An Integrated Approach to Identifying Residual Oil Zones in the Cypress Sandstone in the Illinois Basin for Nonconventional CO_2-EOR and Storage

Nathan Webb

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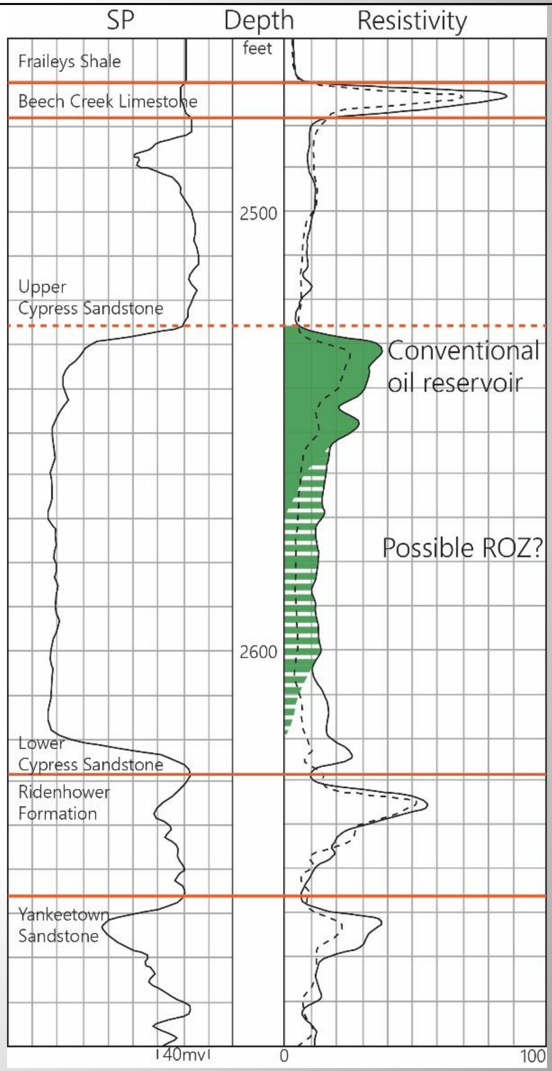
Presentation Outline

- Background
- Geologic Characterization
  - Stratigraphy/Sedimentology
  - Petrography/Controls on reservoir quality
- Petrophysics
  - Archie and Dual Water Methods
  - Interpreting Oil-Water Contacts
  - Applications
- Future Work
- Summary

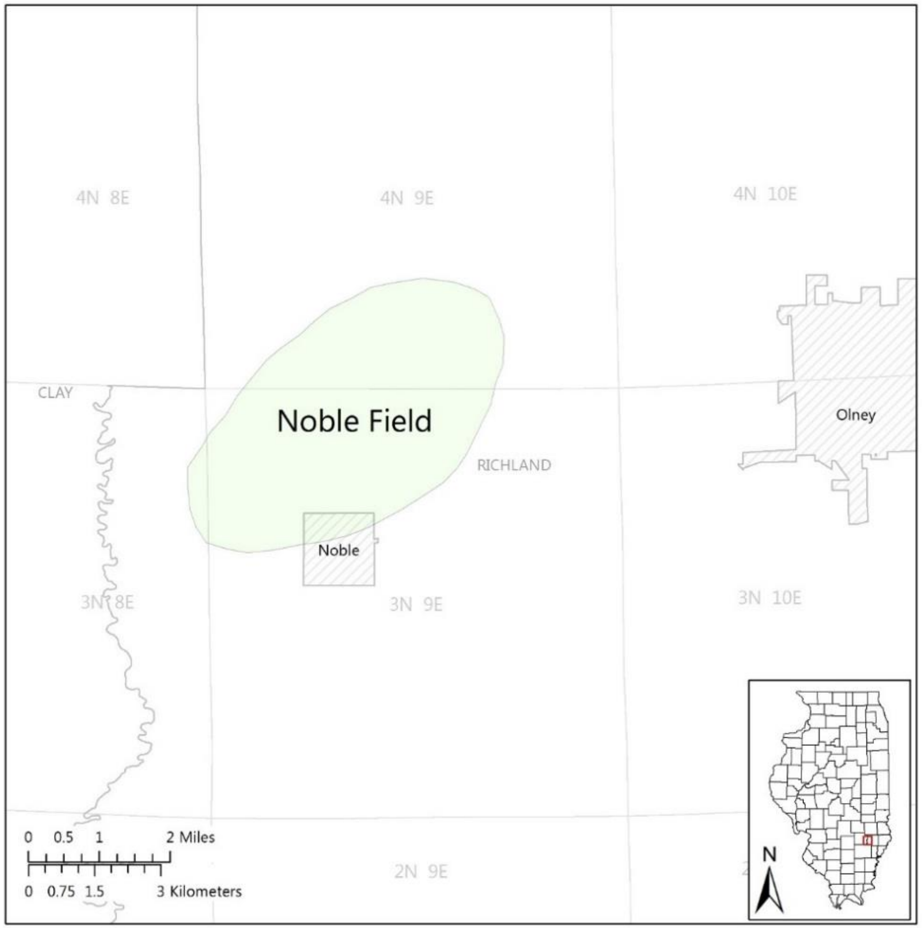
Thick Cypress Ss Reservoirs

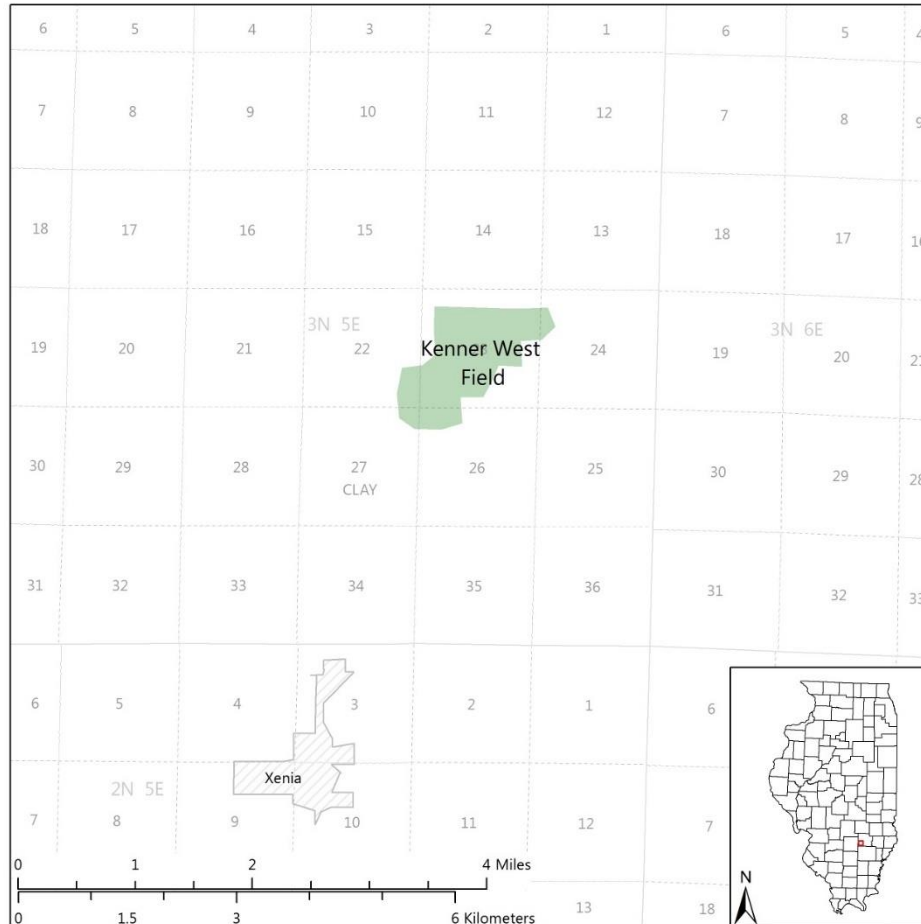
- Thin Oil Reservoirs
  - Residual and mobile oil above brine
  - Fining upward sequence / increasing permeability with depth
  - Difficult to produce economically due to water coning and management
- Nonconventional CO_2-EOR
  - Potential Residual Oil Zone (ROZ)
  - High CO_2 utilization during CO_2-EOR
  - 0.2 to 2.3 Gt saline CO_2 storage potential (DOE/MGSC, 2012)



Geologic Characterization

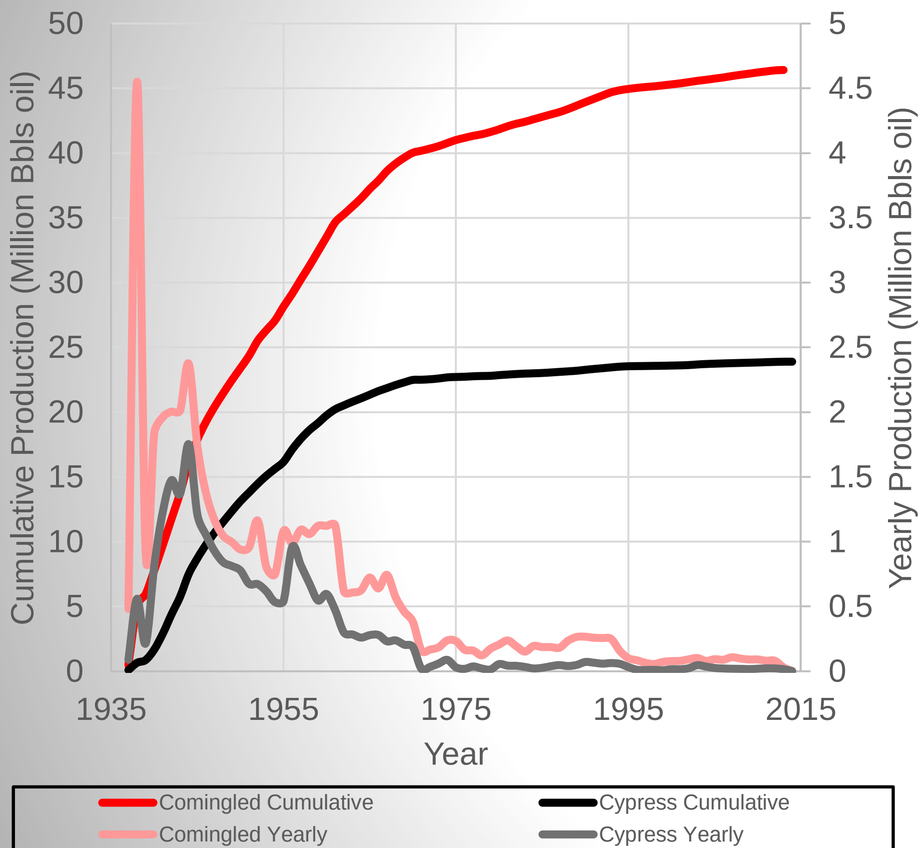
Case Studies: Noble and Kenner West Fields

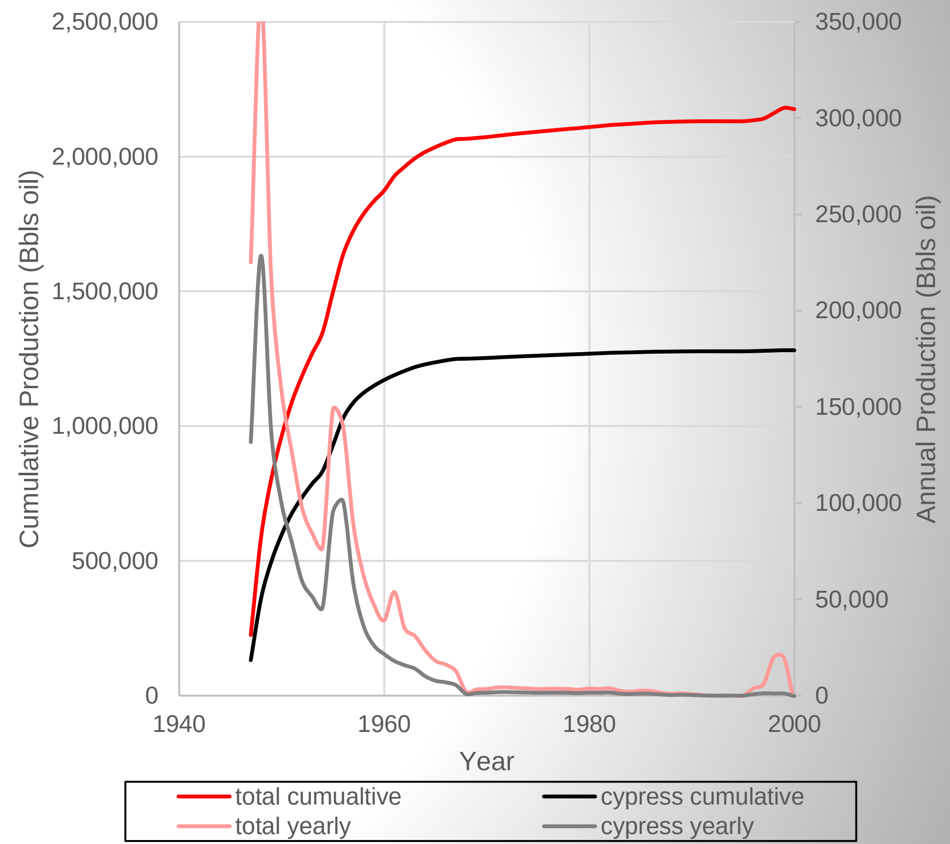




- Oil fields with successful production from the thick Cypress Sandstone
- Abundant core and log data available for detailed characterization

Case Studies: Noble and Kenner West Fields





- Noble Cypress Production = 24 MMBO
- OOIP = 95 to 110 MMBO

- Kenner West Cypress Production = 1.3 MMBO
- OOIP = 8.5 to 10 MMBO

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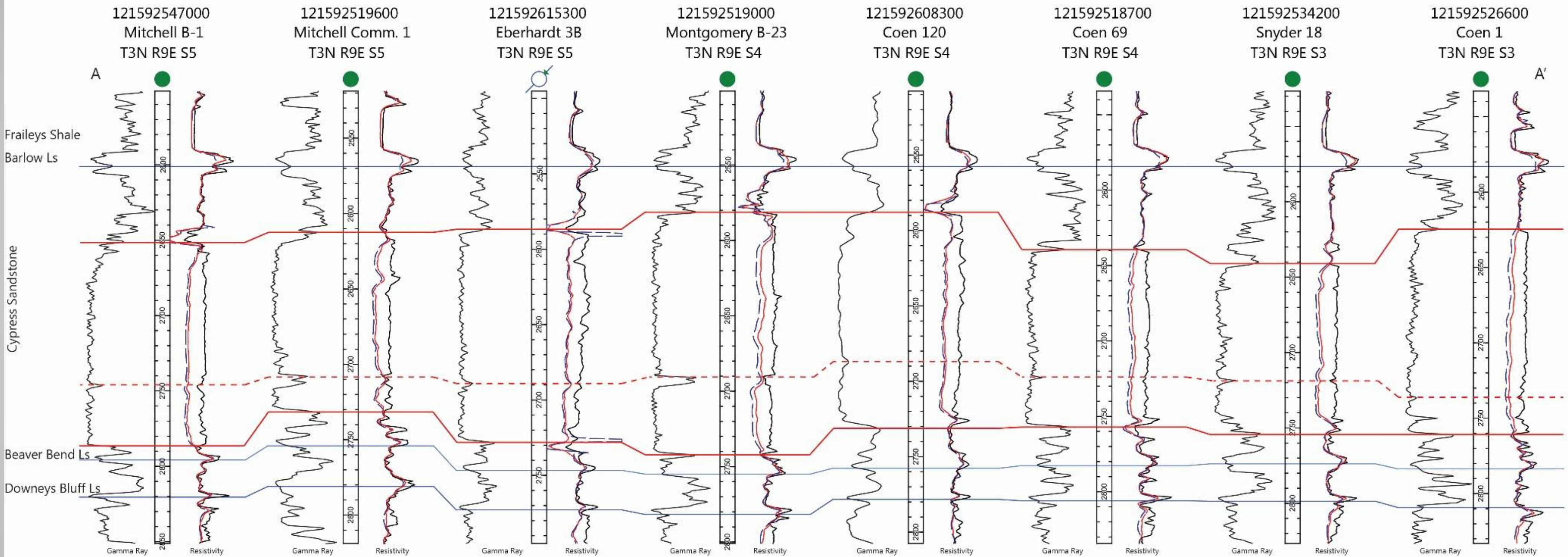
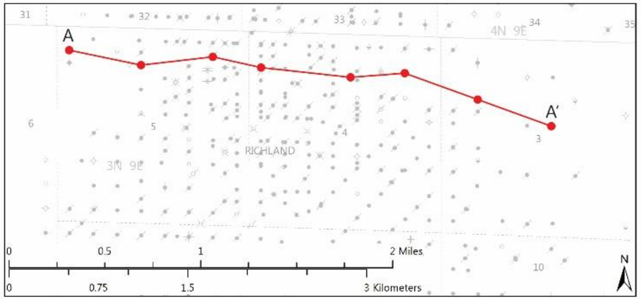
Noble Correlations

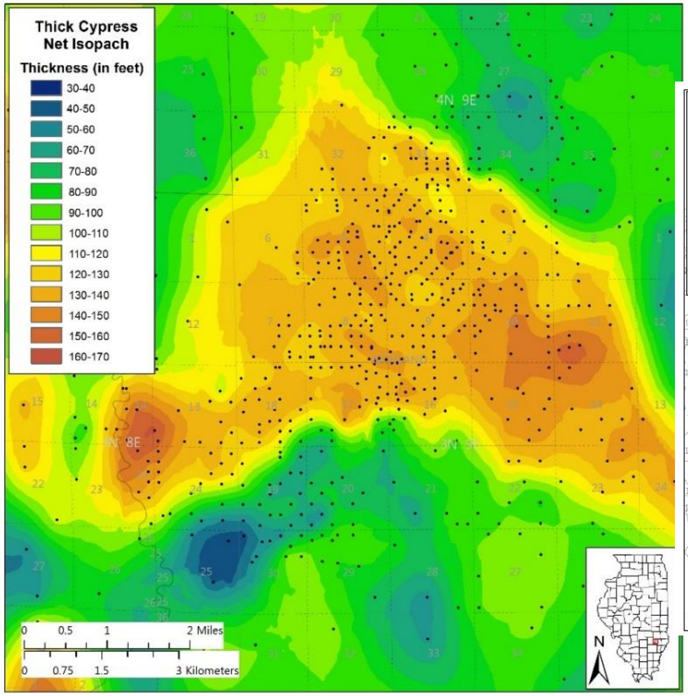
Example Noble Field Cross Section



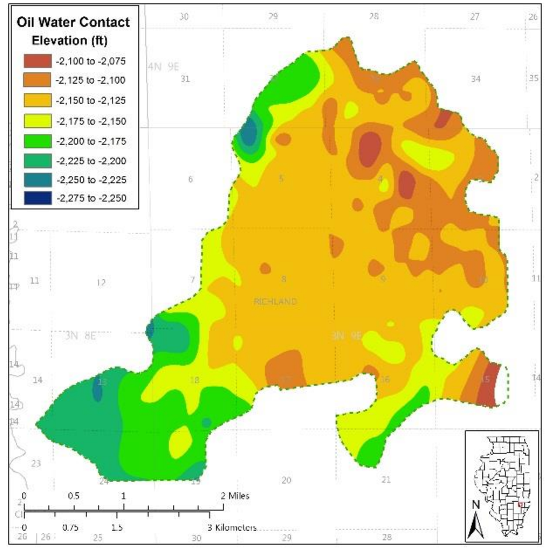


- Correlated nearly 1,000 logs to map geometry of thick Cypress Sandstone
  - Picked upper/lower contacts, baffles (shales, cements), oil/water contact (OWC)
- Lower part of Ss present over whole field

