Using Legacy Data from Cores, Open Hole Logs, and Production Logs to Optimize the Placement of Horizontal Well Targets in the Cotton Valley Formation of North Louisiana and East Texas

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GCAGS Explore & Discover Article #00367*
http://www.gcags.org/exploreanddiscover/2018/00367_markley_and_byram.pdf
Posted September 29, 2018.

*Article based on a full paper published in the *GCAGS Transactions* (see footnote reference below), which is available as part of the entire 2018 *GCAGS Transactions* volume via the GCAGS Bookstore at the Bureau of Economic Geology (www.beg.utexas.edu) or as an individual document via AAPG Datapages, Inc. (www.datapages.com), and delivered as an oral presentation at the 68th Annual GCAGS Convention and 65th Annual GCSSEPM Meeting in Shreveport, Louisiana, September 30–October 2, 2018.

ABSTRACT

The Cotton Valley Group is an Upper Jurassic to Lower Cretaceous sequence of sandstone, shale, and limestone that underlies much of the northern Gulf of Mexico coastal plain from eastern Texas to Alabama. A great many wells have been drilled into this tight gas formation over the years. With the advent of new technology, wells can benefit both from improvements in horizontal well-drilling efficiency and horizontal-well stimulation efficiencies. New horizontal wells are currently being drilled into Cotton Valley sands for gas, oil, and natural gas liquids. Lateral lengths, stimulation volumes, and production results continue to increase substantially.

A great deal of information has been gathered from vertical wells in many fields that can yield critical insight into the evaluation of horizontal well placement. This paper will demonstrate the use of legacy data in the evaluation of Cotton Valley field areas for the placement of horizontal wells into the more productive Cotton Valley intervals.

The U.S. Geological Survey (USGS) has stated: "...the difficulties with wireline logs in tight Cotton Valley sandstones is that logs are of limited value in differentiating between gas-productive and wet intervals, and therefore in identifying gas-water contacts on the flanks of Cotton Valley fields."

Major factors contributing to the abnormally low resistivities in tight Cotton Valley sandstones include bound water (micro-porosity) associated with pore-filling clays or clay grain-coatings and conductive authigenic minerals such as pyrite and ankerite. By using conventional core and rotary core plugs, magnetic resonance logs, and after-stimulation production logs on vertical wells, it is possible to optimize targets for horizontal well production and overcome a number of these problems.

Originally published as: Markley, M. E., and I. M. Byram, 2018, Using legacy data from cores, open hole logs, and production logs to optimize the placement of horizontal well targets in the Cotton Valley Formation of North Louisiana and East Texas: Gulf Coast Association of Geological Societies Transactions, v. 68, p. 309–338.

Using legacy data from cores, open hole logs and production logs to optimize the placement of horizontal well targets in the Cotton Valley Formation of North Louisiana and East Texas.

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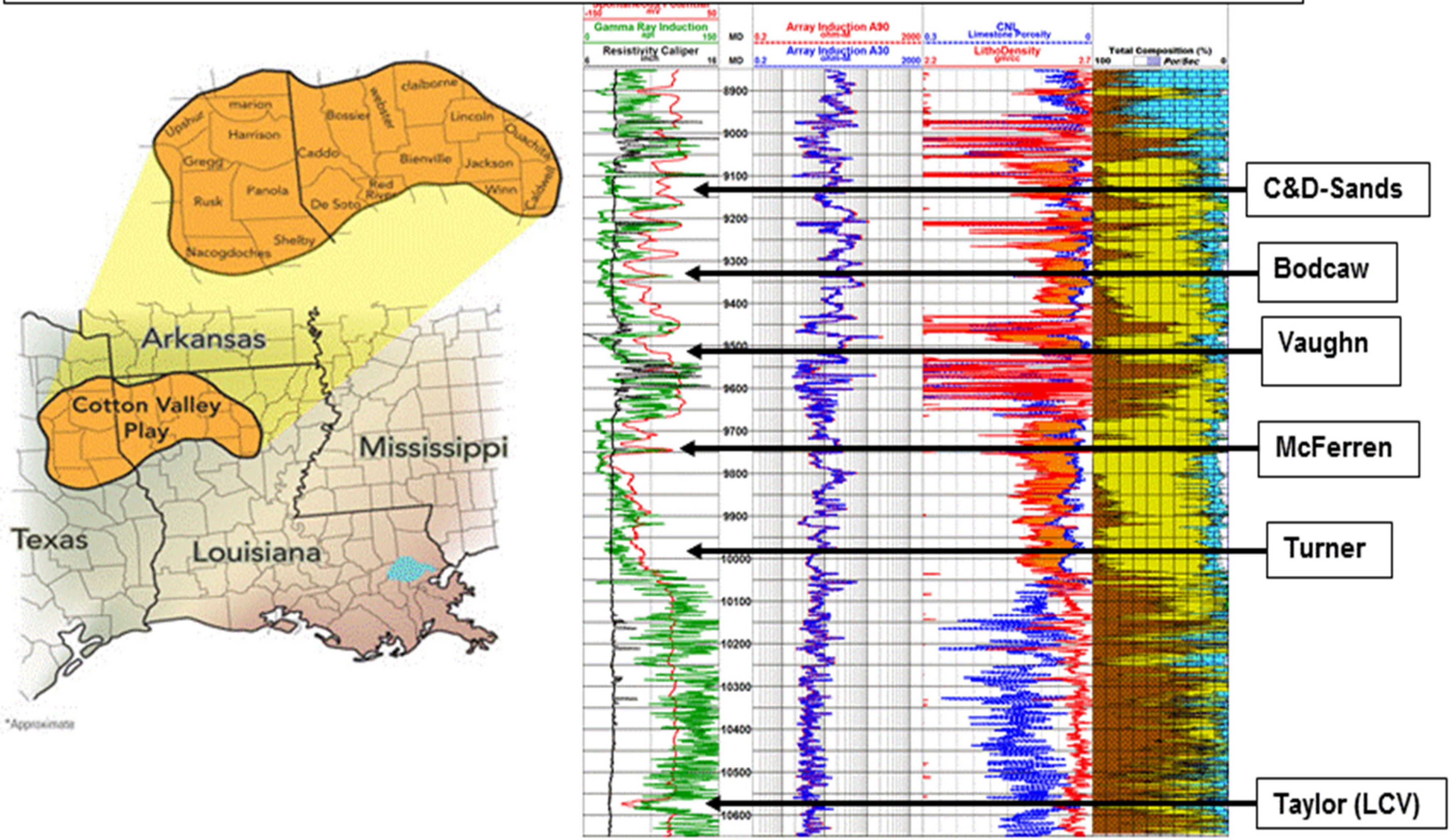
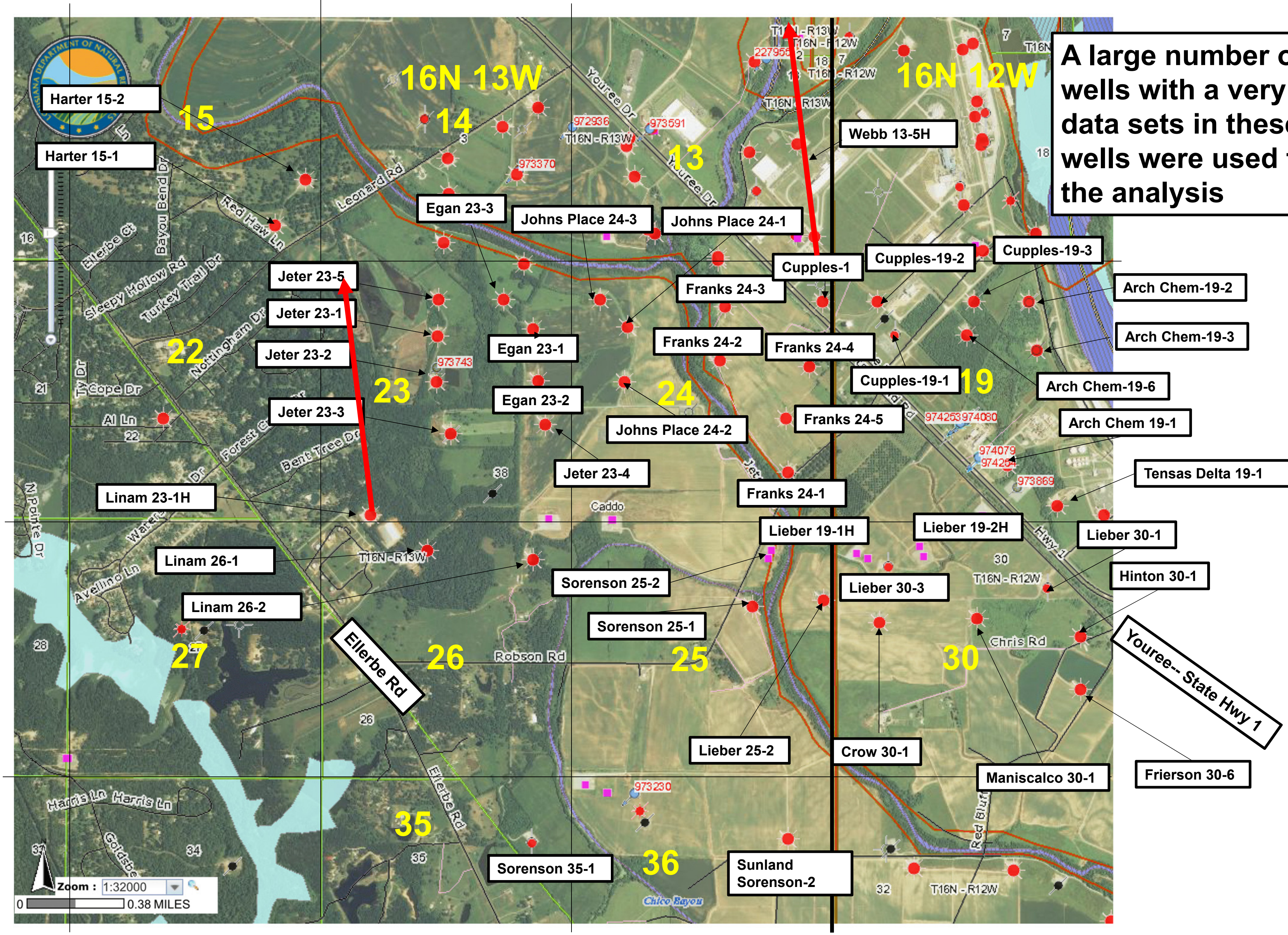
Cotton Valley Play Area and Vertical Section of Field Study Area

