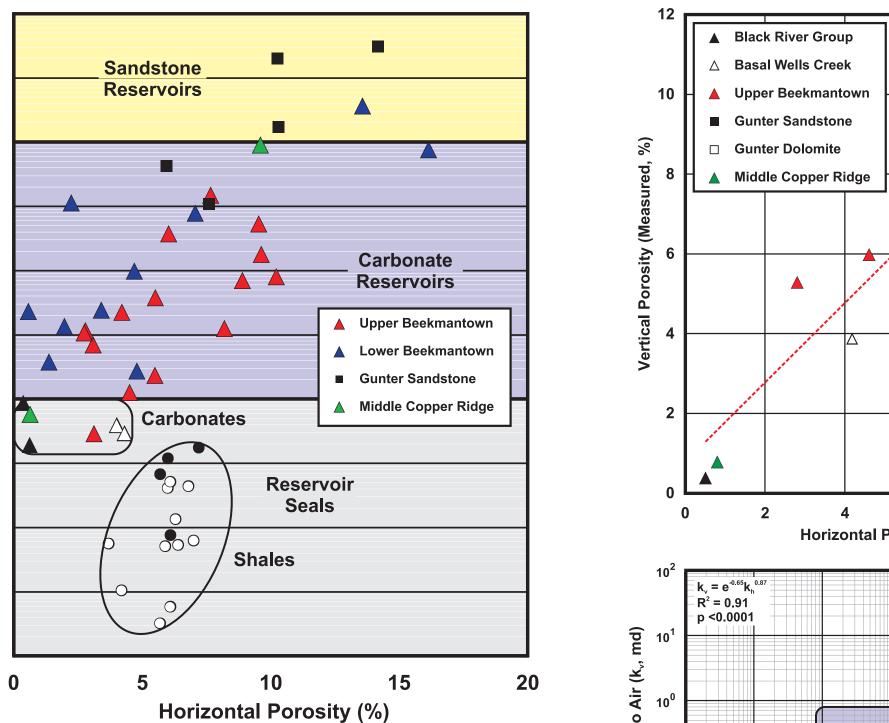
Fractures developed at 3875 ft.



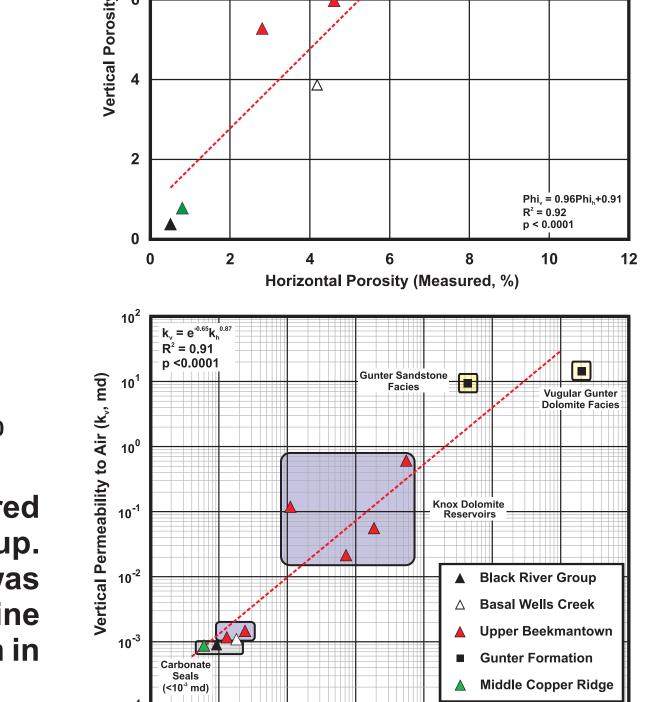
Vuggy porosity zone at 5098.5 ft.

