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Sixth EAGE Rock Physics Workshop

IMPACTS & TRENDS OF THE DIGITAL TRANSFORMATION

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Rock Physics Case studies Western Canada Unconventional Plays

Azer Mustaqeem and Dr. Valentina Baranova
Petro-Explorers Inc. Calgary, AB, Canada

INTRODUCTION AND LAYOUT

- Background of the unconventional plays of Western Canada
- Duvernay – Devonian off-reef shale/marl
  - Base relationships
  - Application of RPT
- Montney – Triassic marine shale
  - Condensate ratios
  - Lithology to detect silty areas
- Second White Specks – Shale of Western Interior Seaway
  - TOC Content
  - Brittleness
- Deductions and scalability of Rock Physics

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WCSB SHALE GAS/OIL PLAYS

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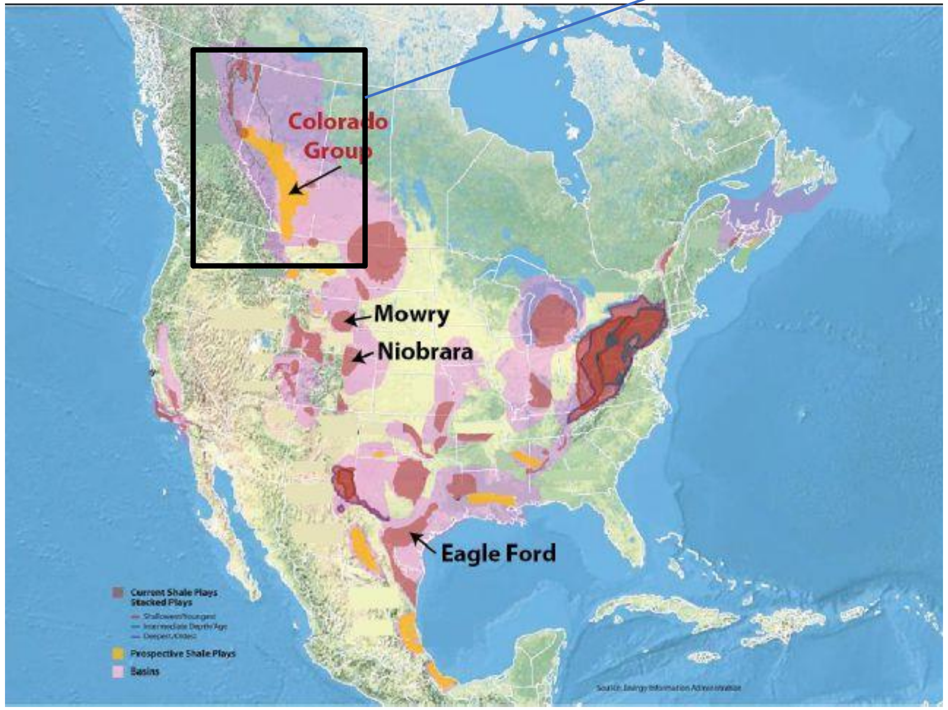
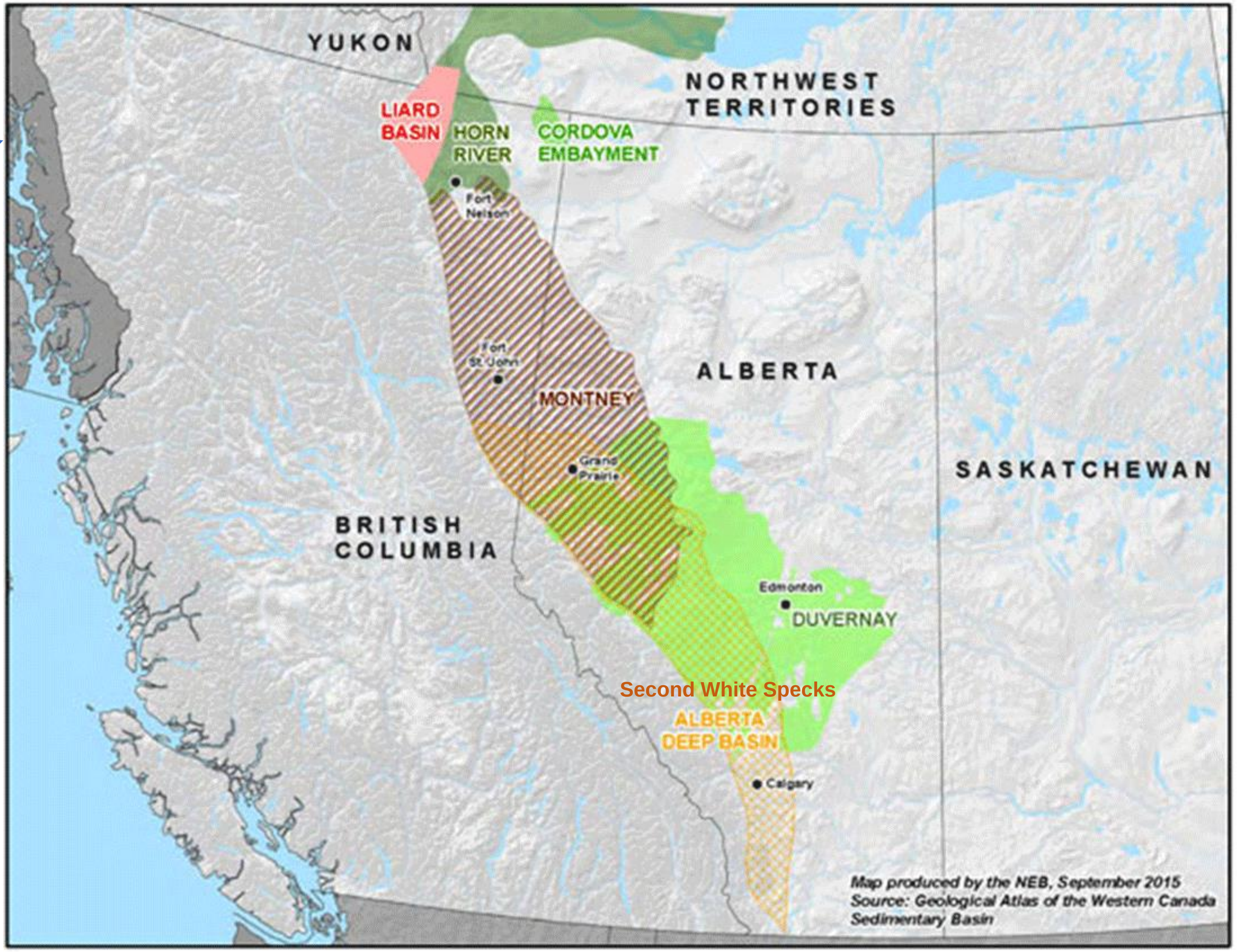
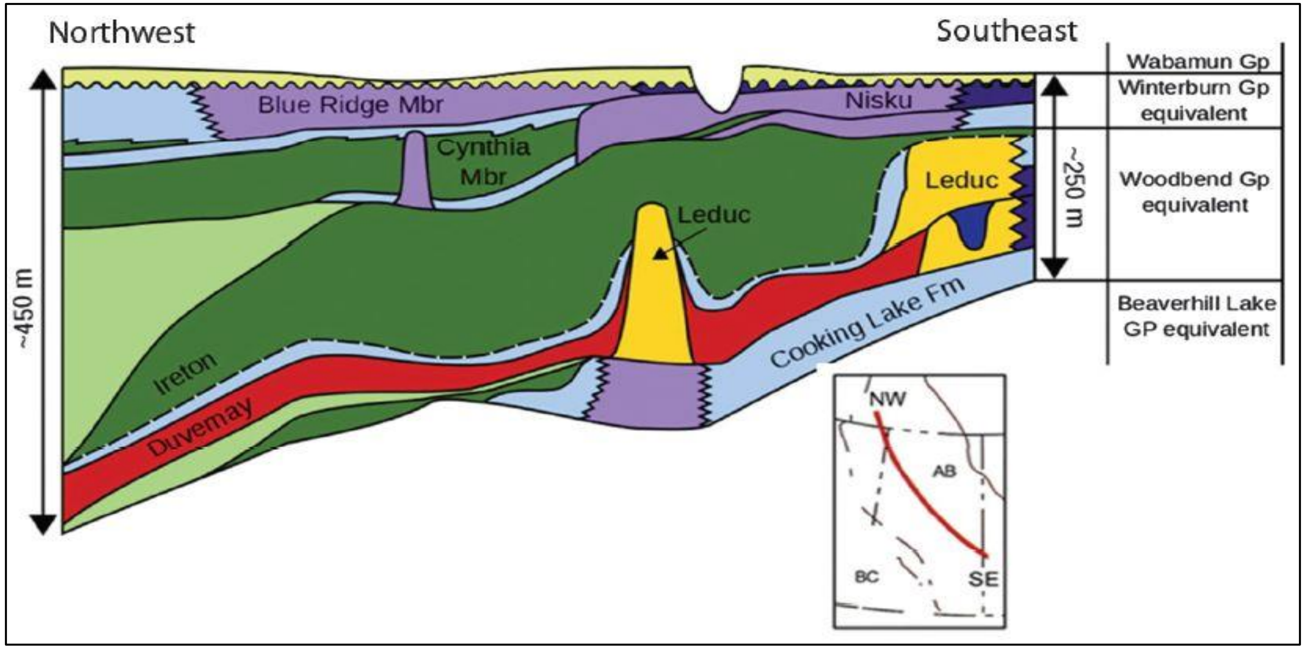


North American Unconventional oil and gas plays



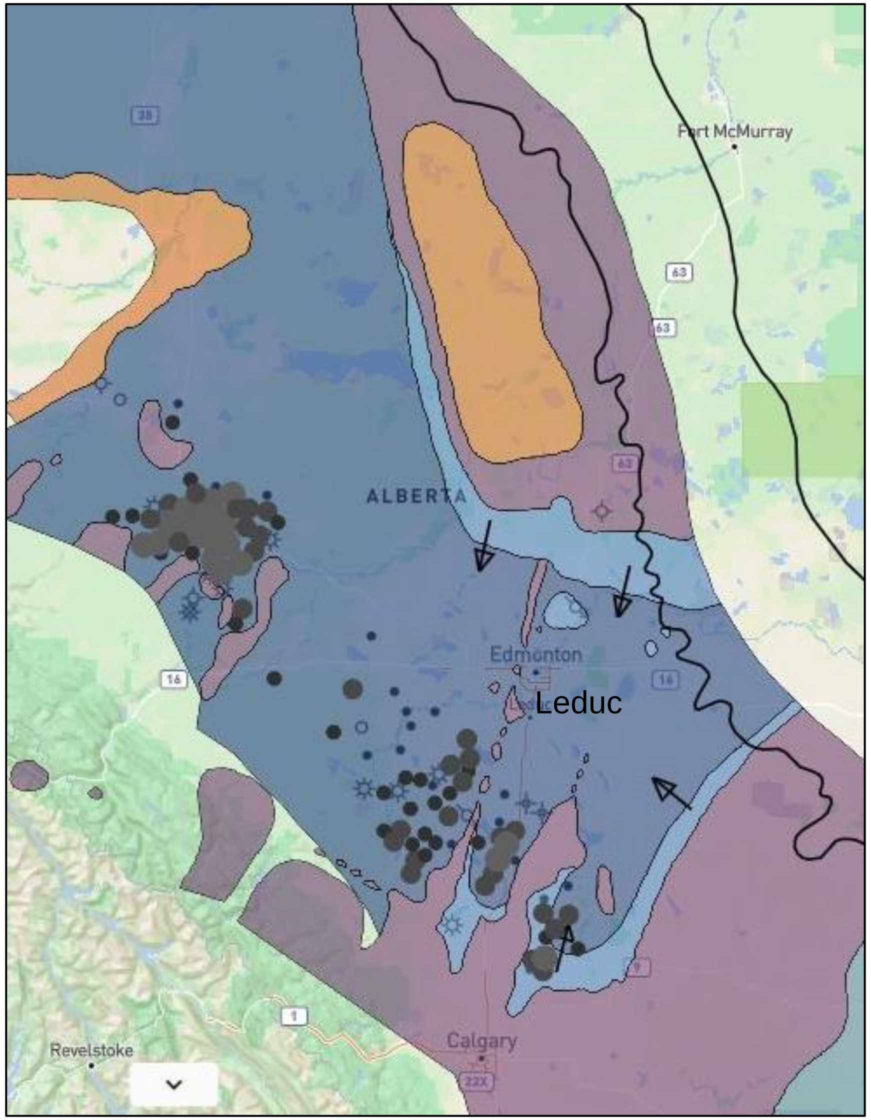
KEY PARAMETERS TO EVALUATE

- TOC and its maturity
- Burial history, Tmax, vol-dolomite etc.
- Clay content and mineral composition
- Brittleness (fracability)
- Pore pressure
- Natural fracture estimation (anisotropy)
- Stress direction



