Optimizing Subsurface Predictions in a Mississippian Carbonate Field, Central Alberta, Canada (Part 2)*

Peter Bauman[1], Chris Barton[2], Torr Haglund[3], and Glenn Sather [4]

Search and Discovery Article #42410 (2019)**
Posted August 5, 2019

*Adapted from oral presentation given at 2019 AAPG Annual Convention and Exhibition, San Antonio, Texas, May 19-22, 2019. Please see closely related article ("Part 1"), "Optimizing Subsurface Predictions with Limited Capital Investment", AAPG/Datapages Search and Discovery Article #42074 (2017).
 DOI:10.1306/42410Bauman2019

[1]Chinook Consultants, Calgary, Alberta, Canada (pbauman@shaw.ca)
[2]Shadow Energy Inc, Calgary, Alberta, Canada
[3]Statcom Ltd., Calgary, Alberta, Canada
[4]Nutech, Calgary, Alberta, Canada

Abstract

Previously we presented the Highvale Oil Pool, located in Central Alberta, Canada, which produces light oil from dolomitized carbonates of the Mississippian Banff Formation. We employed a systematic approach to the integration of outcrop data, a pre-existing 3D seismic survey and petrophysical log data to gain a clear definition of the subsurface. This approach includes outcrop analysis, the creation of an zone internal stratigraphic correlation within the erosional remnants of the Banff Formation, the identification of fluid contacts, estimation of saturations and porosity, mineral identification and the integration of recently developed 5D interpolation of seismic data to regularize and fill in data gaps, to increase the fold and create the common depth point gathers more suited to pre-stack time migration (PSTM).

Further to this, we have taken available data, including seismic characterization parameters such as amplitude, wavelet characterization, attribute analysis pre-stack fracture analysis and mineralogy through X-ray diffraction and X-ray fluorescence. Core calibrated petrophysical log characterization was provided by NuTech and the output parameters include, effective porosity, BVI, free water, hydrocarbon pore volume, clay volume, and permeability.

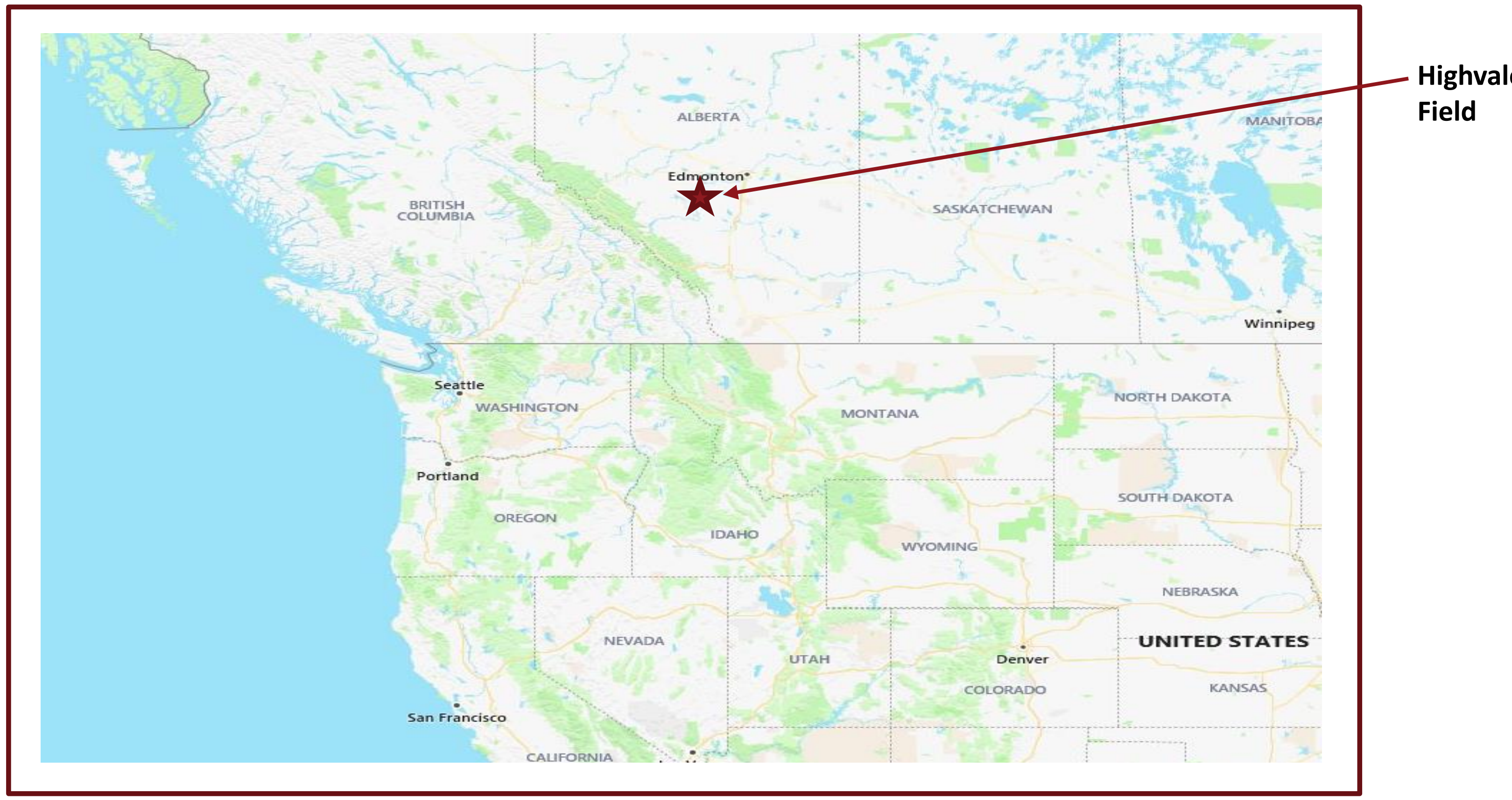
In this study, we have used multivariate analysis to quantify well performance. Well performance has been normalized by lateral length, completion type and time on production. With normalized well production, we can analyze productivity and comment on best practices concerning drilling and completions, along with key reservoir parameters and subsequent economic performance.

This study has also shown how the integration of available data and disciplines can result in improved economic performance. The adage “you cannot engineer bad rock” is more prevalent today than ever as we move forward with more complicated plays, increased horizontal lateral length, increased hydraulic fracturing stages and drilling complexity.

Optimizing Subsurface Predictions in a Mississippian Carbonate field. Central Alberta, Canada (Part 2)

Peter Bauman, Chinook Consulting Services, Calgary, Alberta
Chris Barton, Shadow Energy Inc, Calgary, Alberta
Co-authors: **Torr Haglund**, Statcom Ltd, Calgary, Alberta, **Glenn Sather,** Nutech, Calgary, Alberta

- Mississippian Age Carbonate Reservoir in Central Alberta
- Review all the Variables that Affect the Reservoir
- Goals: Determine the Variables that most impact Production
- Predict Expected Ultimate Recovery (EUR)



NEW STAR ENERGY LTD.

