Statistical Approach to Interpreting Clear Fork Zones for Perforation in Old Wells, Sharon Ridge Field, Texas*

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Abstract

The Bluff Creek area is part of the Sharon Ridge Field in Scurry County, Texas, and is comprised of 23 producing wells, 1 injection/disposal well, and 7 plugged wells operated by H.P. Slagel Producing Company, LLC. Management is with a third generation family member but with less historical well data available than desired. Obtaining logs and other information was of initial concern.

The Sharon Ridge Field produces from Clear Fork, San Andres, and Wichita-Albany zones and dates to 1923. Other wells in the region produce from Wichita-Albany, Wolfcamp, Cisco, Canyon, and Strawn. Slagel production is from upper and lower parts of the Clear Fork; opportunities also exist for Glorieta and San Andres production. Bluff Creek production increased at various times from in-fill drilling along with suspected secondary recovery from specific wells. Recent production is over 1,900 barrels per month.

While logs were not found for all of the wells, many had GR-N logs from 1979 and mid-1980s. Some older logs had footage marked where perforations had been conducted. Other logs had no such markings, though scout cards/tickets usually listed upper and lower boundary for the producing zone. Thus a statistical method was needed for comparison and identification of other possible zones within the Clear Fork based on available GR-N log suites and the known perforated zones. The GR curve defined the percent "shale" within the Clear Fork in 5% increments. The lowest porosity value used was 2% and the highest was

30% for scaling purposes. Limestone porosity was used due to most logs scaled in limestone units. Identifying exact lithology would alter the porosity up or down depending on whether the zone was sandstone or dolomite. This detailed work was not necessary for this statistical analysis.

Four zone categories were defined. The first, classified as “marked”, were zones originally perforated for production when the well was drilled. These zones are in green on cross sections along with matching shale-limestone porosity percent pairs. The second category showing only the upper and lower production limit was called “estimated”. Location of potential perforated zones was chosen based on correlation of cleaner GR with higher porosity and were marked in blue. The third category was called “interpreted”. This category (in purple) represents every other location within the log where a porous and cleaner zone correlates. The fourth category (“projected”) represents producing zones defined by scout cards in three Anadarko wells (colored red) used in a cross section.

A statistical approach to qualify the most likely zones to look at based on known perforated zones had paired shale-limestone porosity percent values counted and plotted as bubble plots. These values were then contoured to visually determine the highest density of paired values. By studying the contoured values, a range of shale and limestone porosity values was suggested that defined the highest paired density. This range of values was then used to choose interpreted zones with paired percent values within this same boundary range.

Active older wells and older fields exist in abundance within the Permian Basin, many of which lack the more modern log suites that developed in the 1990s. The majority of these wells are vertical (409,251), rather than horizontal (16,281) or directionally drilled (4,931). Innovative techniques such as statistical analyses can help in the interpretation process when minimal data is available and used to filter various potential zones into most probable zones based on existing perforated zones in producing wells.

Statistical Approach to Interpreting Clear Fork Zones for Perforation in Old Wells, Bluff Creek Area, Sharon Ridge Field, Scurry County, Texas

E2C

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Sterling 1-1

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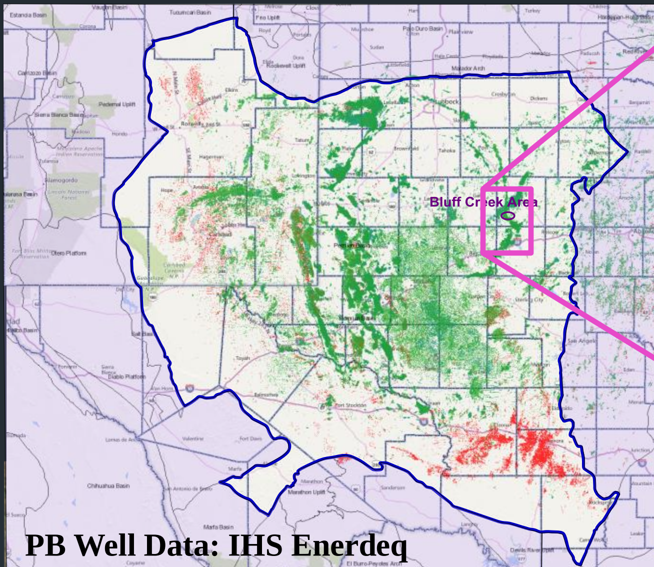
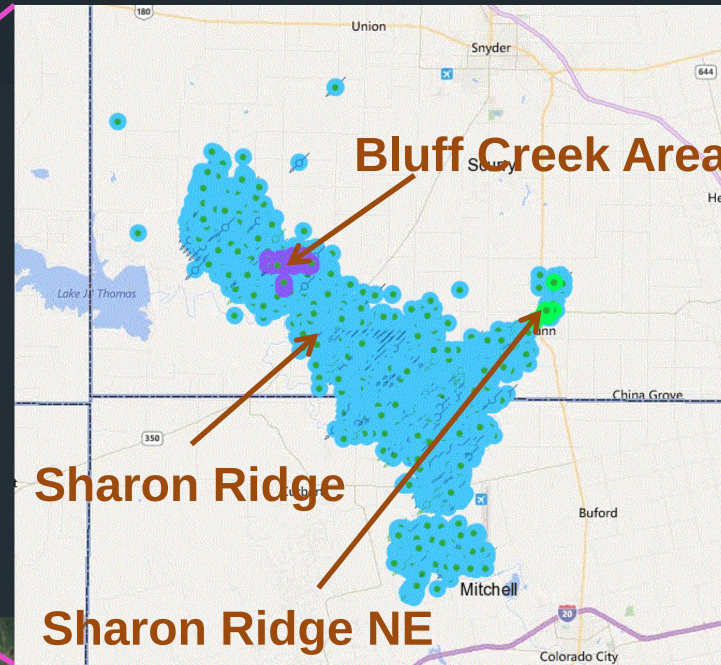
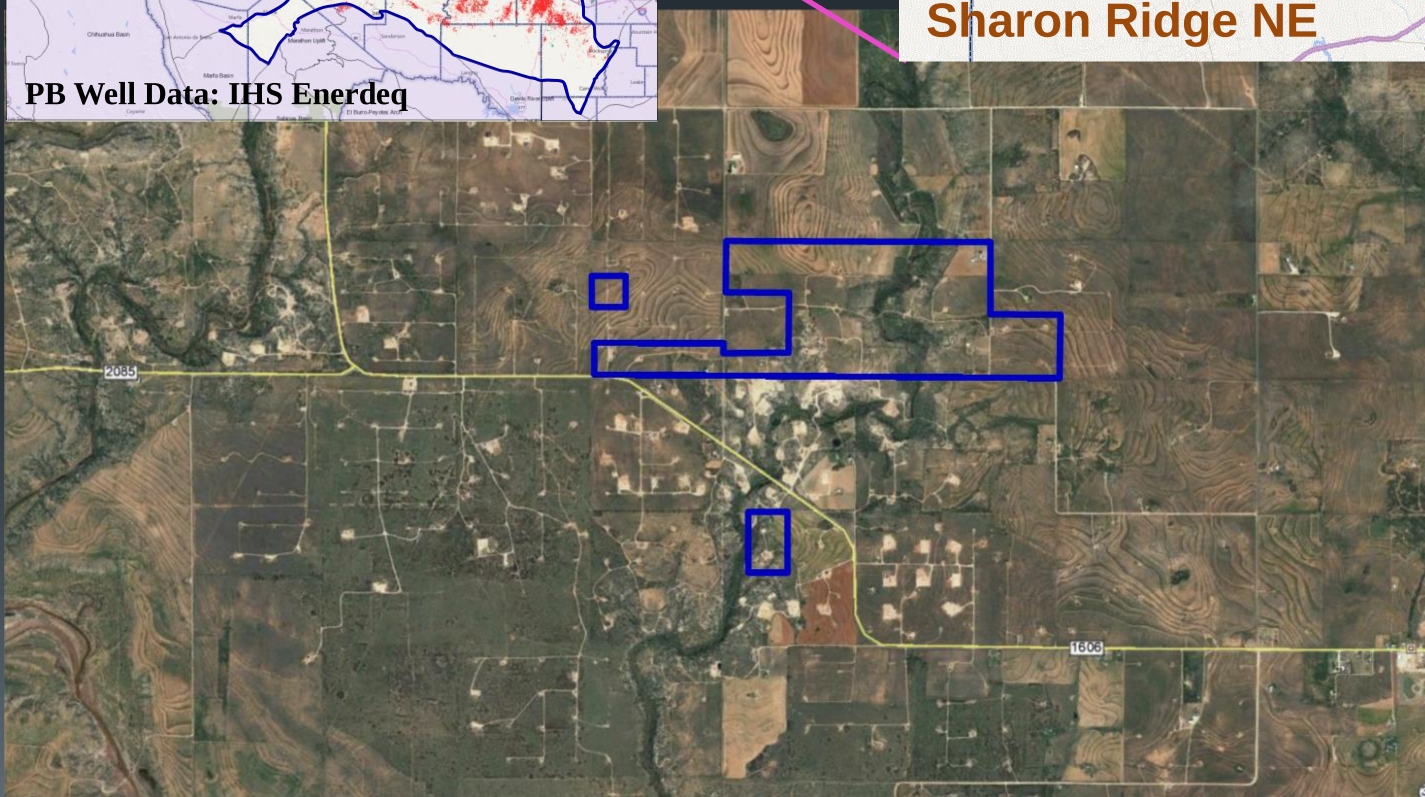
AAPG 2017 Southwest Section Meeting
Horseshoe Arena, Midland, TX

Monday, May 1, 2017
Afternoon Session, 1:15 – 1:35

Regional Setting







Bluff Creek has 23 producing, 1 disposal, and 7 P&A'd wells operated by HP Slagel Producing Co., LLC. within the Sharon Ridge Field of Scurry County.

