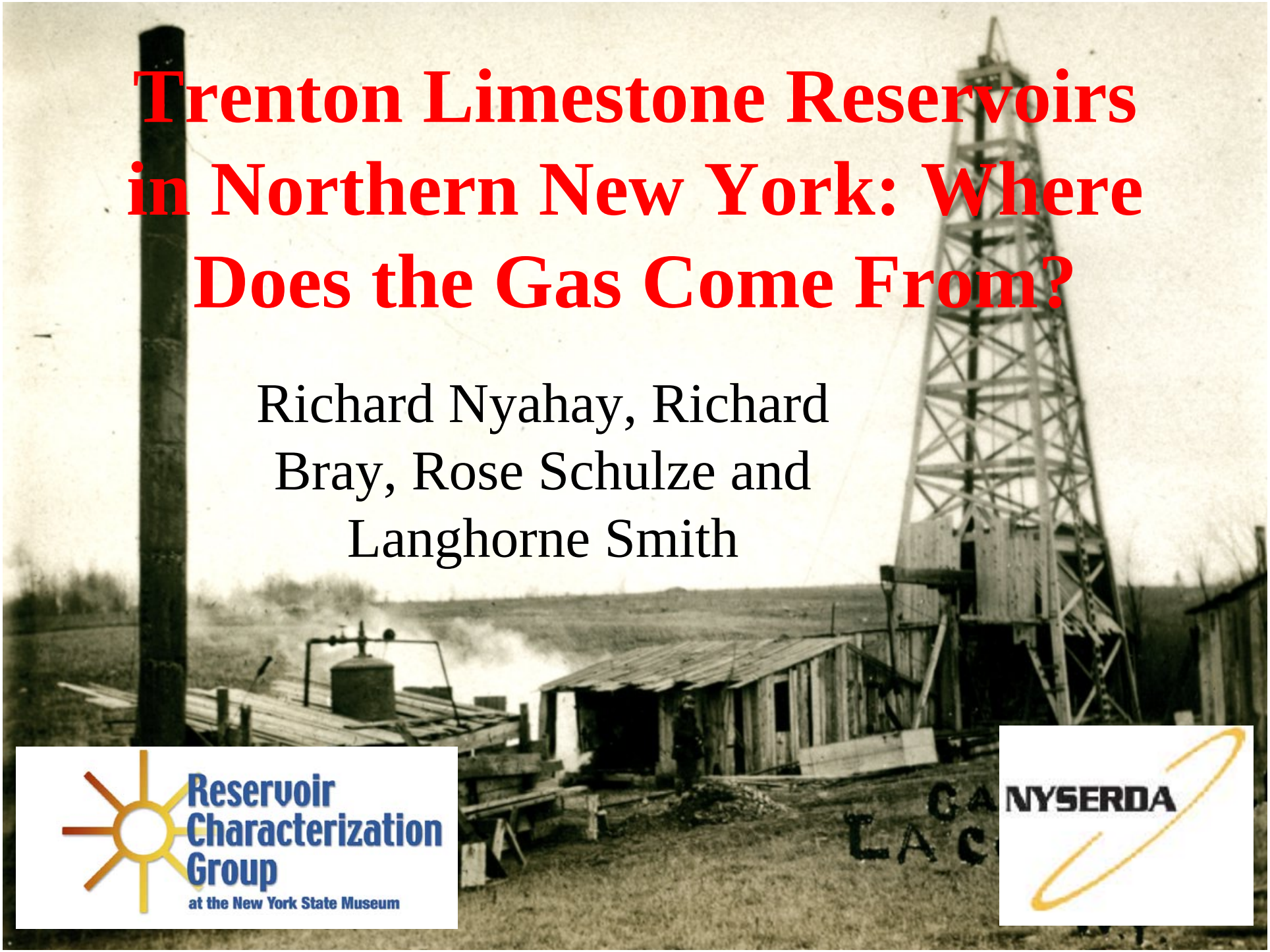
Trenton Limestone Reservoirs in Northern New York: Where Does the Gas Come From?

Richard Nyahay, Richard Bray, Rose Schulze and Langhorne Smith



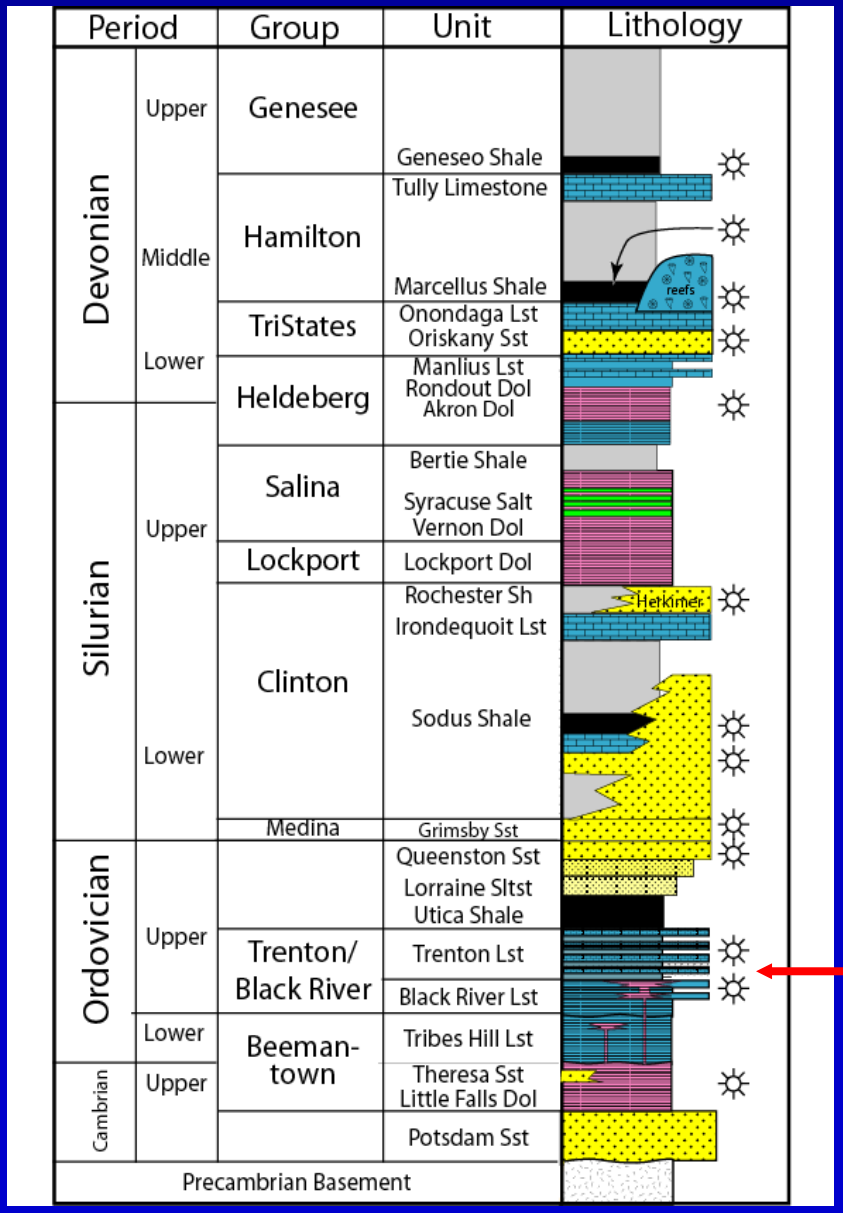
Reservoir Characterization Group
at the New York State Museum

NYSERDA

Brief History of the Trenton Limestone Play

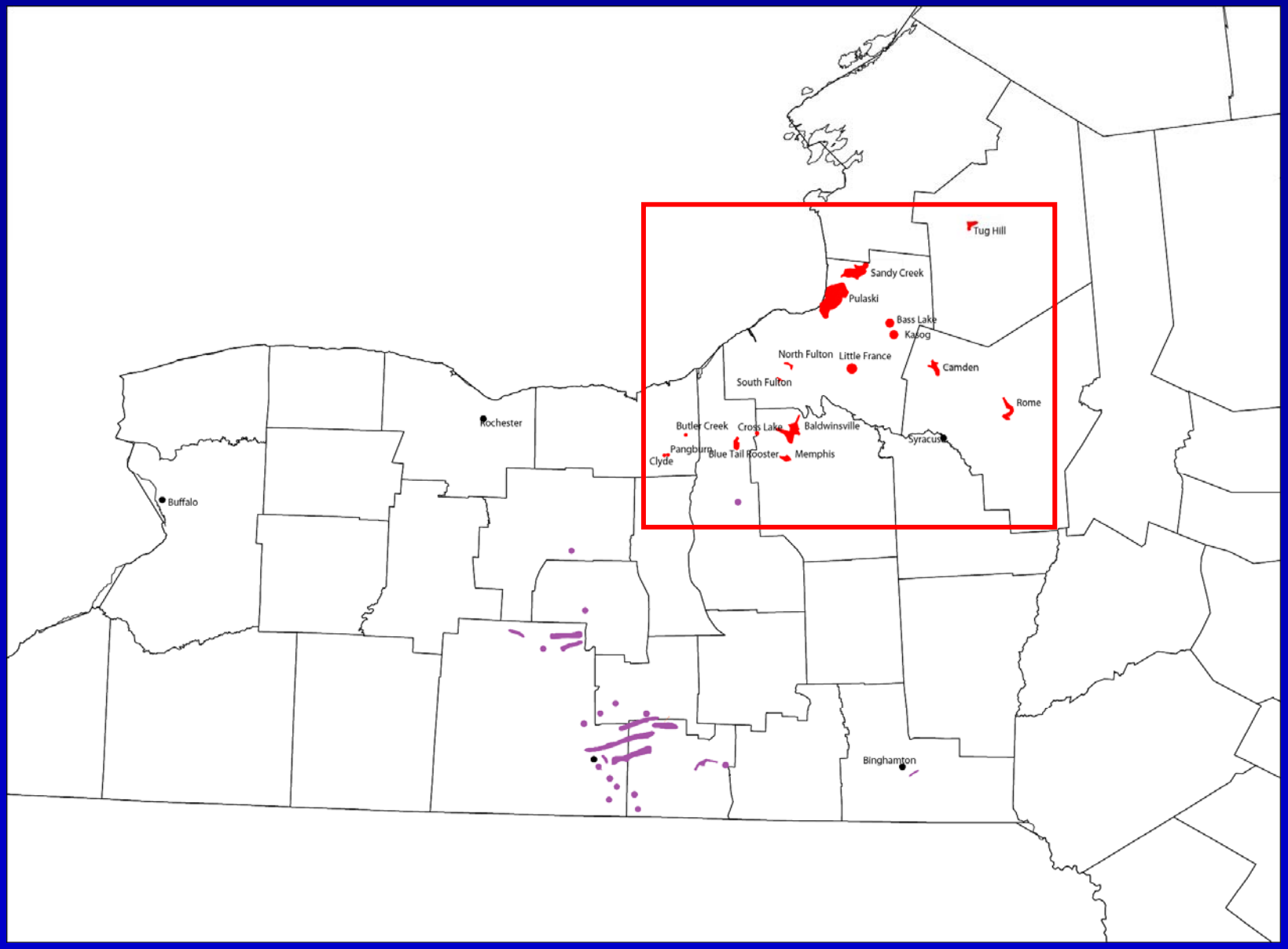
- First commercial well drilled in Sandy Creek Field in 1888
- Pulaski well drilled in 1891
- Many test wells drilled in the surrounding area from 1889- 1900
- Drilling continued steadily through the 1930s then died down
- Gas consumed locally
- Drilling continued sporadically until recent times

Stratigraphy



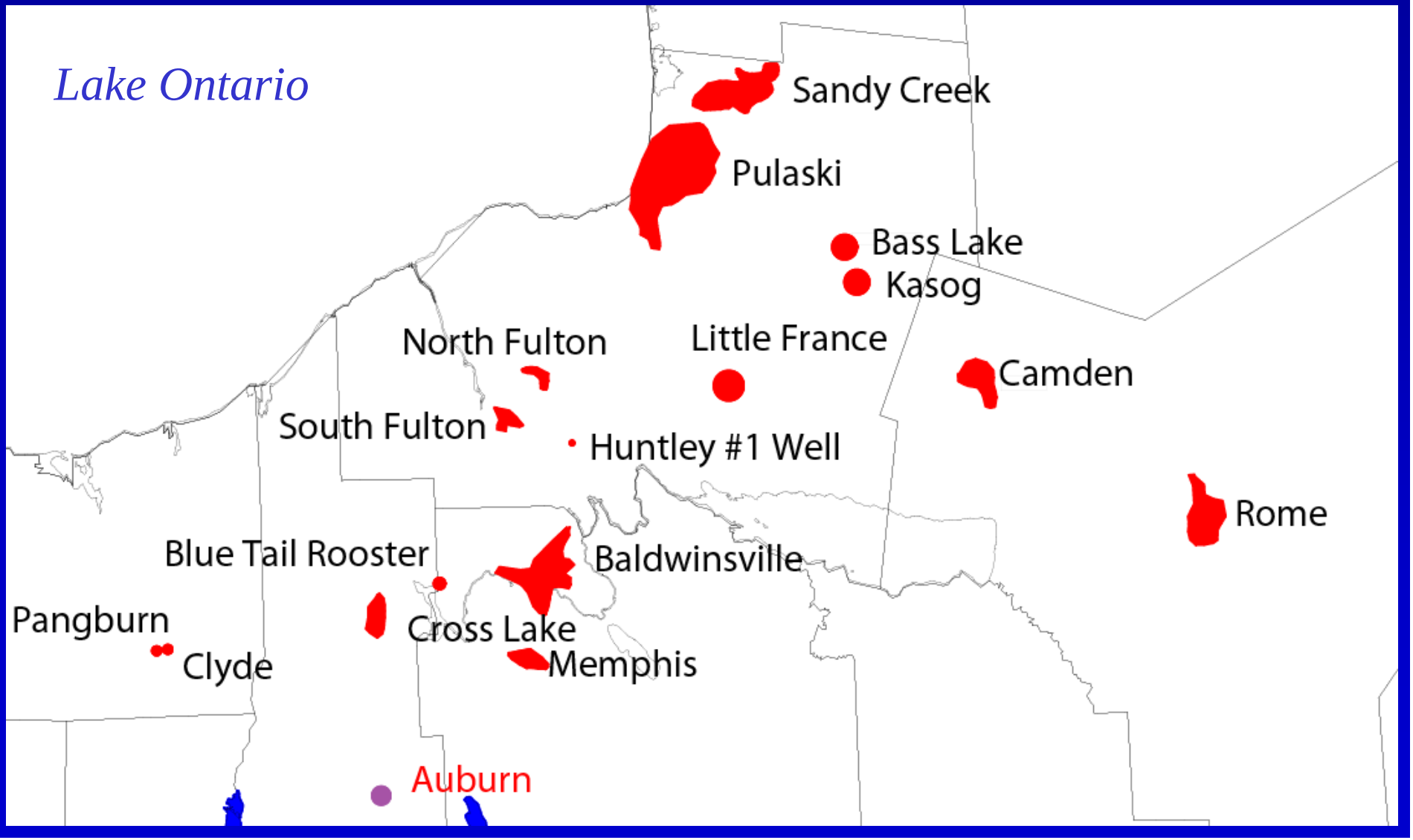
Trenton Limestone is Upper Ordovician in Age

It sits above the Black River Limestone which produces where dolomitized to the southwest



Trenton Limestone play occurs to northeast of HTD play

Trenton Limestone Play In Northern New York



Trenton Limestone Play

- The typical well has several very high pressure gas shows
- The gas will flow at a high rate for a few hours or days and then drop off to a very low rate of ~10 mcfd
- It will flow at this rate for decades
- Drilling practice was to drain high-rate producing intervals and then drill deeper
- A few wells have sustained higher rates for longer periods of time

Very High Pressure

"When shut in, pressure lifted 633 feet of casing and drive pipe out of hole and scattered it about the land. One 80-foot length was thrown 600 feet from the well."

-Scout card from well in Pulaski Field

Previous Work

- Orton, 1899 – no dolomite, different than Ohio, possibly shale gas
- Gillette, 1935 – shale gas
- Robinson, 1985 – fractured limestone

Previous Work

"That the gas is confined to the shale partings and shale layers can be observed at any well during the drilling of the Trenton. The drill first strikes a hard, dense limestone layer which is usually only a few inches thick but is hard to penetrate. As the drill breaks through this layer the gas rushes forth, sometimes under enormous pressure which may even blow the tools out of the hole. When drilling is again resumed it is invariably found that the layer under the hard dense limestone is a calcareous shale… No increase in volume is realized until another hard dense limestone is reached. Unquestionably the limestone acts as a cap rock."

-Gillette, 1935

News Articles

CAMDEN ADVANCE-JOURNAL

CAMDEN, N. Y., THURSDAY, OCTOBER 4, 1934

No. 14

er Camden Girl Marries

A E. CONGDEN, C. H. S. ATE AND FORMER EMPLOYE, BRIDE

Jos. C. West, Oneida

erformed at Millerton, lywods Residing at 212 a Street, Oneida.

t 11, 1934, Miss Edna E. unger daughter of Mrs. ongden of McConnells- seph C. West of Oneida, in marriage at the par- he Methodist Episcopal llerton, Pa., the Rev. C. officiating. The attend- as Mr. and Mrs. Dickin- la.

den is a graduate of h School, class of '31. ting, she has been em- First National Bank & any of Camden. Mr. loyed at the National any in Oneida.

the ceremony, they left notor trip, and later at- chester Centennial. rs. West will reside at eet, Oneida, N. Y.

Car Backs to Grocery Stand

r's Machine in Reverse ees Him the Slip ion Crashed.

motor mishap occurred day about 8:30 when r's car ran away back- shed the display stand ocery on Mexico street.

MR. AND MRS. HENRY PARKER OBSERVE SILVER WEDDING

Mr. and Mrs. Seymour E. Yager and son Ronald were in Syracuse Saturday evening to attend the silver wedding anniversary of Mr. and Mrs. Henry Parker, which was celebrated in a surprise party at the home of their daughter, Mr. and Mrs. William Neville, 104 Peck avenue. A fine social time and delicious refreshments were features of the evening and the celebrants were presented a gift in remembrance of the day.

Mr. Parker, before marriage, was a drug clerk in A. H. Maloney's store, Camden. He also was best man at the wedding of Mr. and Mrs. Yager. To Henry and his bride of twenty-five years, old Camden friends extend hearty congratulations.

SMITH'S AYRSHIRES MAKE HIGH AVERAGE

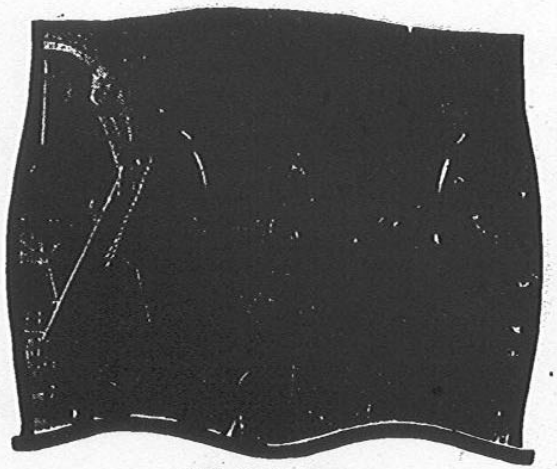
Securing an average production of 647 pounds of milk, 25.19 pounds of butterfat per cow, the eight Ayrshires in the Merritt C. Smith herd at Westdale, N. Y., during August, ranked among the leading herds for production in the United States, tested under the rules of the Ayrshire Herd Test, according to Advanced Registry Superintendent, W. A. Kyle of the National Ayrshire Breeders Association, Brandon, Vt.

LEGION AUXILIARY ENJOYS MOVIE PARTY

The Women's Auxiliary of Arthur S. Moran Post, No. 66, held its regular meeting last evening at the Legion rooms. Mrs. James LeRicheux, president, presided. Twelve responded to roll call. After the business of the meeting Mrs. Reymore and Mrs. Hubbard entertained the ladies at the movies which featured "The Thin Man," successfully presented as a benefit for the Star Boys.

Lock is Elected Head of Legion

Will Give Concert at School



Petrie Novelty Quintet.

The Collins entertainment festival, under the auspices of the Philanthropic Lodge, will be launched October 11, at the Camden High School auditorium, with a concert by the Petrie Instrumental Quintet, headed by Herbert Petrie, renowned trumpeter soloist. The quintet uses 13 different instruments in various combinations to provide serious, light and humorous music.

Herbert Petrie, manager and leader, was a solo cornetist under John Philip Sousa and has had years of experience not only as a solo artist but as a teacher and director. He was a student at the American Conservatory of Music and a pupil of Edward Llewellyn, first trumpeter of the Chicago Symphony Orchestra.

The three other men in the company have been with him for five seasons. Several of the instruments have been made especially for Mr. Petrie and have their particular part in artistically embellishing the program.

Stirring, sparkling and rhythmic band music, soft, dreamy waltz music, and swinging, romantic operetic selections—all have their part in making the Petrie's program one of unusual interest and charm. One part of the evening will be given over to frankly humorous and entertaining bits done for the wholesome enjoyment of those who like to laugh with their music.

Bender Gas Well Contacted Powerful Gas Pocket at One O'clock This Morning

Explosion Skyrockets Two Ton Drill, Disrupts Cable and Fires Rock to Top of Derrick--Work Proceeds for a Main Vein.

The Bender gas well, which is being drilled on the Harvey Dunn farm near this village, struck a pocket of gas this morning at 1 o'clock that hoisted the 3,800 pound drill, dislodged the cable from its track and sent a volume of rock and water into the air to an altitude about the height of the towering derrick.

This is the fourth time within the week that pockets of gas have been struck. Yesterday morning a pocket, capable of flowing 50,000 cubic feet of gas daily, blew in at 8:45 o'clock. Each succeeding strike comes with greater force and the explosions increase in noise. Excitement this morning is running high at the well. Engineer Cady is supervising the two shifts of workmen who have resumed operations to drill on until the main vein is hit. The well is now down 950 feet.

The young gusher that came to light at 1 a. m. today has permeated the air about the premises with a strong odor—sample of the real stuff. The gas is strong enough that some of the workmen complain of it making their heads ache. The flow of gas, from the six inch hole, can be felt on the hand when held six to eight feet above the platform, visitors report.

The monotony of just drilling has reached a different stage—for the workmen stand ready to hustle for their lives with each re-curring explosion. Engineer Cady is highly jubilant over the prospects of the well to date and ventures his belief that within a week they will tap a major vein.

Warning is given to any visitor to the premises that smoking is absolutely forbidden.

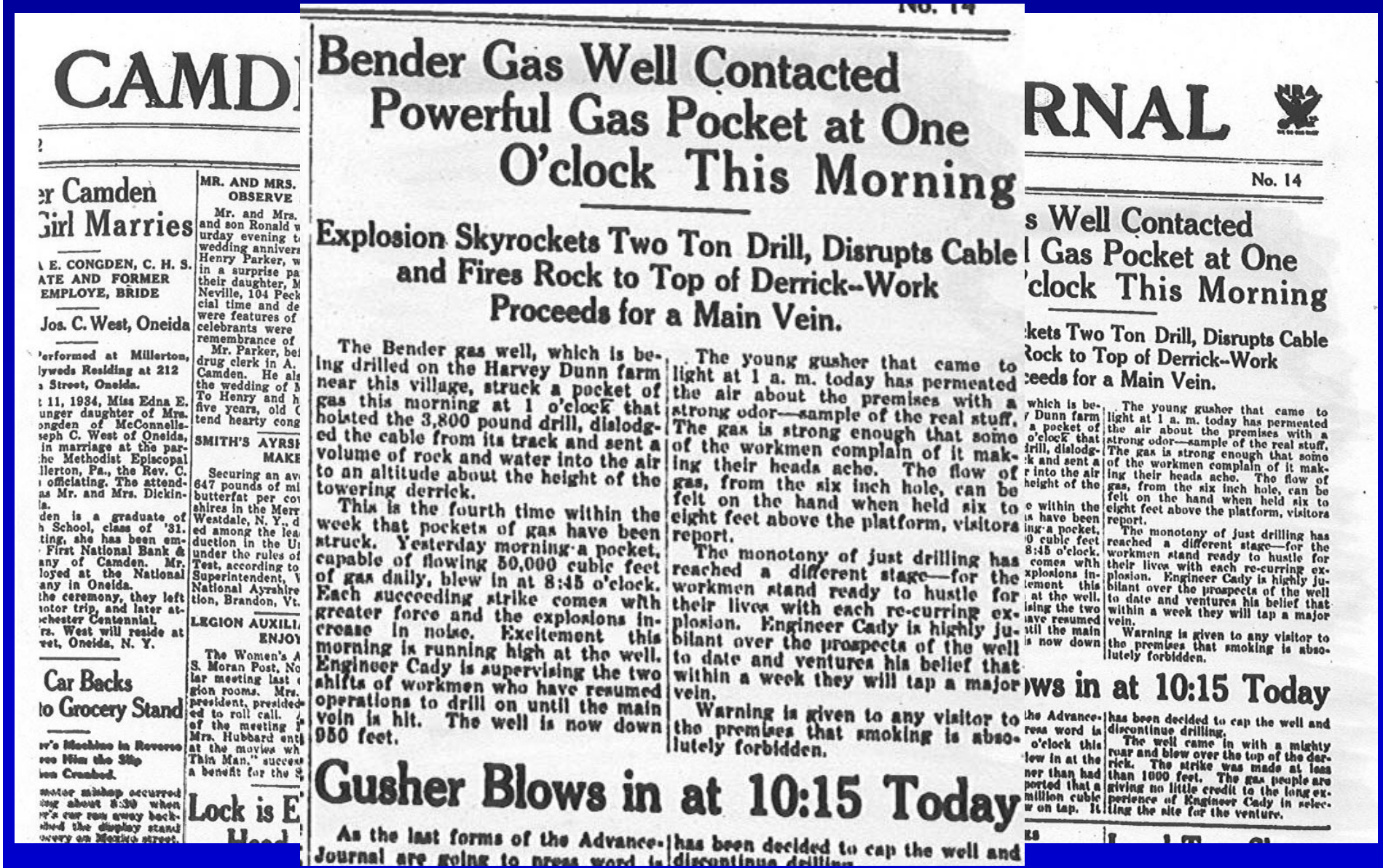
Gusher Blows in at 10:15 Today

As the last forms of the Advance-Journal are going to press word is received that at 10:15 o'clock this forenoon a real gusher blew in at the Bender well, coming sooner than had been expected. It is reported that a flow of at least a half million cubic feet of gas per day is now on tap. It has been decided to cap the well and discontinue drilling.

The well came in with a mighty roar and blew over the top of the derrick. The strike was made at less than 1000 feet. The gas people are giving no little credit to the long experience of Engineer Cady in selecting the site for the venture.

SURPRISE CELEBRATES

News Articles



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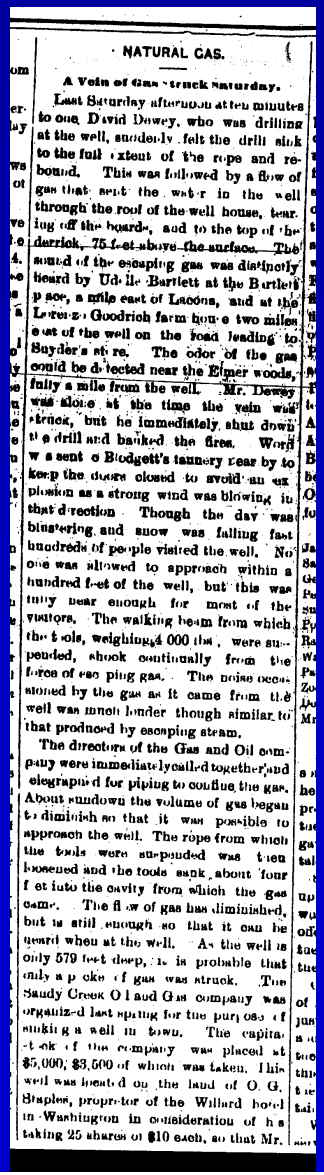
The Sandy Creek News

VOL. XVIII. NO. 39 / SANDY CREEK, N. Y., THURSDAY, JANUARY 17, 1889. $1.50 A YEAR, IN ADVANCE

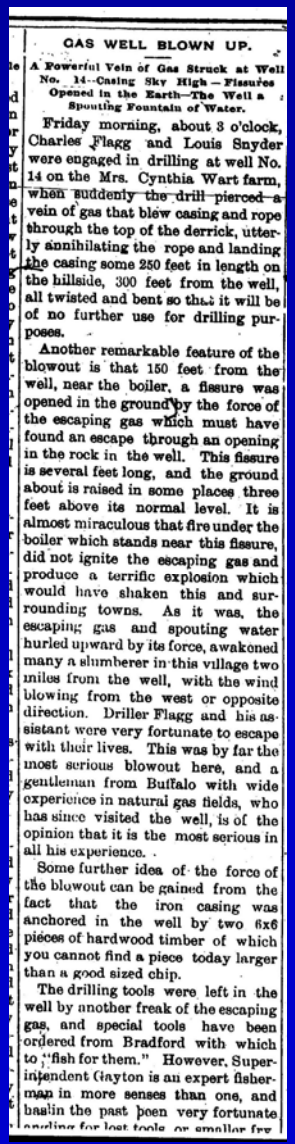


NATURAL GAS.

A Vein of Gas Struck Saturday.

Last Saturday afternoon atten minutes to one David Dewey, who was drilling at the well, suddenly felt the drill sink to the full extent of the rope and rebound. This was followed by a flow of gas that sent the water in the well through the roof of the well house, tearing off the boards, and to the top of the derrick, 75 feet above the surface. The sound of the escaping gas was distinctly heard by Udelle Bartlett at the Bartlett place, a mile east of Lacons, and at the Lorenzo Goodrich farm house two miles east of the well on the road leading to Snyder's store. The odor of the gas could be detected near the Elmer woods, fully a mile from the well. Mr. Dewey was alone at the time the vein was struck, but he immediately shut down the drill and banked the fires. Word was sent to Blodgett's tannery near by to keep the doors closed to avoid an explosion as a strong wind was blowing in that direction. Though the day was blustering and snow was falling fast hundreds of people visited the well. No one was allowed to approach within a hundred feet of the well, but this was fully near enough for most of the visitors. The walking beam from which the tools, weighing 4 000 lbs., were suspended, shook continually from the force of escaping gas. The noise occasioned by the gas as it came from the well was much louder though similar to that produced by escaping steam.

The directors of the Gas and Oil company were immediately called together and telegraphed for piping to confine the gas. About sundown the volume of gas began to diminish so that it was possible to approach the well. The rope from which the tools were suspended was then loosened and the tools sank about four feet into the cavity from which the gas came. The flow of gas has diminished, but is still enough so that it can be heard when at the well. As the well is only 579 feet deep, it is probable that only a pocket of gas was struck. The Sandy Creek Oil and Gas company was organized last spring for the purpose of sinking a well in town. The capital stock of the company was placed at $5,000; $3,500 of which was taken. This well was located on the land of O. G. Staples, proprietor of the Willard hotel in Washington in consideration of his taking 25 shares of $10 each, so that Mr.



GAS WELL BLOWN UP.

A Powerful Vein of Gas Struck at Well No. 14—Casing Sky High—Fissures Opened in the Earth—The Well a Spouting Fountain of Water.

Friday morning, about 3 o'clock, Charles Flagg and Louis Snyder were engaged in drilling at well No. 14 on the Mrs. Cynthia Wart farm, when suddenly the drill pierced a vein of gas that blew casing and rope through the top of the derrick, utterly annihilating the rope and landing the casing some 250 feet in length on the hillside, 300 feet from the well, all twisted and bent so that it will be of no further use for drilling purposes.

Another remarkable feature of the blowout is that 150 feet from the well, near the boiler, a fissure was opened in the ground by the force of the escaping gas which must have found an escape through an opening in the rock in the well. This fissure is several feet long, and the ground about is raised in some places three feet above its normal level. It is almost miraculous that fire under the boiler which stands near this fissure, did not ignite the escaping gas and produce a terrific explosion which would have shaken this and surrounding towns. As it was, the escaping gas and spouting water hurled upward by its force, awakened many a slumberer in this village two miles from the well, with the wind blowing from the west or opposite direction. Driller Flagg and his assistant were very fortunate to escape with their lives. This was by far the most serious blowout here, and a gentleman from Buffalo with wide experience in natural gas fields, who has since visited the well, is of the opinion that it is the most serious in all his experience.

Some further idea of the force of the blowout can be gained from the fact that the iron casing was anchored in the well by two 6x6 pieces of hardwood timber of which you cannot find a piece today larger than a good sized chip.

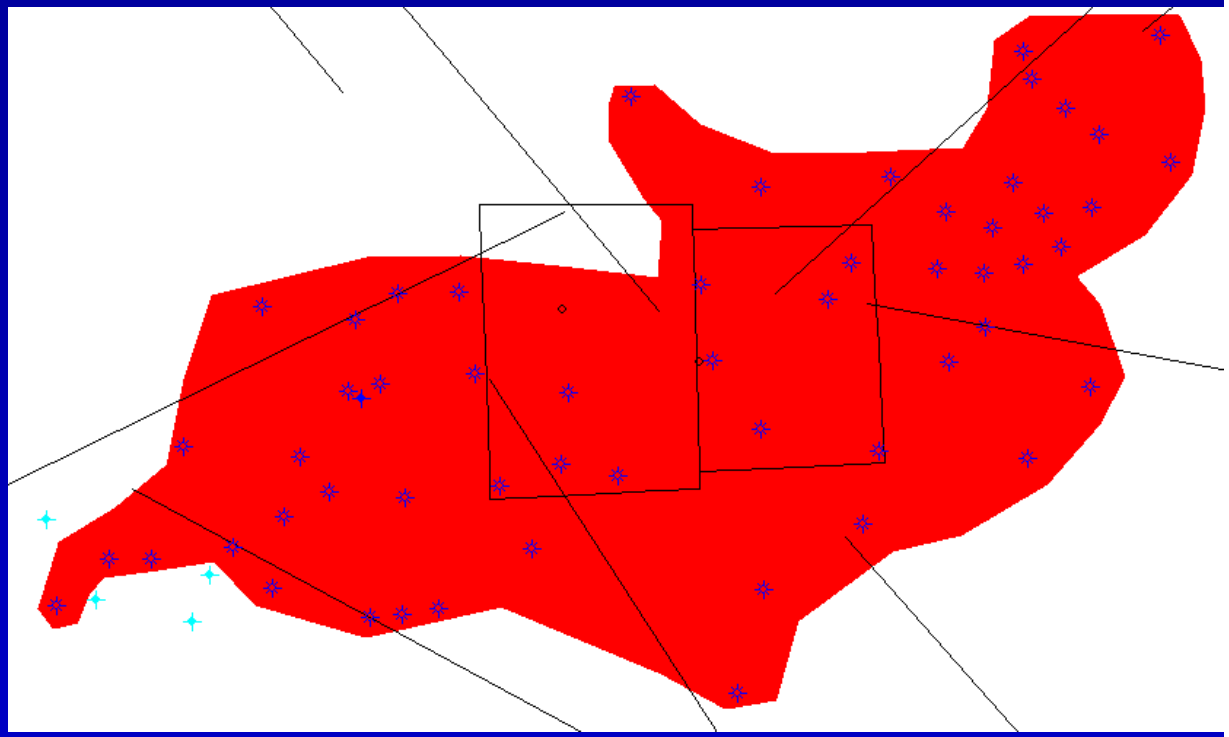
The drilling tools were left in the well by another freak of the escaping gas, and special tools have been ordered from Bradford with which to "fish for them." However, Superintendent Gayton is an expert fisherman in more senses than one, and has in the past been very fortunate

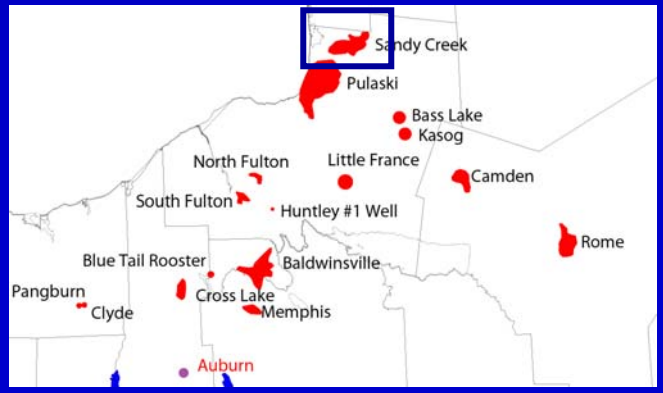
Well @ 579 ft. Located on the land of O.G. Staples. Since November drilling on done on one ten hour shift per day. Gas Pocket @ 550 ft. found on February 2, 1889.