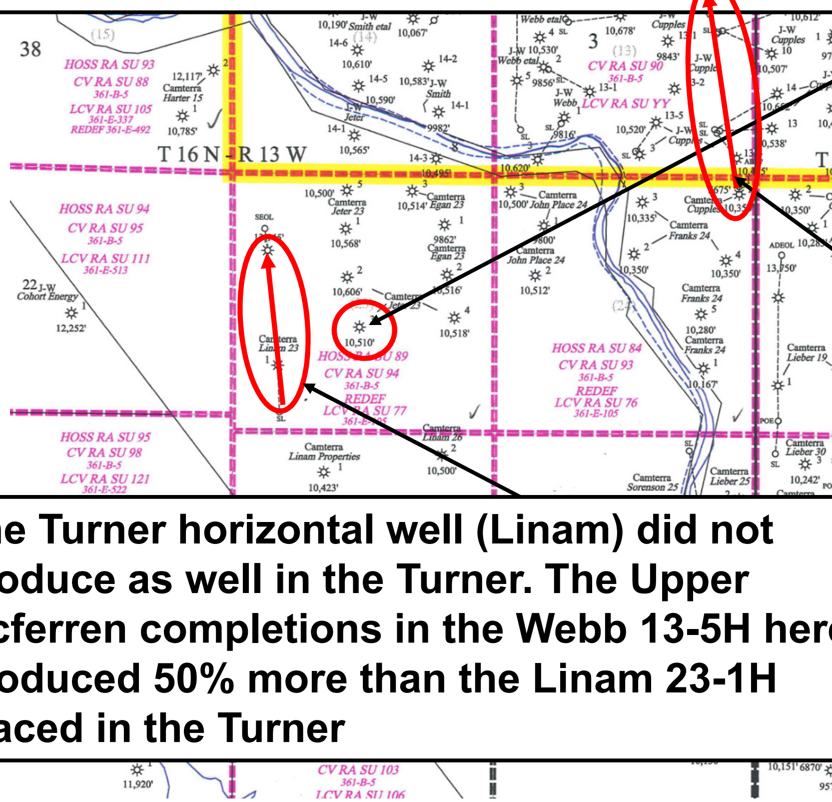




A large number of wells with a very rich data sets in these wells were used for the analysis

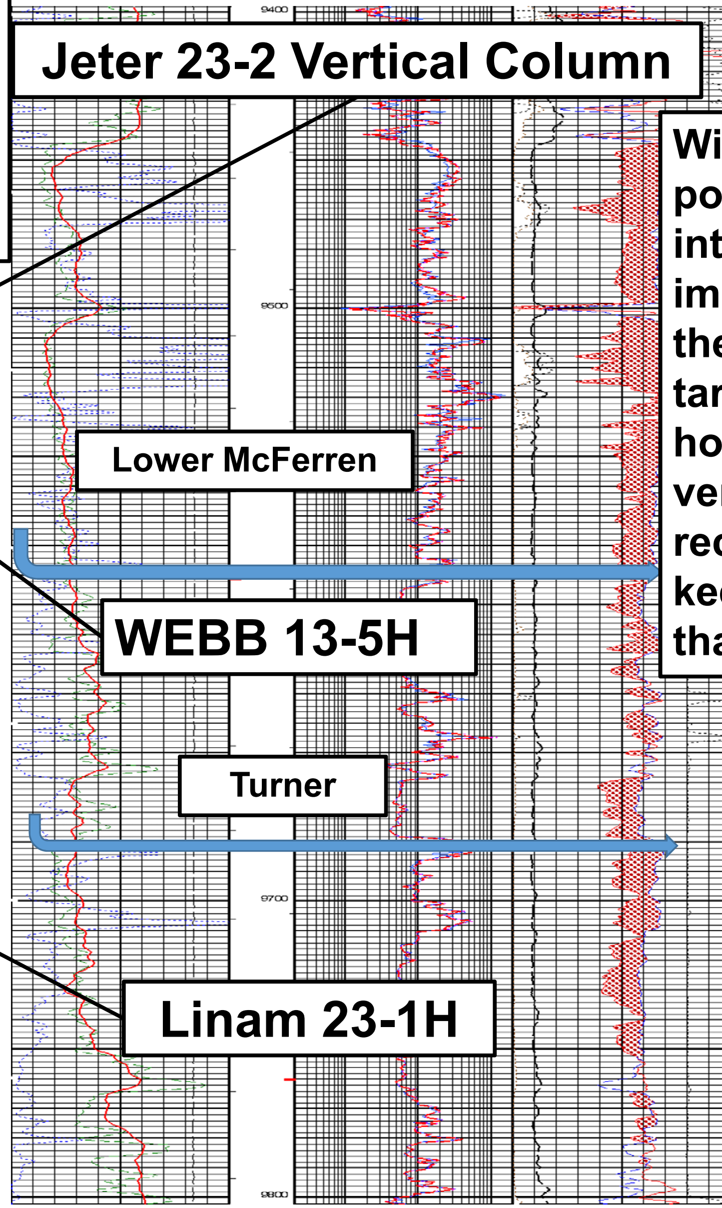
The Aethon Webb 13-5H ALT is higher in the ssection and produced 3-Bcf from a 3250ft lateral→ 1-Bcf/1000ft using 2008 technology

The Linam 23-1H is lower in the section and produced 2.03 Bcf from a 3000ft lateral- .67 Bcf/1000ft



The Turner horizontal well (Linam) did not produce as well in the Turner. The Upper Mcferren completions in the Webb 13-5H here produced 50% more than the Linam 23-1H placed in the Turner

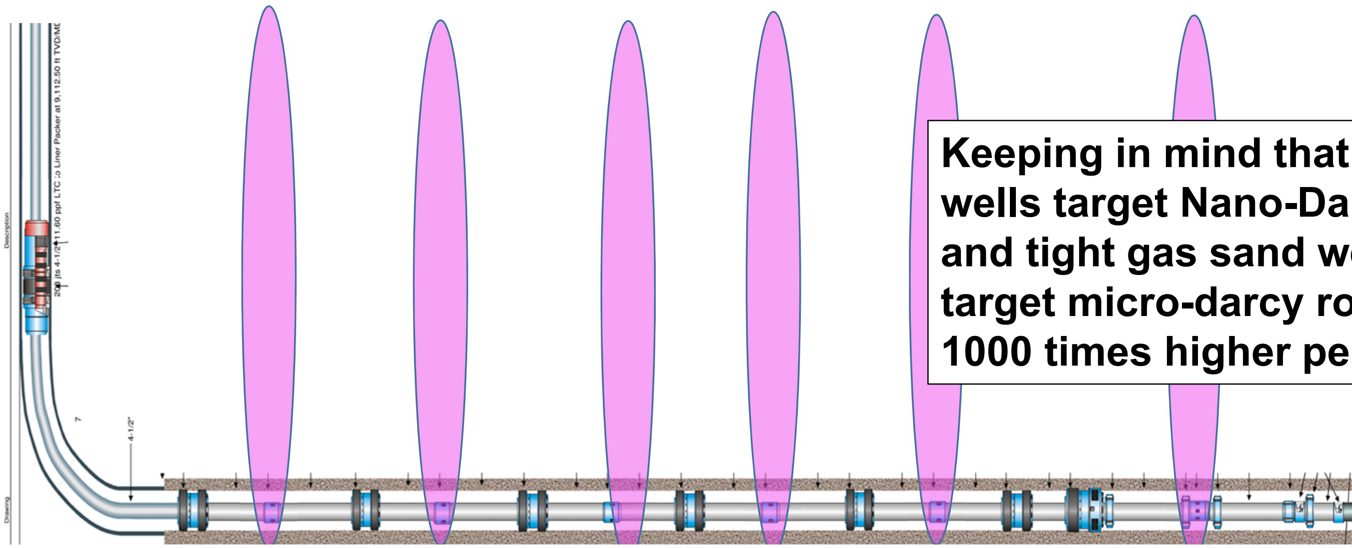
Even with 2008 technology → a good 10,000 lateral would produce 10 Bcf



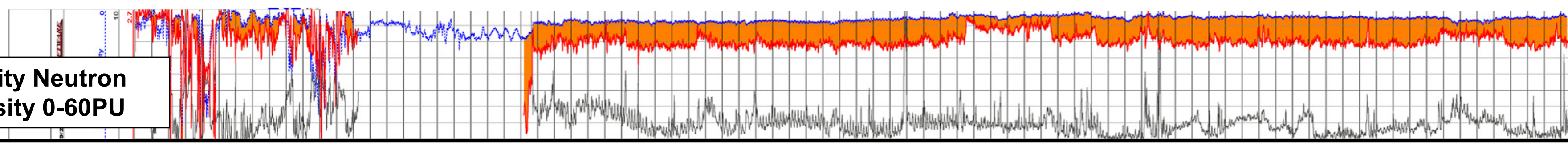
With so many potential tight gas intervals it is important to select the most economic target for a horizontal well or vertical recompletion and keep your frac in that zone