NUTECH VISIONARY RESERVOIR INTELLIGENCE

STATCOM Ltd SEISMIC DATA PROCESSING

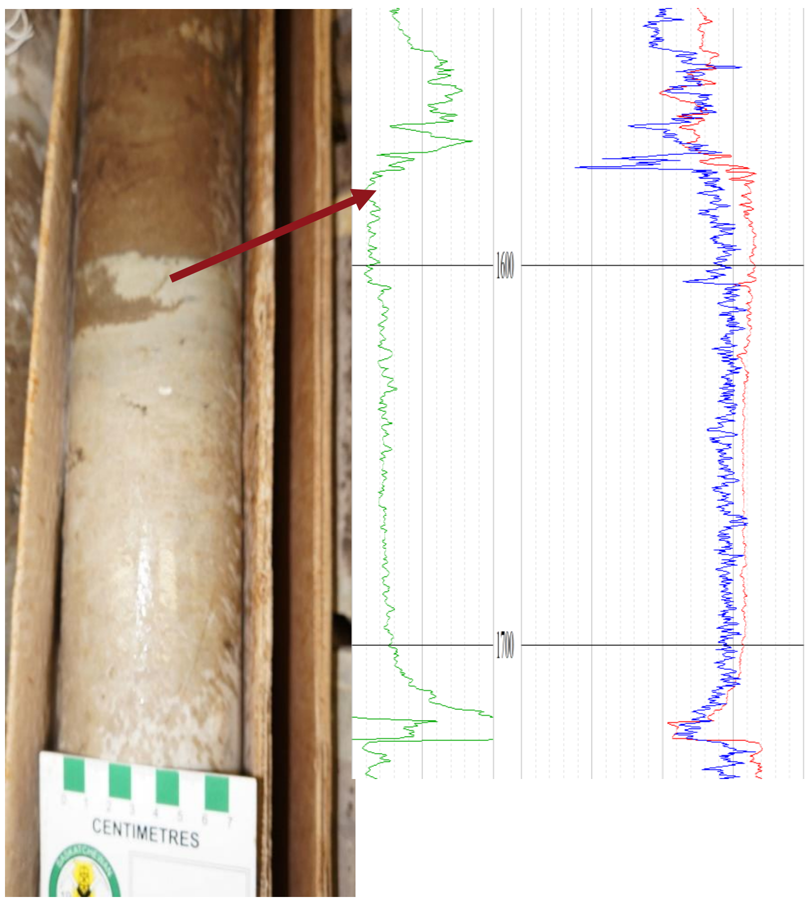
SHADOW ENERGY INC

Outline

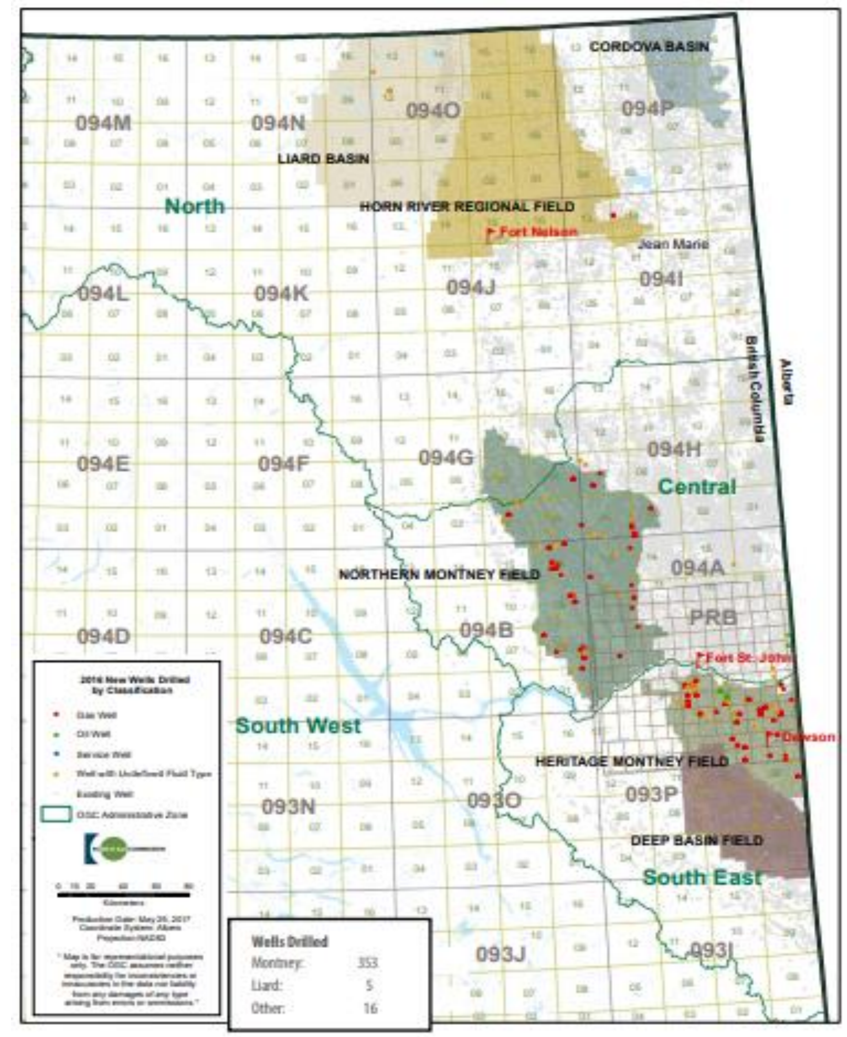
- Why?
- What and Where?
- Methodology
  - Data used in Analysis
- Results
- Conclusions

Why

Micro



Macro

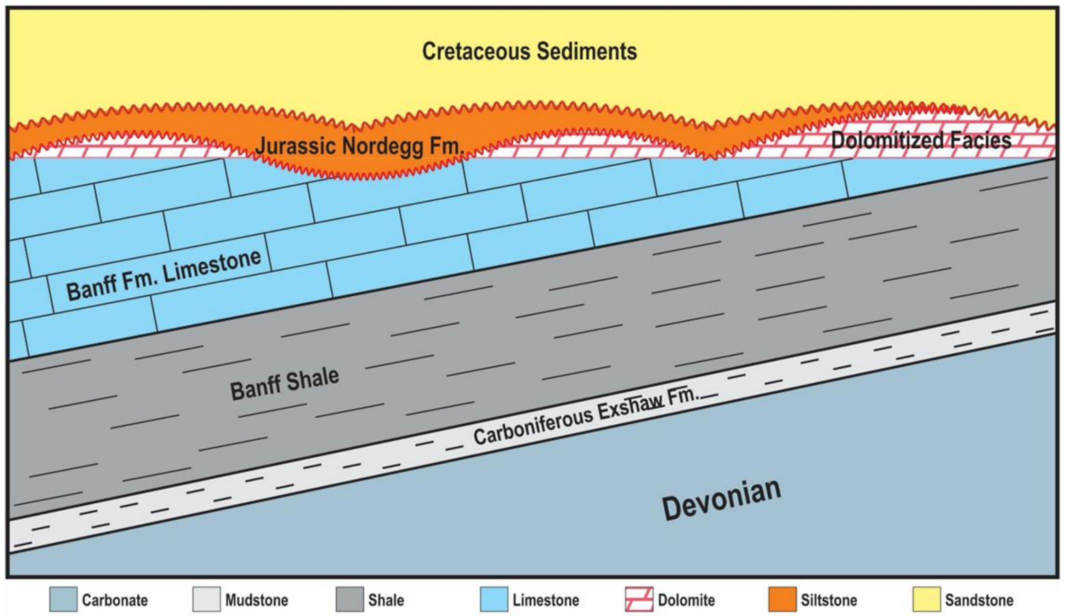


Integrating the Micro & Marco data into Multivariate Analysis at the Field Level

Utilize all available data variables applicable to the field/play

What

Schematic Profile of Highvale Area



Simplified Stratigraphic Column

Highvale Area

SYSTEM	STAGE	UNIT	CENTRAL SOUTHERN ROCKY MTNS. ALTA., B.C.	SUBSURFACE SOUTHERN ALBERTA	WILLISTON BASIN
CARBONIFEROUS	TOURNAISIAN		Banff Limestone	Banff Limestone	Scallion Mbr.
			Banff Sandstone	Banff Sandstone	Lodgepole (part)
			lower Banff Shale	lower Banff Shale	upper Bakken
			Exshaw Silt	Exshaw Silt	middle Bakken
DEVONIAN	FAMENNIAN		Exshaw Shale	Exshaw Shale	lower Bakken
		3	upper Costigan	Big Valley	Big Valley
		2	lower Costigan	upper Stettler	Torquay / Three Forks
		1	Morro	lower Stettler	

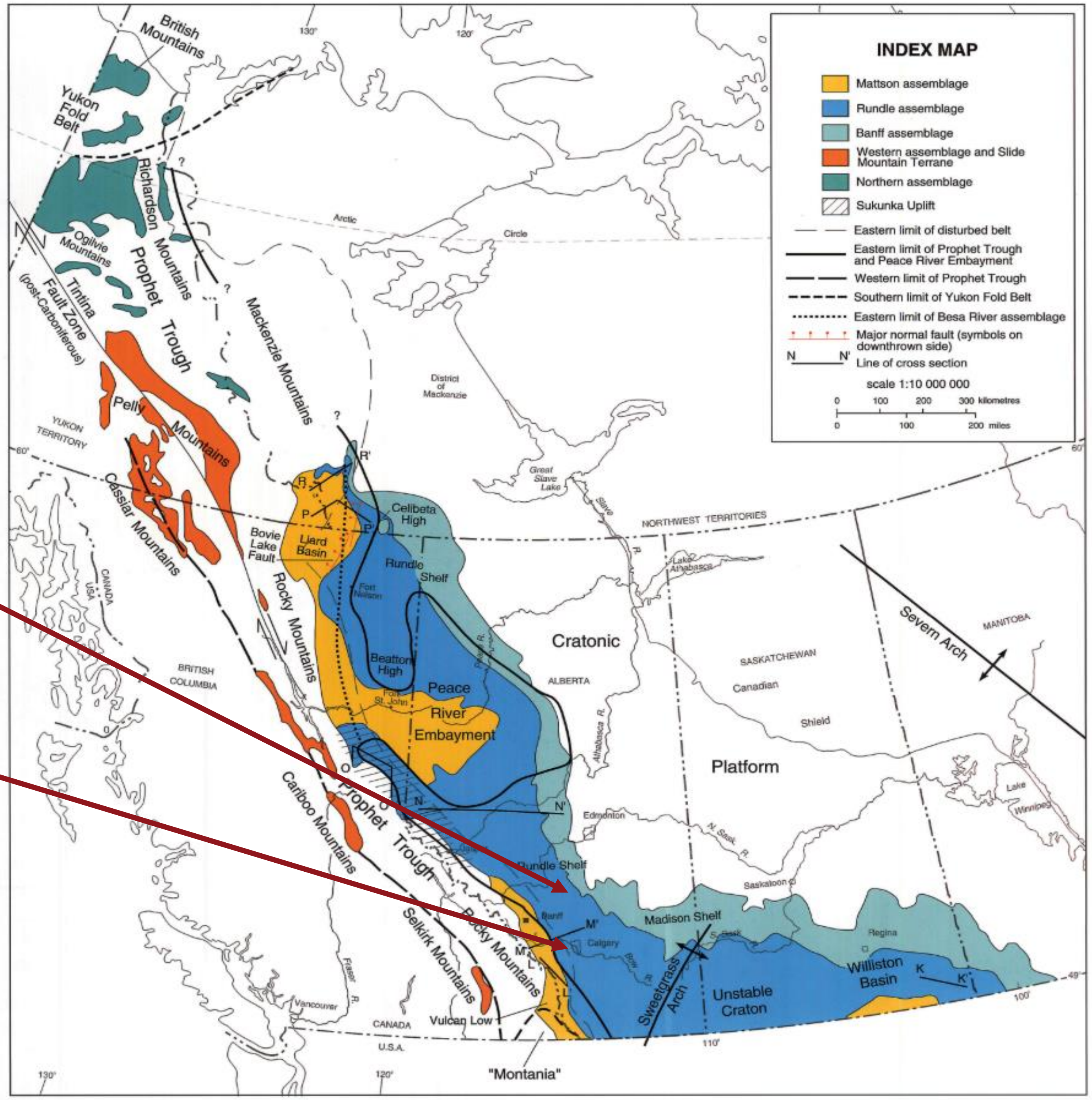
- Banff Formation, Carboniferous (Lower Tournaisian) Banff Formation, Rundle Group
- Argillaceous silty packstone, wackestone and mudstone, with interbeds of cherty lime packestone and wackestone with lenses of crinoidal grainstone and packestone.
- Williston Basin Bakken age equivalent