Large blow out @ 920 ft. , ground opens up 150 ft. away from the large blow out. A fissure several feet long displaced the ground elevation by three feet.

Sandy Creek Field

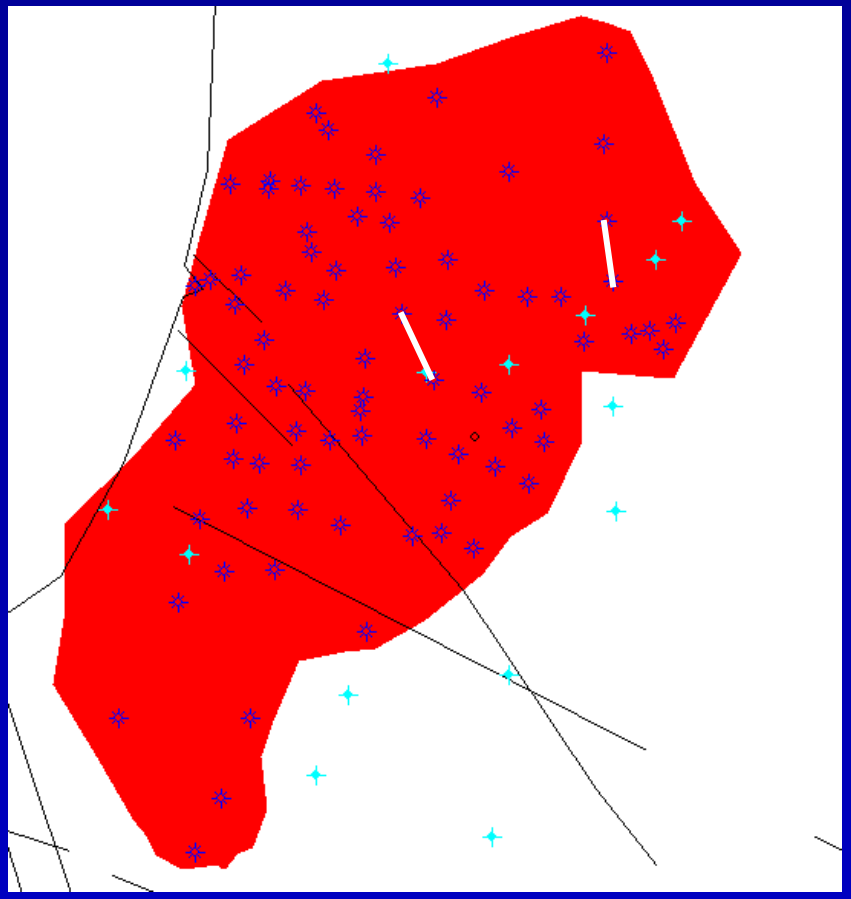
- Discovered in 1888
- Depth to Trenton: 380-600 feet
- Trenton 590 feet thick
- No dolomite reported
- Many gas intervals in the Trenton

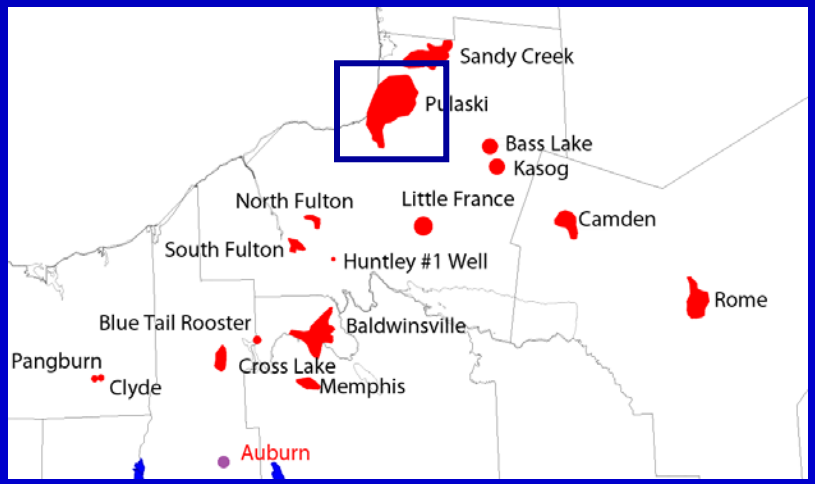




Pulaski Field

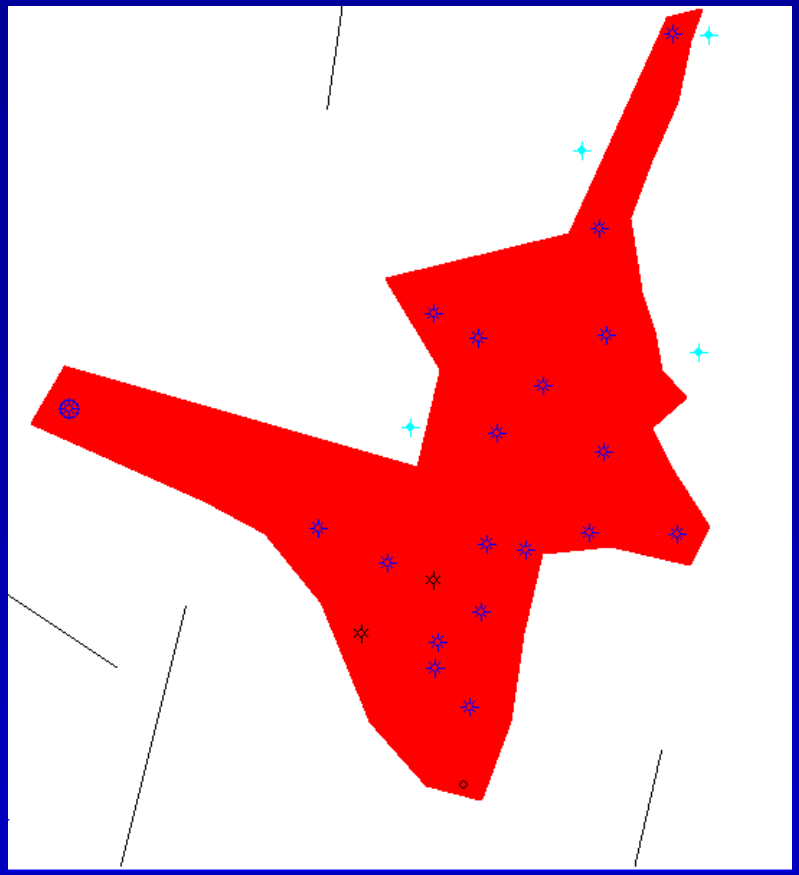
- Discovered in 1891
- Most wells drilled: 92
- Depth to Trenton top: 440-971
- Trenton Thickness: 610 feet
- Two gas intervals @ 675 & 1175 feet
- Typically no communication between wells but there were reports of two sets of wells where drilling of one affected production in another

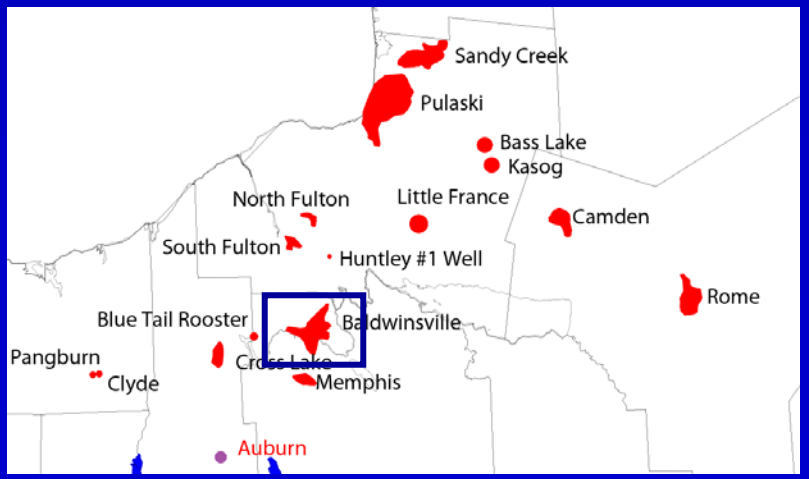




Baldwinsville Field

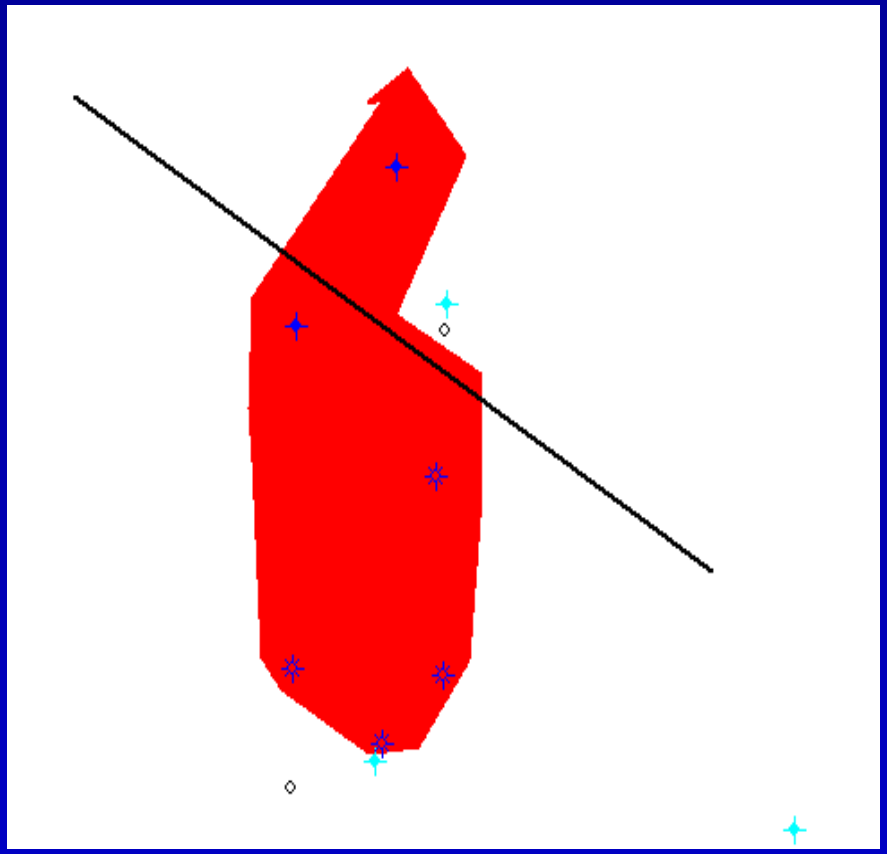
- Depth to Trenton: 2250 feet
- No dolomite
- Many gas intervals from the Medina to the Trenton
- Some wells produced from the Utica
- Gas also found in the Potsdam
- High volumes of gas

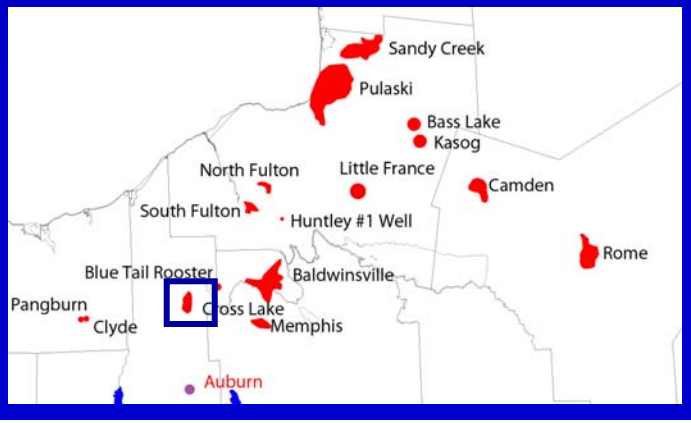




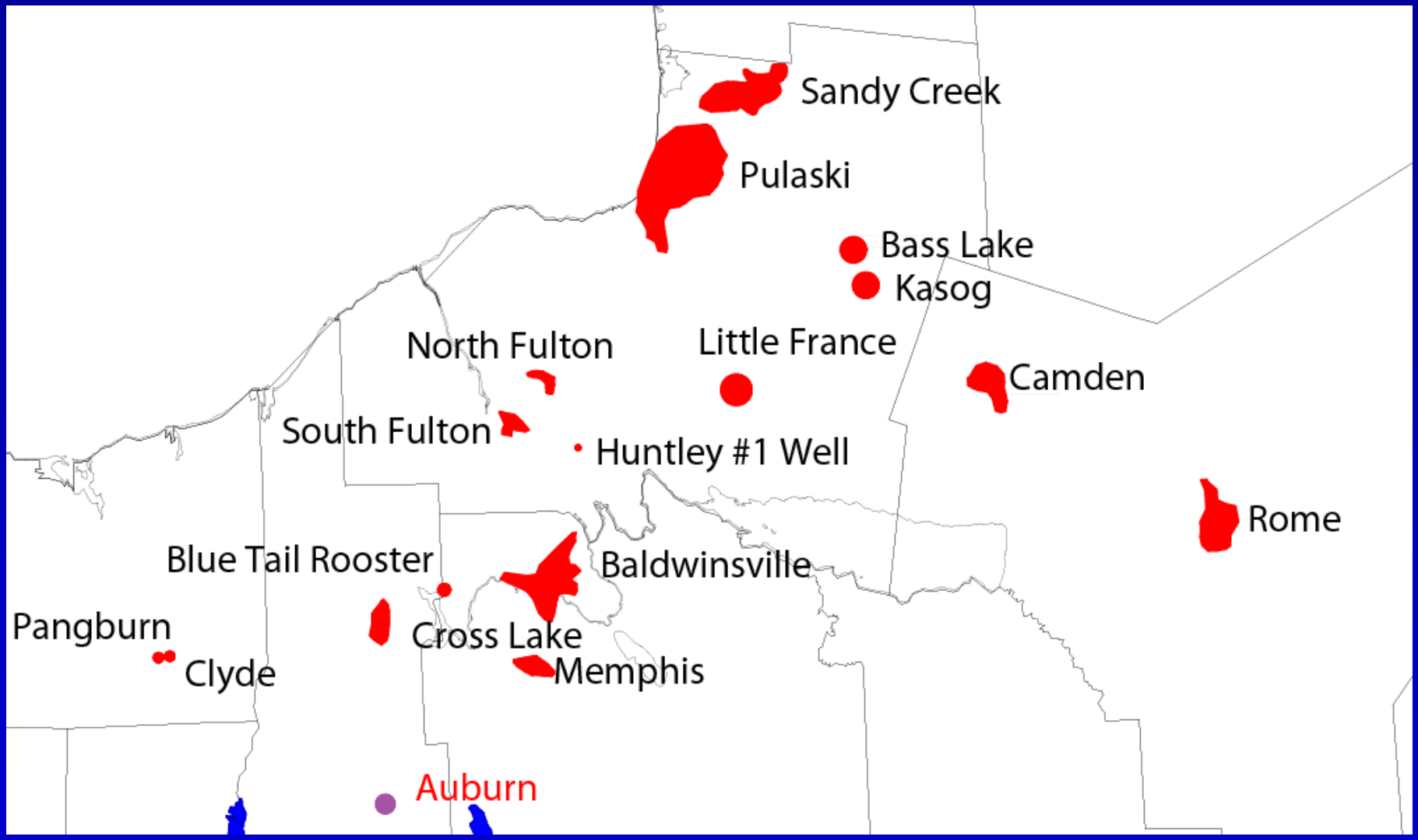
Blue Tail Rooster Field

- Discovered in 1966
- Depth to Trenton
- 2400-2564
- Depth to Black River
- 3083-3242
- Dolomitized fractures found in cuttings Van Tyne, 1984
- Gas intervals from Lockport to Trenton
- Exploration continues

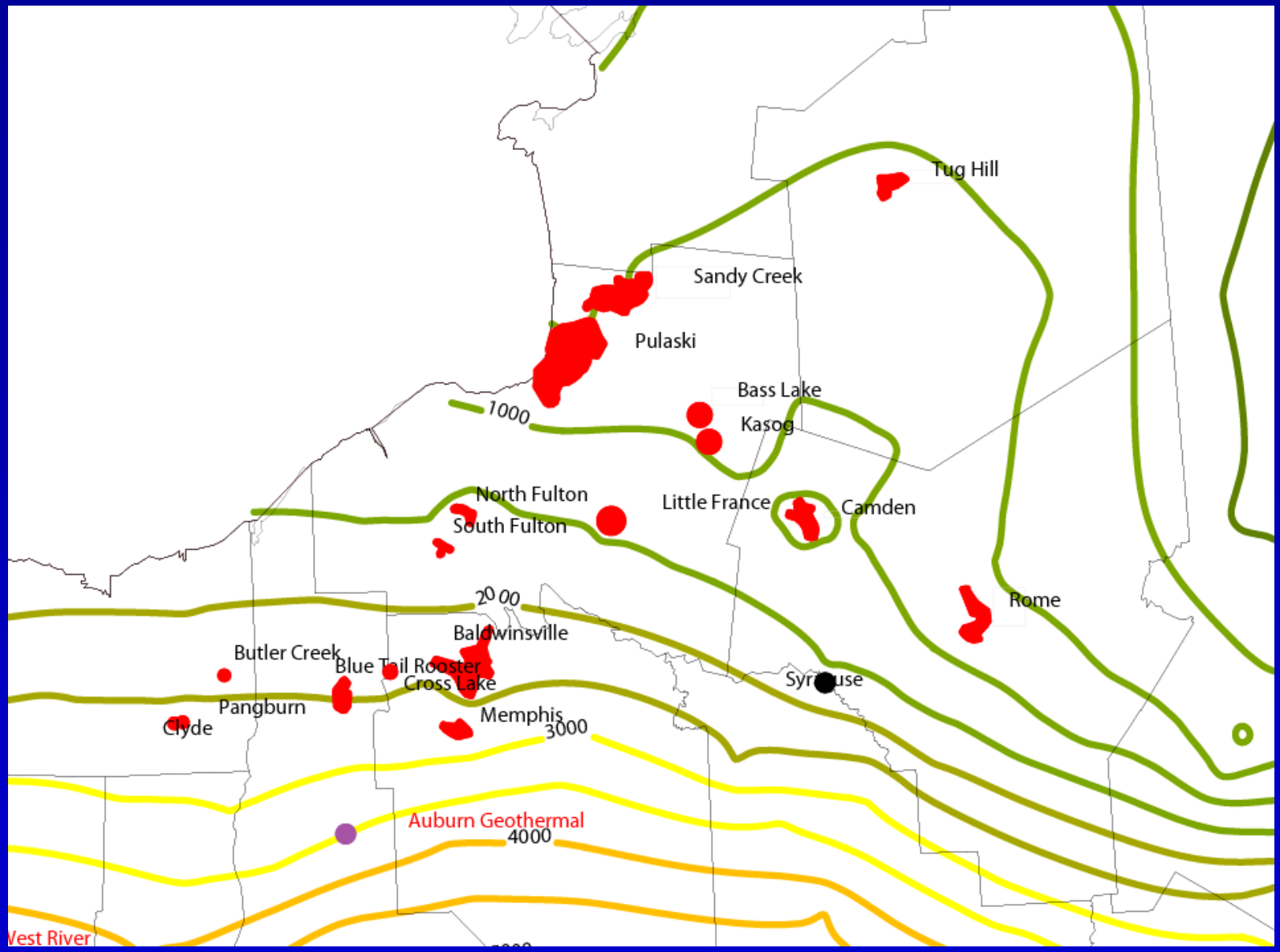




Trenton Limestone Play In Northern New York



Exploration has continued with one well field discoveries and renewed interest in older fields



Fields occur where Trenton is buried to depths of <3000 feet – no high pressured gas found in Trenton below this depth

Questions We Wanted to Answer for This Study

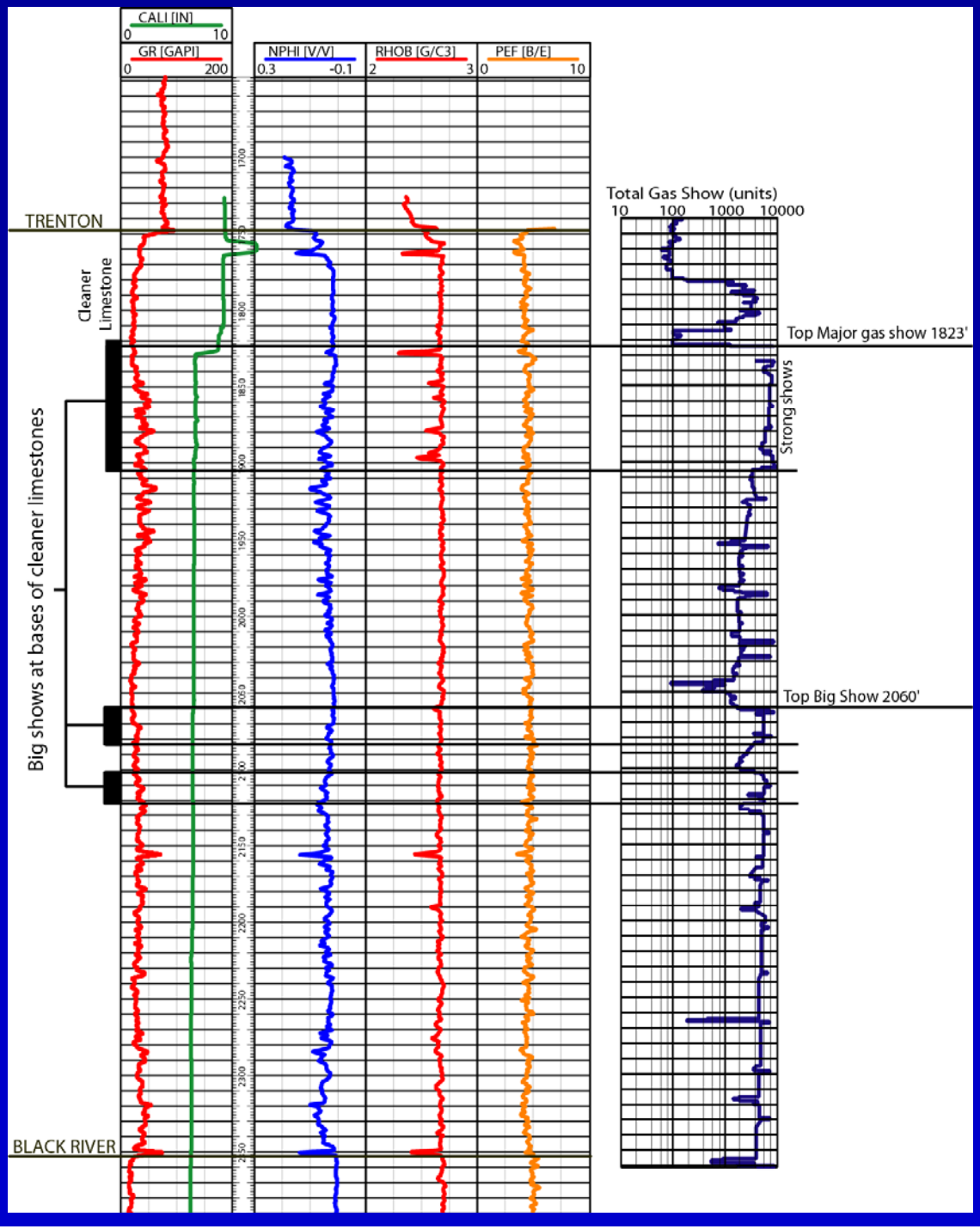
- Where is the gas coming from?
- Does hydrothermal dolomite have anything to do with this production?
- Is there any porosity in the limestones that might work as a reservoir?
- Does the gas come from fractured limestones or fractured shales or both?
- What is the source of the high pressure?
- What is the lateral extent of the play?

Trenton Study

- NYSERDA funded study to acquire a full diameter core in the Trenton Formation in northern New York to study reservoir characteristics
- After a year of trying to get a partner to drill a full diameter core, we partnered with Seneca Resources to take 160 side wall cores from one of their wells in Oswego County (Huntley #1) API 31-075 23071-0000
- After the well was logged we picked intervals from the Trenton mostly to TD to core, study and characterize.

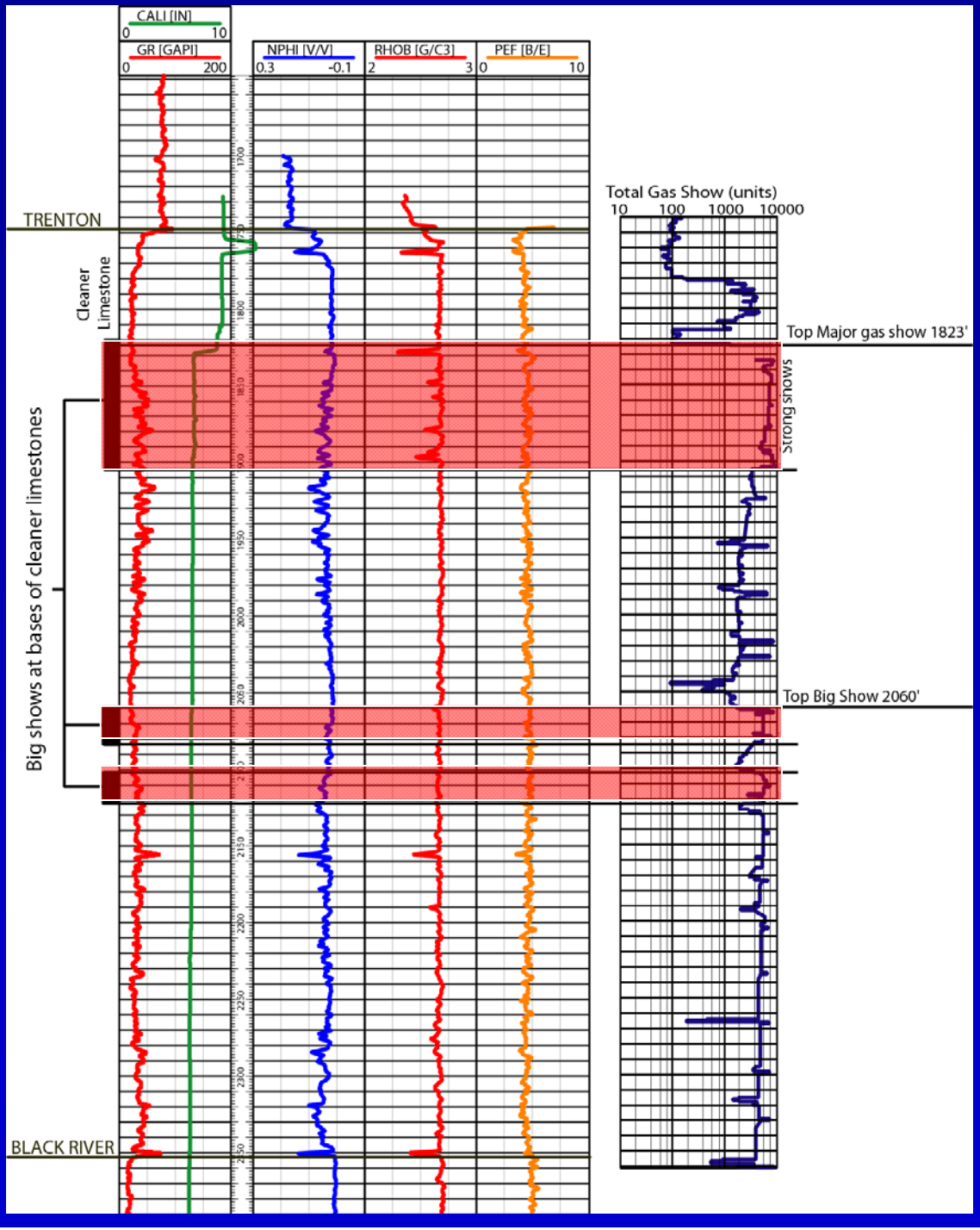
Huntley#1 Drilling Story

- Huge gas shows occurred sixty feet below the top of the Trenton
- First big blow out at 1812 feet
- Mud weight increased from 15 to 18.4 lbs to handle the high pressures
- After this blowout a bigger rig was brought in to finish the well
- 19-pound mud was then used
- Well was tested, gas blew down to sub-economic rates within hours or days
- Eventually the well was drilled all the way to basement



Gas Shows

- First gas at 1778 ft
- First major flow at 1812 ft and the well blew out
- Some are in the clean limestone
- Most and the biggest are in the interbedded shales and limestones especially under base of two cleaner limestones
- Consistent to what has been observed from other wells in this play



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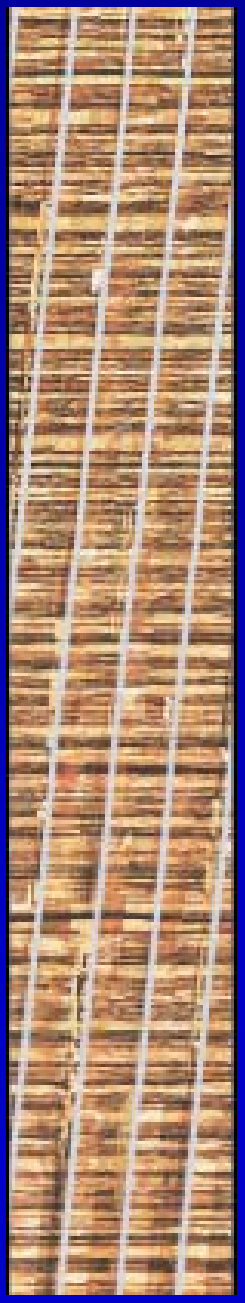
- Most and the biggest are in the interbedded shales and limestones especially under base of two cleaner limestones
- Consistent to what has been observed from other wells in this play

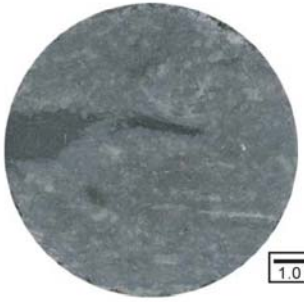


Coring Strategy

- Took 160 sidewall cores
- Used mudlog and FMI to pick coring points
- Sampled every 6 inches where shows occurred
- Tried to sample any zone that had a hint of porosity on density log
- Tried to sample all major rock types based on FMI response
- Sampled Black River, Galway, and Potsdam

Each sidewall was trimmed, polished and scanned and had a thin section made

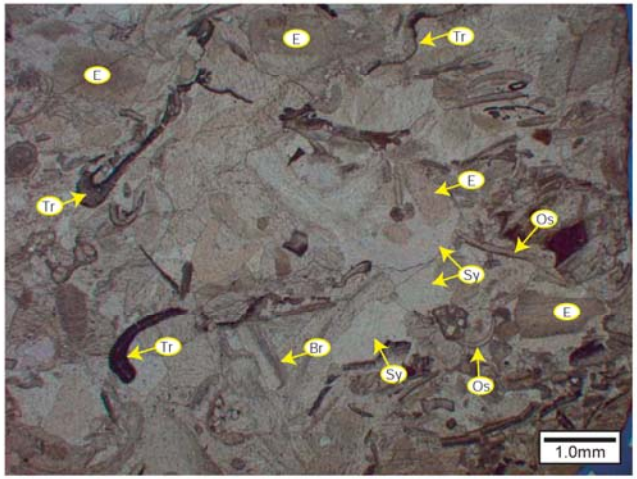
SENECA RESOURCES HUNTLEY #1: 1857.0 FEET



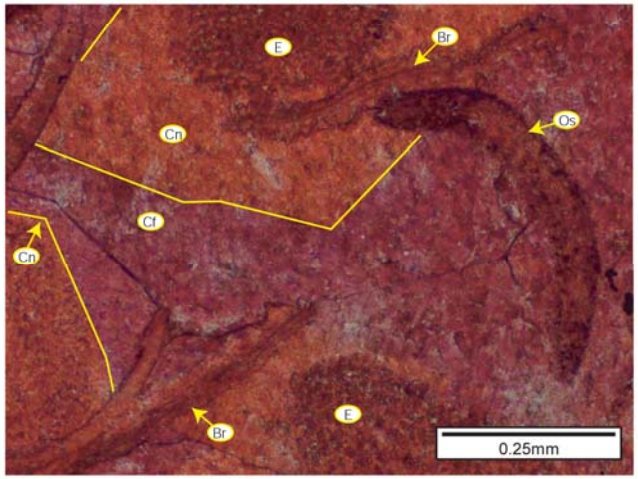
Limestone with dolomite lenses: grainstone

No visible porosity

Dolomite	3%	Echinoderms	78%
Limestone	94%	Brachiopods	5%
Clay	2%	Trilobites	15%
Pyrite	1%	Ostracodes	2%



Echinoderms (E), brachiopods (Br), trilobites (Tr) and ostracods (Os) comprise the skeletal suite of this grainstone. Clear, syntaxial calcite cement (Sy) occludes all primary, intergranular porosity.