Linam 23-1H TVD Cum 2.03 Bcf & 3.65 Bcf EUR (No Cutoff) 3000ft lateral→2008 Fracking

Pink Ovals represent Frac stage "vertical disks"

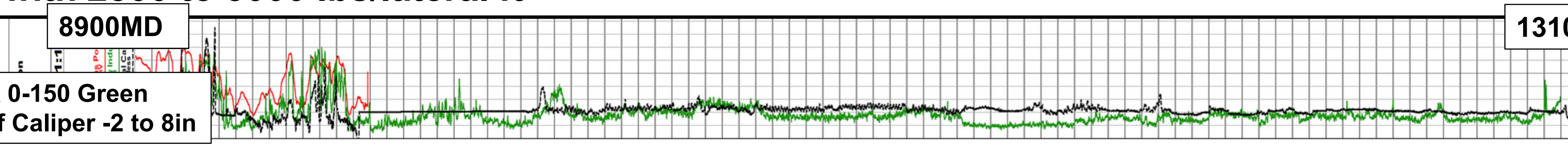


Keeping in mind that shale wells target Nano-Darcy Rock and tight gas sand wells target micro-darcy rock 100-1000 times higher perm



Density Neutron Porosity 0-60PU

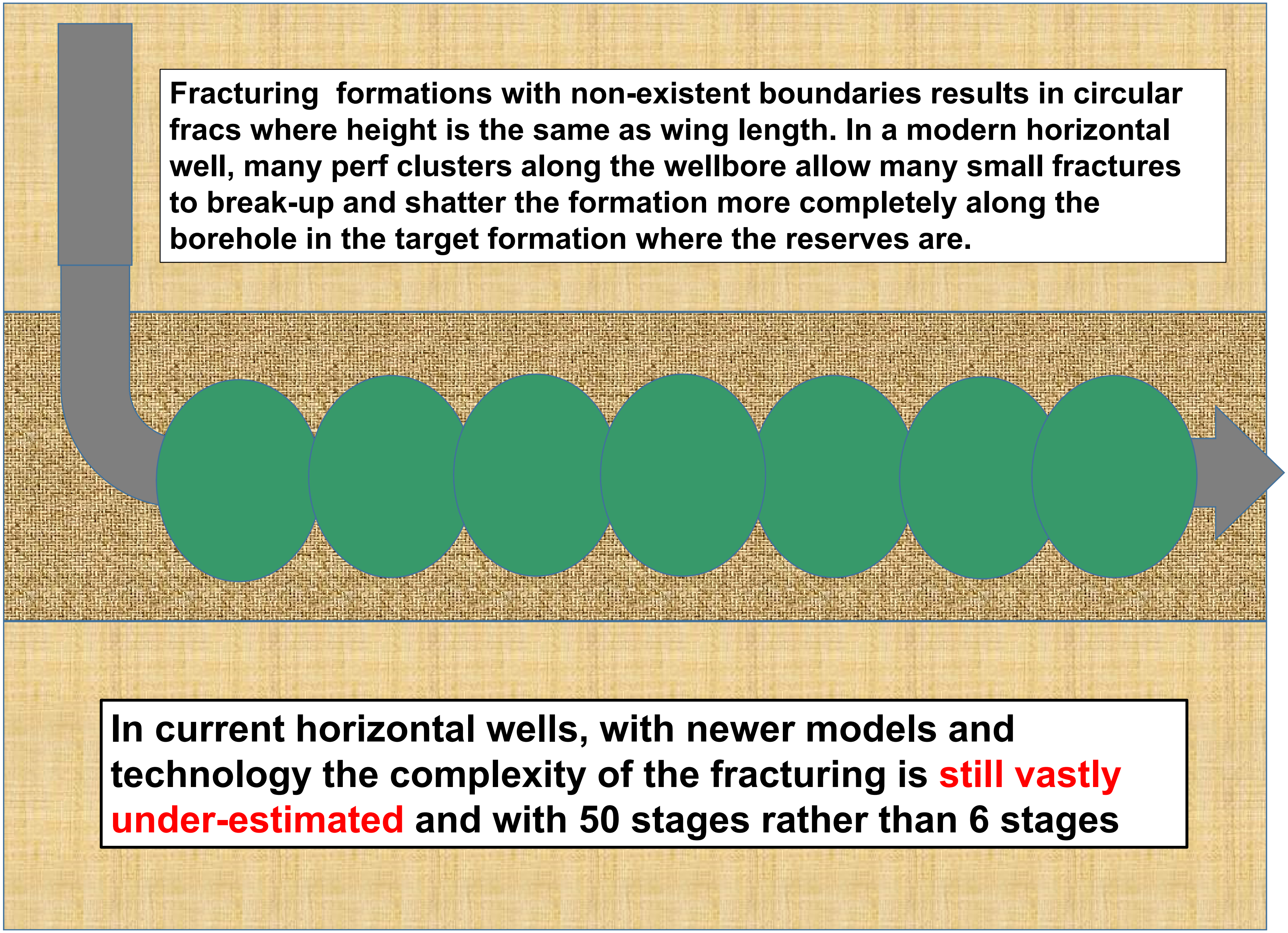
This horizontal well theoretically produced 6 individual fractures from 6 perf clusters and 6 stages with fracture stages and perf clusters 300 to 500 ft apart using approx 750lbs/lateral foot in 6 stages
Today 250 clusters and 50 stages are not unusual with 2500-5000 lbs/lateral ft for the stimulation with 2500 to 5000 lbs/lateral ft



8900MD

13100 TD

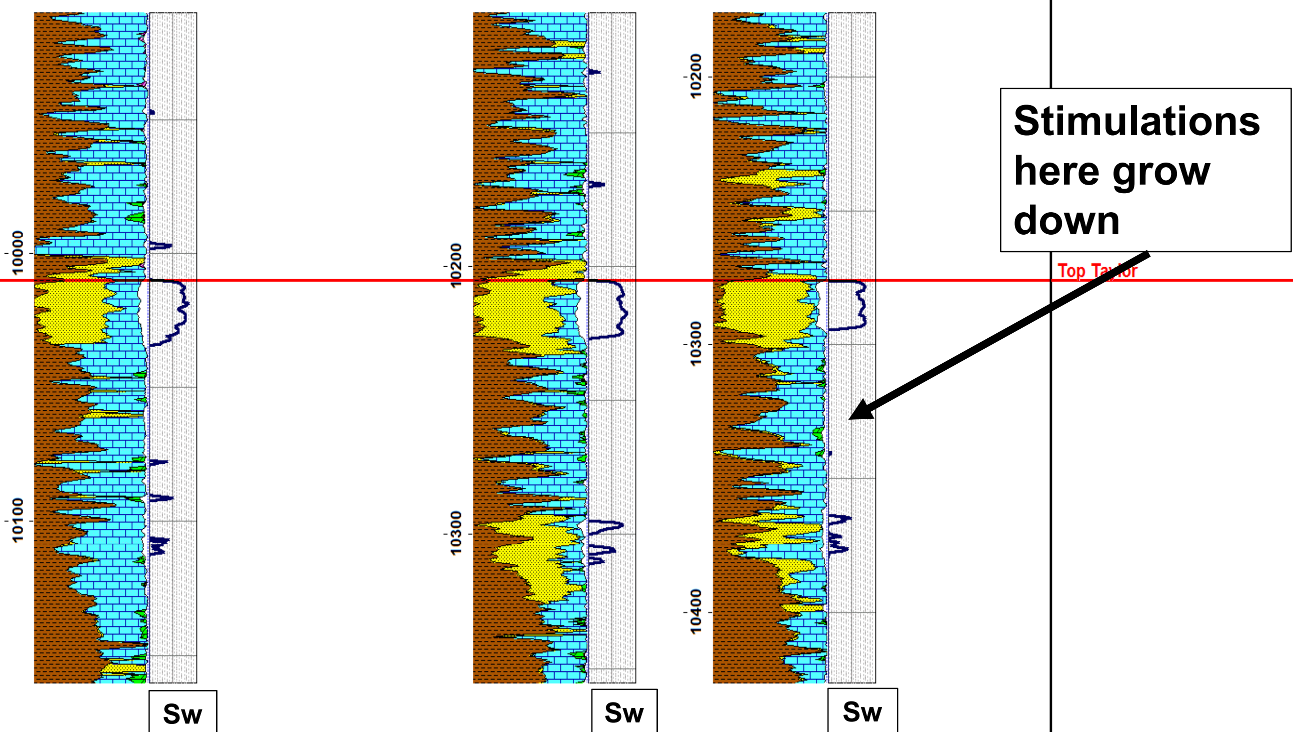
GR 0-150 Green
Diff Caliper -2 to 8in


Fracturing formations with non-existent boundaries results in circular fracs where height is the same as wing length. In a modern horizontal well, many perf clusters along the wellbore allow many small fractures to break-up and shatter the formation more completely along the borehole in the target formation where the reserves are.
In current horizontal wells, with newer models and technology the complexity of the fracturing is still vastly under-estimated and with 50 stages rather than 6 stages