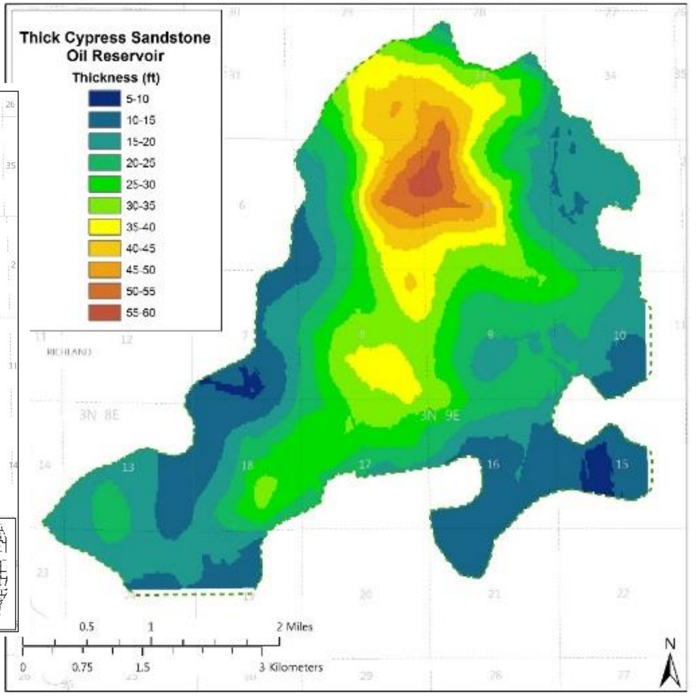
Noble Maps



Cypress net sandstone isopach map



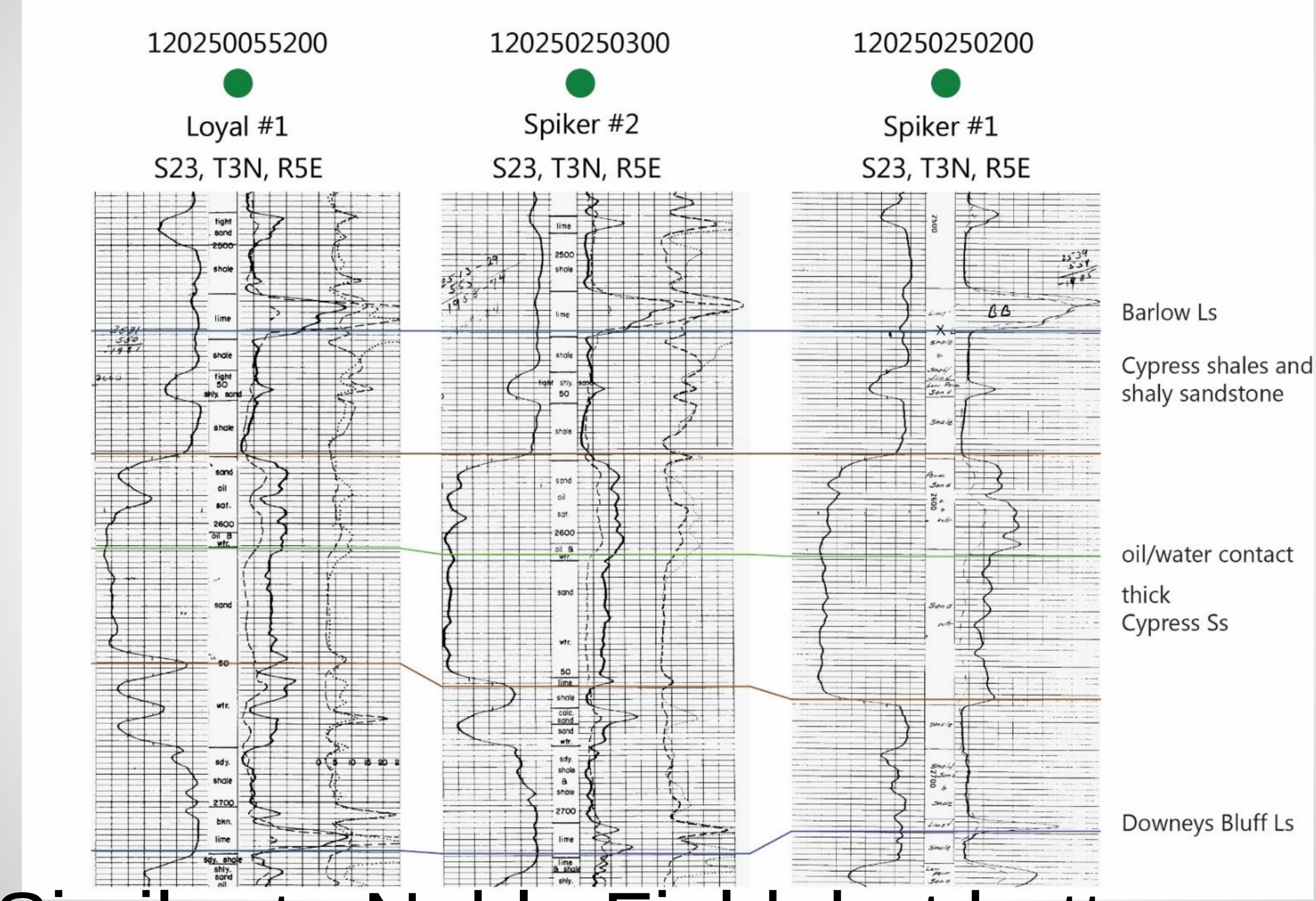
OWC structure map



Oil reservoir isopach map

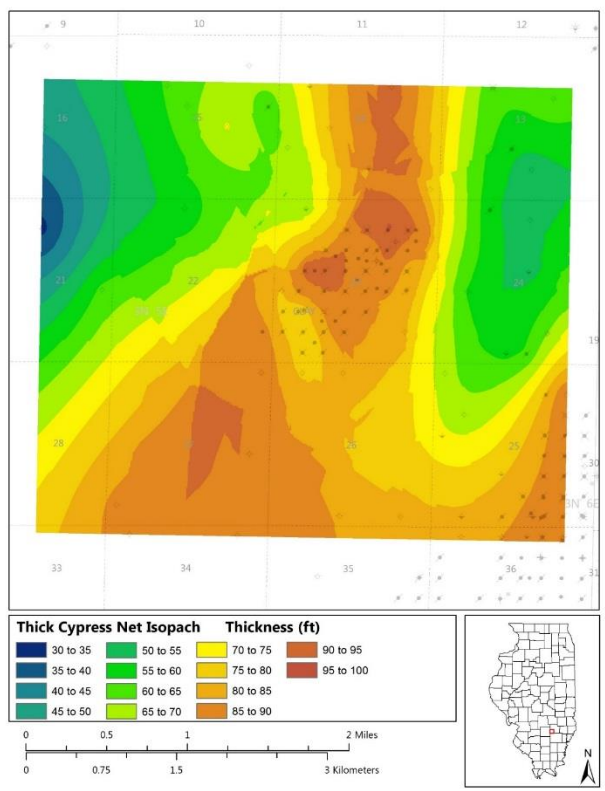
- Inverted "V" geometry, up to 170 ft thick, good lateral connectivity - especially in lower part
- ROZ indicators
  - Tilted OWC; Paleo-OWC related calcite cement?
- Conventional reservoir up to 55 ft thick
- Tilted OWC means oil saturation to the SW

Kenner West Correlations

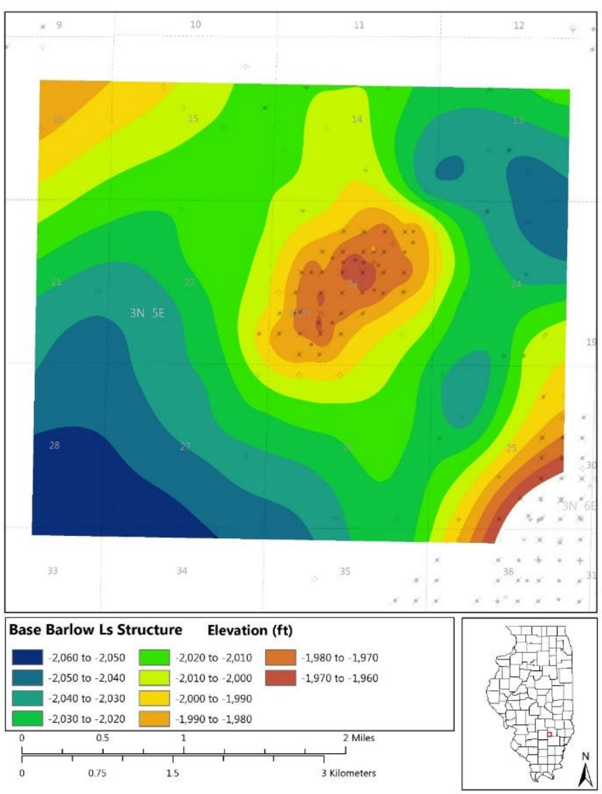


- Similar to Noble Field, but better developed “upper” Cypress Ss lenses

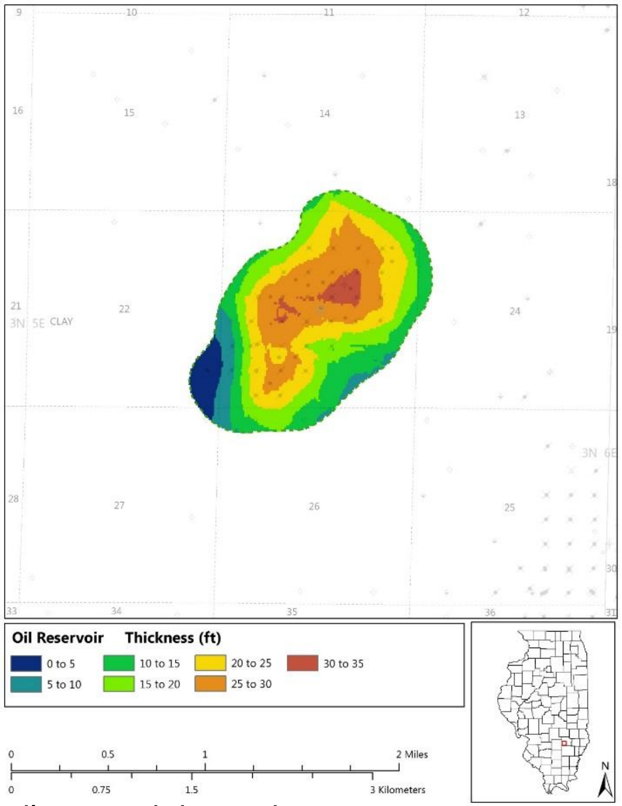
Kenner West Maps



Cypress net sandstone isopach map



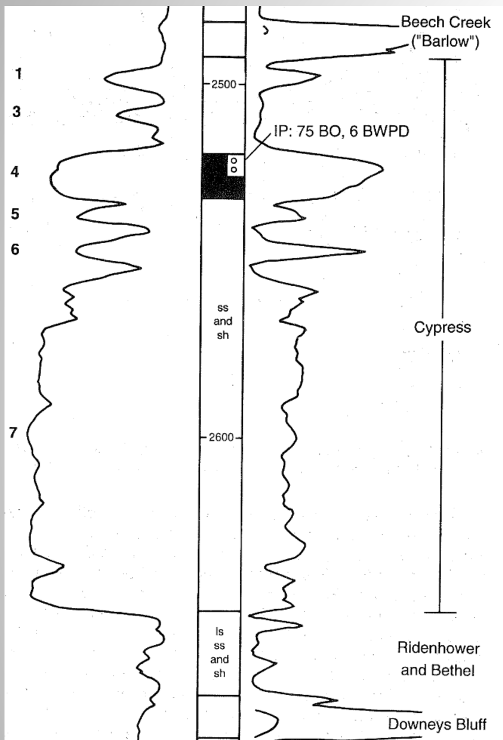
Base of Barlow Ls structure map



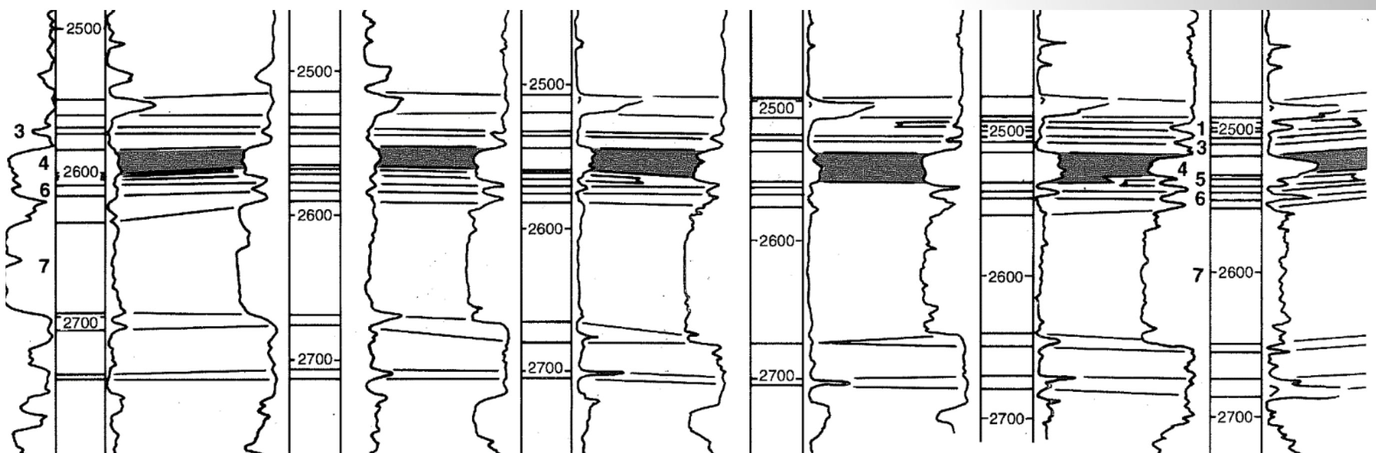
Oil reservoir isopach map

- Thick sandstone trend intersects small dome forming structural-stratigraphic trap
  - OWC tilts slightly to the southeast

Comparison with Xenia East Field



- No thick Cypress Ss oil production from Xenia East, 4 mi south of KW



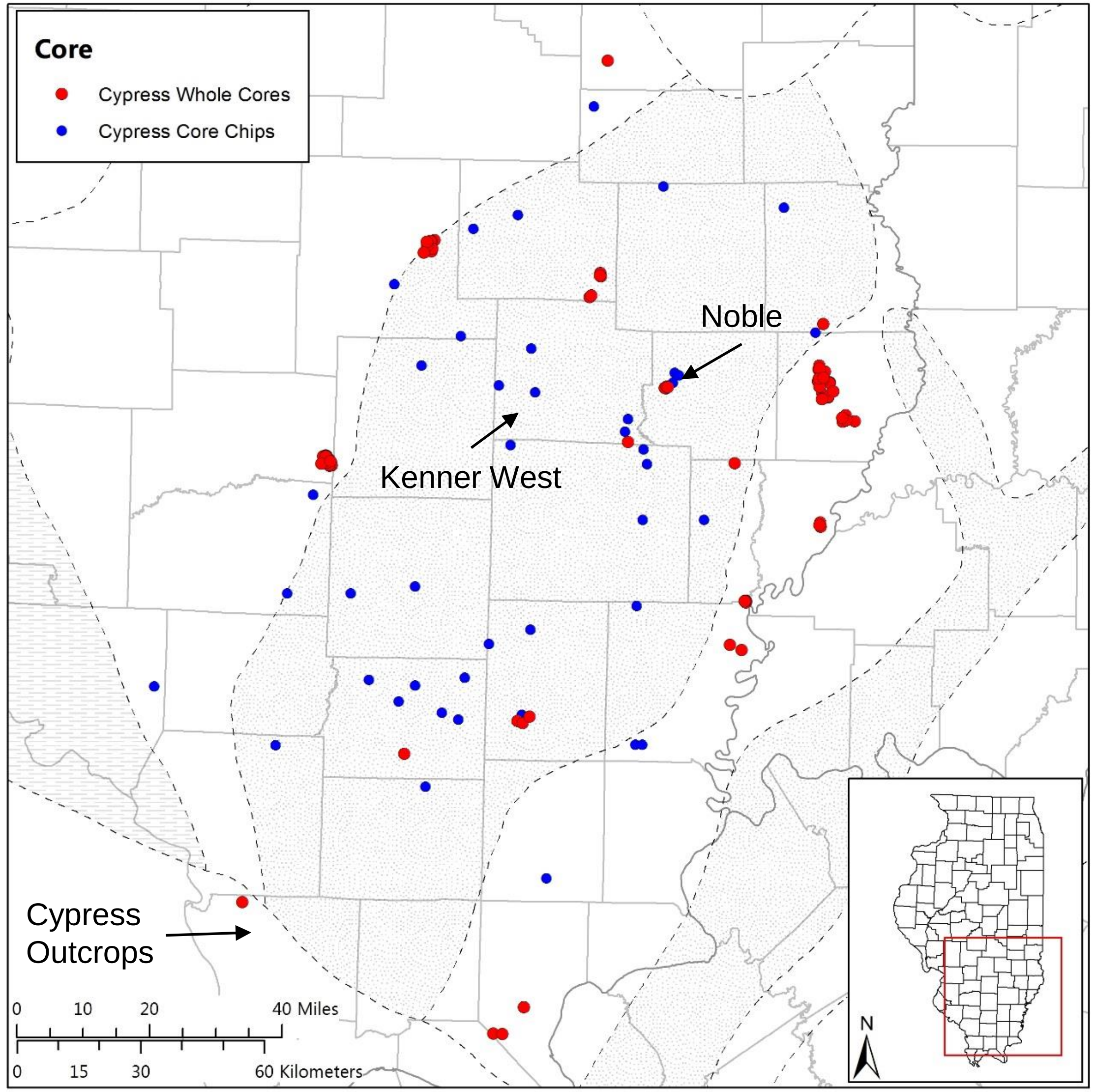
Xu and Huff 1995

- Is the thick Cypress Ss only oil productive when there are not reservoir quality “upper” Cypress Ss lenses above?
  - Cypress shales are leaky seals?

Locations of Existing Core

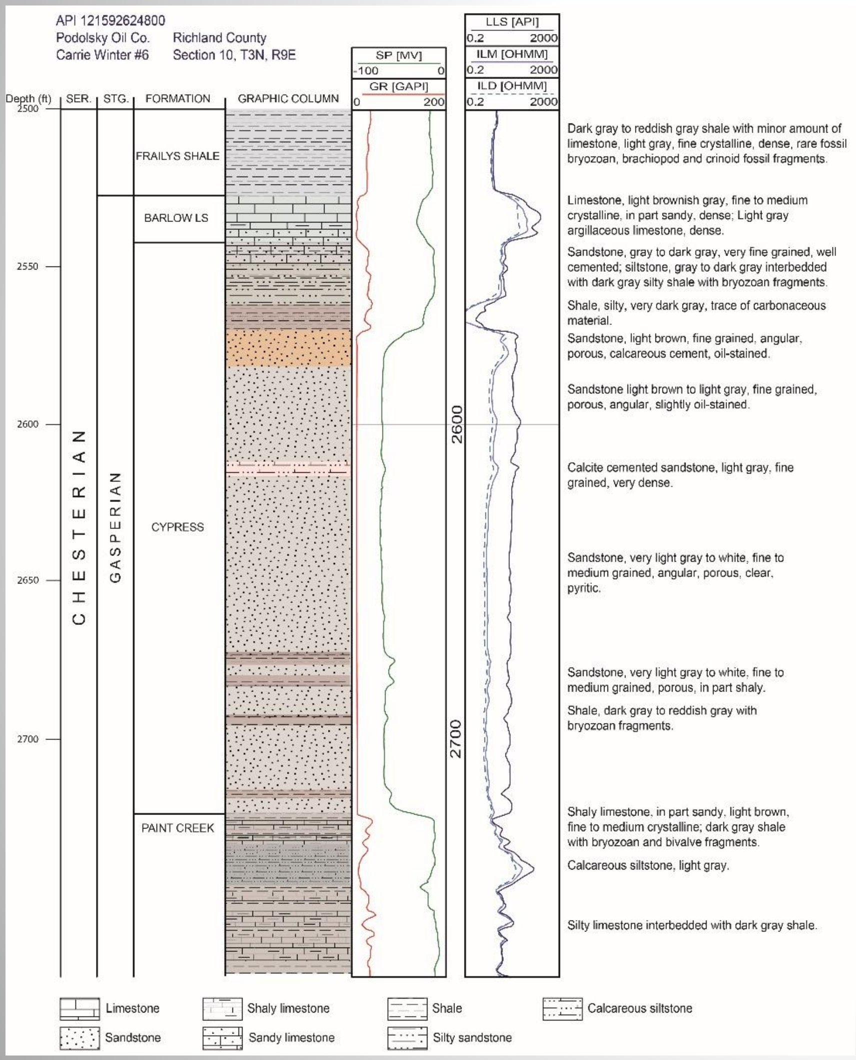
- Noble Field
  - Whole core of upper 30-40 ft in two wells
  - Chips/partial core from a handful of old wells
- Kenner West Field
  - No cores, but lots of core data

How do we interpret the geology and understand how the reservoir will respond to CO_2 injection? Rocks!