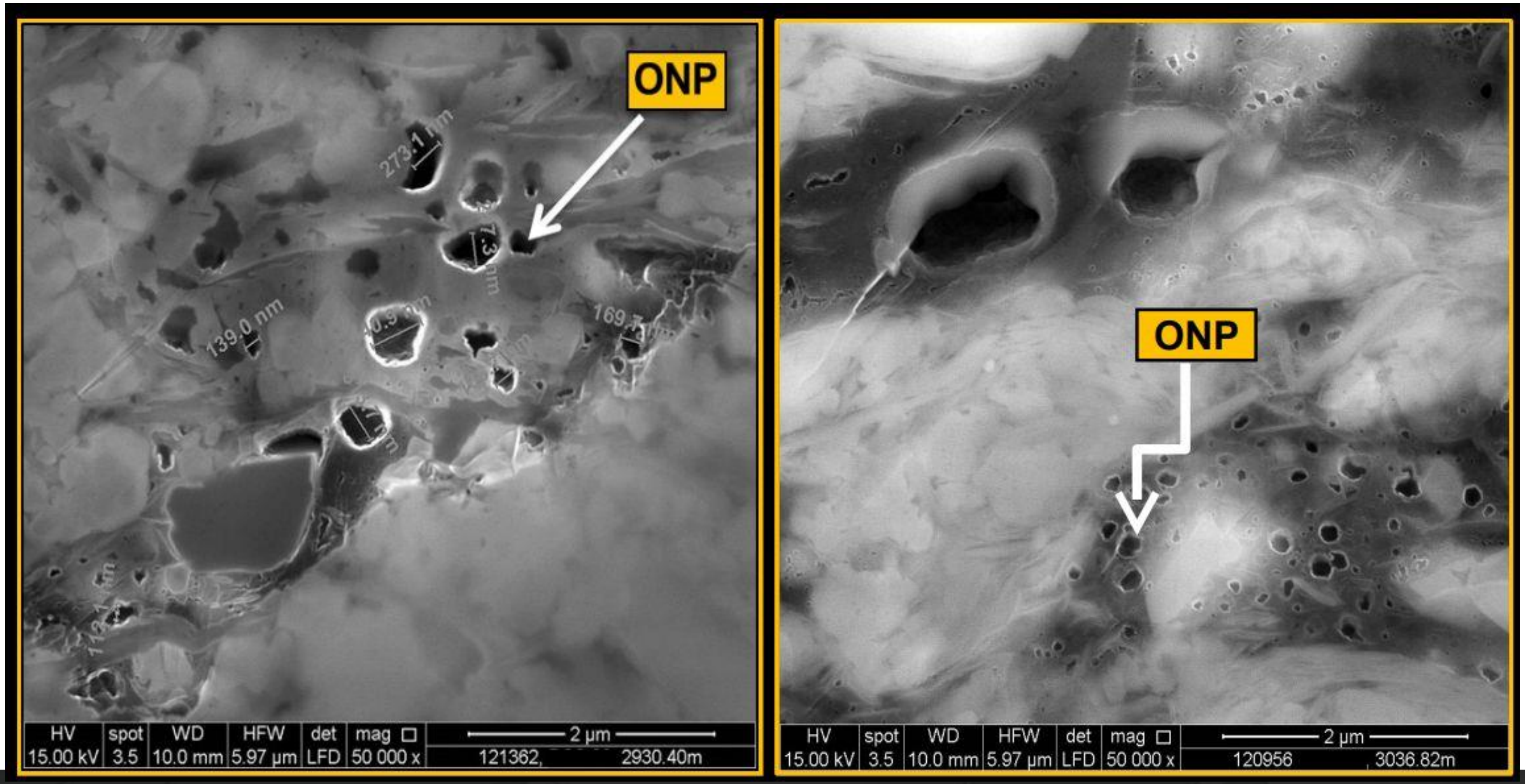
Devonian shale/marl

DUVERNAY



Devonian Reefs and Leduc carbonate banks

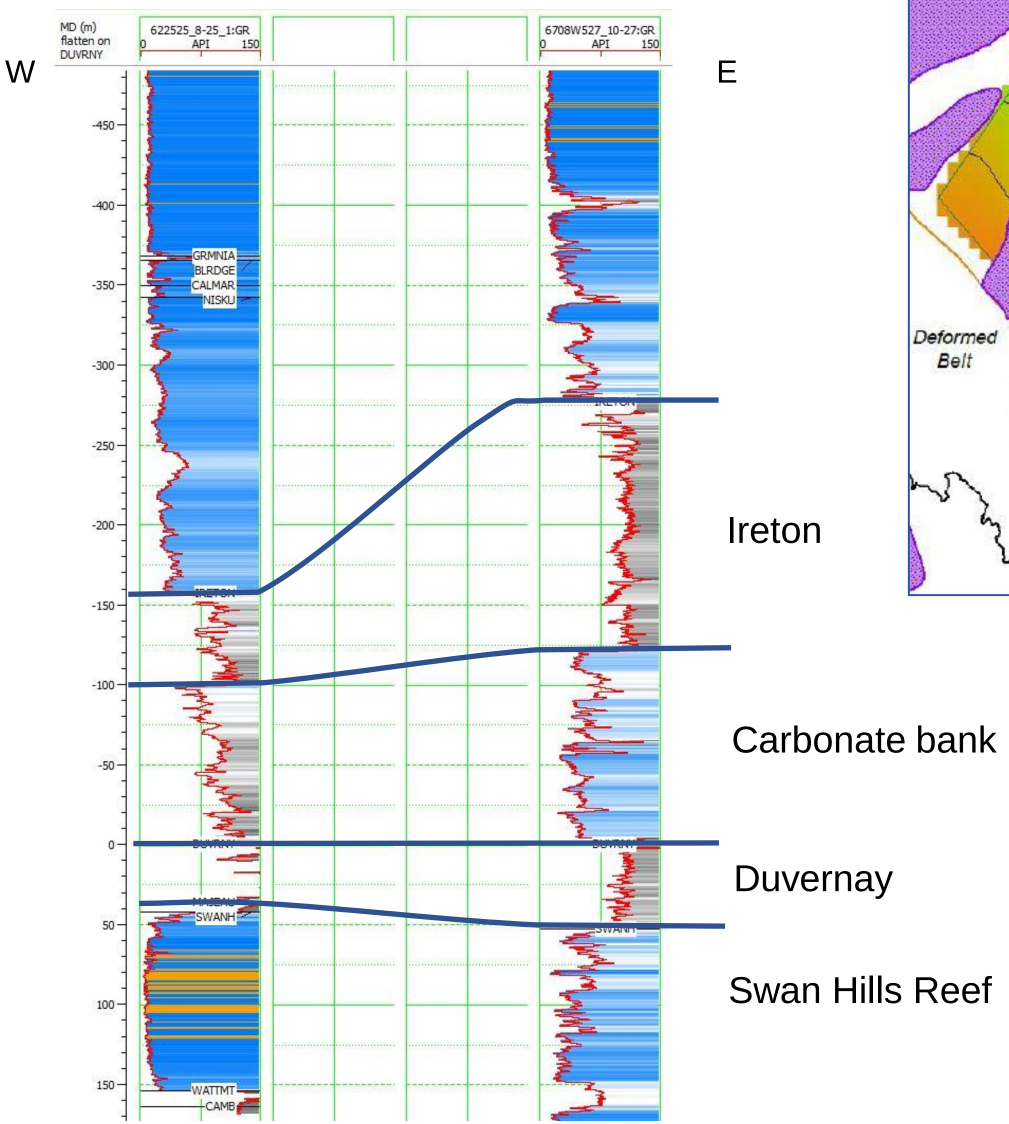
ORGANIC NANO-PORES

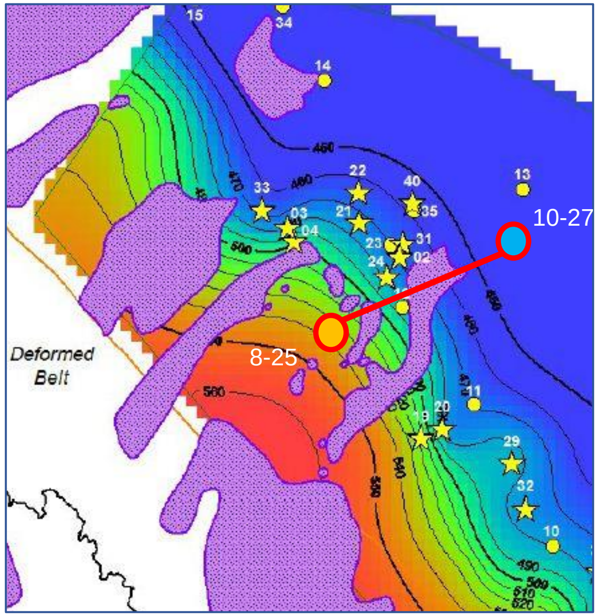


Duvernay formation is an organic rich marl/shale (TOC >5%). Nano-pores within the marly shale contain kerogen. Under high thermal maturity the kerogen are converted to volatile hydrocarbon creating high pore pressure within the shale interval.

Hydraulic fracturing allows production of oil/gas/condensates from this low permeability shale.

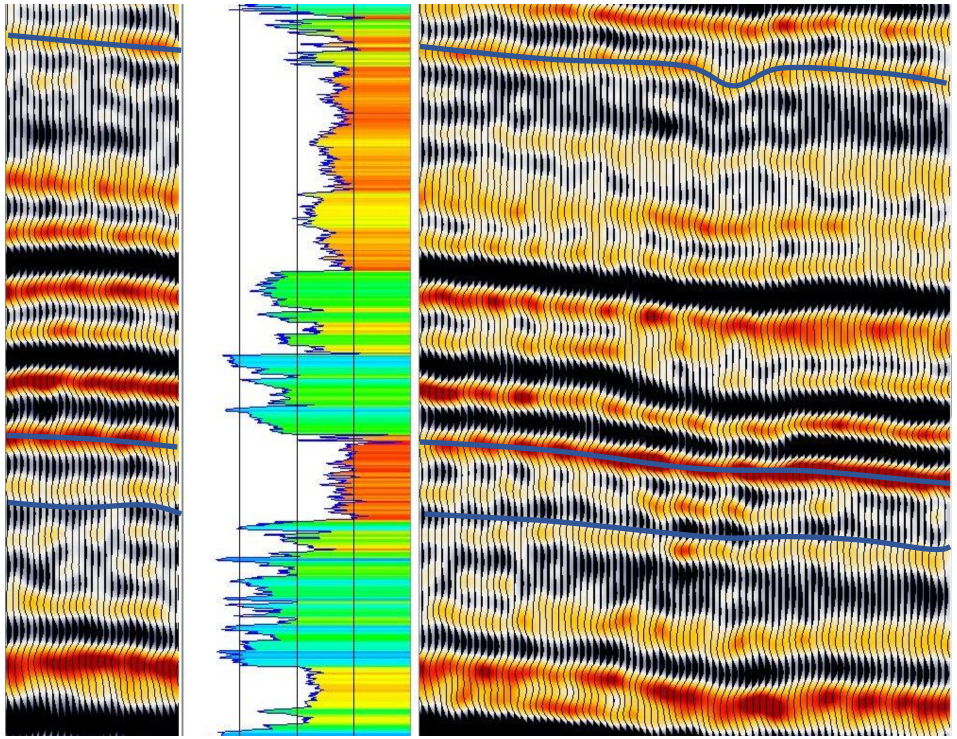
DUVERNAY WELLS 8-25 (MATURE GAS) AND 10-27 (NON-MATURE)



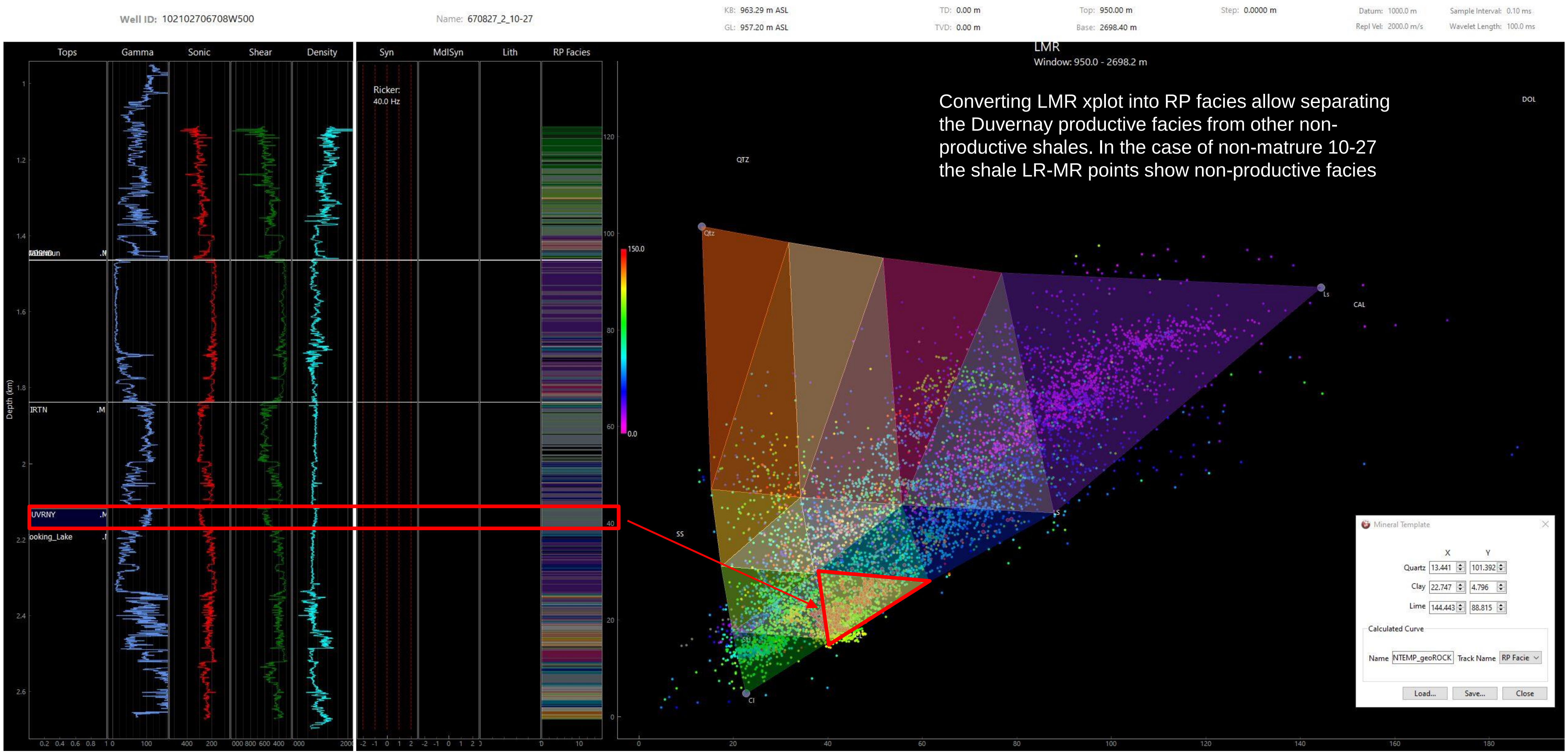


Duvernay Tmax from CoreLab

Well 10-27



MINERAL TEMPLATE WELL 10-27



Converting LMR xplot into RP facies allow separating the Duvernay productive facies from other non-productive shales. In the case of non-matrure 10-27 the shale LR-MR points show non-productive facies