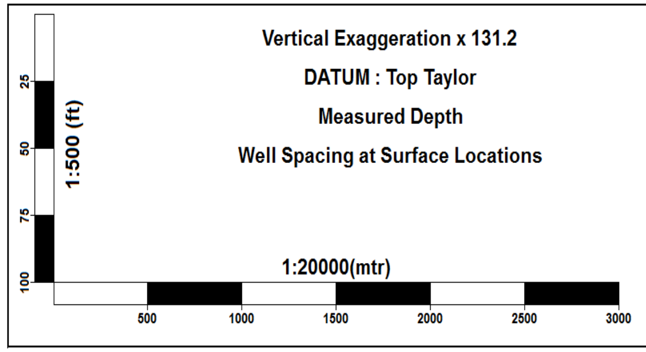
South →		→ North
Lieber 30-3	Jeter 23-4	Egan 23-3
KB =170.0 ft amsl	KB =165.0 ft amsl	KB =169.0 ft amsl

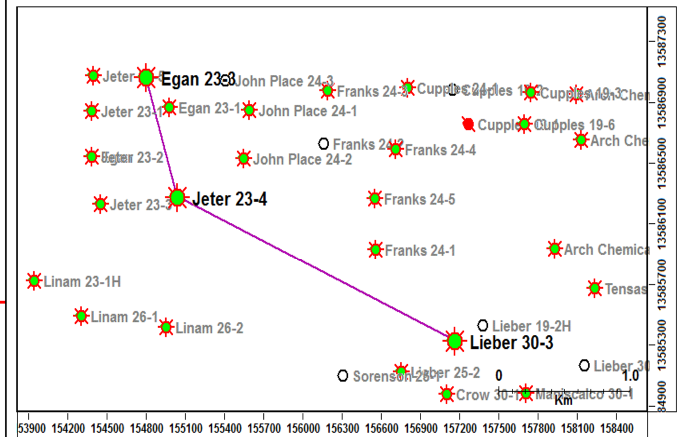
2.325 km (Lieber 30-3 to Jeter 23-4) · 0.822 km (Jeter 23-4 to Egan 23-3)

South to North LCV(Taylor) Sw remains constant



Cotton Valley Sands Zones





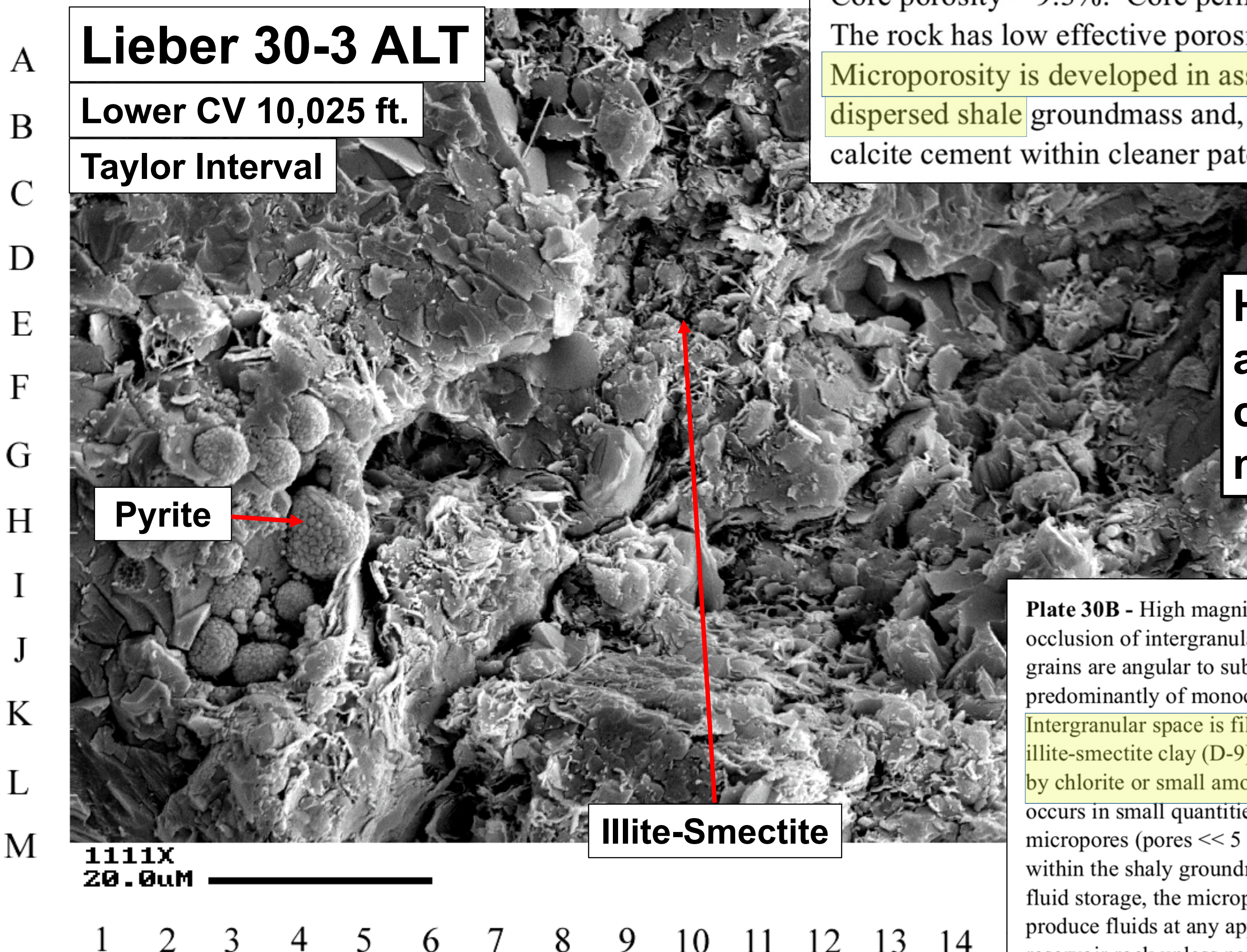
Elm Grove Holdings

N-S Cross Section ElmGrove

MMM

Pore System

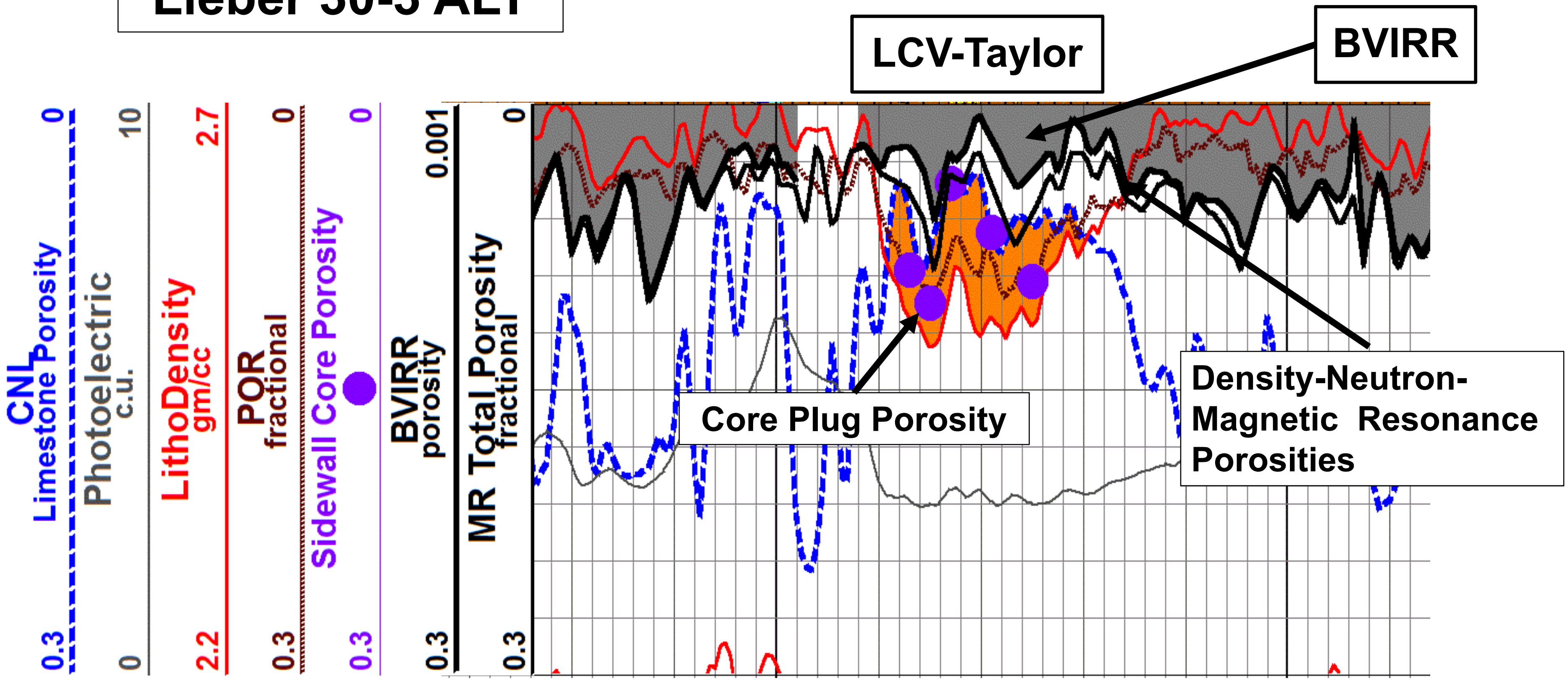
Core porosity = 9.3%. Core permeability = 0.007 md. The rock has low effective porosity and permeability. Microporosity is developed in association with the dispersed shale groundmass and, to a lesser extent, calcite cement within cleaner patches of rock.



High Surface area clays creating microporosity

Plate 30B - High magnification view illustrating the occlusion of intergranular space by shale. Framework grains are angular to subangular in shape and consist predominantly of monocrystalline quartz (C-4). Intergranular space is filled by a mixture of illite and illite-smectite clay (D-9). Some pore space is also filled by chlorite or small amounts of kaolinite. Pyrite (H-4) occurs in small quantities. Porosity is restricted to micropores (pores << 5 µm in diameter) developed within the shaly groundmass. While contributing to fluid storage, the micropore structure is not expected to produce fluids at any appreciable rate. This is non-reservoir rock unless naturally fractured.

