

Assessment of the Newburg Sandstone as a CO₂ Storage Unit in West Virginia*

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Abstract

Concern over CO₂ emissions from power plants has sparked great interest in several deep saline aquifers within the Appalachian Basin. The Silurian Newburg Sandstone Play, a well-developed gas reservoir, has clearly defined fields with high porosity and permeability. However, outside of these fields, well control and well samples are sporadic.

Examination of existing cores yields new information, which questions not only the original depositional model, but also the Newburg correlation with rocks that outcrop in eastern West Virginia. These new data allow for a more complete reconstruction of the depositional history of the basin and help explain the transition into the evaporite sequence of the overlying Salina formation. This thick package of evaporitic strata provides an extensive seal above a potential Newburg storage horizon.

The compartmentalized nature of the Newburg Sandstone suggests that it is more appropriately suited for small-scale injection tests into individual, proven, exhausted production fields as opposed to large-scale, regional storage operations. The unique characteristics of the Newburg make it an interesting formation, which should be considered regarding other energy issues in addition to CO₂ sequestration. A depleted field may also be appropriate for other injection activities, such as the trend of utilization of CO₂ for the enhanced recovery of natural gas. Brine disposal operations might also benefit from the unique characteristics of the Newburg.

Selected References

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Patchen, D.G., 1996, The Atlas of Major Appalachian Gas Plays: West Virginia Geological and Economic Survey (WVGES), v. 25, 141 p.

Smosna, R., and Patchen, D., 1978, Silurian Evolution of Central Appalachian Basin: AAPG Bulletin, v. 62, p. 2308-2328.

Ryder, R.T., C.S. Swezey, R.D. Crangle, and M.H. Trippi, 2008, Geologic cross section E-E' through the Appalachian basin from the Findlay arch, Wood County, Ohio, to the Valley and Ridge province, Pendleton County, West Virginia: US Geological Survey Scientific Investigations Series Map 2985, 2 sheets, 48 p.

Website

Blakey, R., 2010, Paleogeography website: Northern Arizona University, <http://jan.ucc.nau.edu/~rcb7/index.html>

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Cleveland, OH

www.wvgs.wvnet.edu



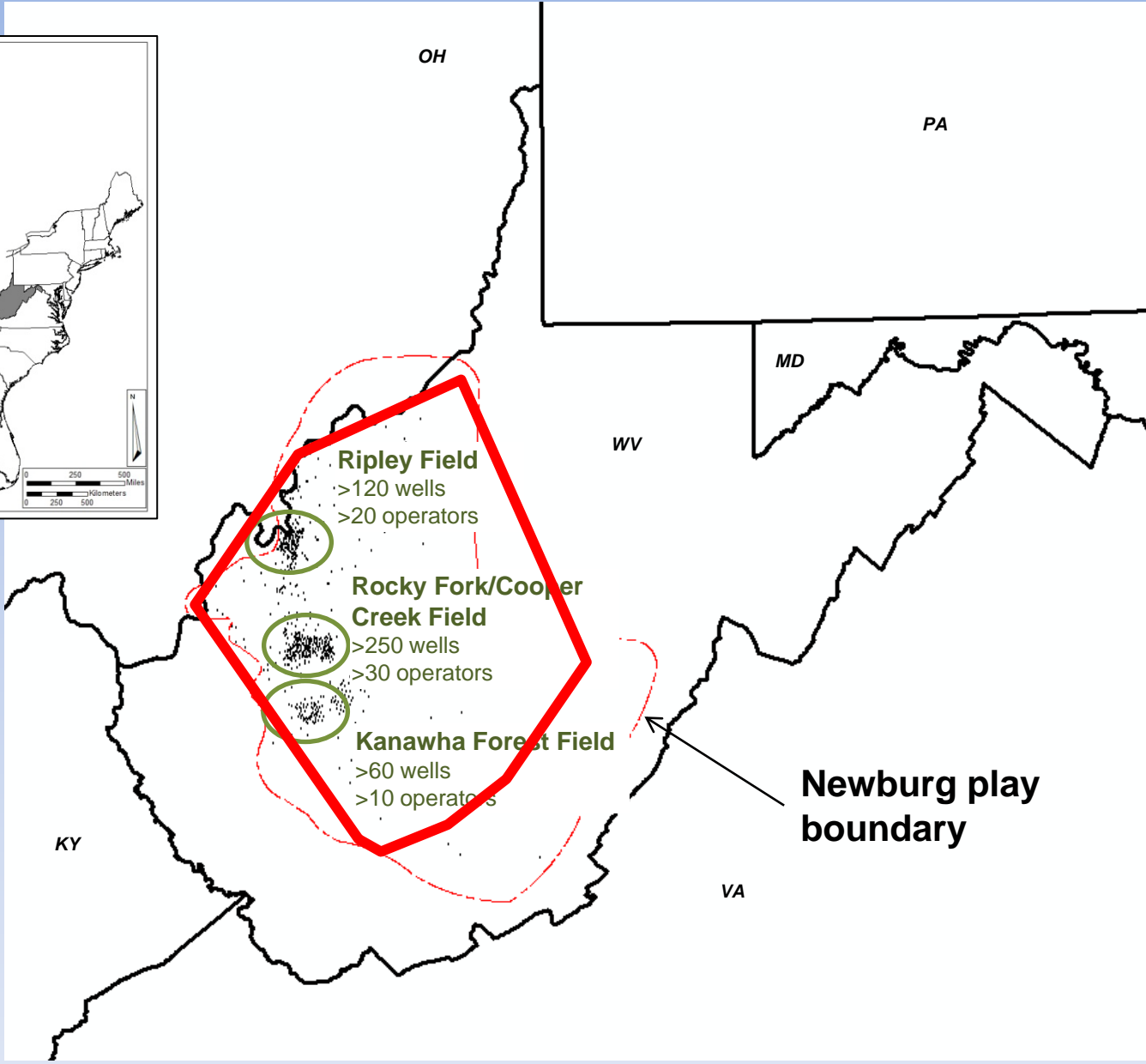
Assessment of the Newburg Sandstone as a CO₂ Storage Unit in West Virginia

- Introduction
- Regional Geology
 - Depositional History
 - Structural Setting
 - Refining the depositional model
- Methodology and Data Set
 - Log analysis
 - Calculations
- Conclusions

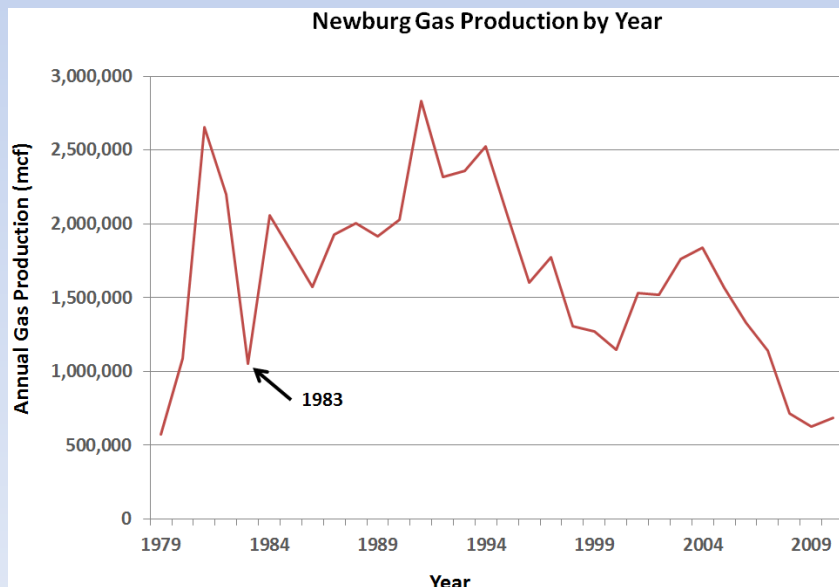
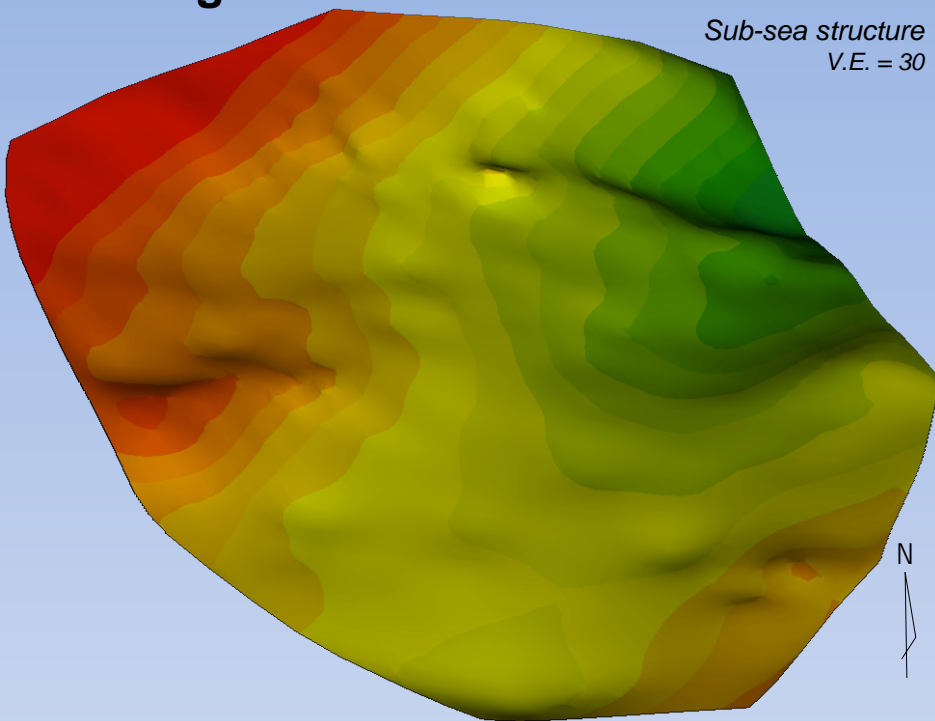
Newburg Assessment – Introduction