394 Surface Acres.

65 BOPD from Clear Fork.

Historical Setting

Sharon Ridge

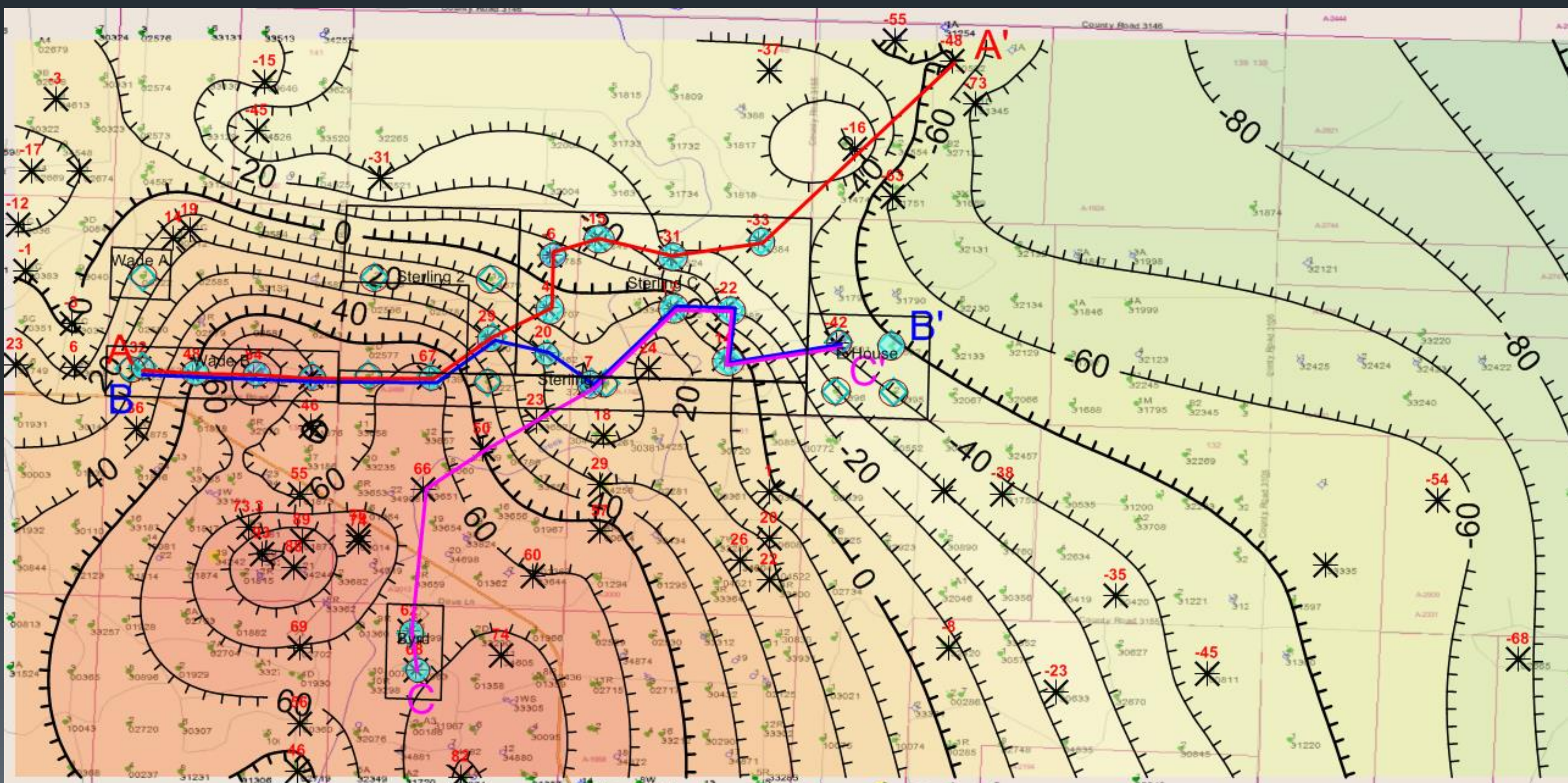
1) The earliest Sharon Ridge Field completion date listed through IHS Enerdeq is October 1923, while the first production start date is listed as July 1935.
2) A total of 6,096 wells comprise Sharon Ridge Field, with three producing zones listed:
   a) Clear Fork – 1,303
   b) San Andres – 4,784
   c) Wichita-Albany/Lm – 9
3) Total production: Oil = 107,384,690 bbls Gas = 2,643,455 mcf Water = 371,601,119 bbls

Bluff Creek Area

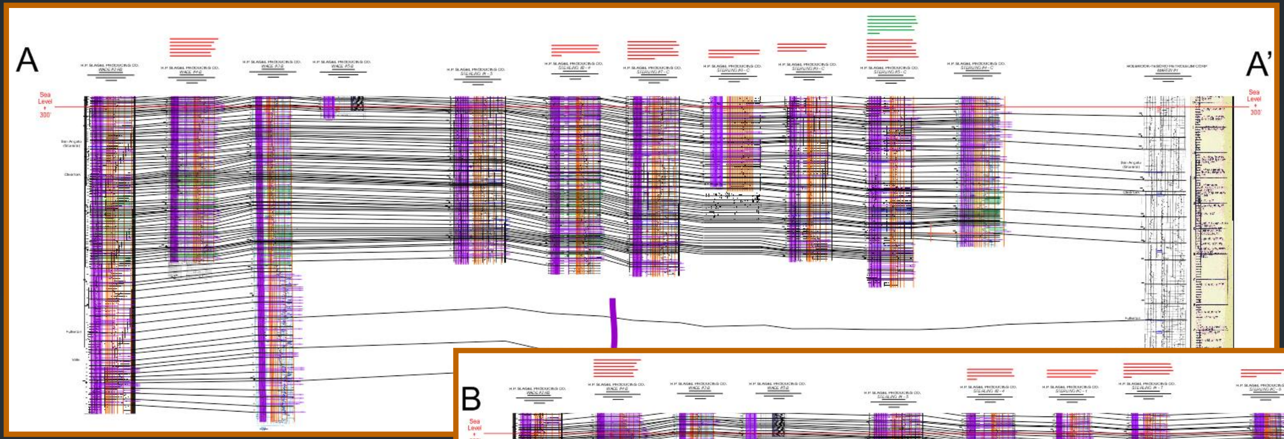
1) The oldest well of the Bluff Creek area dates to 1939, with several additional wells dating to 1942-44.
   a) These wells were eventually acquired by H.P. "Cap" Slagel in 1954.
2) New wells were drilled by HP Slagel Production from 1972 through 1985.
3) Presently managed by grandson.
   a) Updated surface facilities, and restoration of various well bores.
   b) Acquired improved historical well data along with expanded geologic information.
4) Total Clear Fork (upper with some lower) oil production since 1942 is over 1.3 MMbbls.
   a) About 1,900 BOPM.