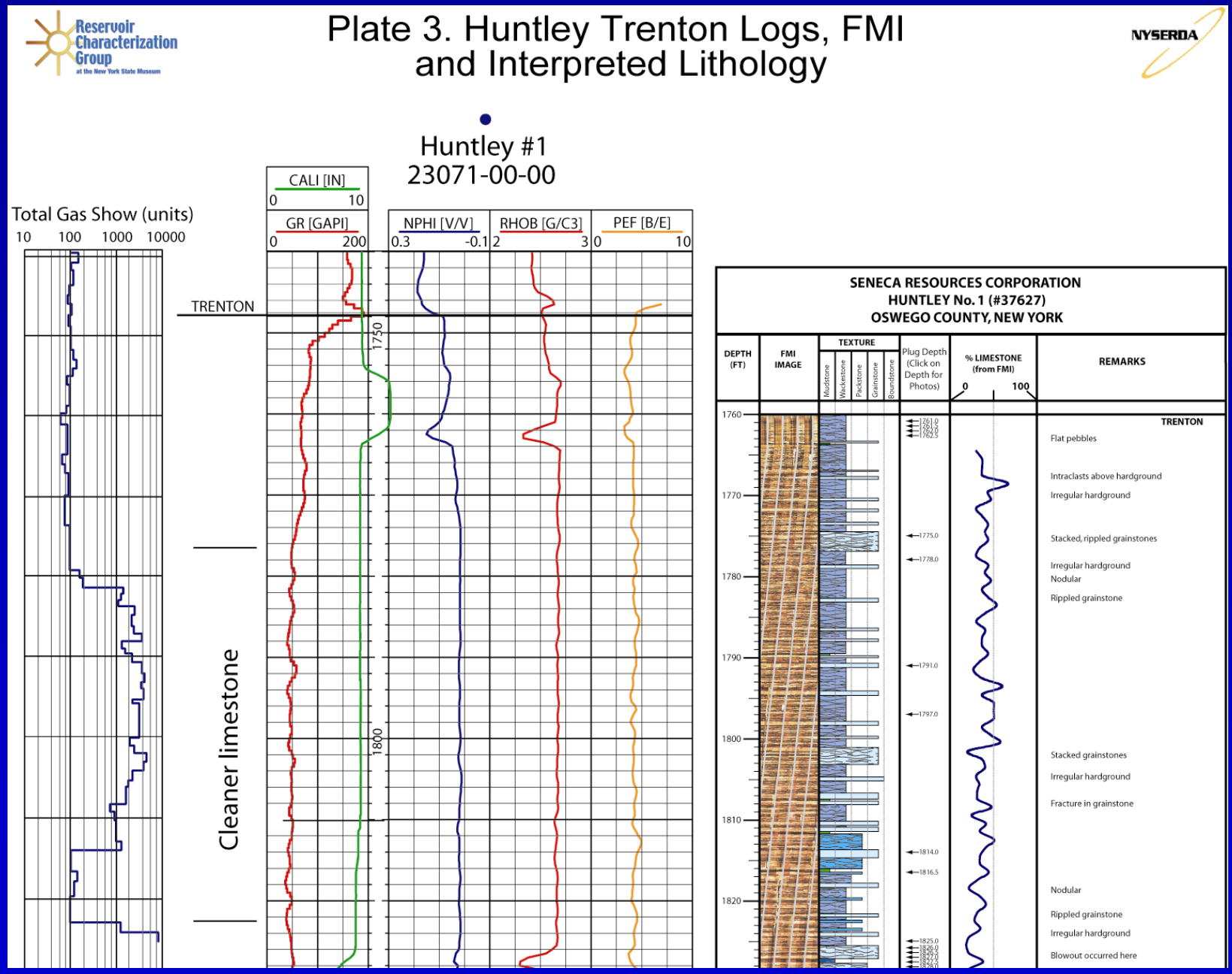
This is a high magnification view of a portion of the thin section stained with Alizarin Red-S and potassium ferrocyanide. Early non-ferroan syntaxial calcite (Cn) and later ferroan syntaxial calcite (Cf) cement brachiopods (Br), ostracods (Os) and echinoderms (E).

Rick Bray

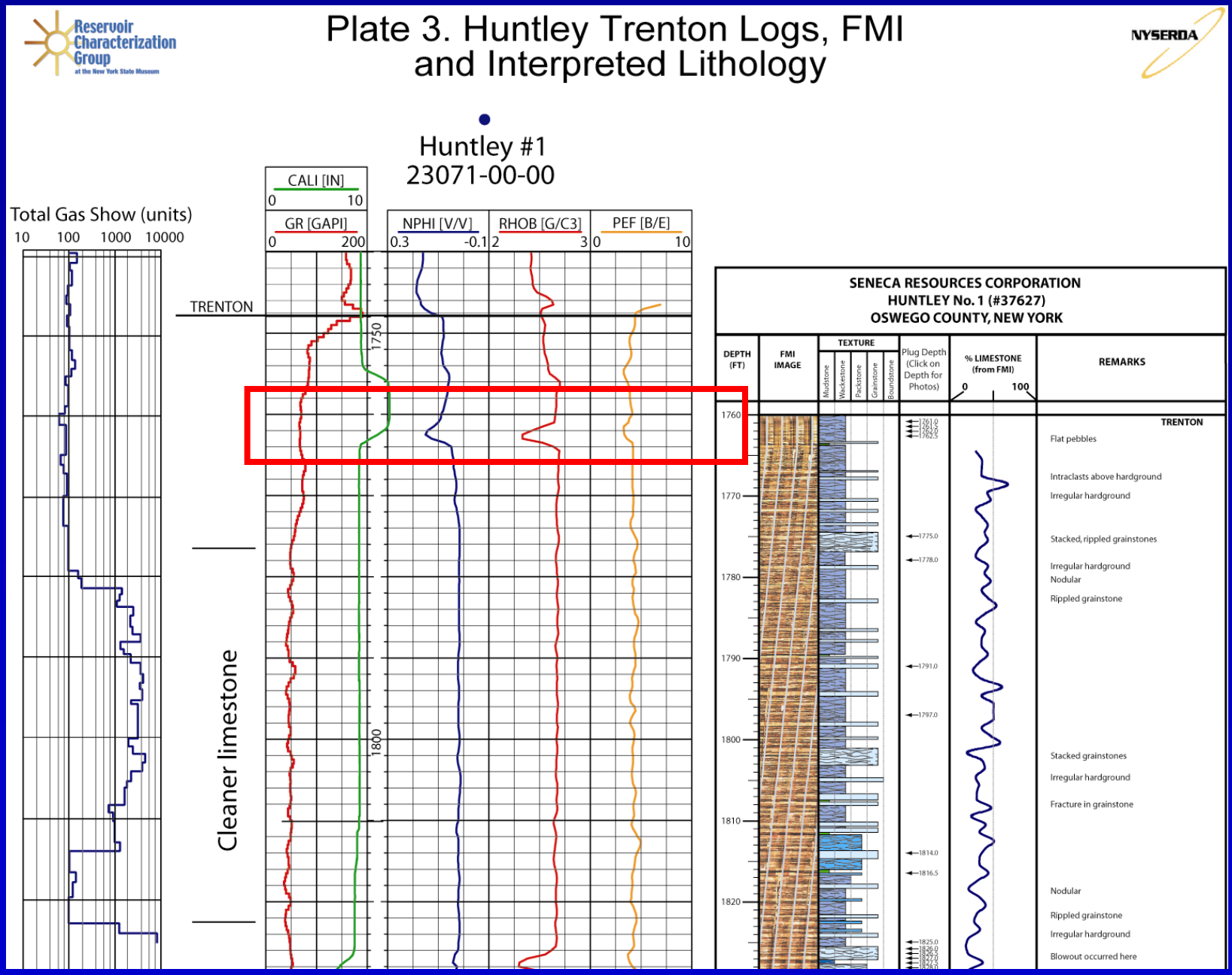
Plates

- Scans of each sidewall core
- Thin section photos and descriptions for each sidewall core
- 107 Trenton
- 36 Black River
- 1 Tribes Hill
- 6 Galway
- 7 Potsdam
- Sidewall cores available for inspection at the Core Blast

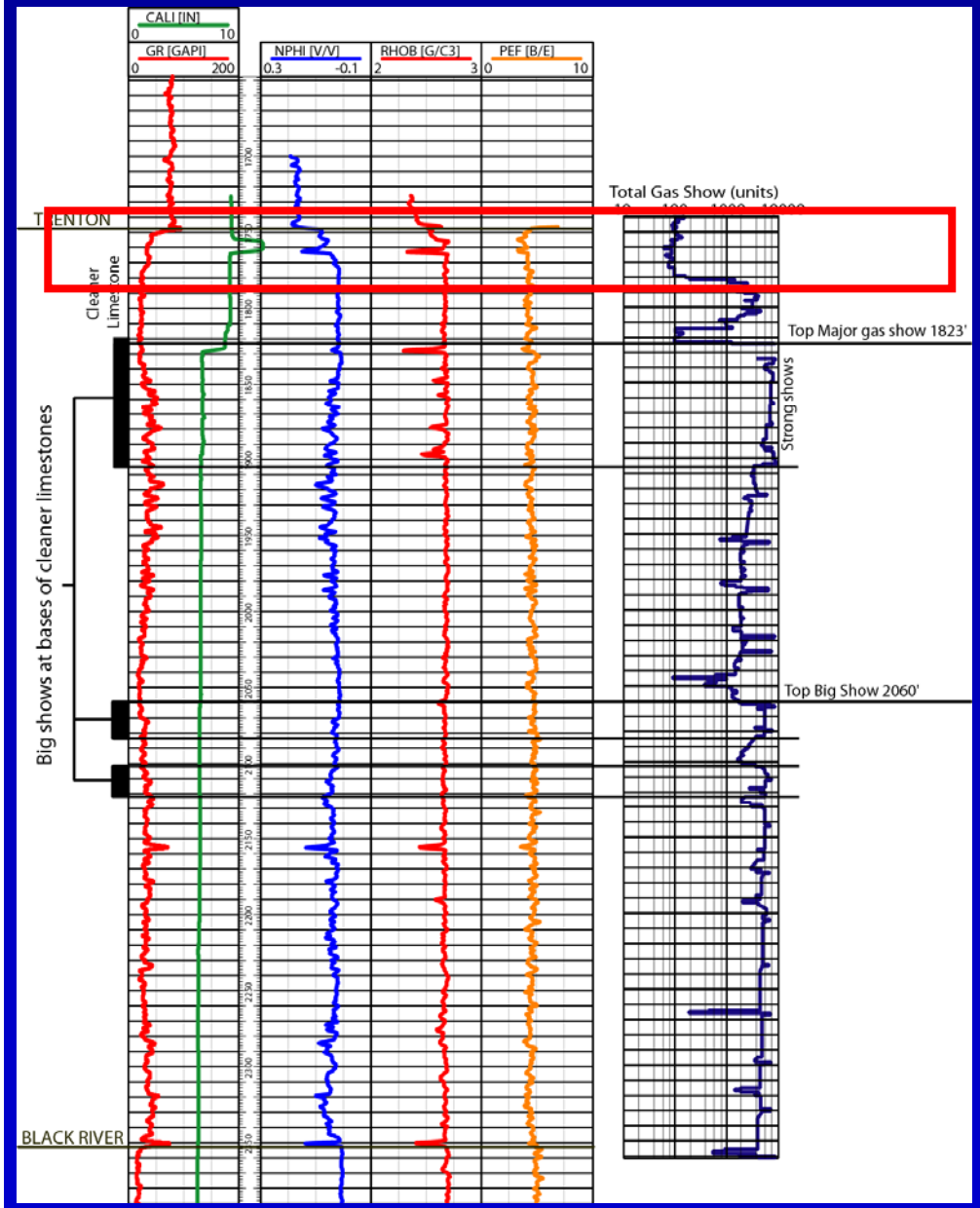
Plates combines gas shows, logs, FMI, plug depths and interpreted lithology

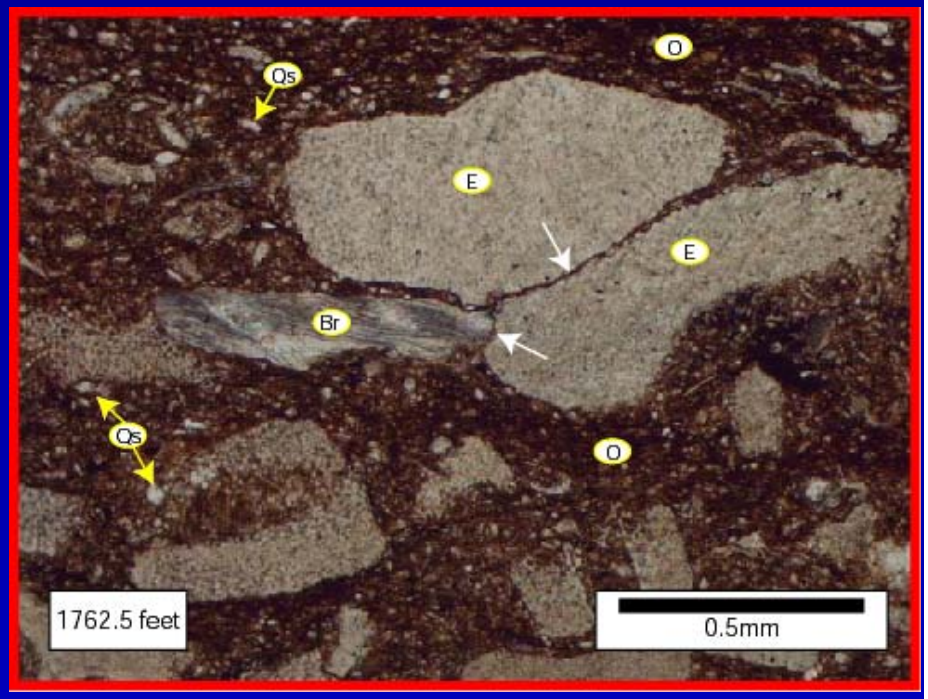


Plates combines gas shows, logs, FMI, plug depths and interpreted lithology



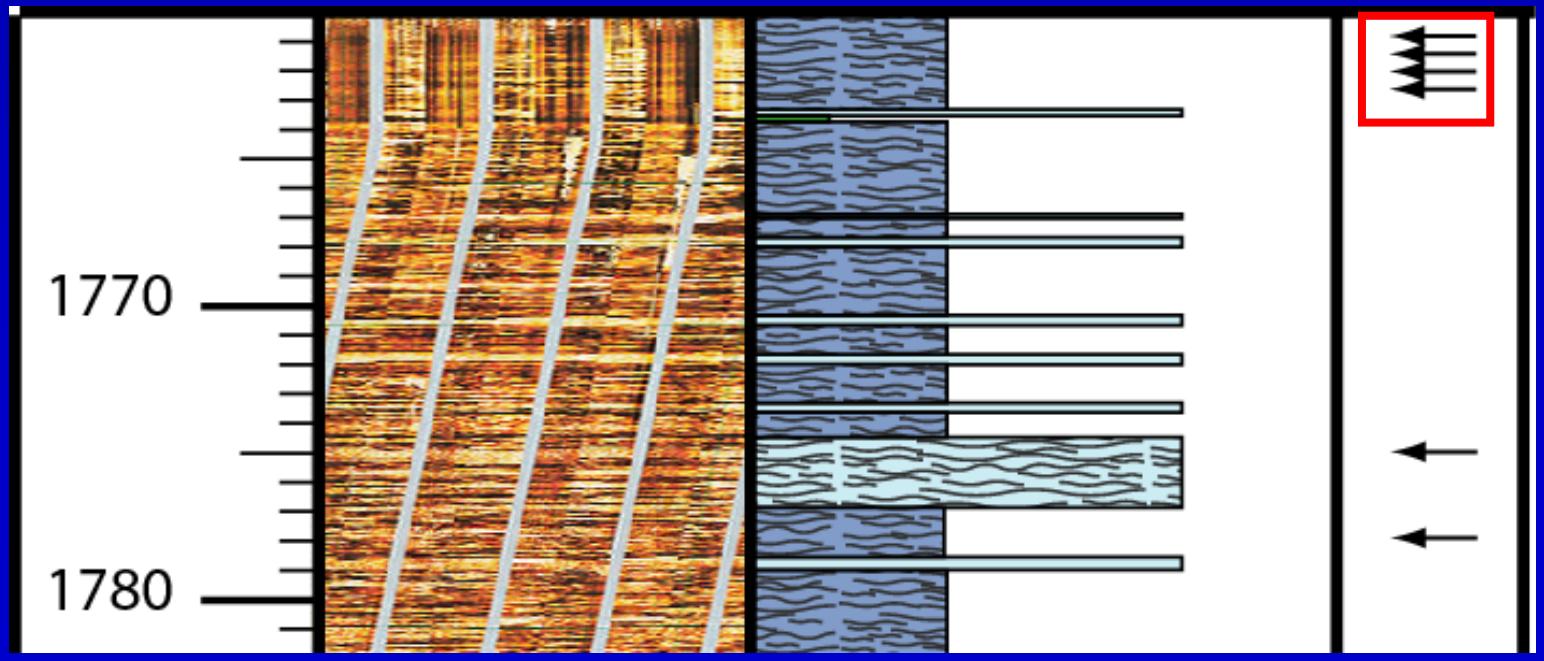
1762 wackestone to muddy packstone

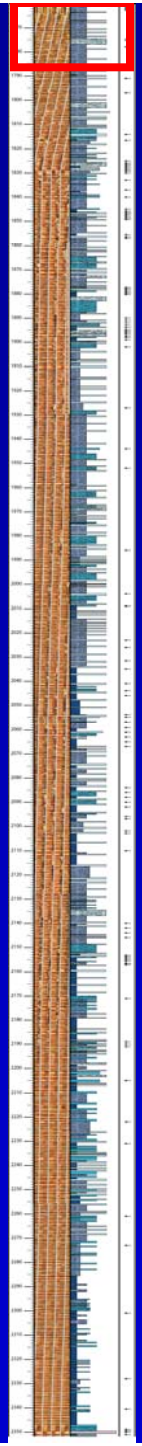




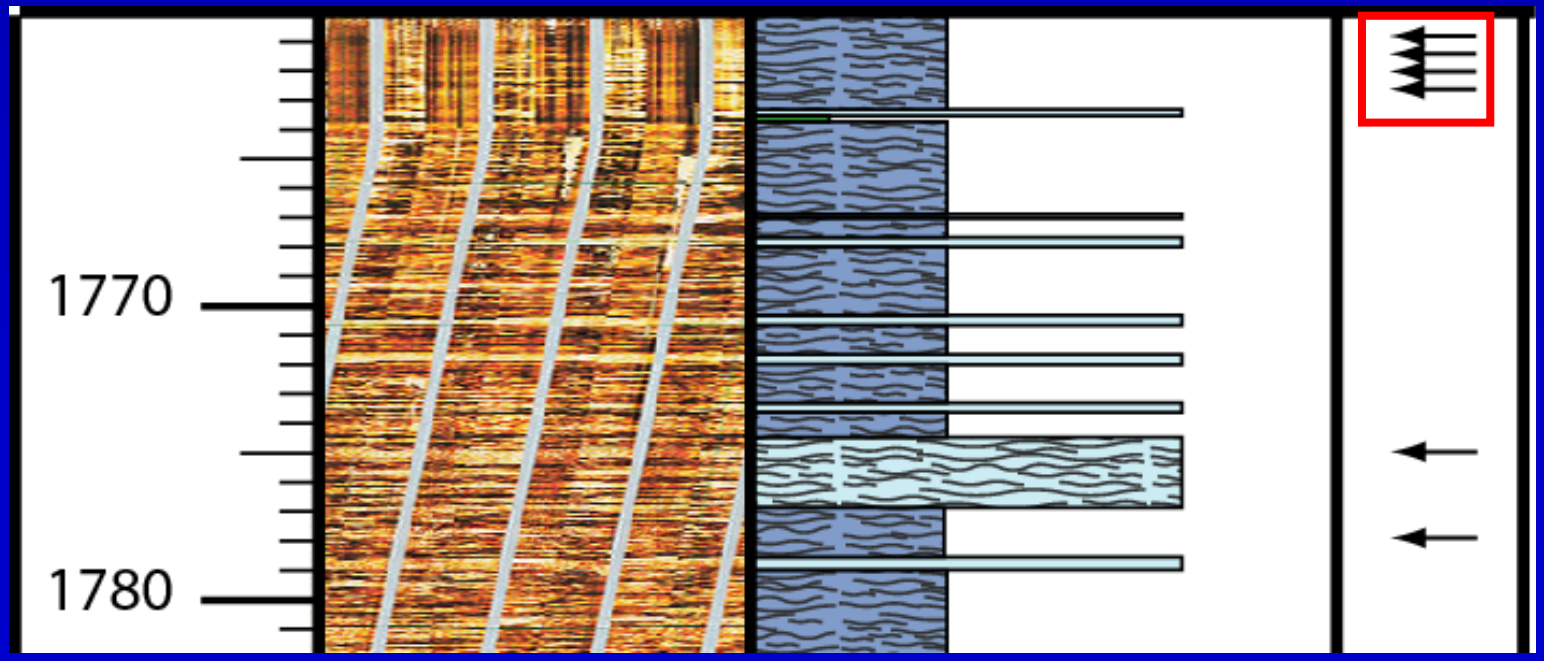
Echinoderm fragments (E) and a brachiopod fragment (Br) exhibit sutured contacts (white arrows). Obvious organic rich seams (O), contains detrital quartz. silt (Qs).

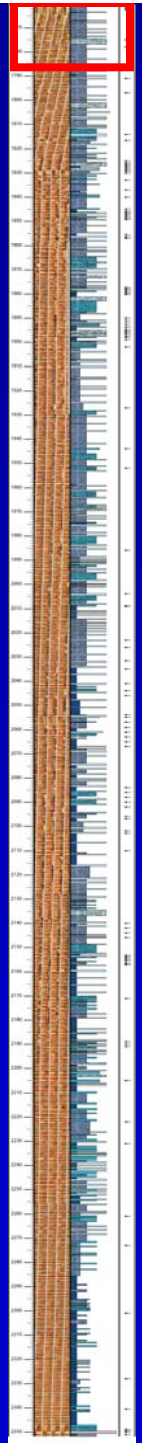
- 1761 feet
- Argillaceous limestone to calcitic shale
- No visible porosity
- No dolomite
- No fractures



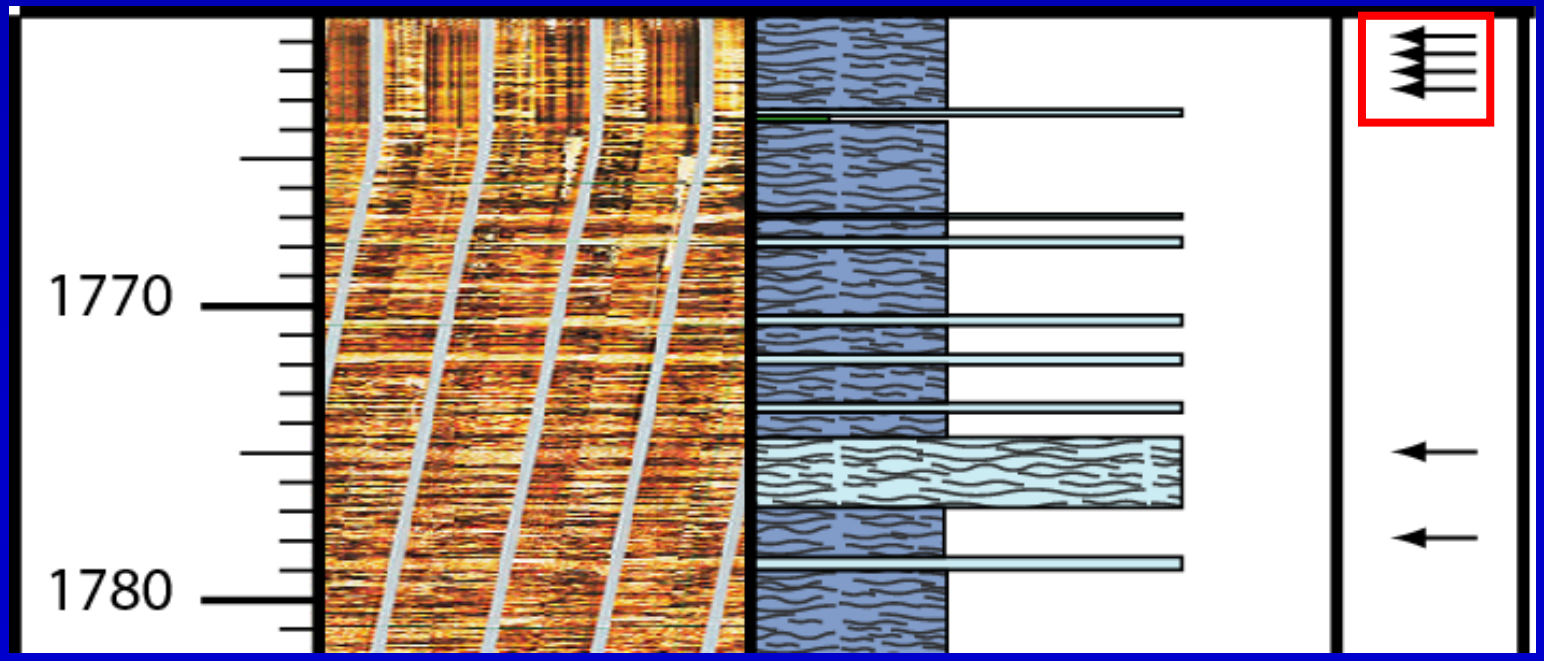


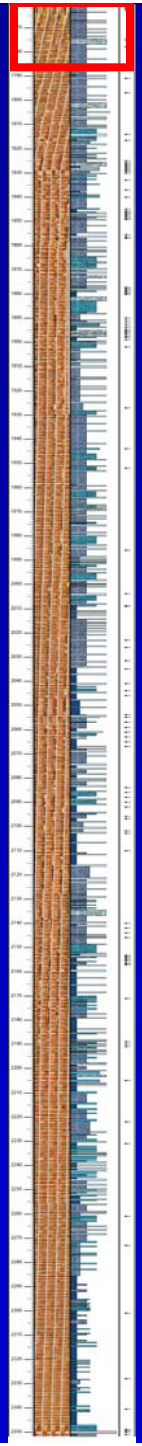
- 1761.5 feet
- Limestone with clay lenses and microstylolites
- No visible porosity
- No dolomite
- No fractures



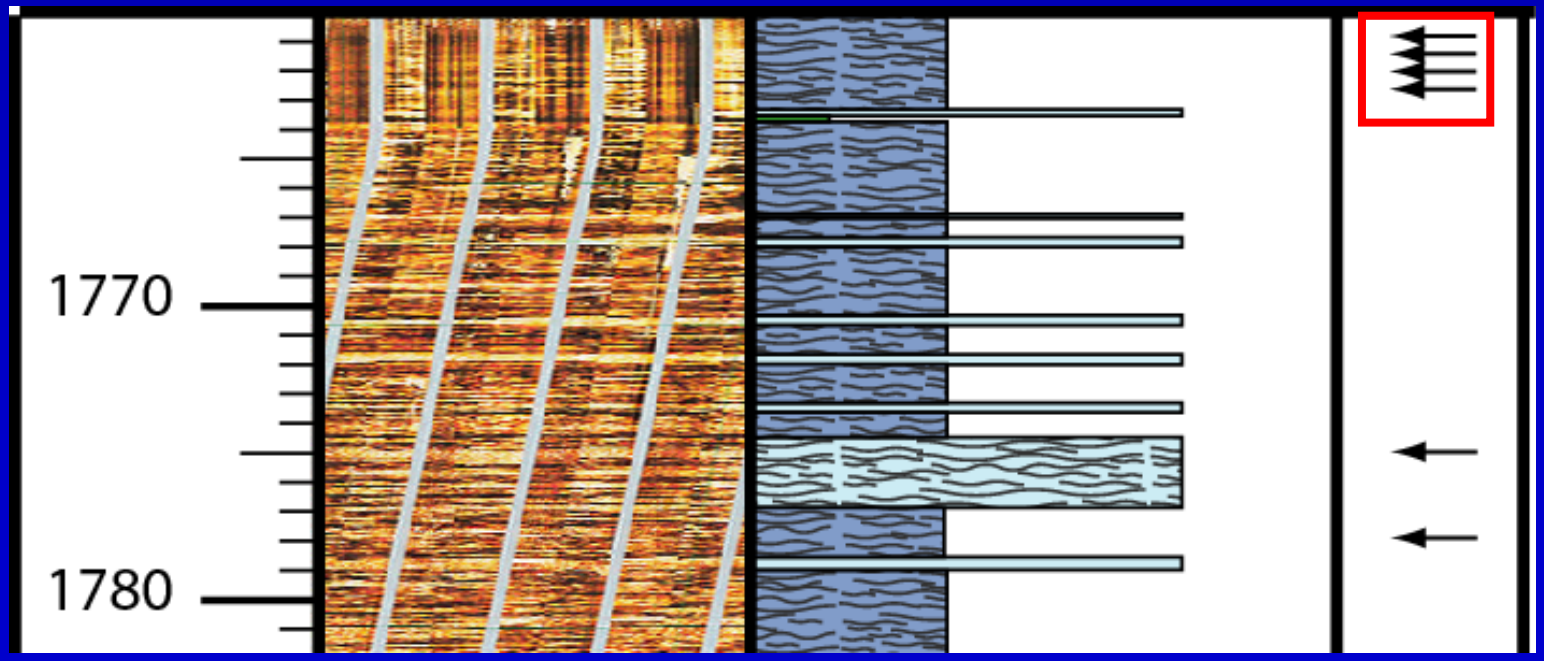


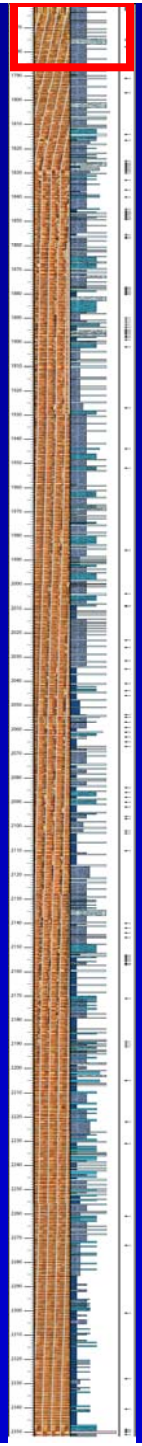
- 1762 feet
- Dolomitic limestone with clay rich laminae
- No visible porosity
- No dolomite
- No fractures

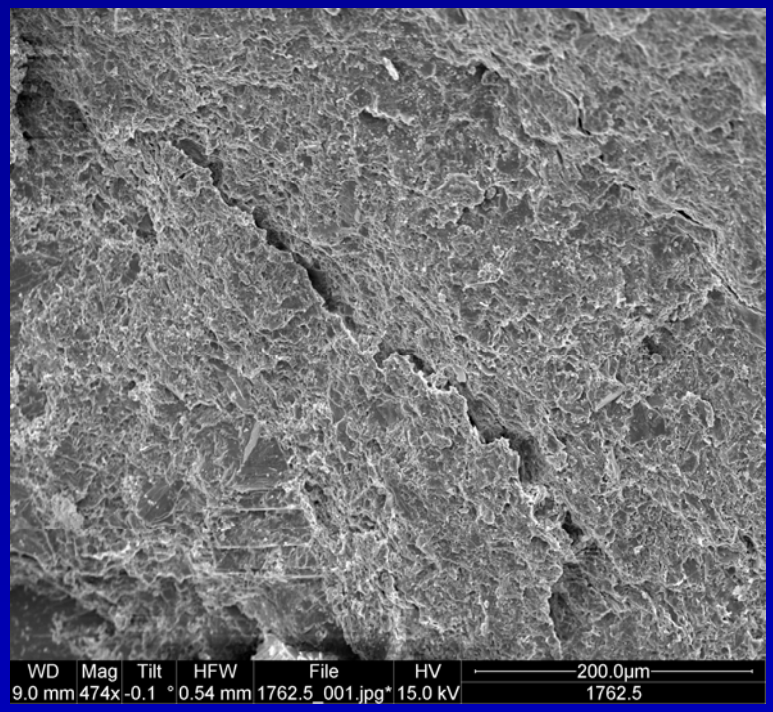




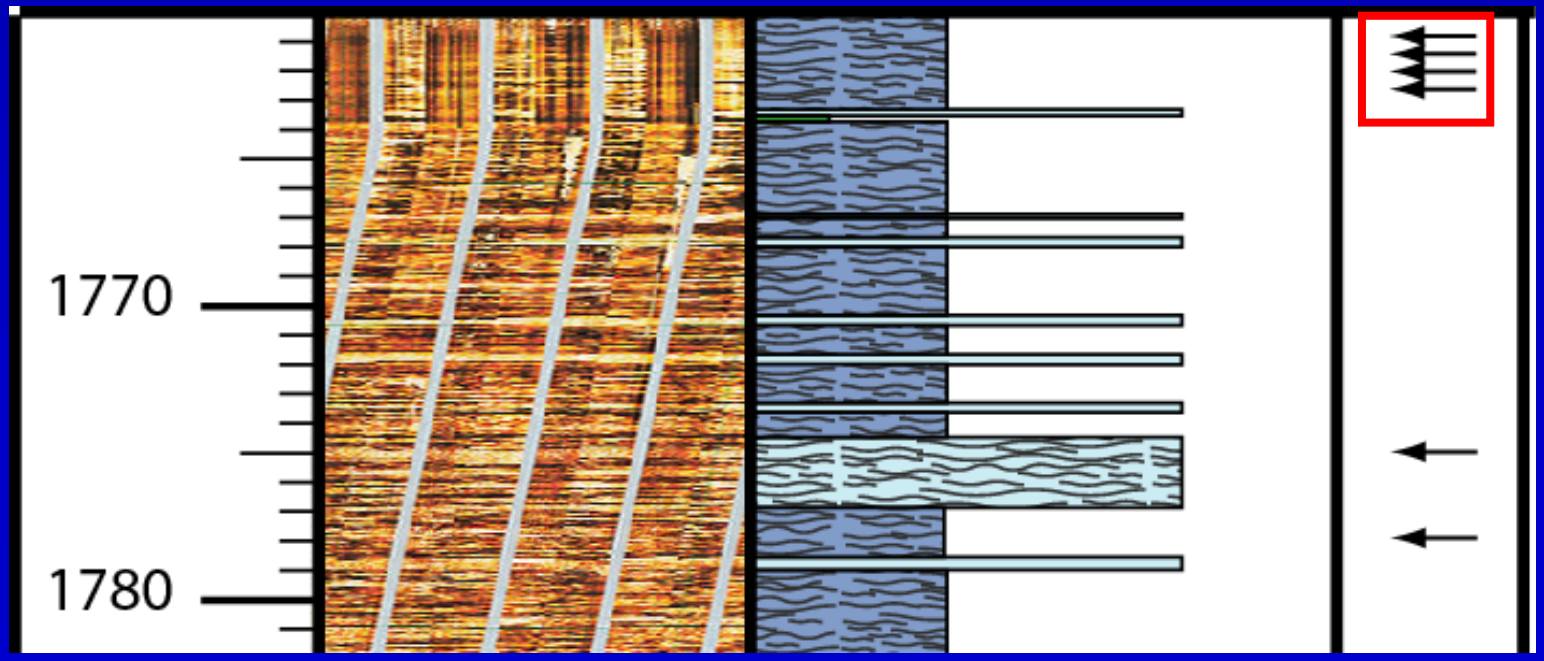
- 1762.5 feet
- Limestone with wispy clay rich microstylolites
- No visible porosity
- No dolomite
- No fractures

