Unlocking North Sea Reserves through AI-Driven Data Conditioning & Reserves Analytics

Oil & Gas Authority

Energective

Energy Focused
Objective Advice - Transformative Results

Energective DNA

- Digital Formation Accelerator and Positive Disruptor
- The Energective Solutions space is “QFD”-driven, ensuring business priorities drive value delivery
- Distinctive Skunkworks-like operating model
- Focused on upstream oil and gas, strengthened by experience in other high tech sectors
- Smart sourcing and rapid integration of advanced technology

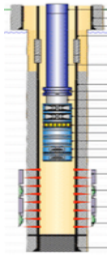
Leadership Experience – 120+ Years
BP Electronic Commerce
Boeing 777
ExxonMobil Transformation
GE
Schlumberger Digital Transformation
Cantium Digital Formation
BP DM, L48, SSA, DWP, UR….
Lockheed Martin
US Air Force

Digital ‘Formation’ Specialists

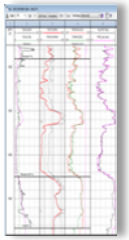
Energective Clients

bp, devon, LINN Energy, Marathon Oil, equinor, USAF Research Labs, OXY, ConocoPhillips, The Oil & Gas Technology Centre, Chesapeake Energy, bhpbilliton, TALISMAN ENERGY, CANTIUM, SWN Southwestern Energy, HESS, ABS American Bureau of Shipping, elpaso, Apache

Deep Data Management Experience



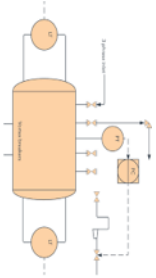
WBS: 25K+ Wells



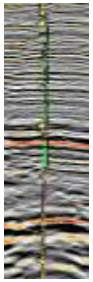
Logs 25K+ Wells

Well Headers 12K+ Wells

Cores: 3K+ Wells



Projects: 200+



Seismic: Significant Volumes

Rich Talent Pool

Data Scientists

Engineers & Geoscientists

Academic and Industry Expertise

Agile Program and Change Managers

What We Do…

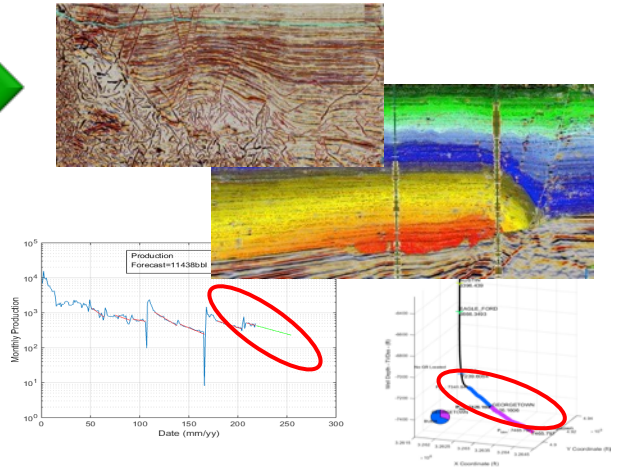
1. Digitize and Condition Legacy Data

At Scale Ingestion of Electronic Data and Physical Documents, using Robots and AI-driven Digitisation and Cleansing

2. Provide, Configure, Manage Unified Data Platform with Advanced Search Tools

'Plug and Play' High Performance, Easy-to-Use, Trusted Data Search, Retrieval and Organization Tools

3. Facilitate Workflow / Deliver Value e.g. Increase Production & Reserves through AI-enabled Analytics



OGTC Project: AI-driven data and Image-based algorithms to find oil and predict performance