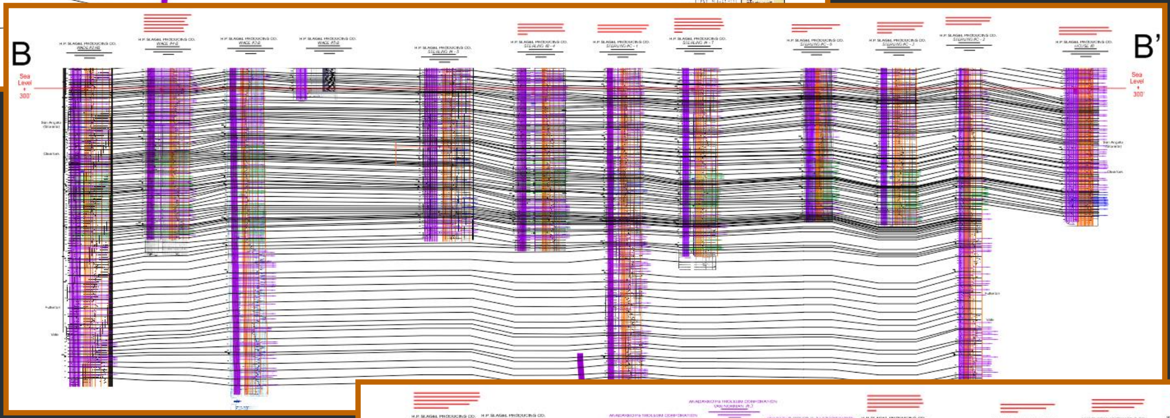
Bluff Creek Geology

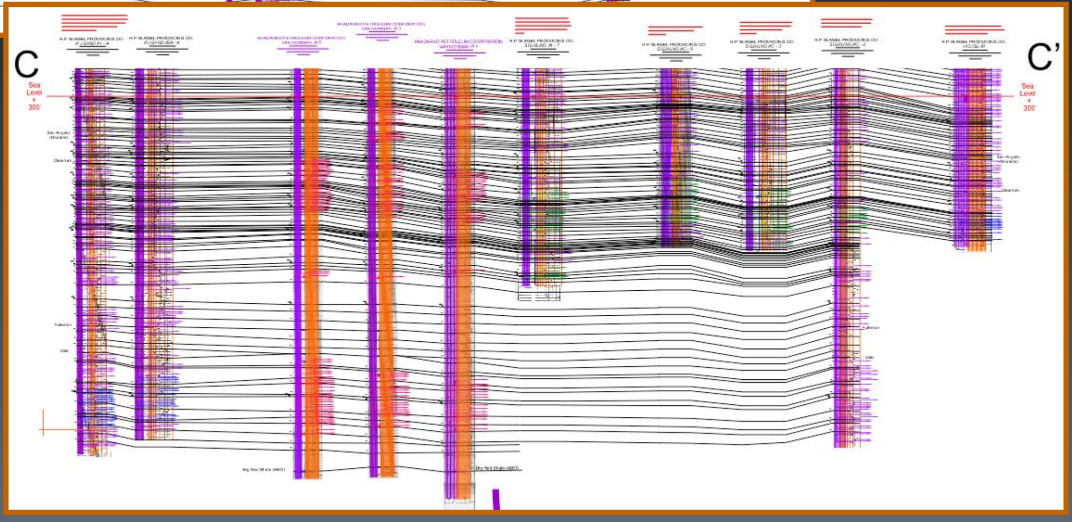
Structure contour map on top of Clear Fork (CLF) at 10’ CI. Software used is Surfer from Golden Software using a Kriging algorithm. Wells shown in blue are the HP Slagel Production wells of Bluff Creek. Areas shown in black boxes are HP Slagel acreage. Three cross section locations through these wells are also shown on map. GR-N logs were available for most but not all of the Slagel wells.



Bluff Creek Geology

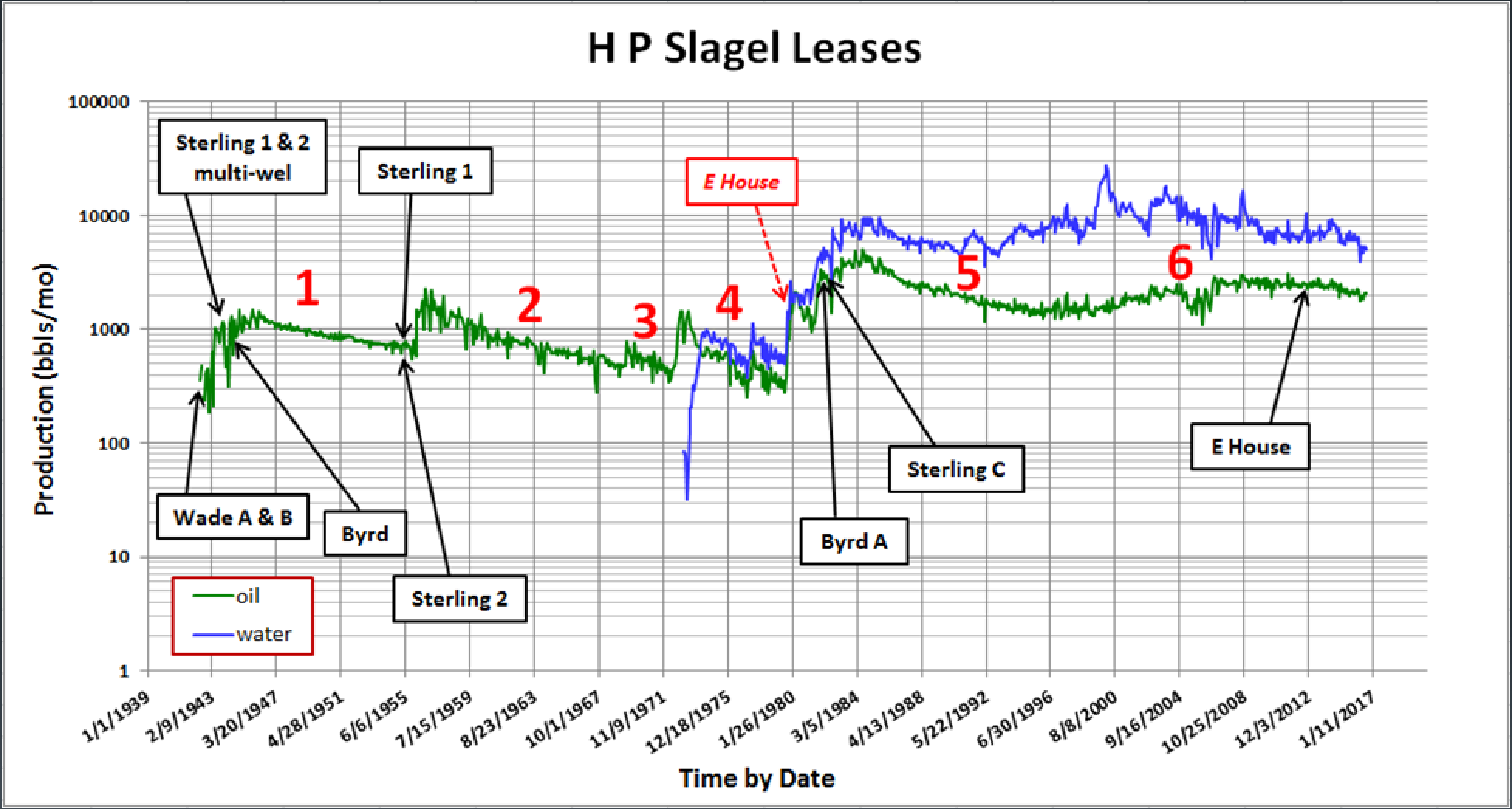






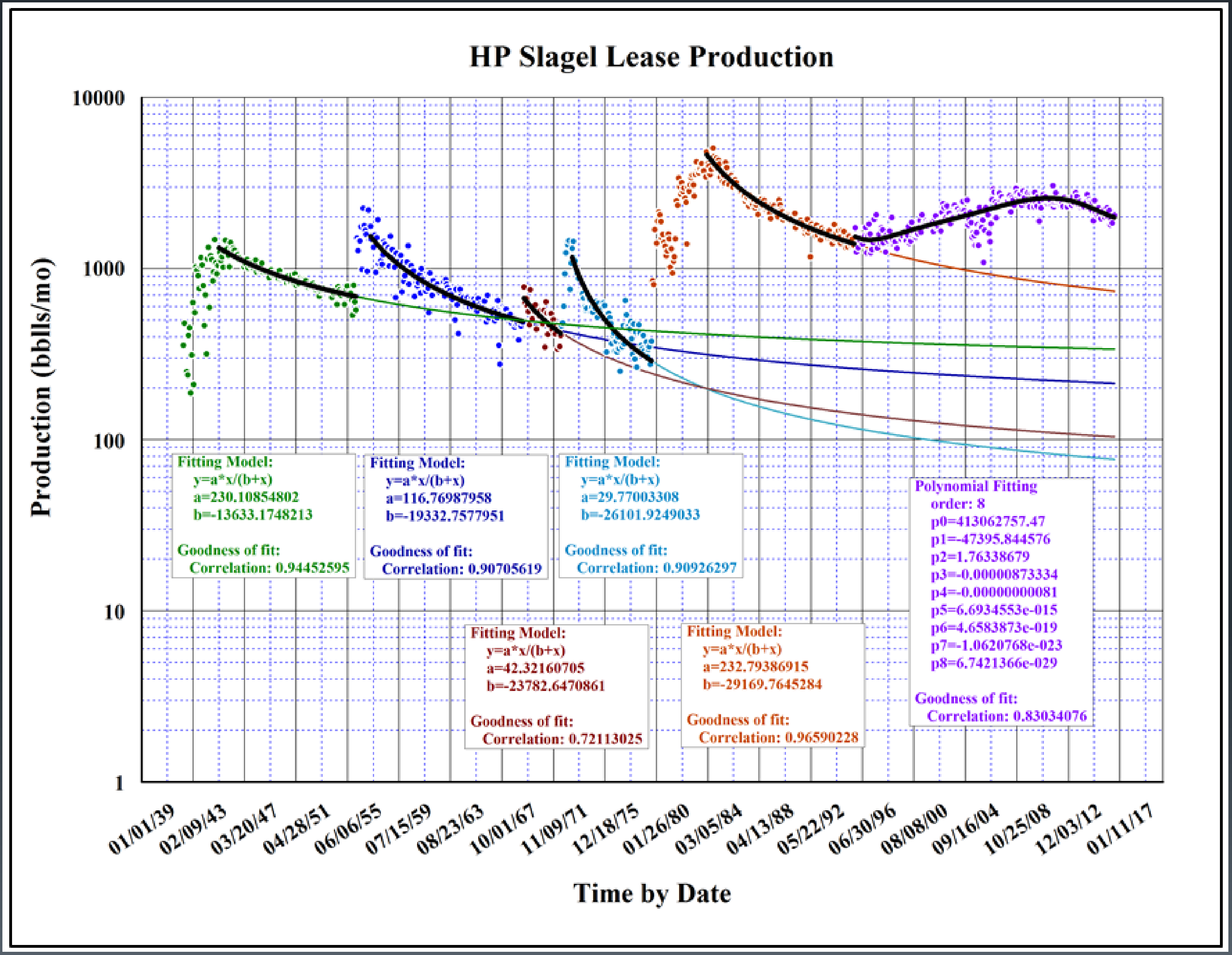
Cross sections built for interpretation of Bluff Creek wells. These show CLF, Glorieta, and lowest San Andres, and are hung at a depth of 300 feet above sea level. The vertical purple line marks location where two cross sections intersect, A-A' with B-B', and B-B' with C-C'. All logs are HP Slagel wells except for three deepest wells (Anadarko [Apache]) on C-C'. Most wells drilled to 2500-2600 ft though a few went to 3100-3200 ft.