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MINERAL TEMPLATE WELL 8-25 (MATURE GAS)

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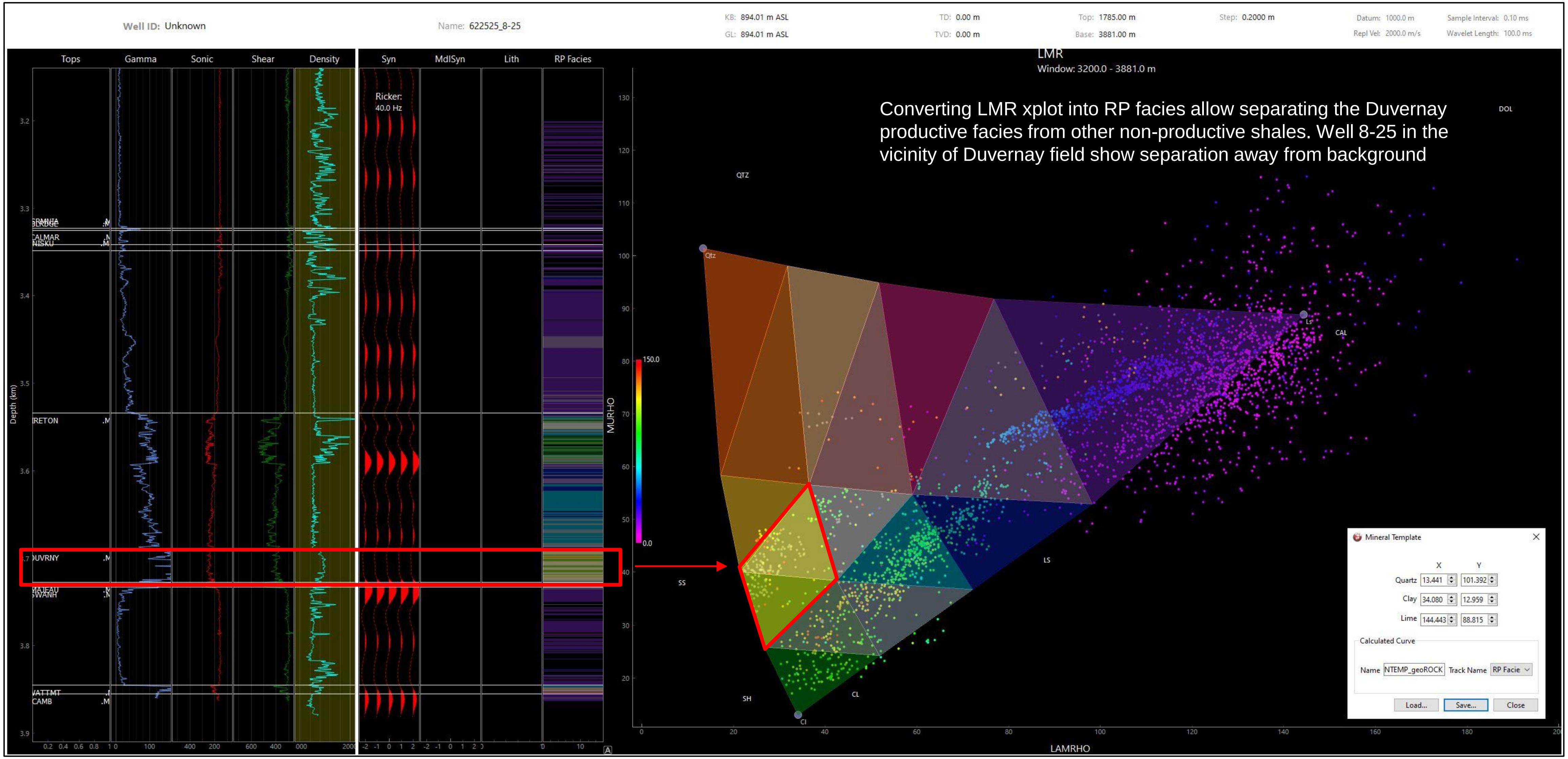
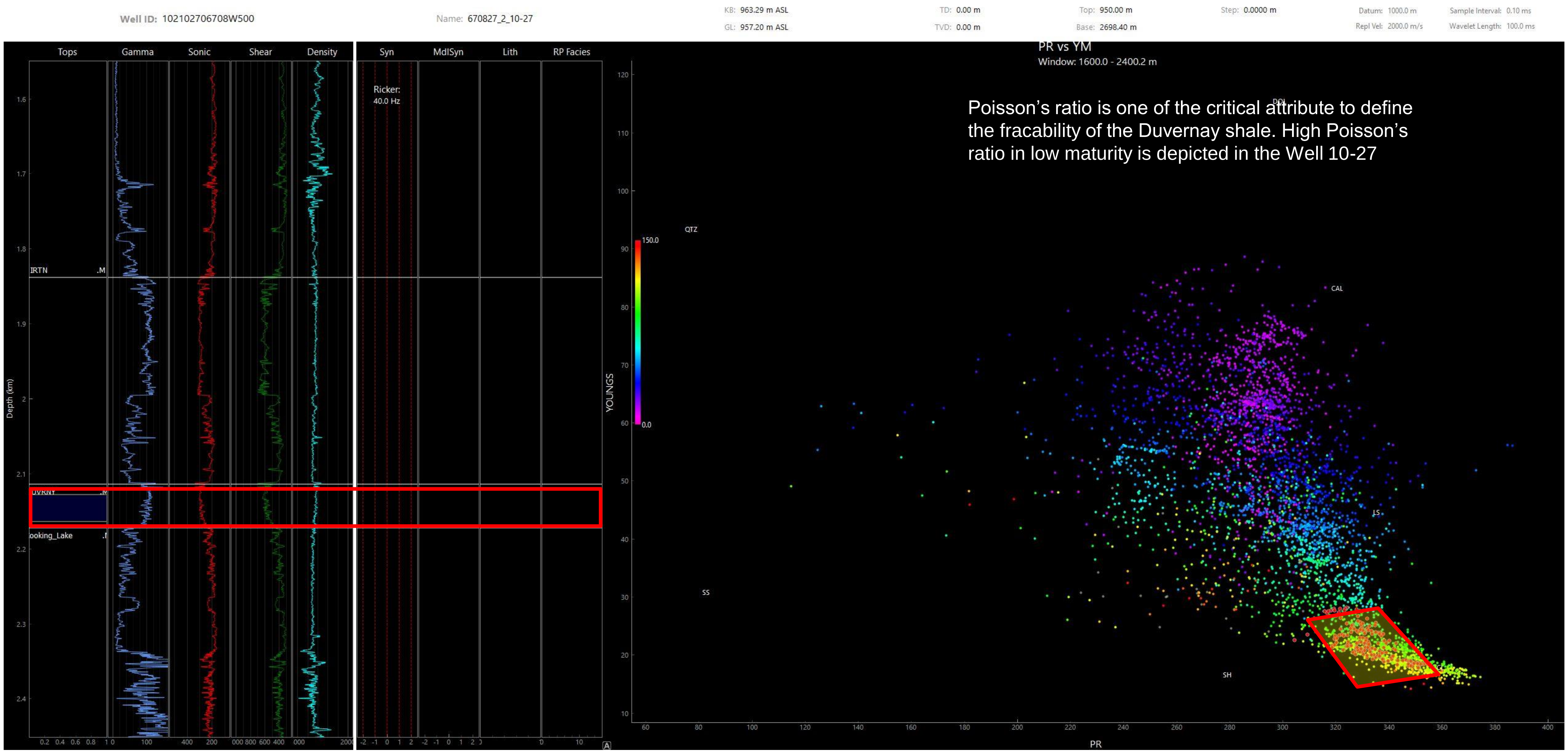
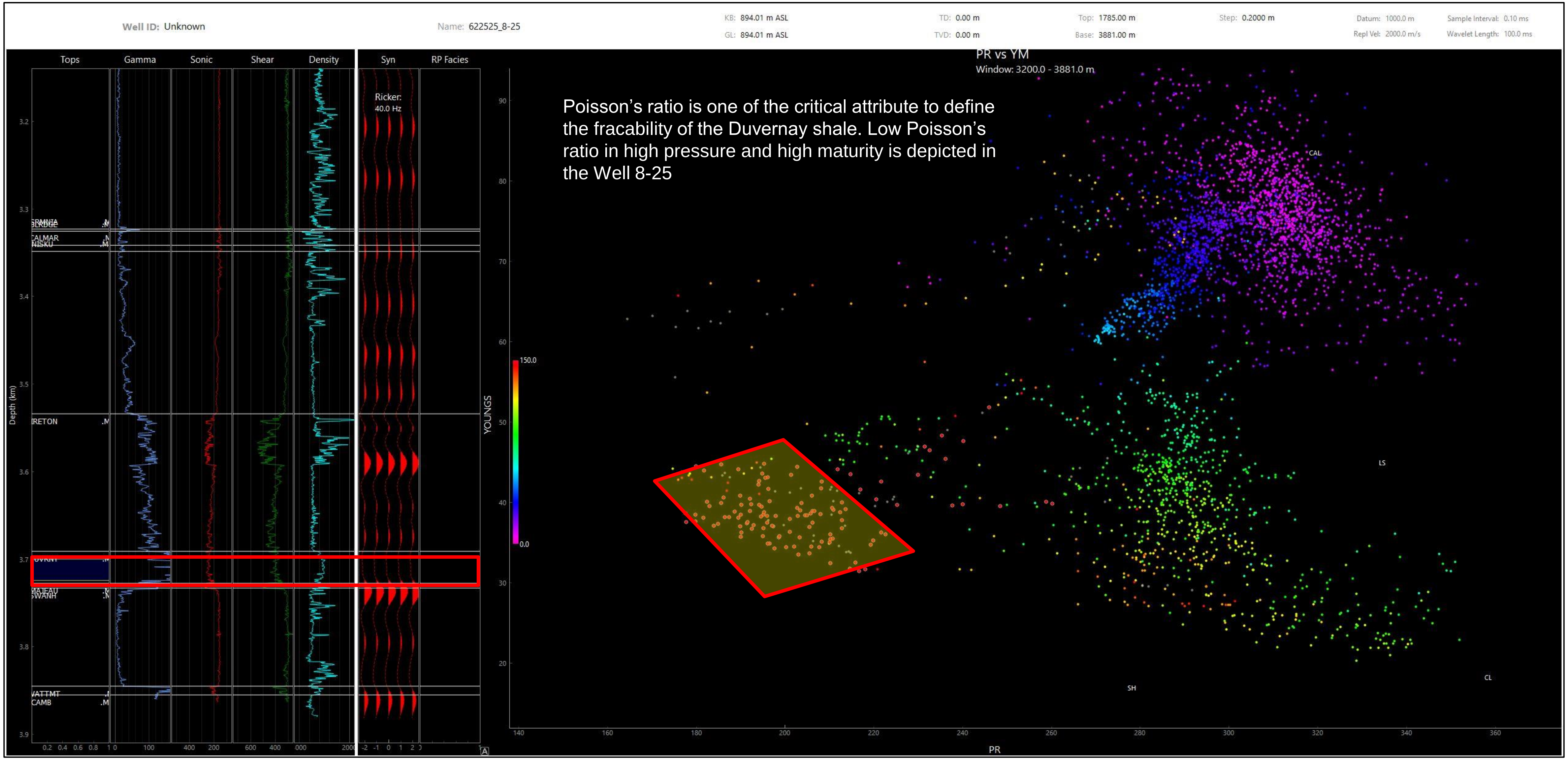


POISSON'S RATIO VS YOUNG'S MODULUS WELL 10-27



Poisson's ratio is one of the critical attribute to define the fracability of the Duvernay shale. High Poisson's ratio in low maturity is depicted in the Well 10-27