What and Where

Carboniferous Regional Distribution

Highvale Area

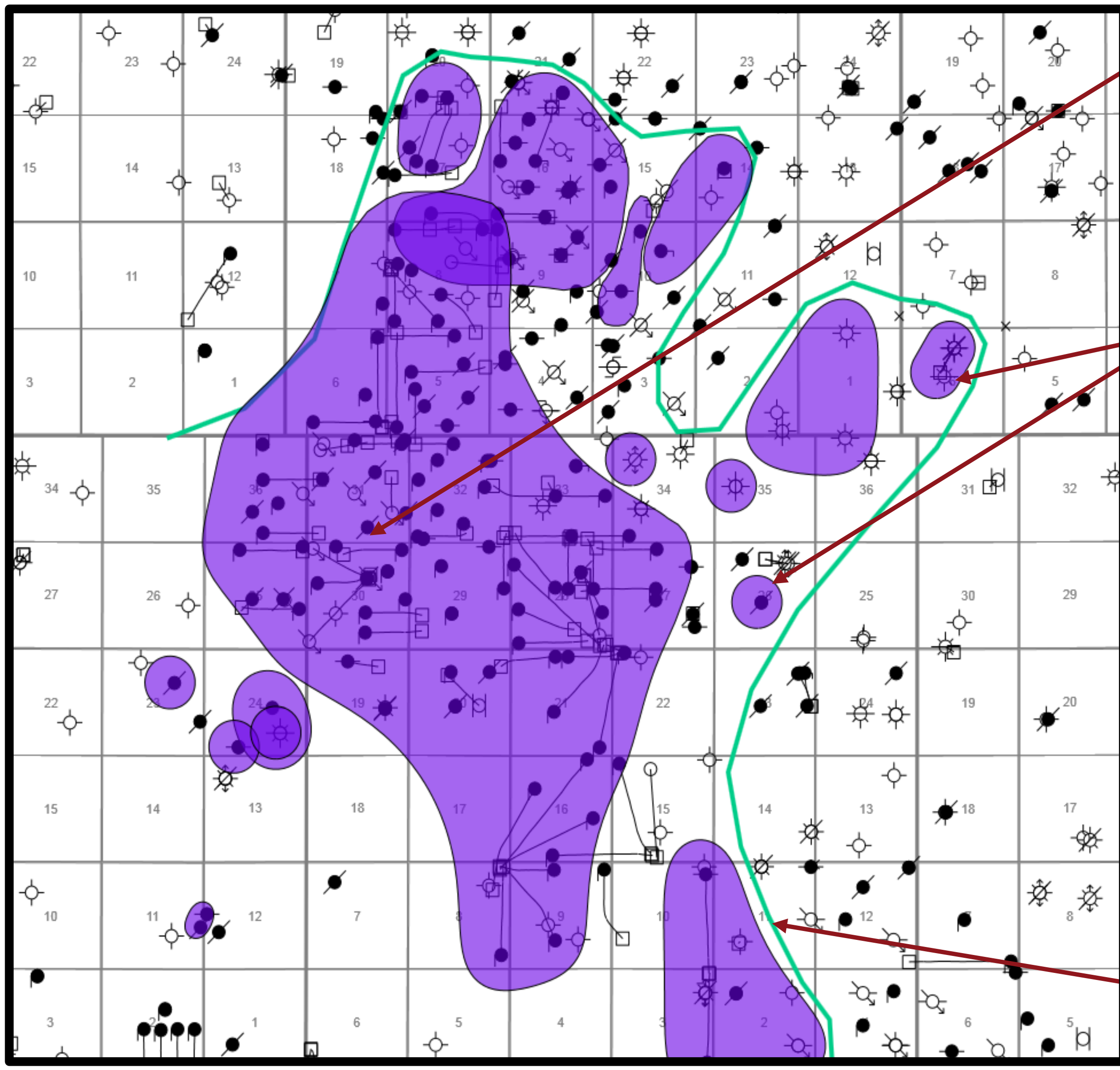
Calgary



*taken from Atlas Of the Western Canadian Sedimentary Basin. Fig 14-1

What

Highvale Field Main field and Outlier pools



Highvale Co-mingled Pool 001

Banff outlying pools

Banff Porosity Subcrop

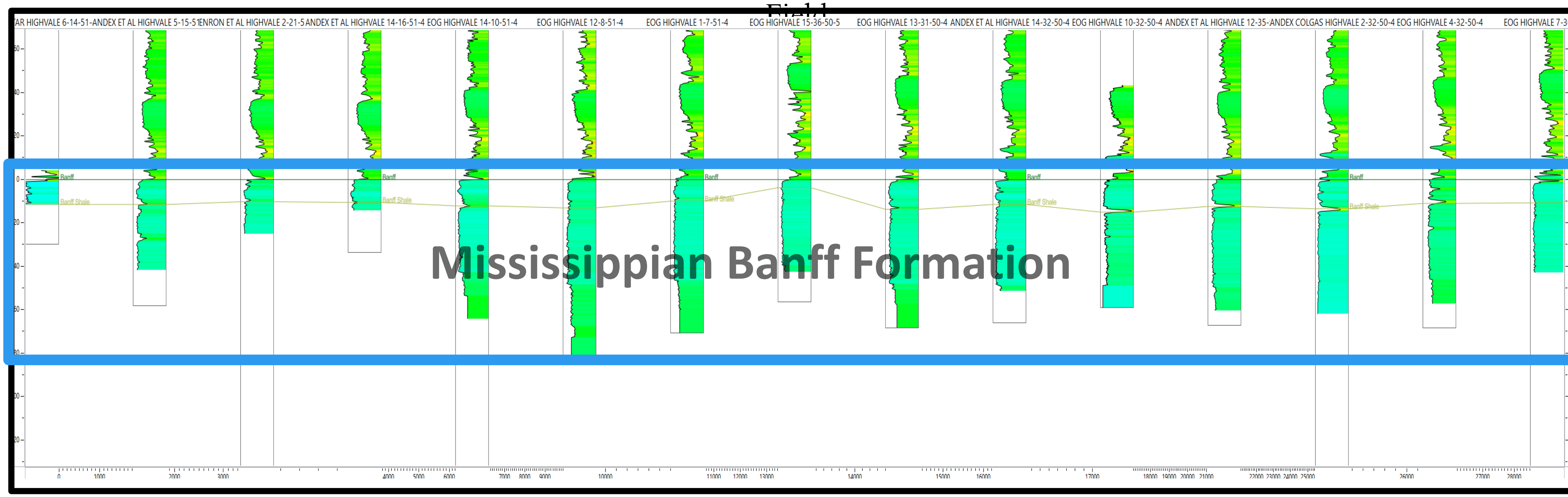
- 147 Banff Formation wells (hydrocarbon produced)
- **<u>Mature field</u> with moderate Horizontal well development**
    - Vertical (83) and Horizontal (64)
    - Horizontal wells are open hole completed.