Bluff Creek Production



Graph showing historical production of Bluff Creek wells along with general timing of activity within the leases operated by HP Slagel Producing. Production data derived from IHS Enerdeq and old RRC production reports. Gas production is in the 1 mcf/mo range and is not displayed. Several wells have seen affects from offsetting water injection, indicating secondary recovery viability.

Bluff Creek Production

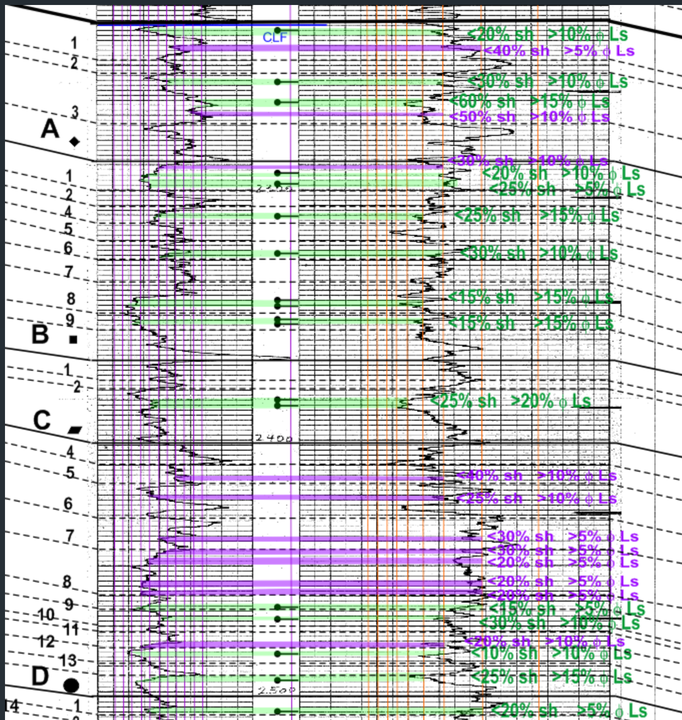


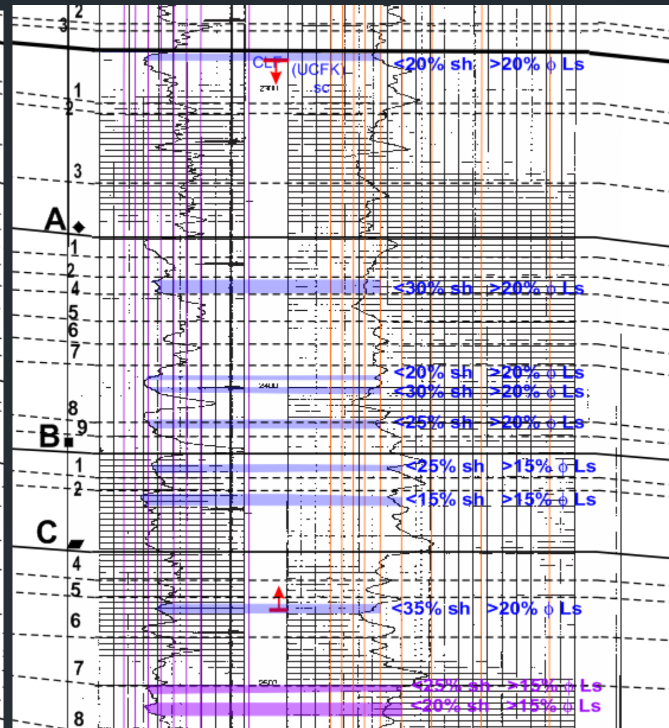
Possible decline curve analyses at various time periods during the lifetime of the Bluff Creek wells.

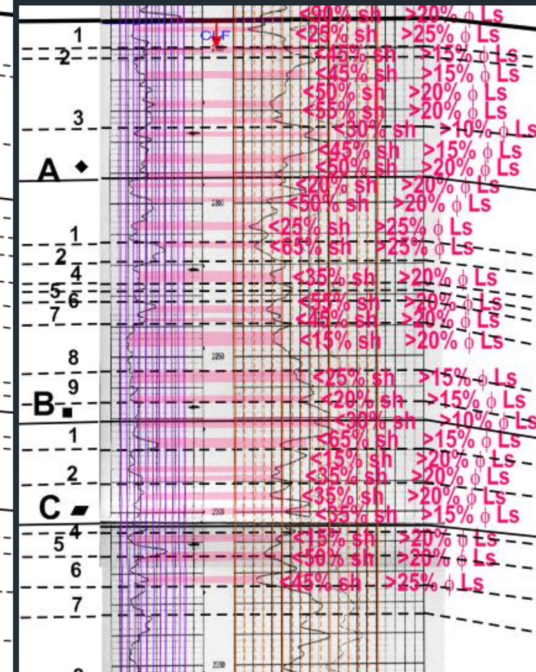
Changes reflect new drilling, production decline in specific wells, and possible workovers.

Changes also reflect more recent probable secondary recovery benefit.

Wells & Data Statistics







The top of CLF from one sample log, scout cards, and scout tickets did not always agree. Once a top for CLF was decided upon, this call along with others labeled in alpha-numeric fashion were traced in all of the wells used. GR curve used to define % "shale" and N curve used to define % "limestone porosity".

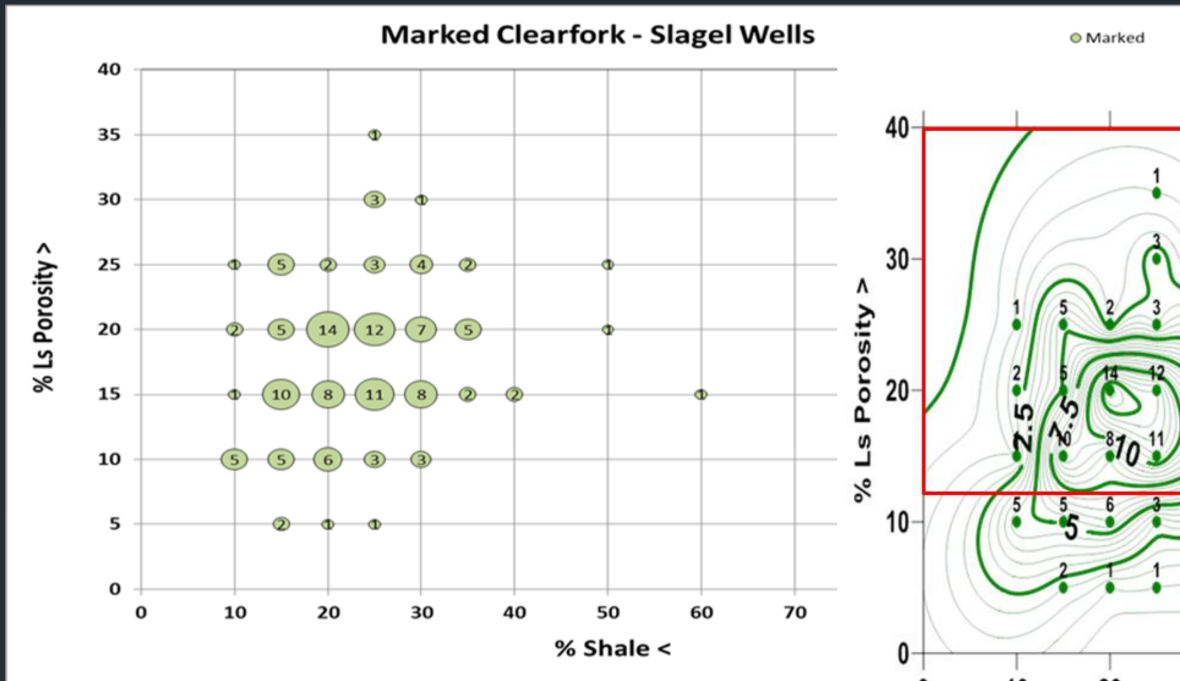
Green = "marked" category where original perf depths were known.