Rick Bowersox 359) 323-0536

Core Porosity and Permeability

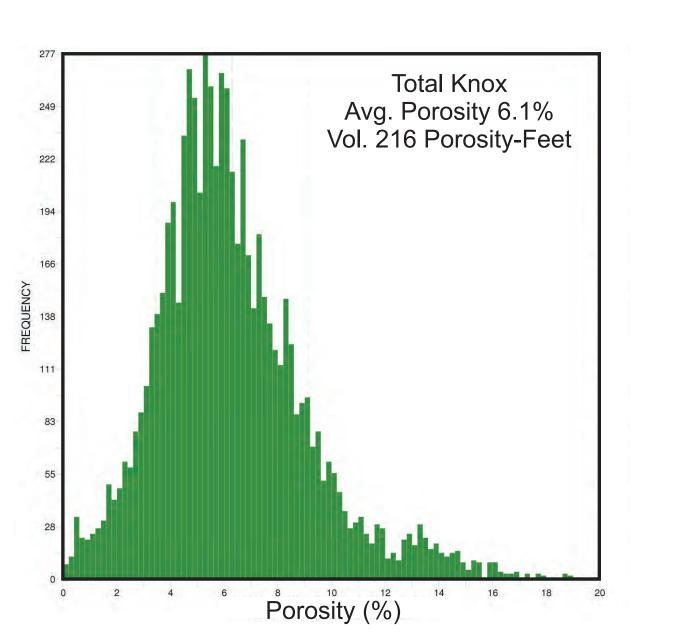


Porosity and permeability were measured in core plugs from the Knox Group. Vertical porosity and permeability was measured in selected plugs to determine the potential for vertical communication in the Knox reservoir.

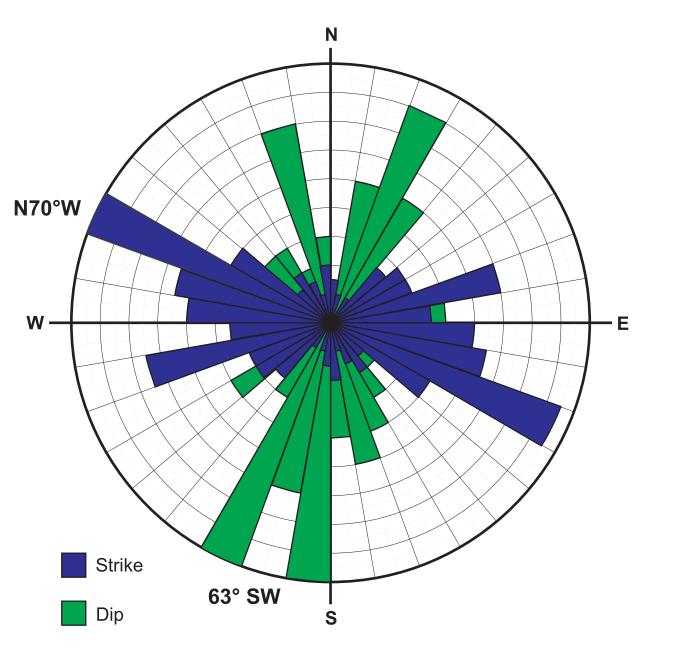


☐ Gunter Dolomite

Knox Reservoir Porosity



Porosity calculated from the density log is generally normally distributed except for the fraction >12.5% porosity. This peak of secondary porosity is most likely from secondary, vugular porosity.