- WVGES involved in a research support program initiated by the WV DOE in October 2007.
- Deep saline aquifers in this study include the Oriskany, Newburg and Tuscarora Ss.
- All considered in initial MRCSP phases.



Newburg Assessment – Introduction



(Source: WVGES database)

- Gas play developed during the 1960's and 1970's.
- High initial open flows >2000psi.
- Uncharacteristically over pressured compared to most flows in the basin.
- Sourced from Taconic uplifts to the east.
- Thin, but extensive “sheet” sandstone underlying most of WV.
- Mixed carbonate-siliciclastic sediments cemented by calcite, silica, and evaporites.
- Well sorted, fine- to very fine-grained.
- Gas fields are structural and stratigraphic traps.
- Production last 7-10 years.
- Depth 4000' – 9000'; thicknesses up to 50'.

(Source: Patchen, 1967, 1968, Newburg Gas Development in West Virginia)

Newburg Assessment

Regional Geology

- Depositional history
- Structural setting
- Refining the depositional model

Newburg Assessment – Regional Geology

Approach of Greenland and Europe towards North America



Early Silurian 430 mya

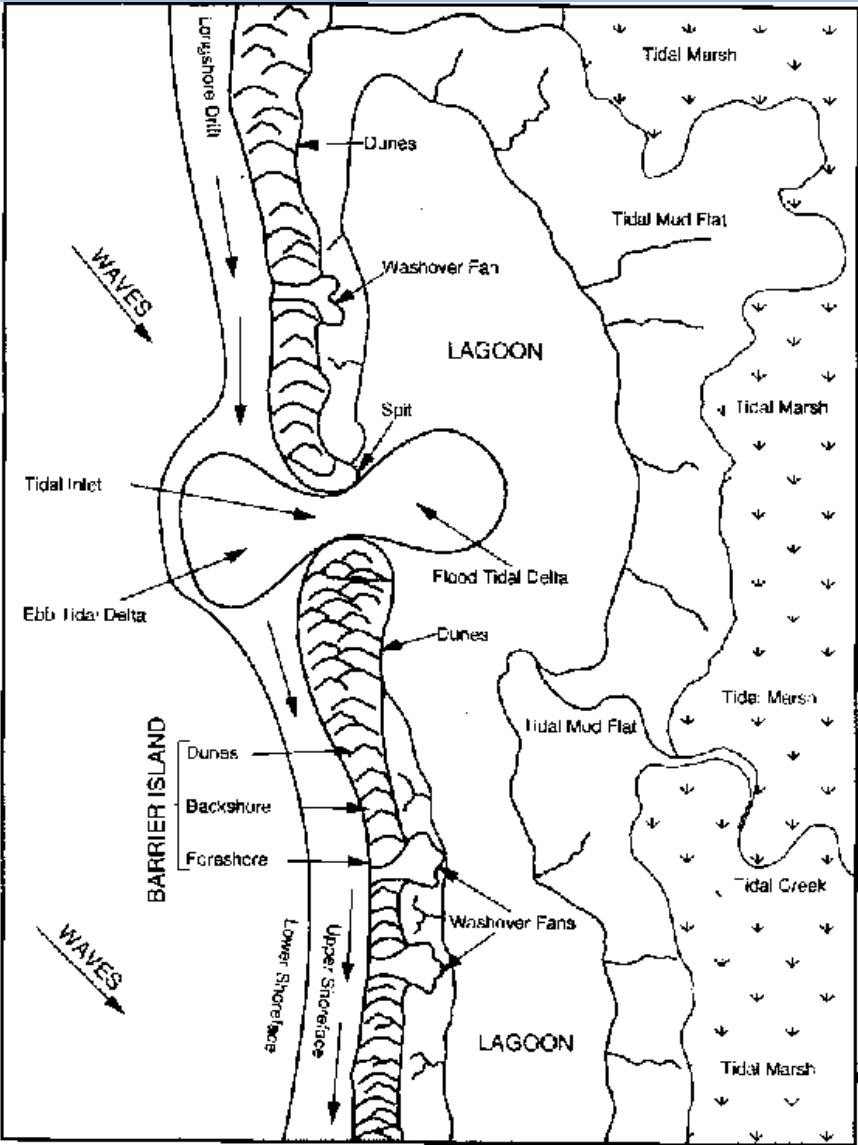
Seaway to open ocean



Late Silurian 420 mya

Late Silurian, seaway gets cut off by uplift, formation of Salina

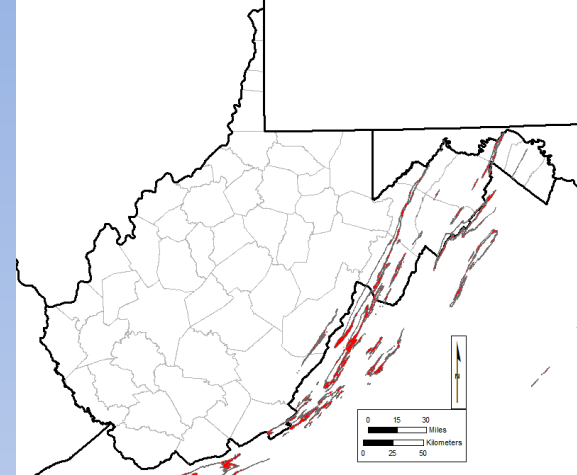
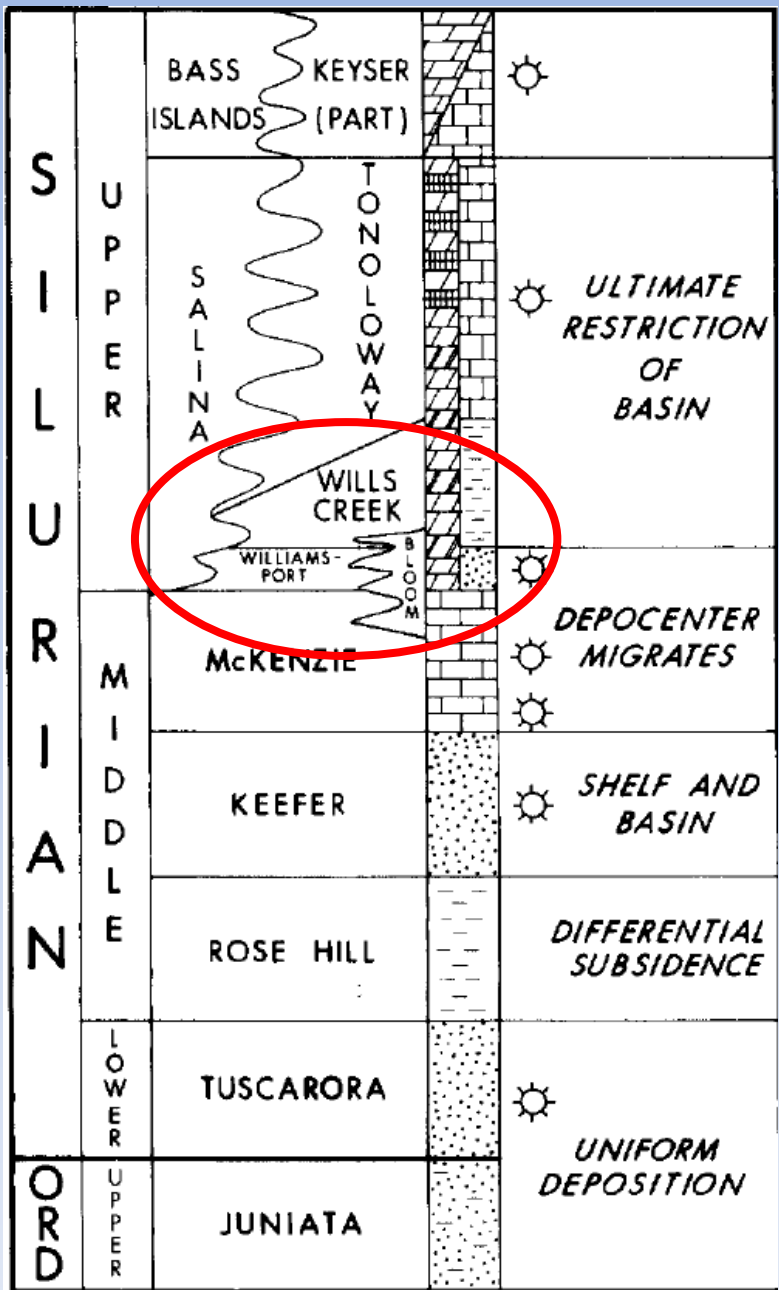
Standard depositional model



Barrier Island

- **Foreshore**
High energy/wave action
Reworked sediments
Longshore drift
- **Backshore**
Lagoons
Washover fans
- **Tidal deposits**
Marshes
Mud flats

Newburg Assessment – Regional Geology



• **Outcrop** - Tonoloway, Wills Creek and Williamsport correlate with the Salina.