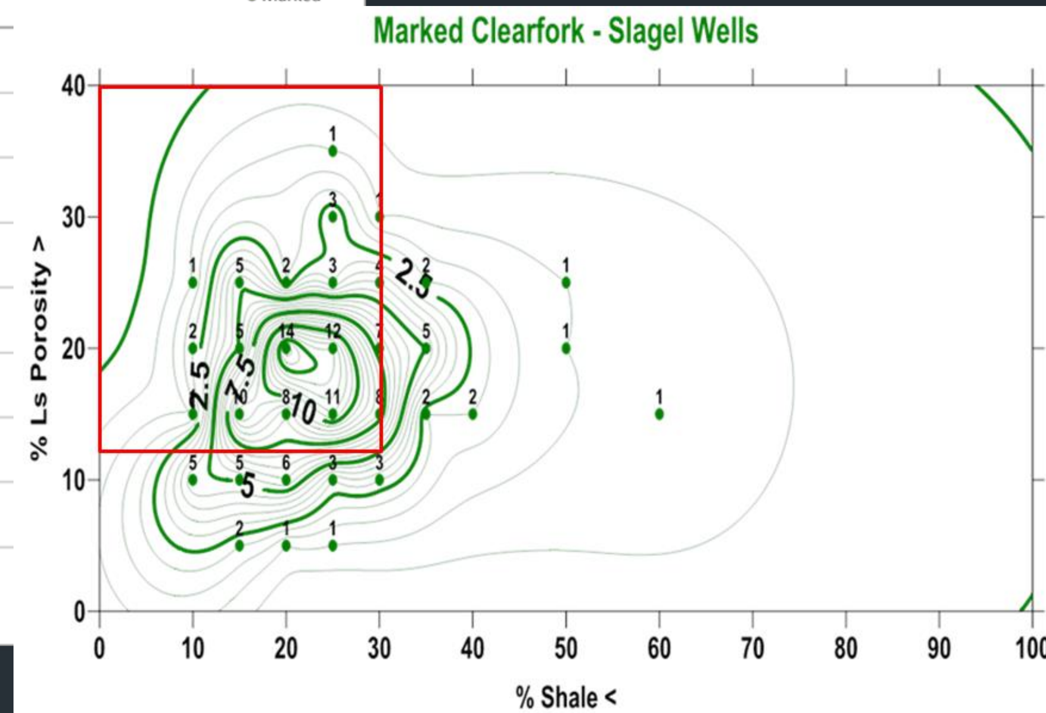
Blue = "estimated" category where only top and bottom of a production depth interval was known and cleaner zones correspond with higher porosity.

Purple = "interpreted" category are zones where cleaner zones correspond with higher porosity and were not perfed in the perf zone or are outside the perfed interval but have similar clean-porous values.

Red = "projected" category was used for three Anadarko (Apache) wells where top and bottom of producing zone is listed and clean-porous zones were observed.

Upper CLF Statistics

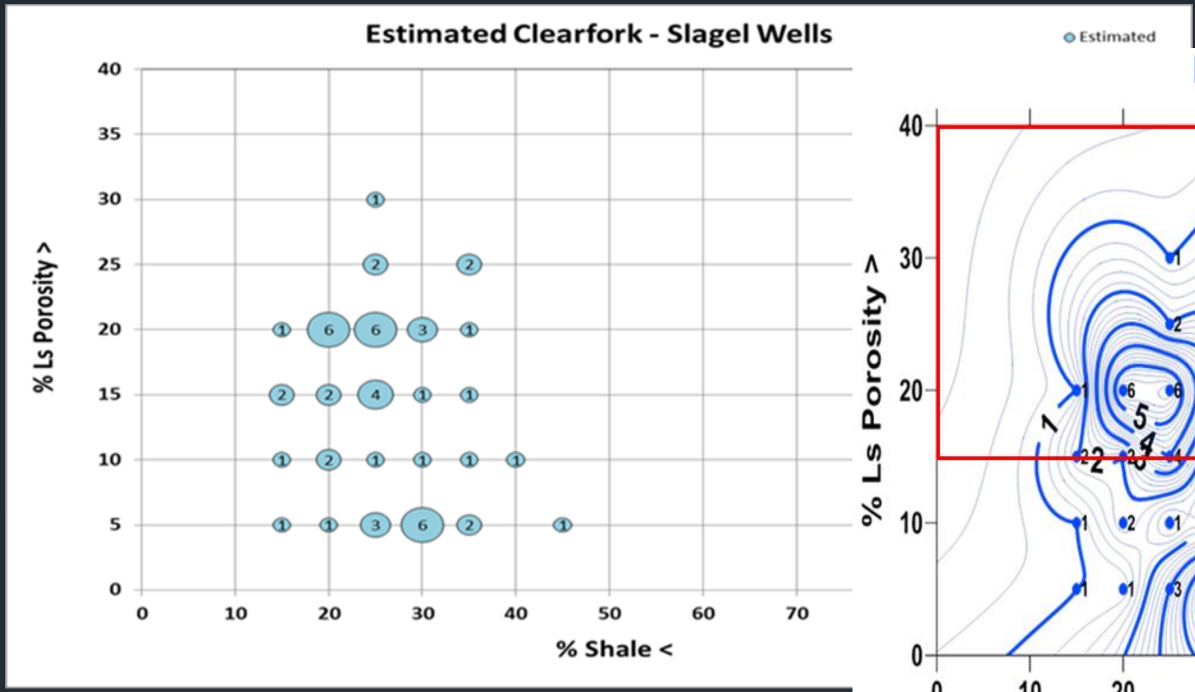


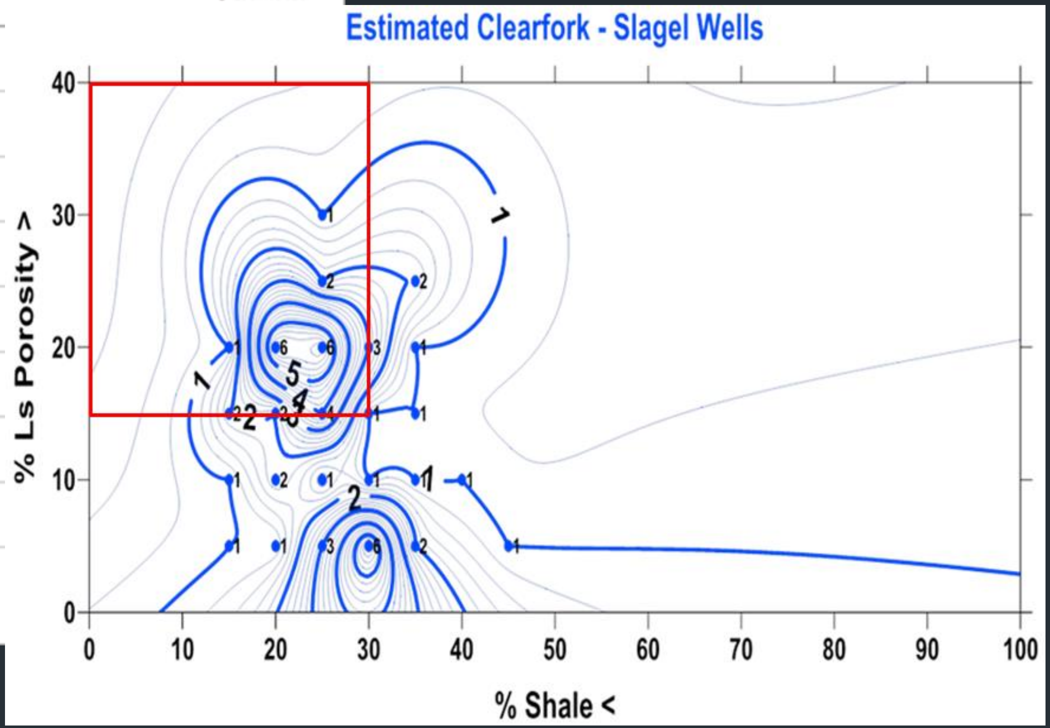


Bubble plot on left of the "marked" perfed zones in 9 wells showing the number of times each pair of % shale-porosity value occurs within the 9 wells of the cross sections. Contour map gives a 3-D depiction of the paired values in the bubble map. Contour lines represent the number of times that shale-porosity pairs of a certain value are found. The black numbers next to each dot represents the same number found within the circles of the bubble plot. It is not known which perfs actually produced.

Highest density clustering is around a maximum value of 20% shale-20% porosity. How far from this % pair should one go for choosing shale-porosity pairs? Visual inspection used to identify greatest slope in contours and defined by the red box, with "shale" content ≤ 30% and limestone porosity ≥ 12%.