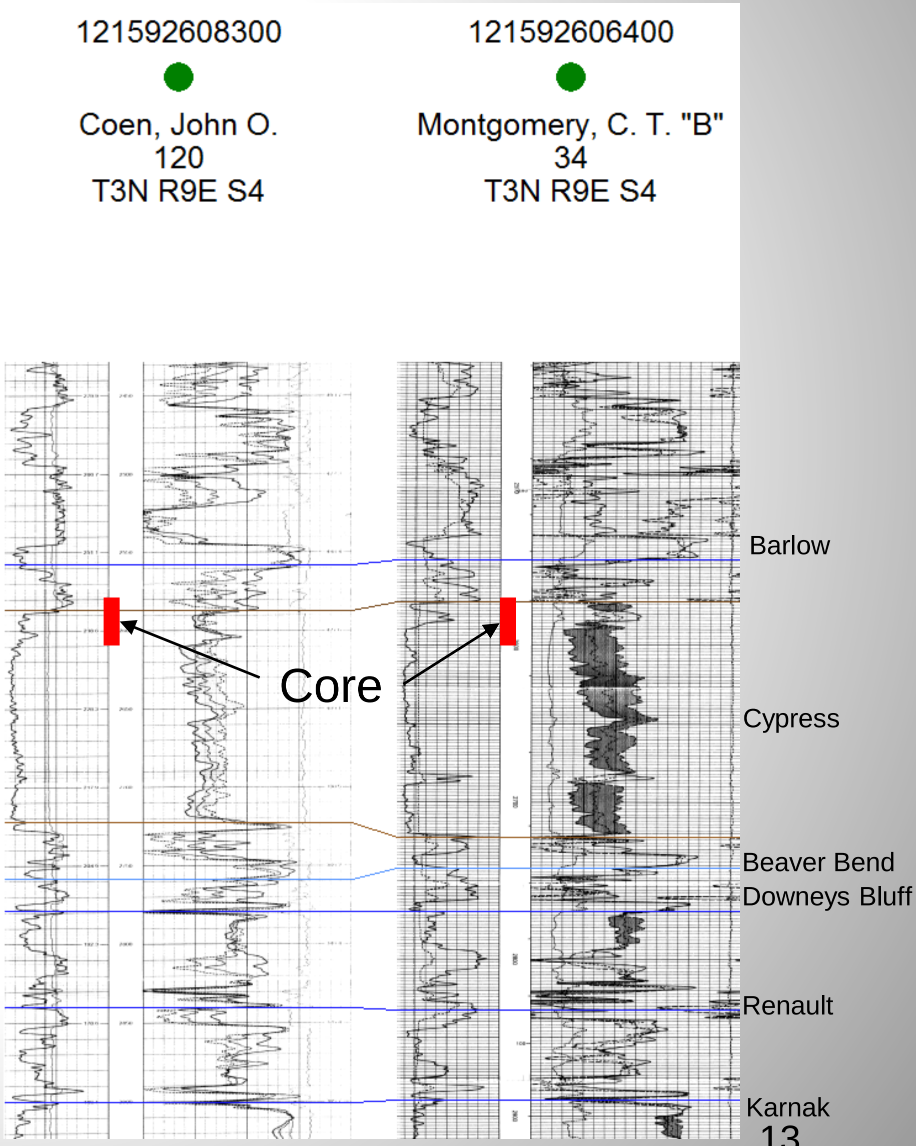


Now a brief tangent…

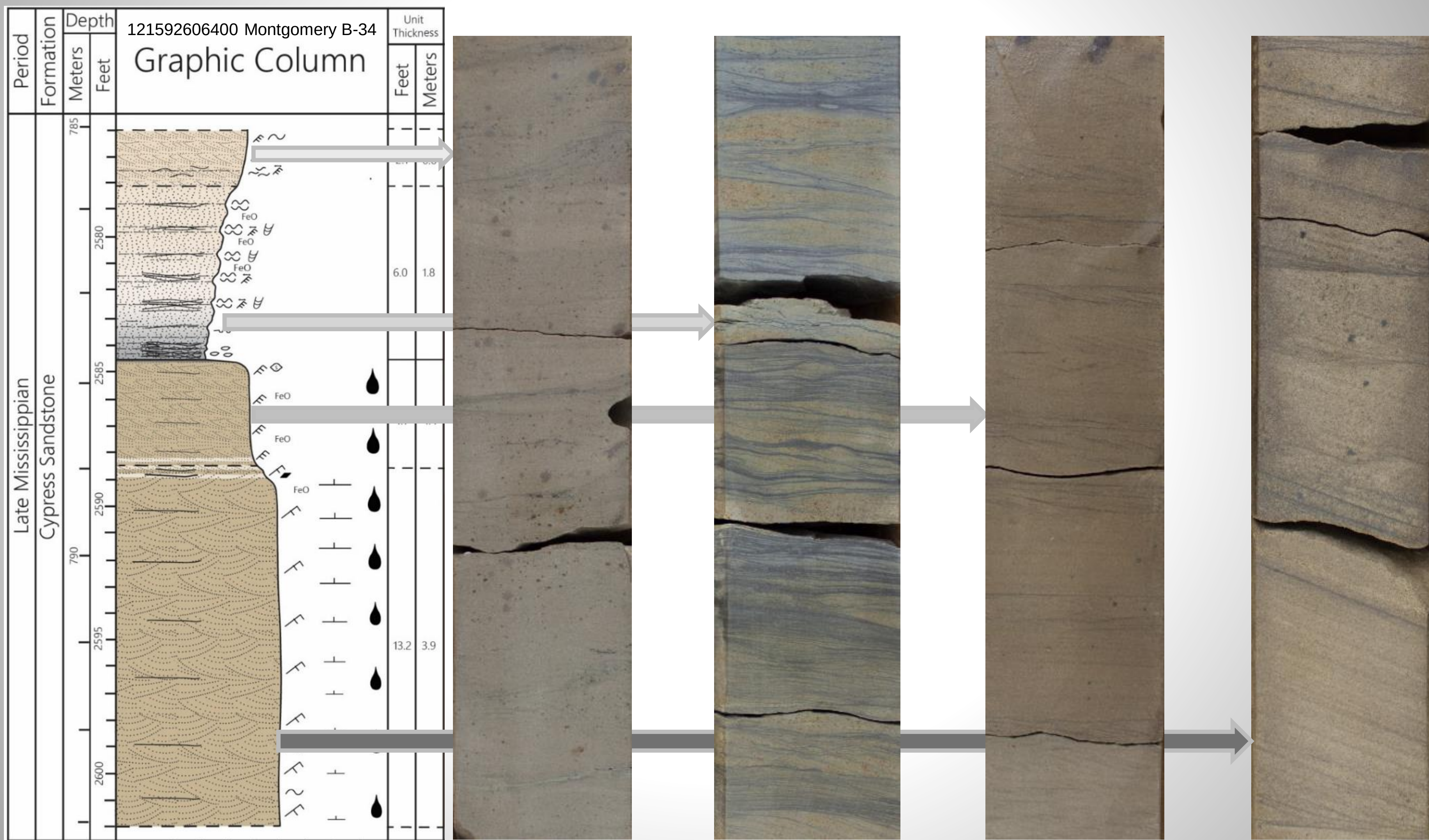
Sedimentology



Samples can reveal general lithology and texture



Sedimentology

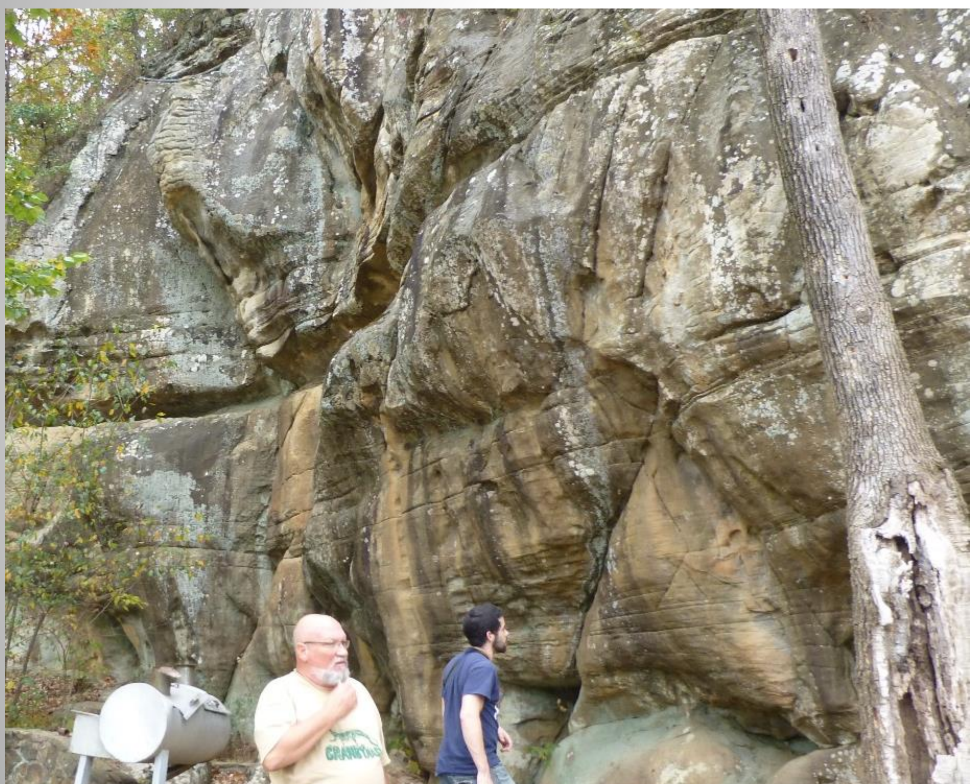


Ripple-bedded vf-f Ss | Flaser/wavy-bedded vf Ss | Ripple-bedded vf-f Ss | Cross-bedded f-m Ss

Sedimentology

Facies	Description	Grain Size	Cross-Set Thickness	% Bioturbation	Depositional Process
Mudstone	Light to dark grey shale, planar laminated, finely bedded and commonly fissile, commonly slicken-sided and bioturbated, common pyritization; may or may not contain: low silt abundance, carbonaceous fragments, pyrite, fenestrate bryozoans, brachiopods, gastropods, crinoids, rare calcite cement	Clay	----	0- 30%	Low energy suspended sediment fall out
Silty Mudstone	Light gray shale with homogeneous matrix of silt and mud, planar laminated, finely bedded, more or less bioturbated with rare carbonaceous debris; may or may not contain: silty interbeds and/or laminations, fenestrate bryozoans, brachiopods, gastropods, crinoids, carbonaceous fragments, pyrite, iron-oxide, rare calcite cement	Clay to silt	----	0- 30%	Low energy fine sediment fallout >= low energy periodic sedimentation
Heterolithic, Lenticular bedding	1-4 cm whitish-grey silty lenses encased in mud or silty mud matrix, lenses commonly contain ripples with clay drapes on foresets, lenses range from thick to thin; may or may not contain: calcite cement, bidirectional ripples, carbonaceous fragments, connected sand lenses	Clay to very fine-grained	1-2 cm	0- 100%	Low energy fine sediment fallout-without-traction >higher energy episodic flows
Heterolithic, Wavy bedding	Whitish-grey silt to very fine sand interbedded in equal proportion with grey mud laminations which are commonly wavy, less commonly consists of planar interlaminations, commonly contains ripples with mud drapes defining foresets; may or may not contain: calcite cement, bidirectional or sigmoidal ripples, reactivation surfaces, carbonaceous fragments, shaly rip up clasts, rare calcite cement	Clay to very fine-grained	1-2 cm	0- 100%	Low energy sediment fallout-without-traction = higher energy episodic flows
Heterolithic, Flaser bedding	Grey to dark grey shaly flasers encased in a whitish-grey very fine to fine grained sand matrix, flasers range from bifurcated to wavy to bifurcated-wavy; may or may not contain: calcite cement, asymmetrical or bidirectional ripples, reactivation surfaces, shaly rip up clasts, rare calcite cement	Clay to very fine-grained	1-2 cm	0- 40%	Low energy sediment fall-out-without traction < higher energy episodic flows
Massive Sandstone	Whitish-grey grained massive quartz arenite to sublitharenite with angular to subangular grains; may or may not contain: oil staining, calcite cement, microscopic crinoid fragments, iron-oxide mottles, calcite cement	Very fine to medium-grained	----	0- 2%	Bedload dominated sedimentation, deformation post deposition
Ripple-bedded Sandstone	Whitish-tan ripple bedded arenite to sublitharenite with angular to subangular grains, commonly bidirectional or asymmetric with laterally migrating or slightly climbing foresets; may or may not contain: oil staining, calcite cement, climbing or sigmoidal ripples, shale rip up clasts, calcite cement	Very fine to medium-grained	1-2 cm	0- 2%	Bedload dominated sedimentation, lower flow regime traction currents
Ripple-bedded Sandstone with clay Drapes	Whitish-tan ripple bedded arenite to sublitharenite with angular to subangular grains, commonly bidirectional or asymmetric with laterally migrating or slightly climbing foresets, may or may not contain: oil staining, calcite cement, climbing or sigmoidal ripples, shale rip up clasts, calcite cement	Very fine to medium-grained	1-2 cm	0- 2%	Bedload dominated sedimentation, low energy traction currents with intermittent suspension dominated sedimentation or; low energy unidirectional to bidirectional traction currents with clay filled troughs
Planar-bedded Sandstone	Whitish-tan to brown planar bedded arenite to sublitharenite with angular to subangular grains, occasional oil staining, may or may not contain: oil staining shaly-carbonaceous laminations, carbonaceous debris, shale rip up clasts, calcite cement	Very fine to medium-grained	----	0- 4%	Low to moderate energy sediment fallout-without-traction (hypopycnal flow?) or; moderate to high energy unidirectional bedload sedimentation
Cross-bedded Sandstone	Whitish-tan to brown arenite to sublitharenite with angular to subangular grains,, frequent oil staining, fine to coarse grained, cross-bedded; may or may not contain: shaly carbonaceous laminations, carbonaceous debris, shale rip-up clasts, calcite cement	Very fine to medium-grained	8-60 cm	0%	Moderate to high energy unidirectional traction sedimentation
Conglomerate	Conglomerate with very fine to medium grained sand matrix, commonly matrix supported; may or may not contain: clay clasts, clay laminations, carbonaceous fragments, rounded carbonate pebbles, crinoids, brachiopods, gastropods, fenestrate bryozoans, iron staining, and calcite cement	Clay to coarse gravel	----	0%	High energy unidirectional traction currents
Deformed bedding	Distorted laminations or bedding in a wide range of lithologies, commonly contains slump structures and/or convolute bedding; may or may not be: intense bioturbation	Clay to medium-grained	----	----	Post or syndeposition deformation
Pedogenically altered	Variegated (varying from red to green to yellow to grey) lenticular bedding, wavy bedding, or siltstone; may or may not contain: carbonate nodules, carbonaceous material, root casts, and slickensides	Clay to silt	----	0-20%	Pedogenesis post deposition

Integrating Core/Outcrop Studies



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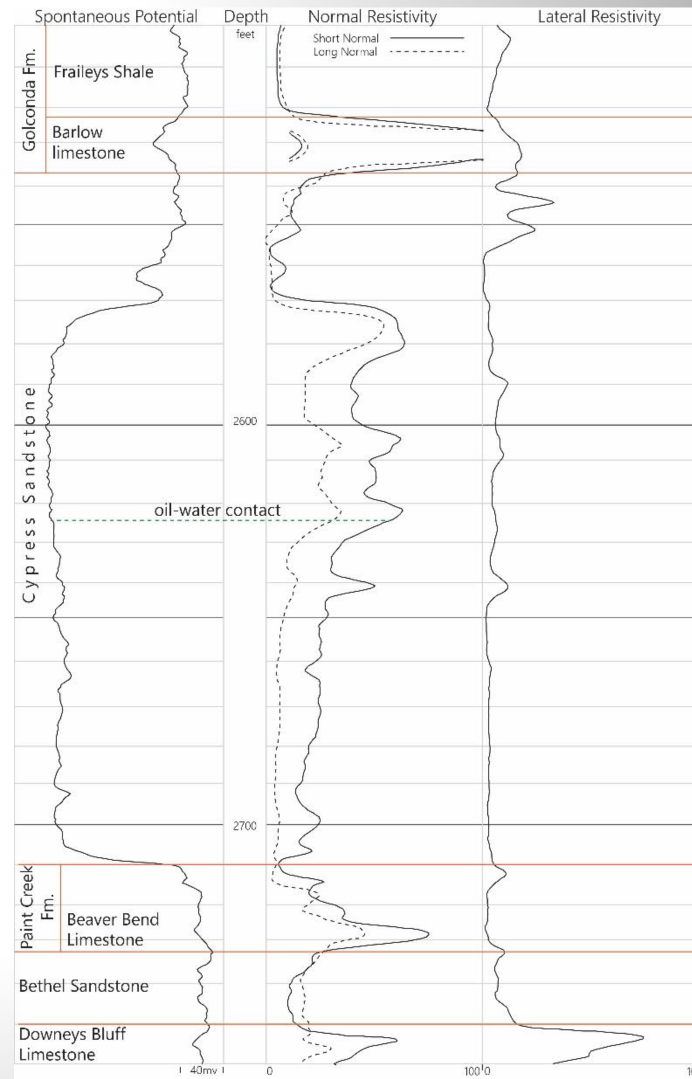
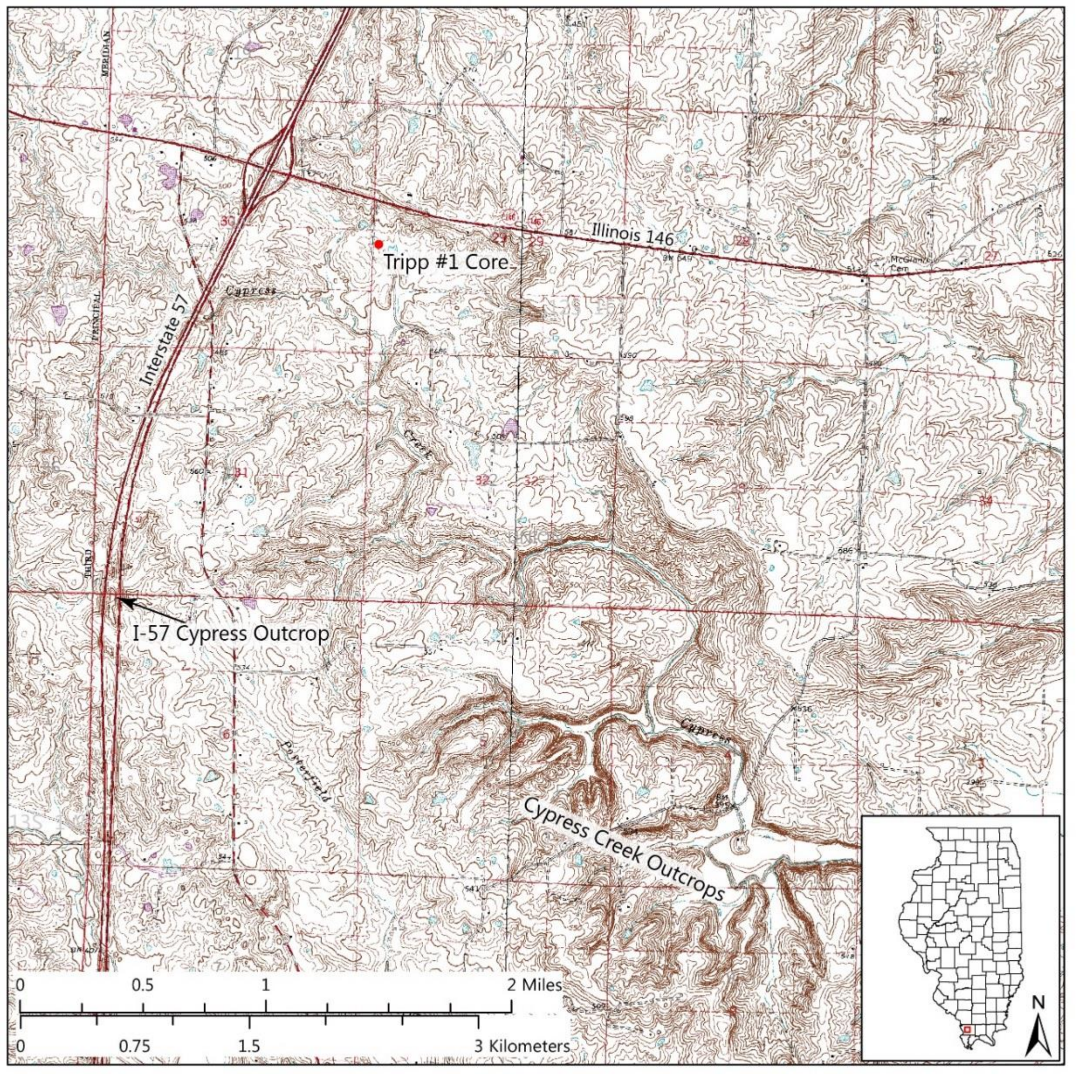


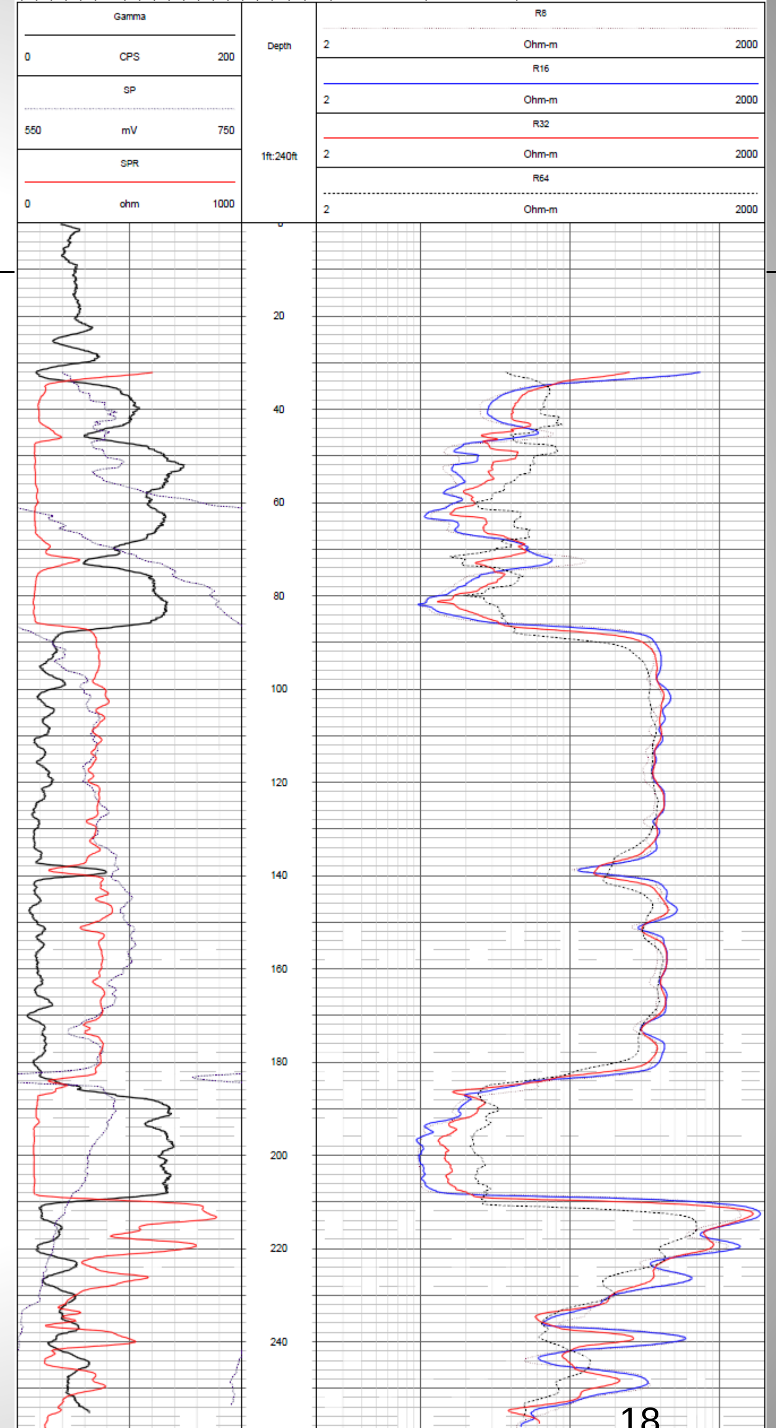
Tripp #1 core

- Drilled Sept 6 – 13
- 259 ft TD
  - 25 ft surficial
  - Thin, weathered Barlow Ls
  - 160 ft Cypress Fm
    - 100 ft thick Ss
  - 72 ft of Ridenhower Sh and Ls
- 1 mi from I-57 roadcut, 2-3 mi from Cypress Creek outcrops