• **Subsurface** - “Middle” Silurian Newburg lies between Salina and overlies McKenzie.

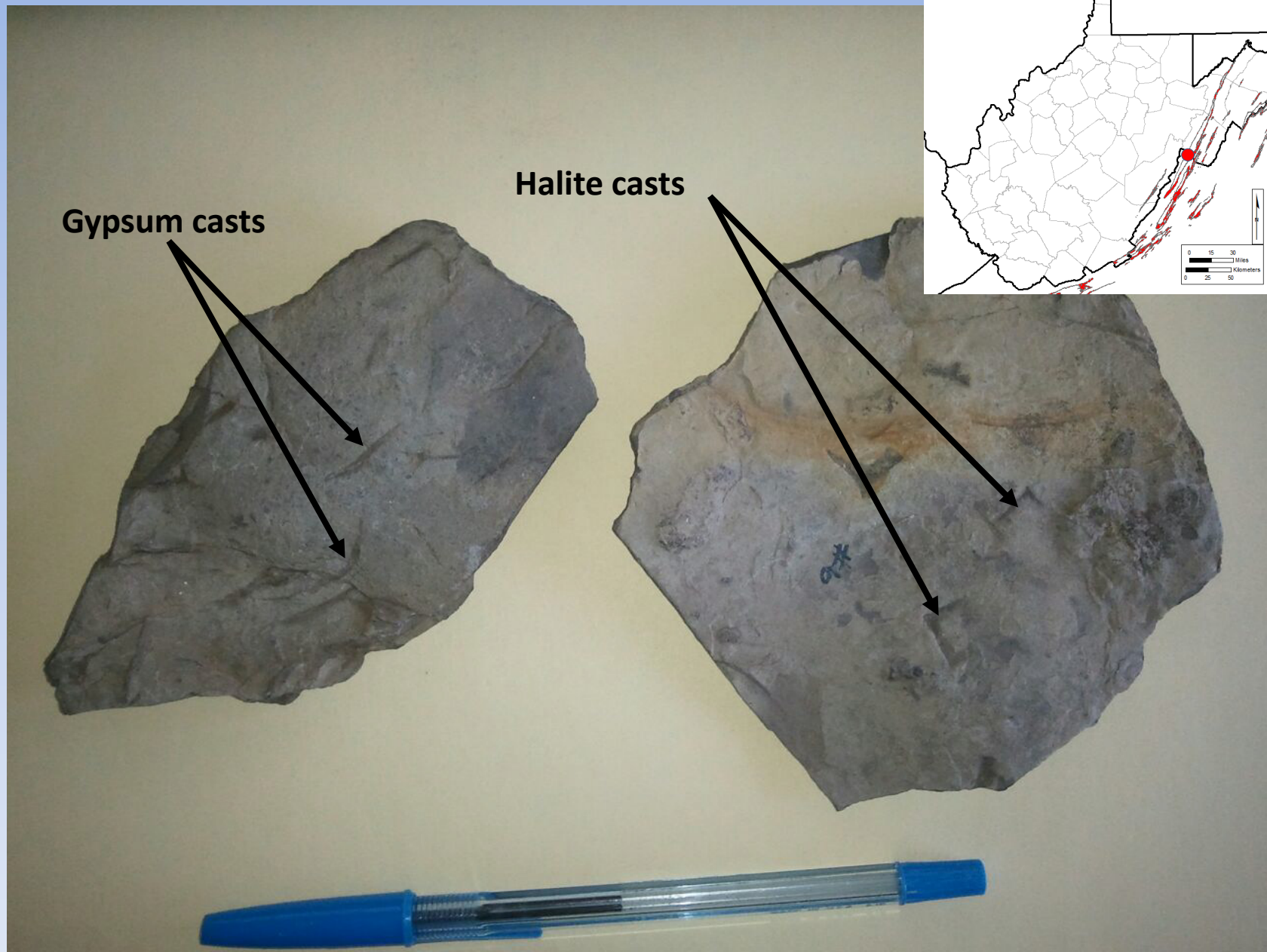
• **Traditionally correlated with Williamsport** (blocky, highly fractured, quartz sandstone)...

but...

Modified from Smosna, R., and Patchen, D., 1978, Silurian Evolution of Central Appalachian Basin, AAPG V. 62, pp. 2308-2328