Upper CLF Statistics

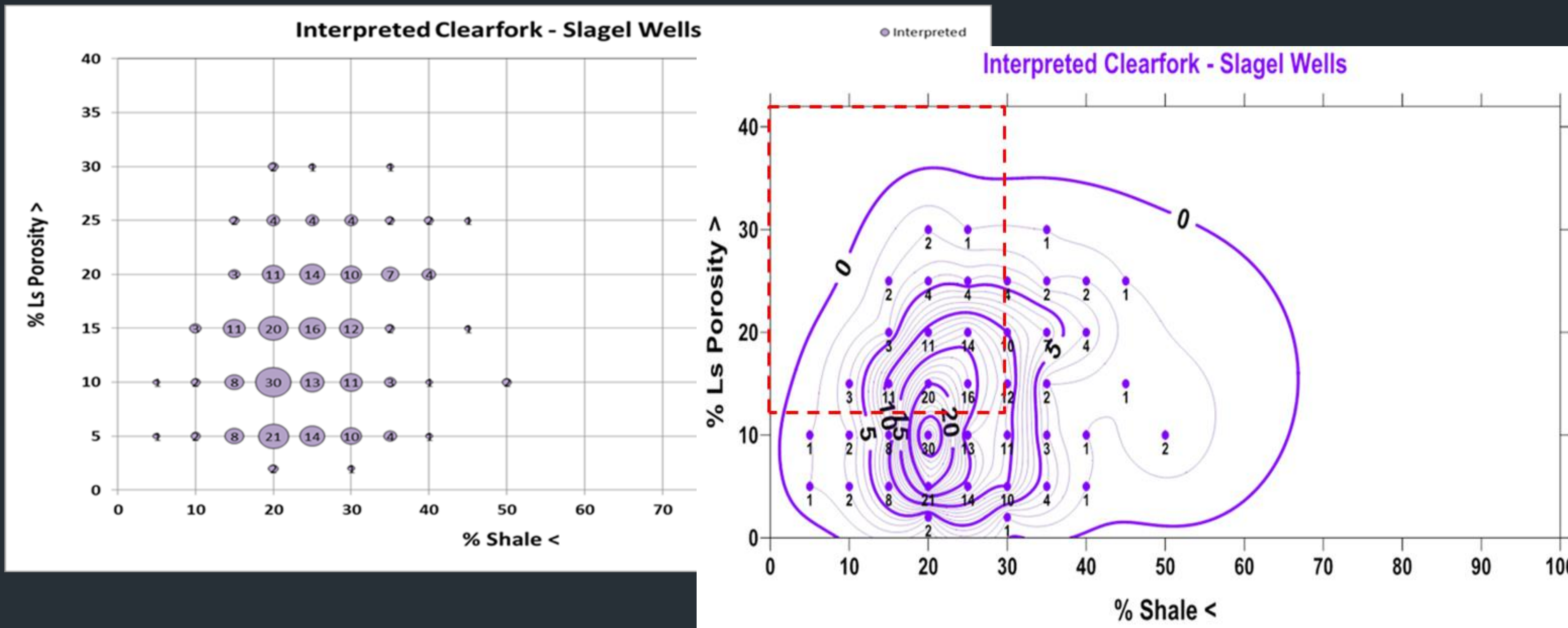




Bubble plot on left of the "estimated" perfed zones in 6 wells showing the number of times each pair of % shale-porosity value occurs within the 6 wells of the cross sections. Contour map gives a 3-D depiction of the paired values in the bubble map. Contour lines represent the number of times that shale-porosity pairs of a certain value are found. The black numbers next to each dot represents the same number found within the circles of the bubble plot. Only the top and bottom of produced depth range is known.

Two areas of concentration identified: 20-25% "shale"-20% porosity; 30% "shale"-5% porosity. Upper peak nearly the same as for "marked" zones, and thus represents the most likely area of zone pairs that would be expected to produce oil. Red box on steepest contours suggests ≤ 30% shale but ≥ 15% porosity.

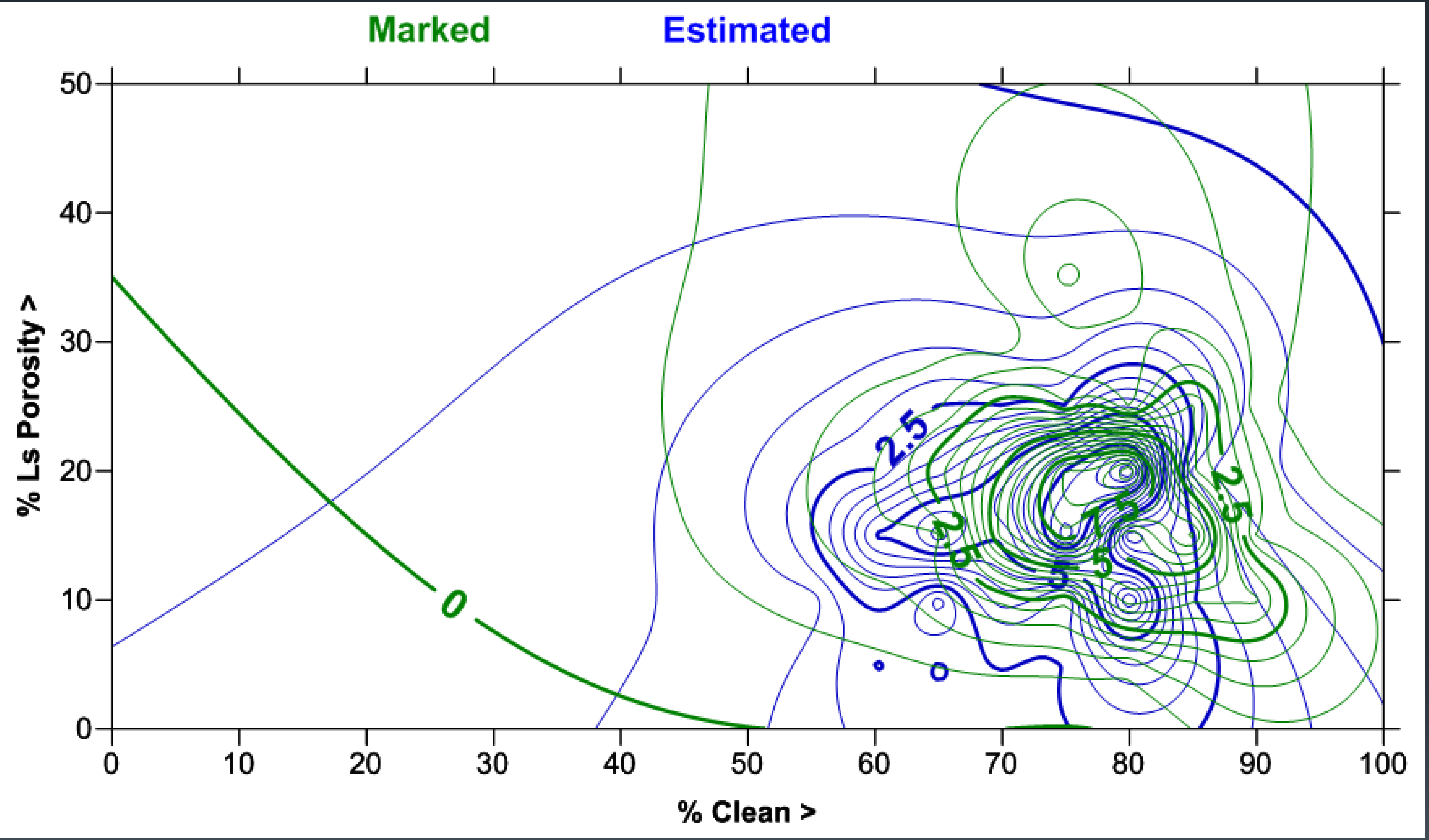
Upper CLF Statistics



Bubble and contour maps were done for all 15 wells in "interpreted" zones where GR-N curves showed deflections to the left (clean zones and higher porosity) but were not perfed for production. Highest data concentration occurs at 20% "shale" and 10% porosity.