POISSON'S RATIO VS YOUNG'S MODULUS WELL 8-25



Poisson's ratio is one of the critical attribute to define the fracability of the Duvernay shale. Low Poisson's ratio in high pressure and high maturity is depicted in the Well 8-25

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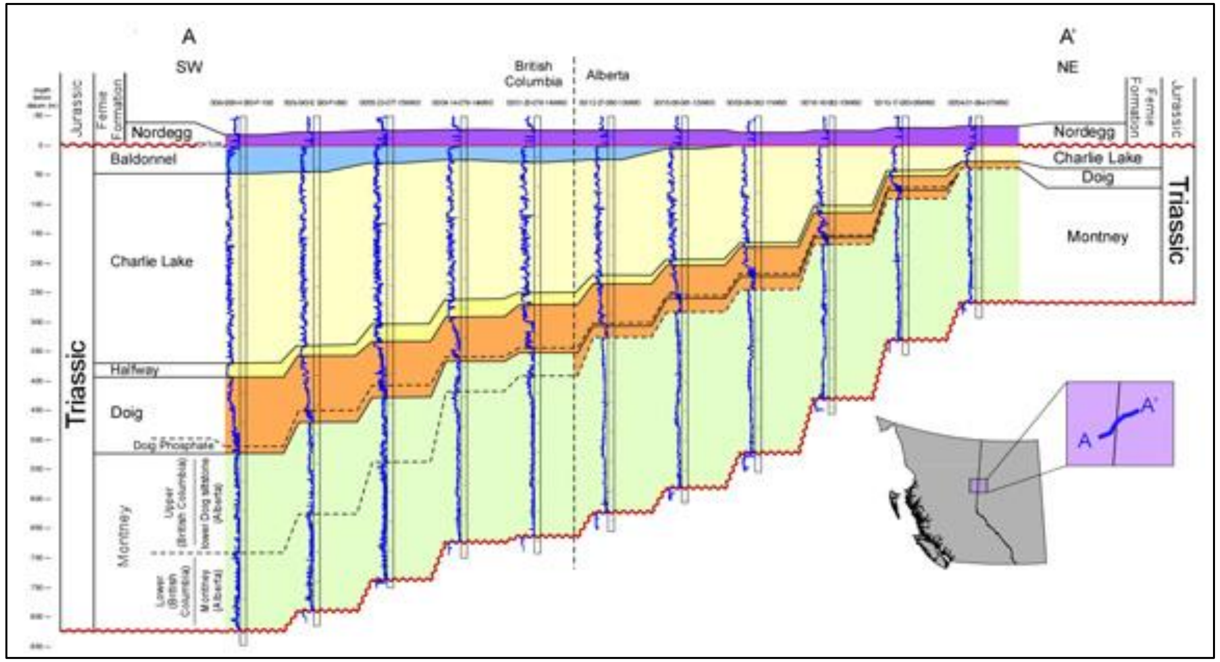
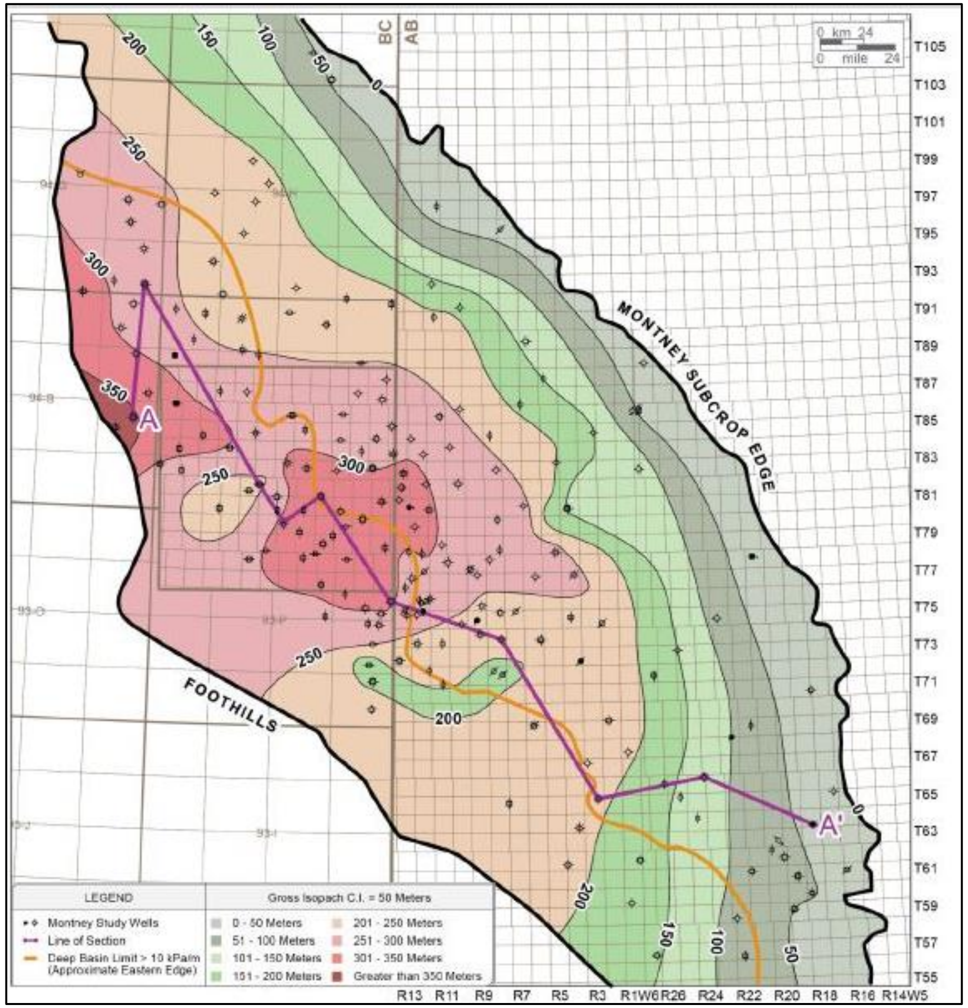




Triassic shale

MONTNEY

SEDIMENTOLOGY OF MONTNEY FORMATION

Montney formation is deposited in a large shallow see open to Pacific Ocean during Triassic time. The formation shows coarsening upward trend that is more silty/sandy to the East while progressively shaly to the West.

Conventionally small scale turbidites within the lows were targeted for conventional production. Various bioturbated zone and low energy turbidites can provide excellent targets for condensate rich shale gas.

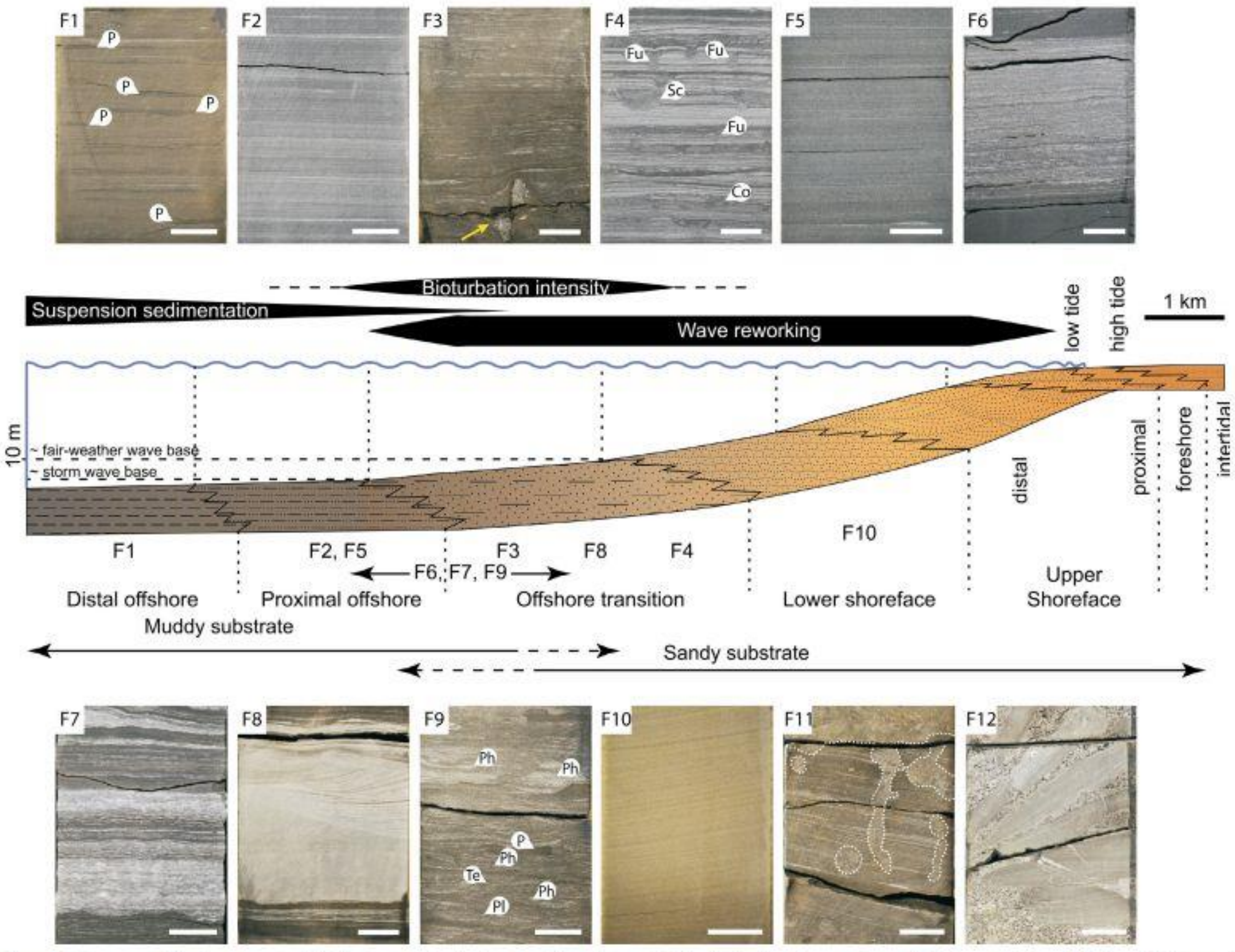
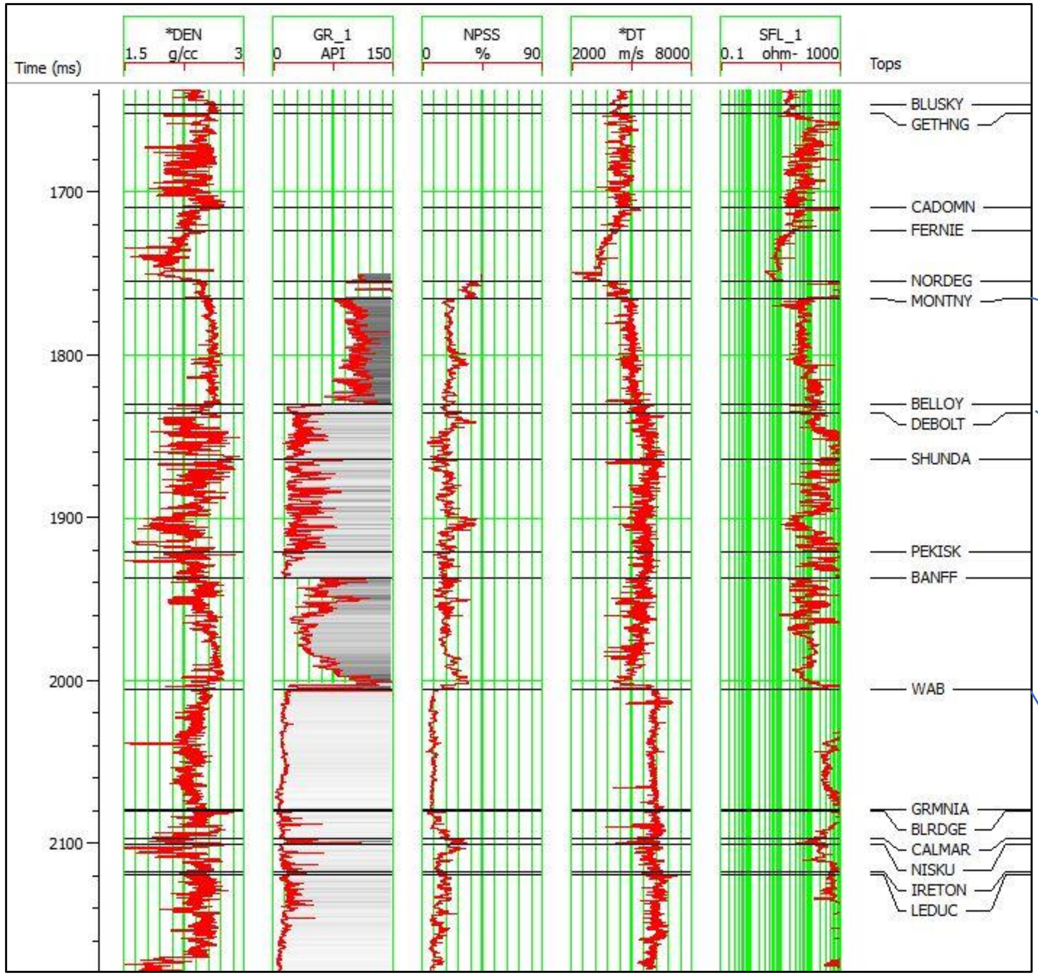
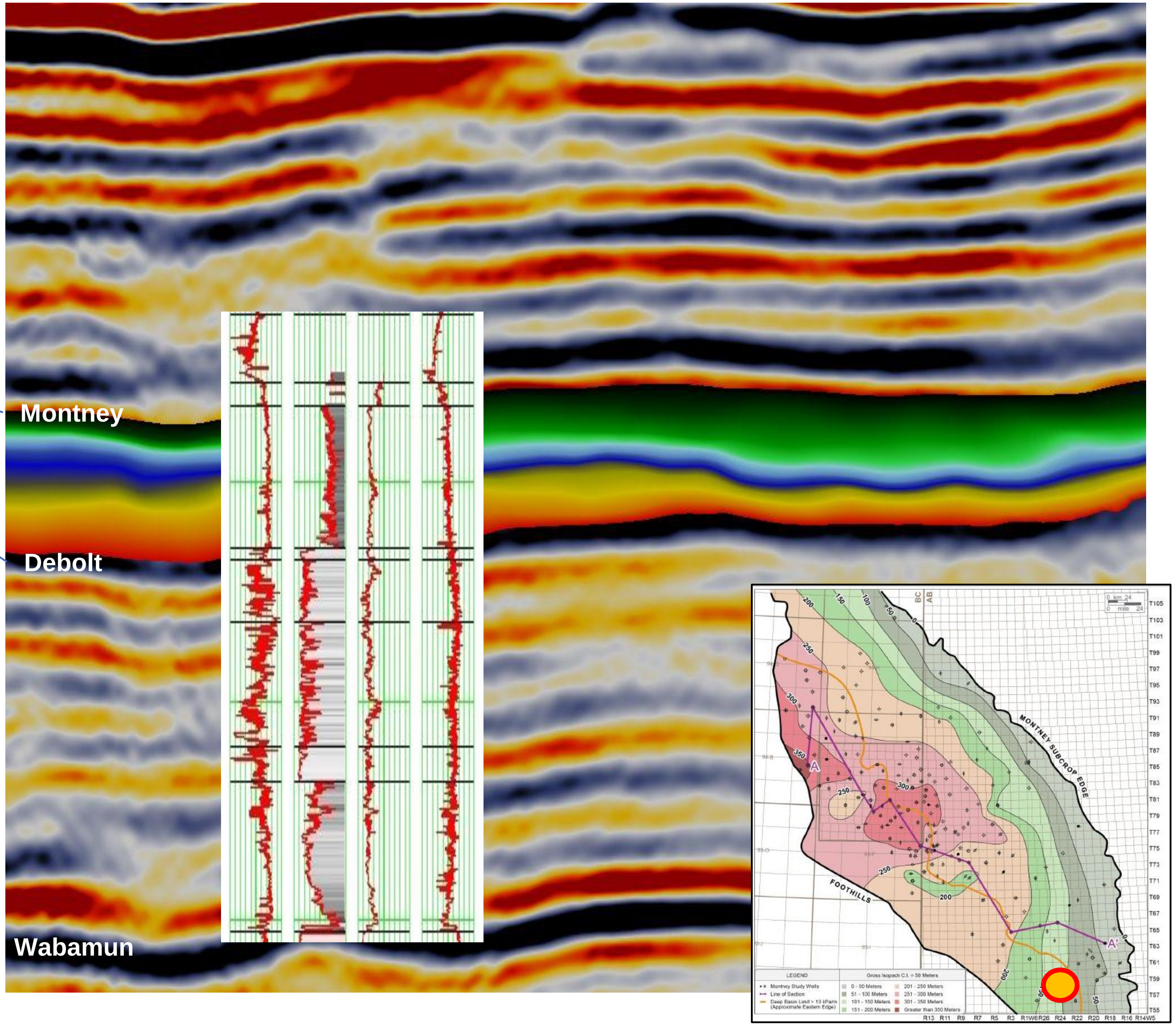