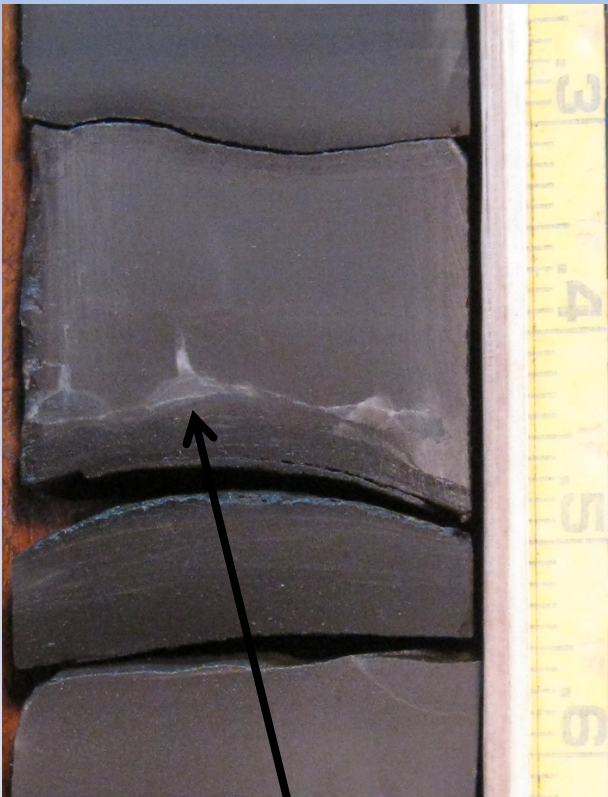


Newburg Assessment – Regional Geology

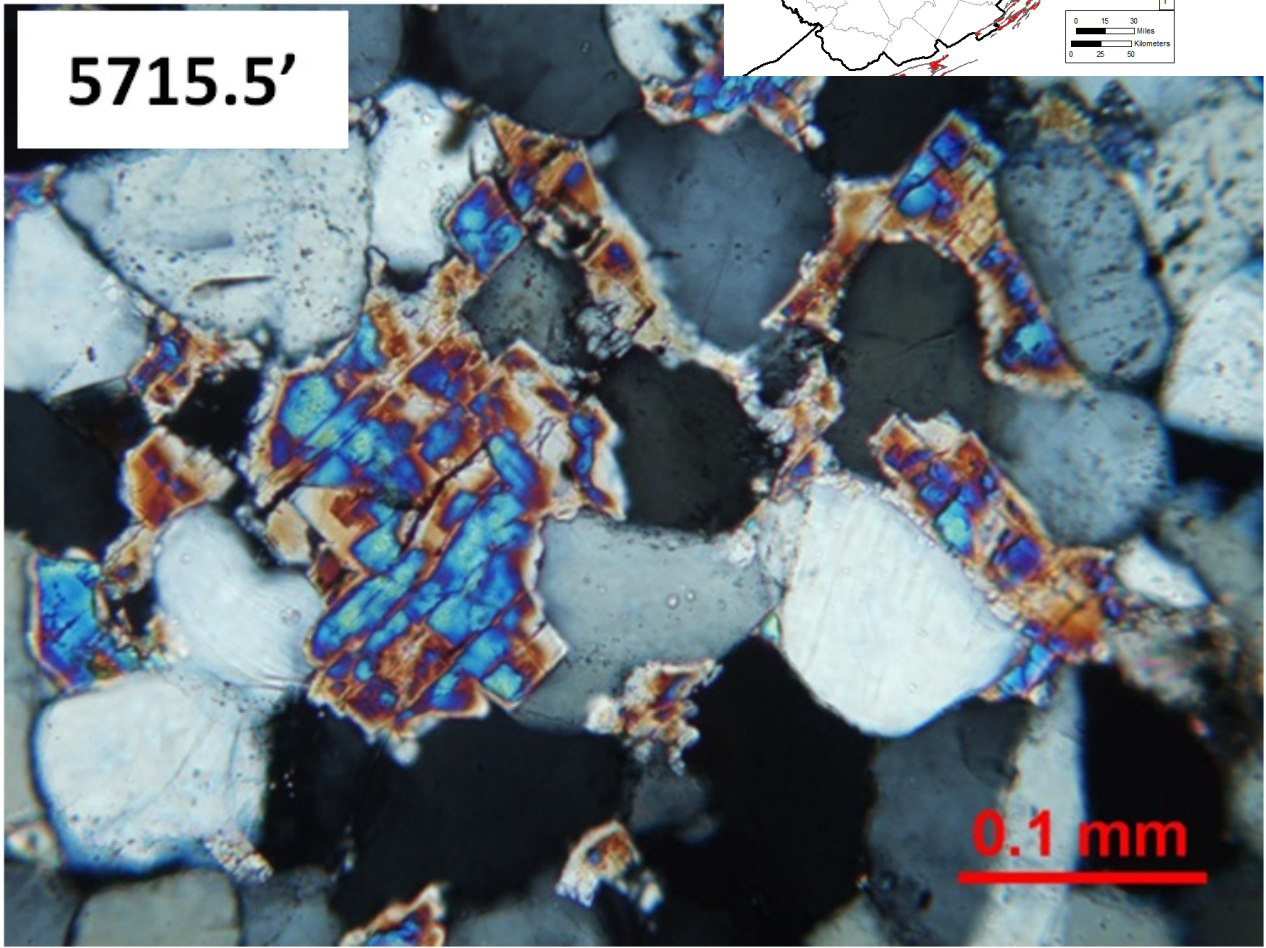


Wills Creek Outcrop - Calcareous/siliceous, silts/sands/shales

Jackson Co. - permit #1136



Gypsum at 5705.4'

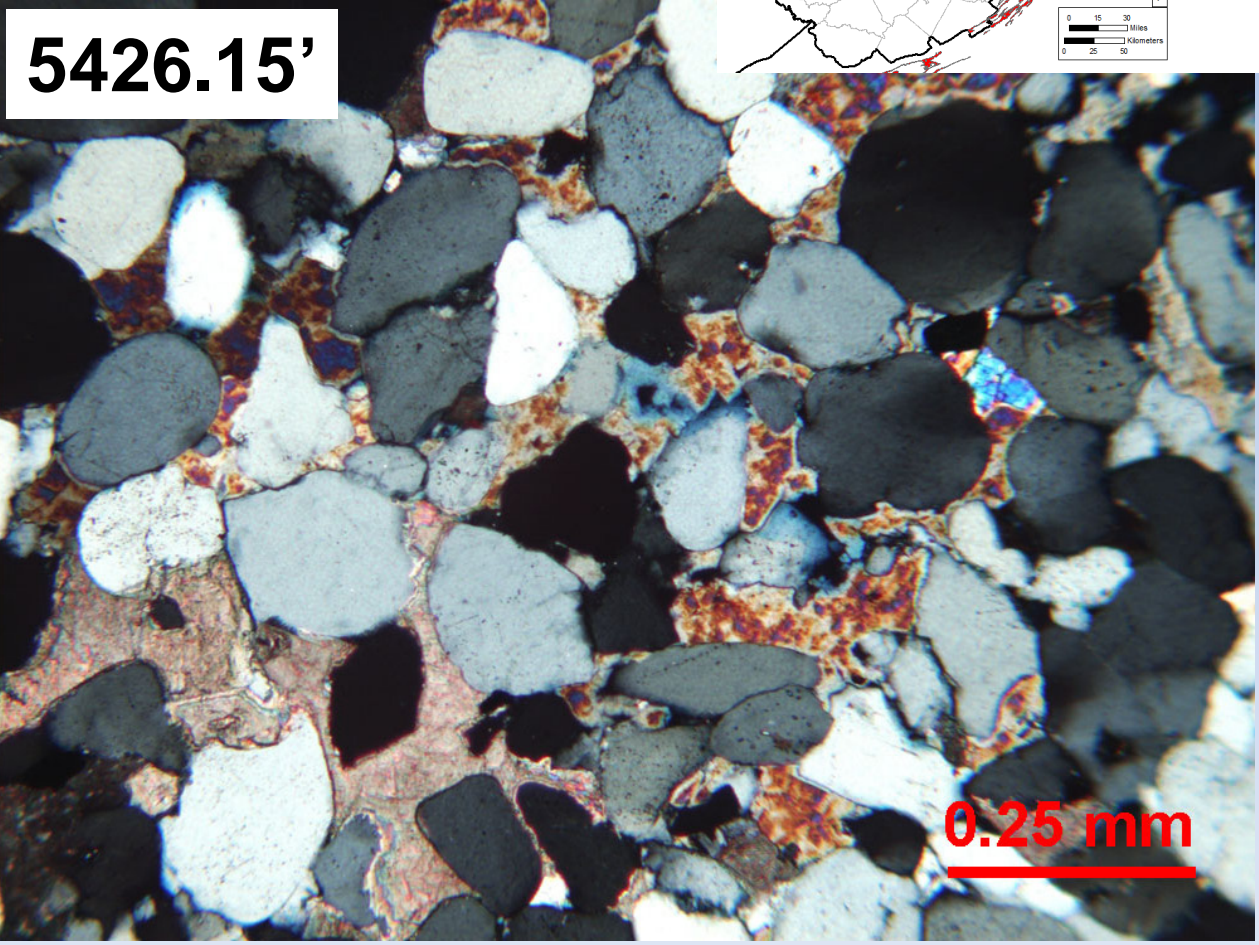


Gypsum filling pore space

Kanawha Co. - permit #2112



Gypsum at 5406.3'