Lieber 30-3 ALT



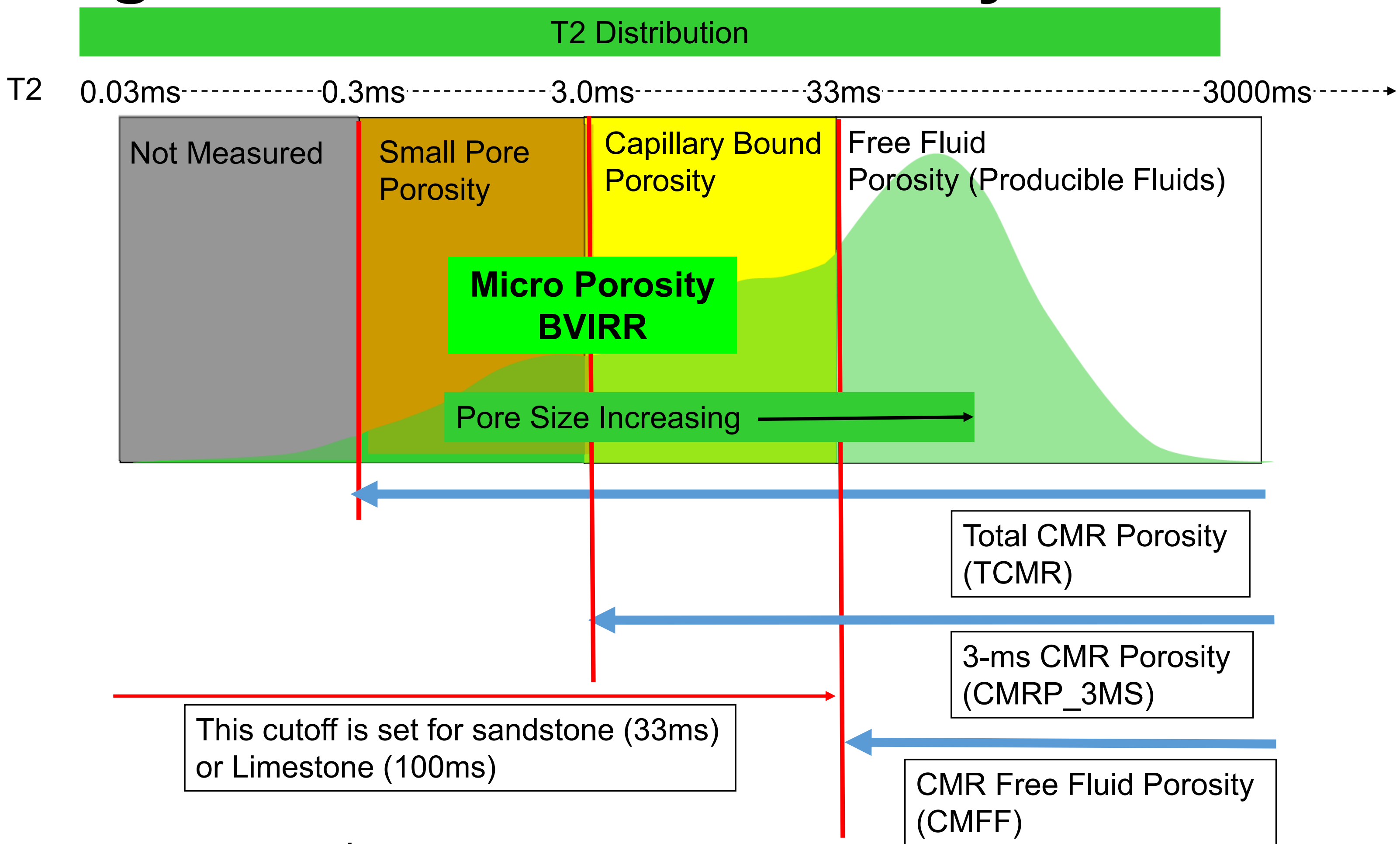
$$Swirr = \frac{BVIRR-Magnetic\ Resonance}{PHI-Density-Neutron}$$

Equation 1→ Porosity ONLY- No Resistivity

$$Sw - Archie = \sqrt[n]{\frac{a*Rw}{\Phi^m Rt}}$$

Equation 2 → A Resistivity Ratio

Magnetic Resonance Porosity Definitions



$$Swirr = \frac{BVIRR - Magnetic\ Resonance}{PHI - Density - Neutron}$$

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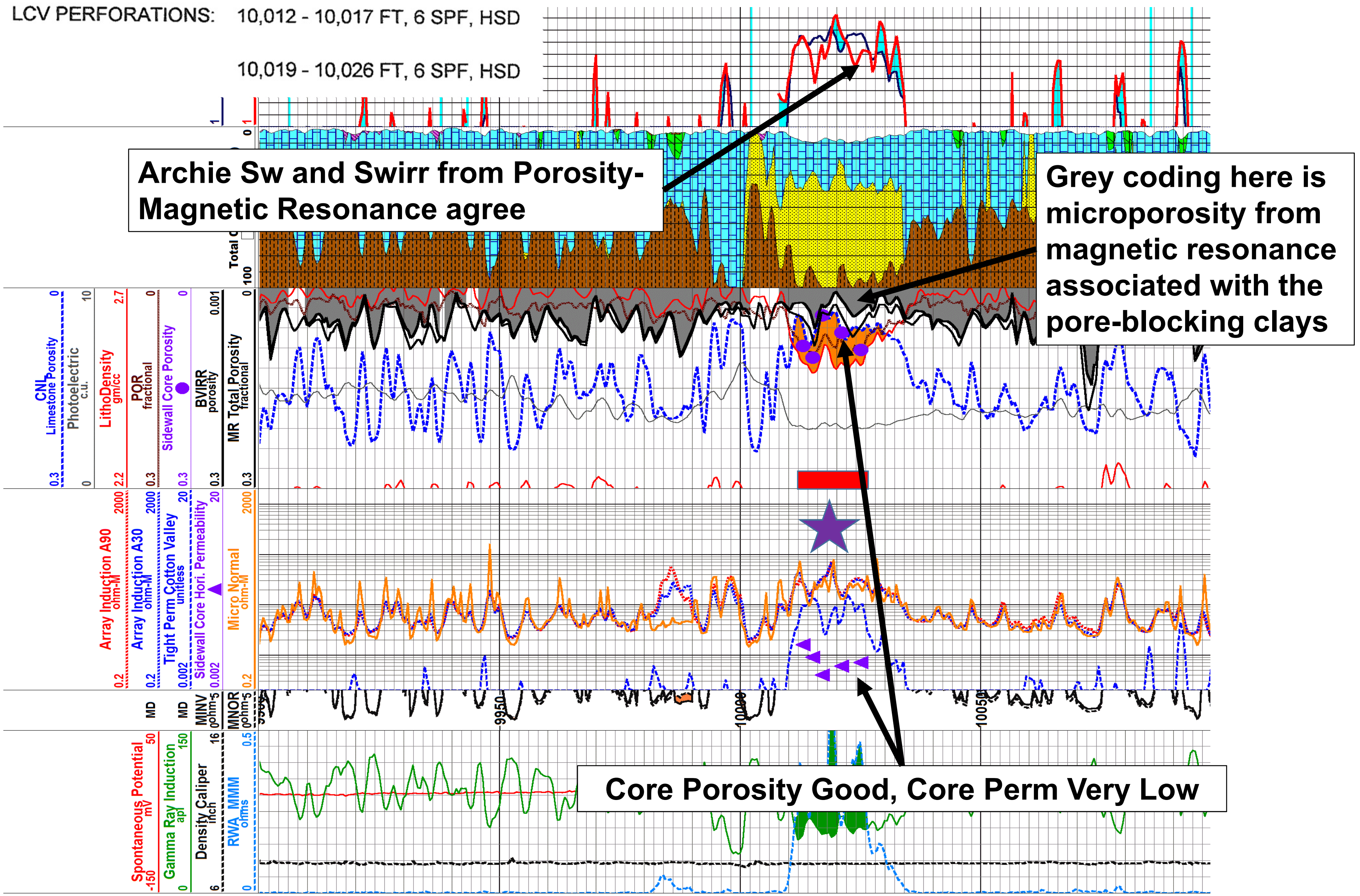
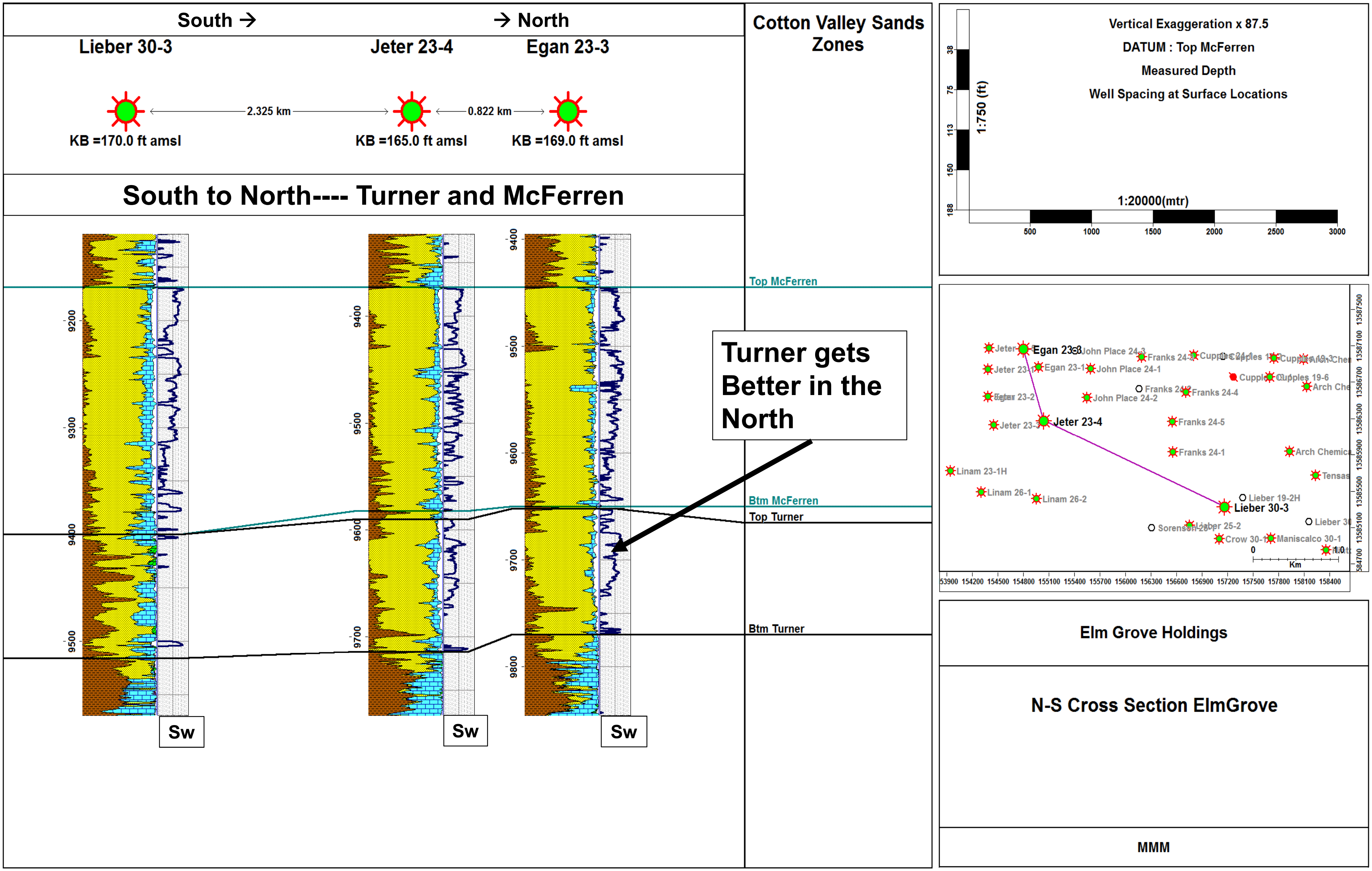
Lieber 30-3 With Rotary SWCs Porosity, Magnetic Resonance and Perm LCV