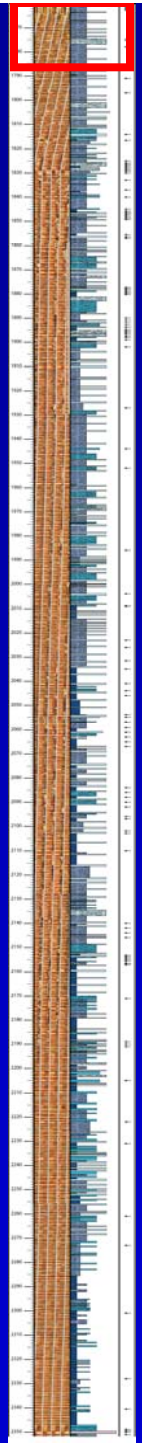


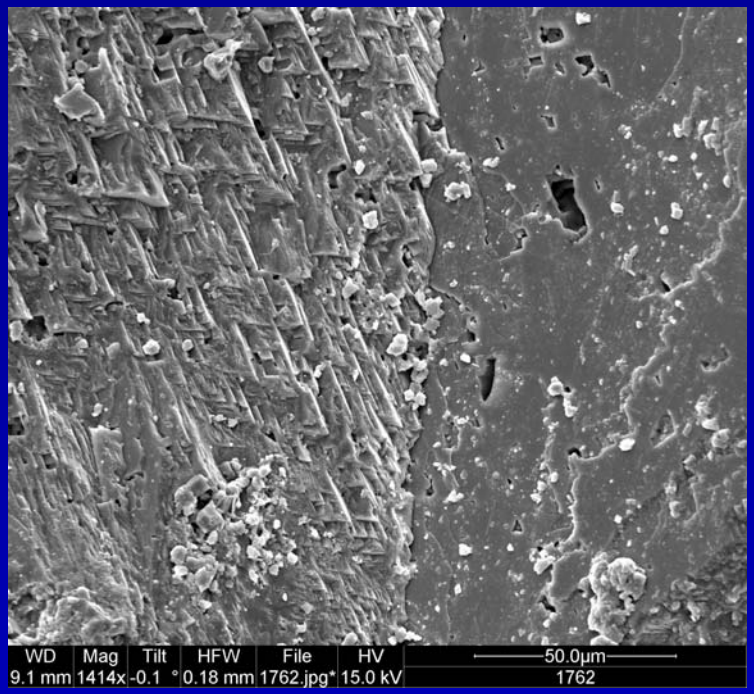




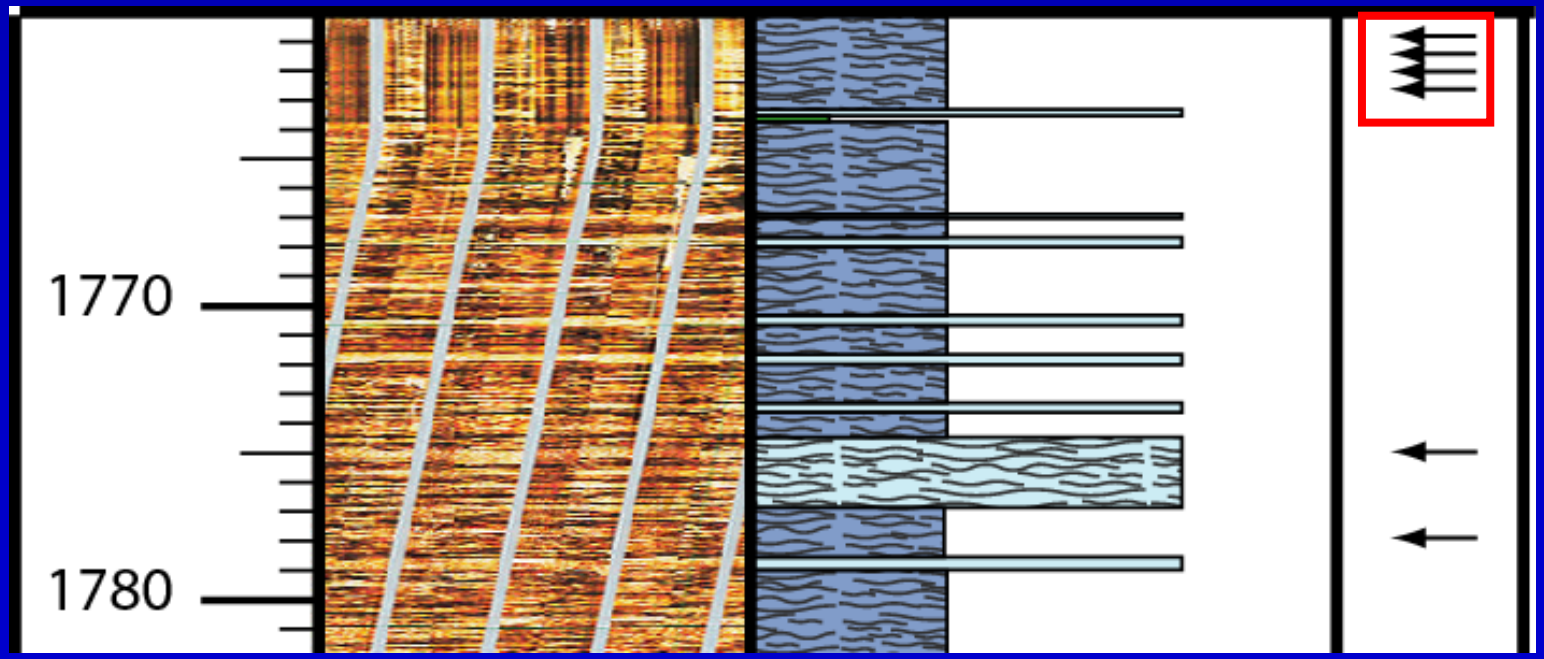
- 1762 feet
- SEM show possible microfractures



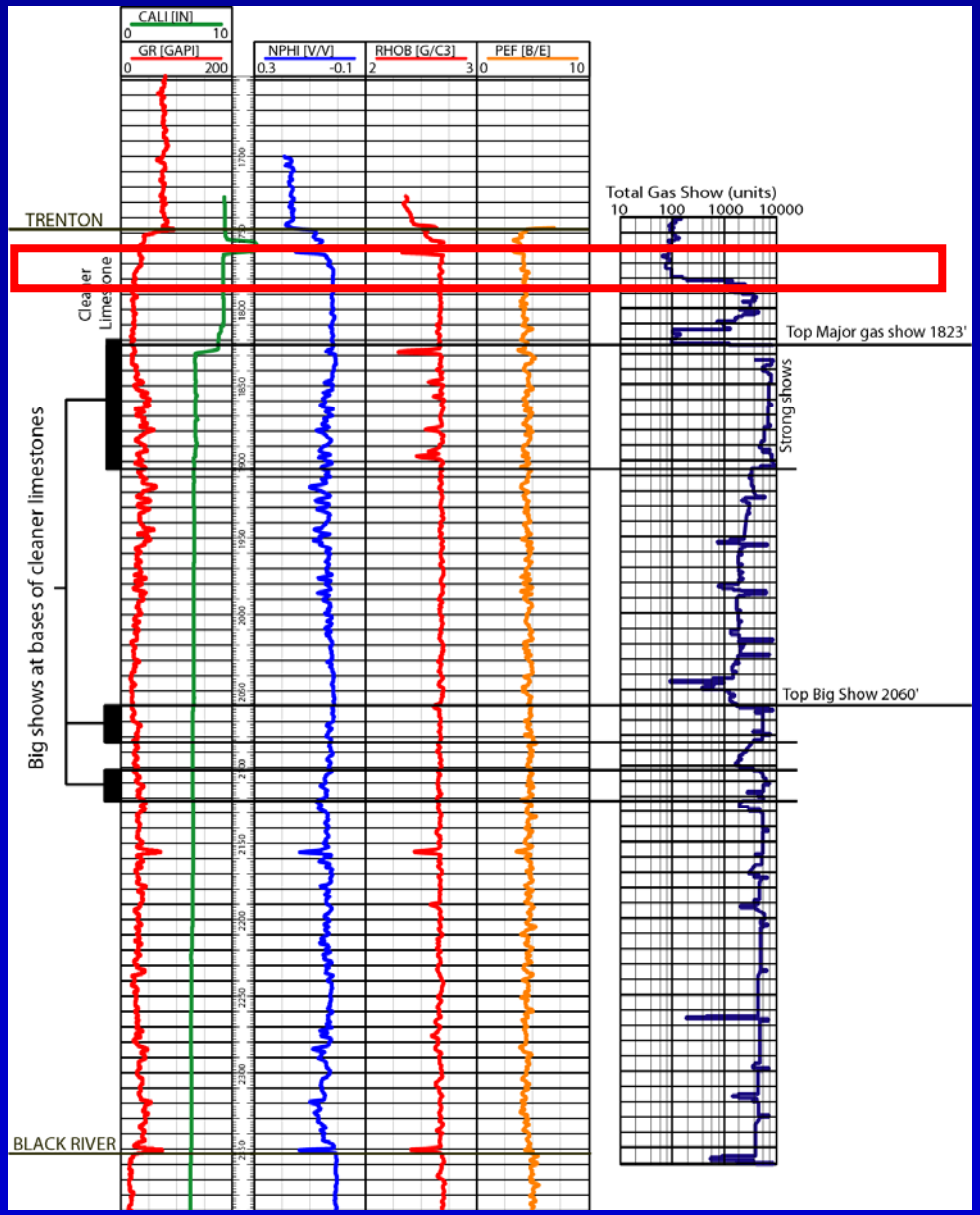


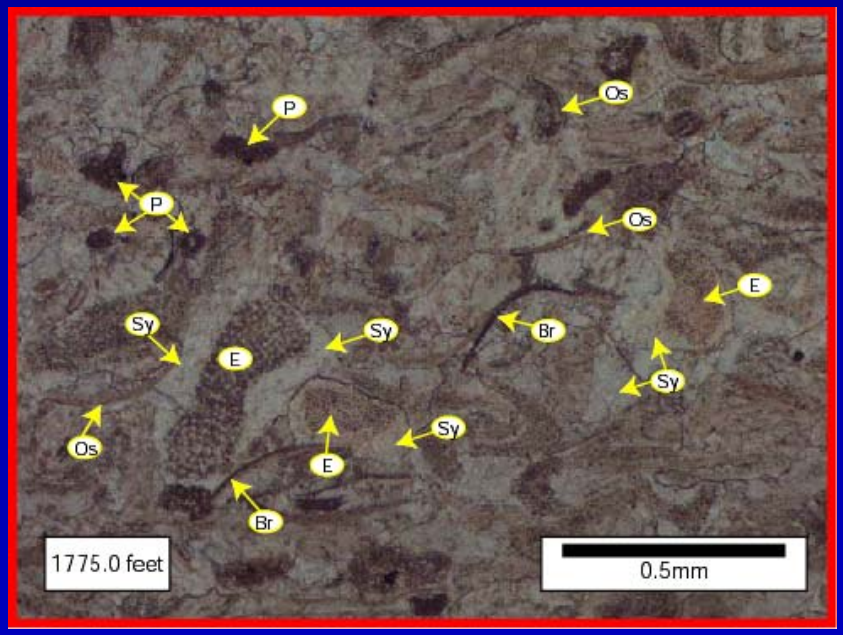


- 1762 feet
- SEM shows possible microporosity in calcite



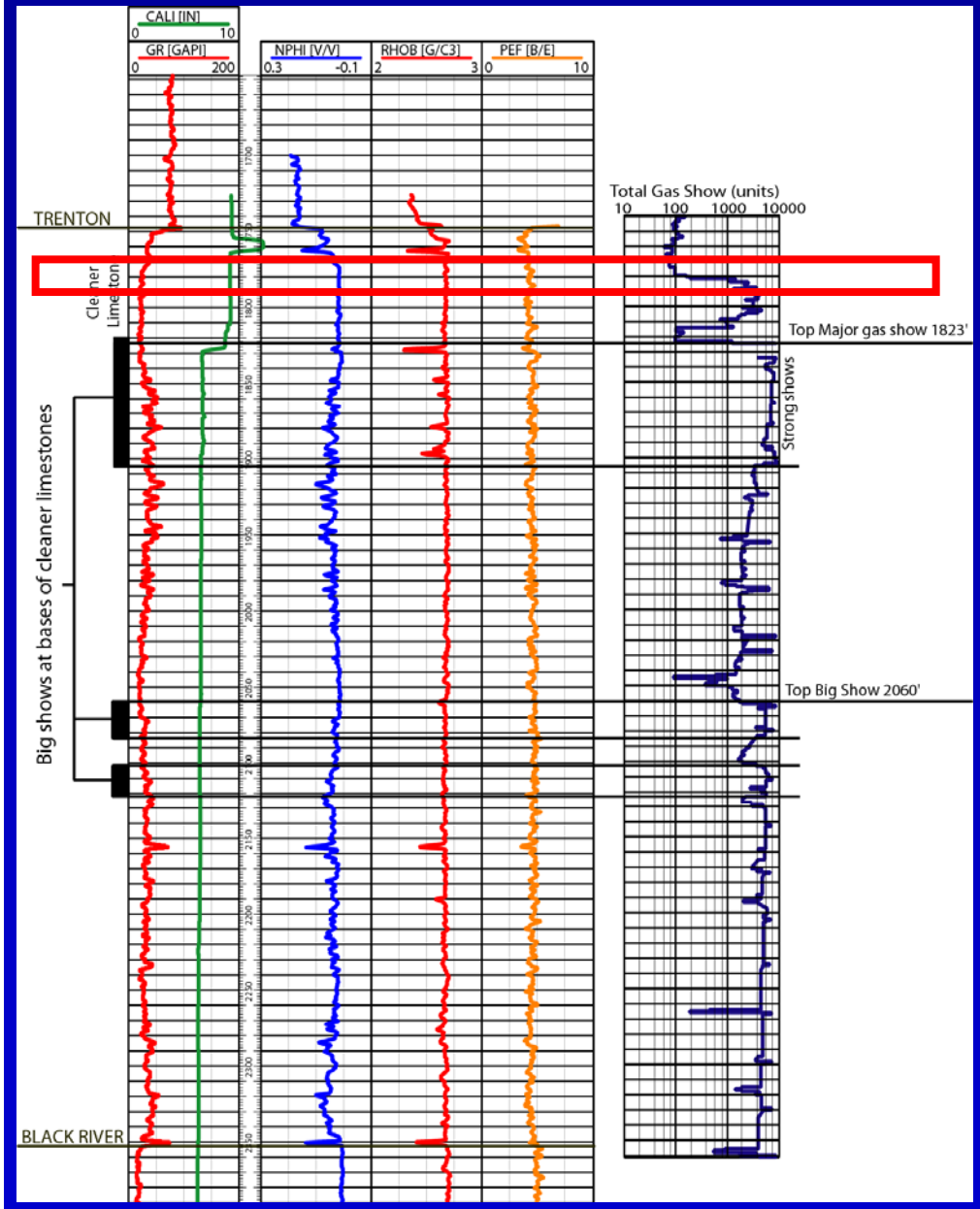
1775 fine grainstone

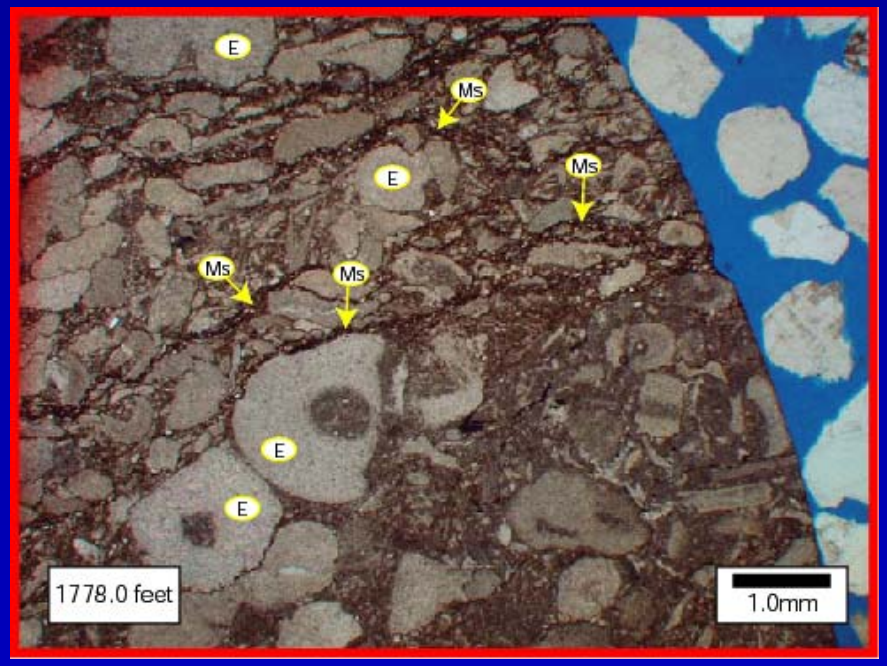




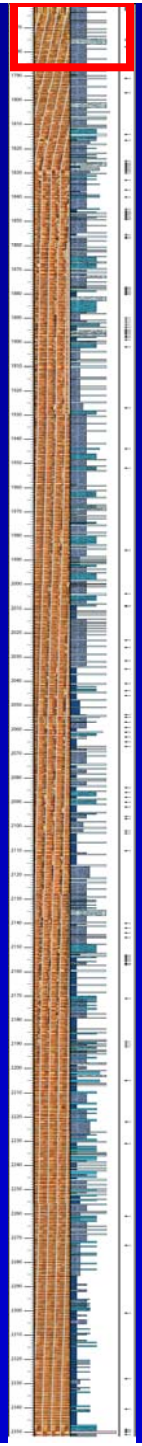
Most cement appears to be syntaxial calcite (Sy), which is in optical continuity with echinoderm fragments (E). The cement also invests peloids (P), ostracods (Os) and brachiopods (Br). Notice the various shapes of the peloids, indicating a skeletal rather than fecal origin.

1778 packstone

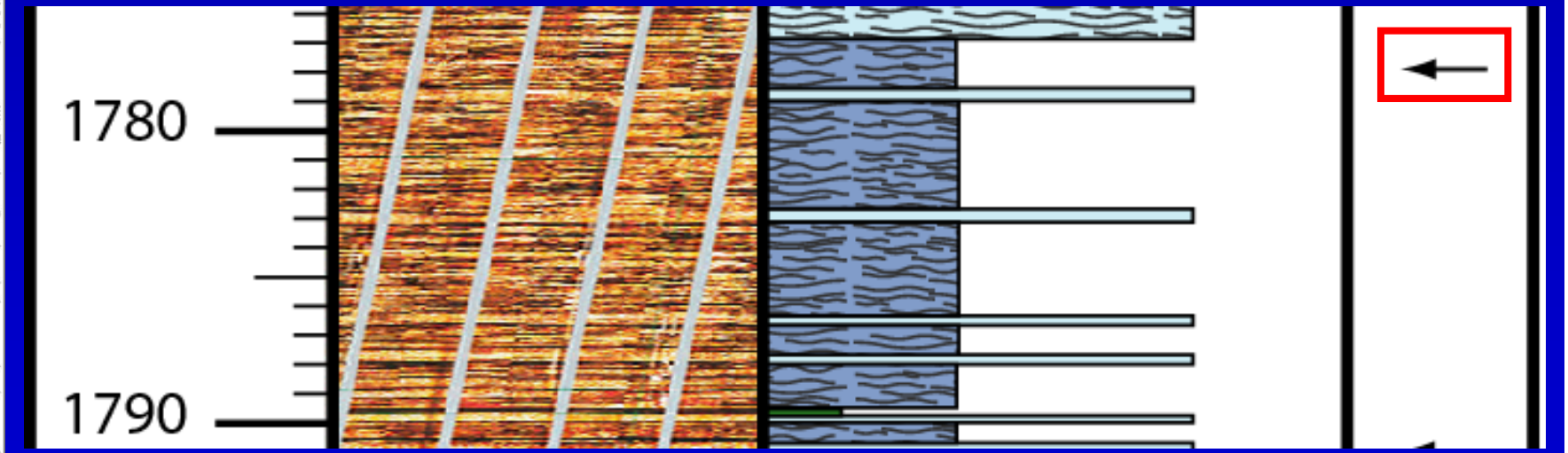


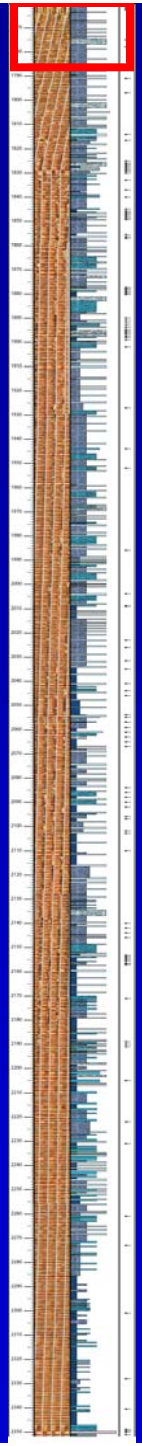


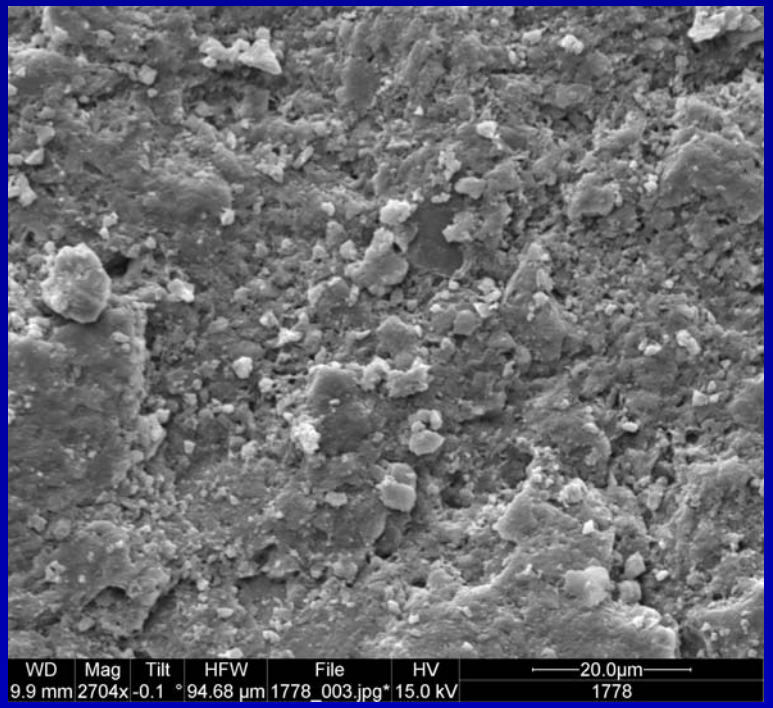
Virtually all skeletal fragments are echinoderms (E). Microstylolites (Ms) are pressure solution features which concentrate insoluble residues such as detrital quartz silt, clay and organics.



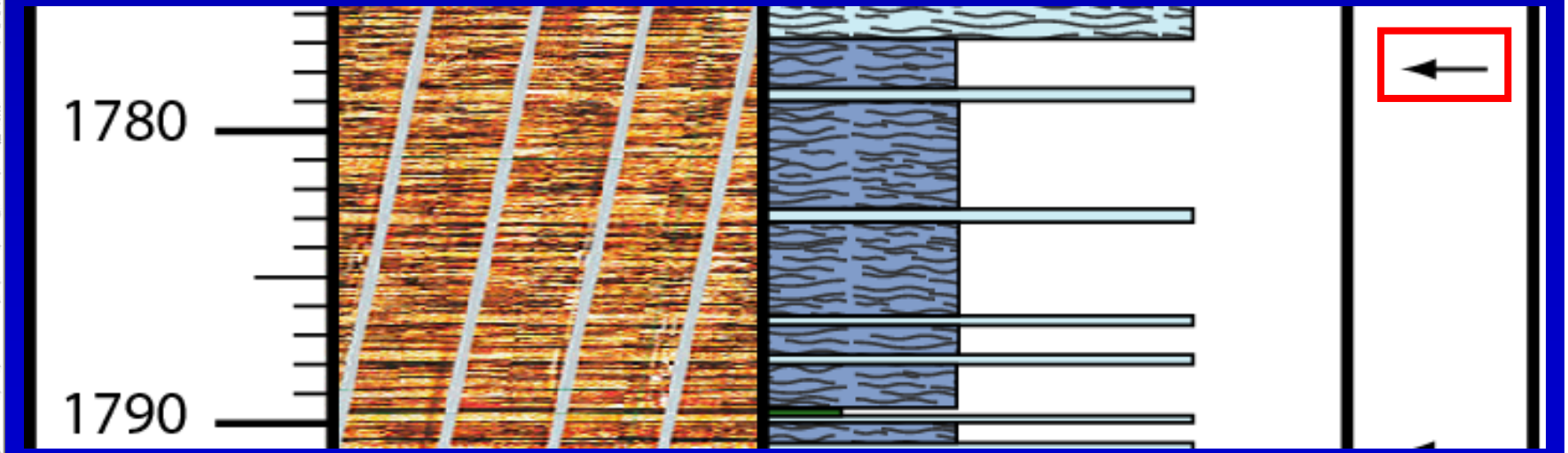
- 1778 feet
- First gas show
- Limestone with thin clay and silt rich lamina microstylolites
- No visible porosity
- No dolomite
- No fractures



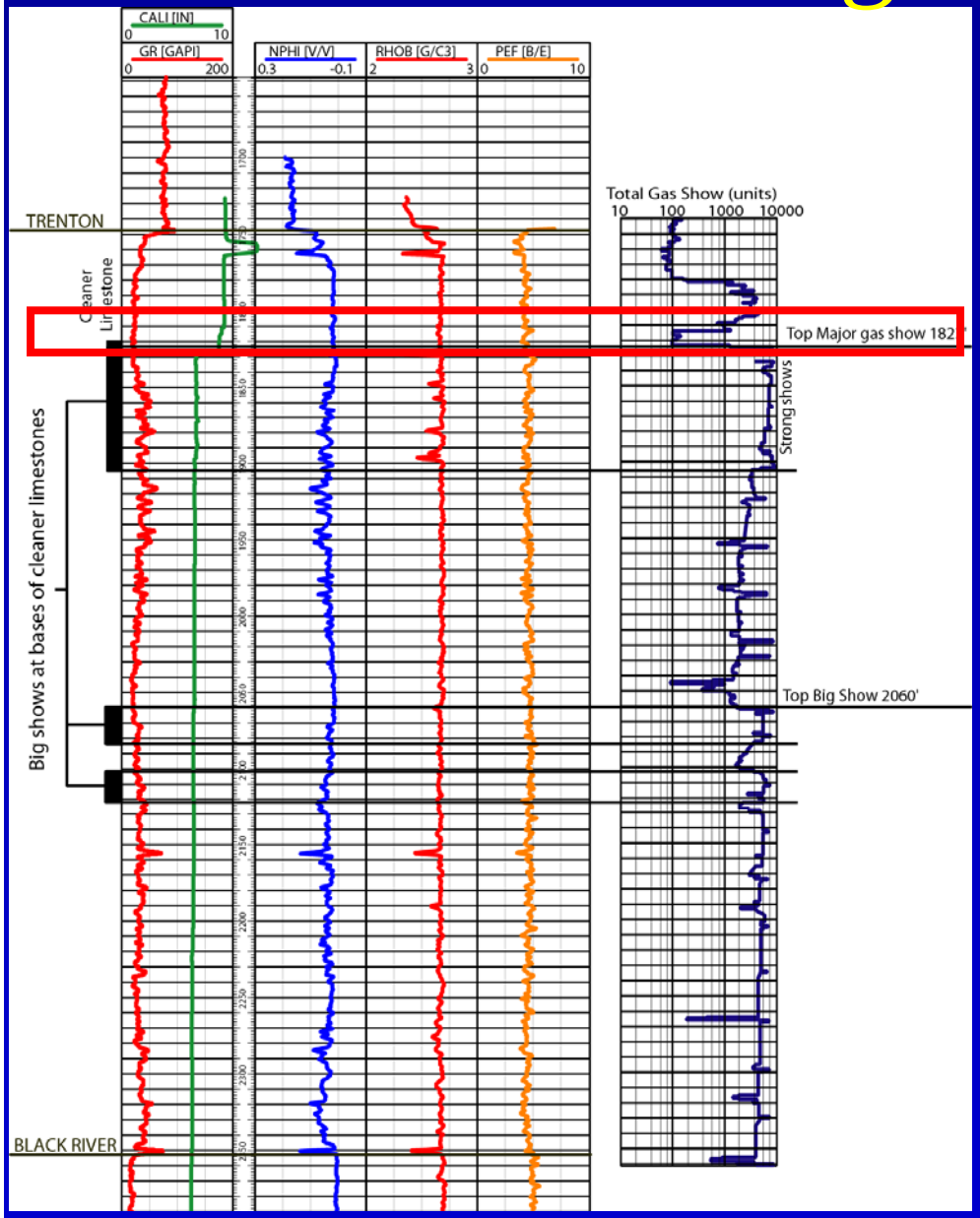


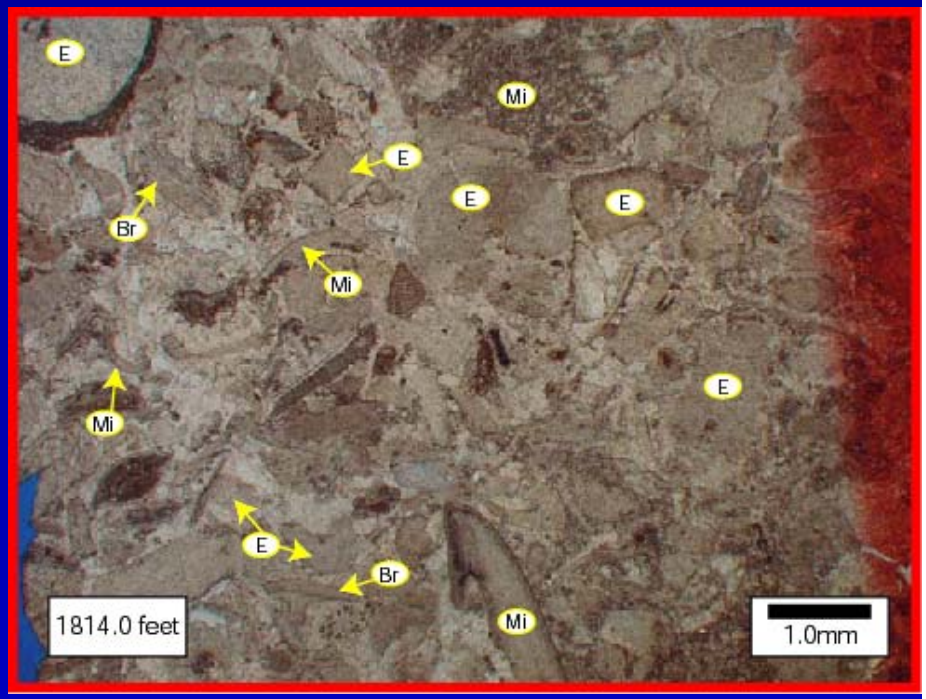


- 1778 feet
- SEM shows possible microporosity that is not well connected

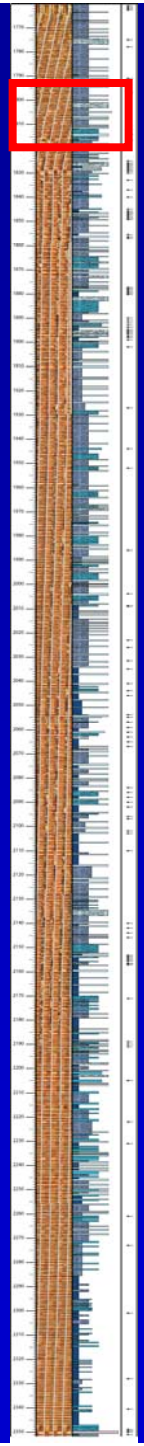


1814 grainstone

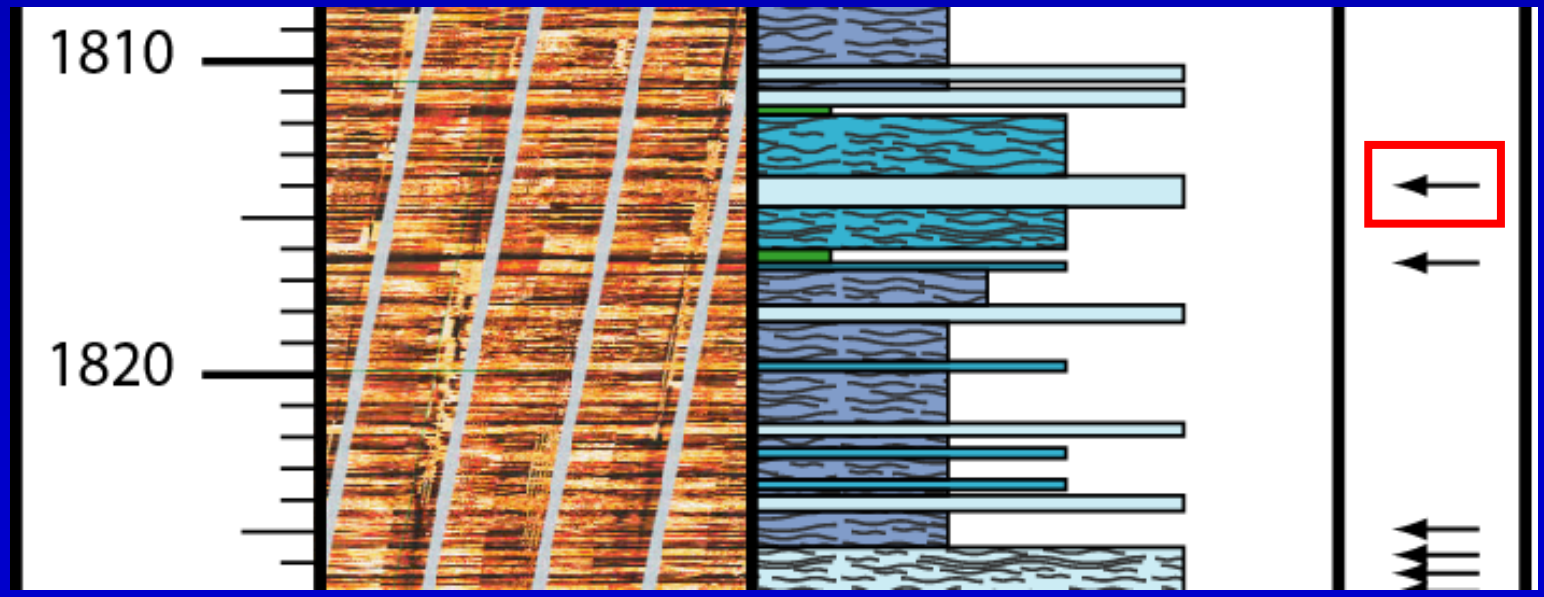




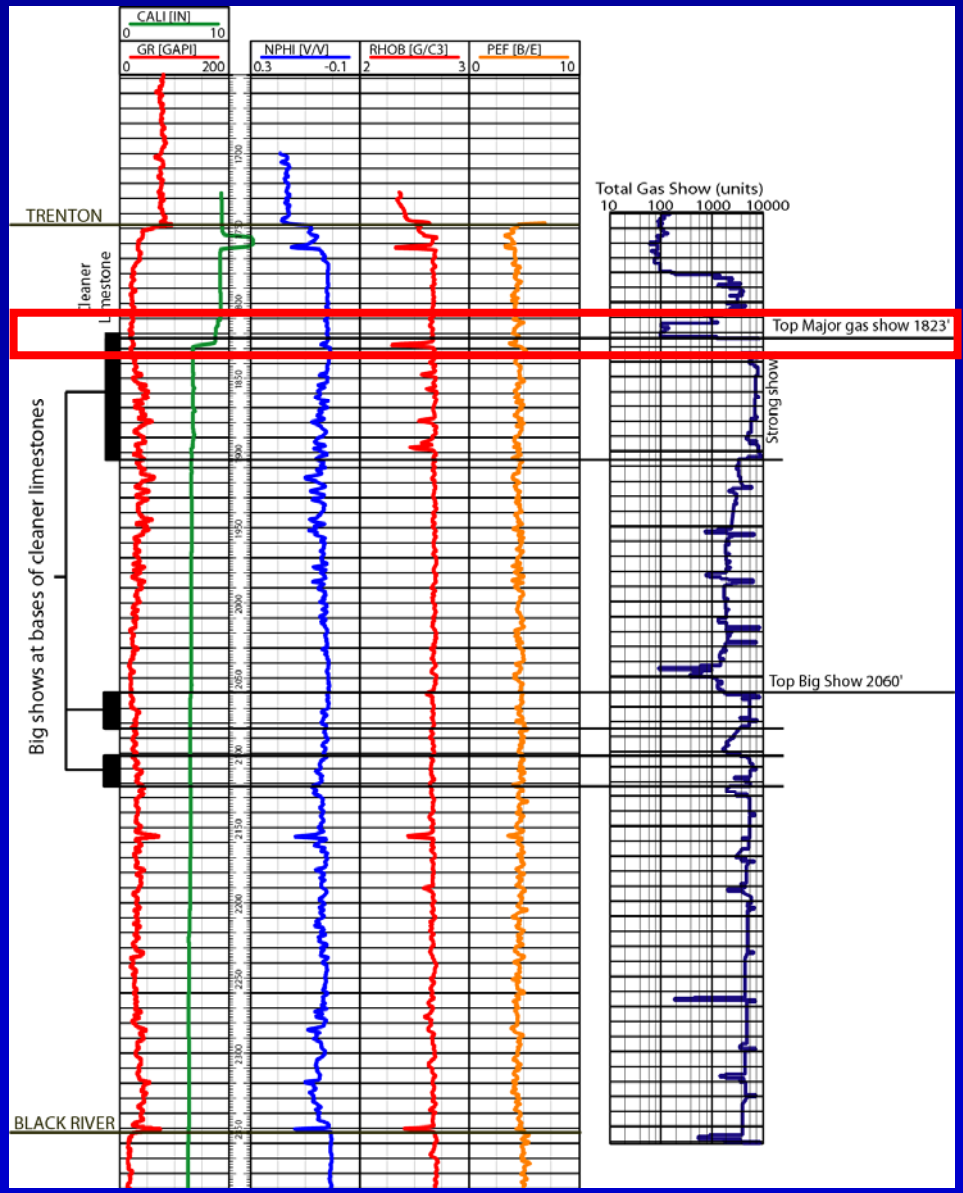
This echinodermal grainstone contains patches of micritic mud (Mi), perhaps unwinnowed lime mud or burrow fill. Echinoderms (E) dominate with lesser amounts of trilobites (Tr), brachiopods (Br) and ostracods (Os).