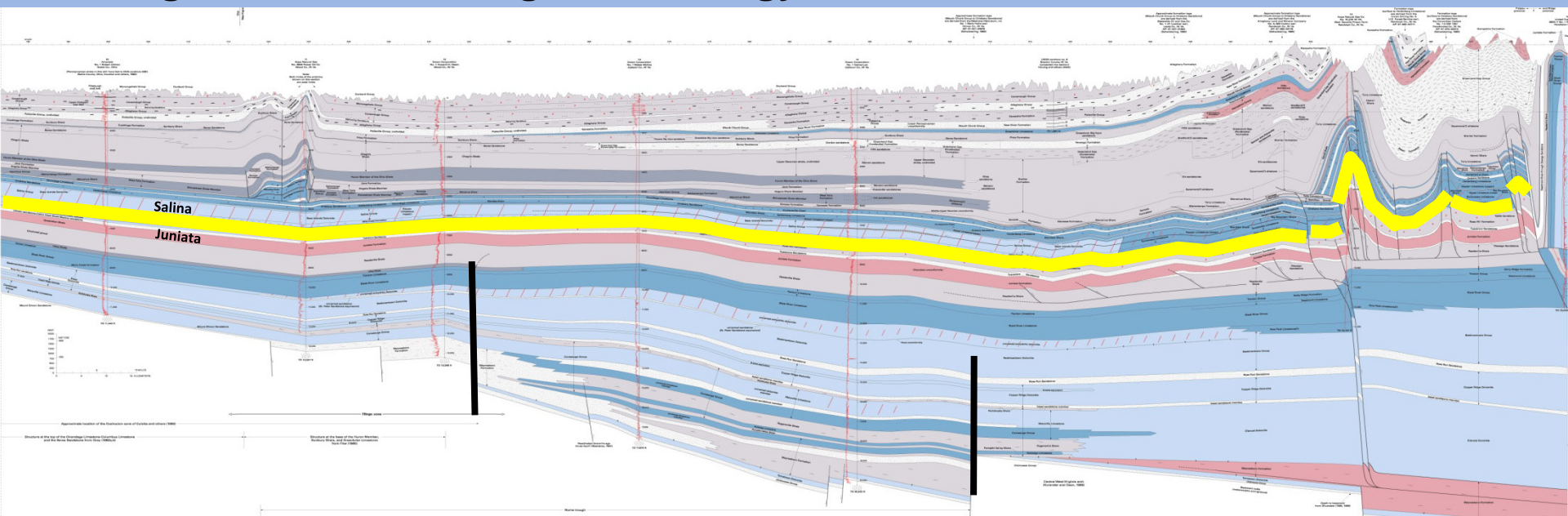


Gypsum filling pore space



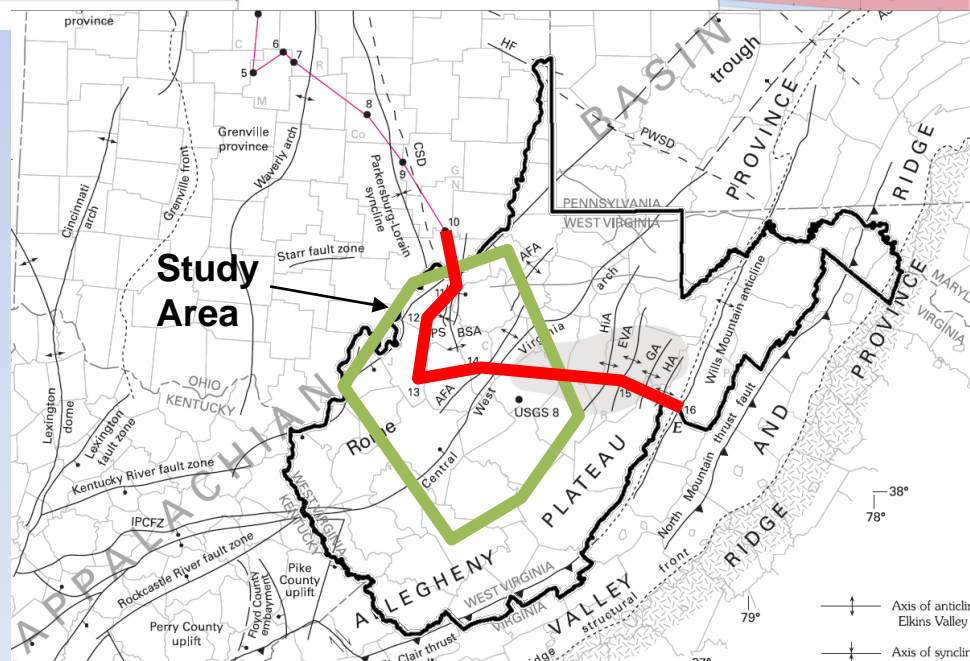
<http://ourlifeinprague.wordpress.com/2011/09/23/desert-safari-part-1/>

Newburg Assessment – Regional Geology



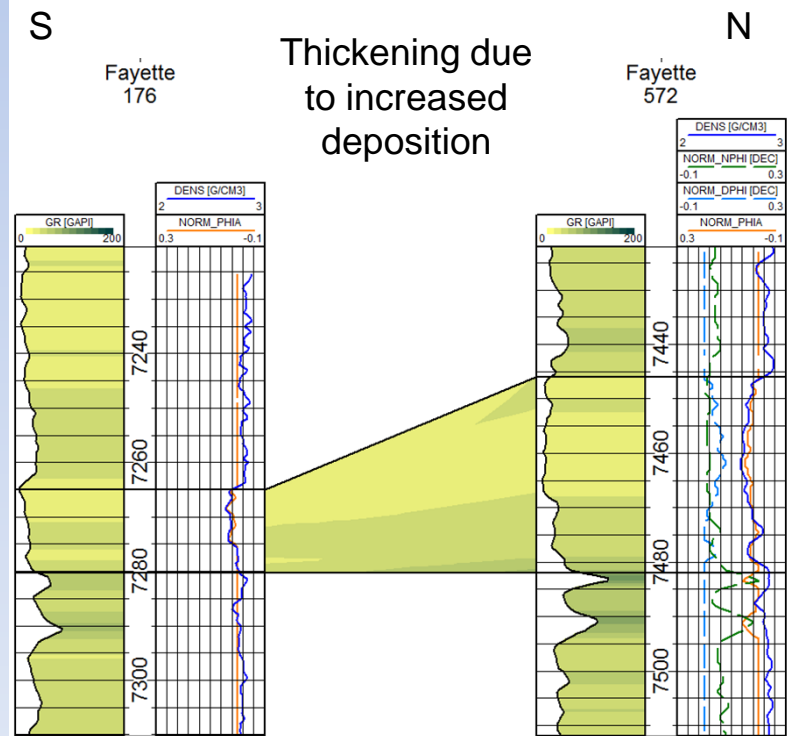
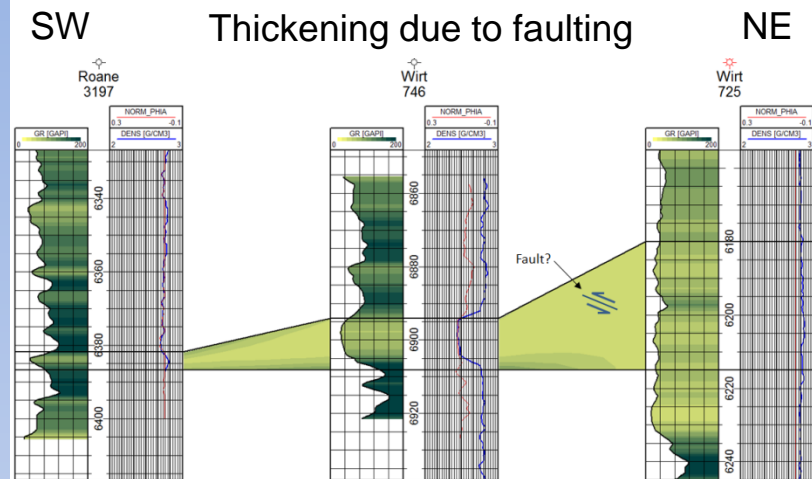
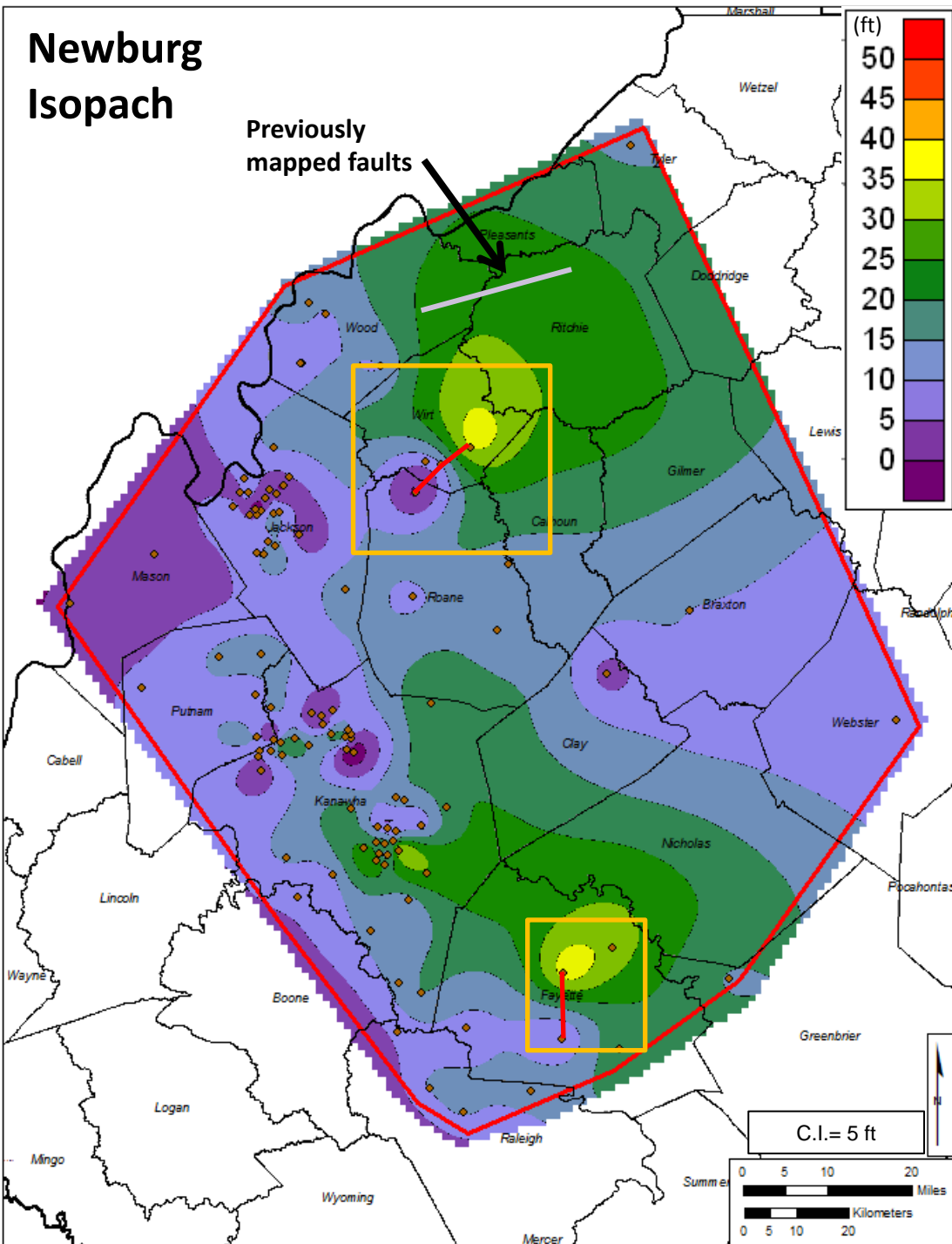
- Most thrust faulting to the east of study area