South →
→ North
Lieber 30-3
Jeter 23-4
Egan 23-3
2.325 km
0.822 km
KB =170.0 ft amsl
KB =165.0 ft amsl
KB =169.0 ft amsl
South to North---- Turner and McFerren
Cotton Valley Sands Zones
Top McFerren
Btm McFerren
Top Turner
Btm Turner
Turner gets Better in the North
Sw
Sw
Sw
Vertical Exaggeration x 87.5
DATUM : Top McFerren
Measured Depth
Well Spacing at Surface Locations
1:750 (ft)
1:20000(mtr)
Egan 23-3
Jeter 23-4
Lieber 30-3
John Place 24-3
John Place 24-1
John Place 24-2
Egan 23-1
Franks 24-4
Franks 24-5
Franks 24-1
Cupples 19-6
Linam 23-1H
Linam 26-1
Linam 26-2
Lieber 19-2H
Lieber 25-2
Maniscalco 30-1
Km
Elm Grove Holdings
N-S Cross Section ElmGrove
MMM

Pore System

Core porosity = 11.5%. Core permeability = 0.043 md. While porous, the rock has low permeability, a function of extensive microporosity development associated with clay cements (plate 14A, D-12). The rock has relatively little intergranular macroporosity or secondary porosity.

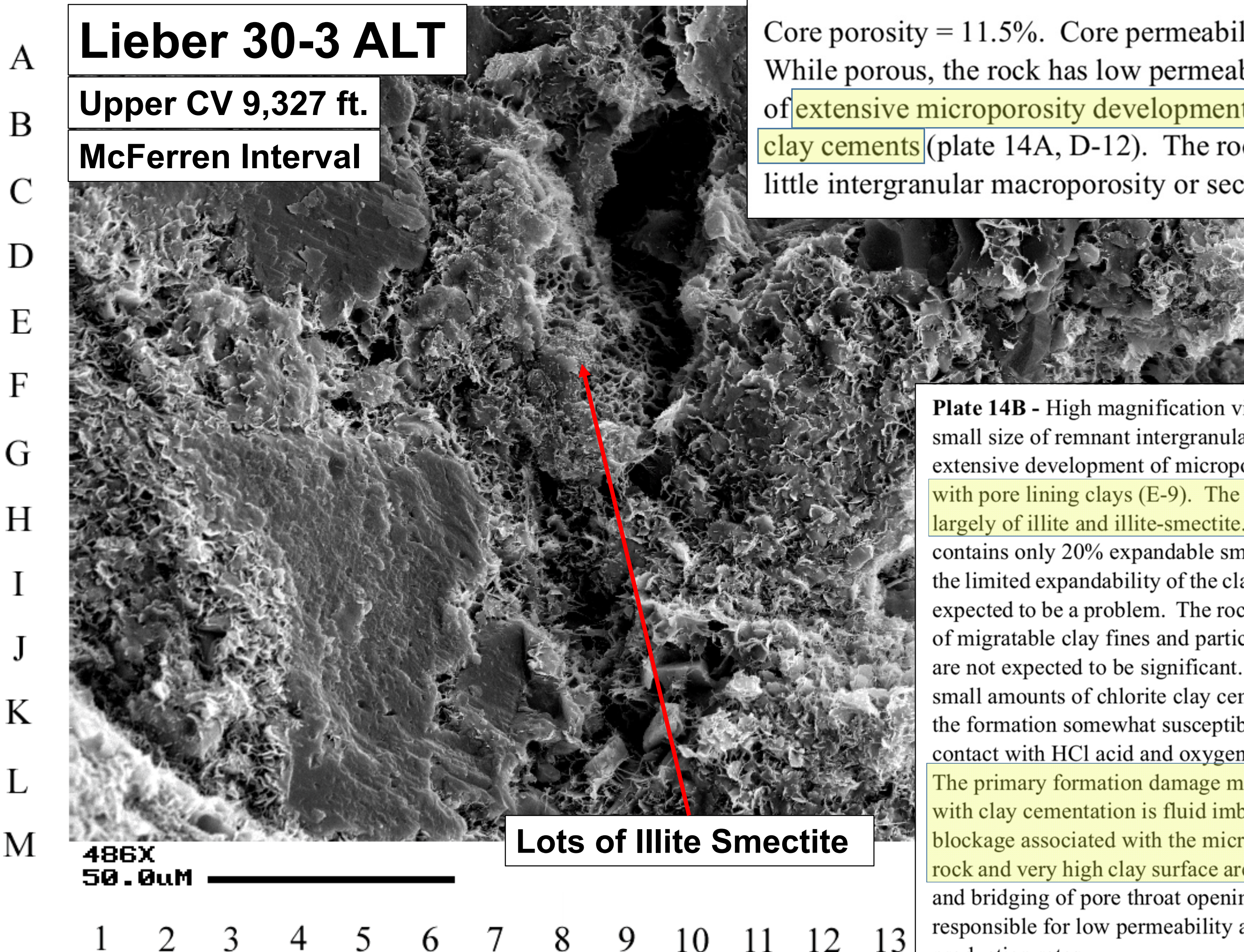
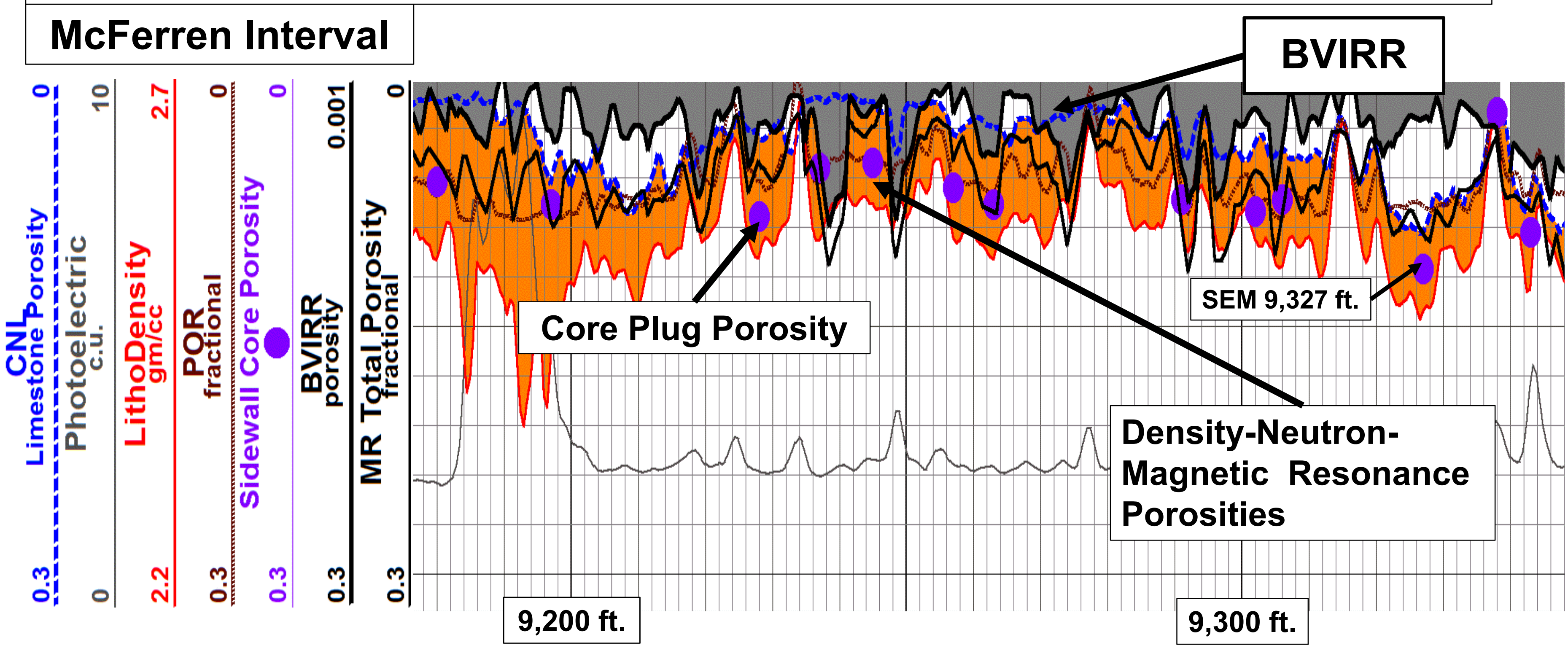