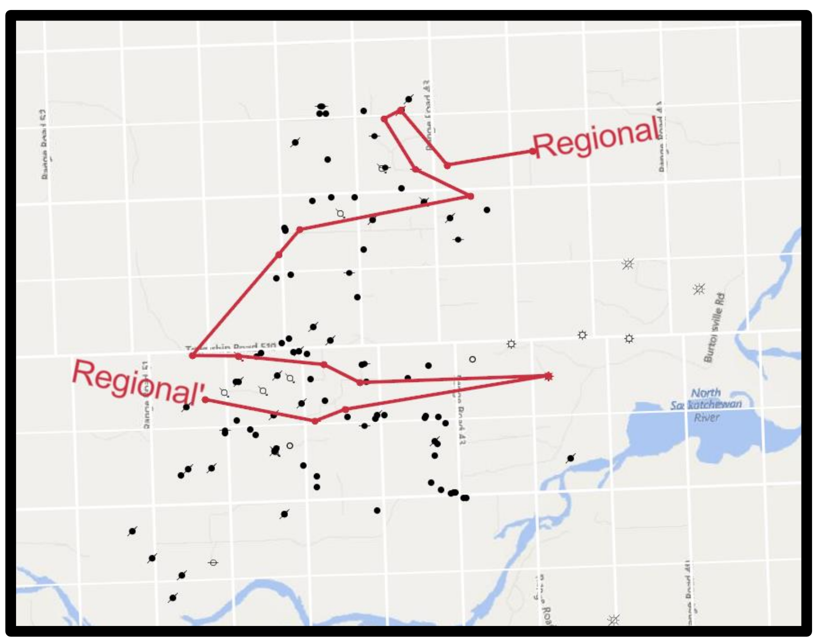
What

R

R’

Gamma Ray Log display cross-section through Highvale Field





Reservoir Parameters:

- Average thickness: 30-50 ft (Banff Reservoir Zone)
- Average Total Thickness: 300 ft
- AVG PAY: 10-15 ft
- AVG Depth: ~5000 ft
- Average PHIE: 10 %
- AVG SW: 40%
- AVG Perm : 10-25mD

Methodology: Mineralogy & Petrophysical Workflow

Available Data

Core & Cuttings

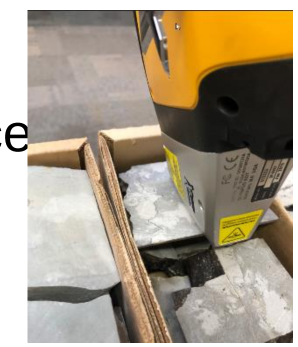
Wireline Logs

NUTECH
VISIONARY RESERVOIR INTELLIGENCE

Interpretation

Data Acquisition

- Portable X-ray fluorescence
- X-Ray Diffraction
- ICP-MS
- SEM-EDS



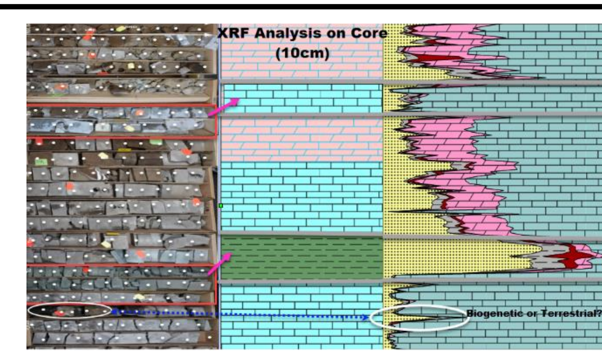
Data Validation

Data Integration

Determine linear regression association between “predictor proxies” and “response” variables