- Major normal faulting activity does not surpass Ordovician



Newburg Isopach

Previously mapped faults

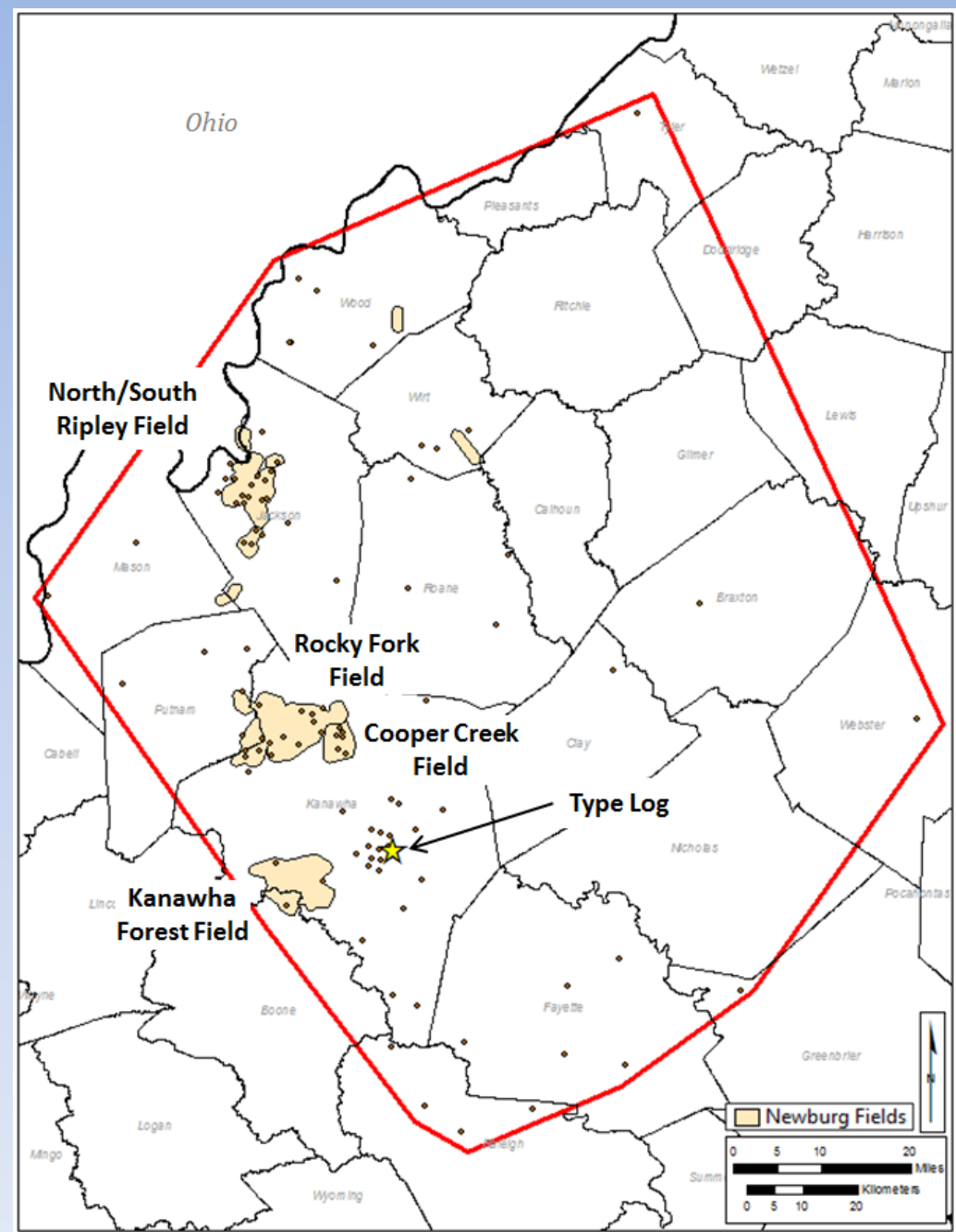


Newburg Assessment

Methodology and dataset

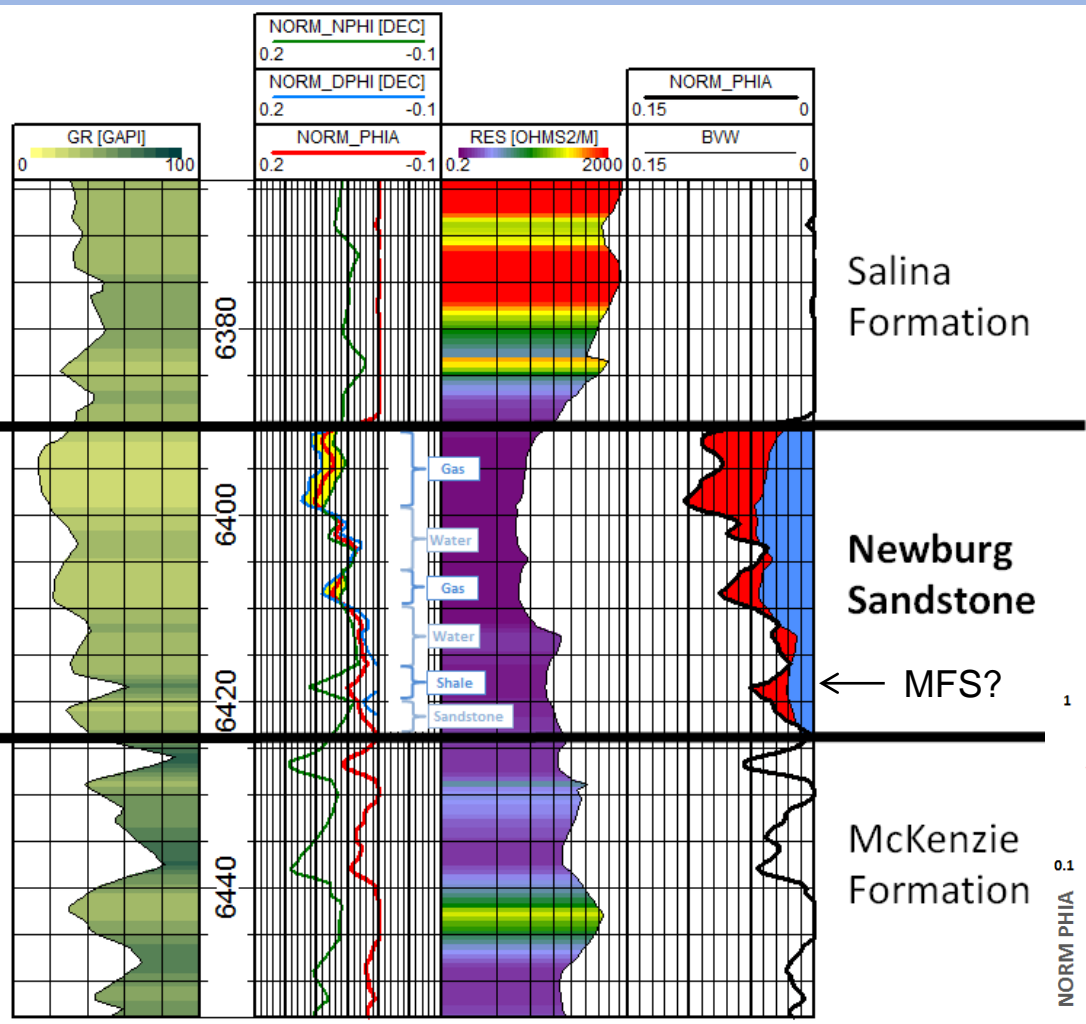
- Log analysis
- Calculations

Newburg Assessment – Methodology and dataset

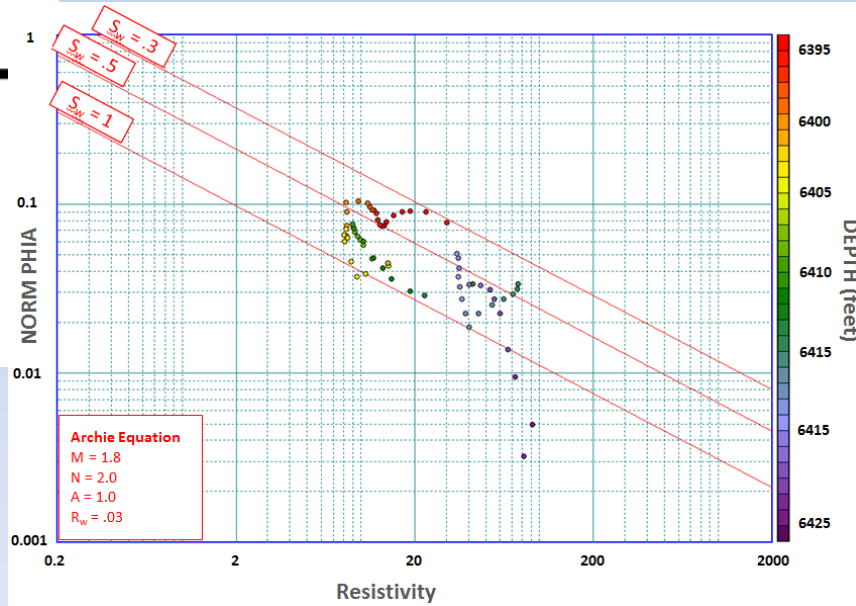


102 wells with GR, NPHI, and DPHI logs