Tripp #1 Logs

- Weatherford
  - Combo Photo Density/Neutron, Array Induction, Gamma Ray
- ISGS
  - SP, Gamma Ray, Single-Point Resistance, 8-16-32-64 inch Normal Resistivity
  - Spectral Gamma Ray
  - Full Waveform Sonic
  - Magnetic Susceptibility
  - Acoustic televiewer



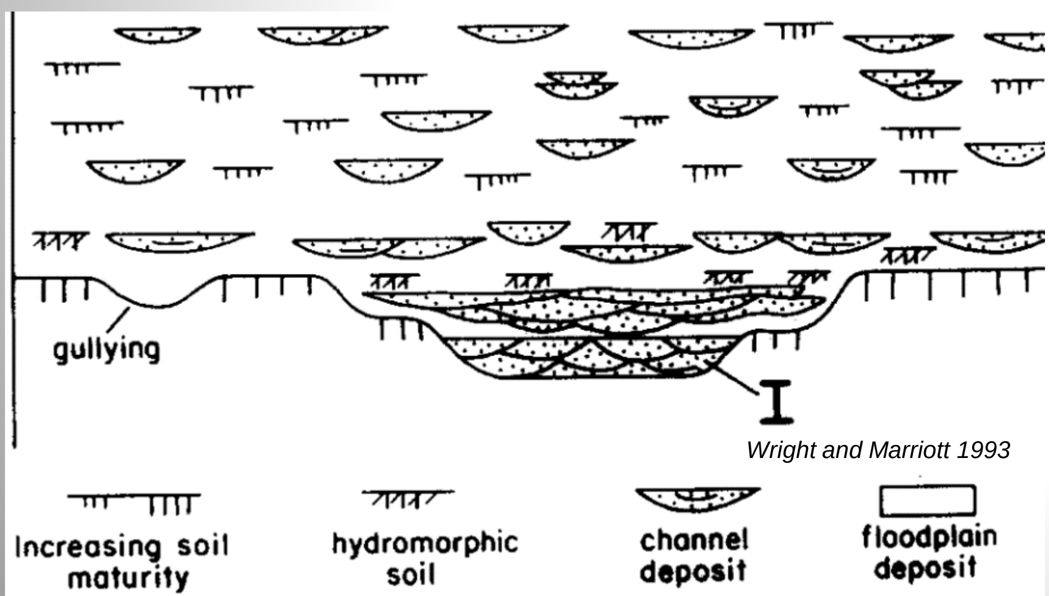
Objectives for Core Processing

- Detailed geologic description/facies analysis
- Identification/quantification of any residual oil saturation
- Porosity/permeability measurements
  - Porosimeter/permeameter, mini-permeameter
- Gamma Ray measurements
- Sampling for petrography and mineralogy

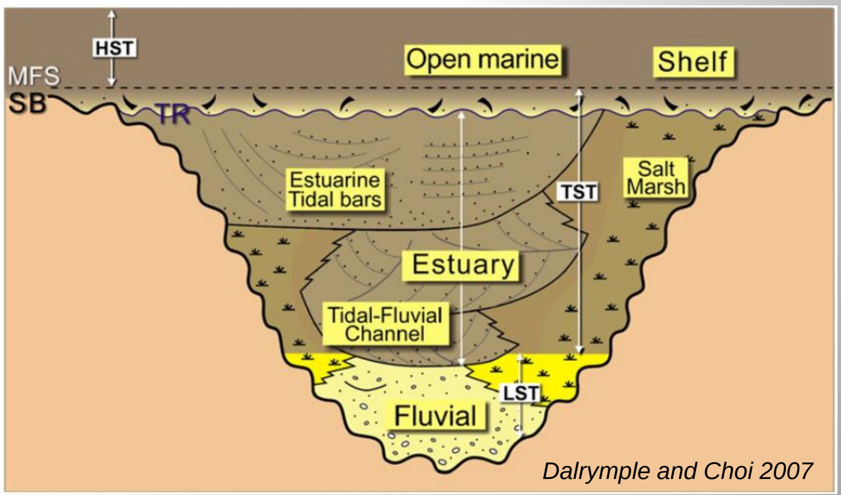
We're still trying to get a complete core in the basin interior

Depositional Environments

- Interpreted the Cypress Sandstone at Noble Field as part of an incised valley fill system (LST-TST)
  - Erosional base, overall fining upward, coarser grained than Cypress tidal bars
  - Multistory sandstone built through parasequence-scale successive fluvial to estuarine depositional episodes

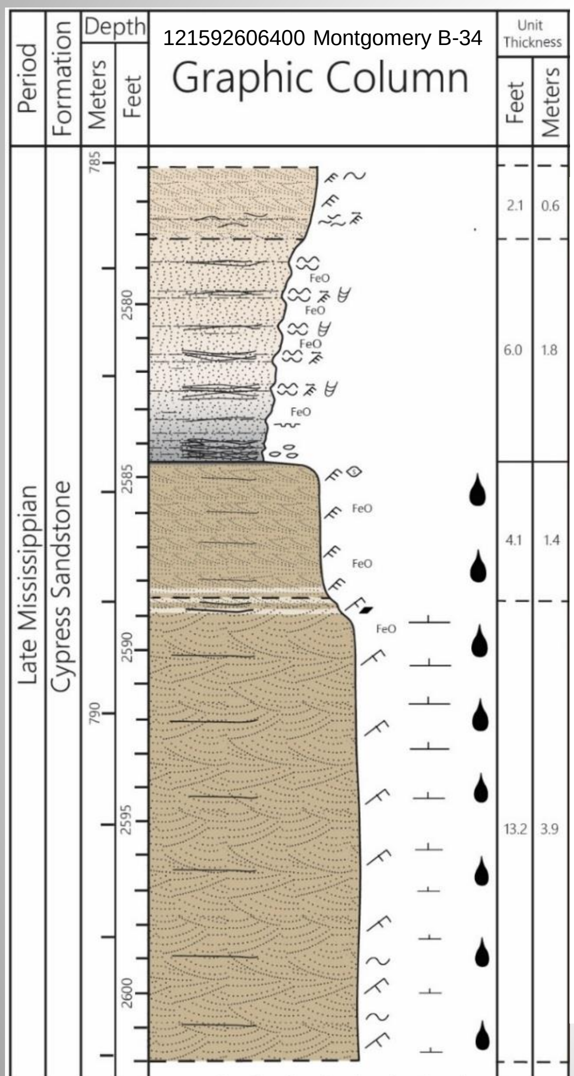


Wright and Marriott 1993

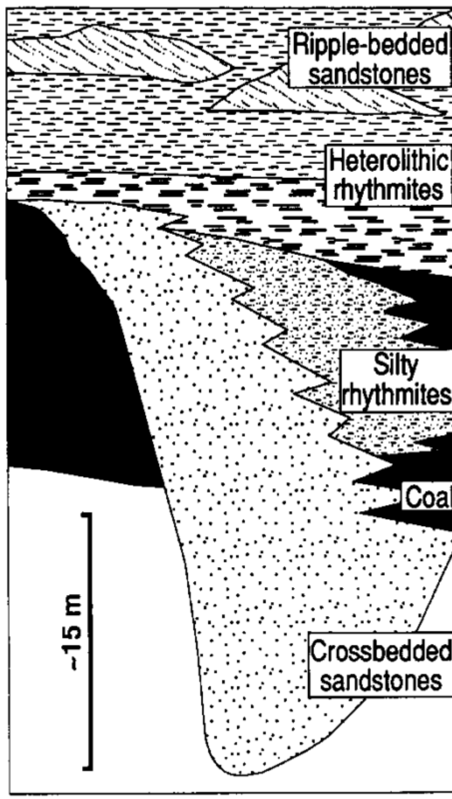


Dalrymple and Choi 2007

Depositional Environments



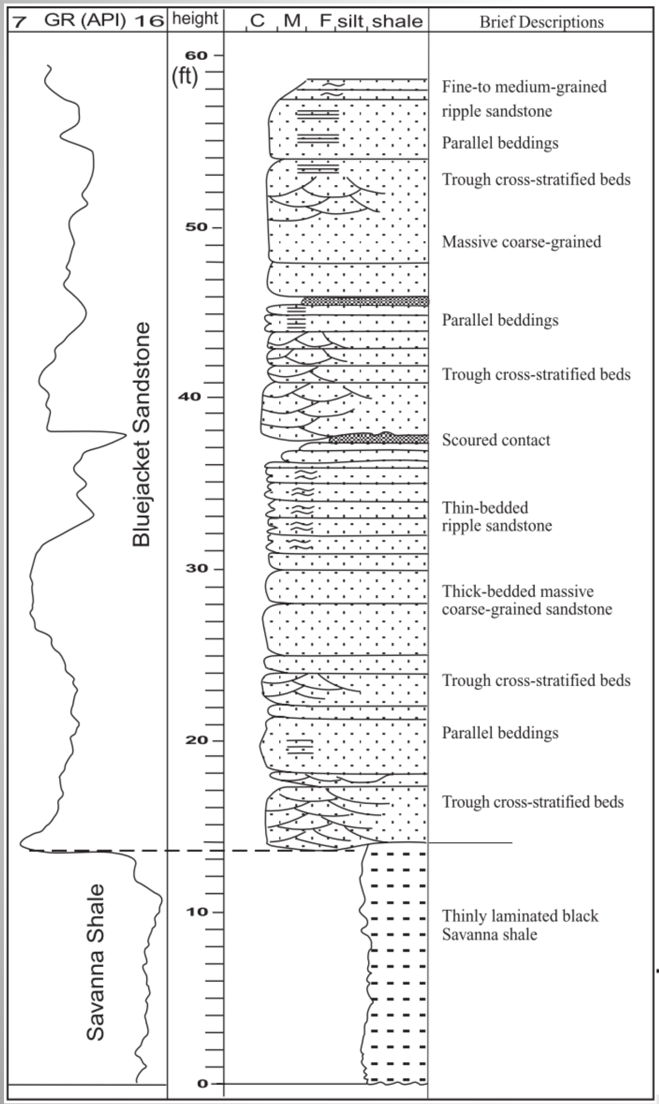
Summary of major facies and attributes for Carboniferous valley-fill sequence



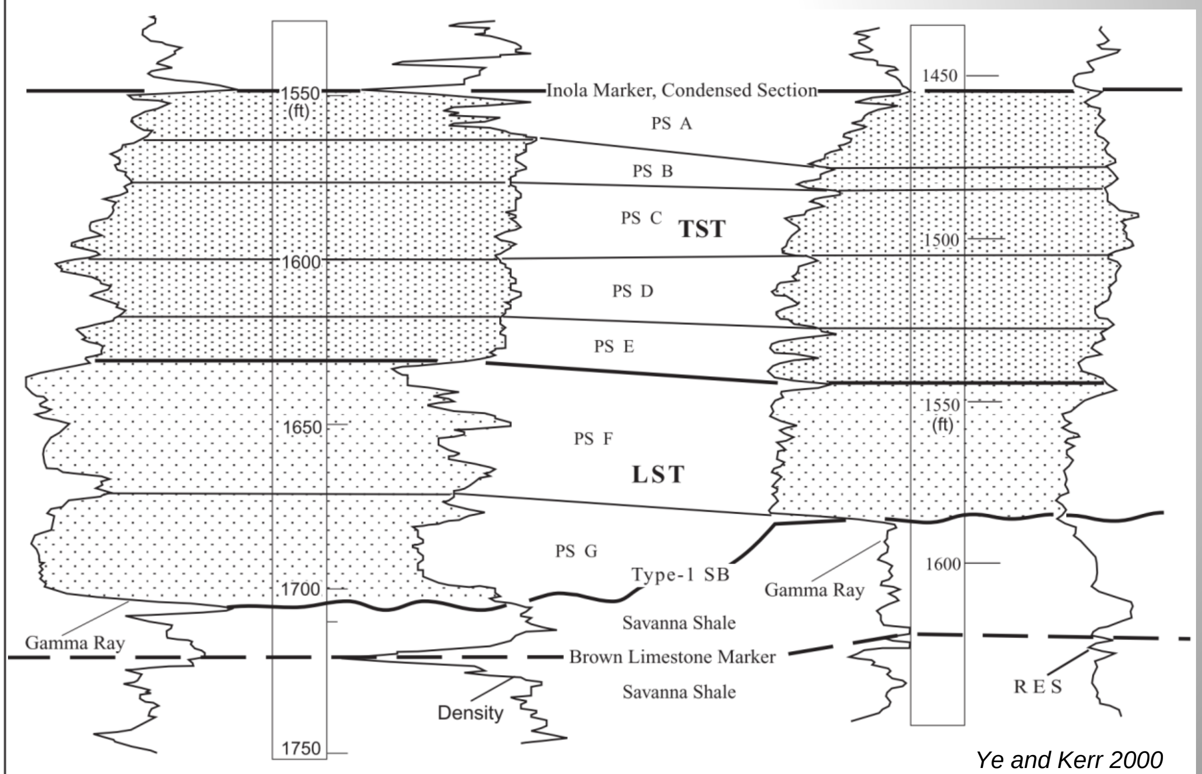
Facies	Physical attributes	Biological attributes
Ripple-bedded sandstones	Flaggy, internally ripple bedded, 5 to 50-cm thick, discontinuous clay drapes,current and wave ripples, planated ripples, runzel marks	Fragmentary, abraded stems and wood, *Scolicia, Lockeia, Rhizocorallium, Rusophycus, Cruziana, Eione*
Heterolithic rhythmites	Planar laminae to lenticular, wavy, and flaser bedding, well-developed clay drapes, tidal periodicities, current and wave ripples	Upright trees (2-m tall), well preserved foliage, lowest part nonbioturbated, overlain by vertical-*Lockeia*, overlain by horizontal-*Lockeia* assemblage, upper part bioturb. by *Asterosoma, Teichichnus, Conostichus*
Silty rhythmites	Vertically accreted laminae to thin beds (10 cm) of silt, thin clay drapes, CRL, tidal periodicities, exposure features (raindrops, rills, drain features), current ripples only	Upright lycopods, calamites, pteridosperms (3-m tall), well preserved foliage, cones, *Plangtichnus, Treptichnus, Haplotichnus, Kouphichnium*, fish-fin drag marks, tetrapod trackways
Coal	During drier intervals, restricted to paleovalley, during wetter intervals, laterally widespread, splits common in paleovalley, low-sulfur (1.5%) under rhythmites, high-sulfur (>5%) under bioturbated marine roof	Upright trees only in areas of rhythmite roof, upright ferns project into roof facies in areas of silty-rhythmite roof, carbonate diagenetic features, such as coal balls, only in areas of bioturbated marine roof
Crossbedded sandstones	Medium grained, basal conglomerates, shoestring geometry, 30-m thick, trough crossbedding at base, tabular-planar crossbedded at top, clay-draped bedforms at top	Logs in basal conglomerates, fragmented plants and leaf-litter on foresets, nonbioturbated, rare *Cochlichnus, Planolites*

Archer et al 1994

Analogue: Bartlesville Ss



- Braided fluvial lower "sheet" sandstone
- Meandering fluvial middle sandstone
- Tidal-estuarine upper facies



Ye and Kerr 2000

Linking Clay Mineralogy to Depositional Environment

- Distribution of early-diagenetic (eogenetic) clay minerals in sandstones is controlled by depositional environment

Controls on eogenetic clay mineral precipitation:

- Relative sea-level
- Sediment supply/sedimentation rate
- Prevailing climatic conditions
- Permeability of sediments during deposition
- Volume of unstable silicates

→

- pore-water chemistry
- duration of pore-water circulation

→

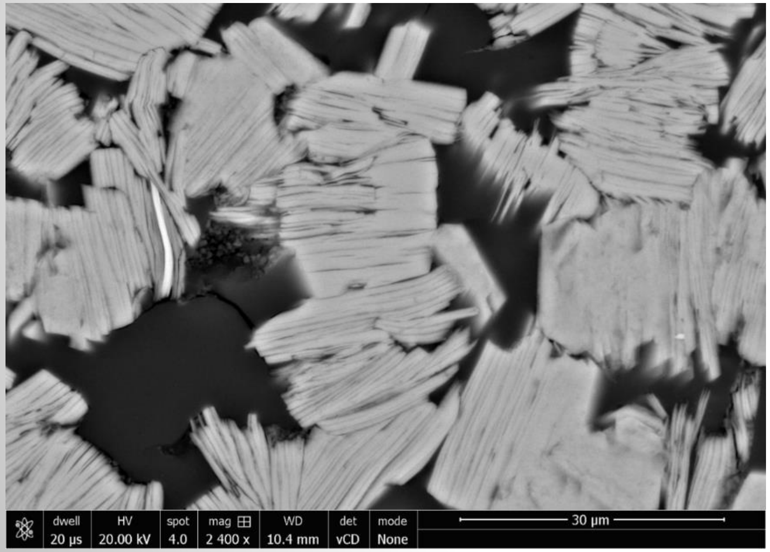
eogenetic clay mineral assemblage

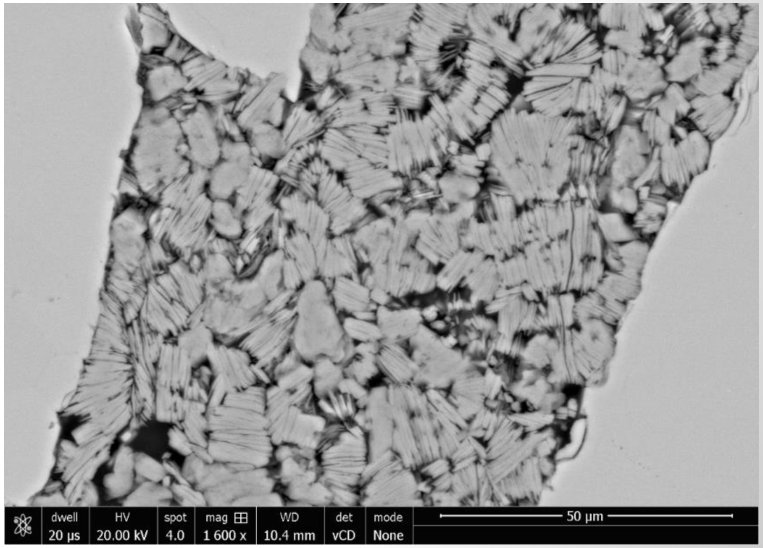
Formation of Eogenetic Kaolinite

- Kaolinite forms as the result of extensive meteoric water dissolution of detrital silicates (e.g. feldspars)
  – Permeable **fluvial deposits within incised valleys** are subjected to meteoric water-flushing under humid climatic conditions, and thus more kaolinite
- Upper part of the LST is expected to contain progressively less kaolinite towards the TS (Ketzer et al., 2003)
  – Rise in relative sea level ➔ less meteoric water influence

Evidence for Eogenetic Kaolinite

- Microporous, randomly arranged booklets are characteristic of direct precipitation from aqueous Al-rich solution (Keller, 1978)
- No textural relationship with K-feldspar or other clays implies direct precipitation during eogenesis