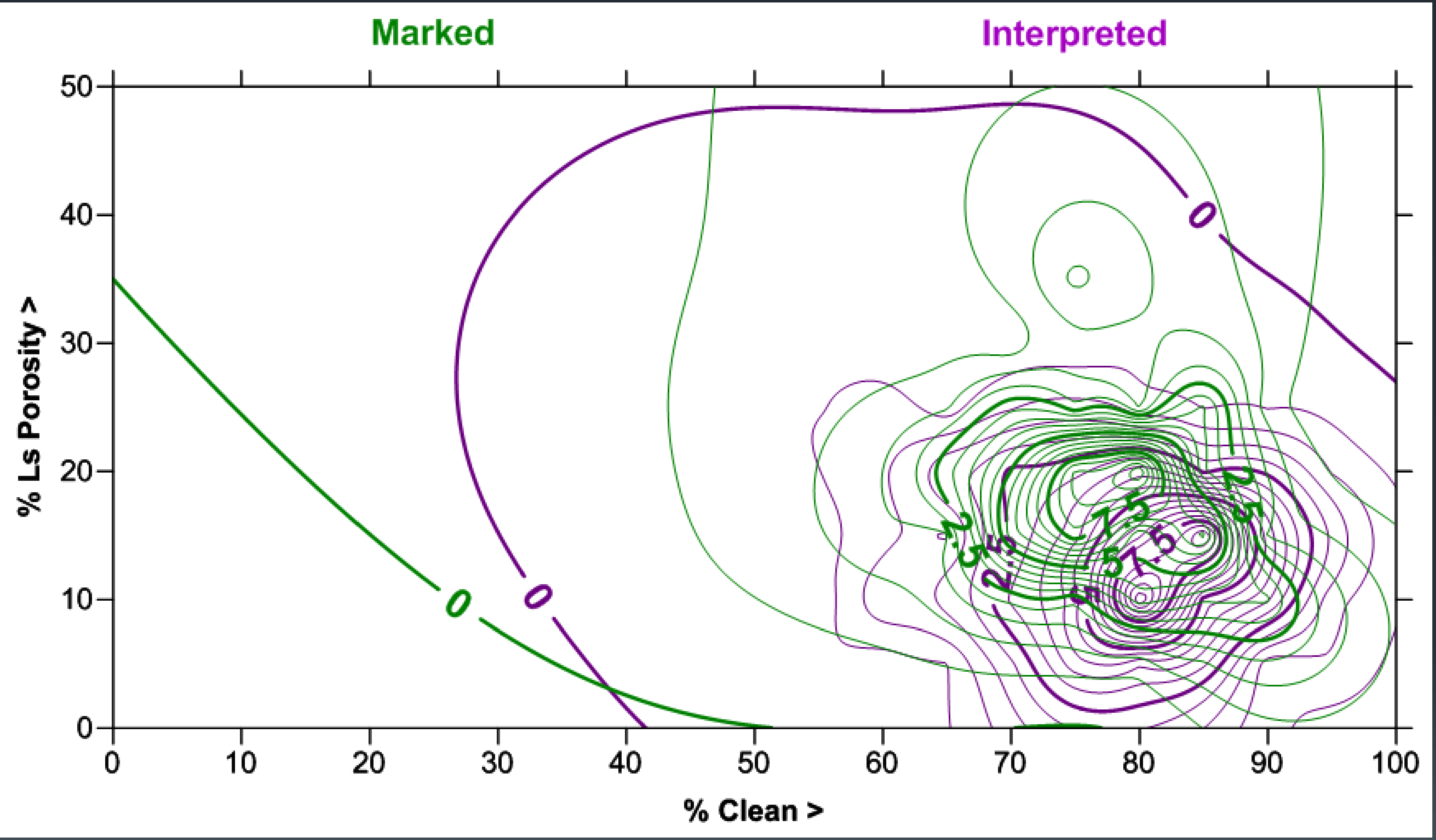
Red dashed box is a combination of the highest % shale ("estimated" category) and the lowest % ls porosity ("marked" category). Suggests that no zone > 30% "shale" should be considered for future perfs. Best comparison of data is through an overlay process.

Upper CLF Statistics



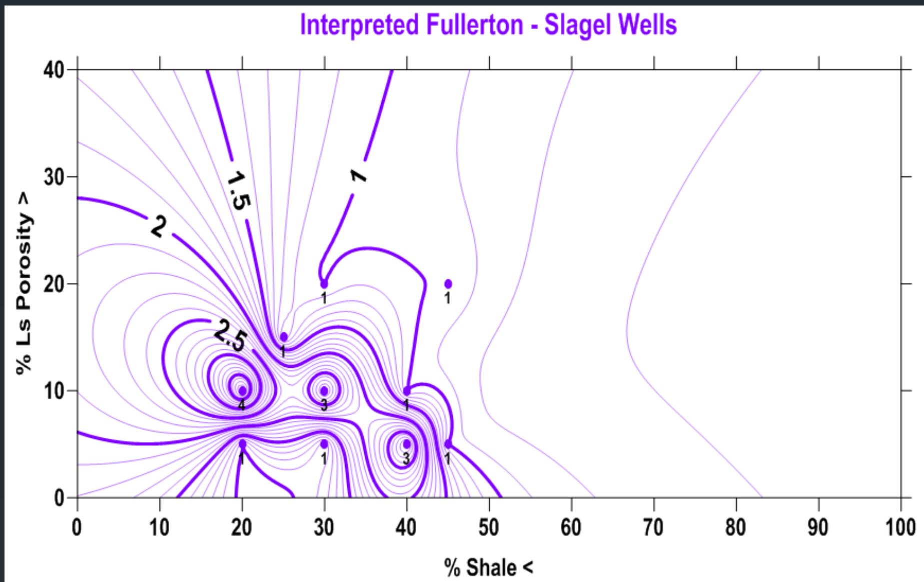
Overlay of the "marked" and "estimated" clean-porous data pairs. Contours now represent the % corresponding to the number of times a % clean-% porous data pair occurs. These two data sets display a strong concordant overlay, suggesting that the "estimated" zones were most probably the zones perfed within the upper-lower bounds of the perfed footage.

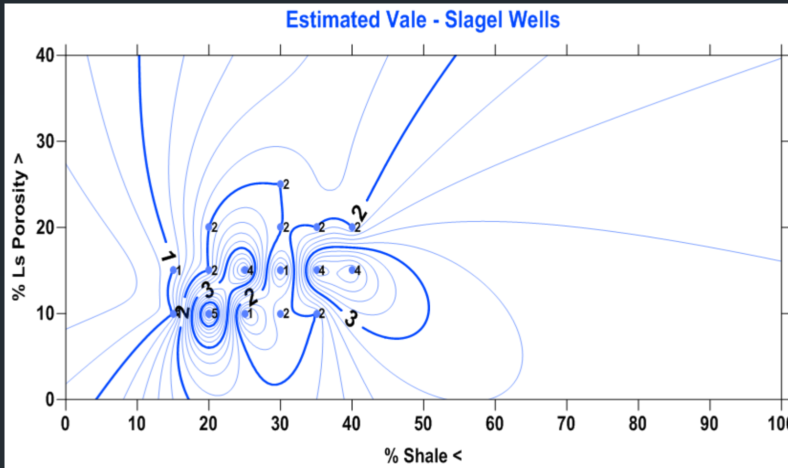
Upper CLF Statistics

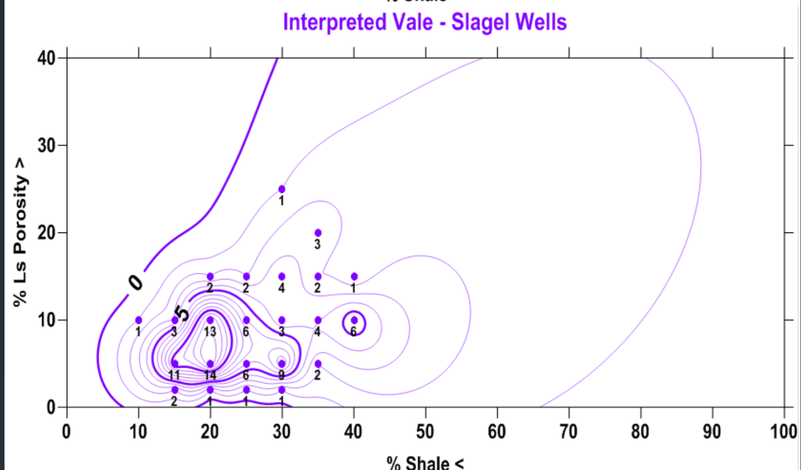


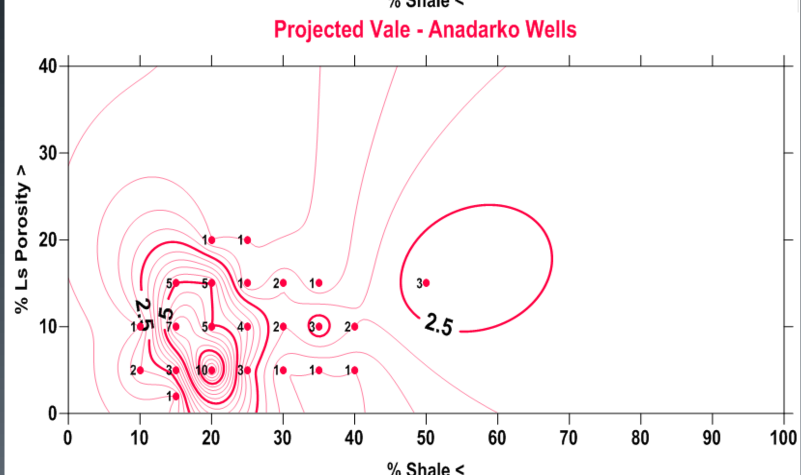
Overlay of the "marked" and "interpreted" clean-porous data pairs. Contours now represent the % corresponding to the number of times a % clean-% porous data pair occurs. These two data sets display a less concordant overlay, suggesting that not all of the "interpreted" zones should be considered for potential perfs.