Case Study of Energective at Work - Pace, Agility and Delivering Value at Scale

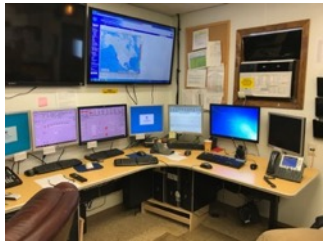
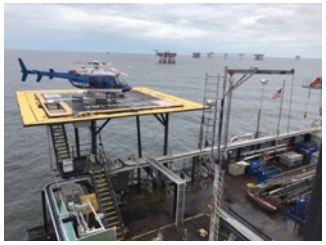
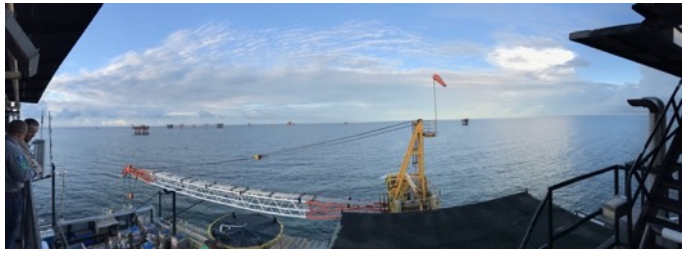
CANTIUM
Velox, Elegantes, et Efficiens

Speed, Elegance, and Efficiency

Cantium Digital Formation

- Stood up start-up operator of 75 offshore platforms in 60 days
- Created world's first truly digital, data-driven oil company, across whole E&P value chain
- Broke records (e.g. quickest to transition operations; first Petrel implementation on Cloud/Delfi…)
- Helped drive significant incremental business value
  - Identified hundreds of millions boe behind pipe incremental reserves
  - Doubled production in 12 months
  - Achieved amongst most reliable assets in GoM



Delivered in Months

Project Objectives

AI-Driven Data Digitization & Reserves Analytics

The project will apply advanced technology to:-

- ingest, cleanse and integrate relevant legacy well data into a trusted Data Lake using various AI-driven techniques;
- provide rapid search-and -retrieval tools to that data;
- and then automate geo- and petro-physics workflow analysis using machine learning models on sample data to extract correlatable features…
- …indicative of incremental reserves.

AI-Driven Data Digitization & Reserves Analytics - Status

Activity 1 – Acquire/Profile Data - Completed

- All data has been ingested into a secure Data Lake, inventoried and profiled to determine a well and block data completion score

Activity 2 – Condition Relevant Data - Completed

- Conditioning is complete

Activity 3 – Extract Basic Correlations – In Progress

- Current work is analyzing conditioned data in the analytics system. We have started to build a petrophysical (RW, lithology model, porosity system) model.

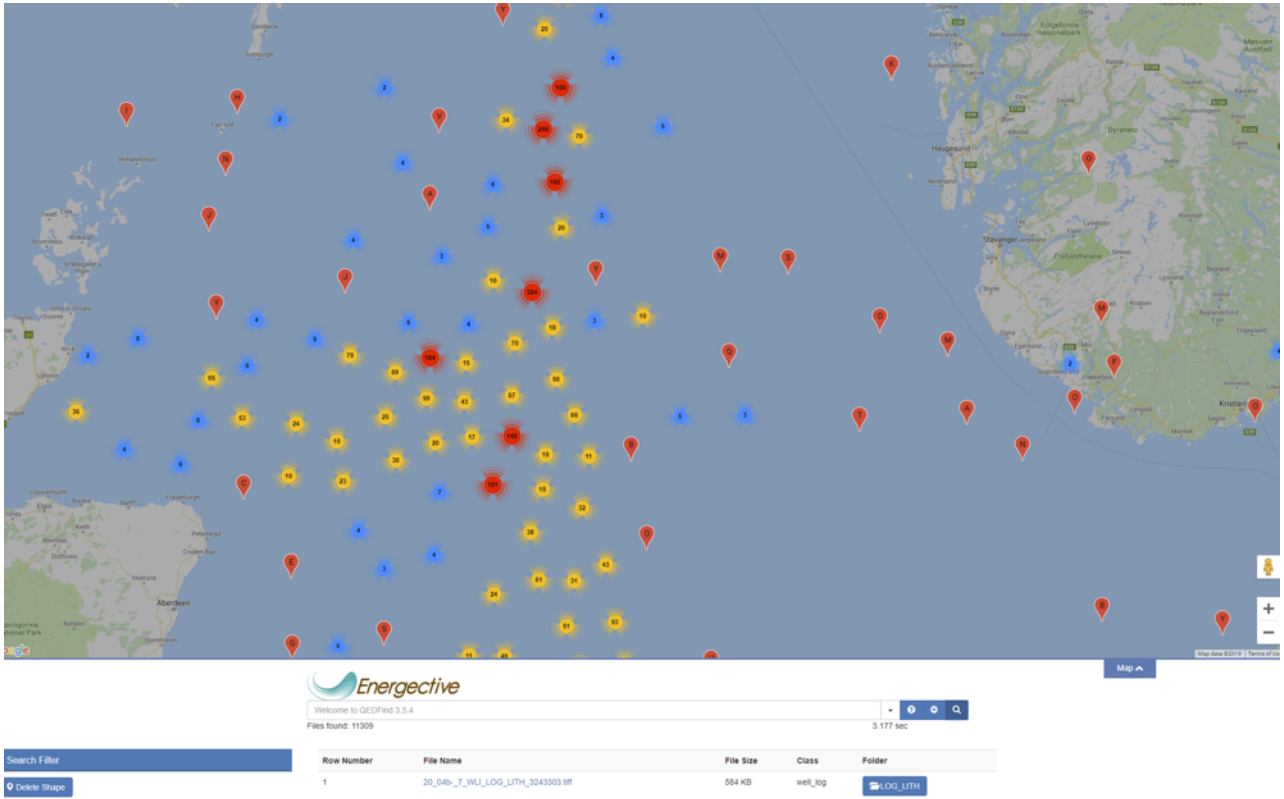
Activity 4 – Run Interpretation Algorithms– In Progress