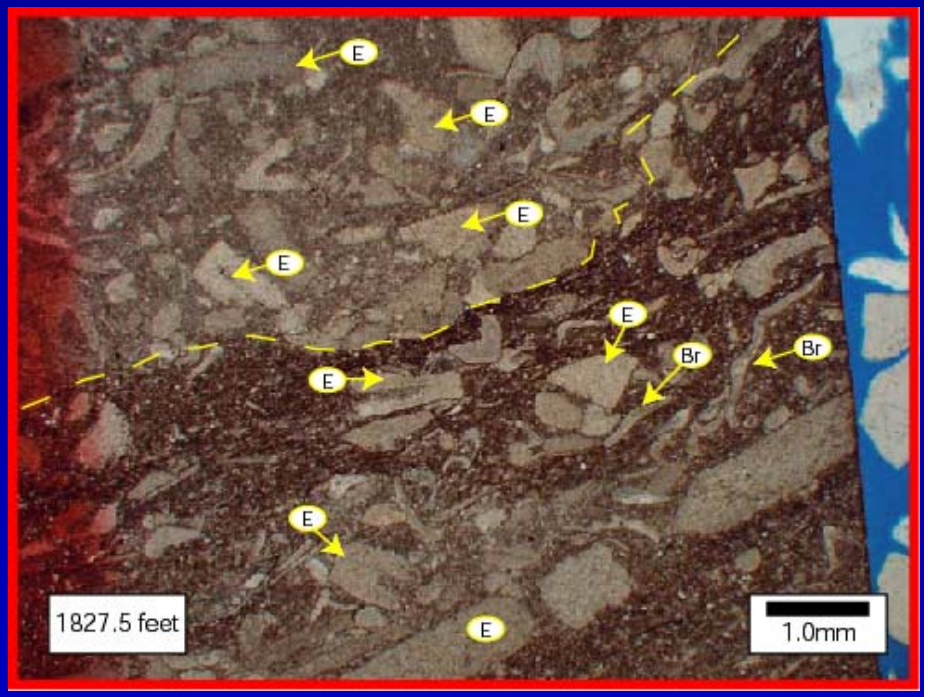


- 1814 feet
- Limestone : grainstone with rare patches of mud
- Gas show
- No visible porosity
- No dolomite
- No fractures

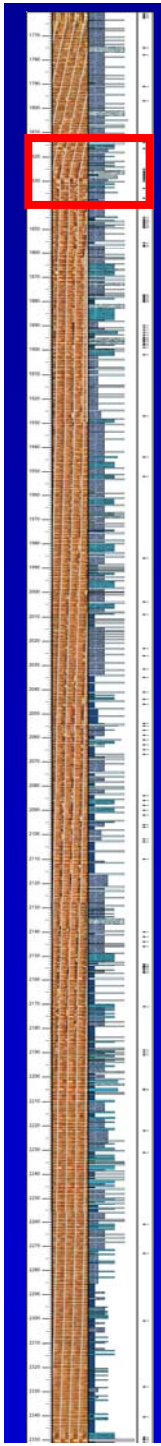


1827.5 wackestone

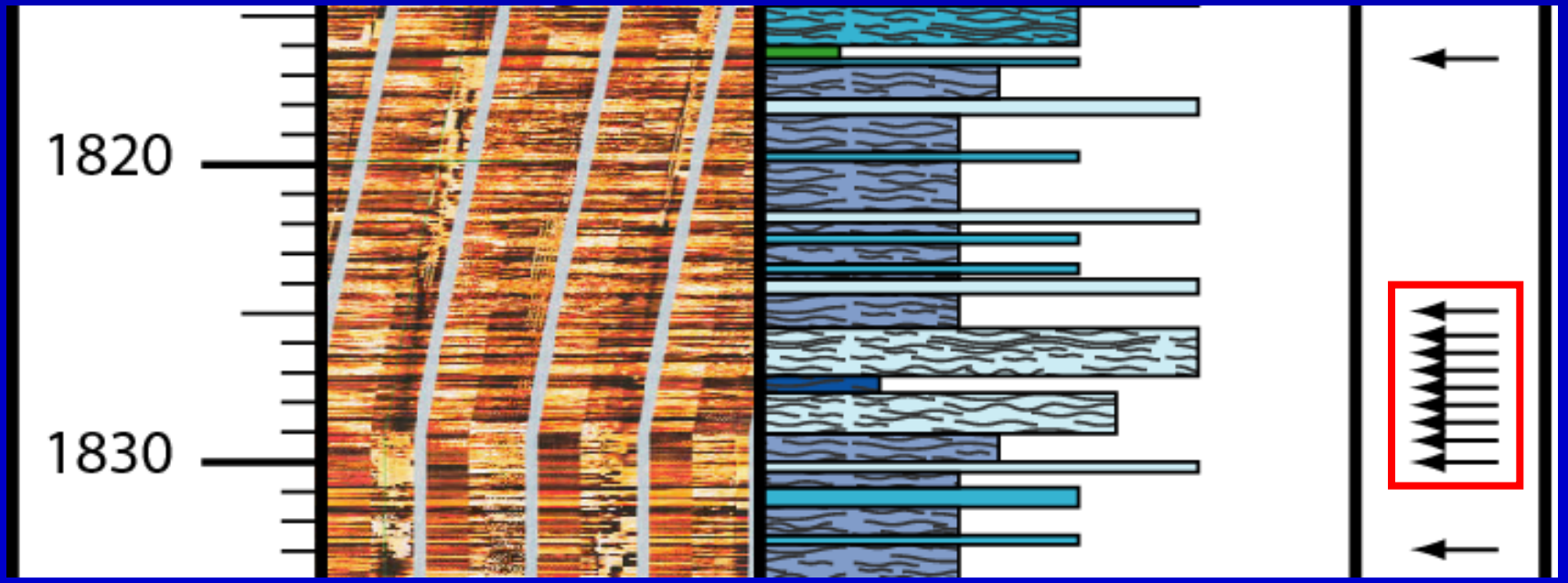


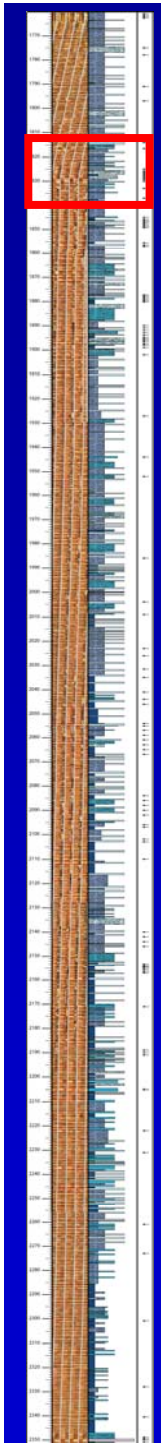


The yellow dashed line defines the boundary between the thinner organic rich, sometimes clayey, interbed (below) and purer limestone (above). The dominant skeletals are echinoderms (E) and brachiopods (Br). The paucity of pressure solution features in the purer limestone may indicate early lithification.

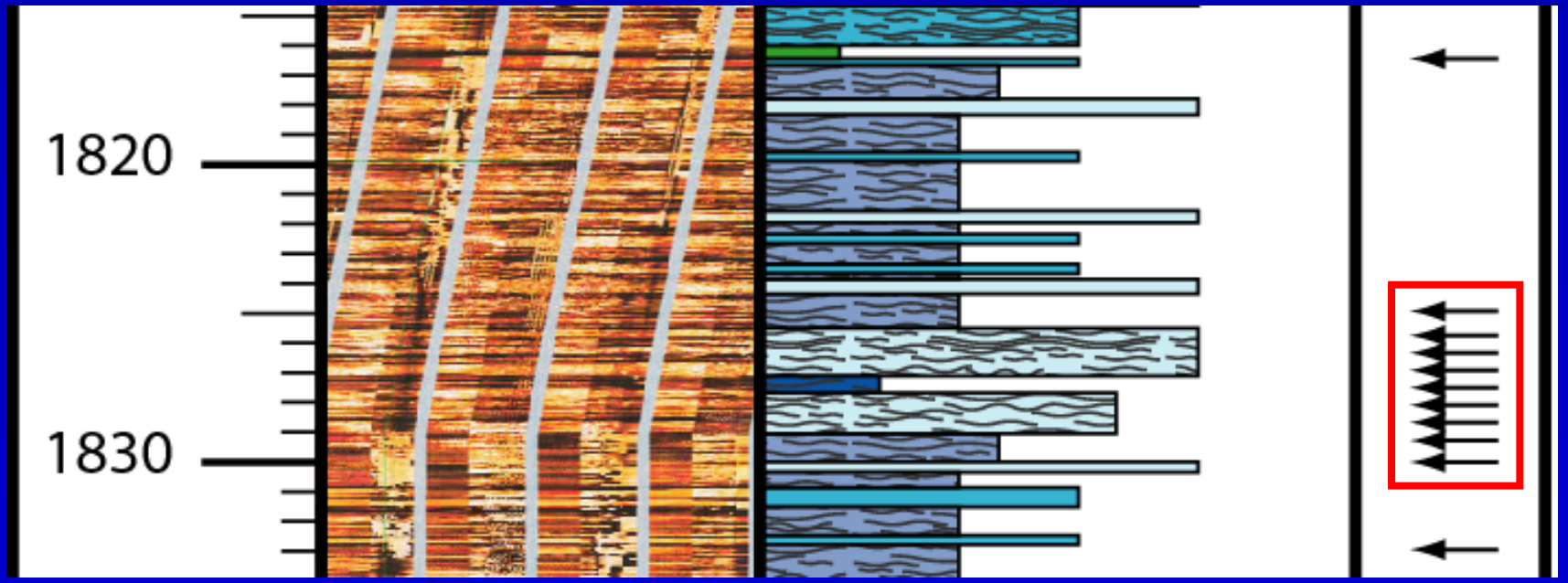


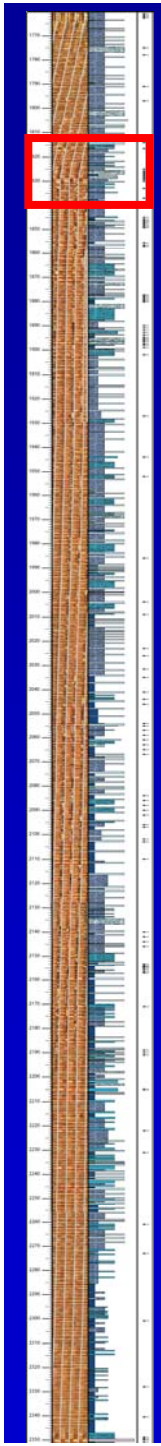
- 1825 feet
- Major gas show
- Limestone with wispy microstylolitic seams
- skeletal wackestone
- No visible porosity
- No dolomite
- No fractures



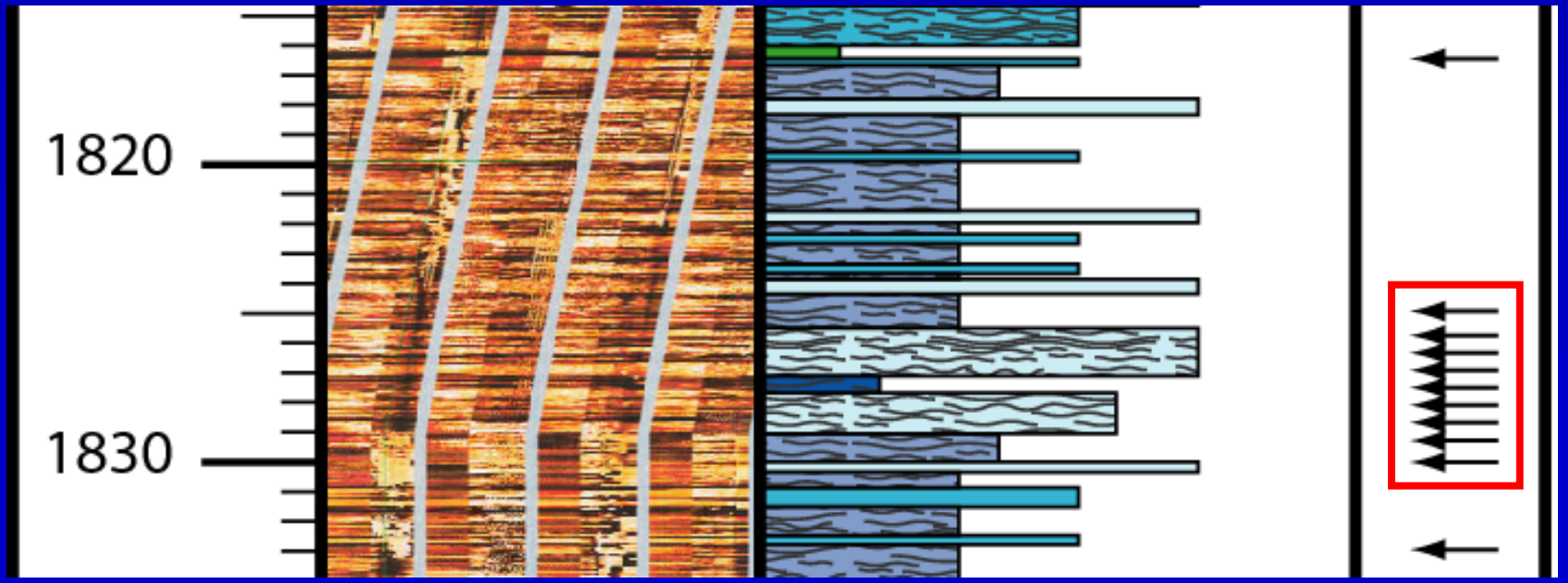


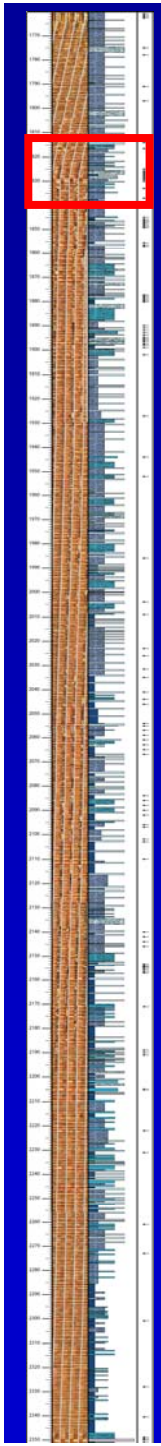
- 1826 feet
- Limestone and silty limestone
- mudstone grainstone
- No visible porosity
- No dolomite
- No fractures



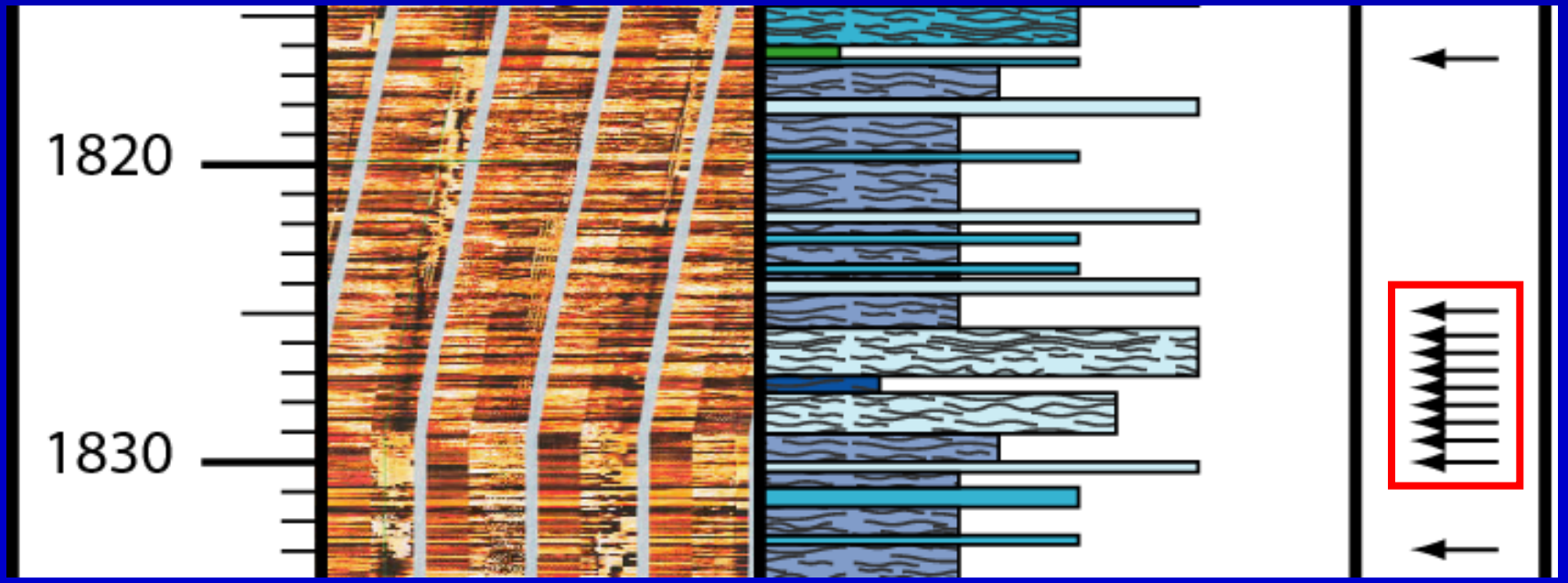


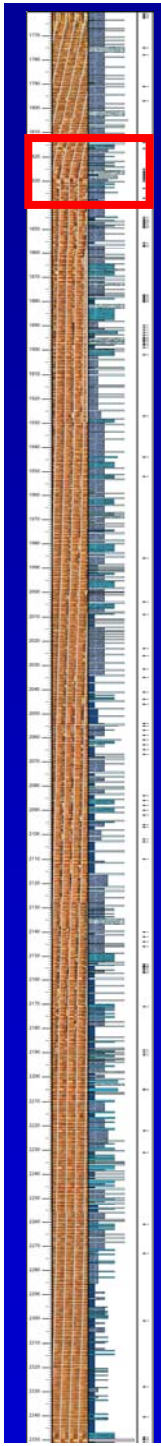
- 1826.5 feet
- Limestone
- grainstone
- No visible porosity
- No dolomite
- No fractures



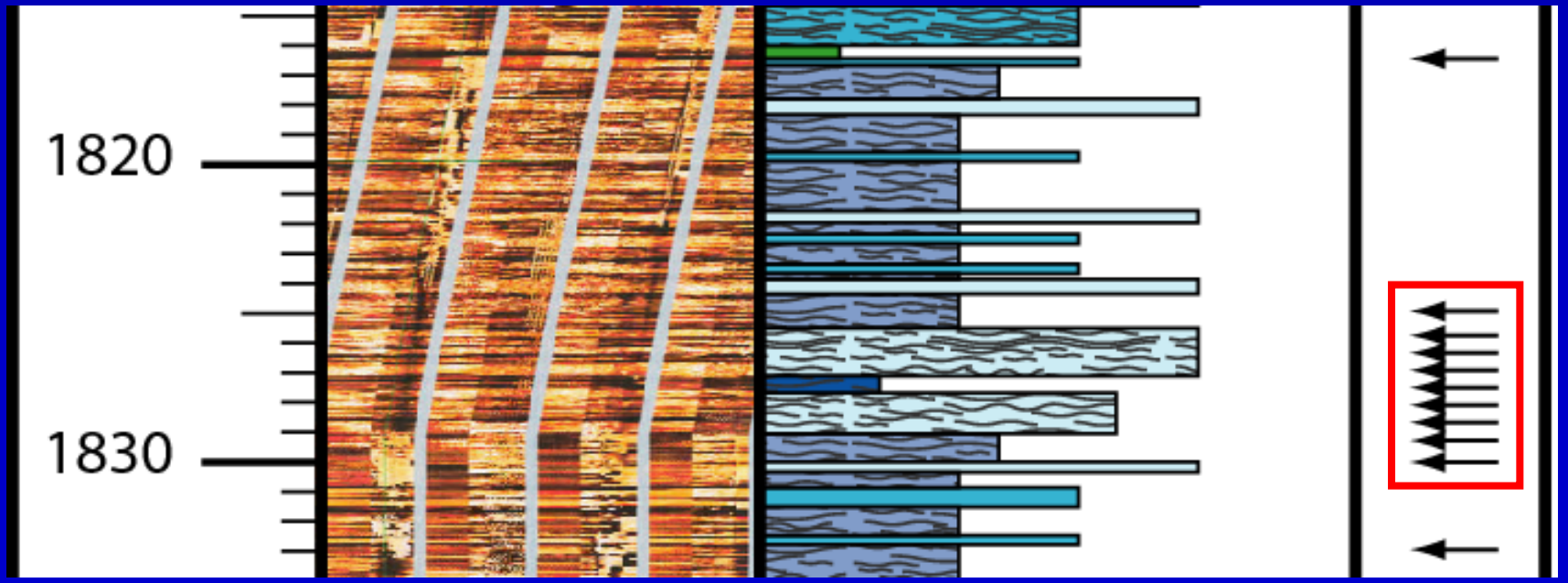


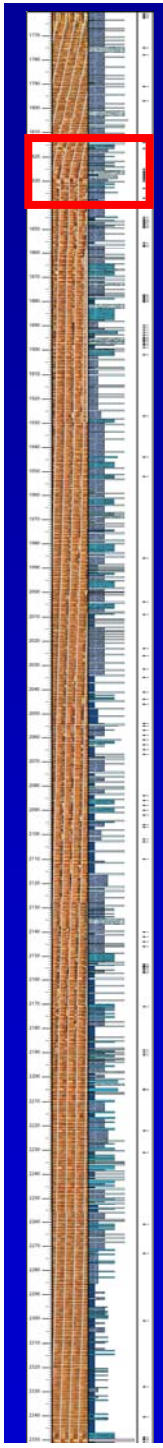
- 1827 feet
- Limestone
- grainstone
- No visible porosity
- No dolomite
- No fractures



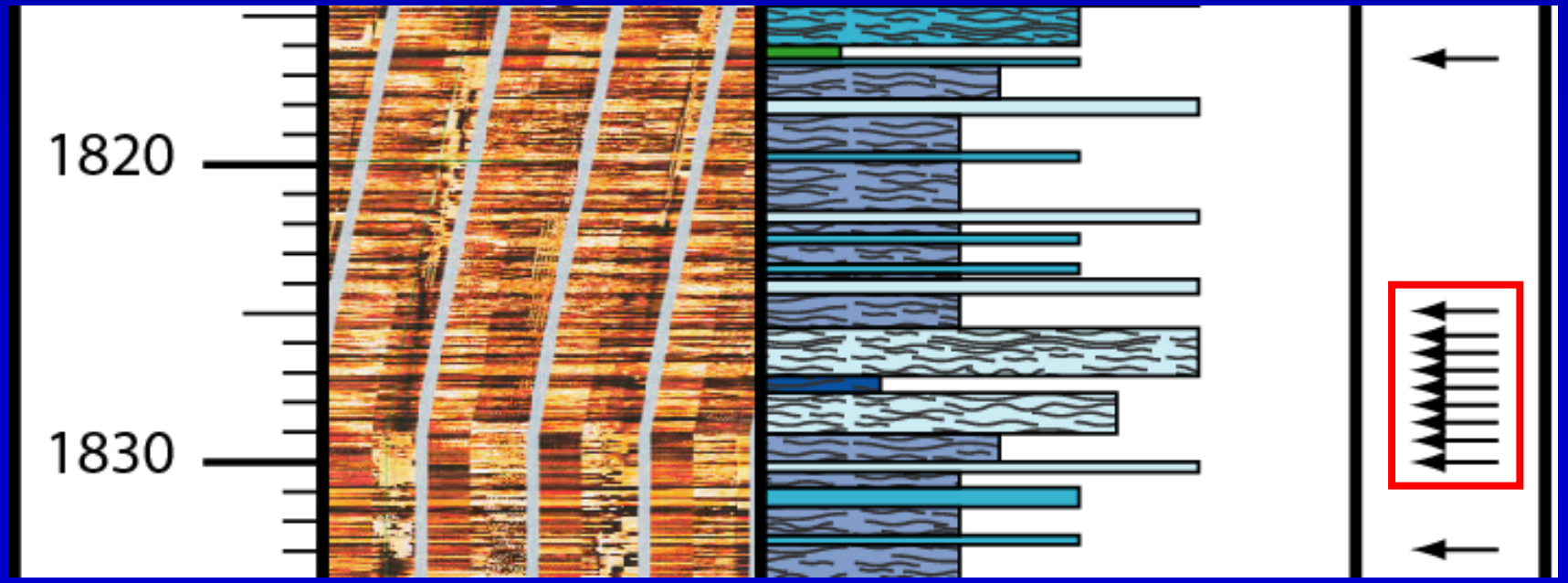


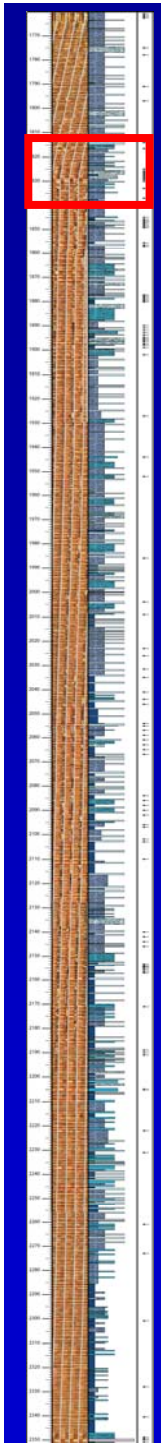
- 1827.5 feet
- Limestone and argillaceous, silty limestone
- wackestone
- No visible porosity
- No dolomite
- No fractures



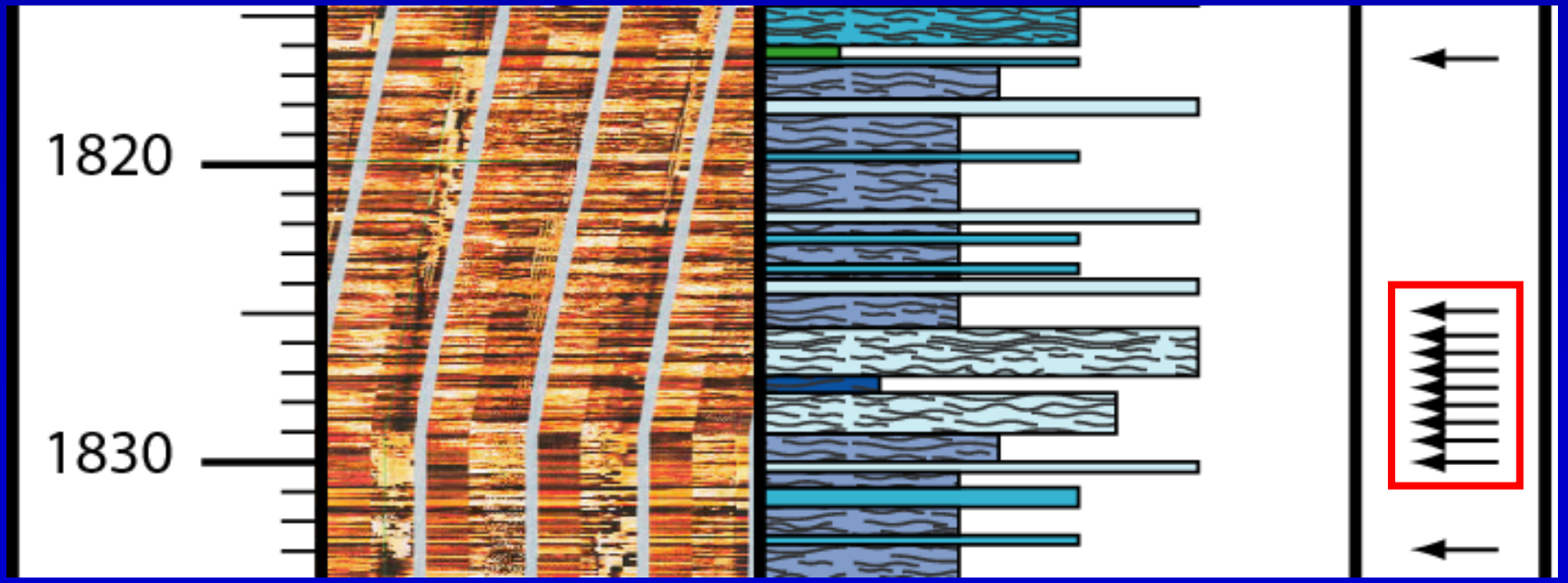


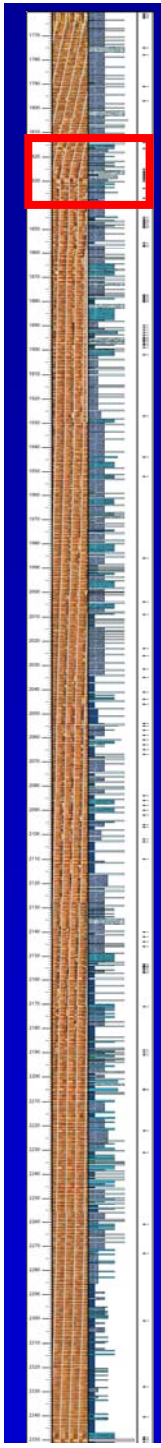
- 1828 feet
- Limestone with thin, argillaceous, silty, microstylolitzed,lamina
- grainstone
- No visible porosity
- No dolomite
- No fractures



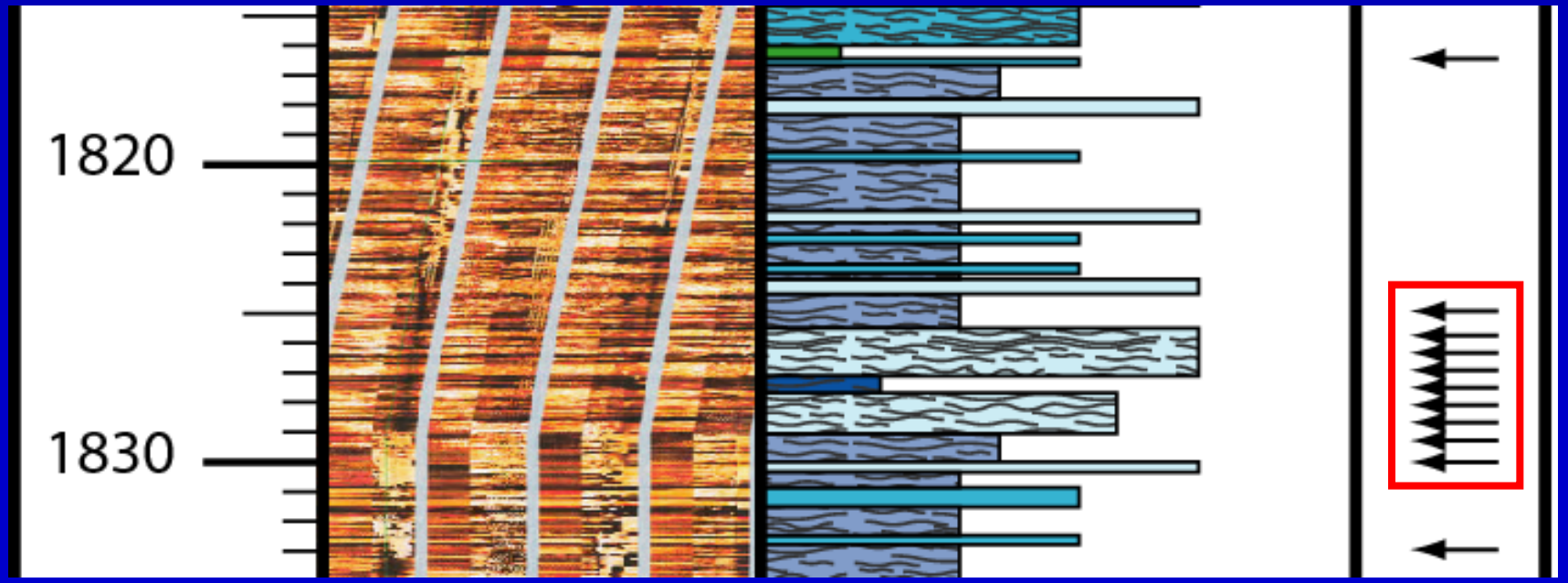


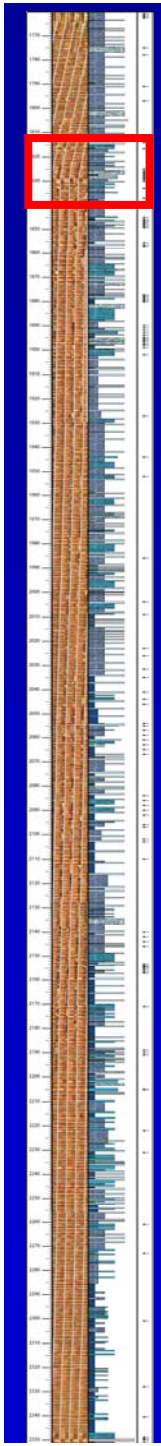
- 1828.5 feet
- Limestone with thin agillaceous, silty microstylolitized lamina
- grainstone
- No visible porosity
- No dolomite
- No fractures