Lower CLF Statistics







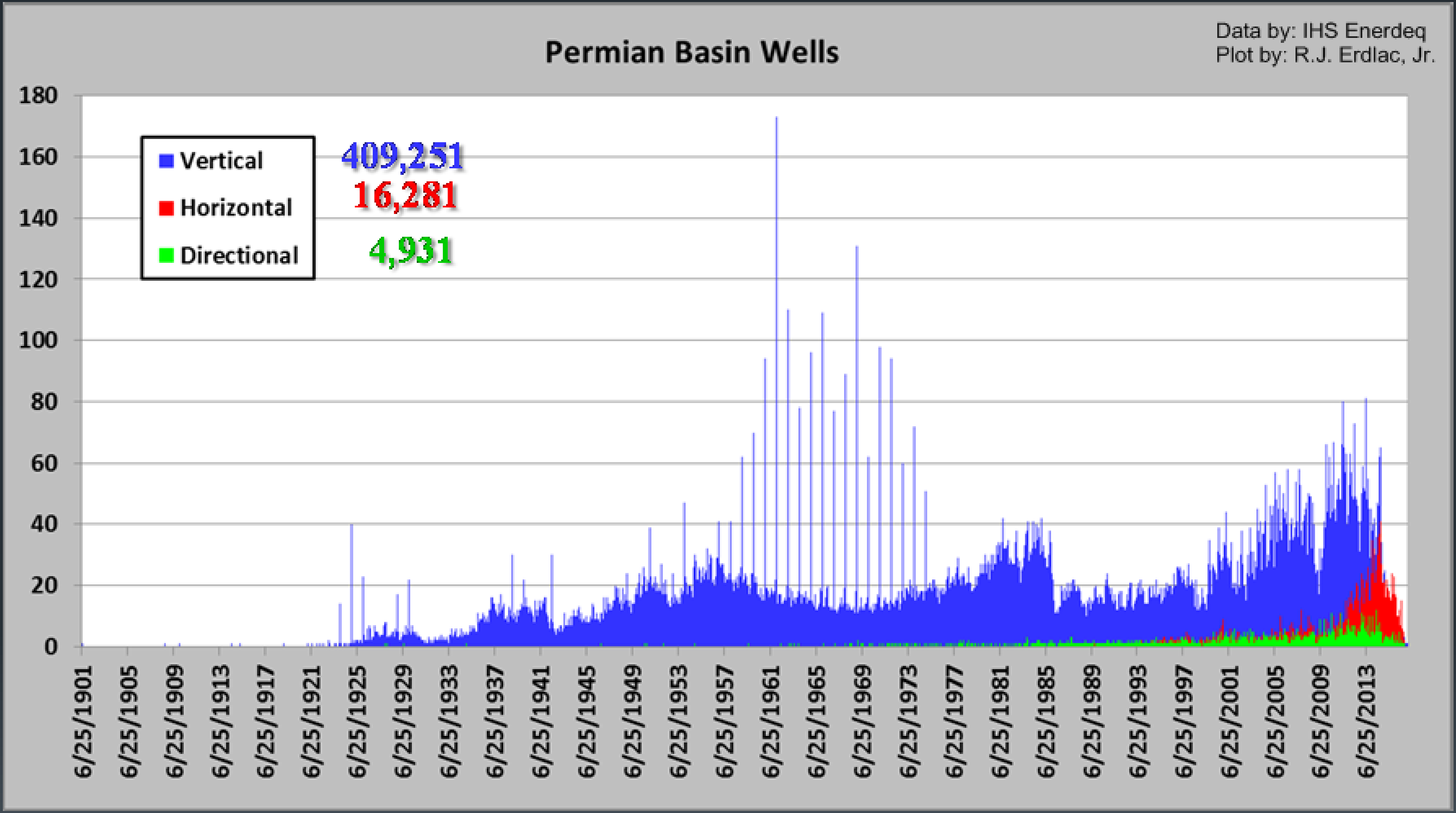


The same statistical approach was also conducted for deeper parts of the Clear Fork. No production exists from the Fullerton zone so no comparison was possible.

While the depth classified as Vale does produce, the actual perfed depths are unknown. Also very few wells investigated actually penetrated sufficiently deep to encounter this zone.

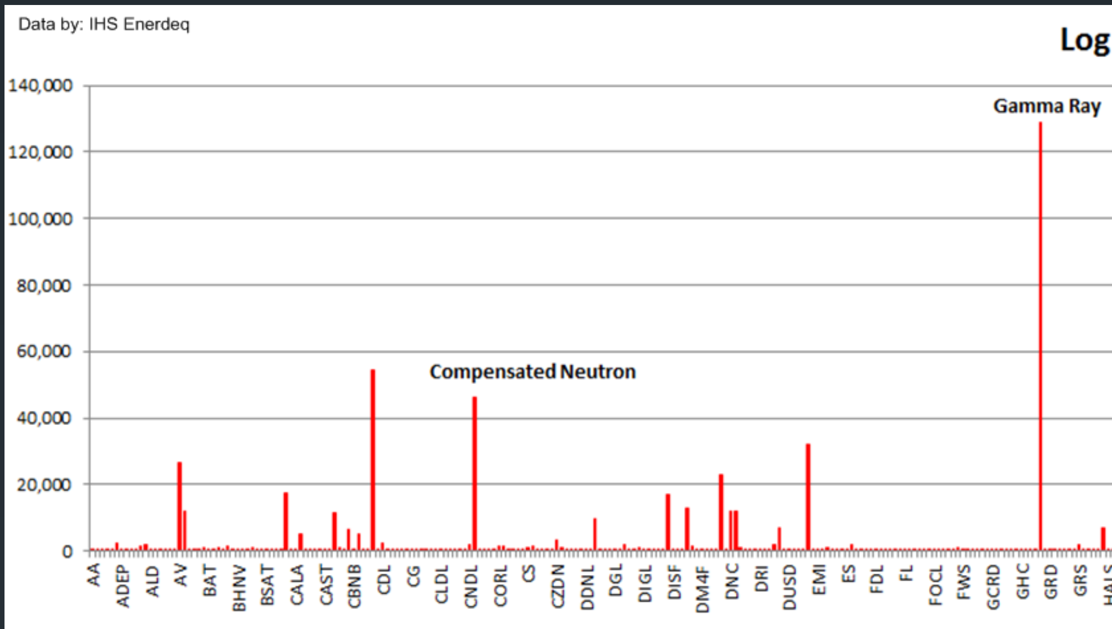
Why might this type of "first pass" approach be useful to the geologist?

Permian Basin Well Distribution



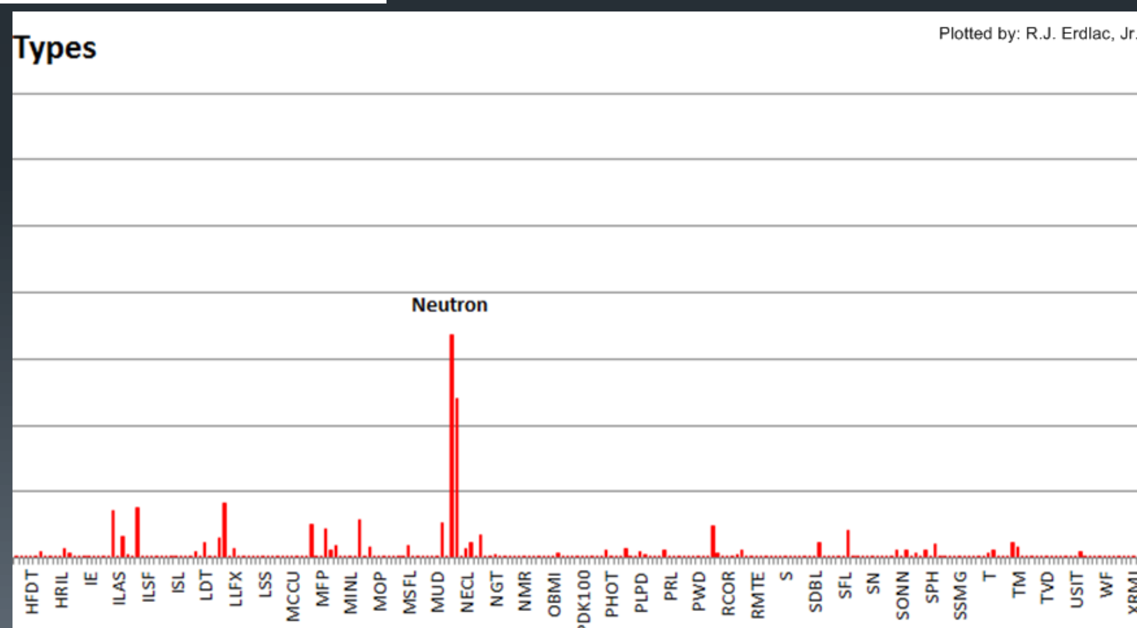
The distribution of the 430,463 Permian Basin oil and gas wells over time shows that the largest number of these wells predate the 1990's when newer modern log suites became more common and non vertical wells began to increase in occurrence.

Permian Basin Well Distribution



Out of 832,111 log curves from 430,463 wells, a minimum of 129,645 curves are represented by GR logs while N curves are at least 173,520 in number. These represent the largest single numbers of curve types acquired from well bores in Permian Basin.

While the oldest wells had only SP and Resistivity curves (if any), GR-N curves were a step up in technology and have been a main stay of curve types in the industry, with many wells having only these types of curves. Thus a statistical approach in well analysis can be a first pass with many of the older wells prior to new drilling and updated log curves.



Conclusions

1) Older wells can be more limited in data availability due to:
   a) more restricted set of log curves available when the wells were drilled, and
   b) the availability of drilling records either acquired at the time of drilling or maintained between generations.

2) Information regarding the upper and lower boundary of perfed zones will usually be known, but:
   a) detailed information on the actual foot by foot perf in a well may or may not be available.

3) When a few wells in a grouping of wells does have information listing the actual foot by foot perf information, it is possible to statistically compare this well information with other wells that have only top and bottom listed for the perfed interval.

4) So long as consistency is maintained, these wells can be statistically compared to each other to gain a first pass idea of which zones may have been perfed in wells with less detailed perforation information.

5) This can be used for potential prediction of other zones that may also fall within the statistical viability for perforation when little else is known.