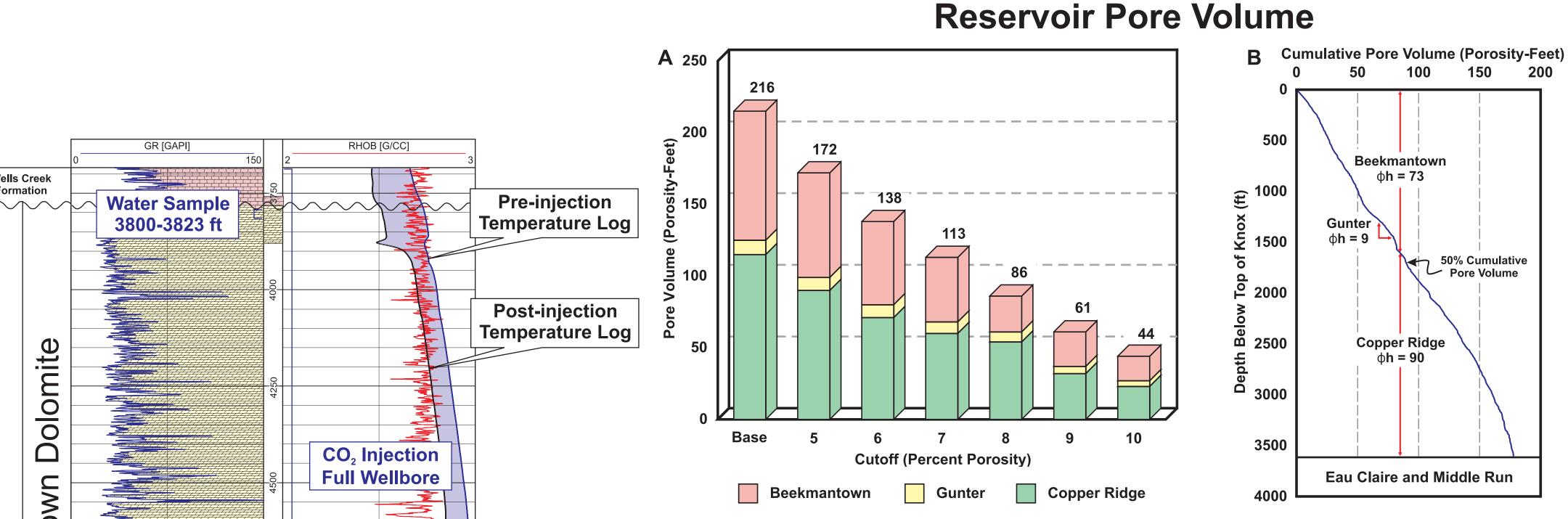
 0^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}

Knox Fracture System

The natural fracture system in the Knox was interpreted from the formation imaging log. Average strike of fractures is N70°W and dip is 63° SW. Most fractures occur in the **Copper Ridge Dolomite.**

Kentucky, and a consortium of industry and government partners, including: Western Kentucky Carbon Storage Foundation, Inc., Louisville, Kentucky; ConocoPhillips Company, Houston, Texas; Peabody Energy, St. Louis, Missouri; E.ON U.S., Louisville, Kentucky; Tennessee Valley Authority, Knoxville, Tennessee; Illinois Department Technology Laboratory, Morgantown, West Virginia; GEO Consultants, LLC, Paducah, Kentucky; Schlumberger Carbon Services, Houston, Texas; Smith Management Company, Lexington, Kentucky; Wyatt, Tarrant & Combs, LLP, Lexington, Kentucky.

Drillsite access was granted by Marvin and Brenda Blan, Hawesville, Kentucky, and R&B Resources, LLC, Gaylord, Michigan. Project management services were ovided by Sandia Technologies, LLC, Houston, Texas. Seismic data acquisition and processing services were provided by WesternGeco, LLC, Houston, Texas.



Knox pore volume was evaluated in 7 cases. The Copper Ridge has the greatest contribution to total pore volume due to its longer section. A.) At a 5% porosity cutoff, total pore volume was 172 porosity-feet, or sufficient to store one million tons of CO₂ under a 200 acre surface tract. B.) 50% of the total Knox pore volume occurs in the Beekmantown-Gunter and uppermost Copper Ridge section.