- Once the petrophysical model is built and tested locally it will be expanded to the full regional limit for the interpretation/analysis process and QC.

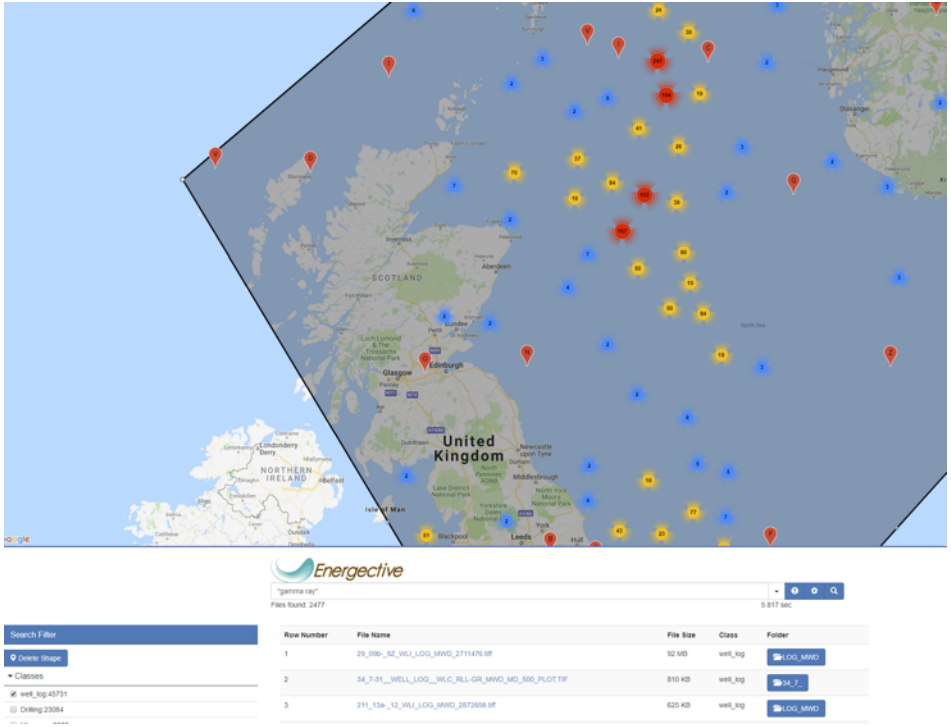
Activity 5 – Identify Opportunities – Expected Completion 31/10/19