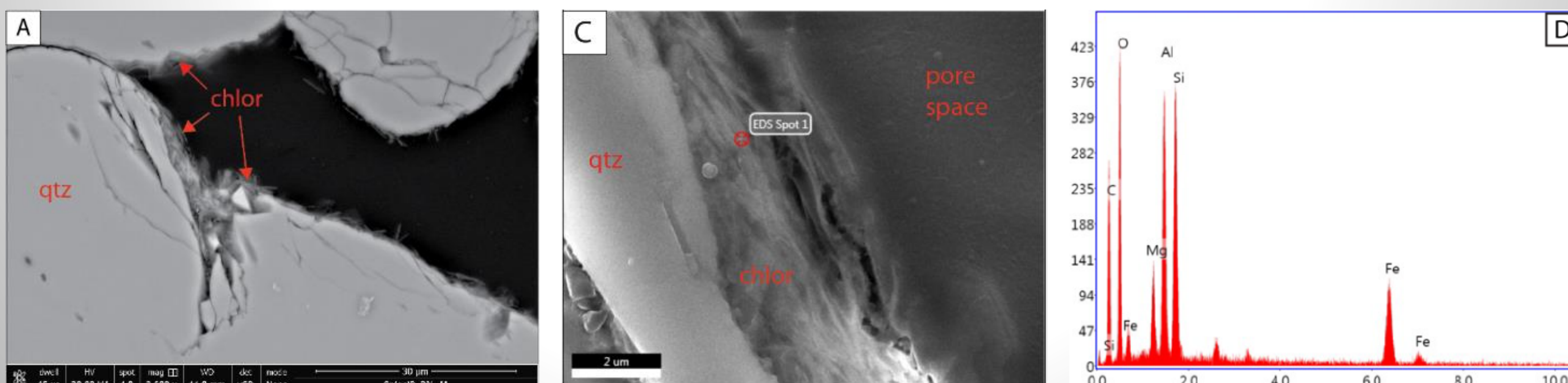




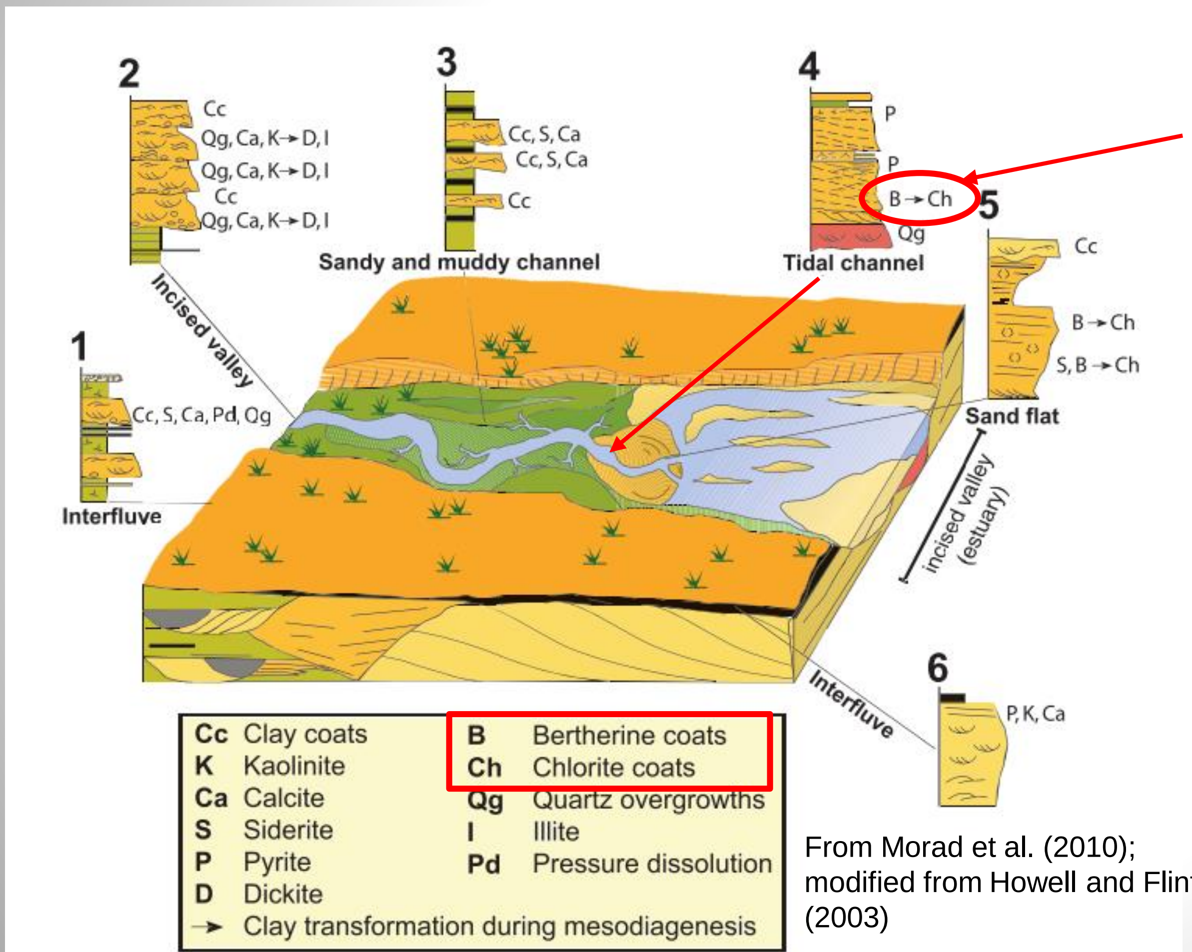
SEM images of kaolinite booklets from the Cypress at Dale Oil Field

Formation of Later Stage Chlorite

- Chlorite in the Cypress:
  - Forms later, during burial diagenesis
  - Iron-rich grain-coating rosettes
  - Transforms eogenetic minerals
- Structure of the chlorite (based on XRD) indicates diagenetic transformation from a berthierine precursor (based on SEM/EDS)



Depositional environment of Fe-rich grain-coating clays



From Morad et al. (2010); modified from Howell and Flint (2003)

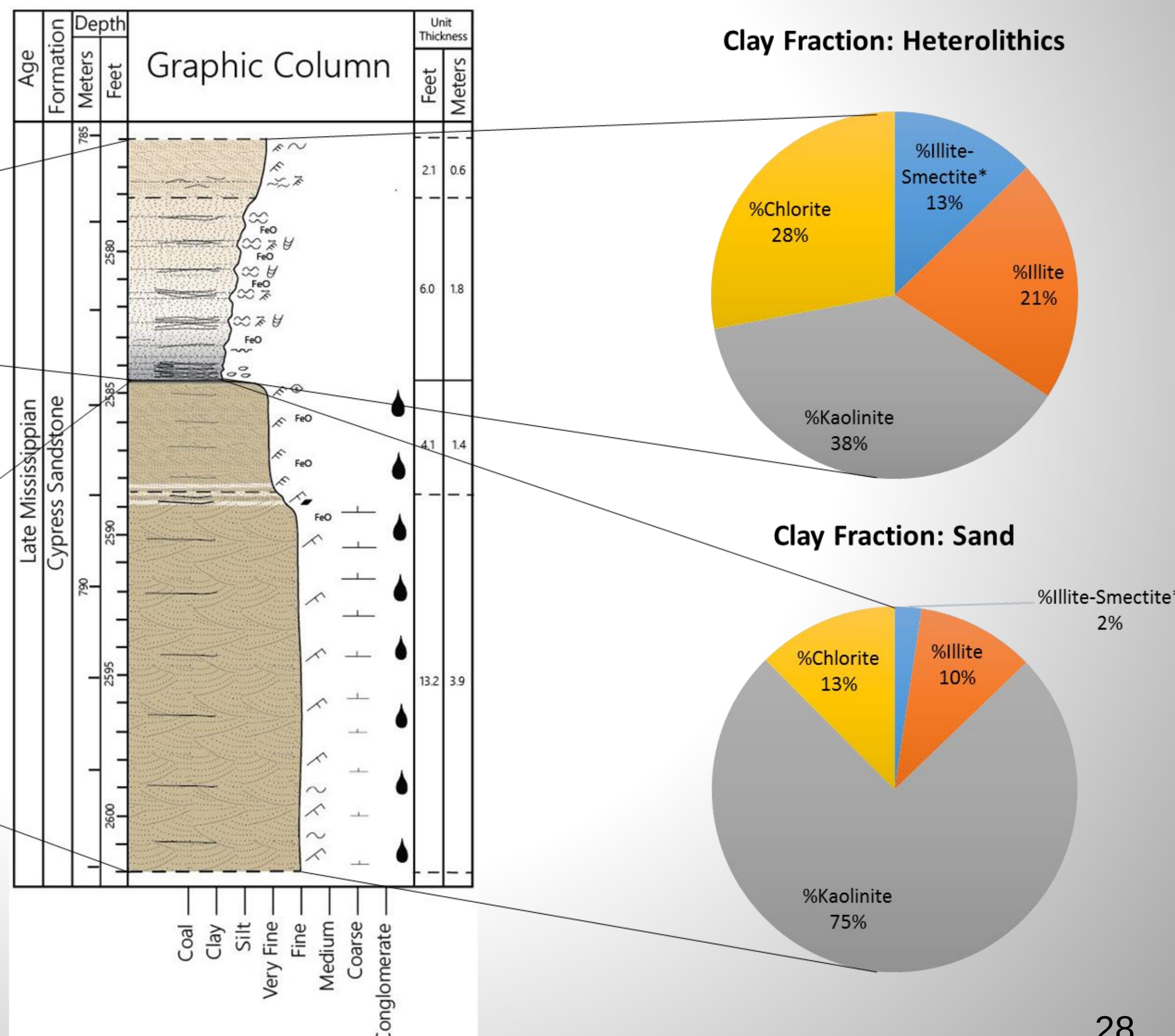
- Berthierine clay-coatings form in **deltaic, estuarine, fluvial and inner-shelf settings** associated with areas of river discharge into marine environments in a **tropical to subtropical climate**
  - **Could indicate fluvial – estuarine transition**

Fluvial-Estuarine Transition

Evidence for humid, fluvial-estuarine environment

Upper LST-TS (estuarine): **Less kaolinite**

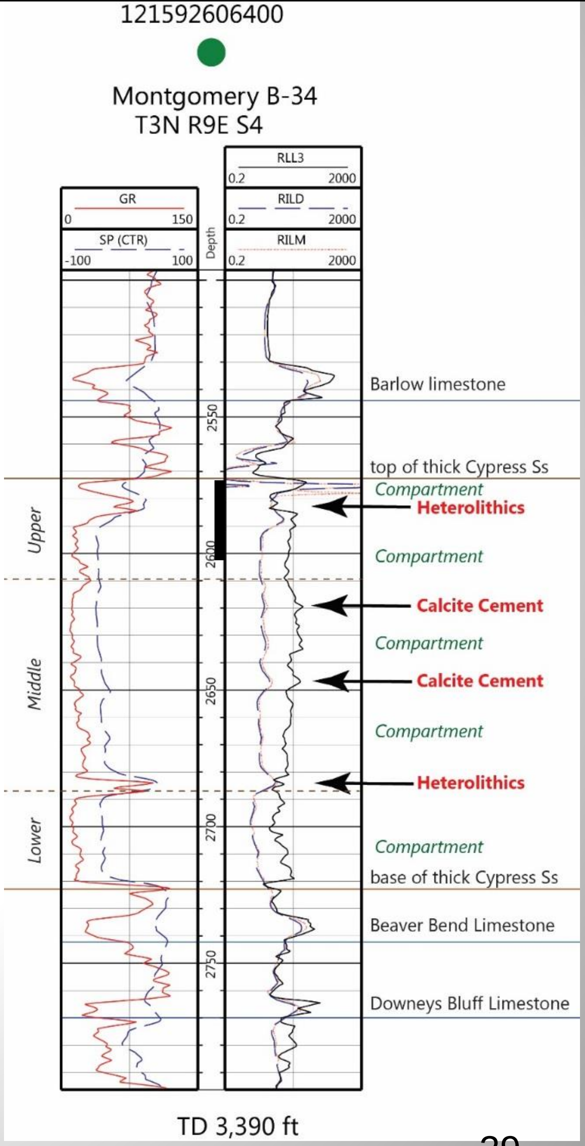
Permeable LST (fluvial): **More kaolinte**



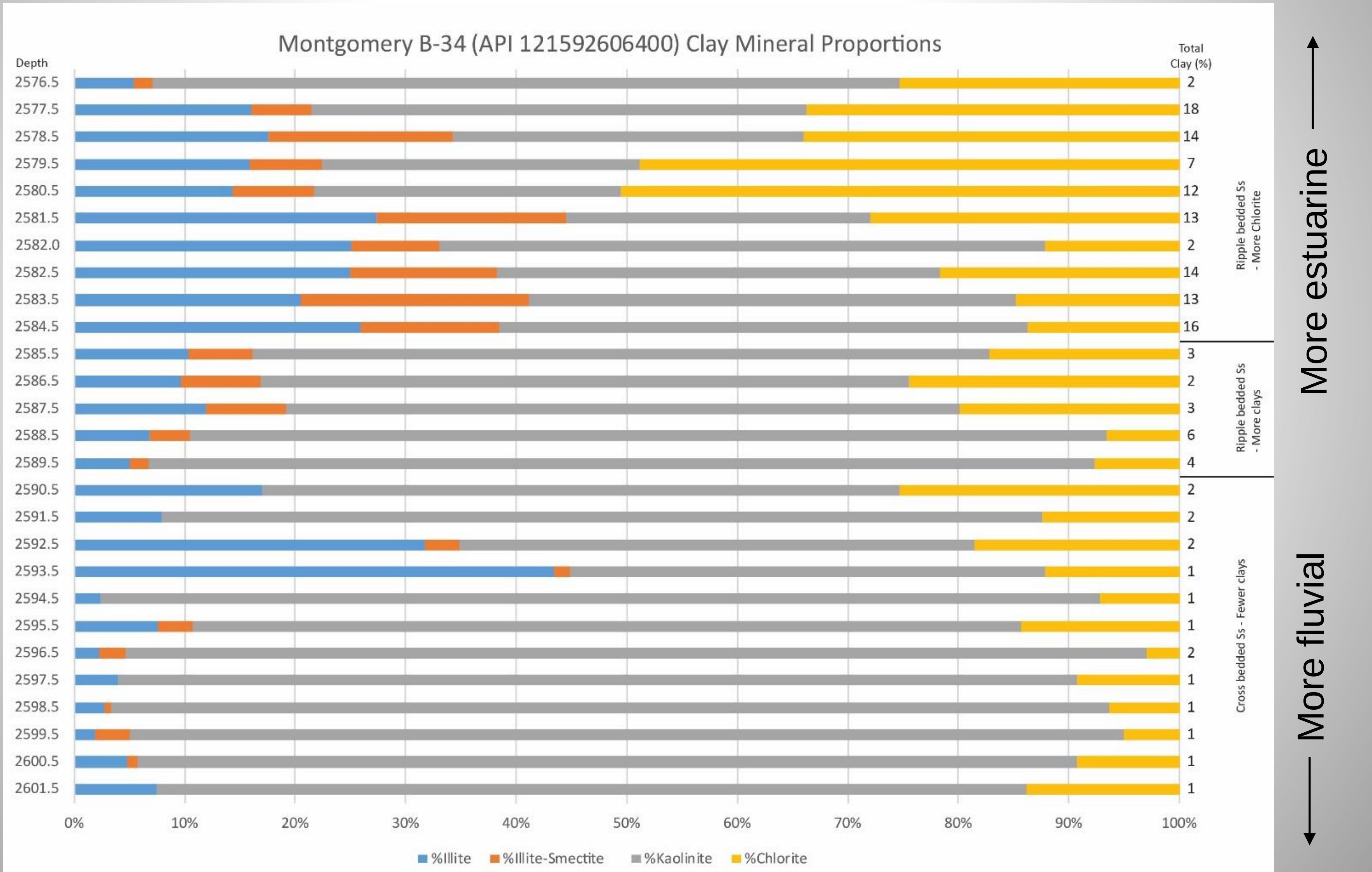
Returning to our case studies…

Reservoir Characterization

- Compartmentalized despite being relatively homogeneous
  - Internal flooding surfaces (?)
    - Thin shale interbeds
    - Heterolithic intervals
  - Calcite cements
    - Concurrent with and below OWC
- Noble Field
  - 160+ ft thick Ss
  - 17.0% ϕ; 438 mD k
    - 28 samples from 7 wells show > 1 D k
- Kenner West Field
  - 100 ft thick Ss
  - 17.7% ϕ; 99.5 mD k



Controls on Porosity/Permeability



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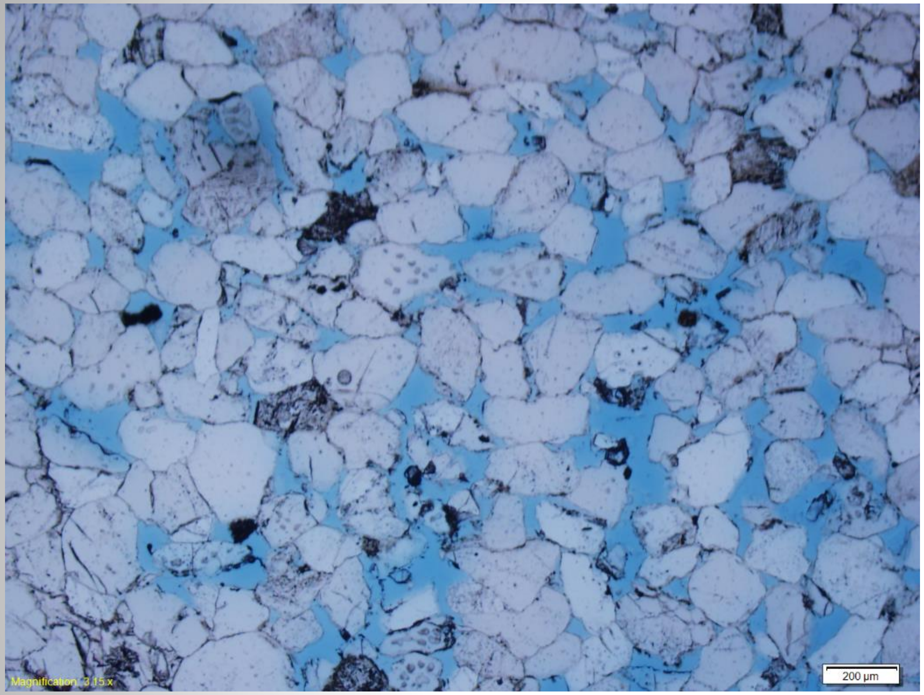
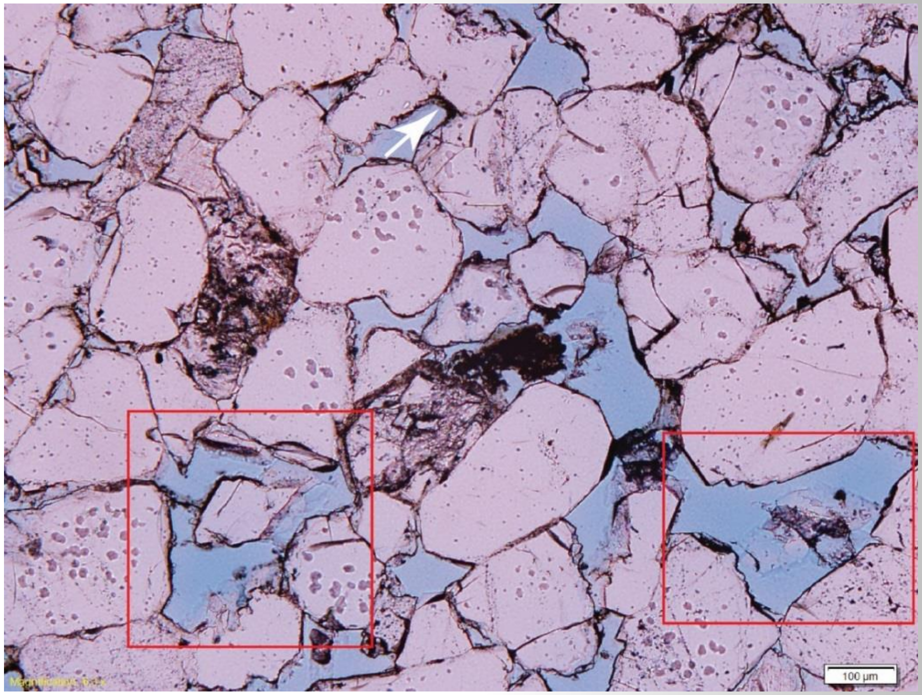
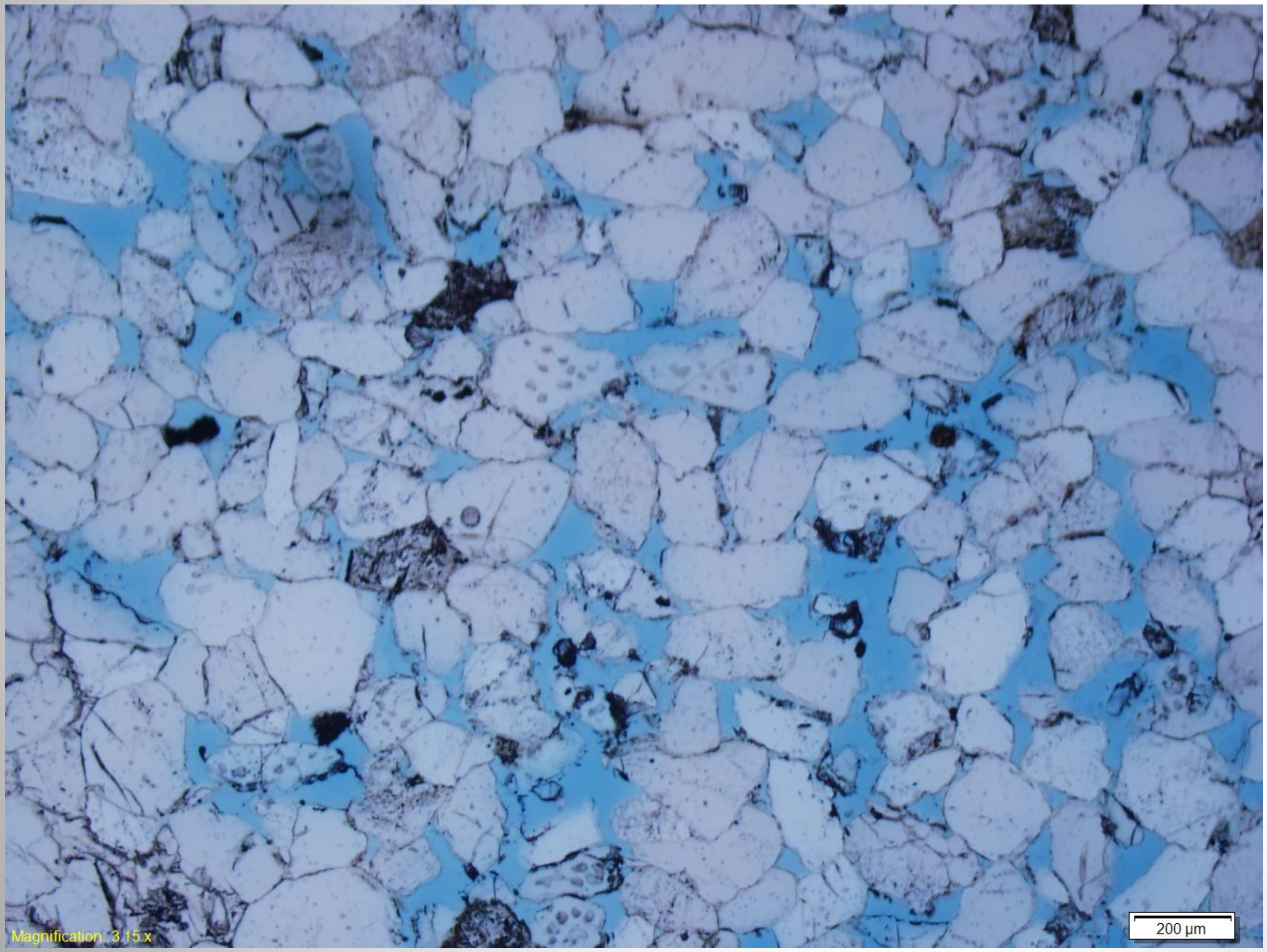
Controls on Porosity/Permeability