Injection Testing



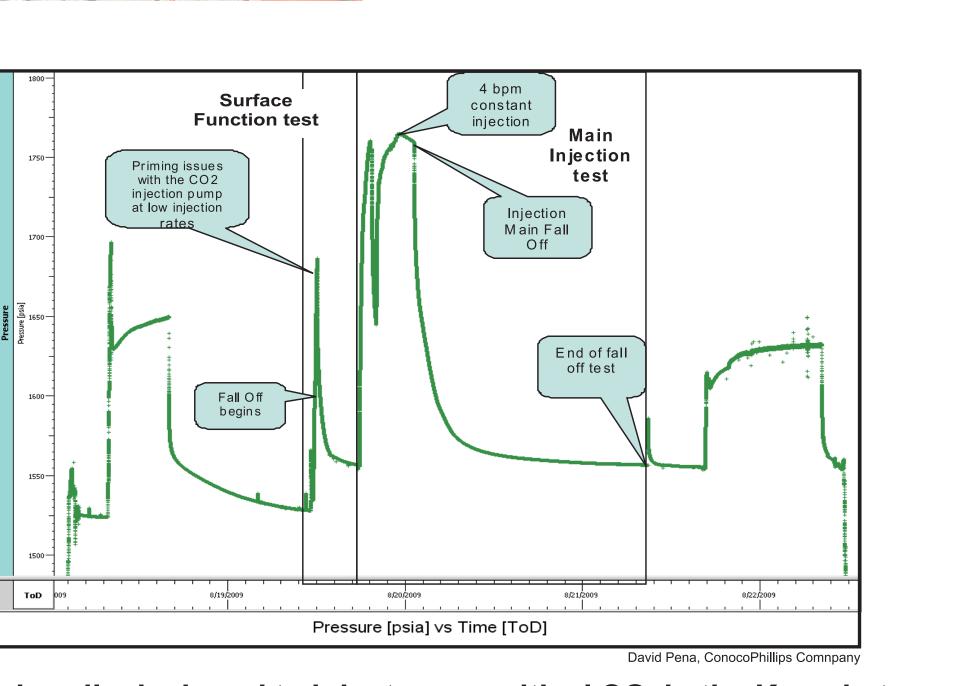
Point 7100 ft

7180-7455 ft

Eau

Claire

Four injection tests were performed using 2% KCI brine. Three tests used straddle packers to isolate short intervals in the Copper Ridge. The fractured basal Copper Ridge broke down at a 0.9 psi/ft gradient and took water on vacuum. Two tests in the upper Copper Ridge lost their seal due to communication through formation porosity system around packers. Two tests were performed with a single packer: 2% KCI brine injected into the Copper Ridge below 6089 ft, and the full wellbore below 3620 ft. In the full wellbore test, 7076 BW with borax tracer were injected at rates to 14 BPM and wellhead pressures of 285-500 psi. Analysis found 70% of water was njected above the Copper Ridge.



Test #6 was primarily designed to inject supercritical CO, in the Knox in two stages. First was a short, 40 ton test to pressure test surface equipment and evaluate the range of injection pressures required to inject at the desired rate for phase two. Phase two injected 300 tons of CO₂ in the Knox. CO₂ was injected at a rate of 4.0 bpm, with a total of 1765 bbl of CO₂ injected during the constant rate test. Final injection BHP and BHT at 3580 ft were 1753.8 psia and 103.2° F. A post-injection temperature survey across the test interval found the deepest injection point of CO₂ at 5230ft.

Western Kentucky CO, Enhanced Oil Recovery Tests²



Euterpe field (Henderson County) with top Cypress structure map,.



Field production 42 BOPD from 33 BOPD since temporary Miss. Jackson Ss. @ avg. 1870 ft Oil: viscosity= 7.5 cp, gravity= 35.8 API OOIP—2,410,000 BO