Figure 6. Summary of facies present within the Lower Triassic Montney Formation and their distribution along a schematic facies model; modified from Walker and Plint (1992), Reading and Collinson (1996), Plint (2010) and Zonneveld et al. (2010b). The twelve sedimentary facies are shown as F1–F12; the yellow arrow in F3 indicates the presence of an ichthyosaur vertebra. Scale bar in the facies photographs is 2 cm. Abbreviations: Co, *Conichnus*; Fu, fugichnia; P, phosphate; Ph: *Phycosiphon*; Pl, *Planolites*; Sc, *Scolicia*; Te, *Teichichnus*.

MONTNEY TYPE WELL AND SEISMIC

Well 2-23





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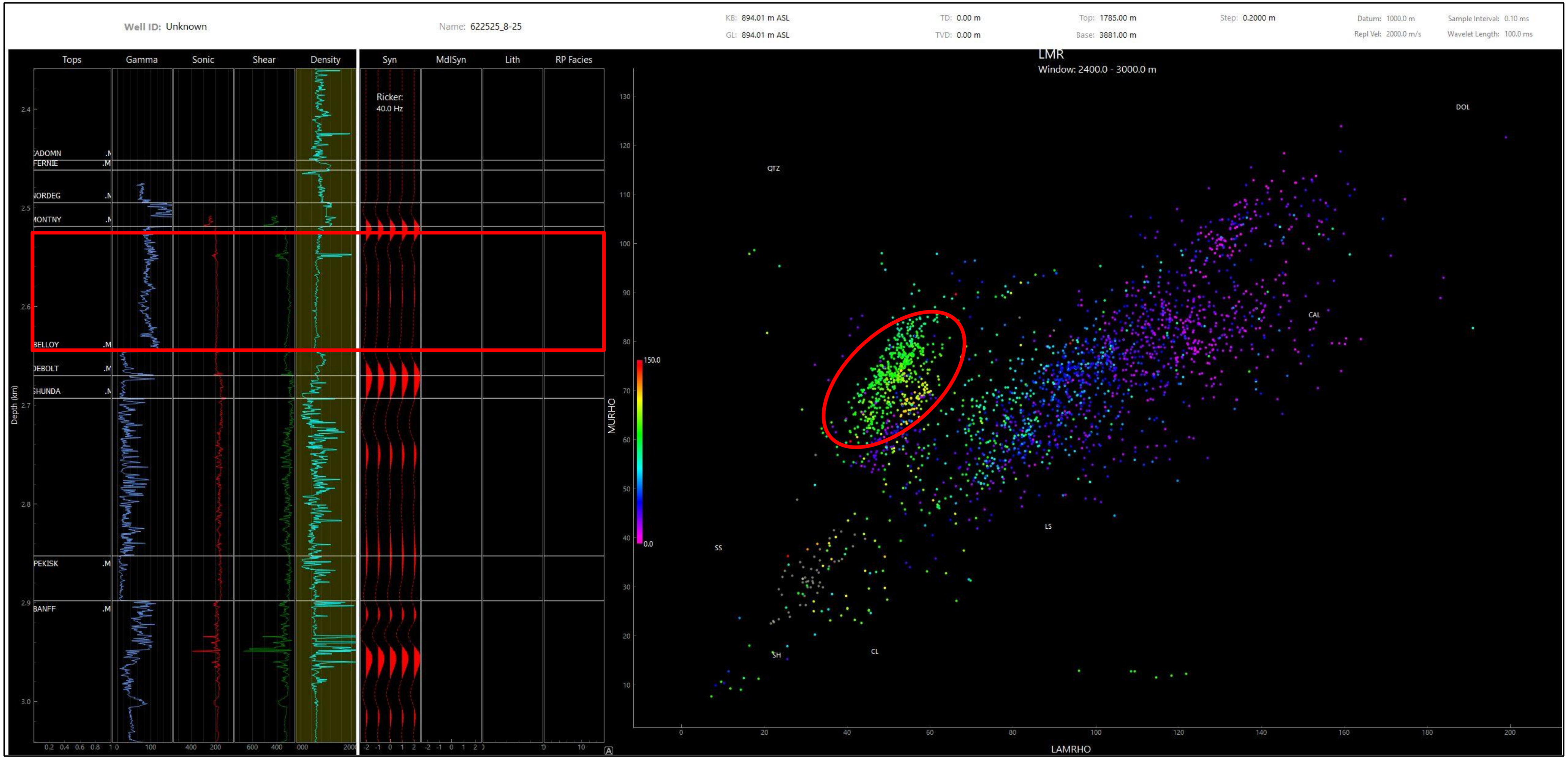
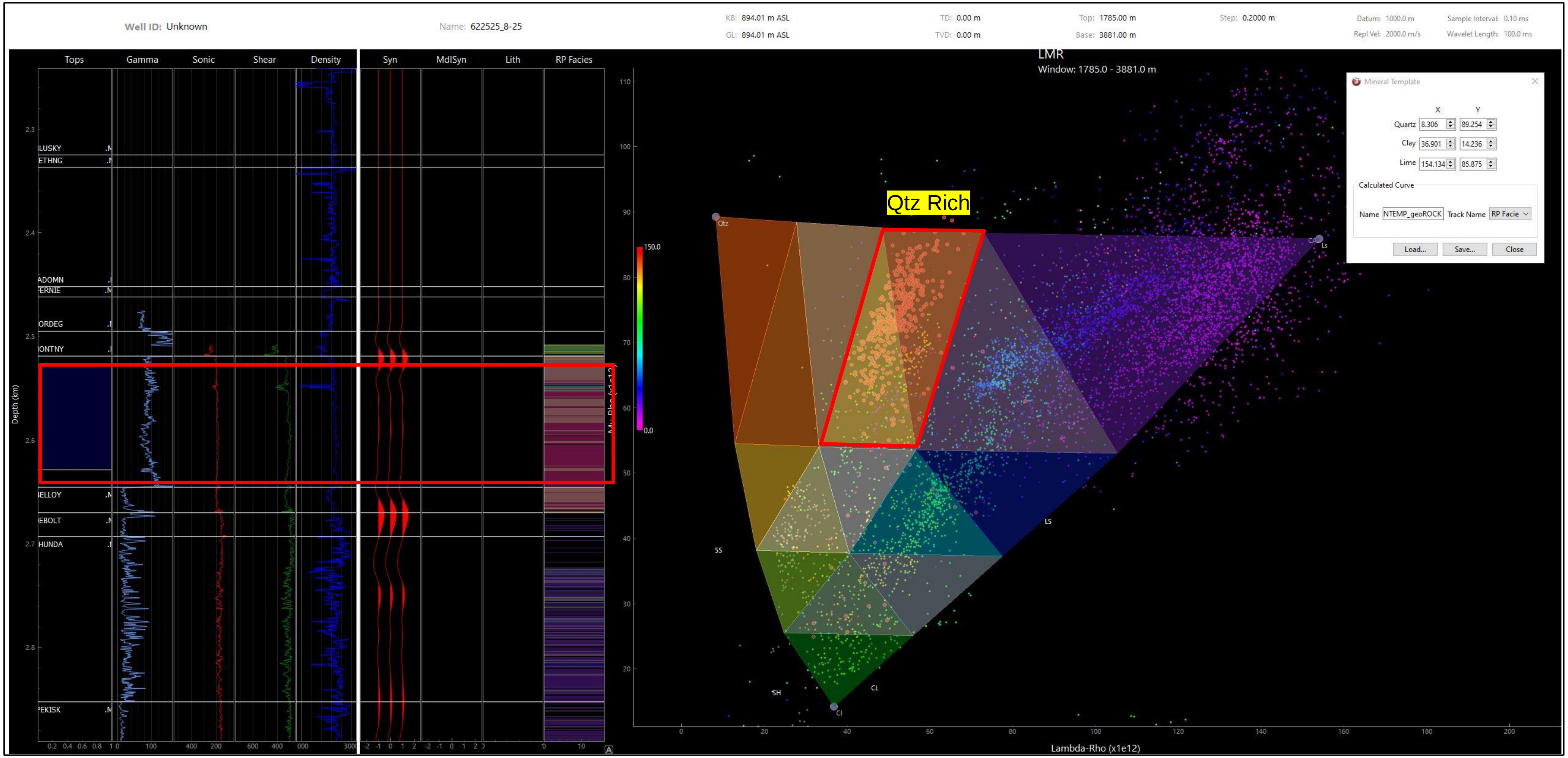
PRODUCTIVE MONTNEY WELL 8-25



MINERAL TEMPLATE WELL 8-25



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NIA TEMPLATE – CRACK DENSITY ESTIMATES