- Depositional environment
  - Higher energy deposits are cleaner and higher reservoir quality
- Hybrid pore system of primary intergranular and secondary porosity from dissolution of grains and cements
  - Long, well-connected pores contribute to the exceedingly high permeabilities

Controls on Porosity/Permeability



121592608300; Coen 120; 2612.5'; 16.3% ϕ; 384 mD k

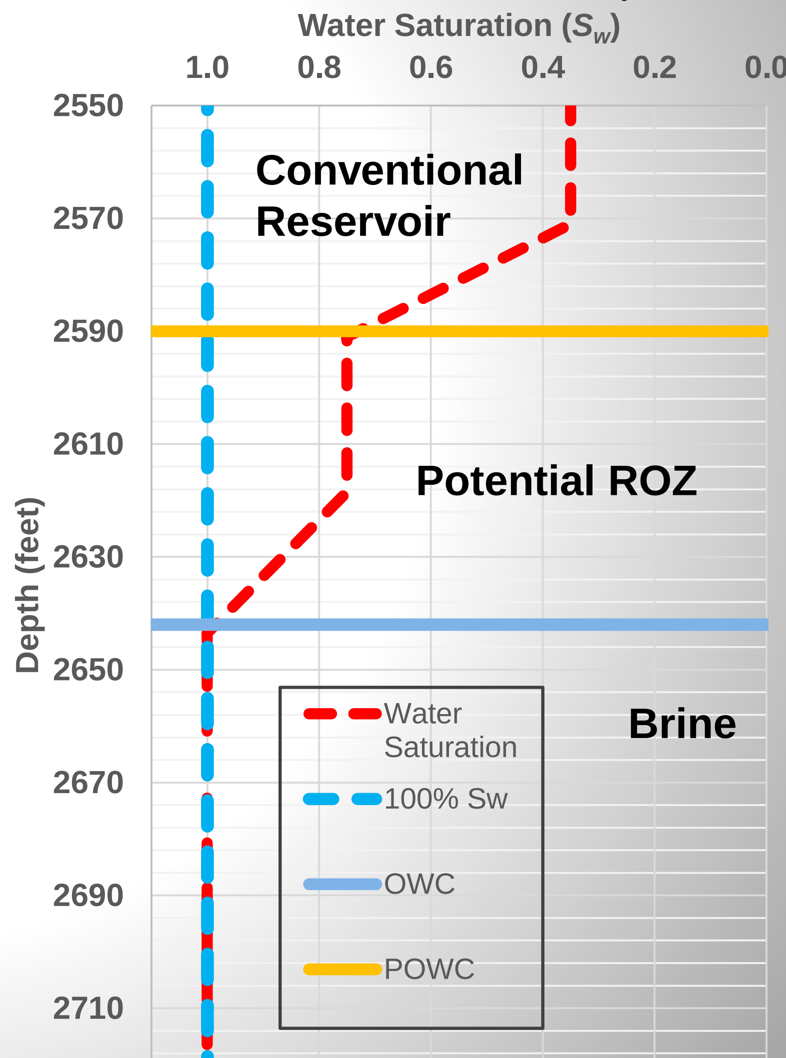
- Compaction, quartz and calcite cement occludes porosity in some areas
- Mature sandstone with, limited detrital clay, preserved primary intergranular porosity and possibly some dissolution of cements enhances porosity and permeability

Petrophysics

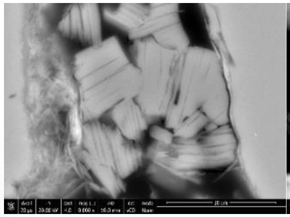
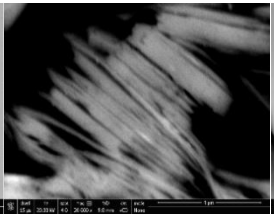
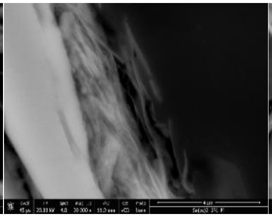
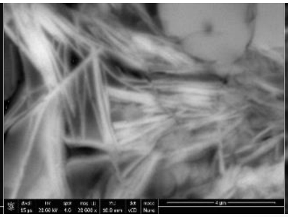
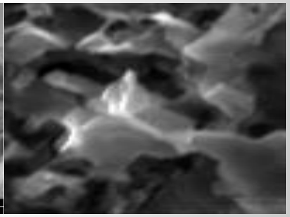
Petrophysics

- Calculated water saturation (S_w) profiles from logs in Noble Field using two methods:
  - Archie (Resistivity + Porosity logs)
  - Dual water (Resistivity + Porosity logs + microporosity data)
    - Mitigates influence of dispersed clay that produces anomalously high S_w values

Ideal water saturation profile



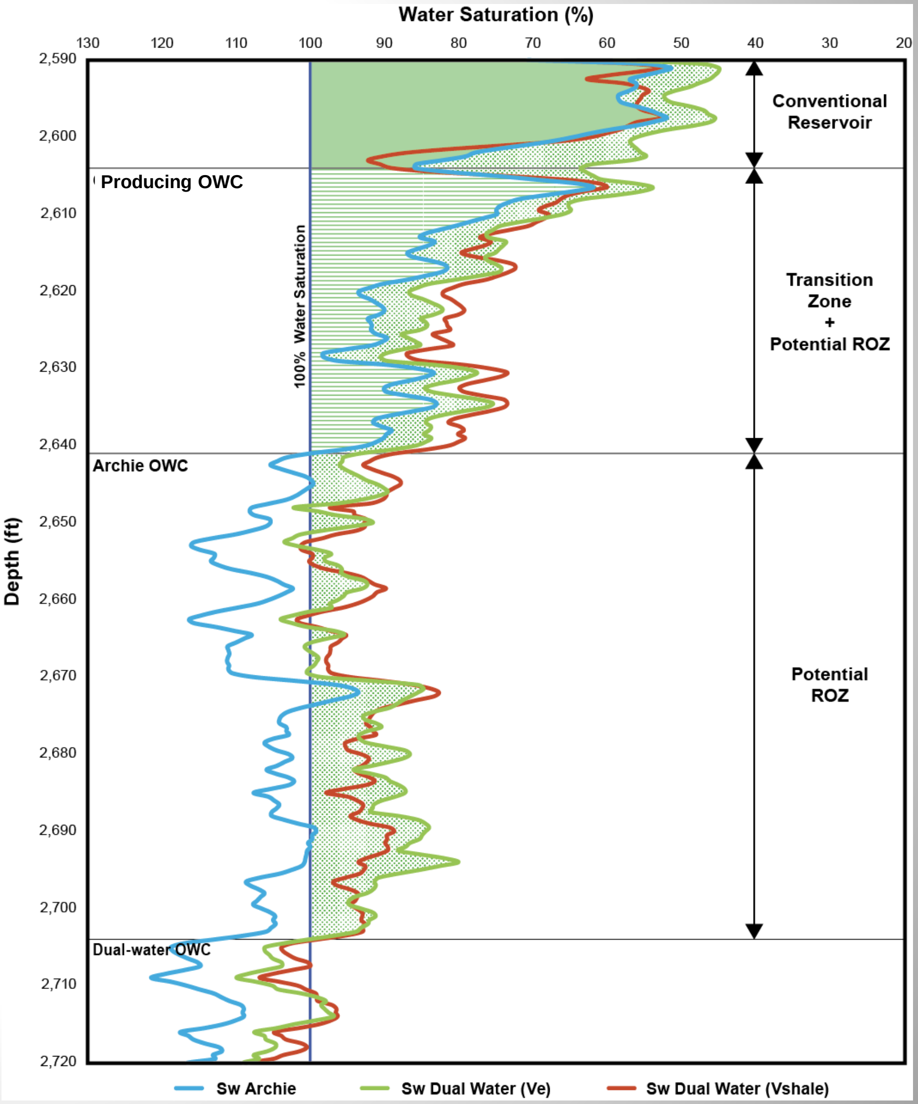
Microporosity Analysis

Mineral	Kaolinite	Kaolinite	Chlorite	Illite	Illite-smectite
Morphology	Booklets	Vermicules	Rosettes	Fibrous	Filamentous webs
Occurrence	Pore-filling	Pore-filling	Grain-coating	Pore-filling, bridging	Pore-filling
Microporosity (%)	40	15	50	65	55
SEM Photomicrograph					

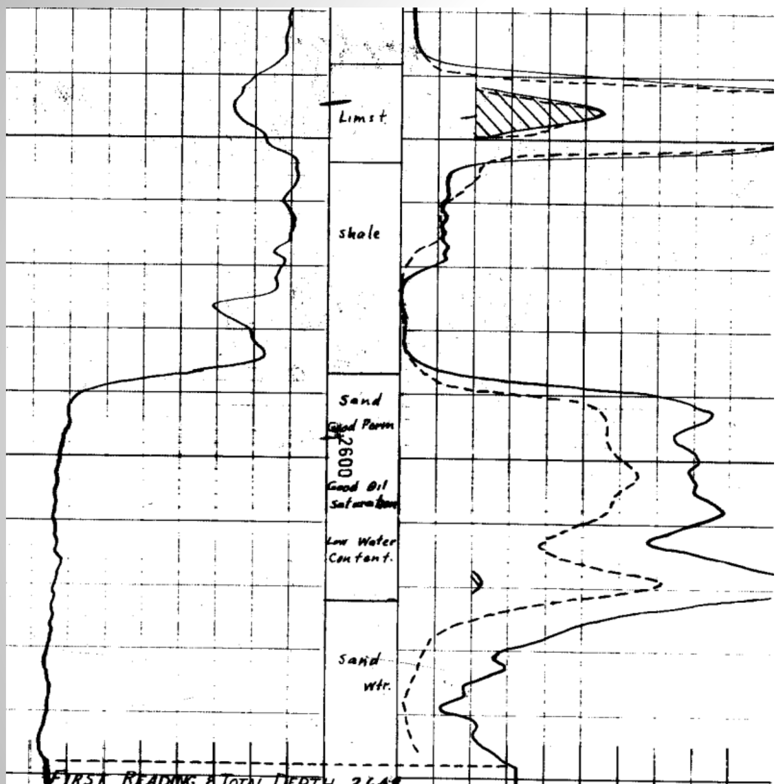
- Determined clay mineral microporosity via scanning electron microscopy and image analysis

Petrophysics

- Analyzed results produced by different methods
  - Determined clay microporosity was affecting Archie results
- Interpreted logs to define **producing oil-water contact** (POWC) and ultimate OWC
  - Mapped thickness of conventional reservoir and potential ROZ
  - Conducted visible cut tests to confirm oil saturation



Picking the Oil-Water Contact



"White, coarse grained, porous water sandstone, shot with pyrites, angular. Looks like water sand at 2625' but still carrying some oil. At 2628' definite white water sandstone with no show of oil."

County Richland S. 4 T. 3N R. 9E
Ft. L. Ft. SW NW
Company Pure Oil Co.
No. 15 Farm C. T Montgomery "B"
Pool Clay City Cons. Elev. 495 DF
Twp. Noble Meth. 8-17-54
R.T.
S.T.
Spd. 8-13-54 Comp. SEP 14 1954
T.D. 3132 P.B.
I.P. 85 BO Plugged
Sand ST LOUIS Top 3114
Casing 10-224 Shot
5-2990
Acid 500
Collector JV Hyd.
Activity AUG 17 1954 @ 1485
AUG 24 DST 2811-60
2 hr. G 1540' 85'
O&GCM BHP 557
Cng. AUG 31 wash
SEP 7 MIST. DD. 3017,
SEP 14 DD 3132, A500,
POP.
TD 3132

	Sample	Elec. H.
Men.		2105-38
M. Men.		
L. Men.		
Walt.		
Vien.		
T.S.		
G.D.		2364-85
Hard.		
Gol.		2449-
Bar.		2521-38
Cyp.	50	2569-2626
P.C.		2712-32
		2752-60
Beth.		2762-78
Ren.		2801-14

CORE LABORATORIES, INC.

Petroleum Engineering Service

Midco Building
TULSA
2-6634

Santa Fe Building
DALLAS
2-8952

Field Laboratory
DALLAS
2-8952

February 14, 1938
Pure Oil Company
Montgomery "B" 2
Page # 2

Sample No.	Depth, Ft.	Percent Porosity	Oil Content (Barrels per Acre Foot)	Saturation (Percent) Oil	Saturation (Percent) Water	Permeability (Millidarcys)
36	2620.0	19.5	364	24.1	26.7	550.
37	2621.0	17.1	356	26.9	35.7	425.
38	2622.0	17.8	341	24.7	27.0	660.
39	2623.0	21.2	380	23.1	29.2	653.
40	2624.0	19.7	395	25.9	23.8	523.
41	2625.0	20.8	380	23.6	27.4	765.
42	2626.0	18.2	364	25.8	33.0	520.
43	2627.0	21.5	443	26.0	31.3	814.
44	2628.0	16.6	388	30.1	22.9	238.
45	2630.0	19.0	434	29.5	30.5	777.
46	2632.0	18.7	364	25.1	28.4	286.
47	2634.0	19.1	380	25.6	35.1	350.
48	2636.0	19.5	395	26.2	32.8	492.
49	2638.0	19.1	349	23.6	32.4	647.
50	2639.0	WATER SAND				112.

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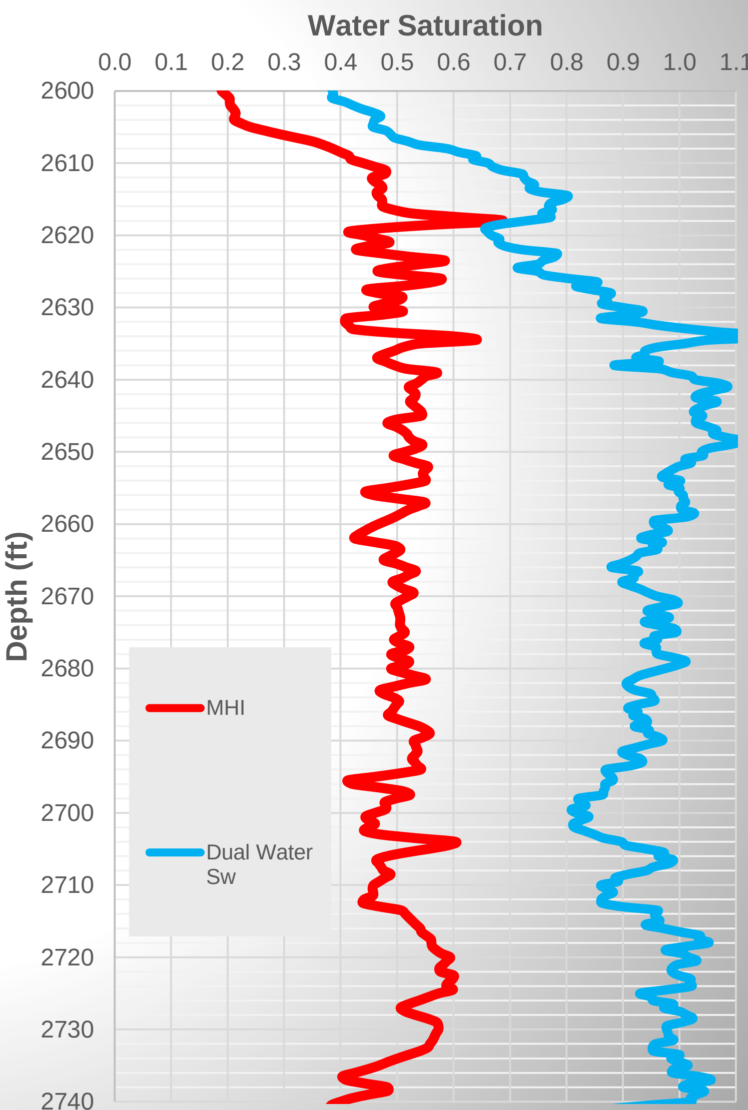
Movable Hydrocarbon Index

- Used MHI to compare shallow and deep resistivity to determine if oil has been flushed
- Picked POWC based on MHI
- What oil saturation is producible?