Facies Characterization

- Mineralogy
- Grain Density
- Porosity



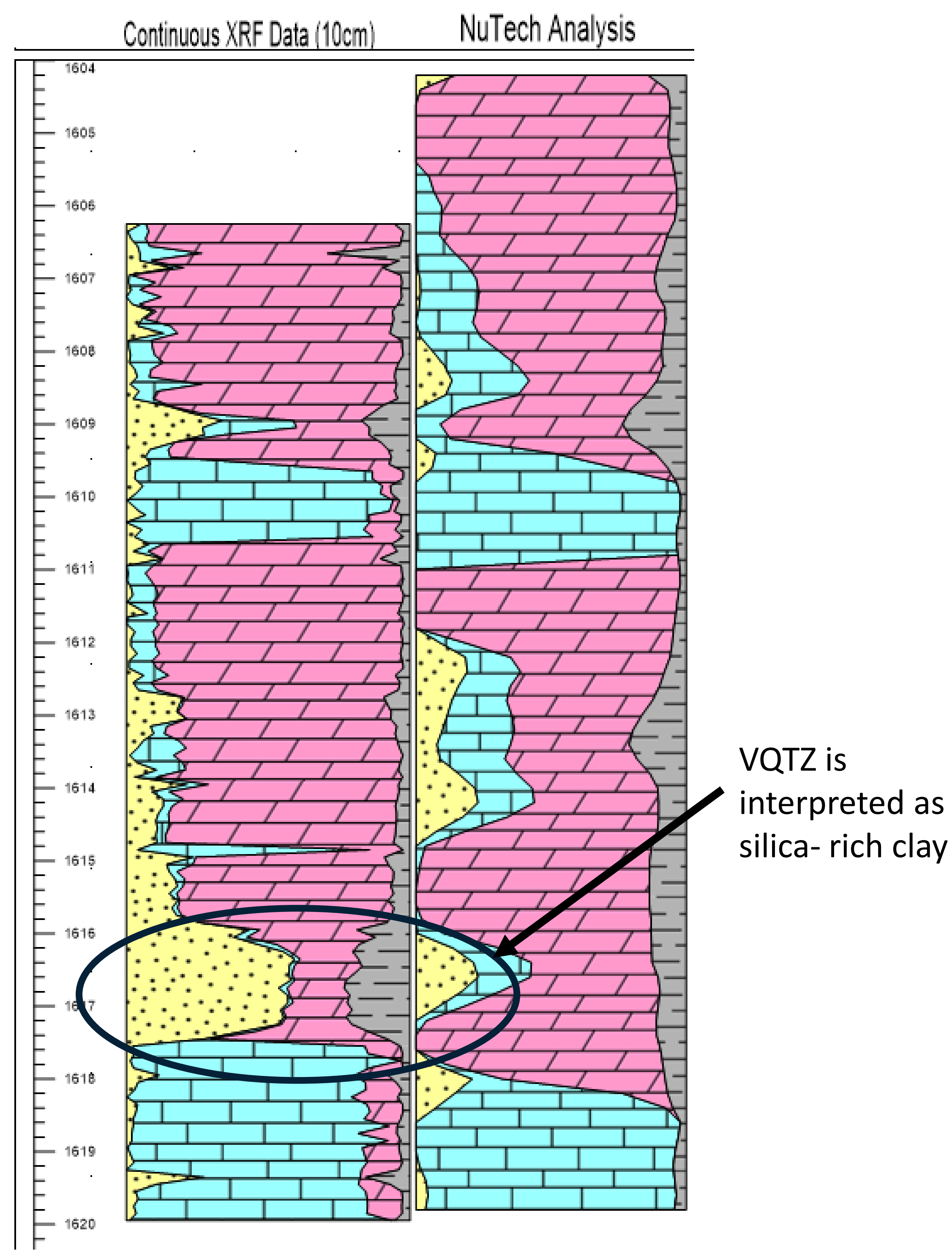
Data

Validation

XRD and XRF need to be complimentary in validating mineralogy

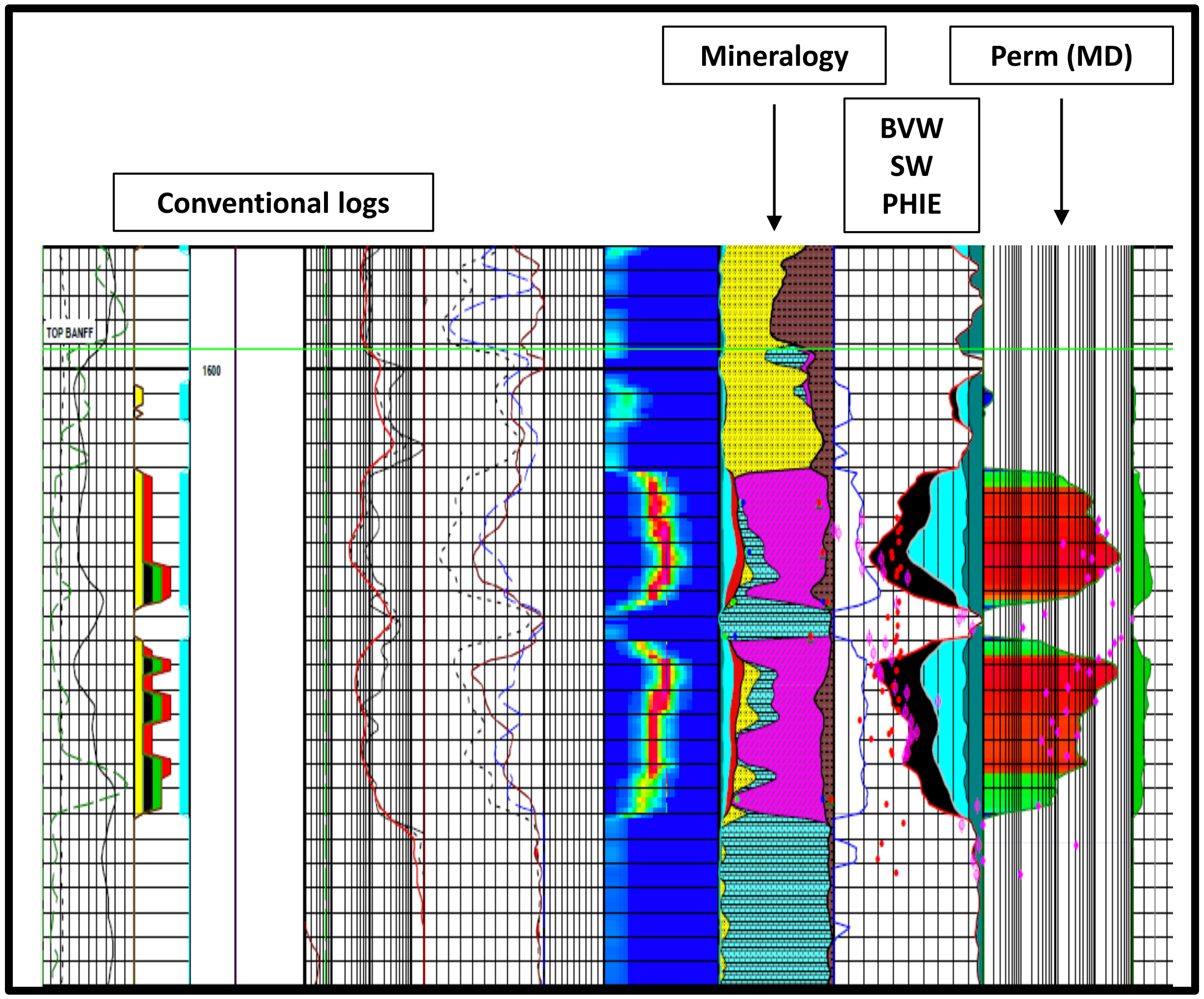
Portable XRF is cost effective and rapid

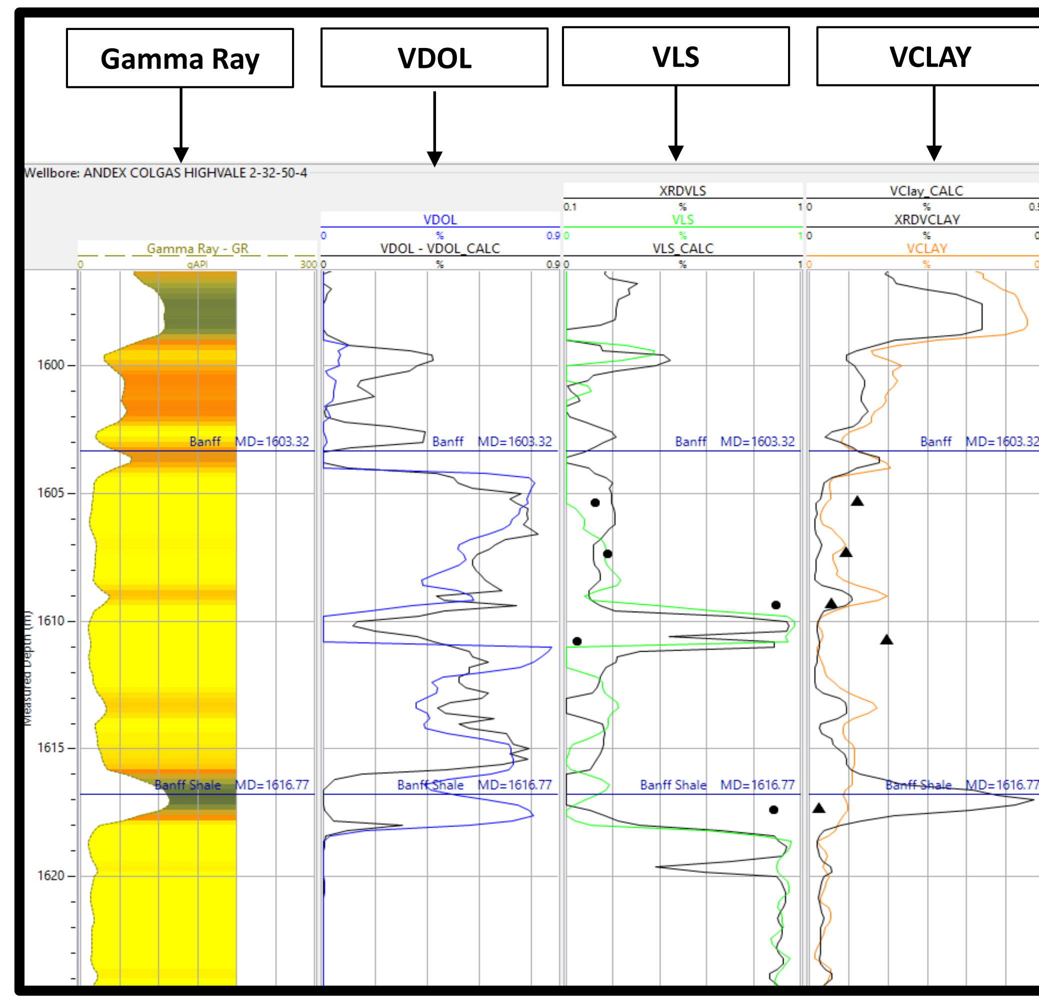
Repeated validation and sampling rate increases mineralogic resolution



Data

Measured versus Calculated Non-linear Regression prediction versus XRD



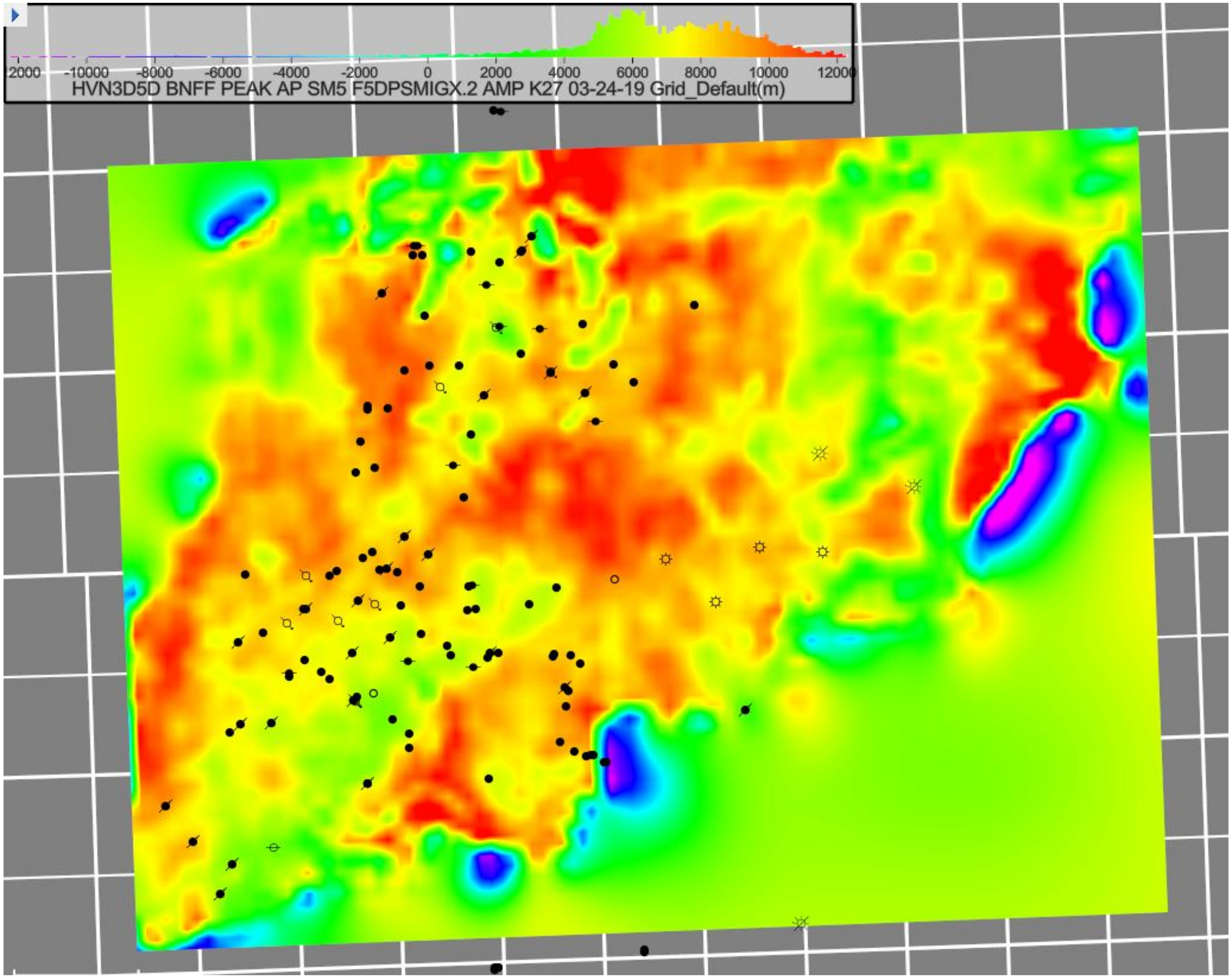


Petrophysical Analysis provided by:

NUTECH
VISIONARY RESERVOIR INTELLIGENCE

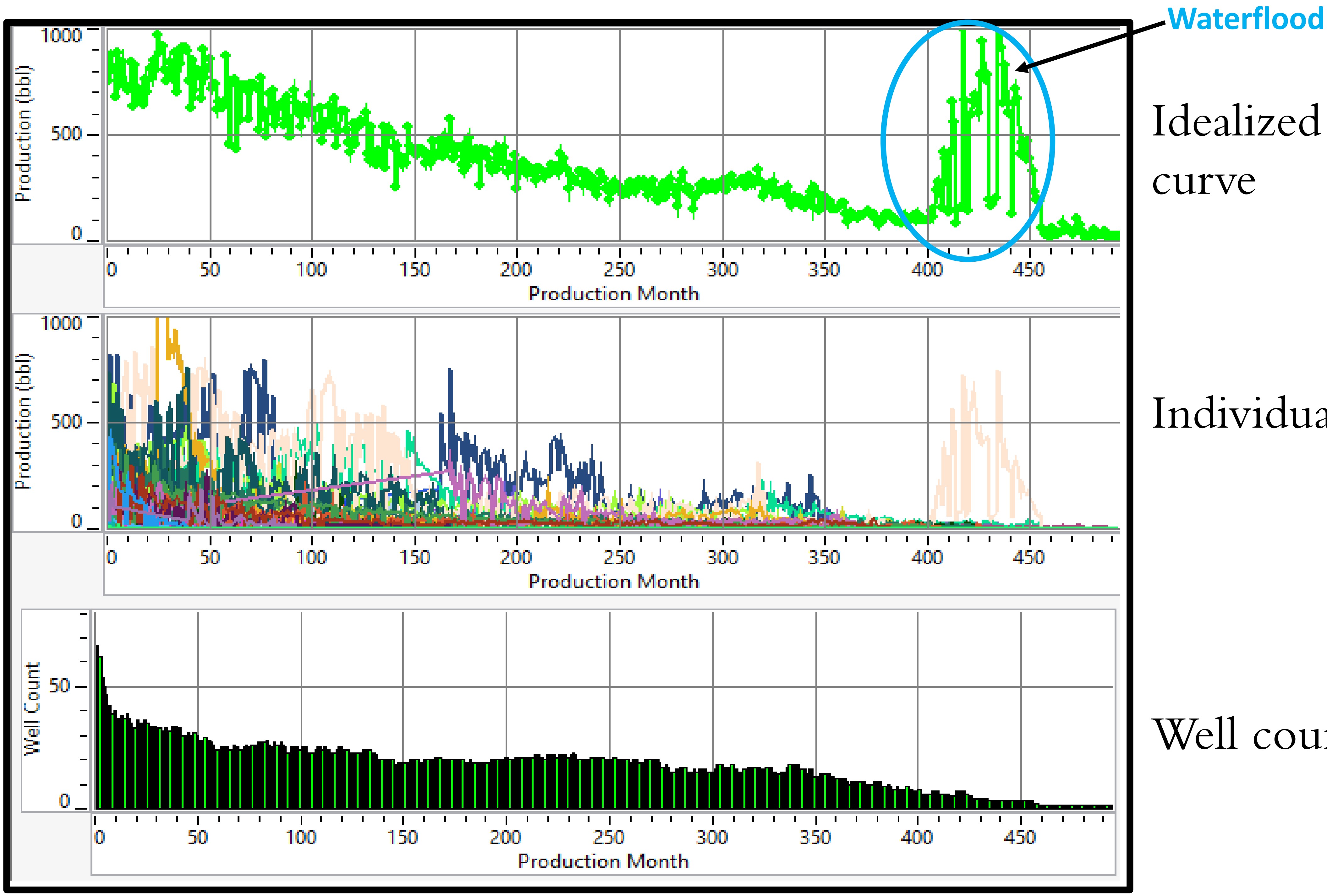
Data

Banff Peak Amplitude-Highvale 3D



Data: Expected Ultimate Recovery

Monthly Oil Production: Vertical Wells, Time series, First Month Production Normalized



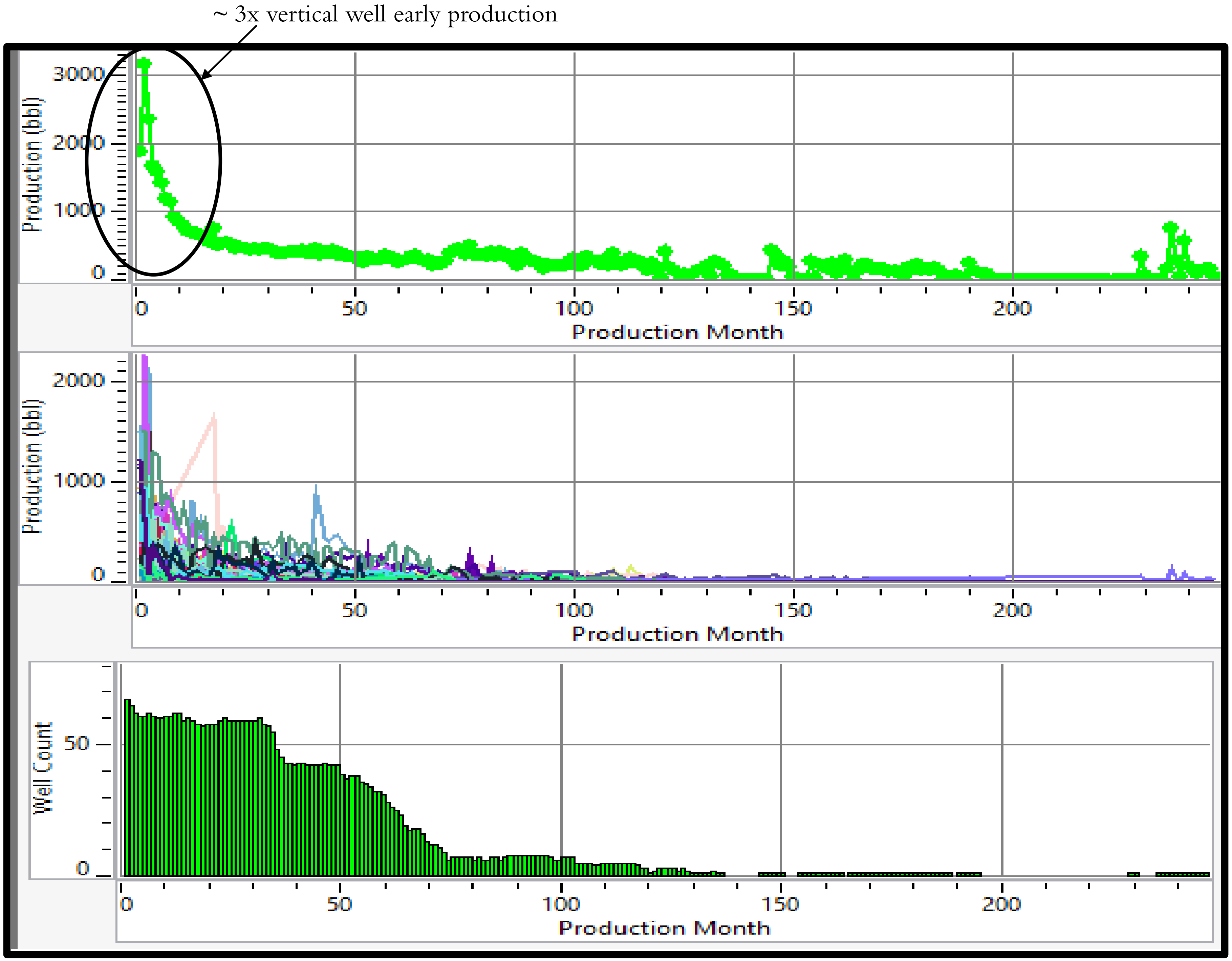
Idealized Type curve

Individual well

Well count

Data: Expected Ultimate Recovery

Oil Production: Horizontal Wells, Time series, First Month Production



Idealized Type curve

Individual well

Well count

Methodology

Variables used in Analytics:

<u>Response Variable:</u>
Expected Ultimate Recovery (EUR)