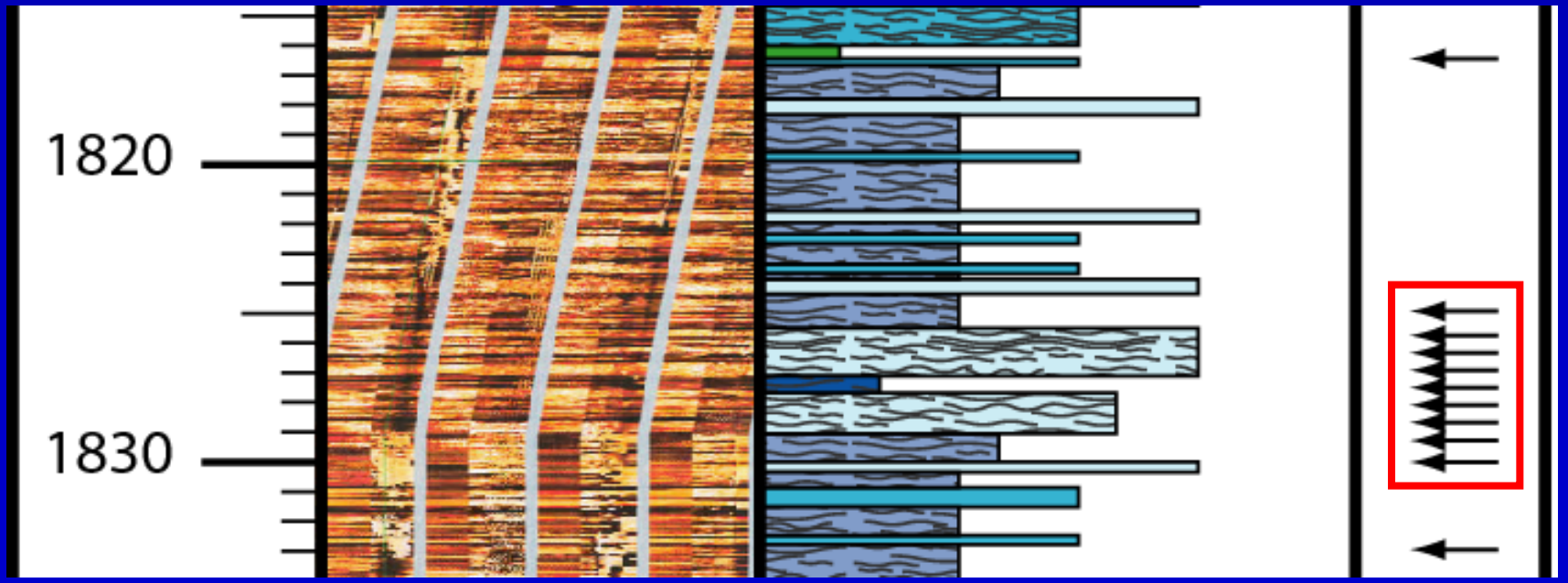


- 1829 feet
- Limestone: muddy packstone
- No visible porosity
- No dolomite
- No fractures

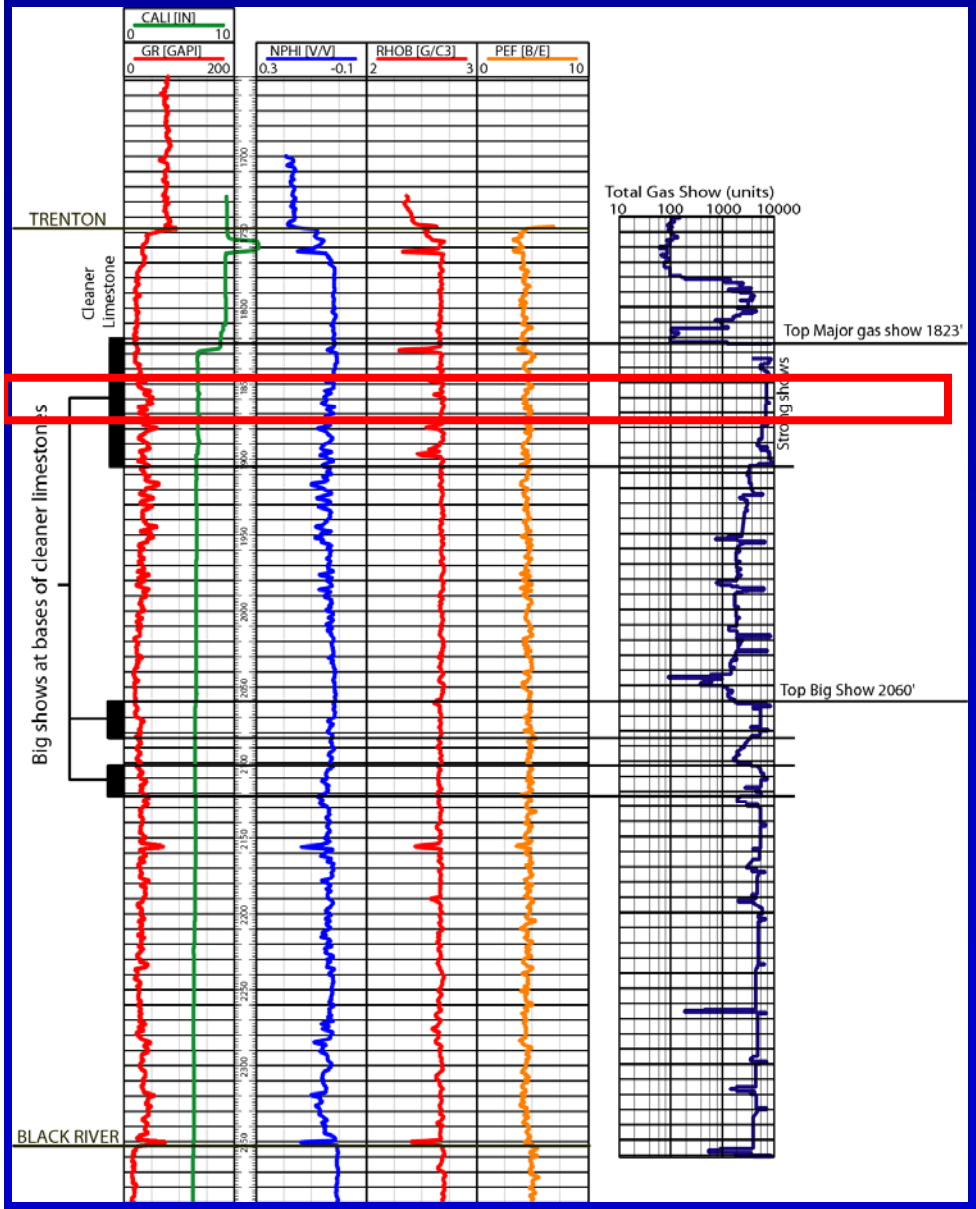


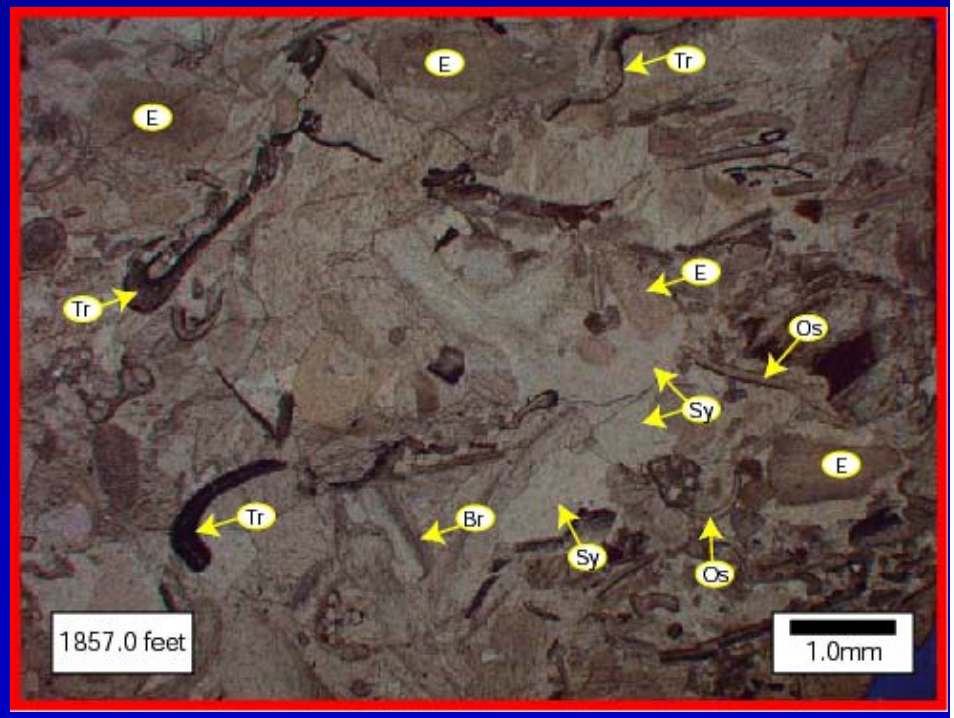


- 1830 feet
- Limestone with rare mud patches
- grainstone
- No visible porosity
- No dolomite
- No fractures



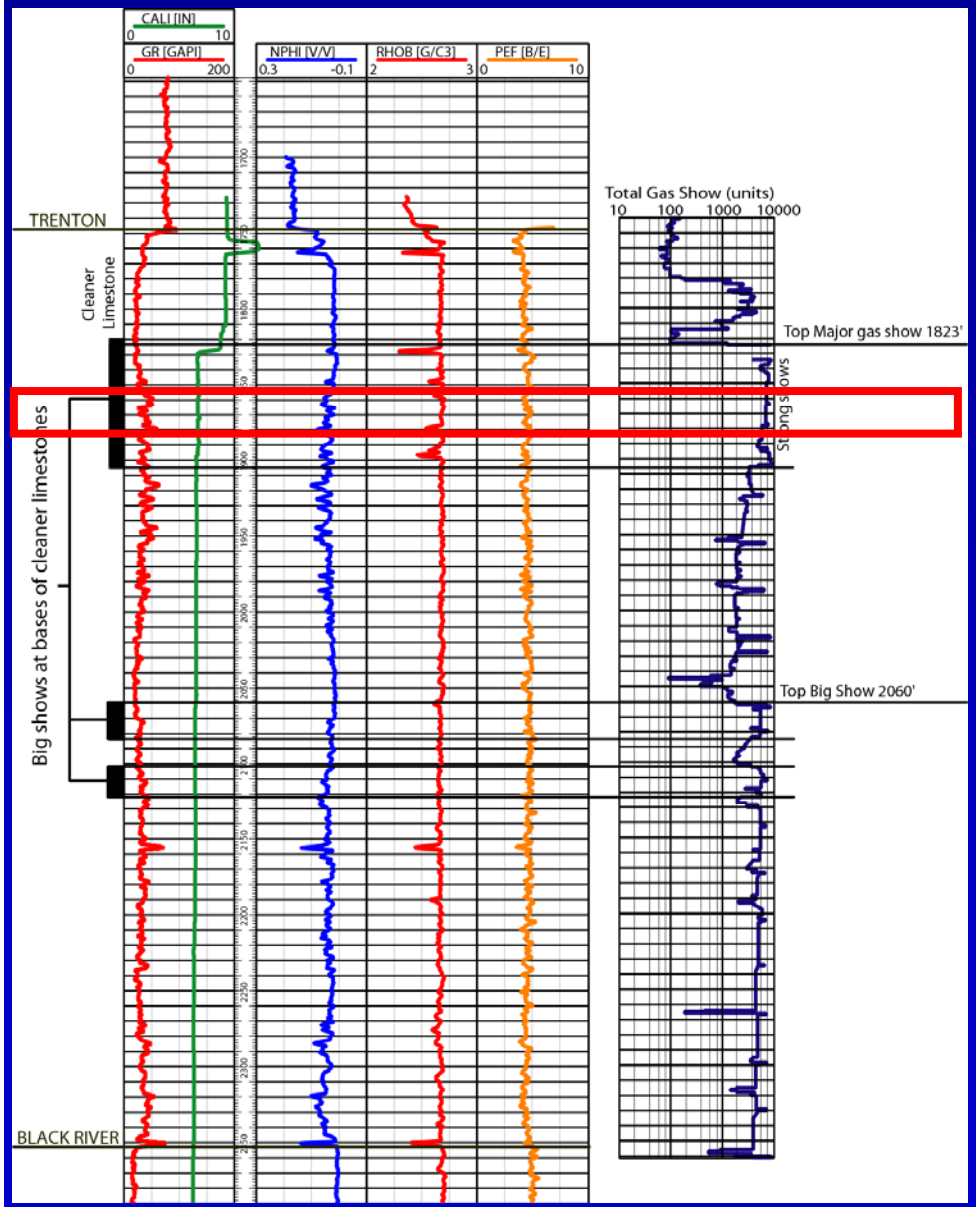
1857 grainstone

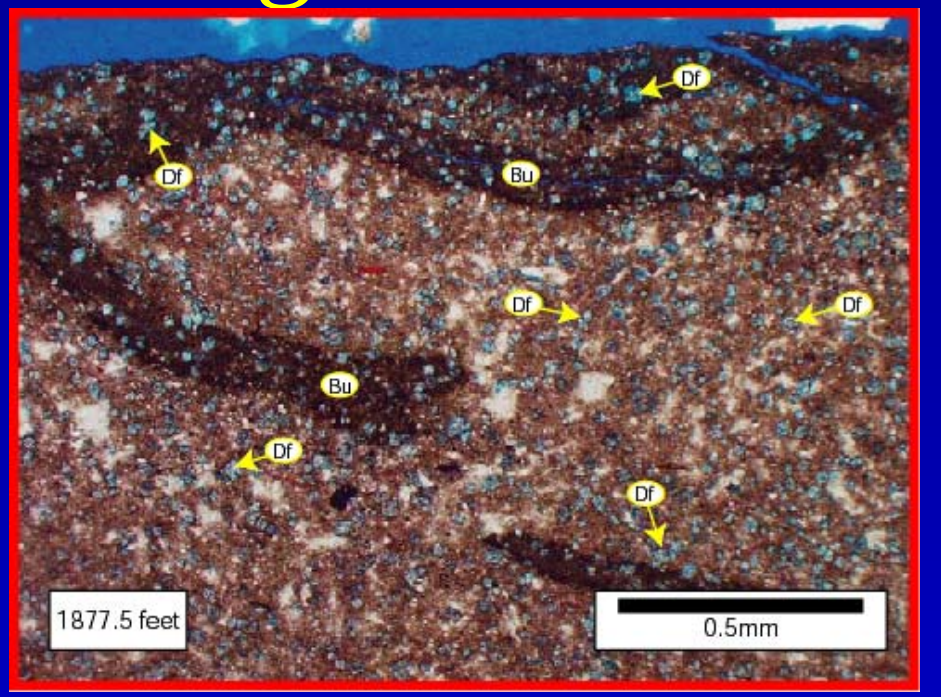




Echinoderms (E), brachiopods (Br), trilobites (Tr) and ostracods (Os) comprise the skeletal suite of this grainstone. Clear, syntaxial calcite cement (Sy) occludes all primary, intergranular porosity.

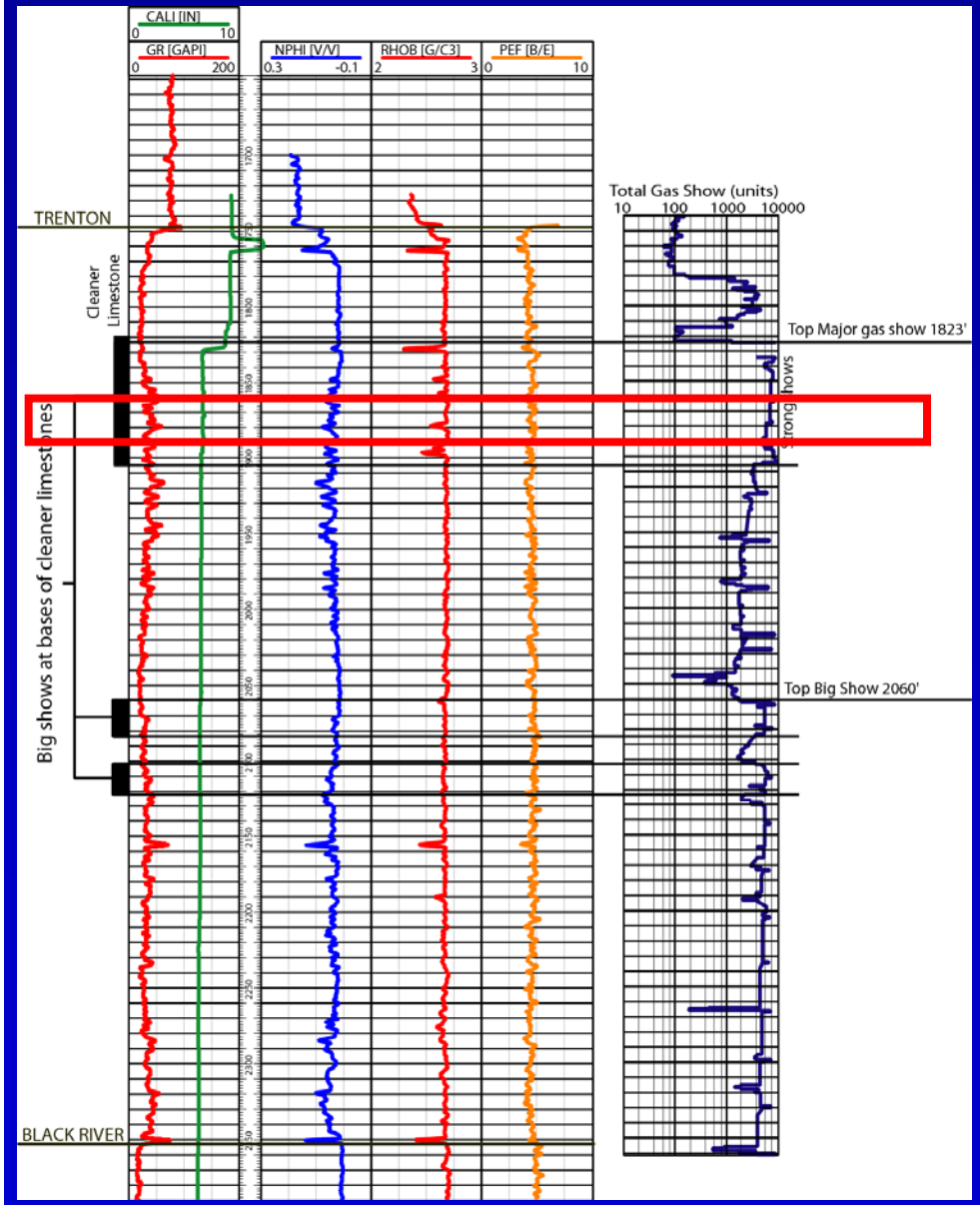
1877.5 mudstone and grainstone

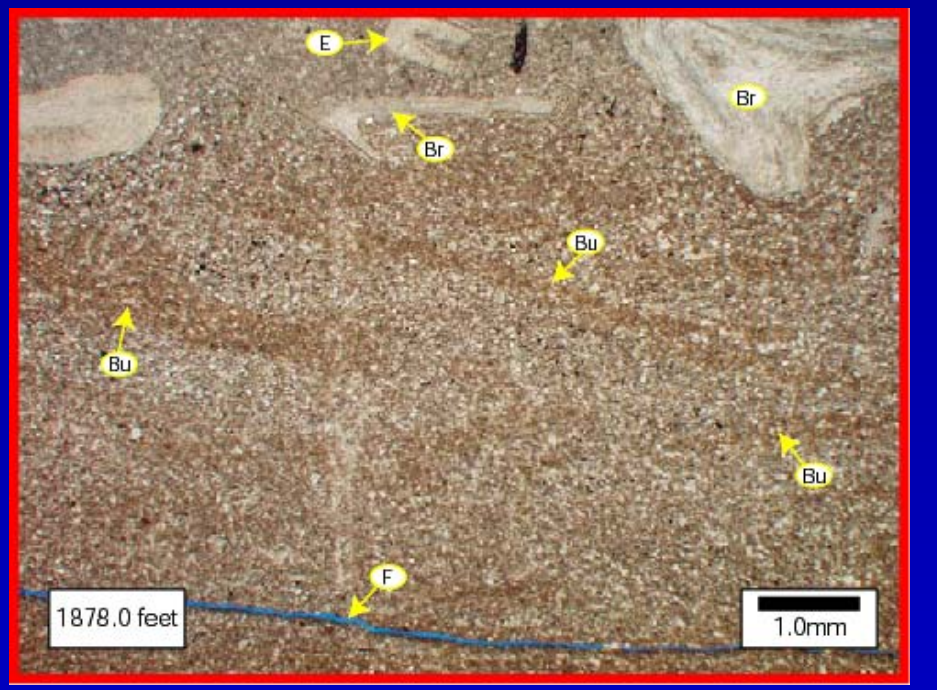




An extensive burrow (Bu) network has developed in the mudstone. Very finely crystalline, replacement dolomite (Df) is ferroan. Typically replacement dolomite is non-ferroan.

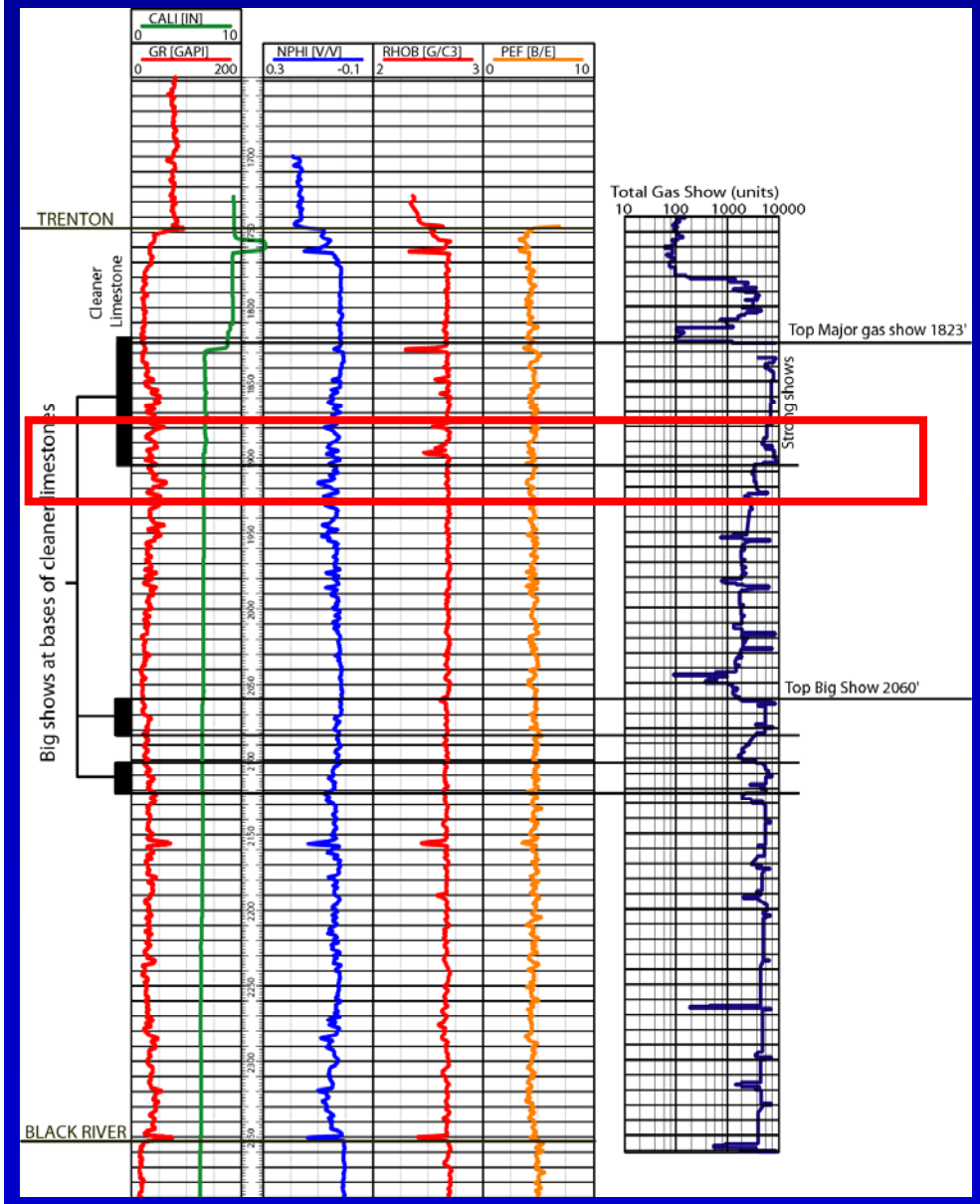
1878 mudstone

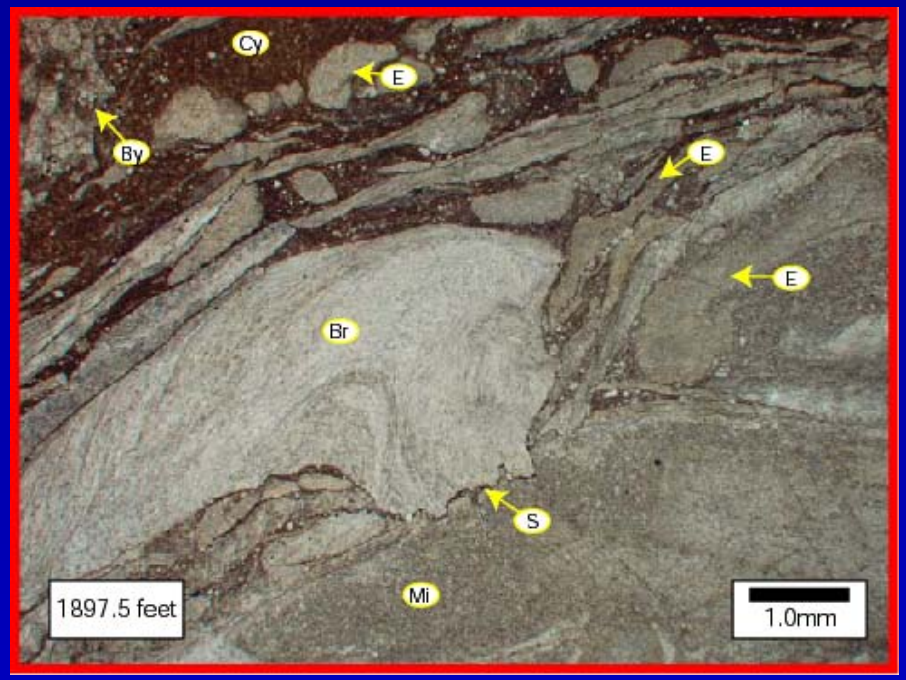




Brachiopods (Br) and echinoderms (E) are scattered throughout this mudstone. Faint, darker areas are probably burrows (Bu). The fracture (F) near the bottom of the frame is an artifact.

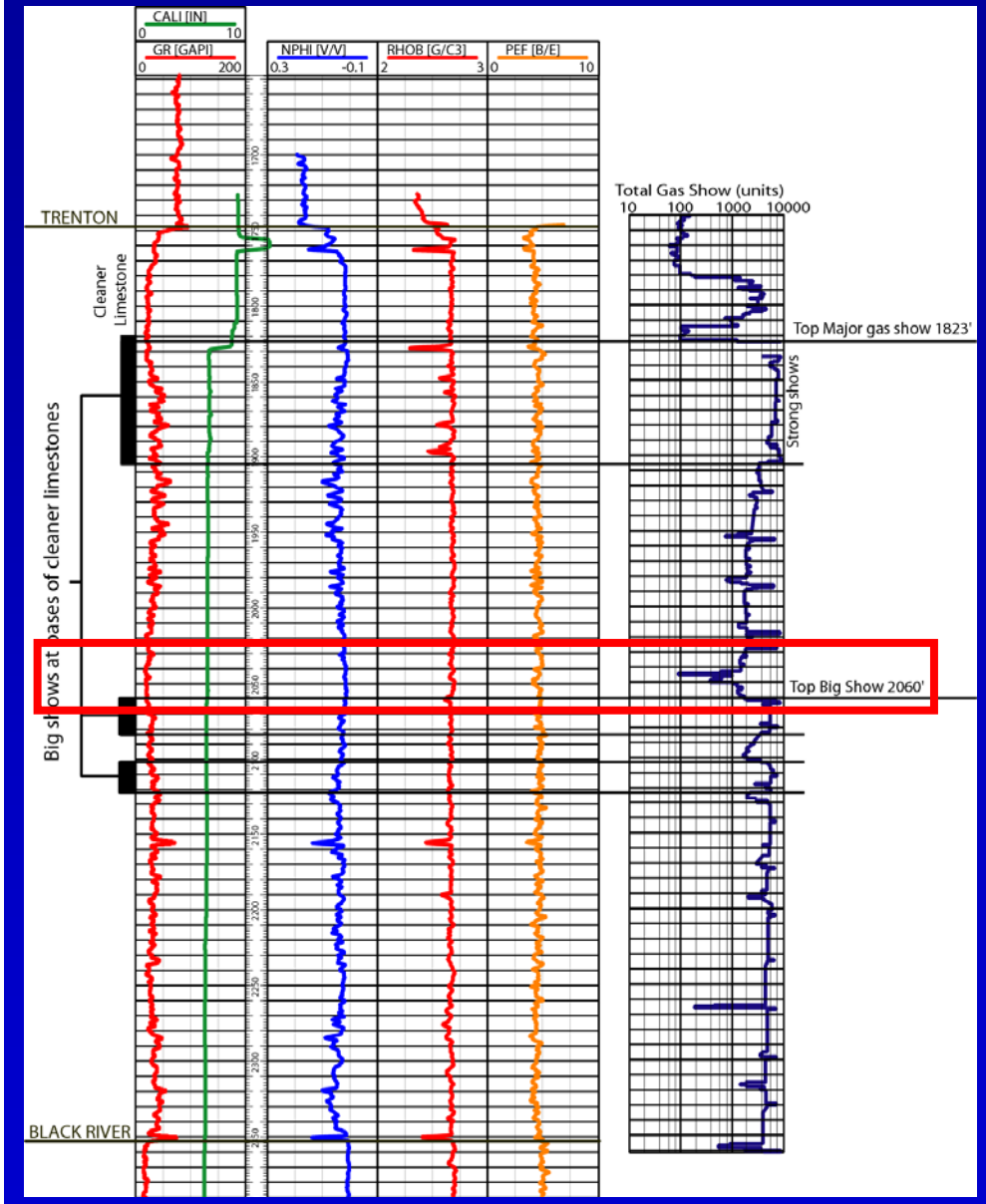
1897 packstone to grainstone

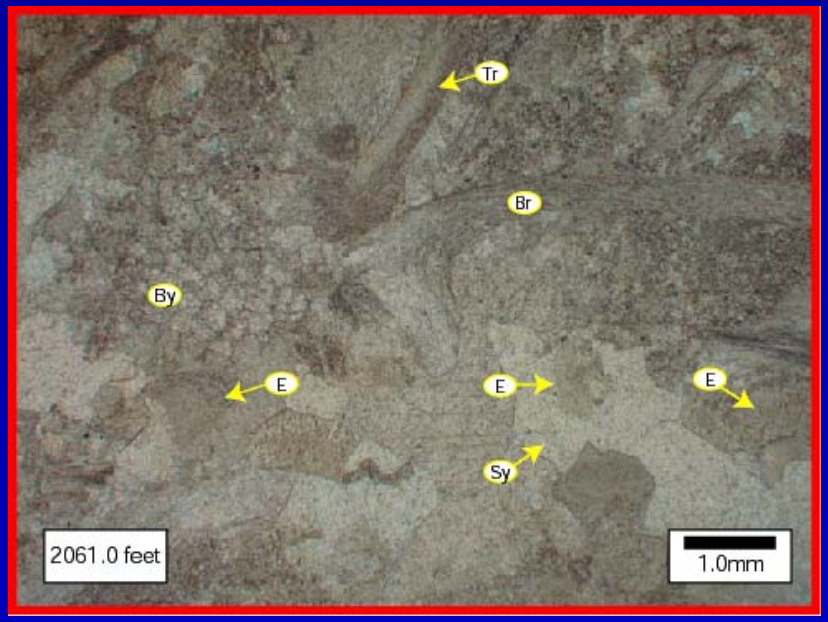




There is a sharp contrast between the clay matrix (Cy) above and the lime mud matrix (Mi) below. Most skeletals are echinoderms (E), although brachiopods (Br) and bryozoans (By) also can be recognized. Notice the low amplitude stylolite (S) between the large brachiopod in the clay matrix and the underlying limestone.

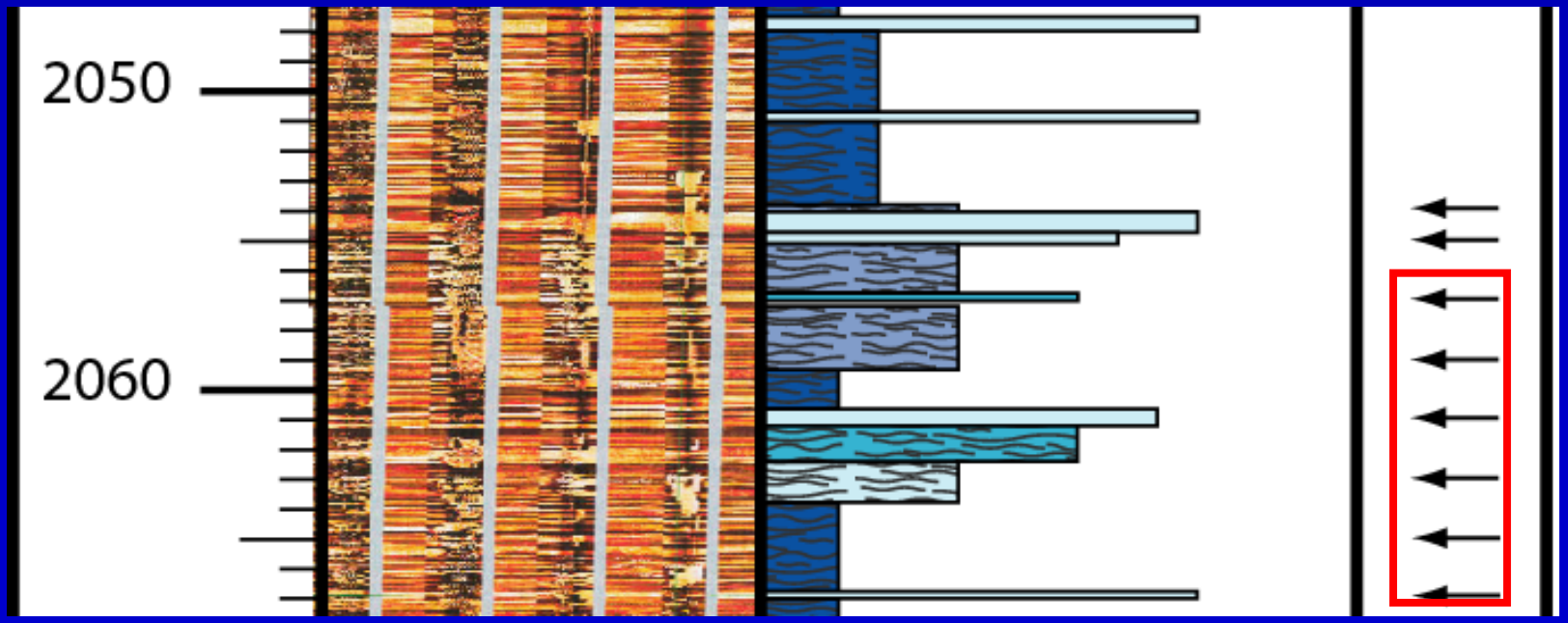
2061



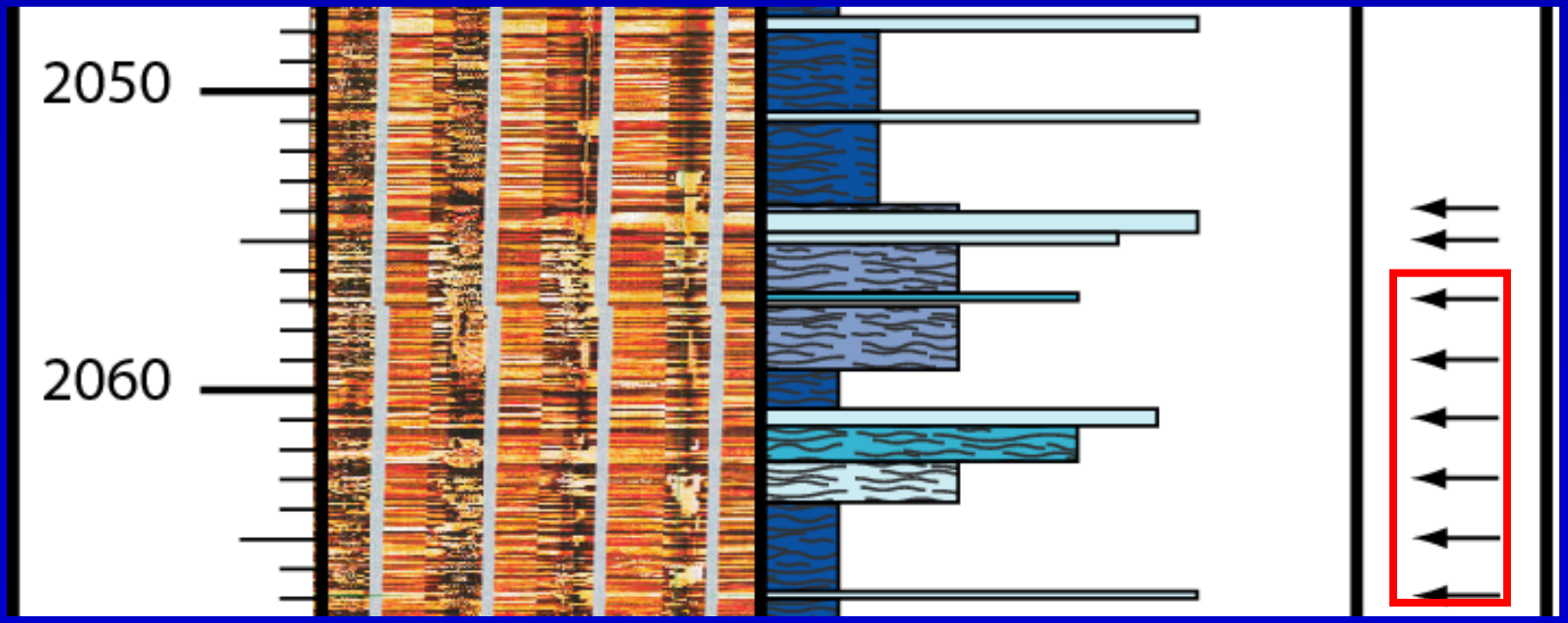


Numerous, large trilobites (Tr), brachiopods (Br), bryozoans (By) and echinoderms (E) comprise this packstone. Syntaxial cements (Sy) envelope the echinoderms and occlude much intergranular pore space.