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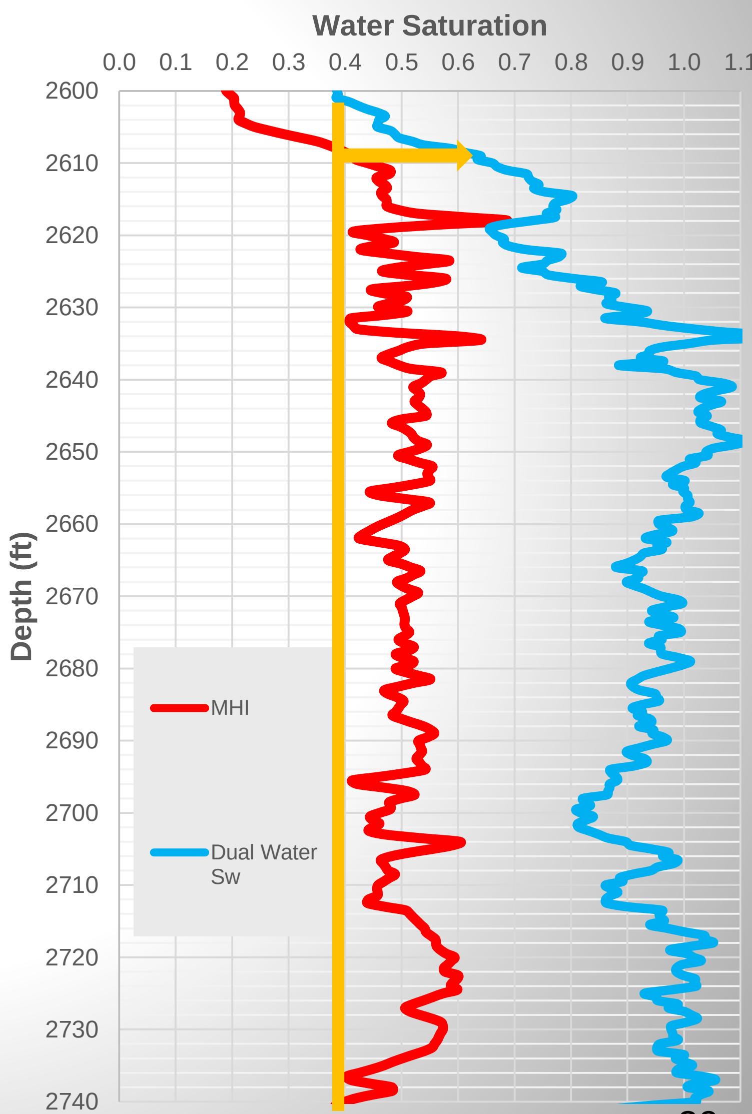
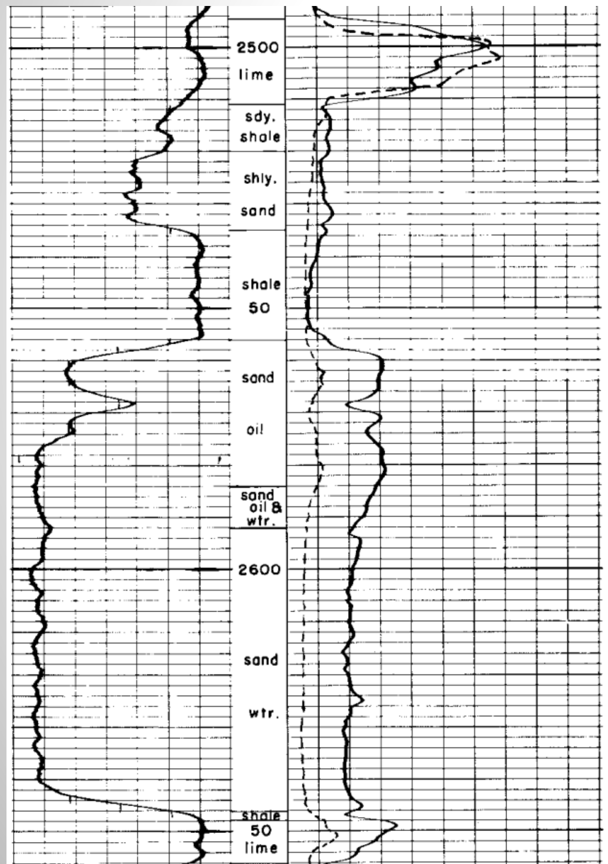
Movable Hydrocarbon Index

- MHI cutoff of 0.4 puts POWC at 2610
  - Any higher would suggest moveable hydrocarbon over whole interval
- What oil saturation is producible?
  - This corresponds to water saturation of 0.65

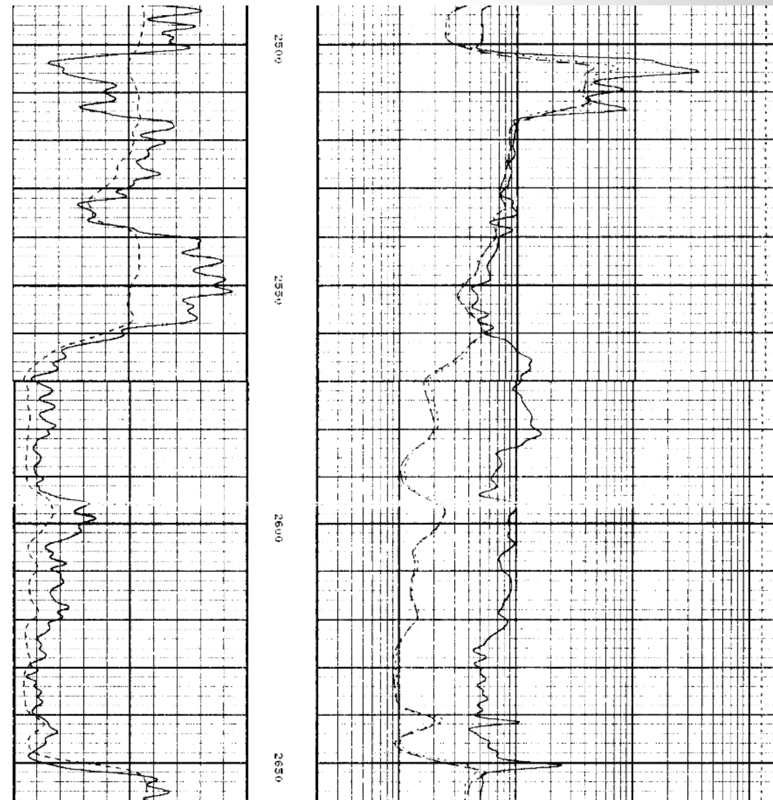


Application: Kenner West Field

120250249300: Resistivity and SP logs from 1947

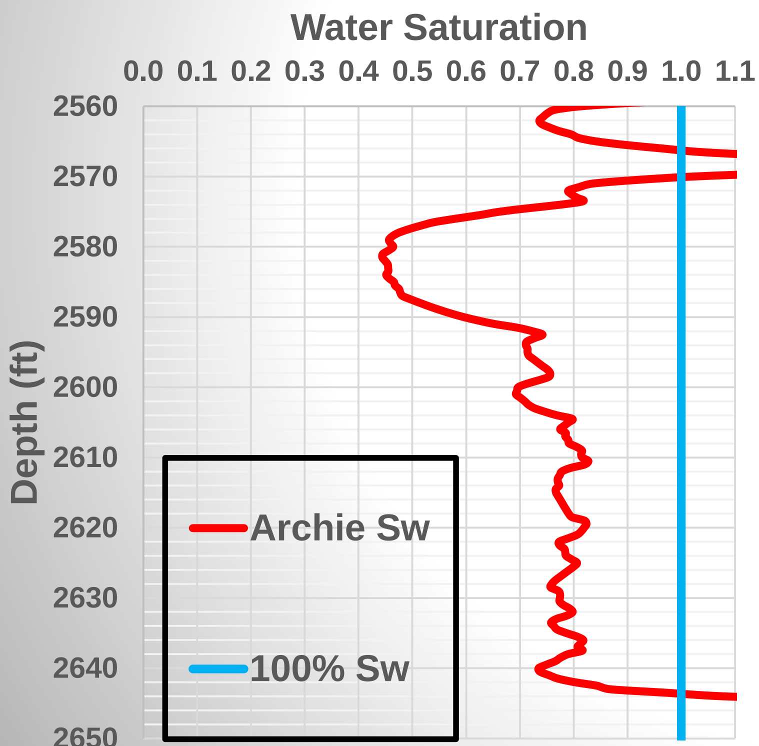


120252837200: Porosity, resistivity, and SP logs from 1996

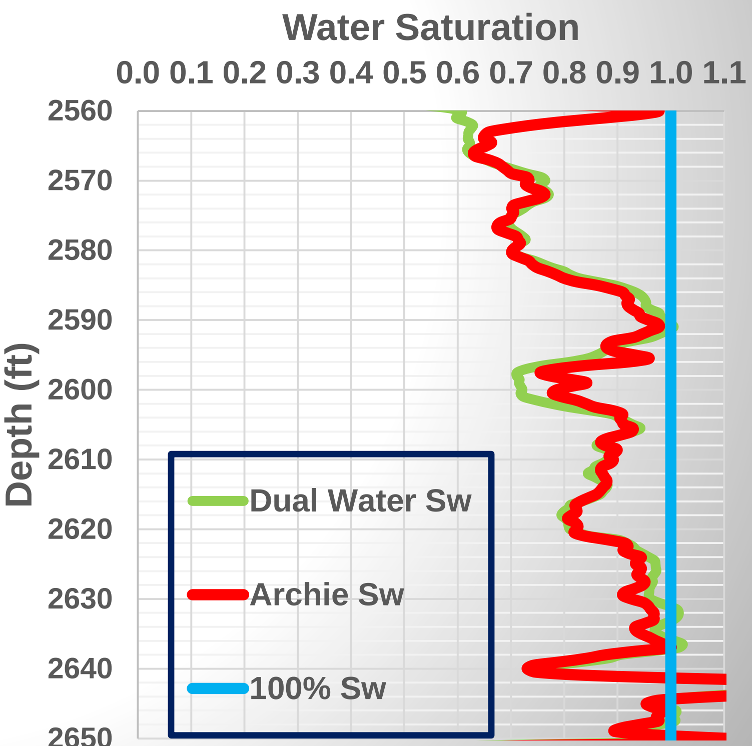


Application: Kenner West Field

120250249300: Resistivity and SP logs from 1947



120252837200: Porosity, resistivity, and SP logs from 1996



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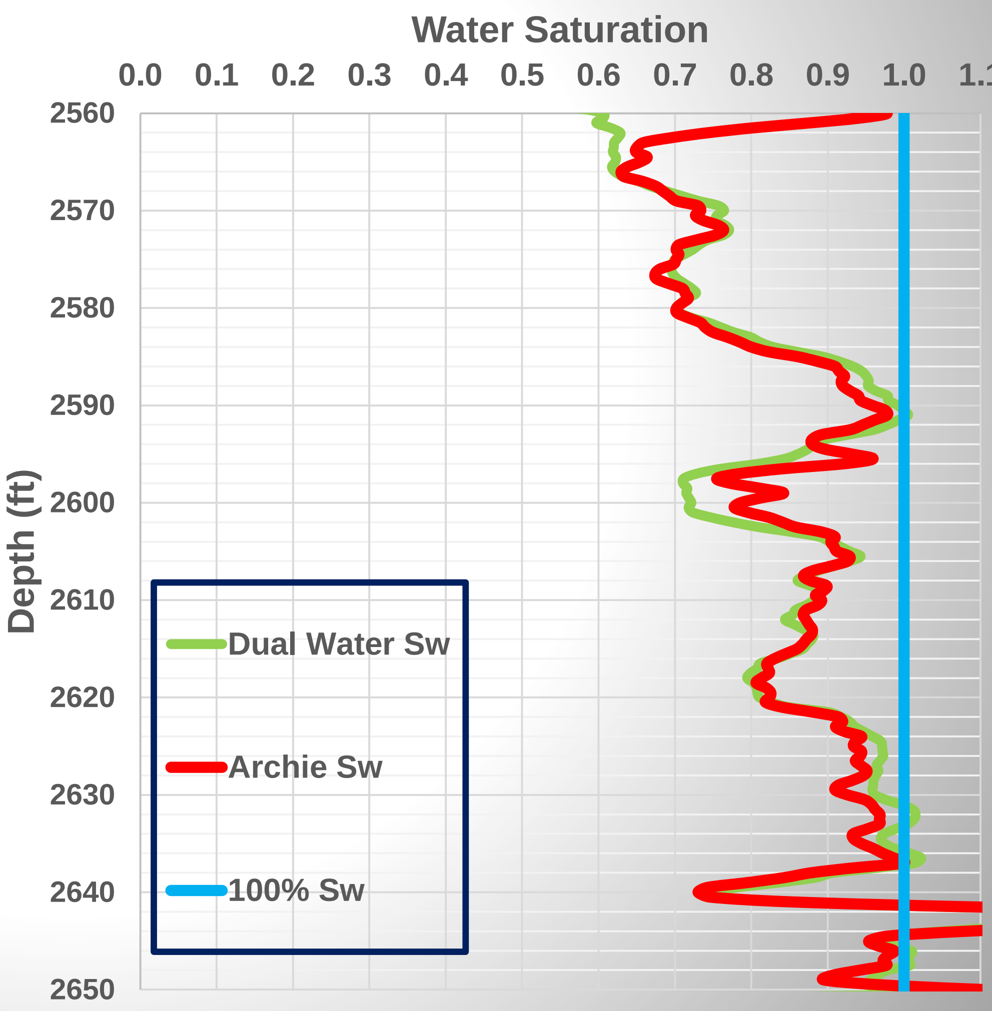
Application: Kenner West Field

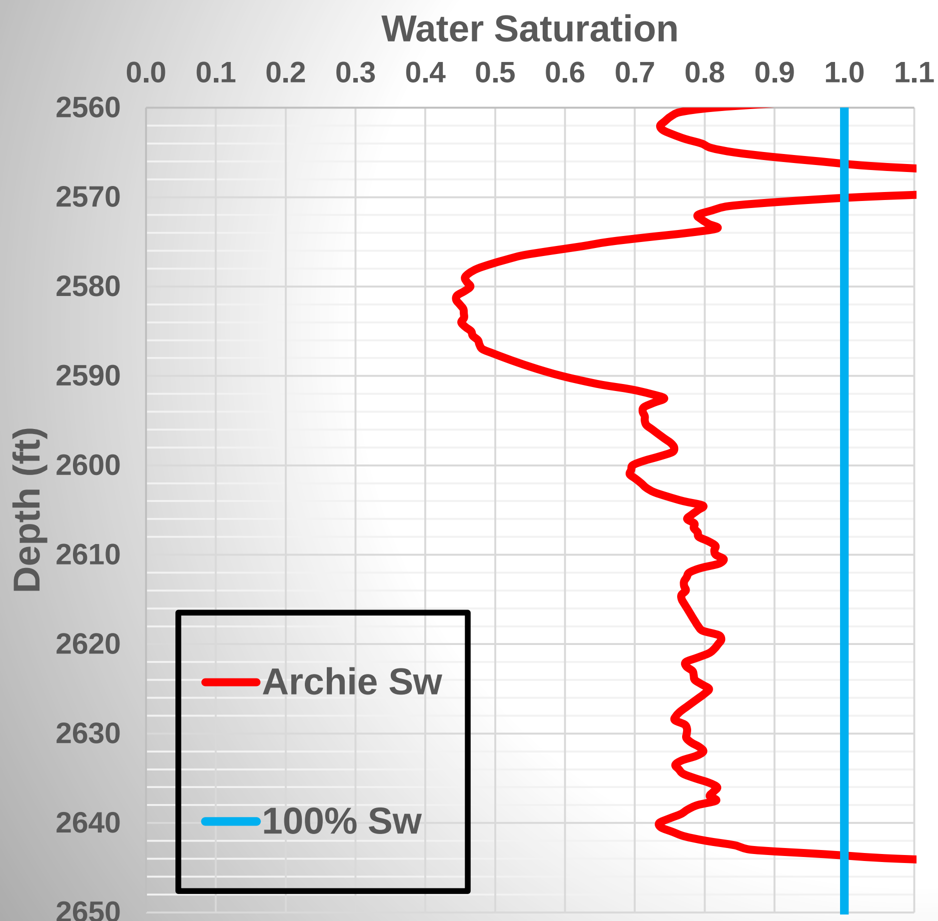
120252837200: Porosity, resistivity, and SP logs from 1996

- Not perforated in Cypress
- Dual water and Archie water saturation curves created
  - Good agreement
- Maximum water saturation for moveable oil is believed to be 0.65 (based on MHI)
- Upper “conventional” portion is diminished (0.65-0.7 Sw)
- Residual oil down to 2630?



Application: Kenner West Field

120250249300: Resistivity and SP logs from 1947

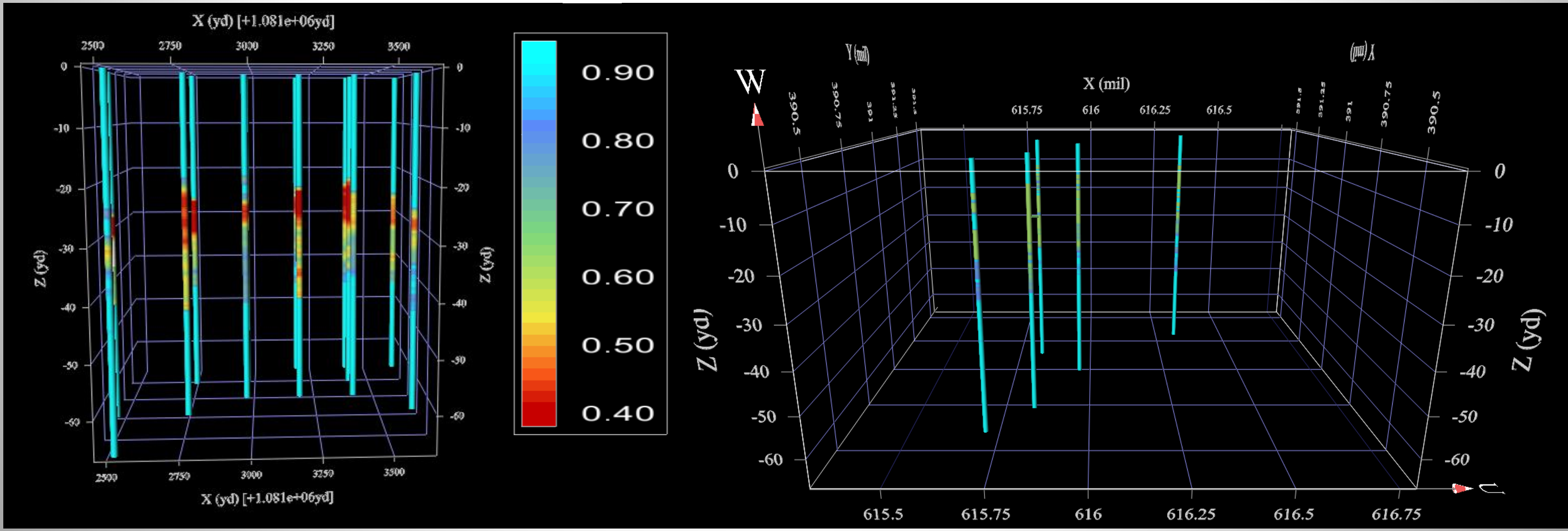


- Perforated from 2562-2582 and produced from Cypress
- Show of oil on scout ticket down to 2588
- SP to porosity transform developed for geocellular model used to create porosity curve from SP
  - Used Archies Equation to calculate water saturation
- Interval with Sw<0.65 matches show of oil
- Clear ROZ

Application: Kenner West Field

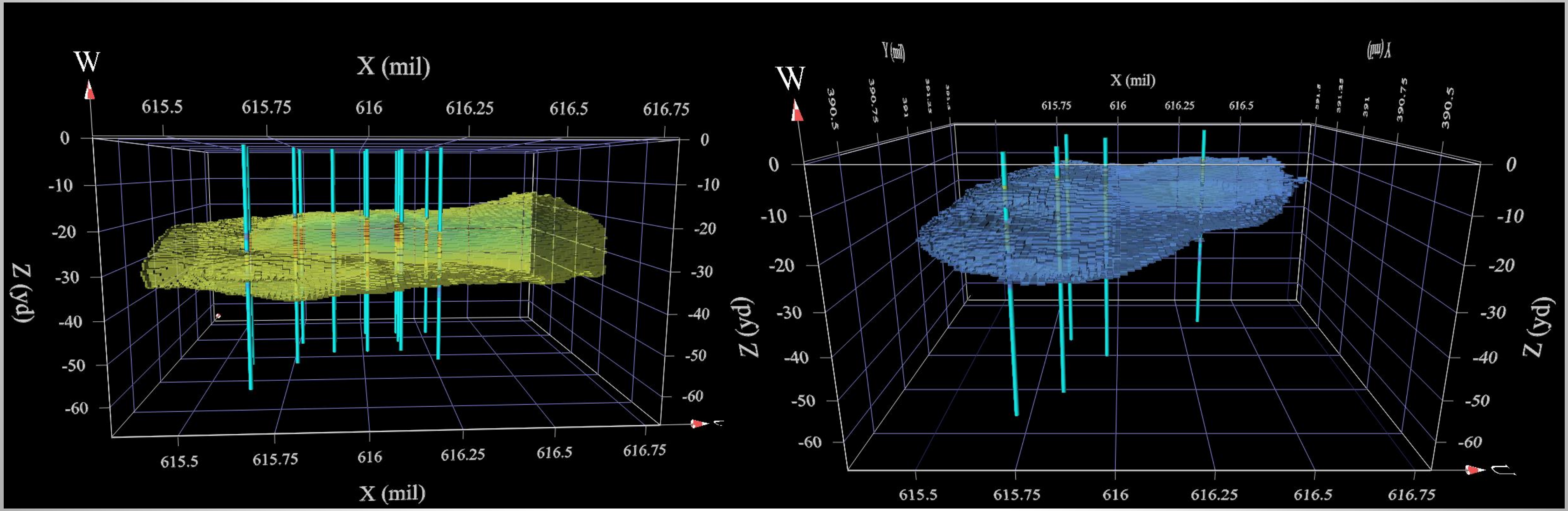
- Group wells by decade and create water saturation models of the 1940s and 1990s

1940s wells **1990s wells**



Application: Kenner West Field

- Residual oil present in both models. Better data coverage=better defined in 1940s



1940s wells +0.8 cutoff **1990s wells +0.8 cutoff**

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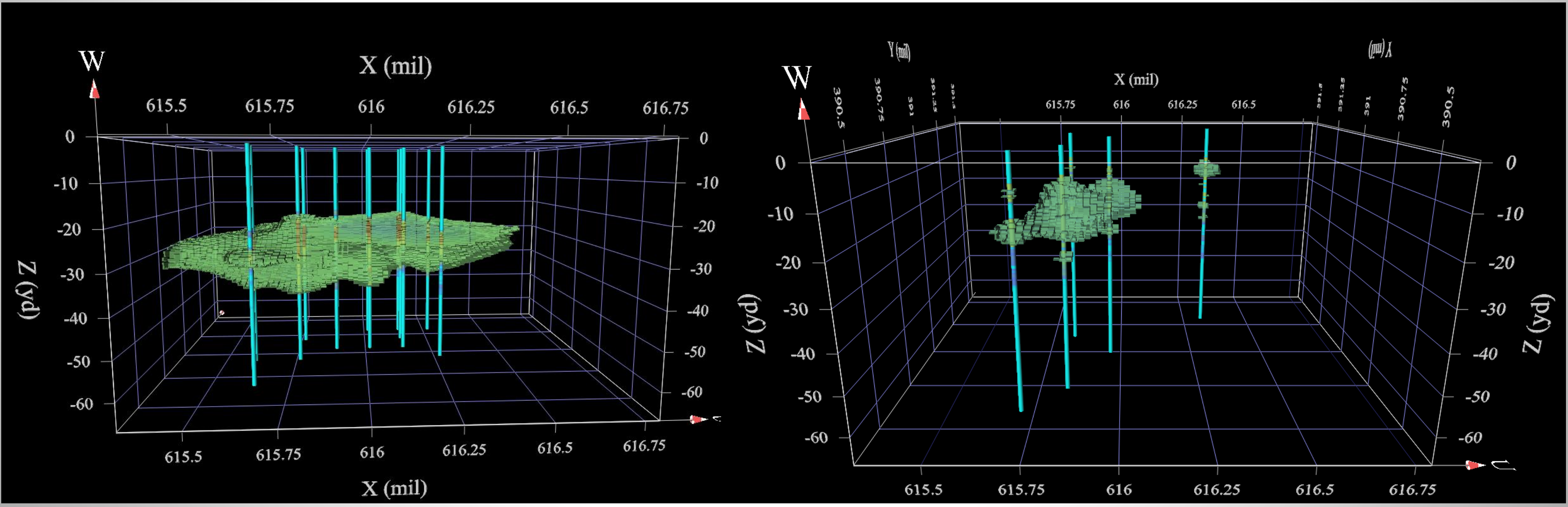
Application: Kenner West Field