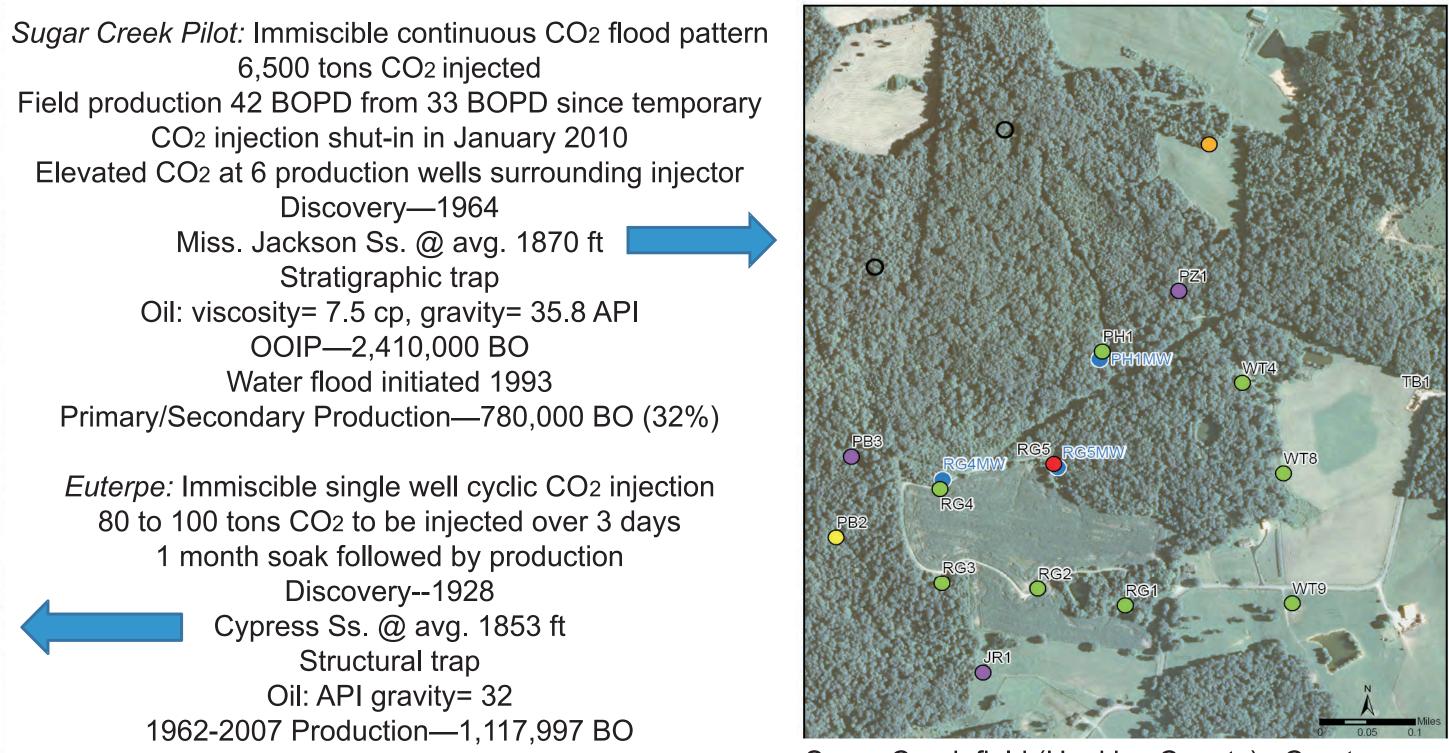
Primary/Secondary Production—780,000 BO (32%) 80 to 100 tons CO₂ to be injected over 3 da

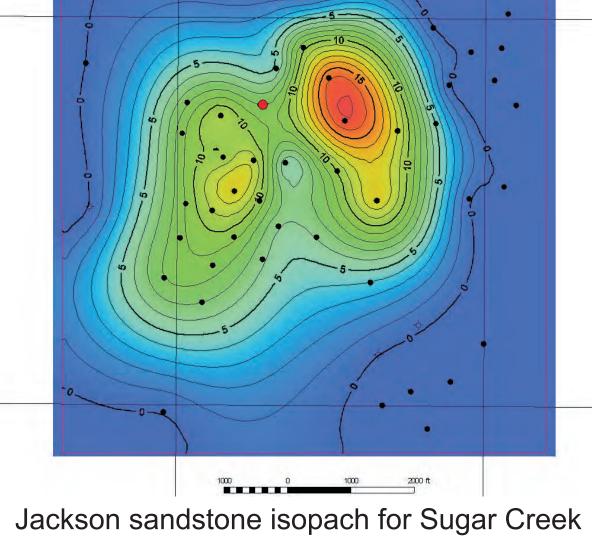
Cypress Ss. @ avg. 1853 ft Oil: API gravity= 32

 Dry or unknown GW monitoring well



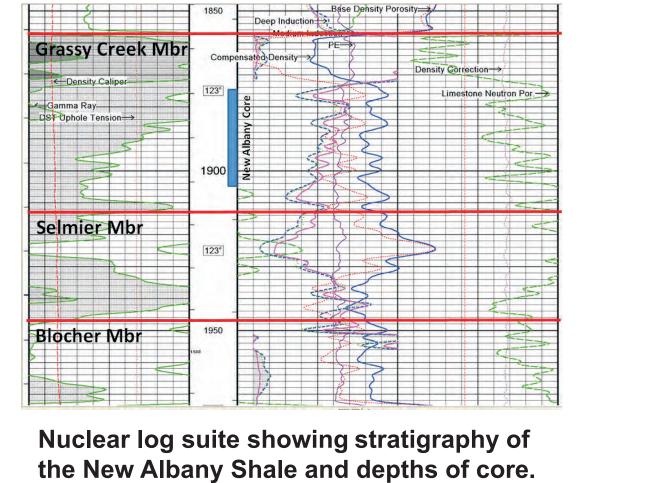
Sugar Creek well with CO2 tank and tank battery in background.