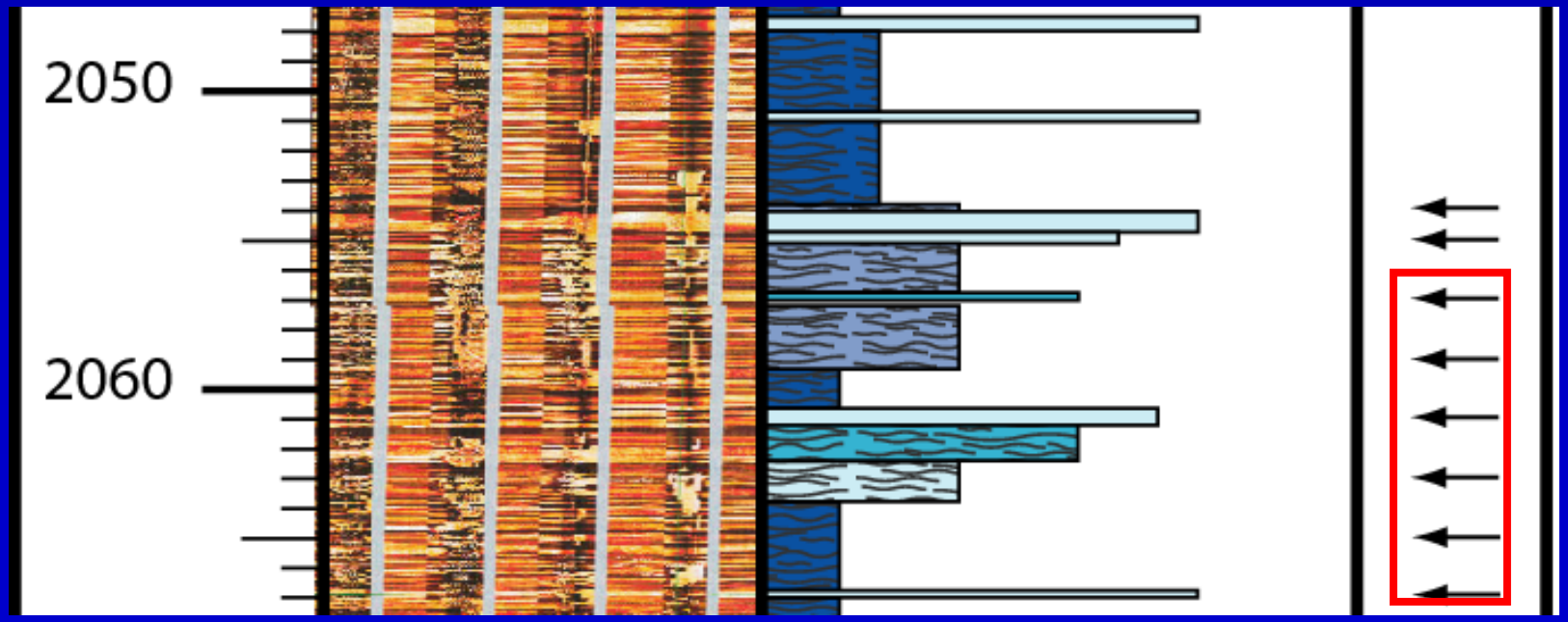
- 2057 feet
- Limestone and slightly argillaceous limestone
- mudstone to grainstone
- No visible porosity
- No dolomite
- No fractures



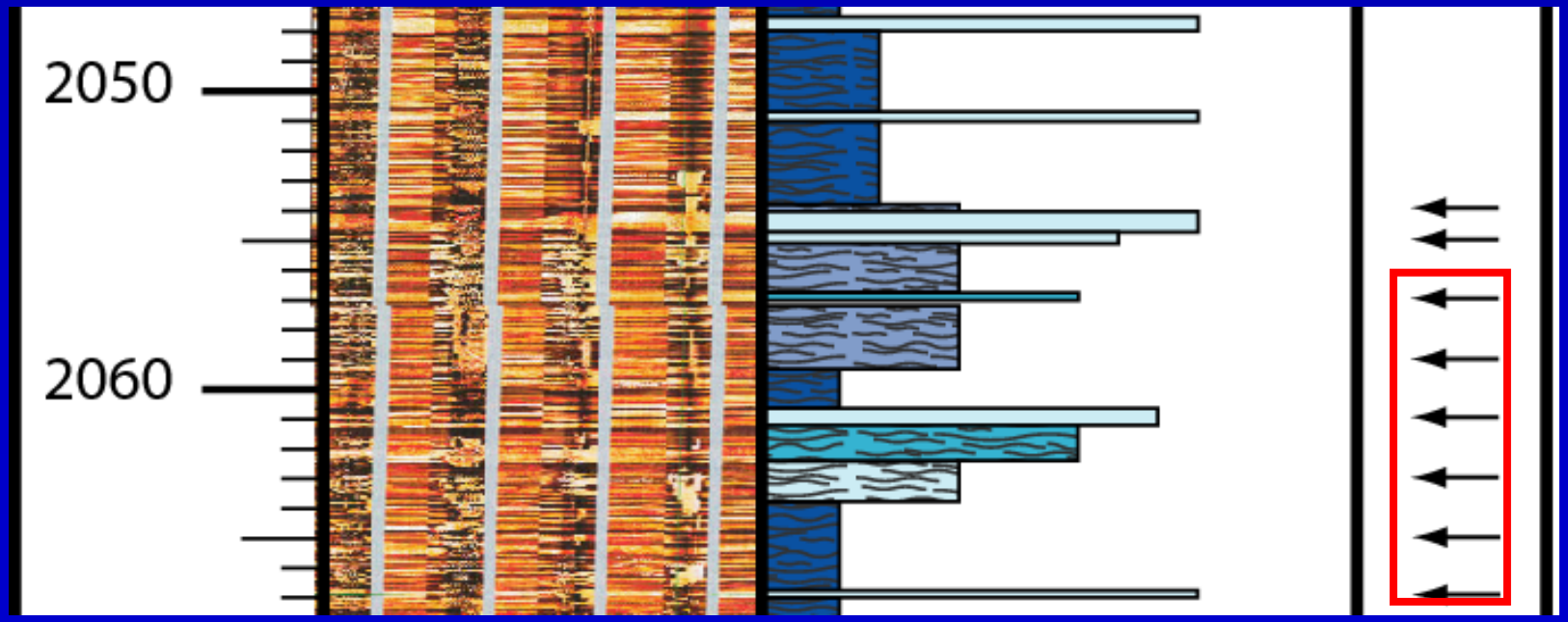
- 2059 feet
- Limestone
- wackstone
- No visible porosity
- No dolomite
- No fractures



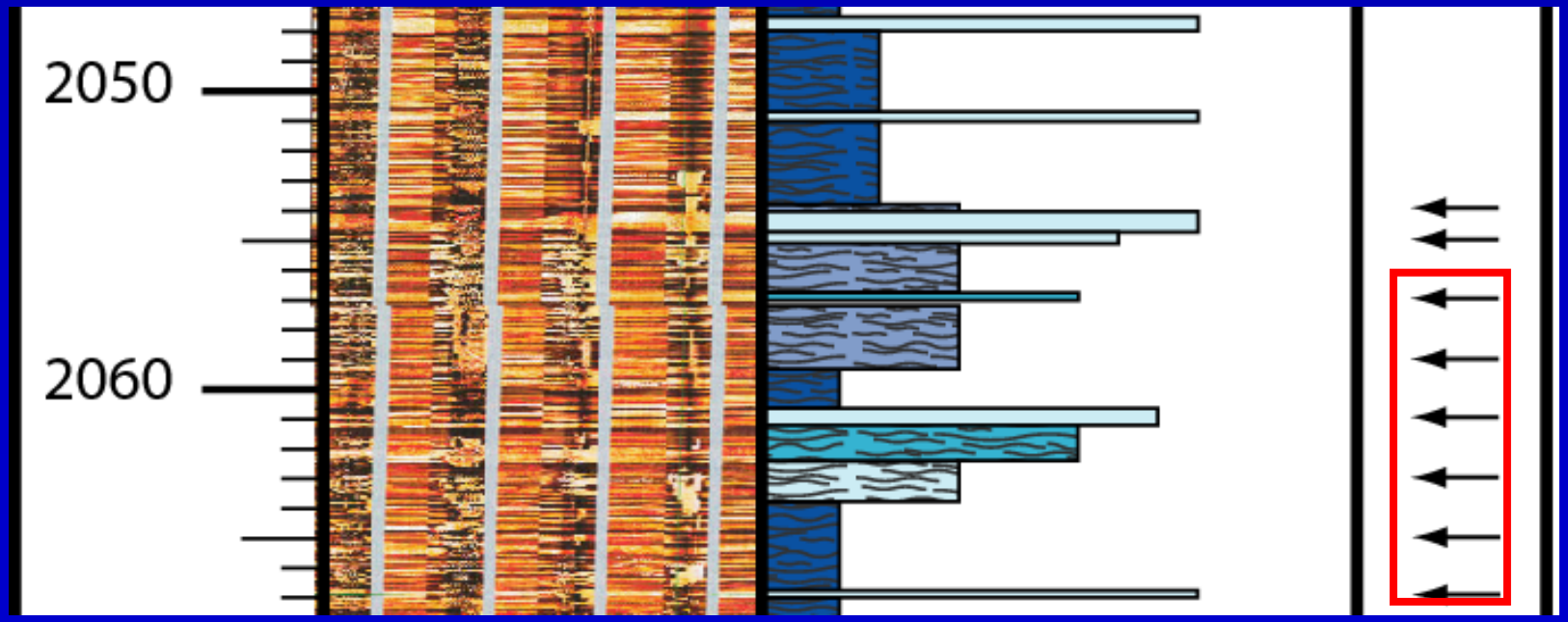
- 2061 feet
- Next large gas show zone
- Limestone
- grainstone
- No visible porosity
- No dolomite
- No fractures



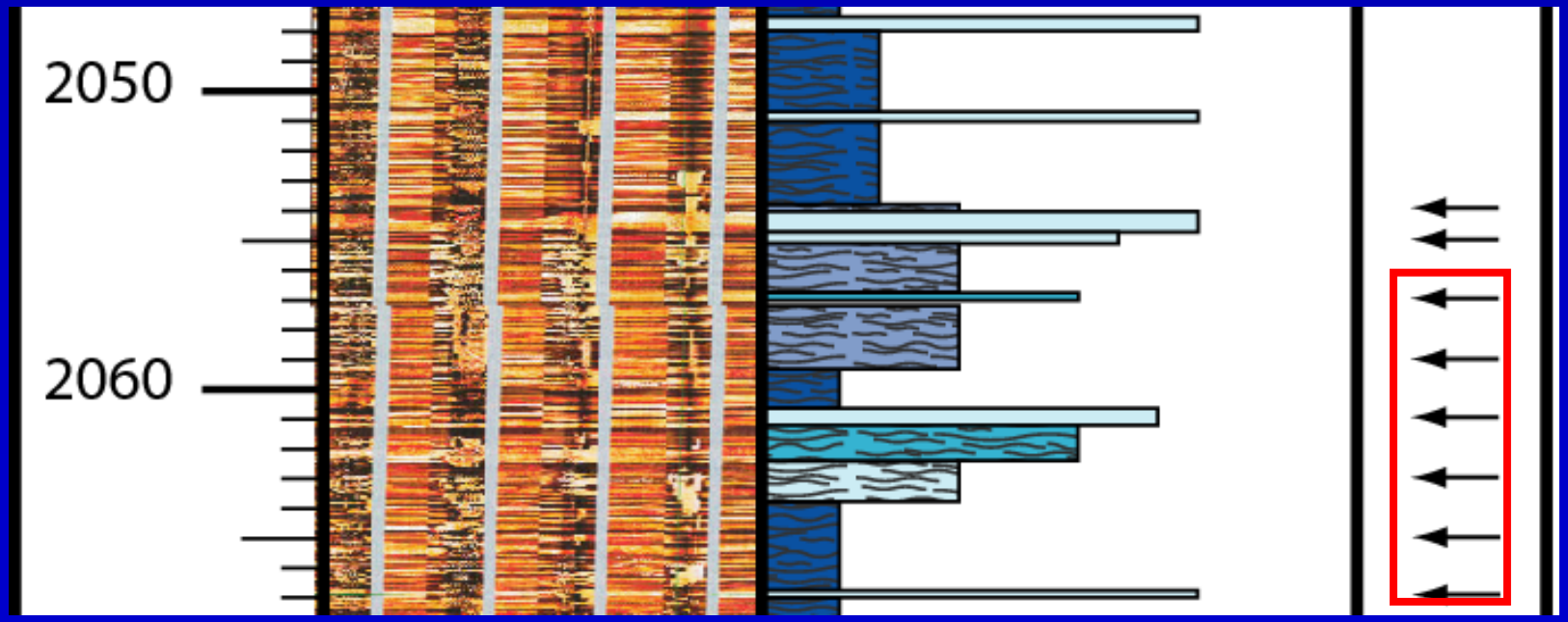
- 2063 feet
- Next large gas show zone
- Limestone
- wackstone
- No visible porosity
- No dolomite
- No fractures

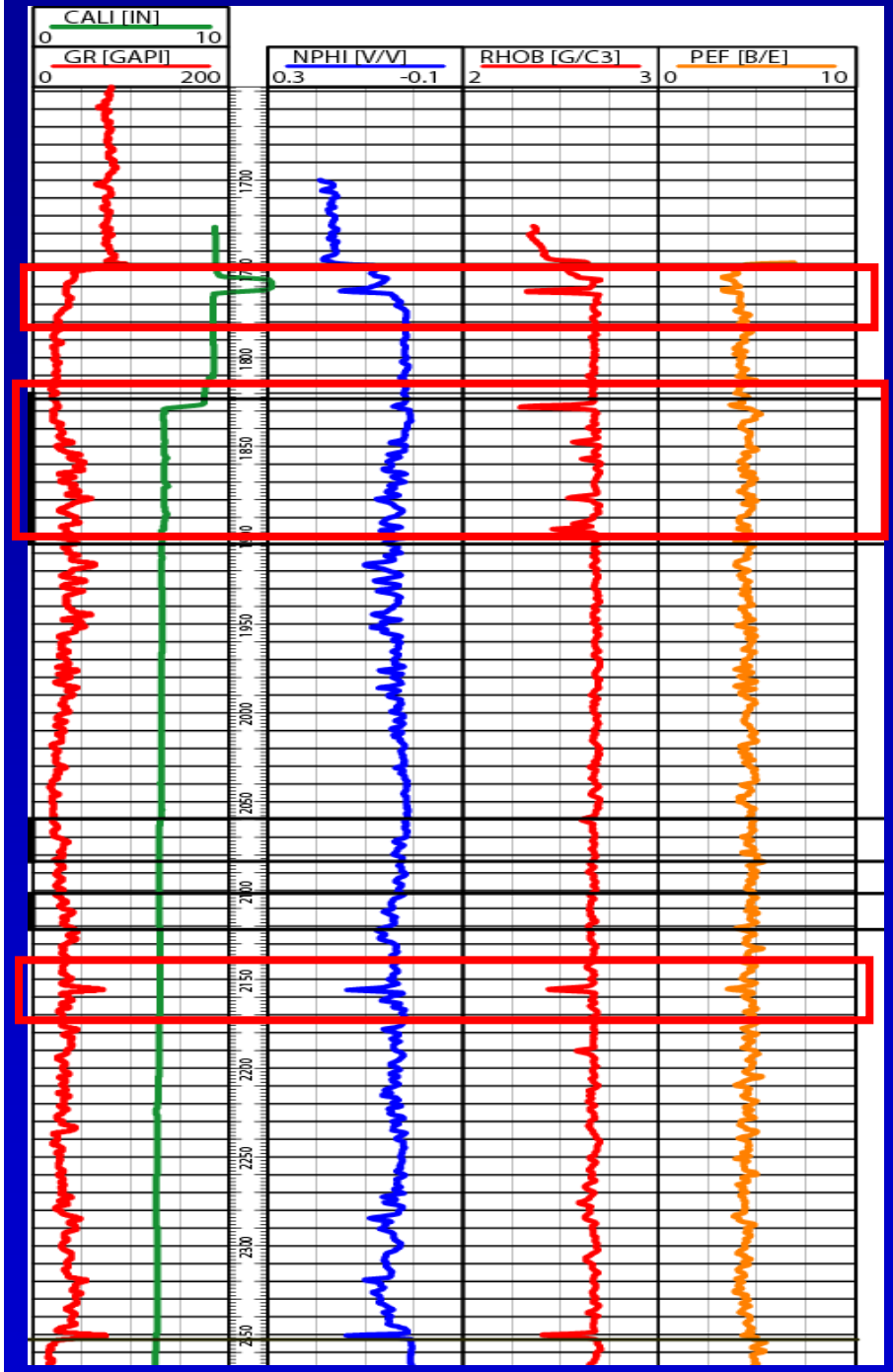


- 2065 feet
- Next large gas show zone
- Limestone
- mudstone
- No visible porosity
- No dolomite
- No fractures



- 2067 feet
- Next large gas show zone
- Limestone
- mudstone
- No visible porosity
- No dolomite
- No fractures

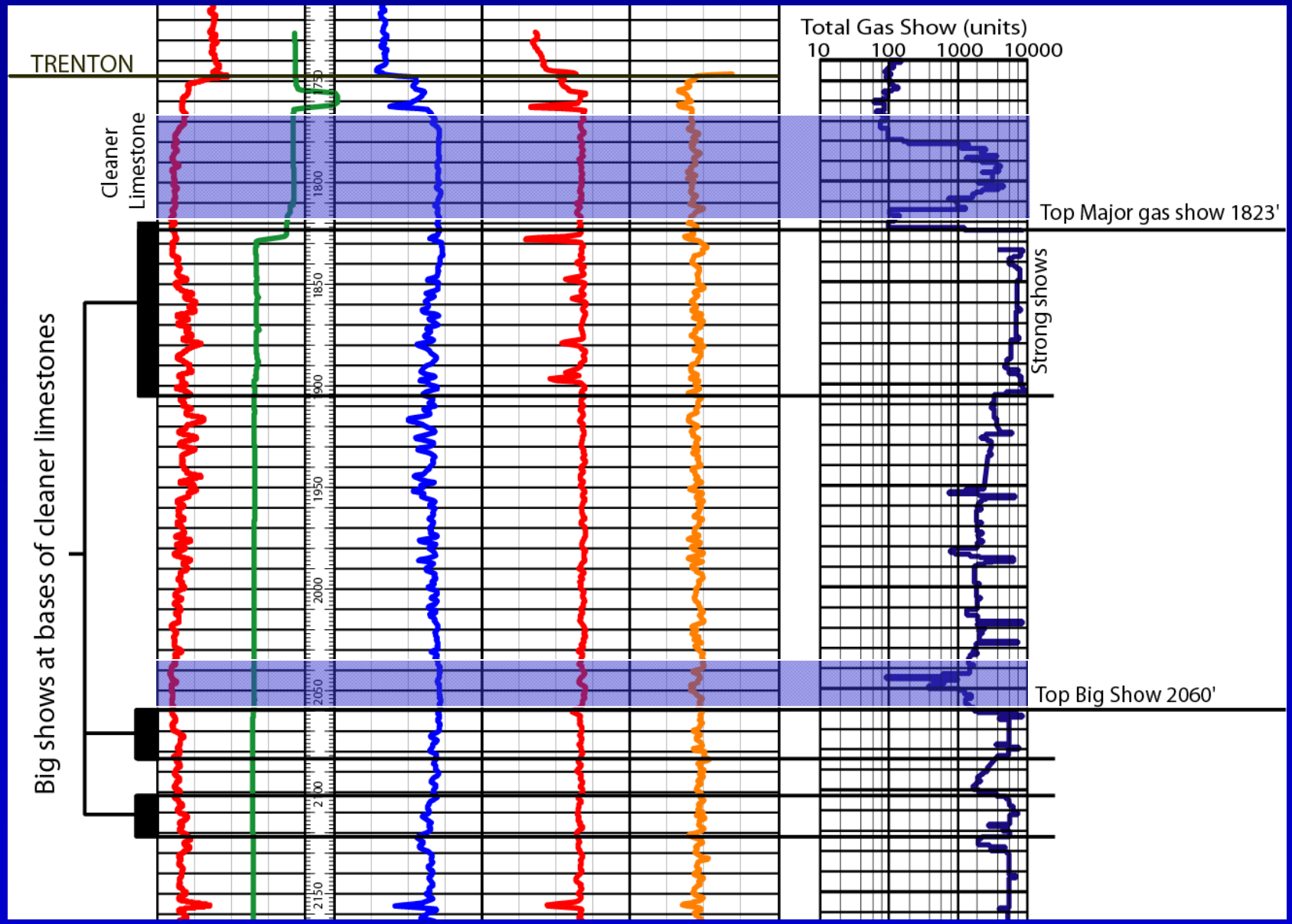




Porosity

- Areas where neutron porosity increases with low density values and high gamma ray values suggests porosity may be related to clay content

- Bentonites signatures have high gamma ray and density values, neutron logs have low values – they are not porous



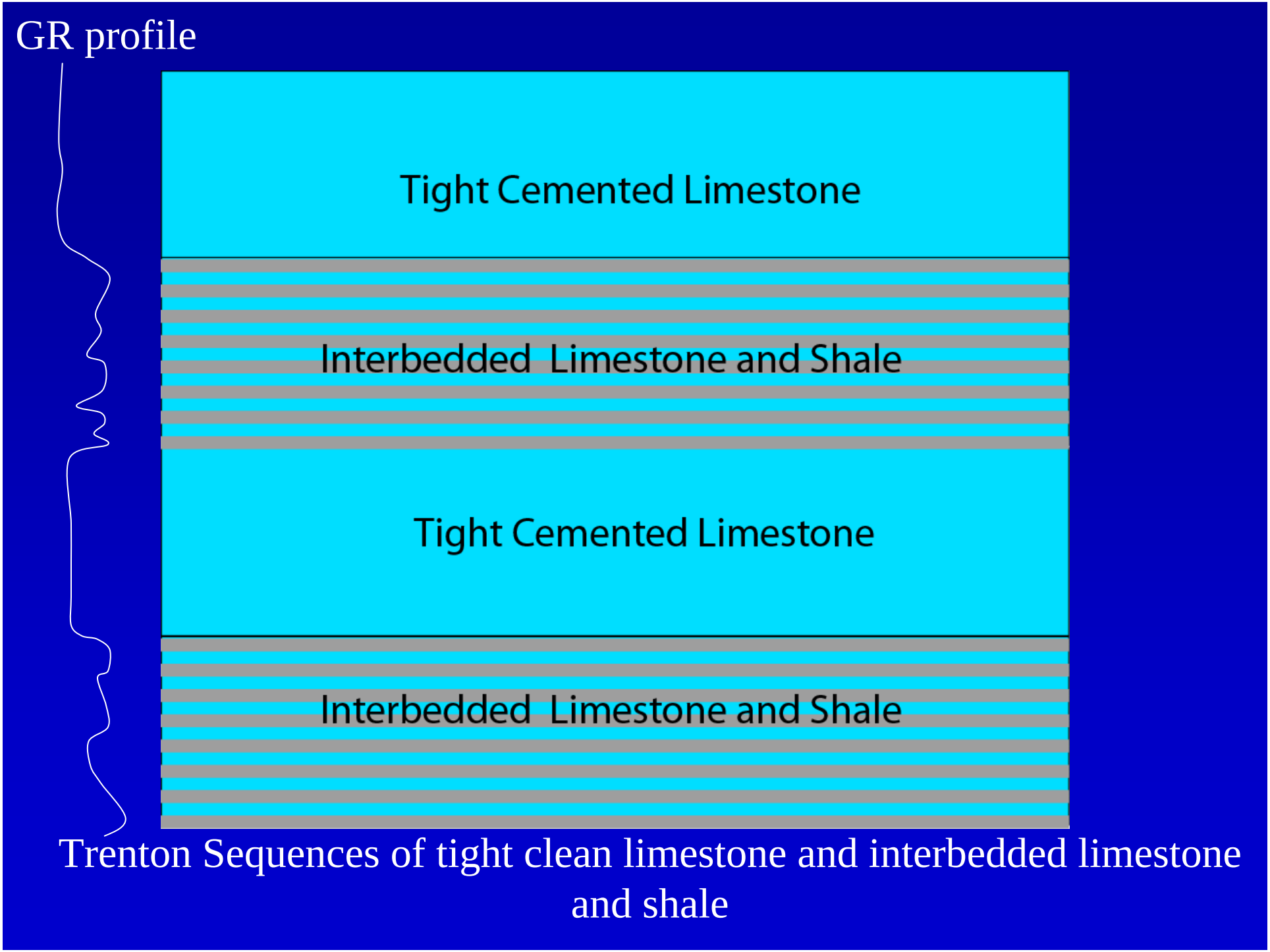
Biggest shows just below clean limestones – this is consistent with what other studies have found including Zagorski, 2005

Interpretation of where the gas comes from in the Trenton

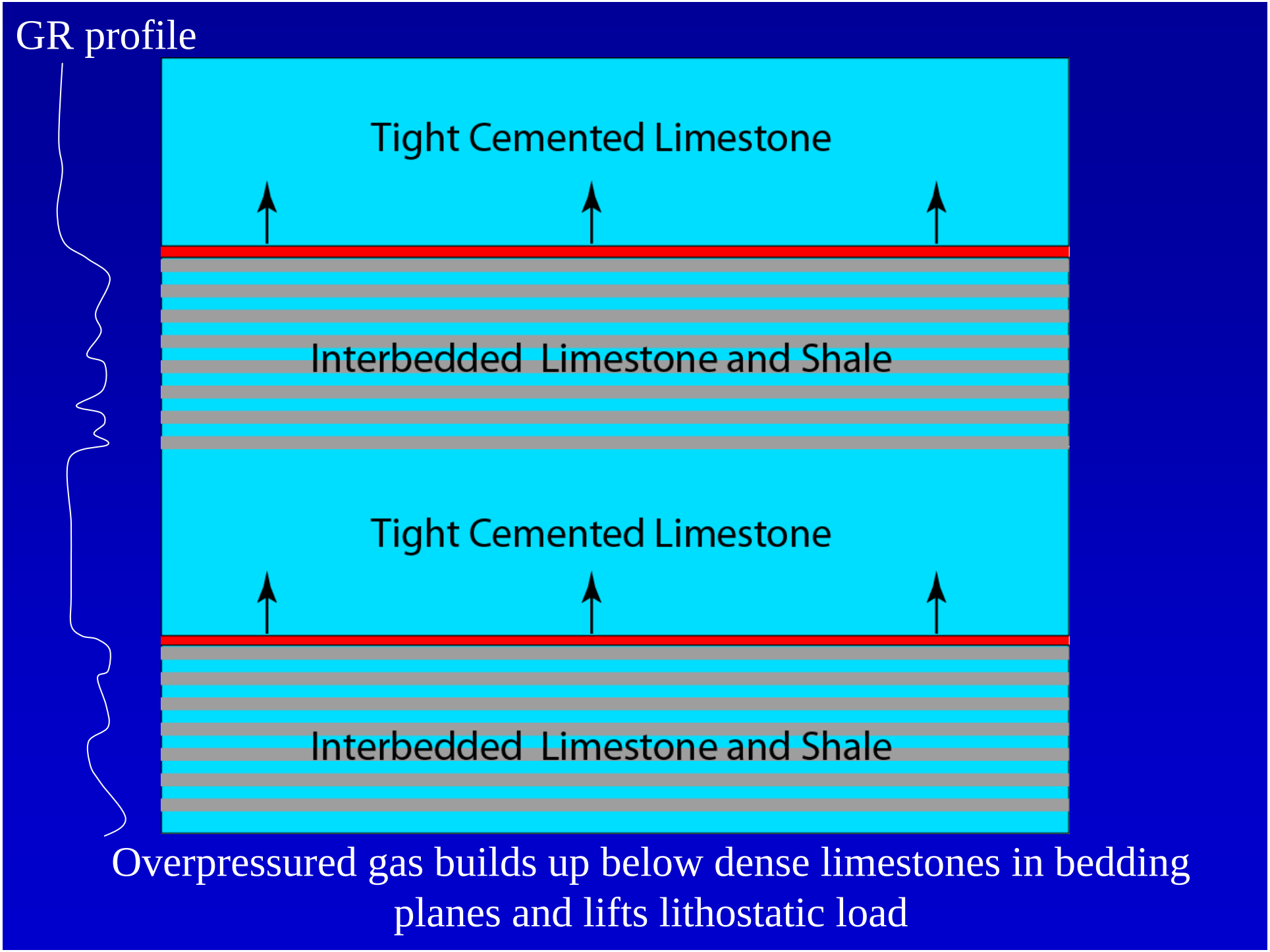
We think the gas comes from open bedding planes partings between limestone and shale or limestone and bentonites or horizontal fractures

Bentonite and limestone with open parting between them

Core plug scan with break in shale

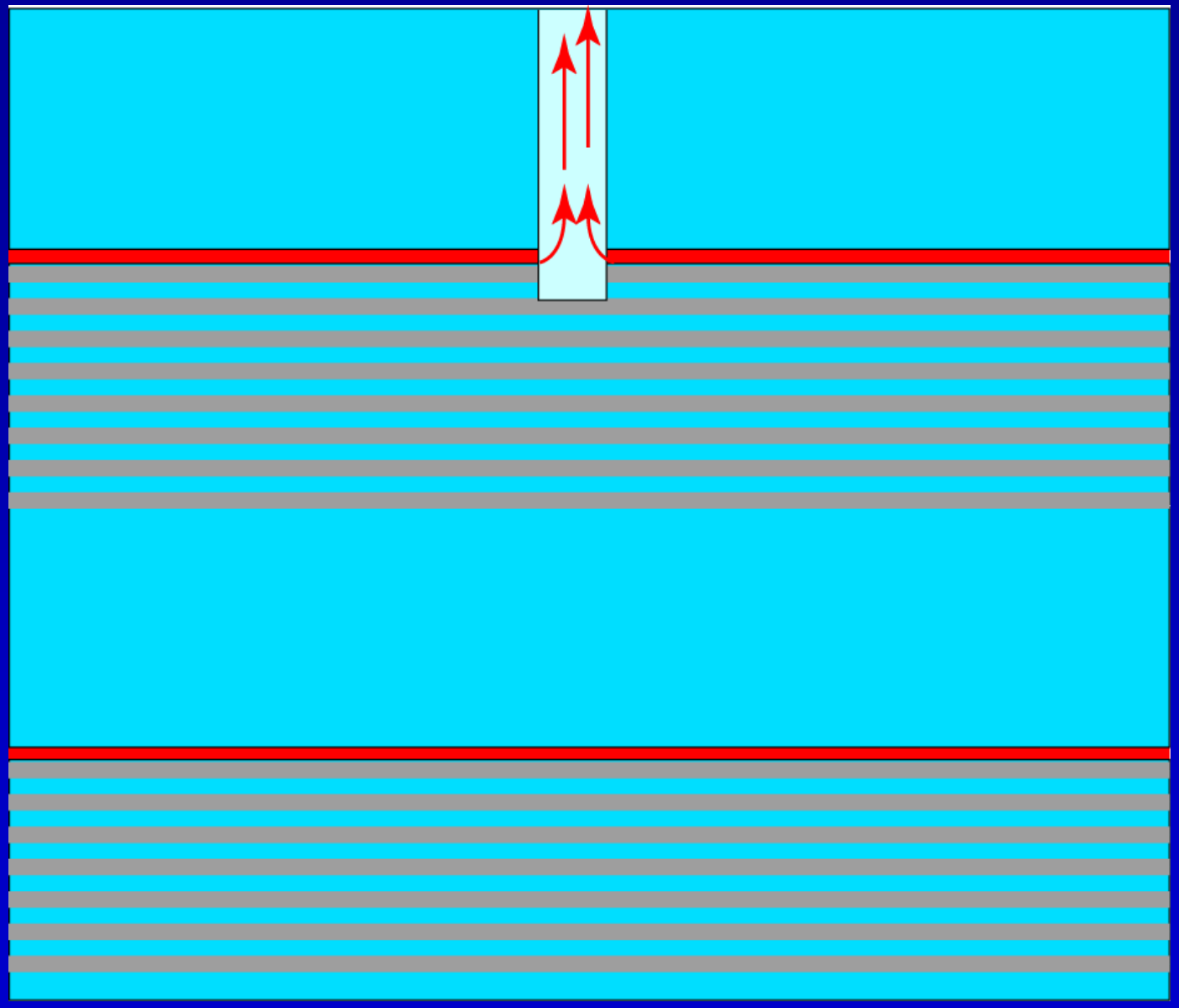


Trenton Sequences of tight clean limestone and interbedded limestone and shale



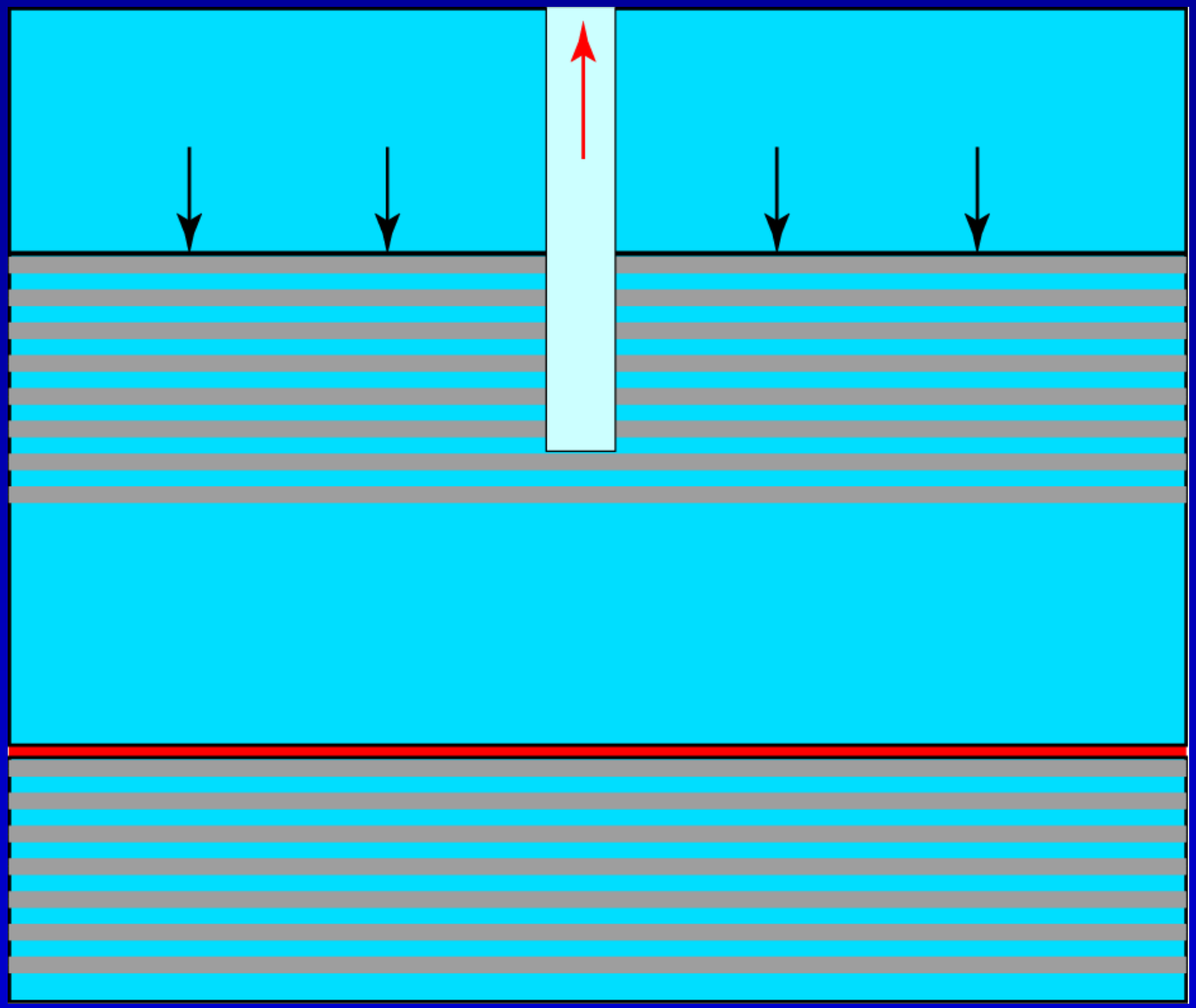
Overpressured gas builds up below dense limestones in bedding planes and lifts lithostatic load