- Residual oil present in both models. Better data coverage=better defined in 1940s



1940s wells +0.7 cutoff **1990s wells +0.7 cutoff**

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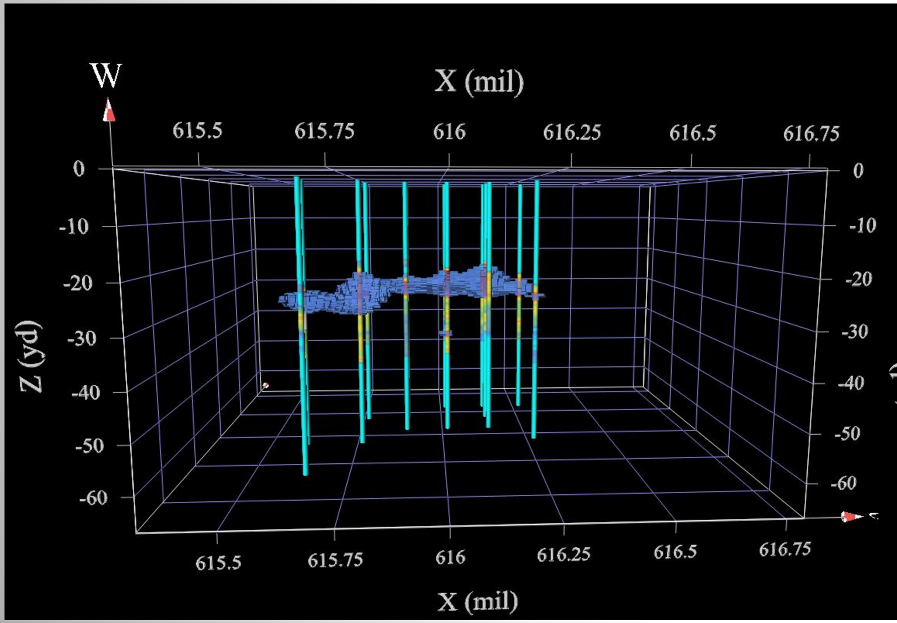
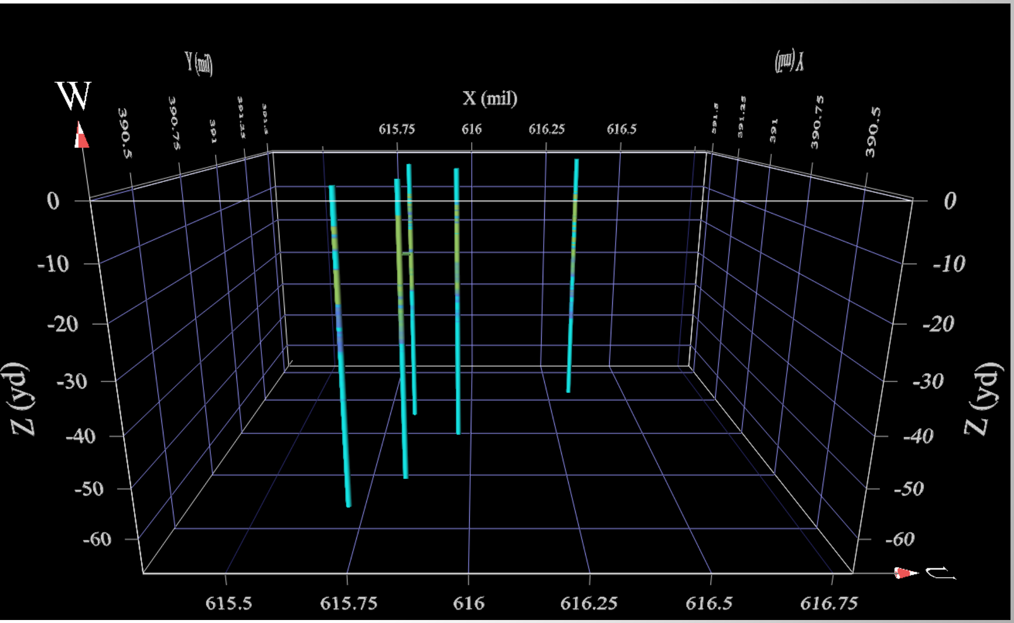
Application: Kenner West Field

- Conventional reservoir present in the 1940s but not in the 1990s



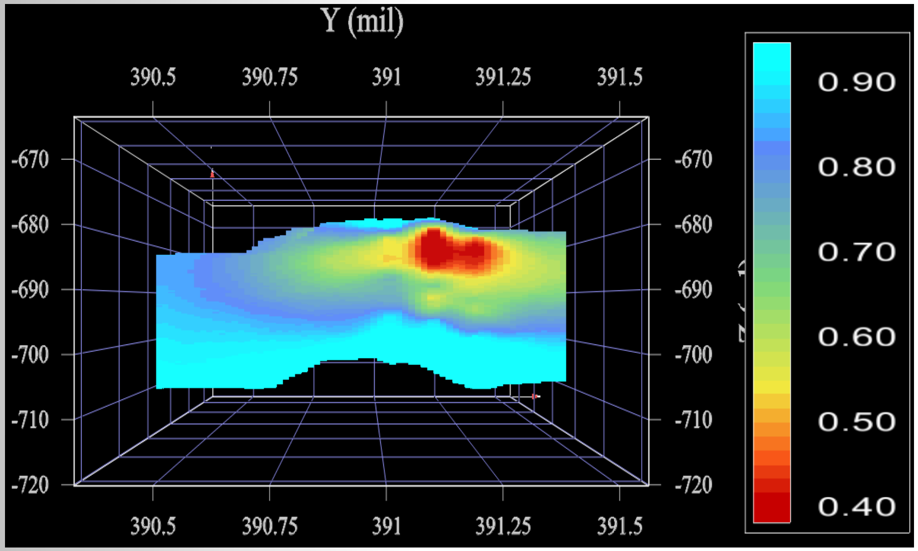
1940s wells + 0.5 cutoff



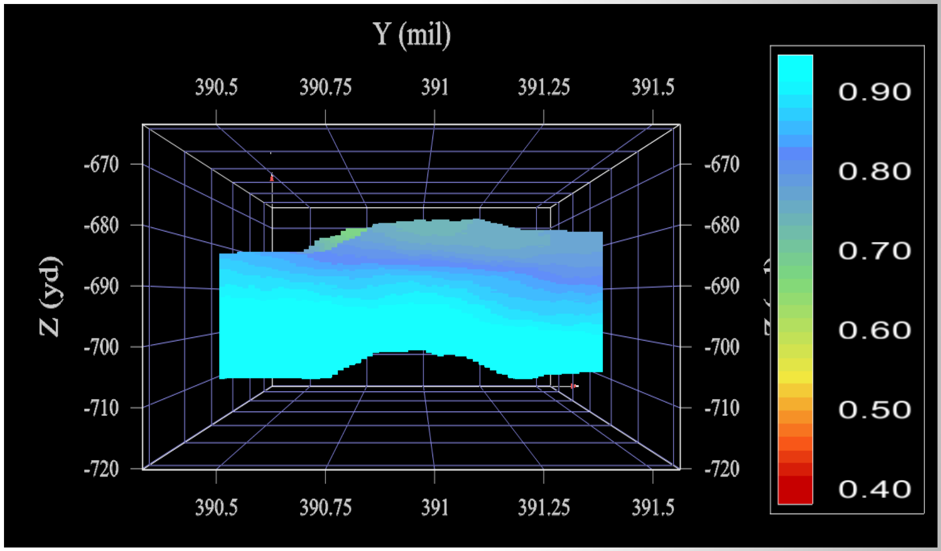
1990s wells +0.5 cutoff

Application: Kenner West Field

1940s model



1990s model



- Pronounced conventional reservoir
- Yellow/green is moveable oil

- Conventional reservoir diminished but widespread residual oil saturation

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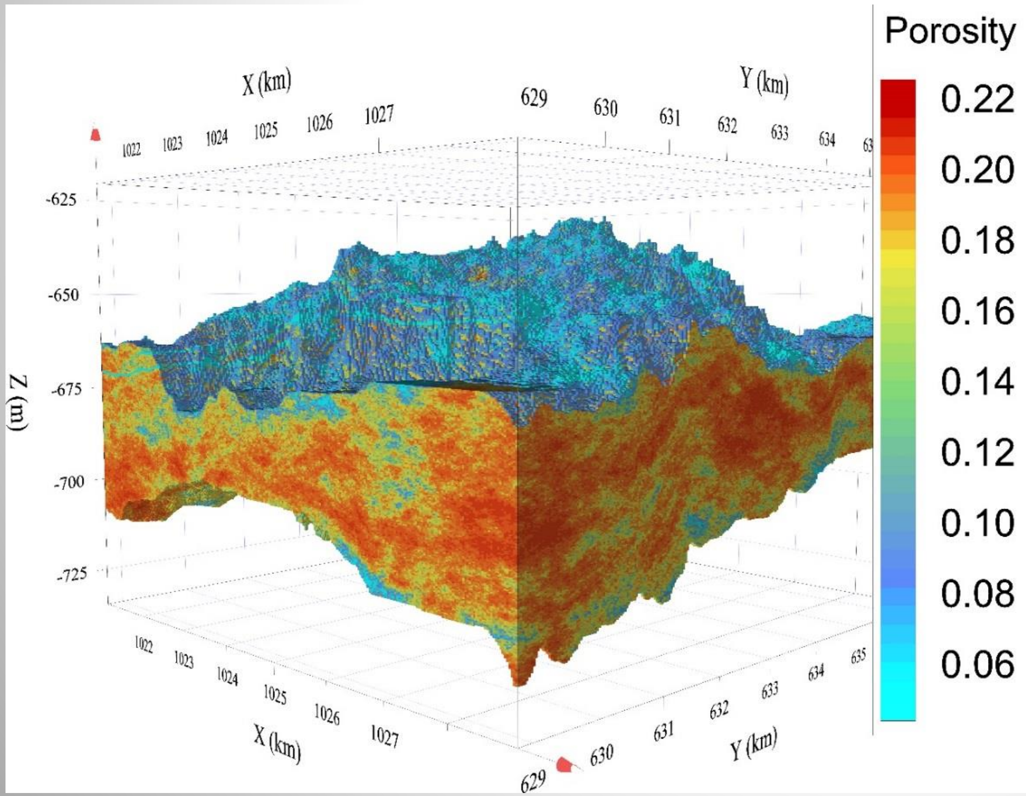
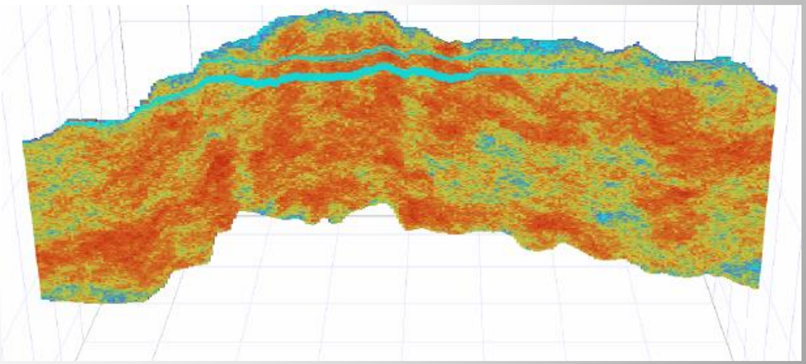
Geocellular Modeling

- Built geocellular models to accurately reflect the geology of the Cypress Sandstone at Noble and Kenner West Fields
  - Encapsulated depositional and diagenetic facies
  - Shaly, estuarine facies at the top of the model; thin shale interbeds

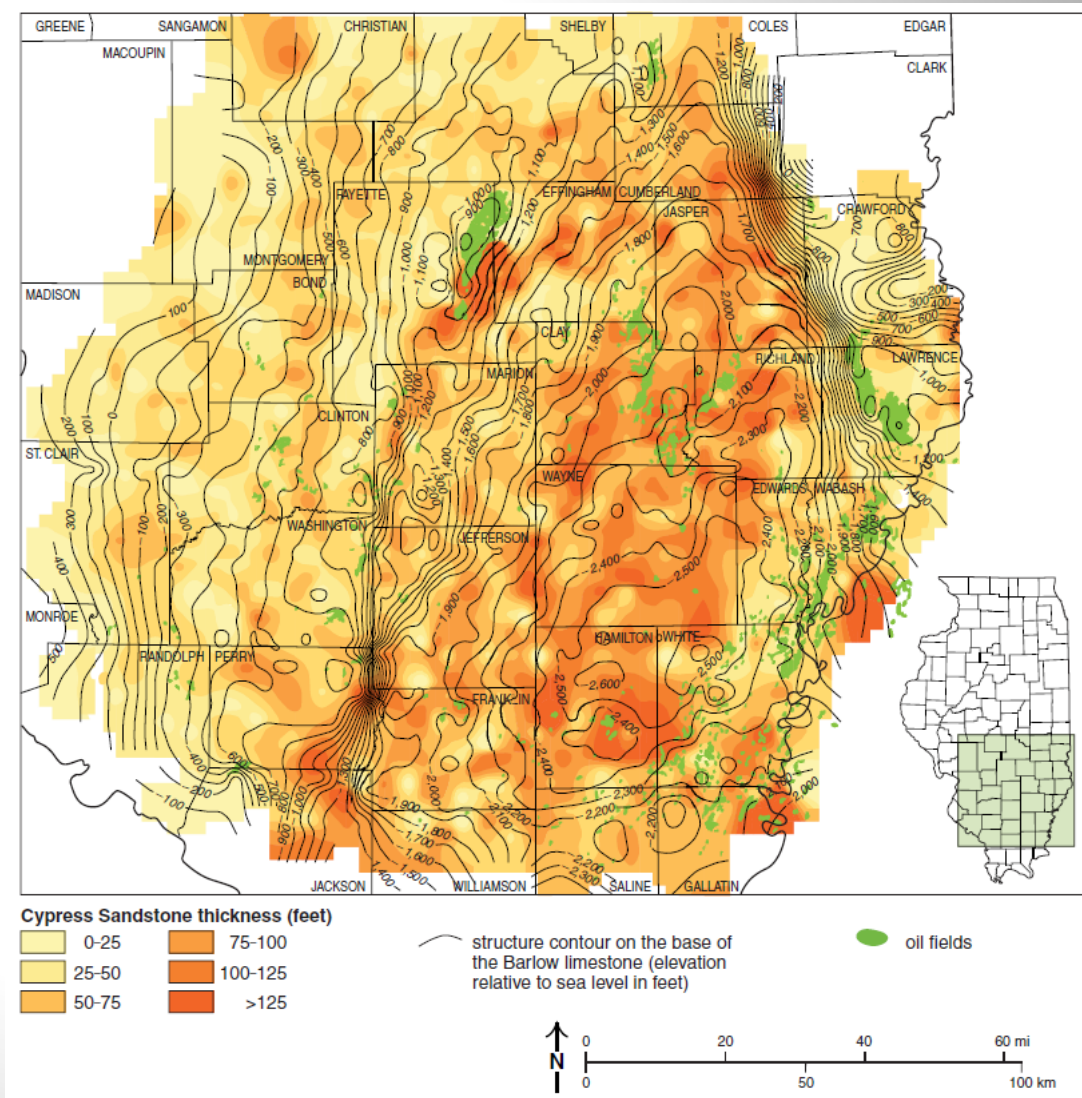


- Low porosity calcite-cemented sandstone zones
- Excluding microporosity from total porosity for accurate resource assessment



Regional Resource Estimate

- Correlating logs to refine regional isopach map
- Developing new regional facies map to define CO_2 storage resource in the thick Cypress Sandstone
- Analyzing logs around the basin to rind ROZs
- Integrating geology, petrophysics, and reservoir simulation to identify areas with nonconventional CO_2-EOR potential



Summary

- Studies of Noble and Kenner West Fields show good quality, conventional reservoirs
  - Tilted OWCs, calcite cement associated with OWC
- Cypress Sandstone is composed of multistory fluvial/estuarine sandstone bodies
  - Homogeneous but still compartmentalized
  - Sedimentological and mineralogical/petrographic studies are critical to understanding geology and controls on reservoir properties
- Petrophysical analysis
  - Significant microporosity affects conductivity of the formation and thus estimates of fluid saturation
  - Petrophysical calculations show saturation below POWC
  - Modeling can predict saturation through a field and show changes through time

Acknowledgments

- Research herein was supported by the US Department of Energy contract number DE-FE0024431
- Through a university grant program, IHS Petra, Geovariences Isatis, and Landmark Software was used for the geologic, geocellular, and reservoir modeling, respectively.

- For project information, including reports and presentations, please visit:

http://www.isgs.illinois.edu/research/ERD/NCO2EOR

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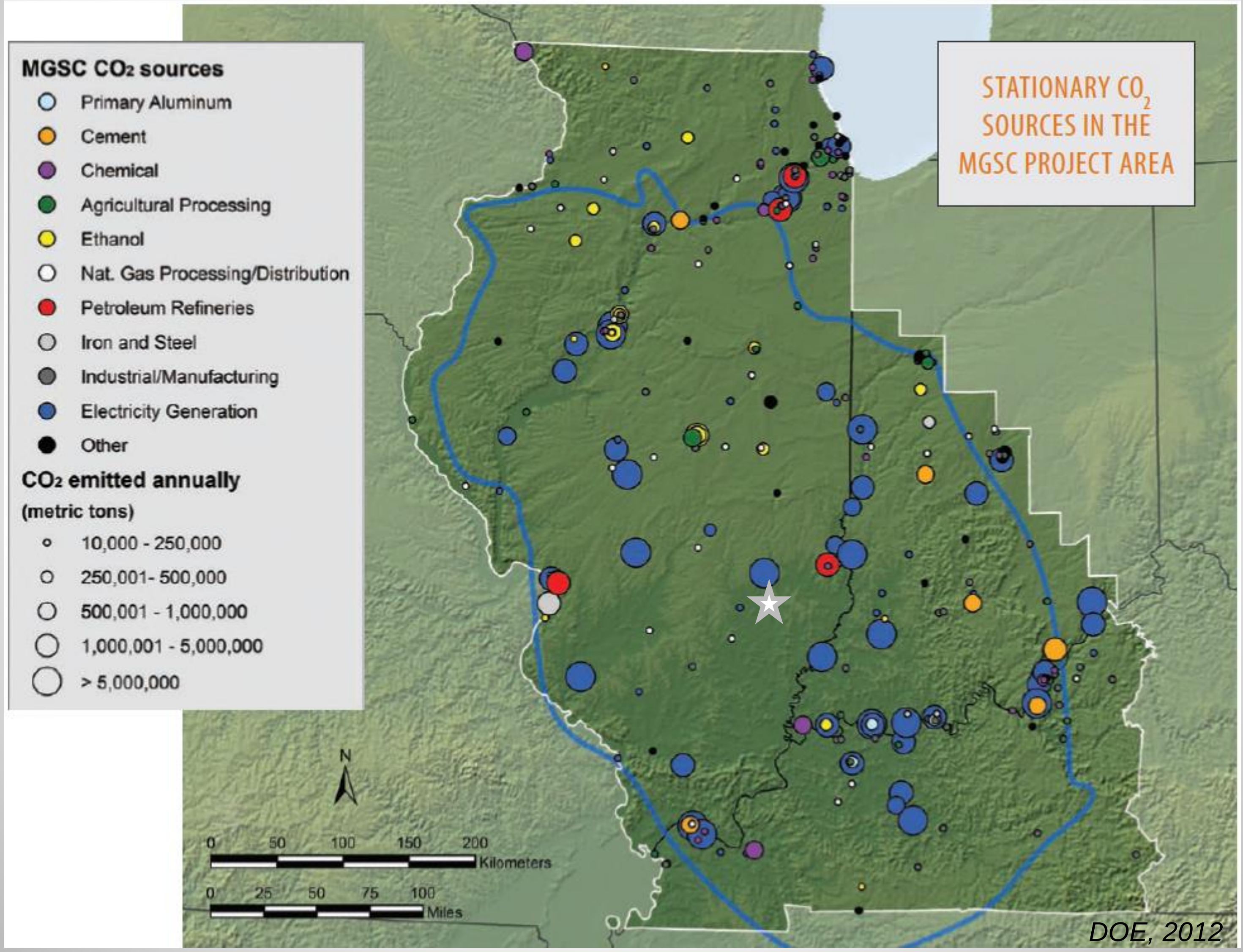
Where will the CO_2 Come From?



DOE, 2012

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