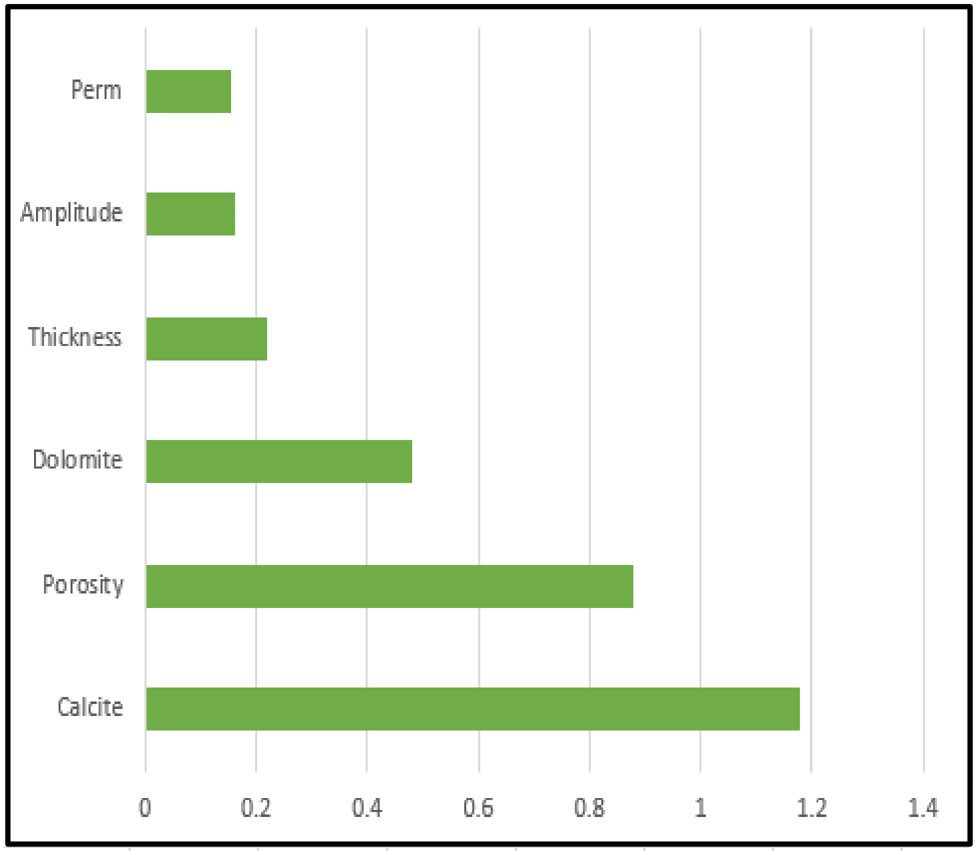
- Individual well Exponential Decline Curve Analysis

<u>Independent Variables:</u>

- Horizontal well Lateral Length
- Seismic Attributes:
    - Banff Peak Gradient,
    - Banff Peak Dip Diff
    - Inline & Cross Line,
    - Banff Peak Amplitude
- AVG PHIE
- AVG Permeability
- Thickness
- AVG Calcite Volume
- AVG Dolomite Volume
- AVG Clay Volume

Results- Vertical Wells

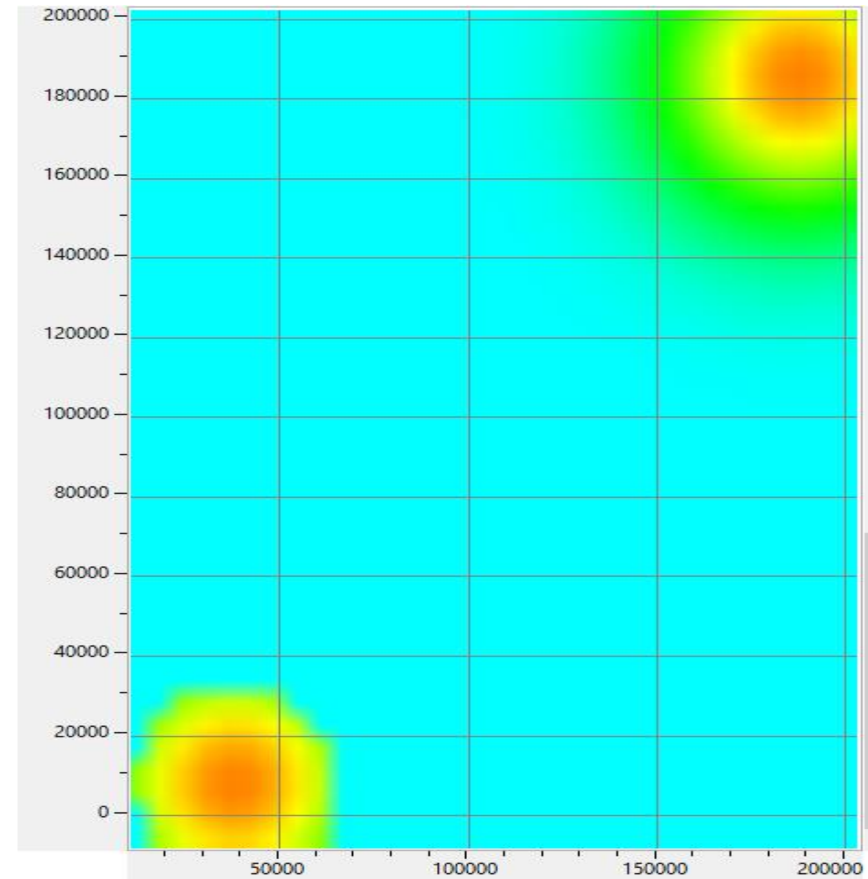
Vertical well EUR significance



Independent variable

Analytic Significance

Multiple Non-linear Regression



Predicted EUR

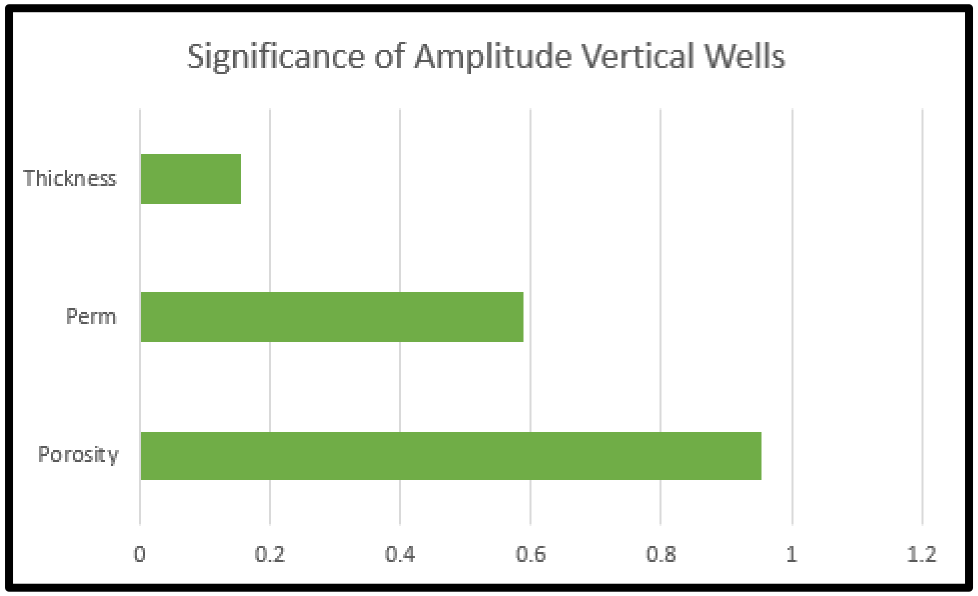
Actual EUR

- Outlier analysis applied
- Geologically and geophysically driven selection of variables that are significant to predicted hydrocarbon bearing zones in this reservoir type, depth and area.