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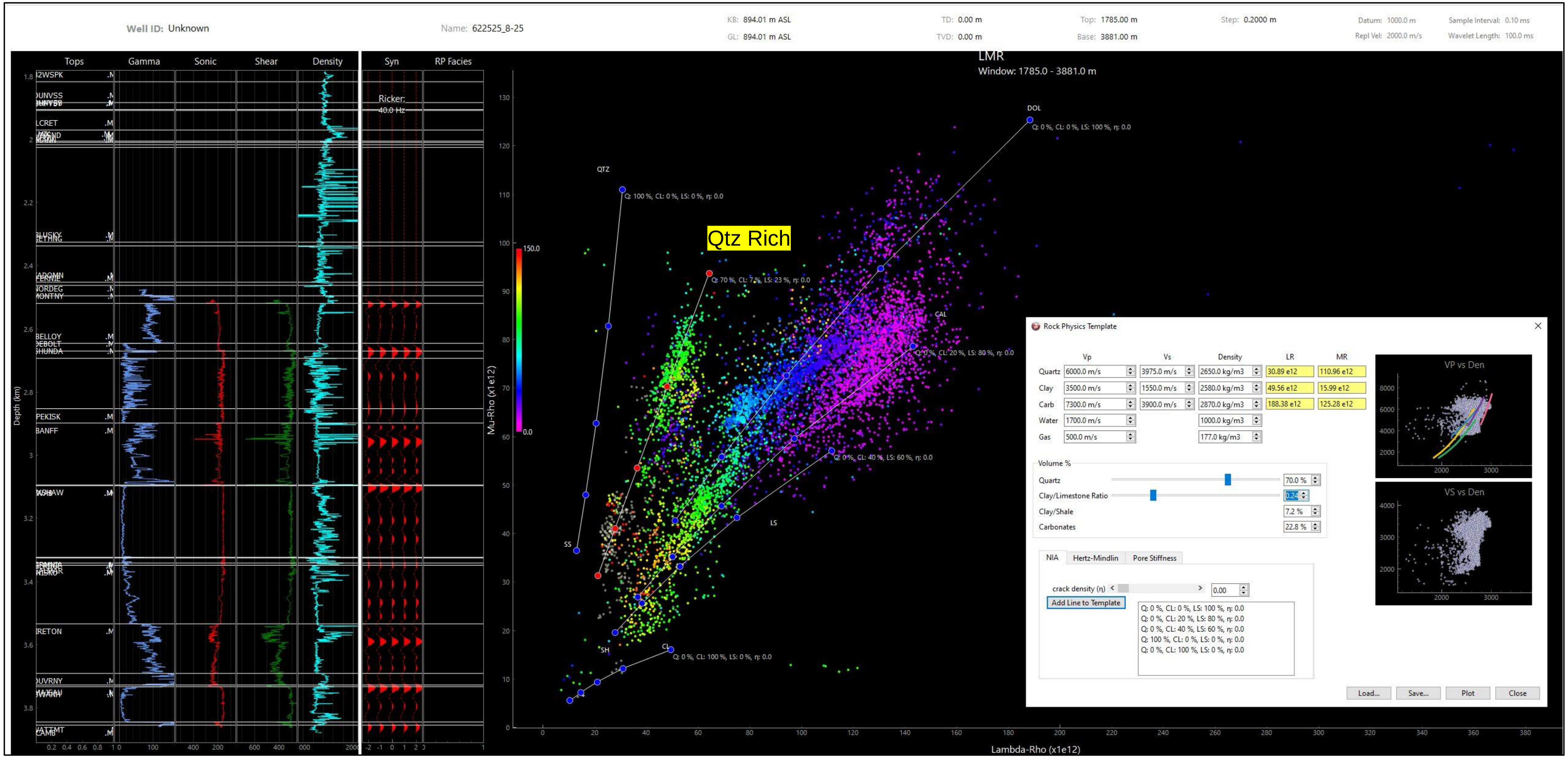
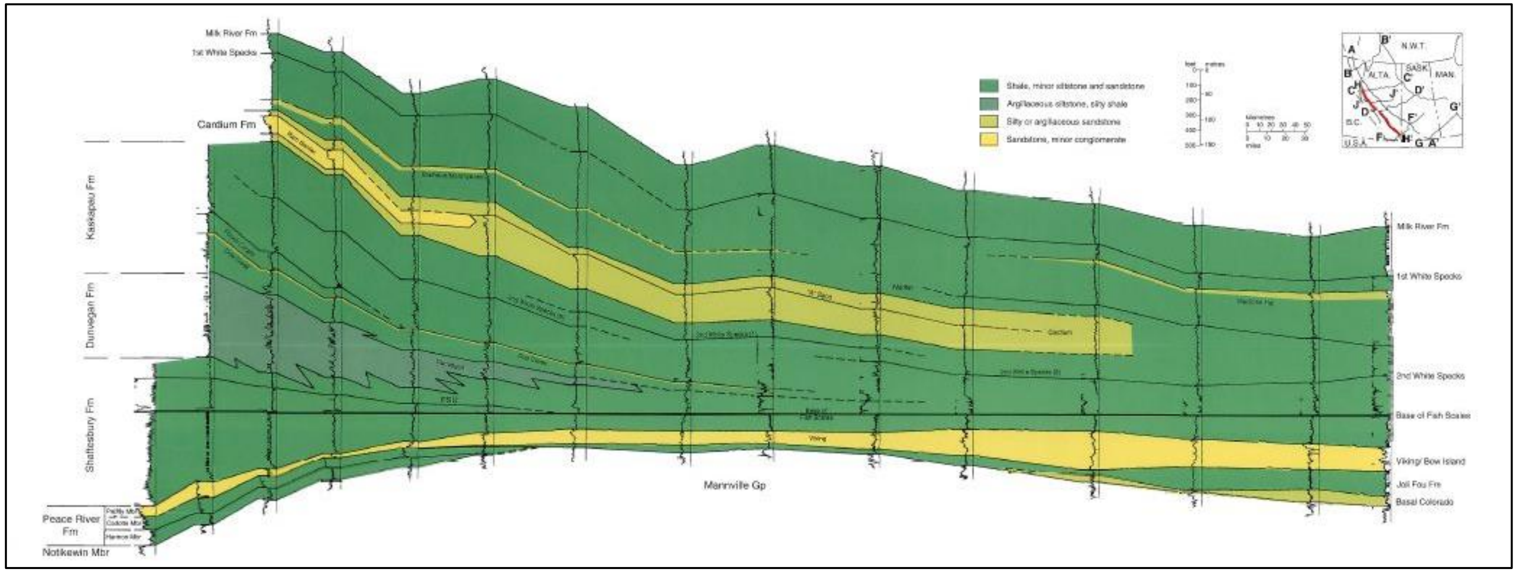
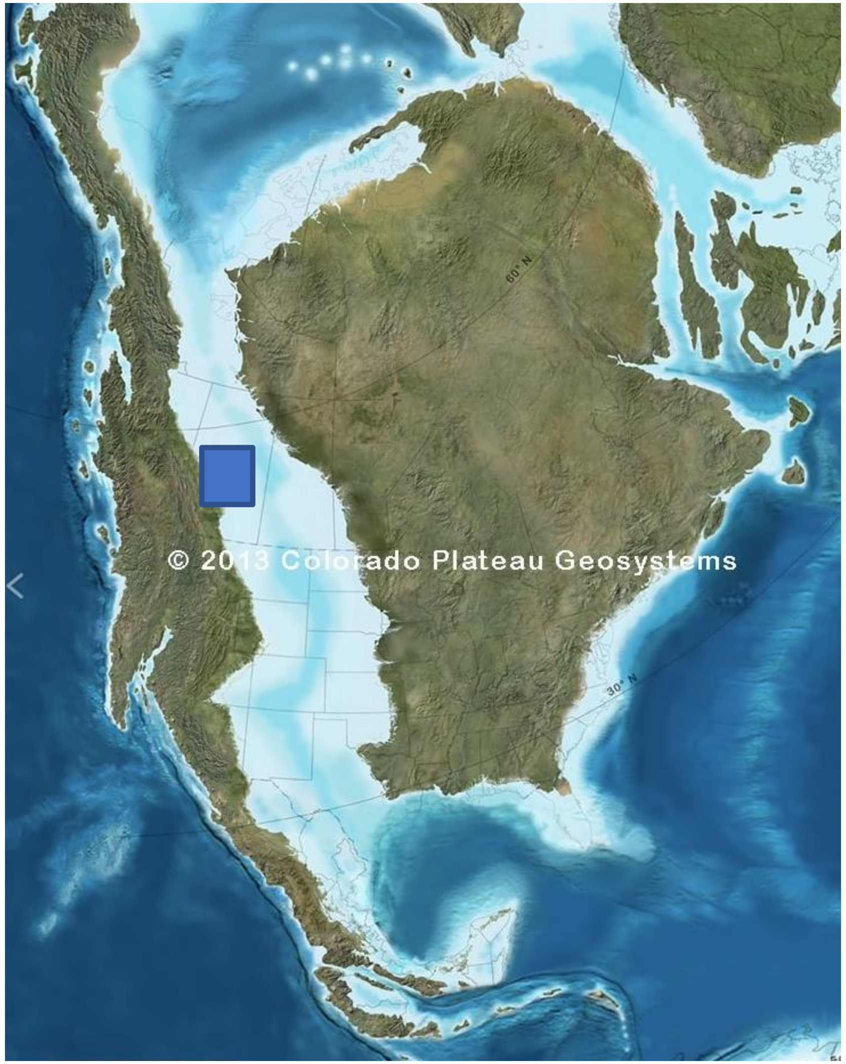