Plate 14B - High magnification view illustrating the small size of remnant intergranular pores (C-9) and extensive development of microporosity in association with pore lining clays (E-9). The clay cement consists largely of illite and illite-smectite. The illite-smectite contains only 20% expandable smectite layers. Due to the limited expandability of the clay, clay swelling is not expected to be a problem. The rock is essentially devoid of migratable clay fines and particle migration effects are not expected to be significant. The rock contains small amounts of chlorite clay cement, thus, rendering the formation somewhat susceptible to damage from contact with HCl acid and oxygenated fluids (minor). The primary formation damage mechanism associated with clay cementation is fluid imbibition and solids blockage associated with the micropore structure of the rock and very high clay surface areas. Clay cementation and bridging of pore throat openings are partially responsible for low permeability and will reduce fluid production rates.

Lieber 30-3 With Rotary SWC Porosity and Log Porosities



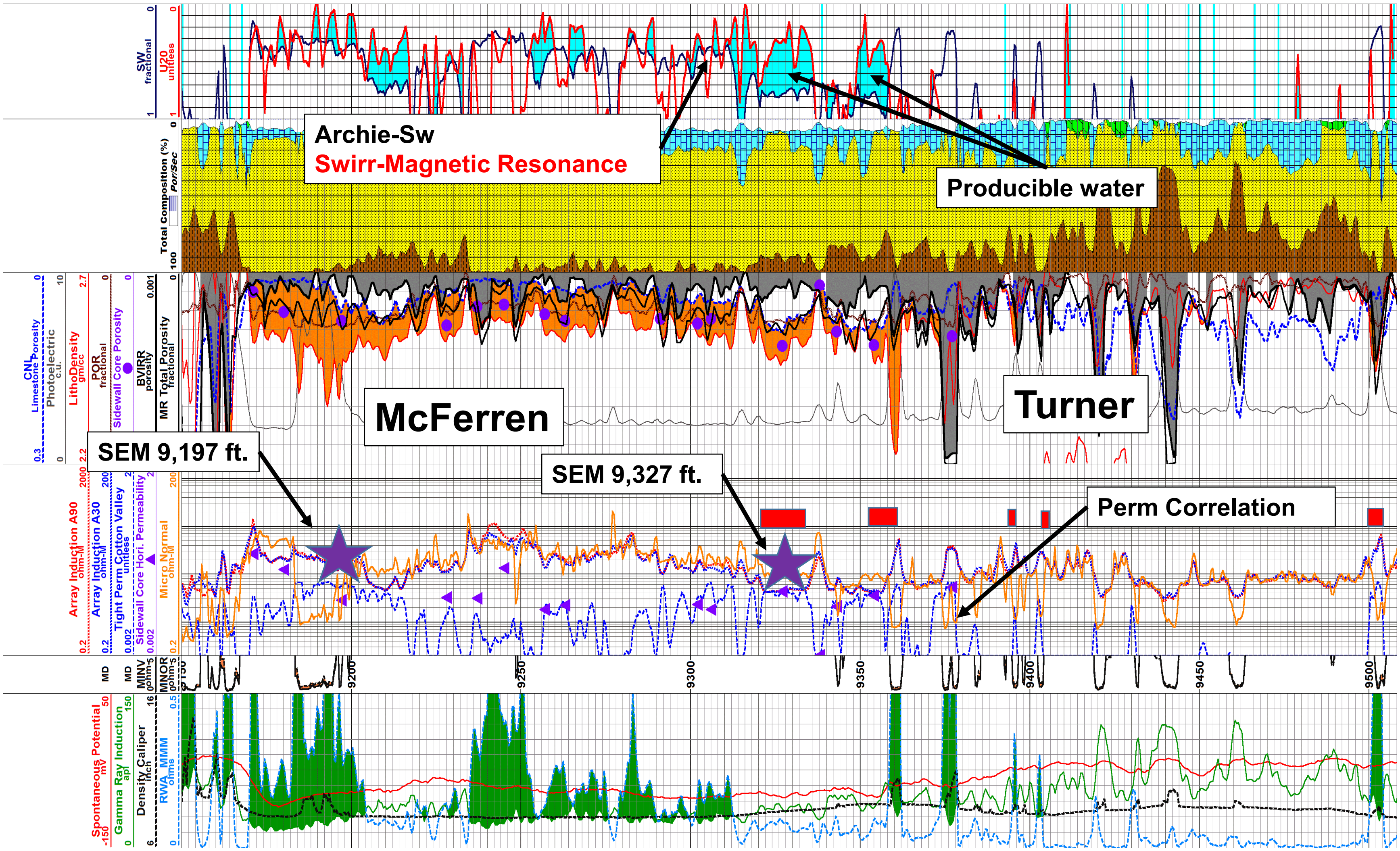
$$Swirr = \frac{BVIRR-Magnetic\ Resonance}{PHI-Density-Neutron}$$