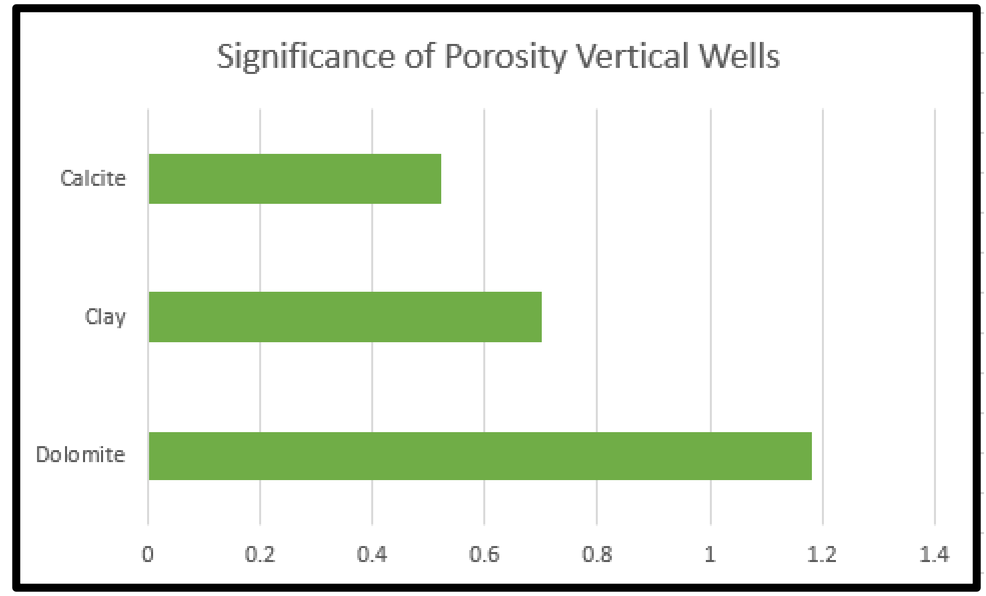
Results- Vertical Wells

Independent variable

Seismic Amplitude Significance



Porosity Significance

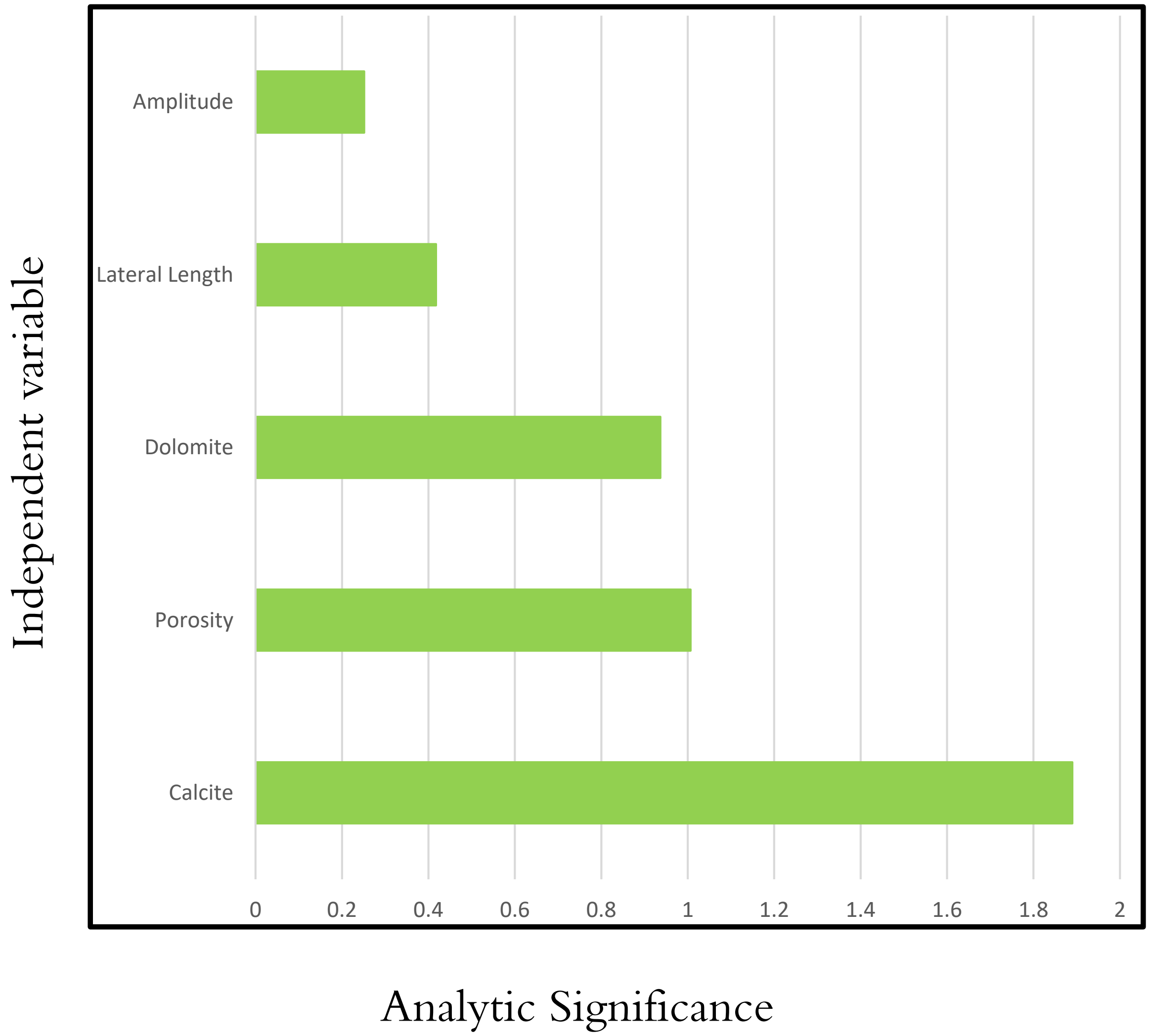


Analytic Significance

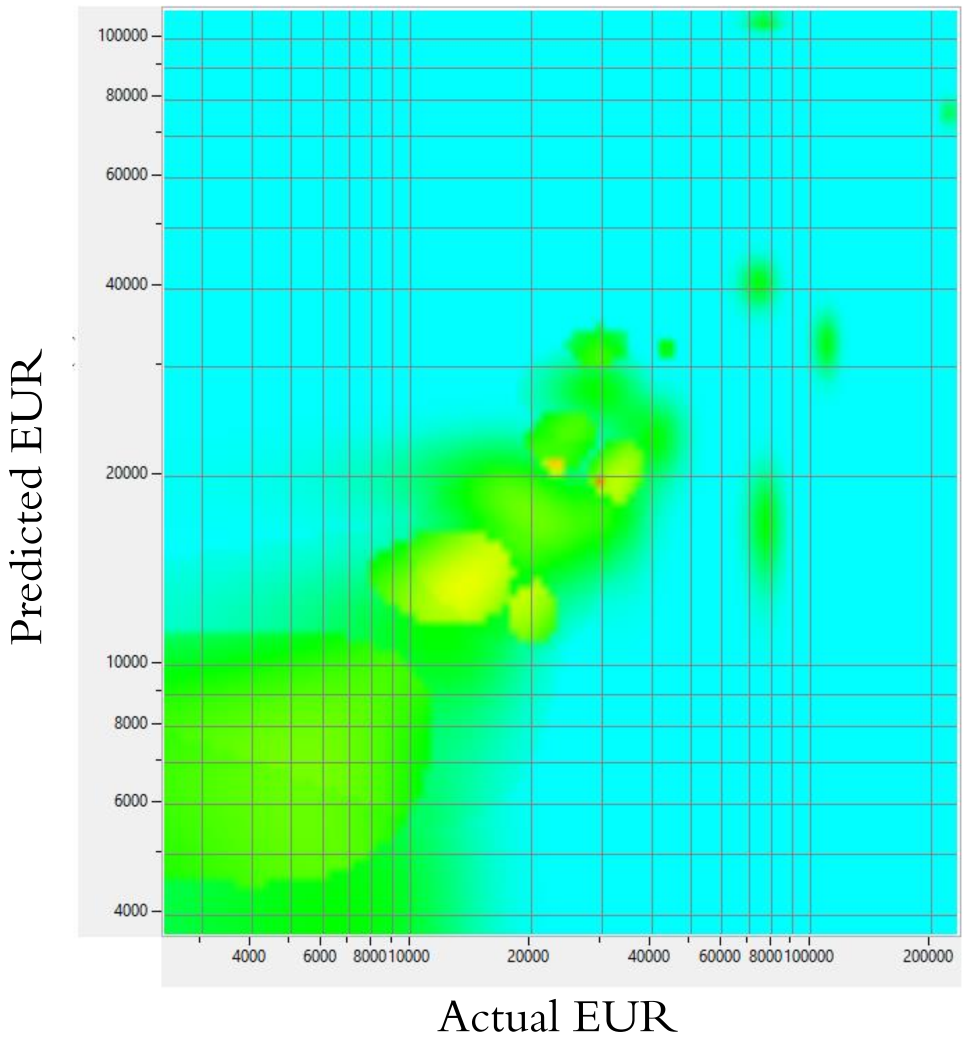
-Little clay in porous intervals-

Results- Horizontal Wells

Horizontal well EUR significance



Multiple Non-linear Regression



Conclusions

- Calcite volume is the most significant factor in productivity in both Vertical and Horizontal wells

- When considering future field development (FFD):
    - mineralogy driving porosity is the most significant variable
    - As permeability is of lower significance, reservoir stimulation is not a driving factor in well performance.

- Horizontal wells will access more porous rock volume thereby increasing rate, but mineralogy is the key factor in porosity and hydrocarbon storage.

- Petrophysical evaluation coupled with mineralogy characterization significantly increased the robustness and validity of reservoir characterization

- Understanding geologic factors even in mature field development is Important!!!!

- Next Steps:
    - Expected Ultimate Recovery (EUR) predication outside 3D coverage area.

Thanks

CHINOOK CONSULTING SERVICES — XRD and XRF analysis and Software

STATCOM Ltd SEISMIC DATA PROCESSING — 3D Reprocessing and Analysis

NEW STAR ENERGY LTD. — Access to Highvale 3D

SHADOW ENERGY INC — Seismic Interpretation and Software

NUTECH VISIONARY RESERVOIR INTELLIGENCE — Petrophysical Analysis