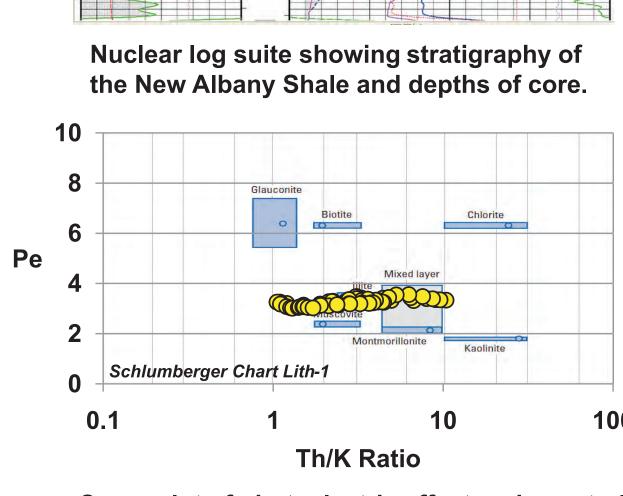




oil field. Courtesy Jim D'Amico, ISGS.

Characterization of the New Albany Shale in the Marvin Blan #1 Well⁴

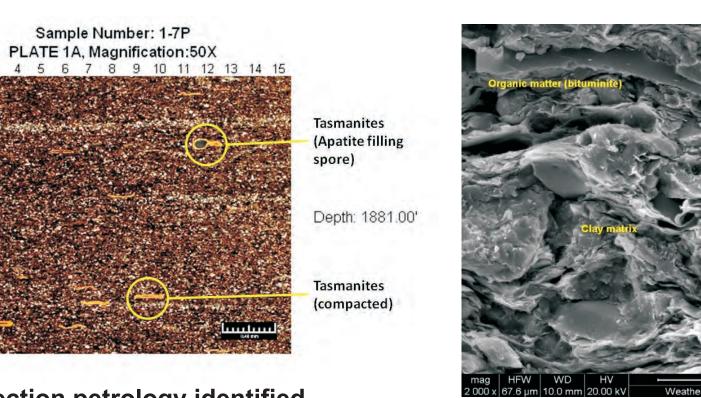




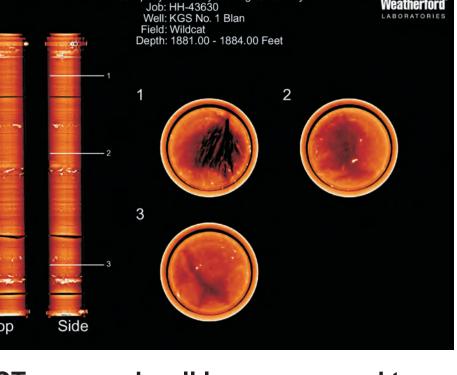
gamma ray for clay mineral identification.

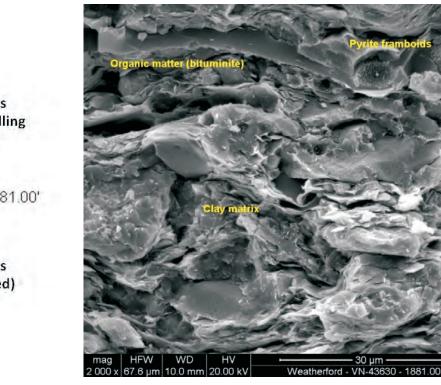


Core recovered in aluminum sleeve was cut into 3-foot sections for shipping

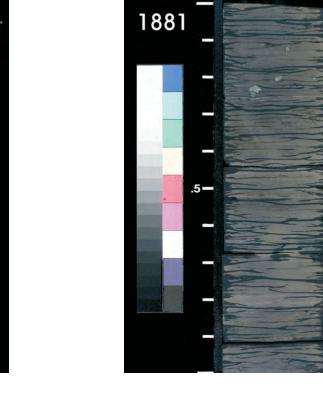


Thin section petrology identified





SEM and nano-porosity analyses a



early pyrite formation as indicated by compaction and drape features.

The New Albany Shale is a continuous, low-permeability organic-rich gas shale occurring throughout the Illinois Basin. The shale is the source rock for most of the hydrocarbons in the basin and