GR profile



Wellbore penetrates gas-bearing bedding plane, gas flows back at very high rate

GR profile

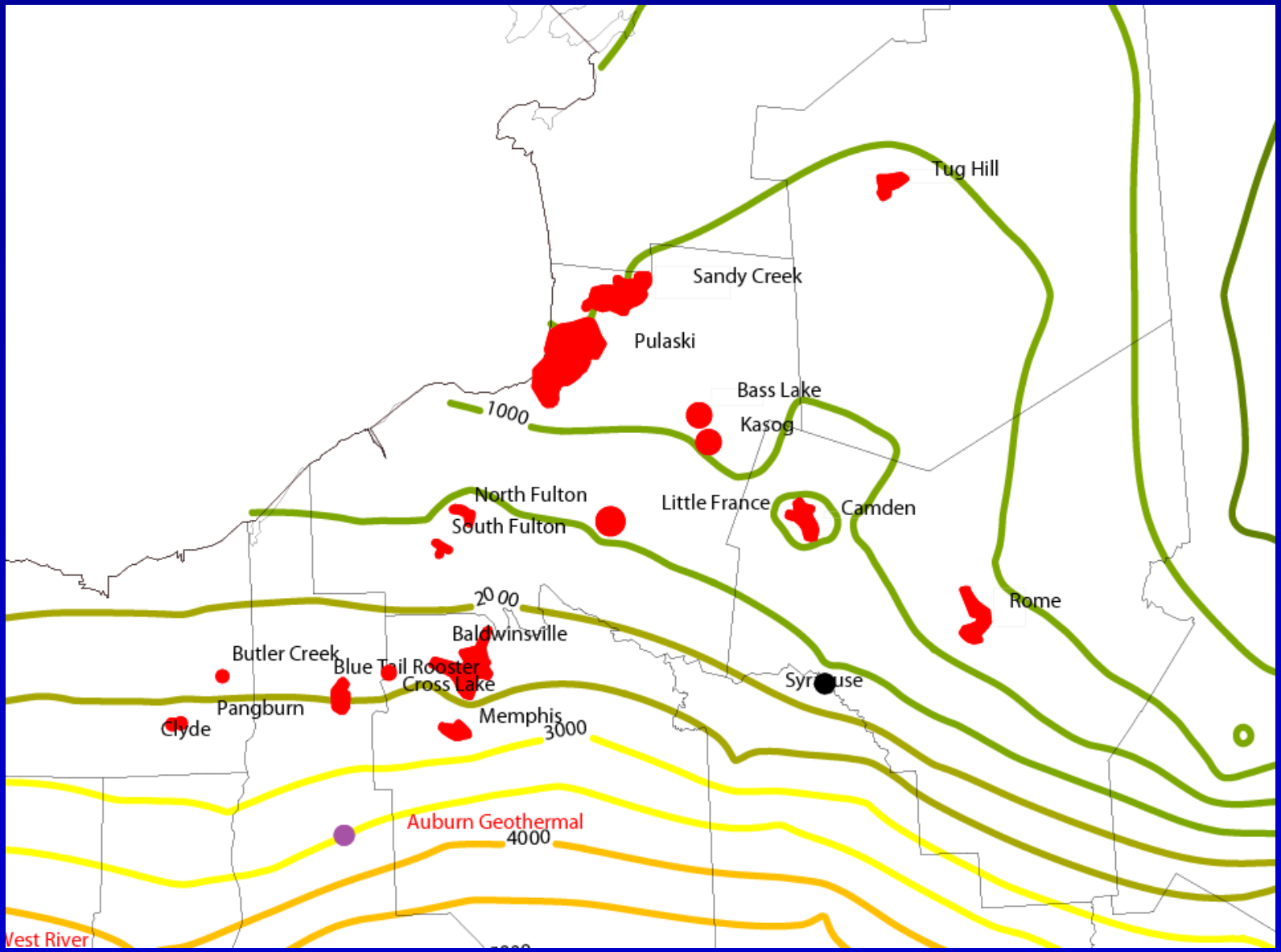


After a few hours or days, pressure declines, weight of overburden causes bedding plane to close, shutting down almost all flow of gas

Supporting Evidence

- 19-pound mud weight suggests at or near lithostatic pressure (20-pound mud is for pressures greater than lithostatic)
- In a compressive stress regime such as present day NY, least compressive stress near the surface is vertical and horizontal fractures are likely to form from overpressured gas or fluid
- At depth of ~3000 feet (1km), this changes so that least compressive stress is horizontal and vertical fractures are likely to form
- The reason this play does not occur at greater depths is because this transition has occurred

Trenton Structure Map

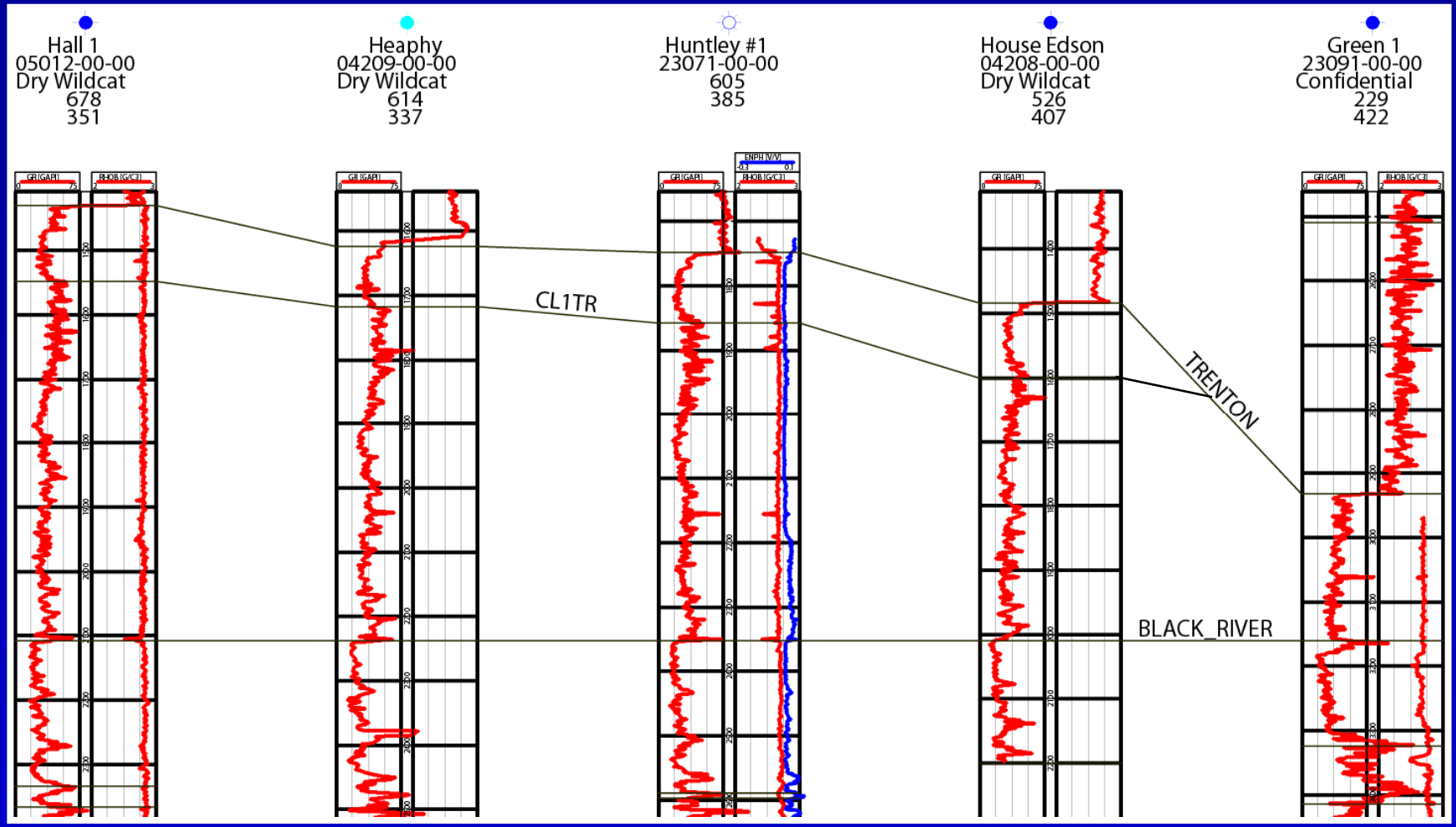


Top of Trenton in the southern part of the play is at <3000 feet

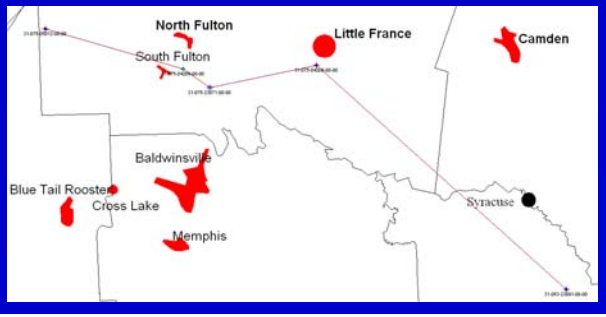
Play boundaries

- To the south the play is apparently bounded by the depth at which the least compressive stress changes from horizontal to vertical – where the Trenton is 2500-3000 feet deep
- The boundary to the east may be the pinchout of the clean limestone at the top of the Trenton that serves as a seal (Steuben Limestone Mbr)
- There are less fields to the west, this may be because the charge is to the east

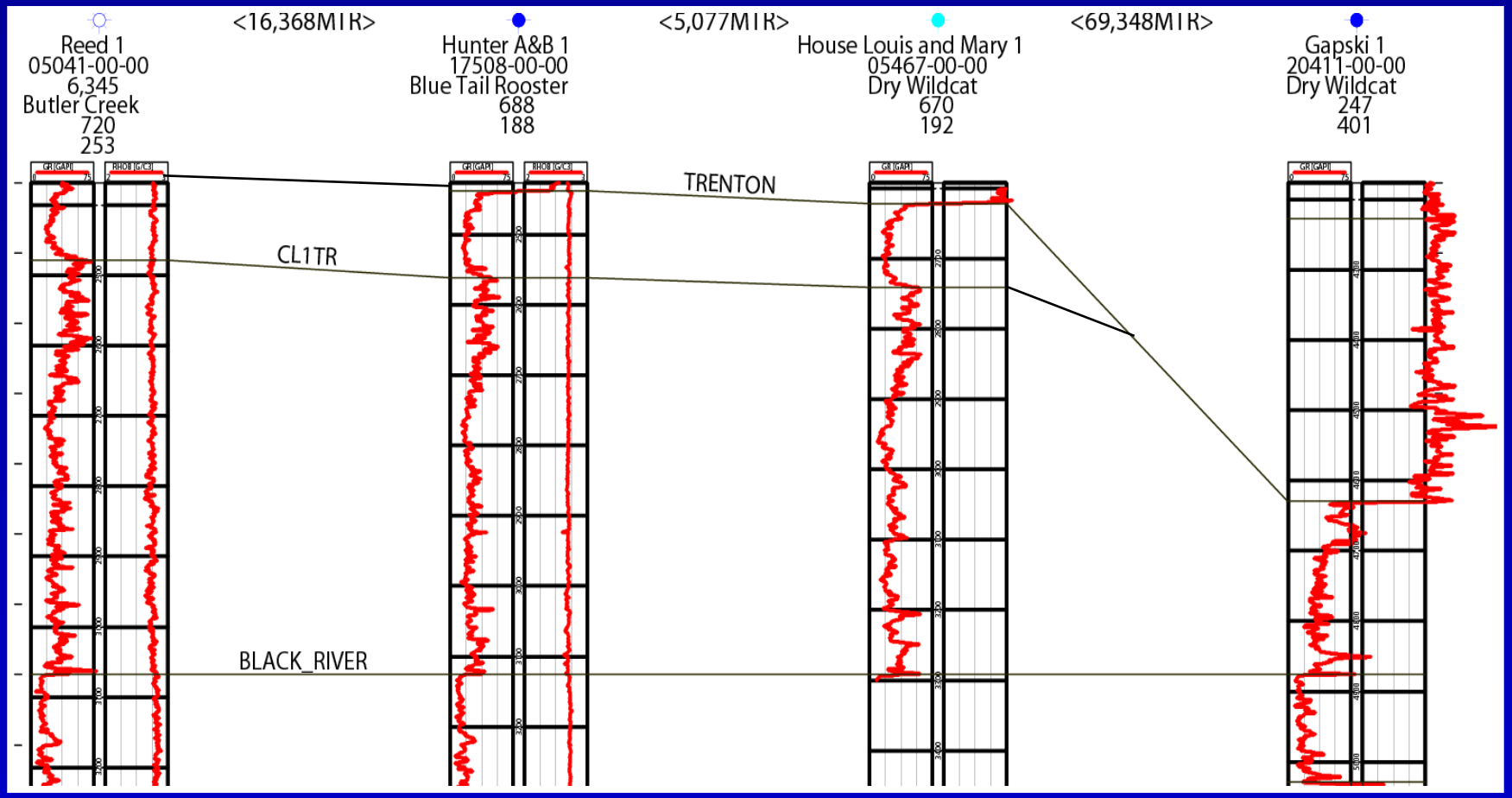
Central Cross Section



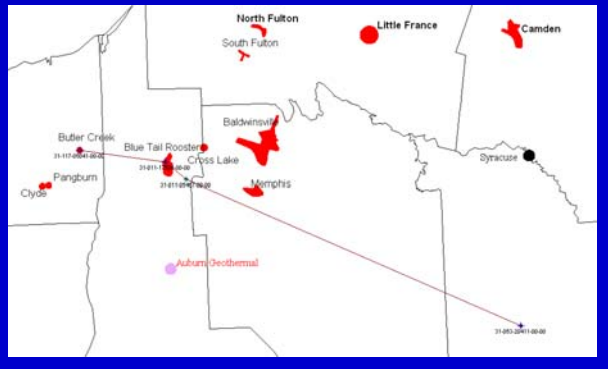
Steuben Limestone pinches out to the southeast

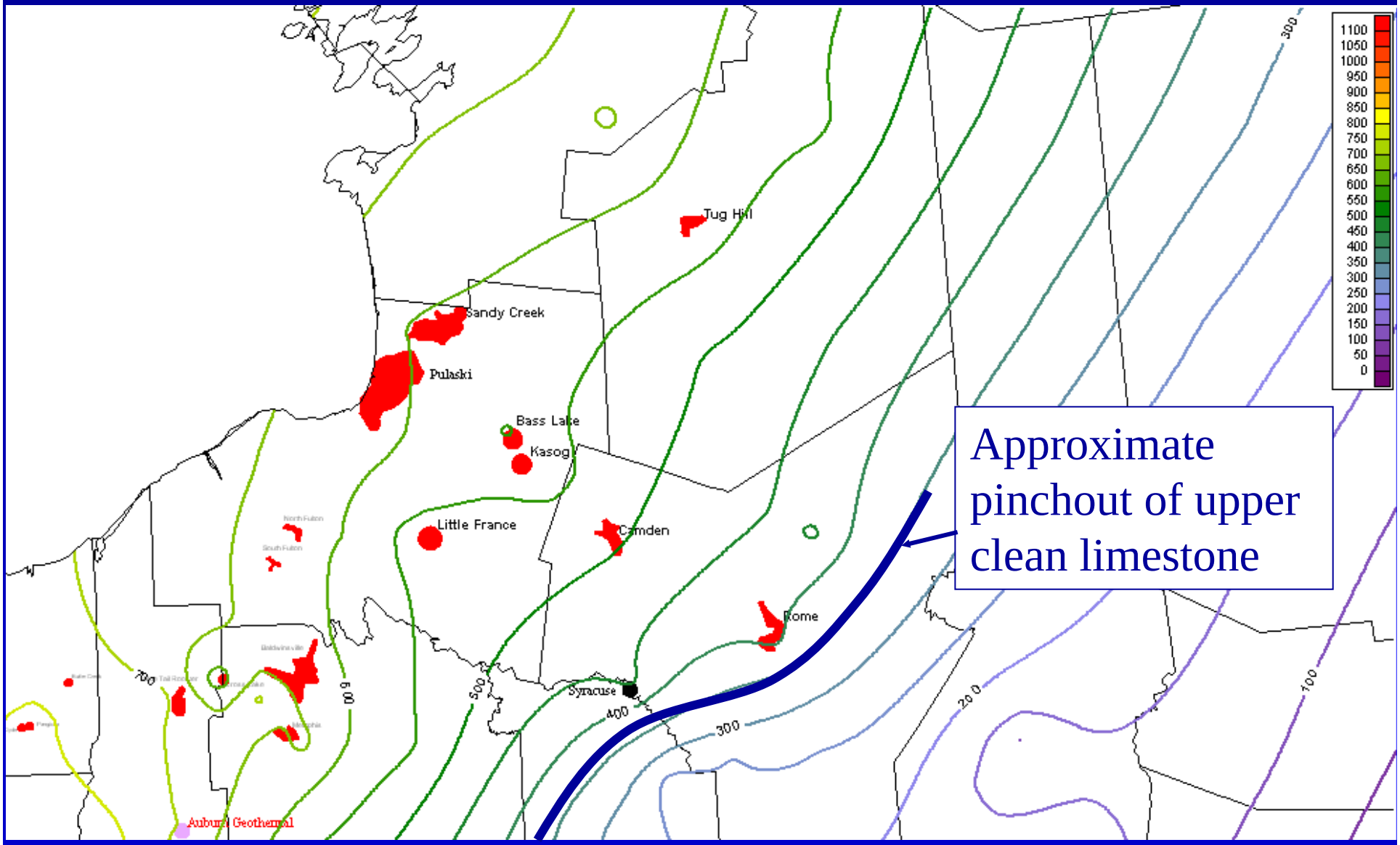


Southern Cross Section



Steuben Limestone pinches out to the southeast





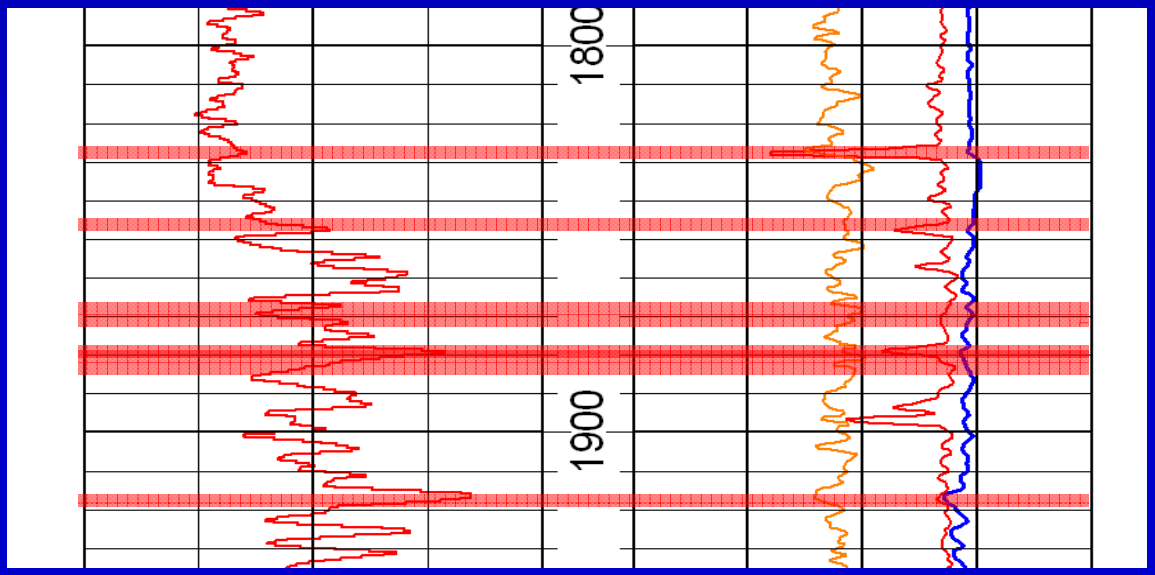
Trenton thins to the SE and the upper clean limestone pinches out – no fields to the east of this line

Source

- We initially thought that the source was organic-rich shale beds interbedded in the Trenton Formation
- TOC values from 10 of the sampled core plugs were too low to have been source rock
- Source may be lateral flow from Utica

TOC Values from Trenton

HGS No.	Depth (ft.)	Sample Type	Leco TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro
05-3072-122176	1846	swc	0.20	0.06	0.02	0.23	394	*	- 1.00	
05-3072-122177	1847	swc	0.24	0.08	0.04	0.21	-1	*	- 1.00	
05-3072-122178	1857	swc	0.07	0.02	0.01	0.15	-1	*	- 1.00	
05-3072-122179	1878	swc	0.21	0.05	0.07	0.20	305	*	- 1.00	
05-3072-122180	1880	swc	0.05	0.03	0.03	0.20	-1	*	- 1.00	
05-3072-122181	1890	swc	0.11	0.04	0.02	0.18	305	*	- 1.00	
05-3072-122182	1892	swc	0.02	0.00	0.00	0.00	-1	*	- 1.00	
05-3072-122183	1893	swc	0.06	0.02	0.00	0.11	-1	*	- 1.00	
05-3072-122184	1927	swc	0.08	0.03	0.01	0.08	-1	*	- 1.00	

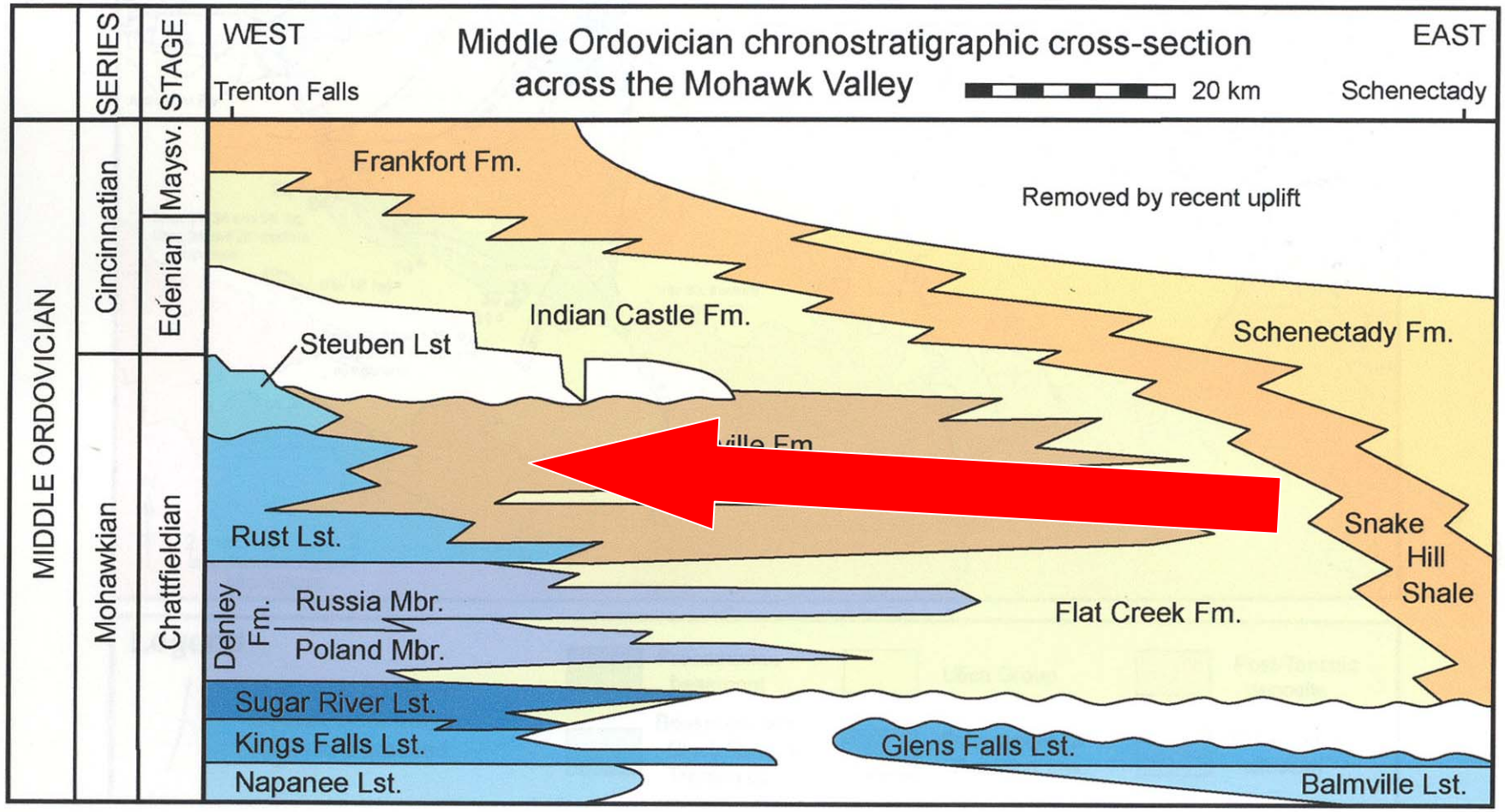


Generally low values

1846 & 1847
1857

1878 & 1880
1890, 1892 & 1893

1927

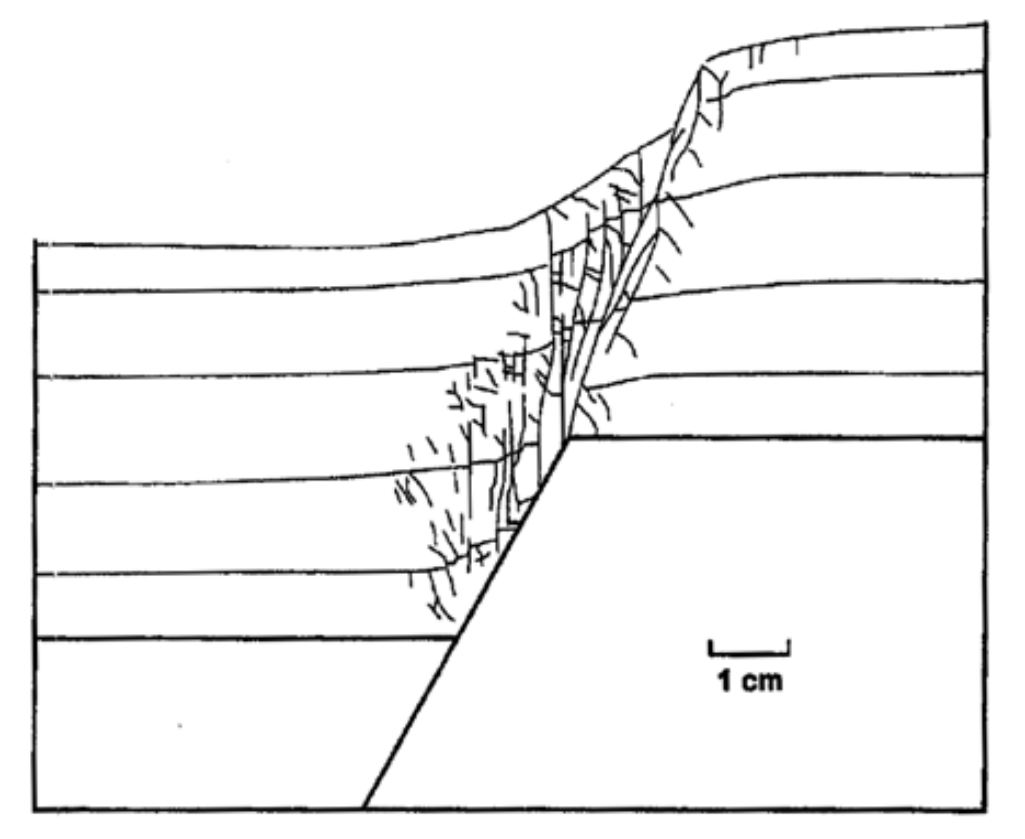


Steuben Limestone pinches out to east – Steuben is the clean limestone at the top of the Trenton – gas may migrate laterally from time-equivalent Utica Shale

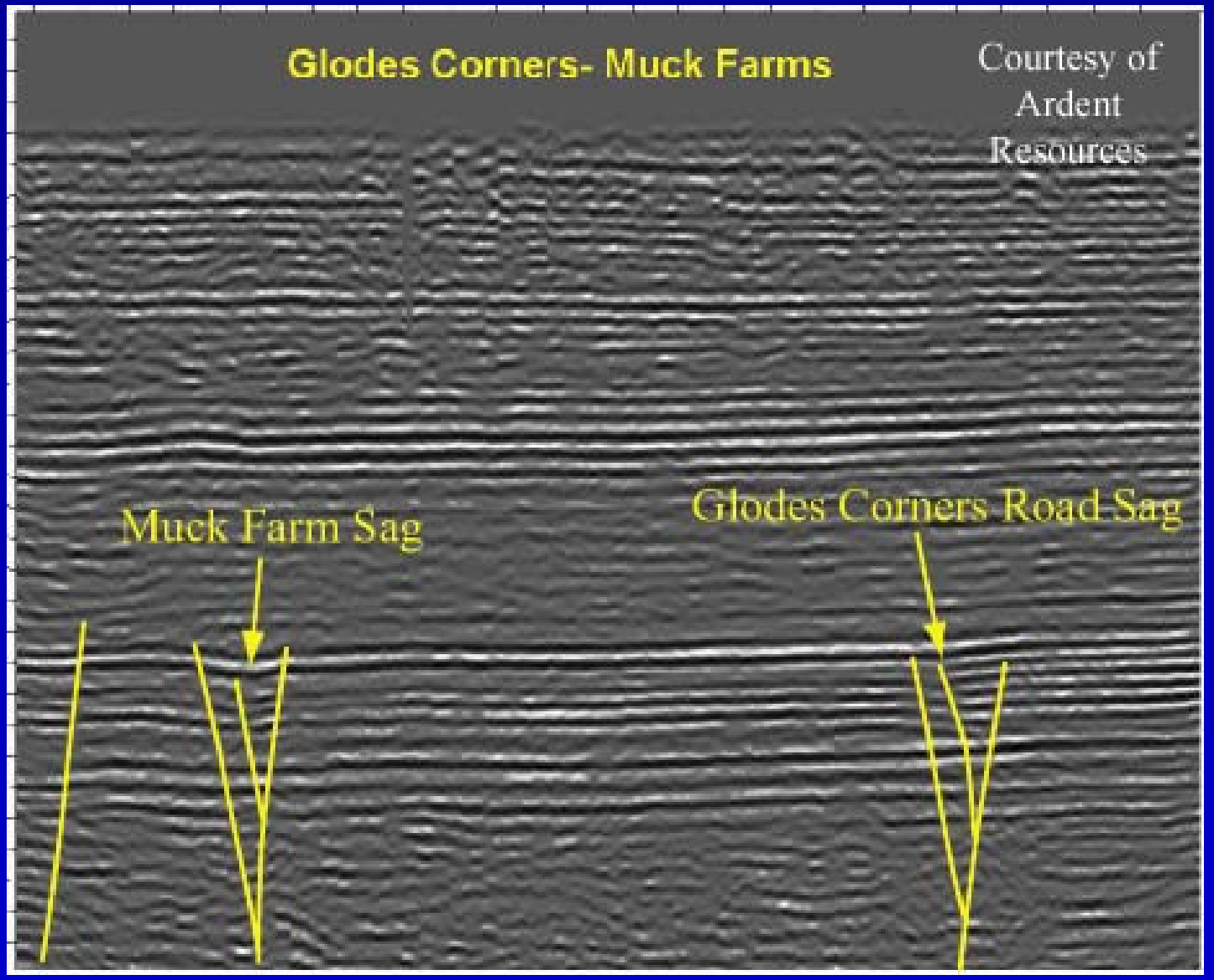
So is this an economic play?

- The wells that only penetrate the bedding plane gas are probably not economic
- Zagorski (2005) suggested that better prodcuing wells penetrate vertical fractures found on the downthrown side of faults
- Production in these wells may hold up at higher rates for longer periods of time
- Seismic and aeormagnetic data are reqired

Subsurface structures



Preferential formation of vertical fractures on downthrown side of normal or transtensional fault (from Witnjack, 1990 by way of Davies, 2001).



Zagorski (2005) showed a line where a better producing Trenton limestone well was located in a sag similar to those drilled in the HTD play – so keep on drillin' those lows!

Conclusions

- Not a hydrothermal dolomite play
- Not a matrix limestone play
- No evidence of significant vertical fractures
- Gas in most wells here interpreted to occur in open bedding planes or horizontal fractures held open by the high pressure gas
- Gas is either self sourced or may laterally come from the Utica
- Wells that penetrate vertical fractures may be economic

Acknowledgements

- John Martin, NYSERDA
- Scott Gorham and Cary Kuminecz, and others at Seneca Resources
- William Zagorski, Great Lakes Energy