Equation 1→ Porosity ONLY- No Resistivity

$$Sw - Archie = n\sqrt{\frac{a*Rw}{\Phi^m Rt}}$$

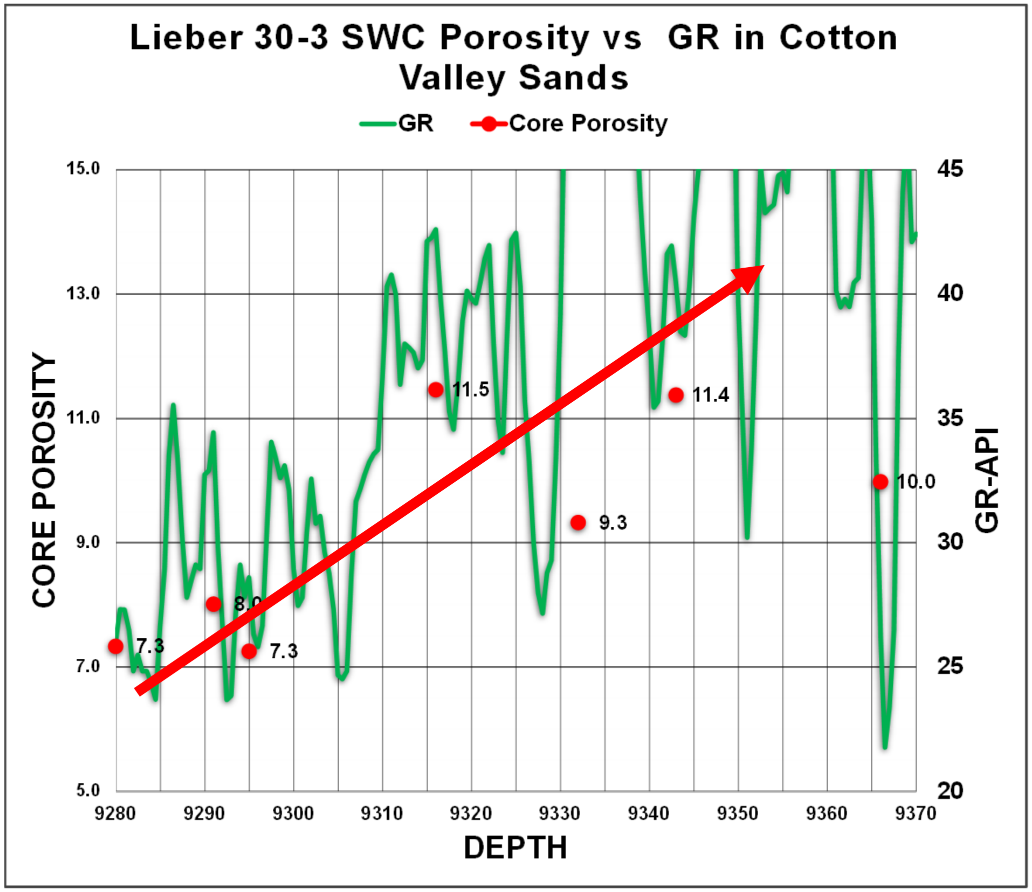
Equation 2 → A Resistivity Ratio

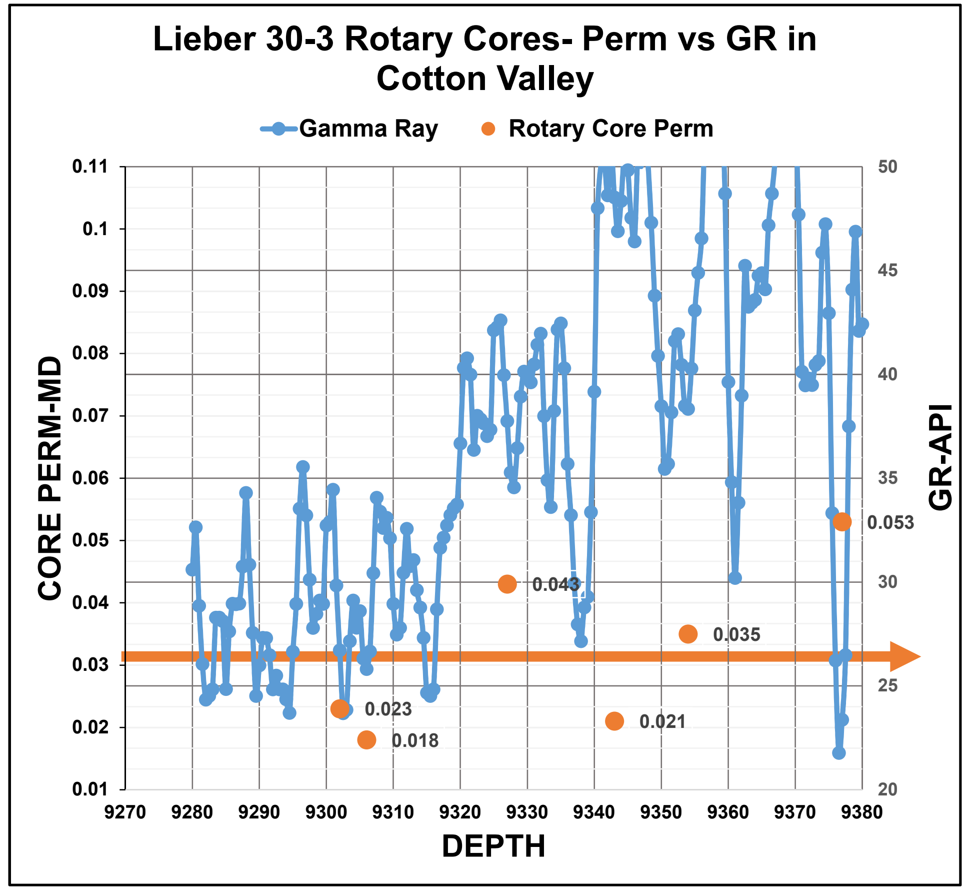
Lieber 30-3 With Rotary SWCs Porosity and Perm



Very High Water Cut and Low Cum (0.43 Bcf) due to water

Diagenetic Clays do fill pores, cover grains and preserve porosity in most Cotton Valley wells in various intervals

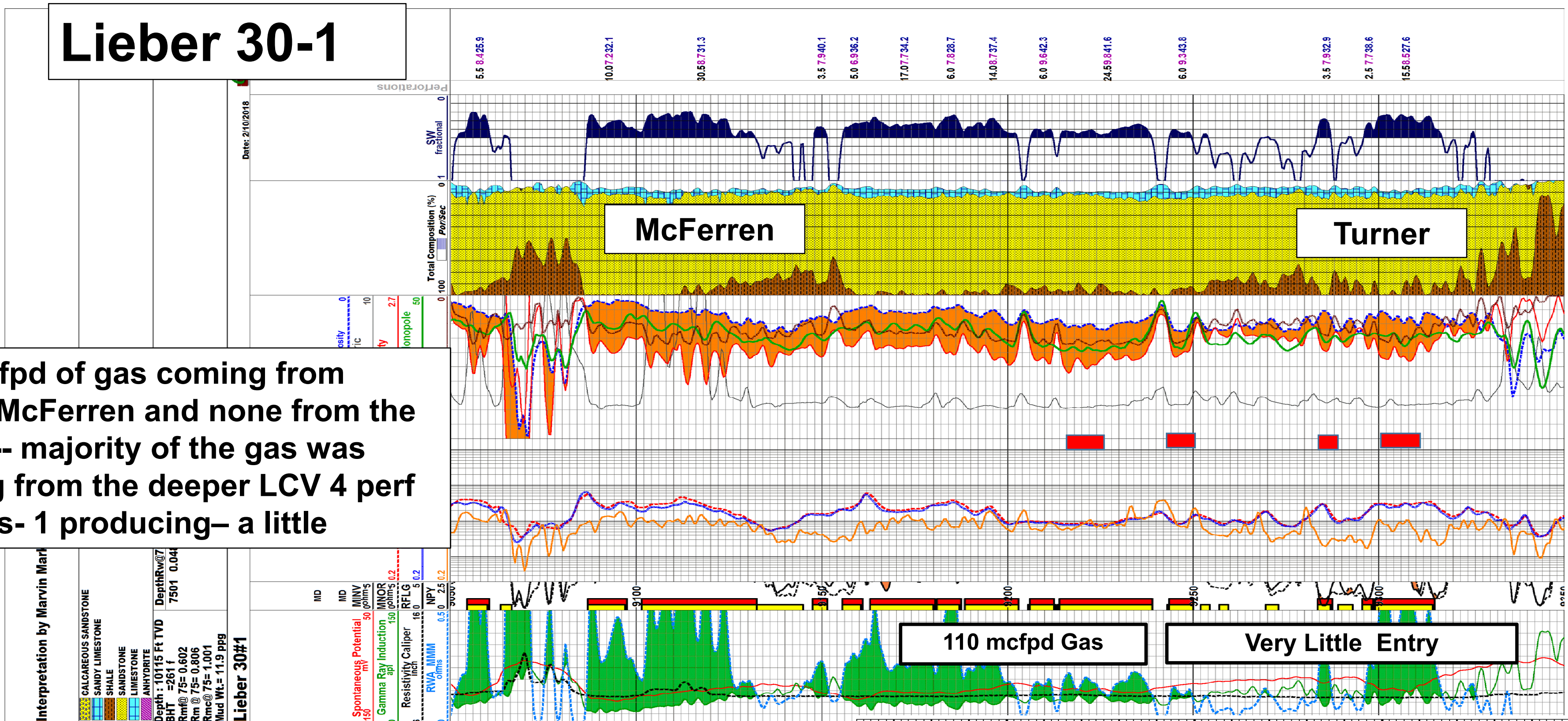




As GR increases Porosity increases in this clay contaminated interval

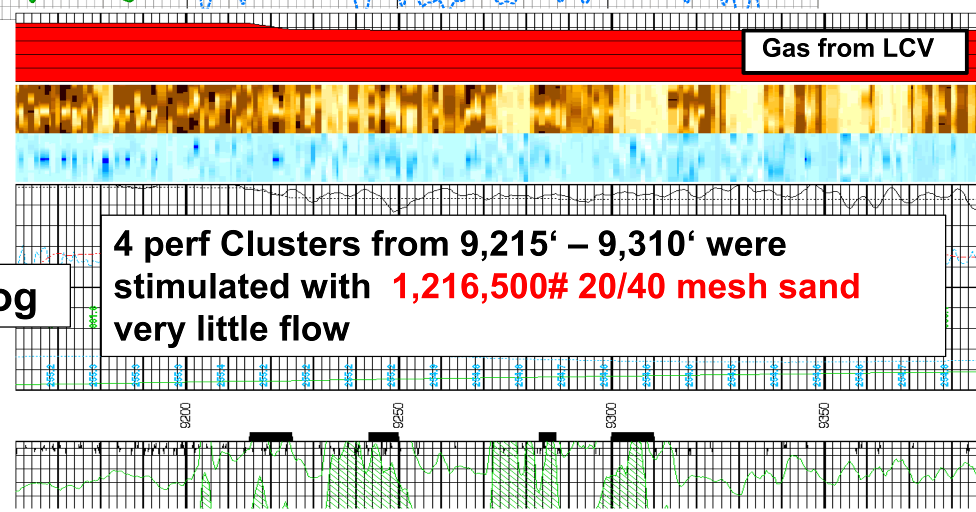
As GR increases Perm does not increase in this clay contaminated interval

Lieber 30-1



% Gas	% Water	Perforations	Q gas Surface Cond. (MSCFPD)	Q water Surface Cond. (BWPD)
10.1%	--	9215 - 9225	110	--
trace	--	9243 - 9250	trace	--
0.0%	--	9283 - 9287	0	--
0.0%	--	9300 - 9310	0	--
89.9%	--	9925 - 9935	980	
0.0%	--	sump	0	--
100.0%	--	Totals	1090	--

Production Log



Linam Properties 26-2

Comments & Summary

- A large data set with good well logs including magnetic resonance, core data, after frac gamma rays and production logs was used in the study
- All wells studied have some zones of higher porosity with higher gamma ray indicating porosity preservation from clays (mostly micro-porosity from pore filling and some grain covering clays). These higher porosities do not preserve permeability
- The addition of magnetic resonance data quantifies micro-porosity and allows a computation of moveable water zones which should be avoided
- Most stimulations (frac stages) in the Upper Cotton Valley were ineffective (meaning less than 50% of perf clusters produced)
- Attempting to stimulate widely spaced 4, 5 and 6 perf-cluster zones in a vertical well were unsuccessful in the upper Cotton Valley
- No Upper Cotton Valley zones have been efficiently drained in these wells
- Depletion is not a problem in the Upper Cotton Valley
- In this area the Cotton Valley Turner interval is not productive in many wells
- Horizontal wells with current technology should increase cumulative production substantially