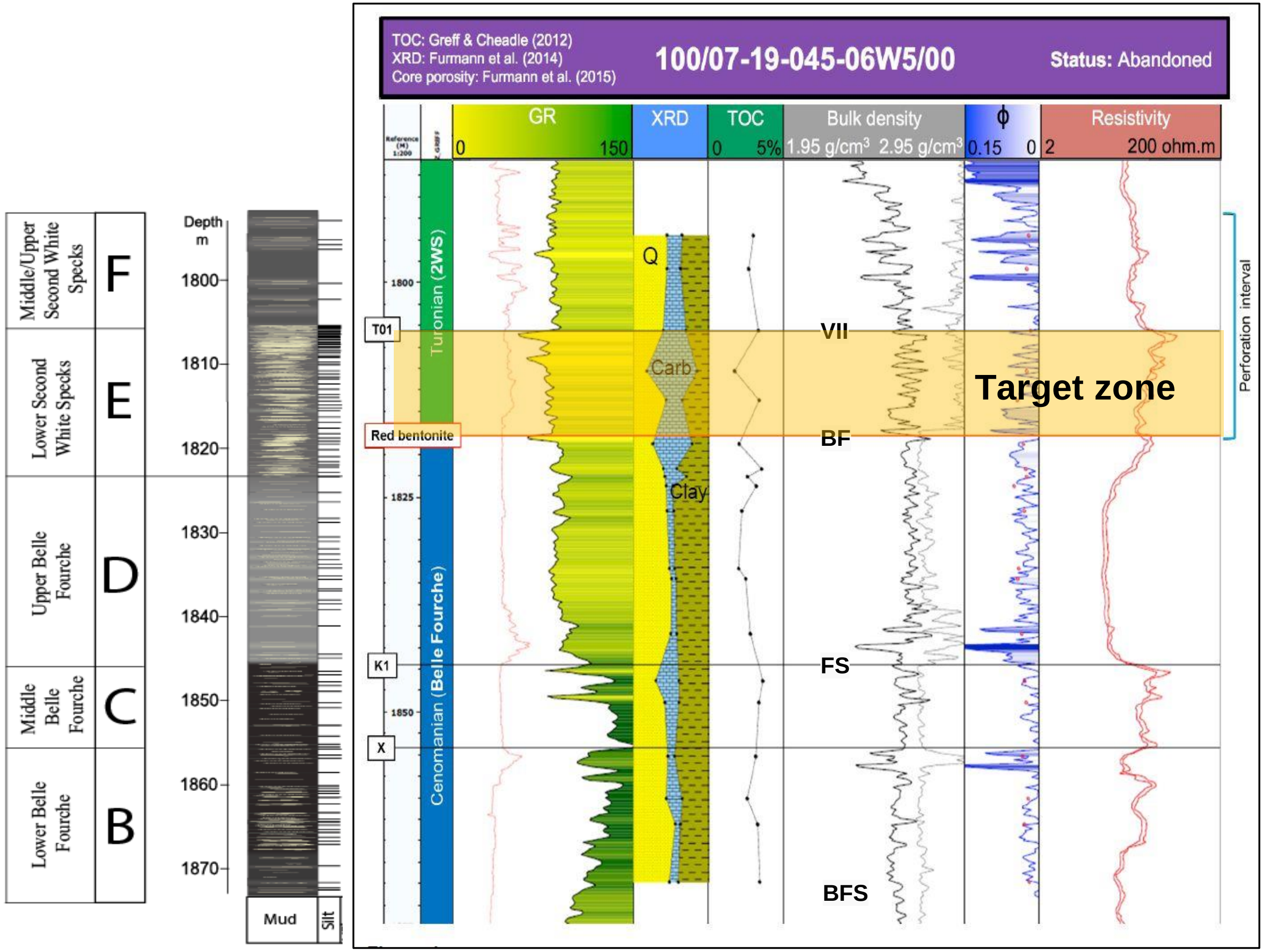




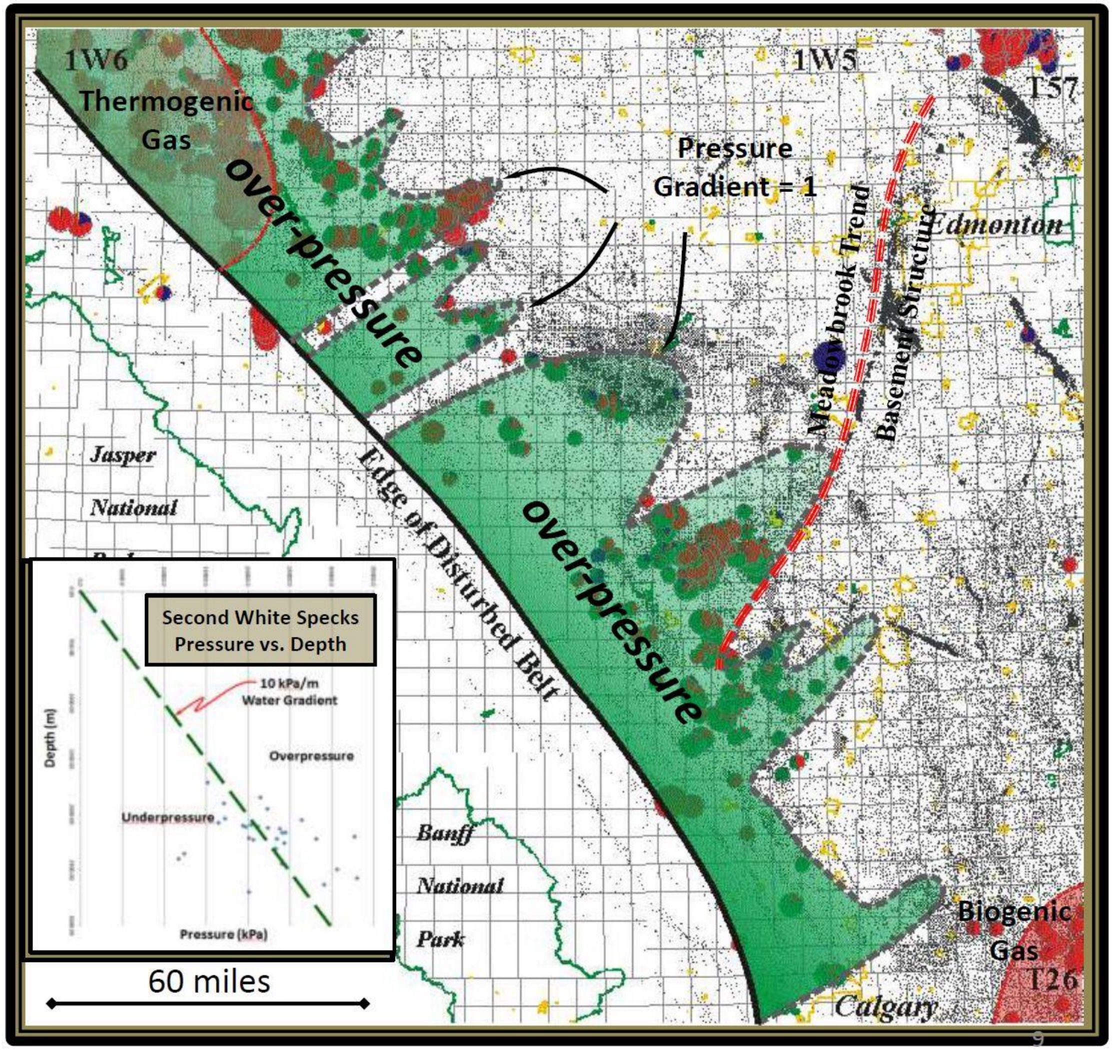
Cretaceous source rock shale/siltstone

SECOND WHITE SPECKS

TURONIAN CALCAREOUS SILTSTONE: OVER-PRESSURED SYSTEM



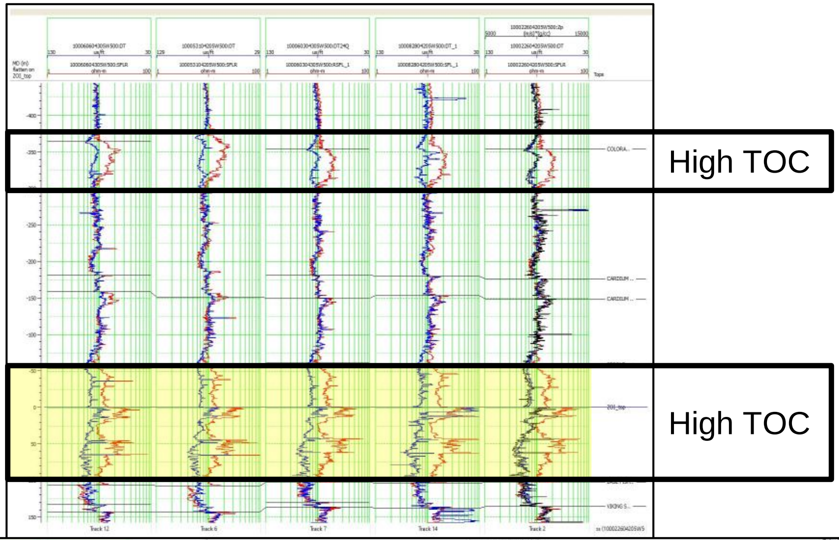
Modified from Marion 2018

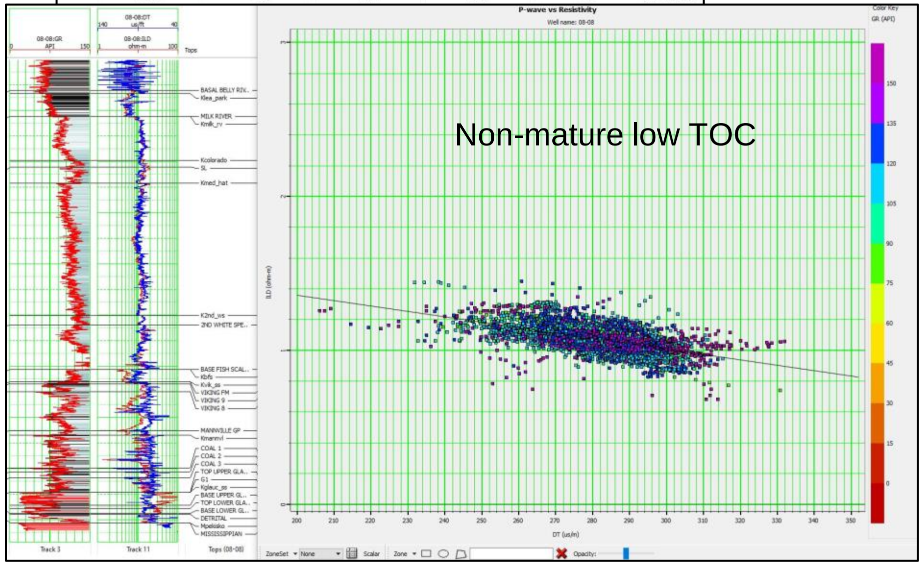


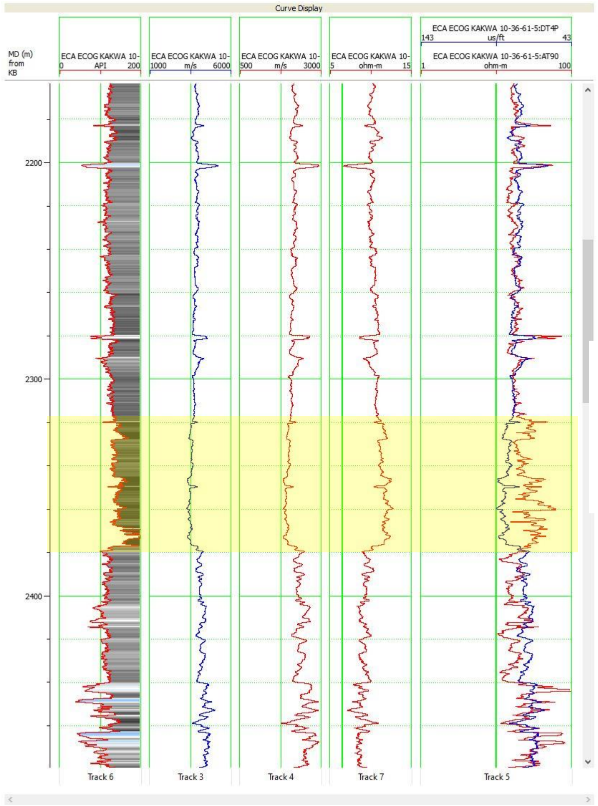
from Mackay 2013

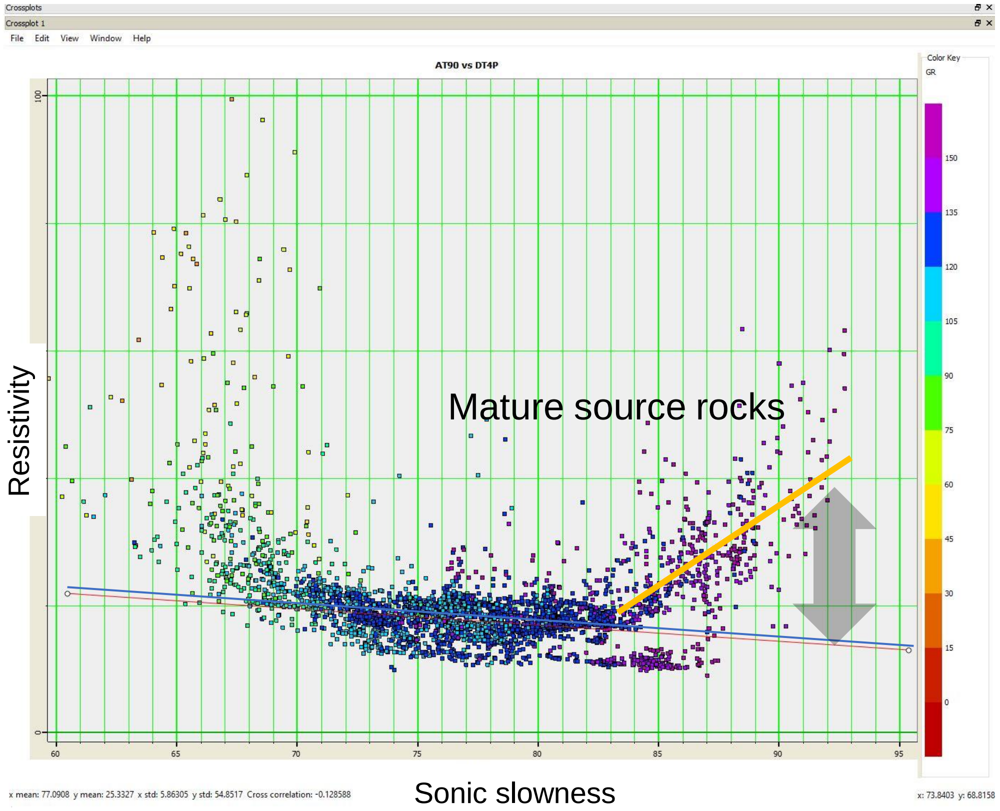
ΔLOG R TOC ANALYSIS FOR SOURCE ROCK EVALUATION

$$\Delta LogR = log\, {}^{R}/_{R_{baseline}} + 0.02x(\Delta t\text{-}\Delta t_{baseline})$$







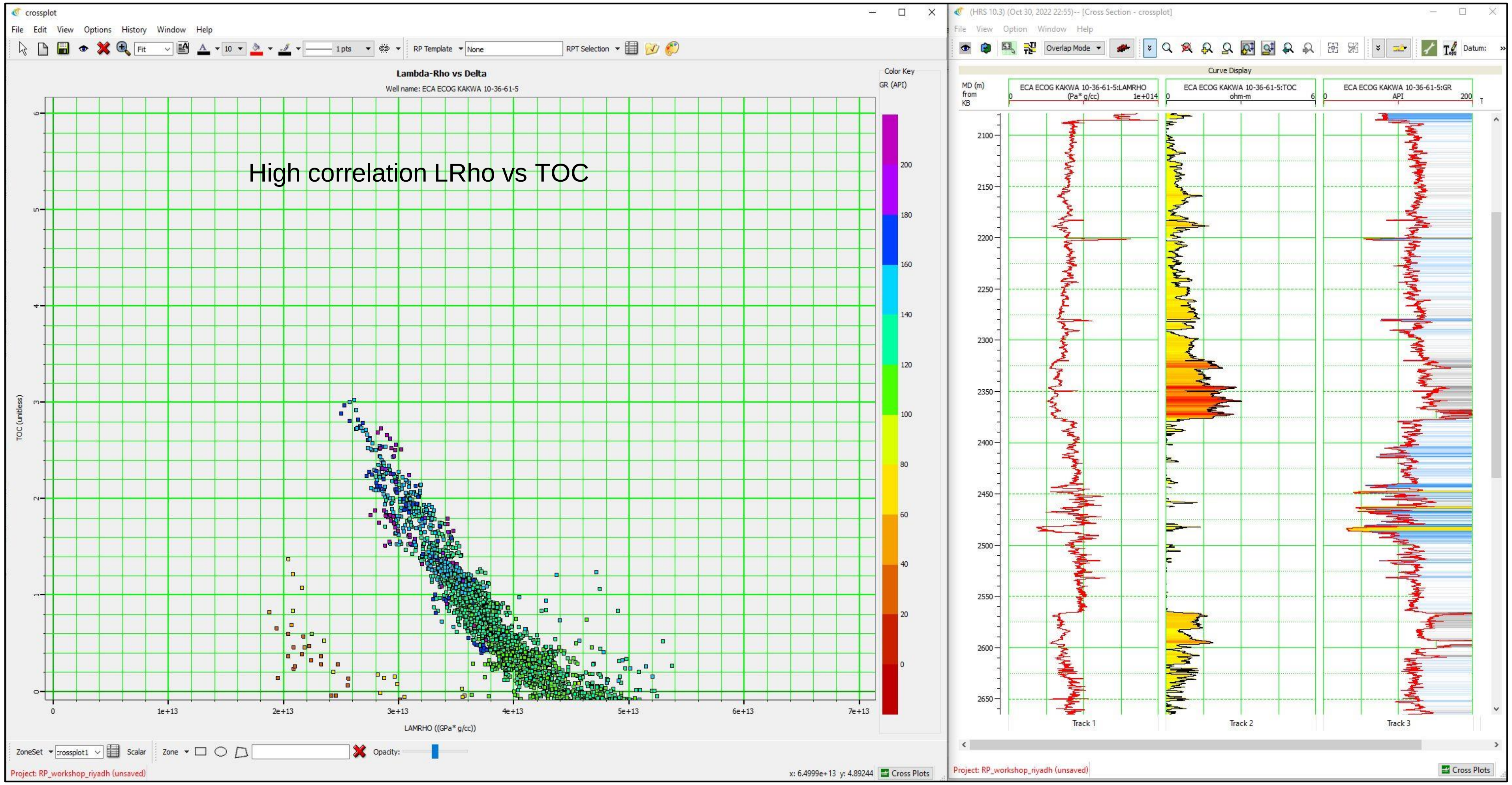


LAMBDA-RHO AND TOC ESTIMATES

Based on cross-plot a straight-line inverse relationship between Lambda-Rho and TOC estimates based on ΔLogR method is seen in source rock intervals.