Newburg Assessment – Methodology and dataset

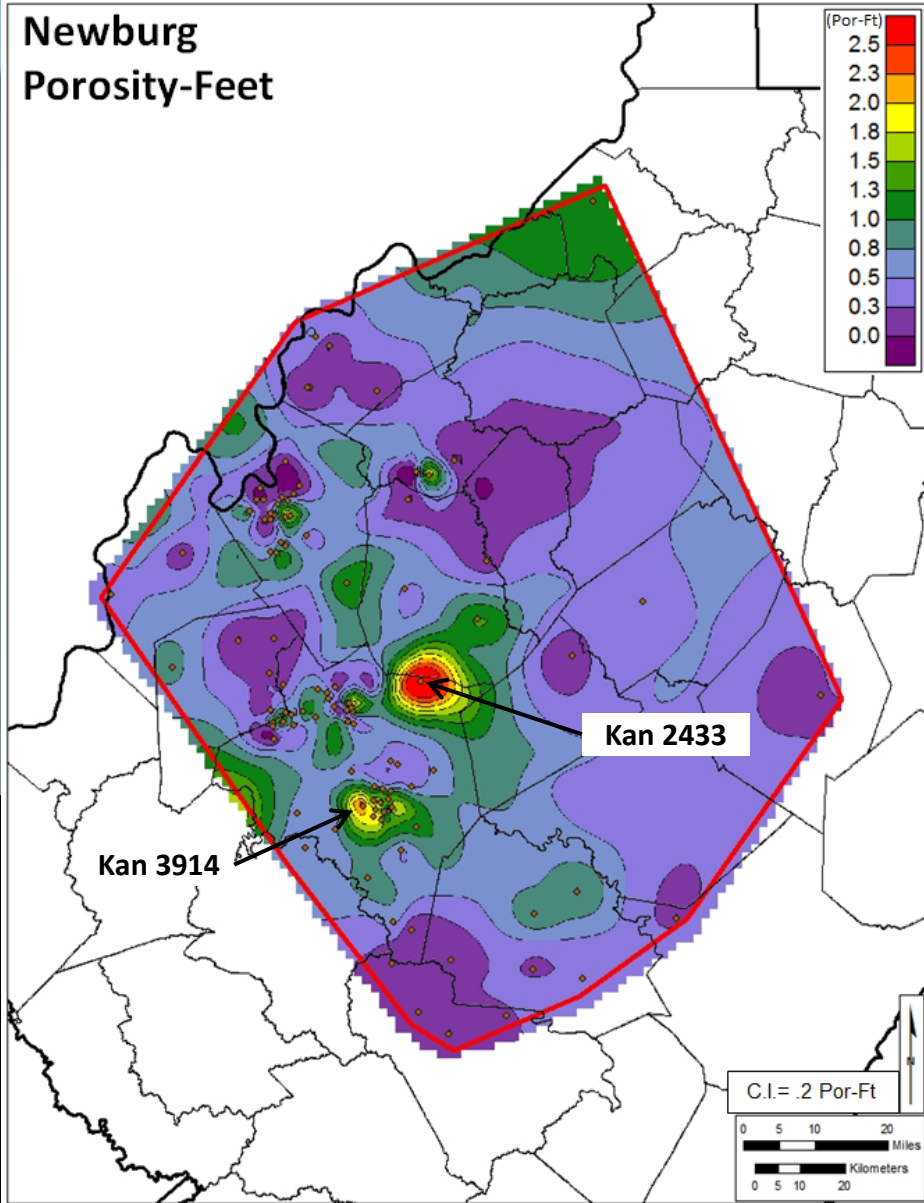
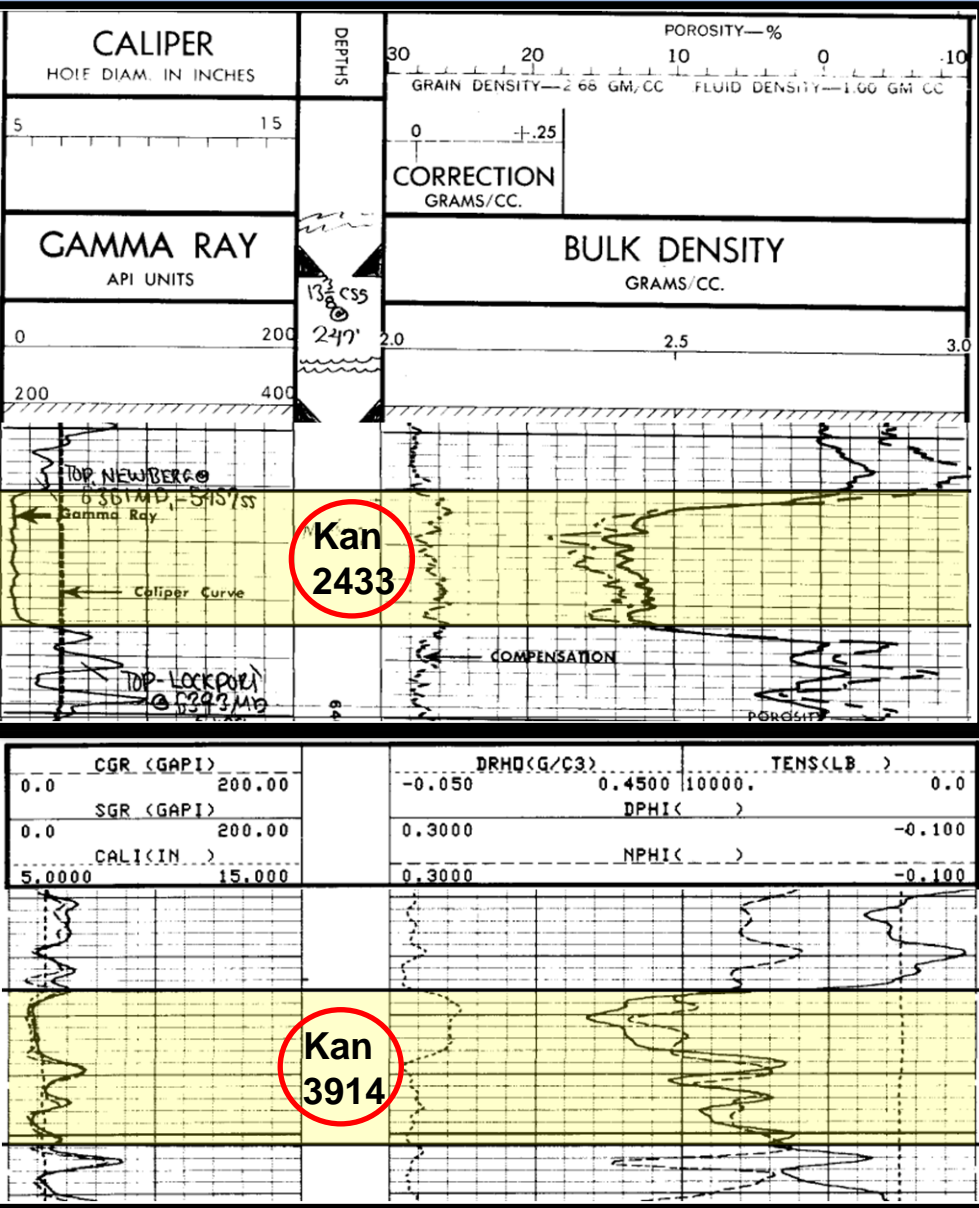


- 10% porosity at top (½ water; ½ gas)
- Water takes up most of pore space throughout the rest of the formation
- Low DPHI values above and below Newburg indicate denser minerals (evaporites)
- Localized sea level rise and fall?