Lambda-Rho from seismic can directly be converted to the TOC estimates.

The similar conclusion has been published Sharma et. al. 2014, where they have applied the procedure in Montney shale play.

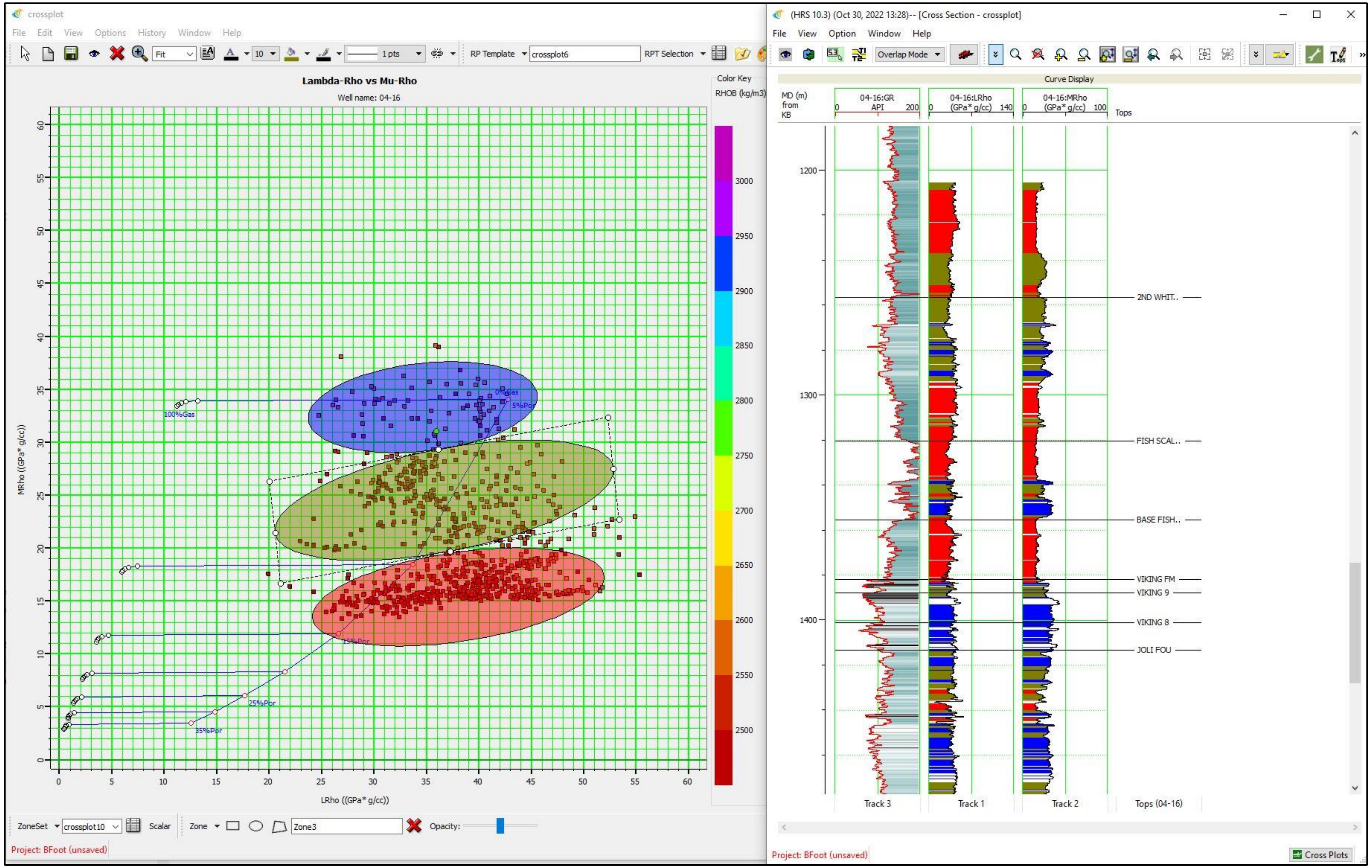


JUXTAPOSITION OF HIGH TOC AND BRITTLE RESERVOIR

The Second White Specks shale can be divided into three zones using Lambda-Rho and Mu-Rho cross-plot.

The well is in low TOC and maturity area as depicted by wet signature of RPT template.

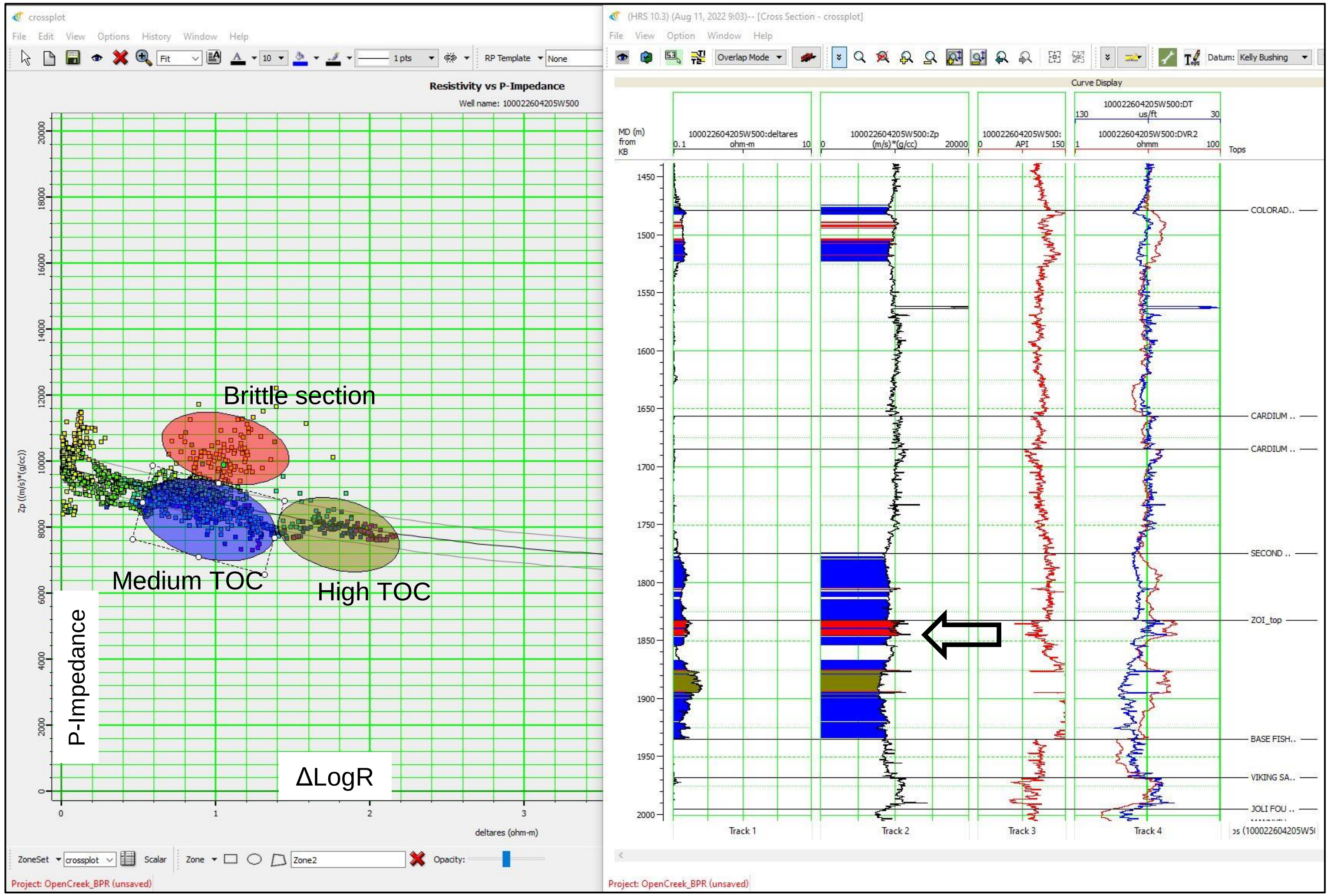
Mu-Rho becomes the discriminatory factor as one must frac brittle rock



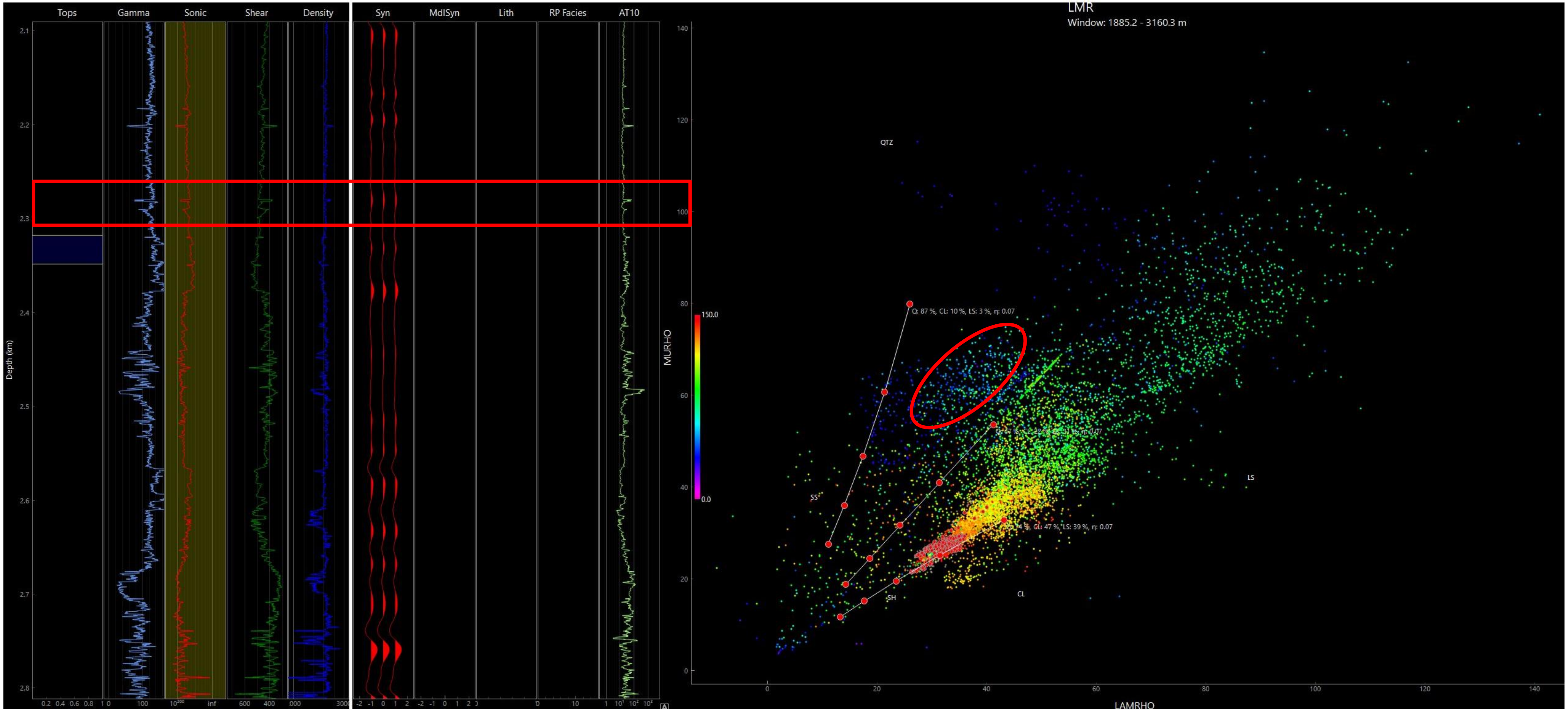
JUXTAPOSITION OF HIGH TOC AND BRITTLE RESERVOIR

In the case where the pre-stack data is not available, post-stack seismic inversion can provide a good estimate of the maturity and harder rock section

By carrying out large scale screening using ΔLogR method new unconventional target can be quickly identified



NIA TEMPLATE TO IDENTIFY THE CLAY CONTENT



TAKE AWAYS

- Every play is different and need local calibration of rock physics to the lithology, pressure and HC content
- Generalizations are detrimental but by keeping the workflow consistent one can resolve the play
- Rock Physics templates provides link between seismic and petrophysics with calibration to other geological parameters
- Brittleness, fracability and mature organic content are important parameters that could be detectable through rock physics and inversion
- Non-Ineracting Approximation (NIA) and Hertz-Mendlin Hashin-Shtrikman (HMHS) are the most used models and can allow insights to build a local mineral template.

THANK YOU

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