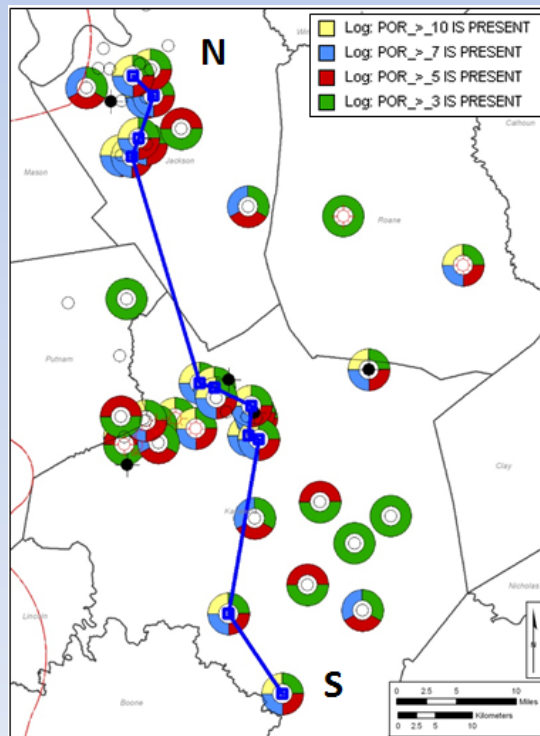
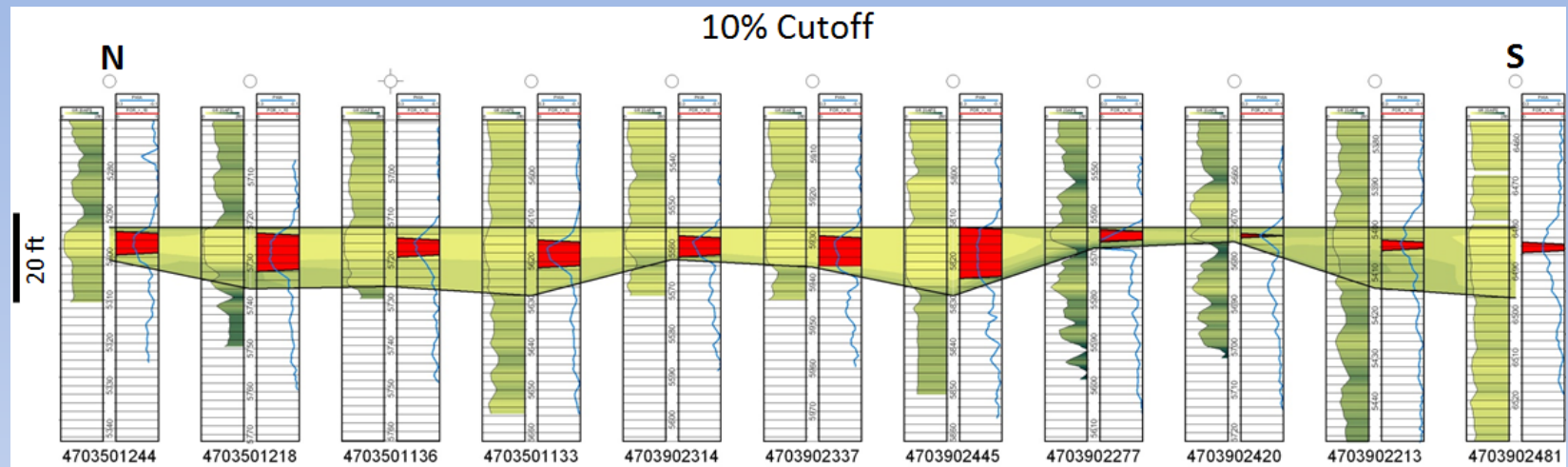
Kan & Hocking C&C #20653
API# 47-039-03646
Dry well targeting Tuscarora (gas show)

Newburg Assessment – Methodology and dataset



Kan 3914, Columbia, Gas well, target Tuscarora
Kan 2433, United Fuel, dry well, target Tuscarora, Newburg produced salt water

Newburg Assessment – Methodology and dataset



- Wells with “yellow” >10% porosity
- X-section spans the 3 major fields
- 10% porosity is variable
- Connectivity on a regional scale, at a minimum.

Newburg Assessment – Methodology and dataset

$$G_{CO_2} = A h_g \Phi_{tot} \rho E$$

(USDOE, 2008)

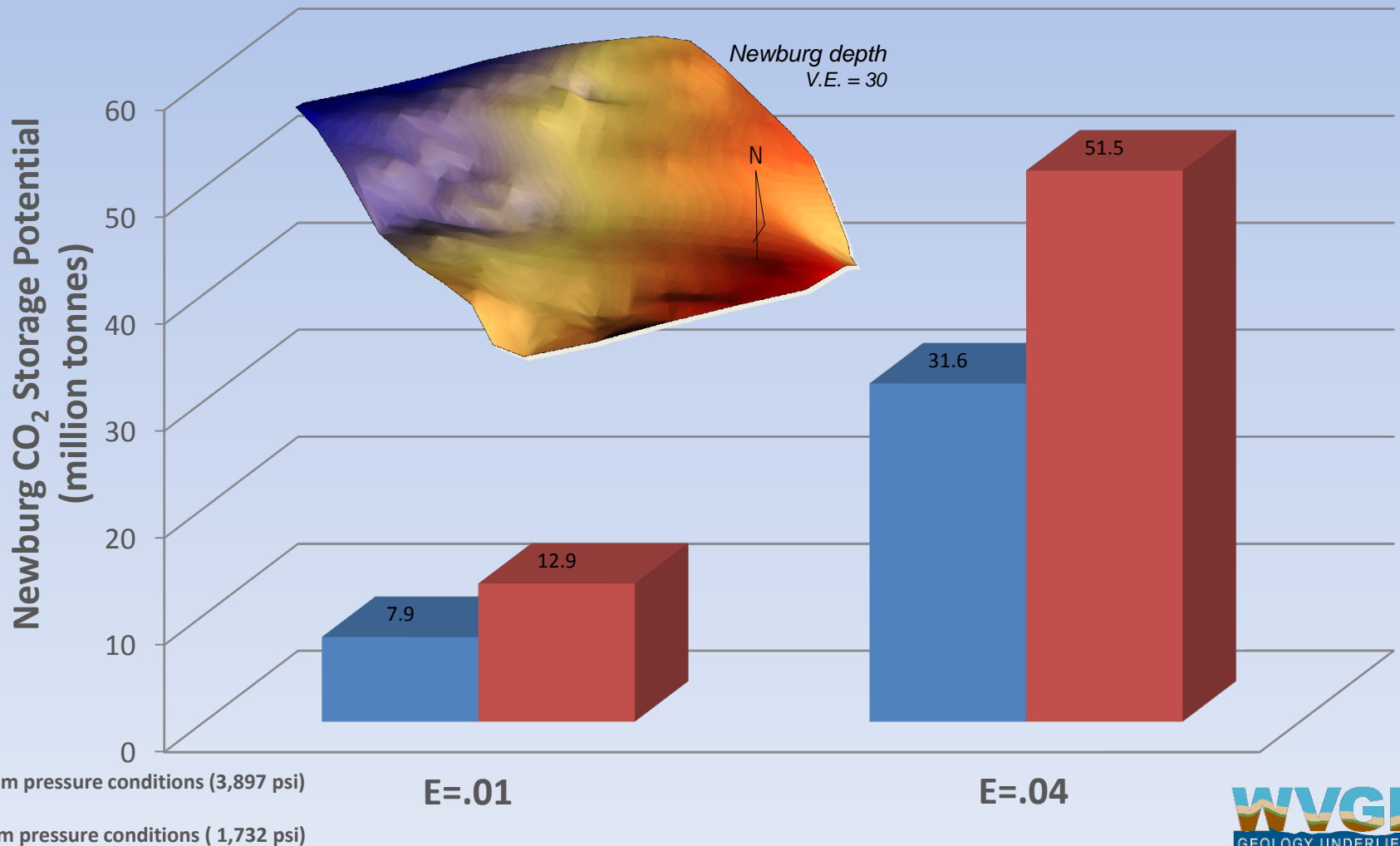
$$A = 200 \text{ bill ft}^2 (1.9 \times 10^{10} \text{ m}^2)$$

$$h_g = 15.2 \text{ ft (4.6m)}$$

$$\Phi_{tot} = .018$$

$$\rho = 69 - 78.4 \text{ lbs/ft}^3 \text{ (NIST, 2011)}$$

$$E = .01 - .04$$

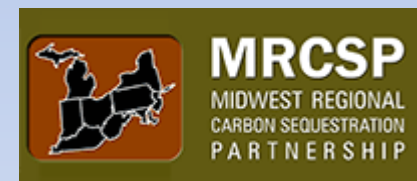


Newburg Assessment – Conclusions

- Evaporite deposits in Newburg appear to be more characteristic of the Wills Creek Formation.
- Refinement of current depositional model proposed ...
Carbonate Ramp/Estuarine?
- Log analysis can be used to potentially locate additional faulting.
- Connectivity between highly porous zones does not exist across study area.
- Regional scale injections not feasible.
- Small scale CO₂ injection tests, EGR, brine disposal.



QUESTIONS?



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