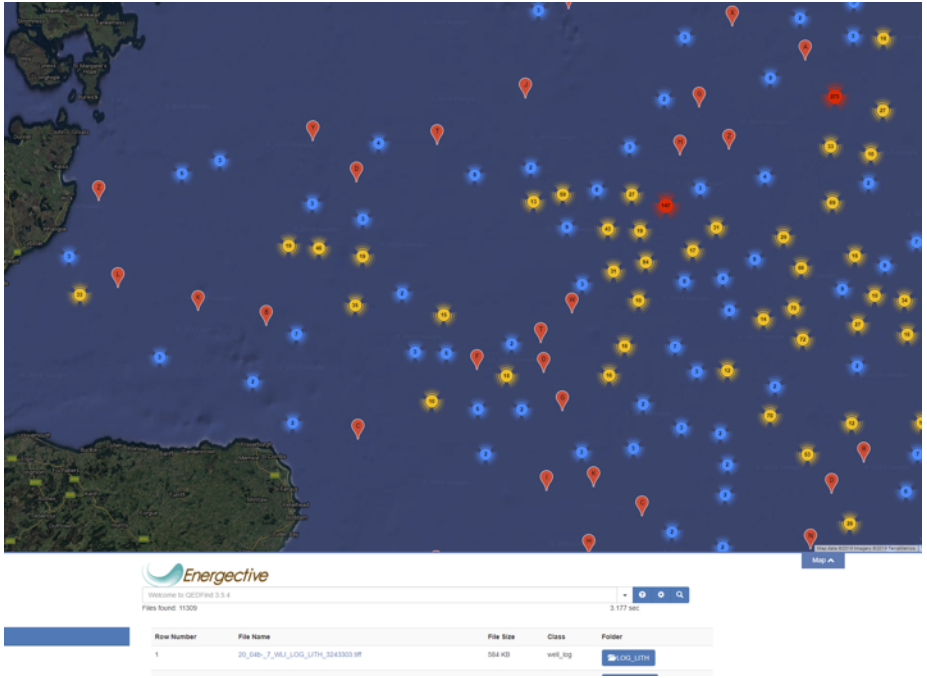
- Preparations underway to commence this activity

Energective QEDFinder Showing OGTC Conditioned Data

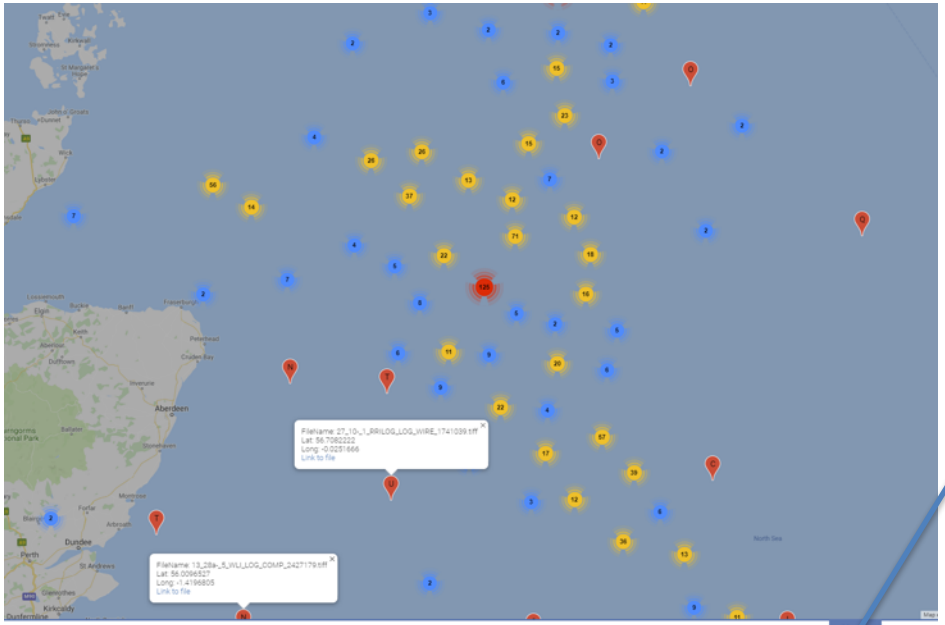


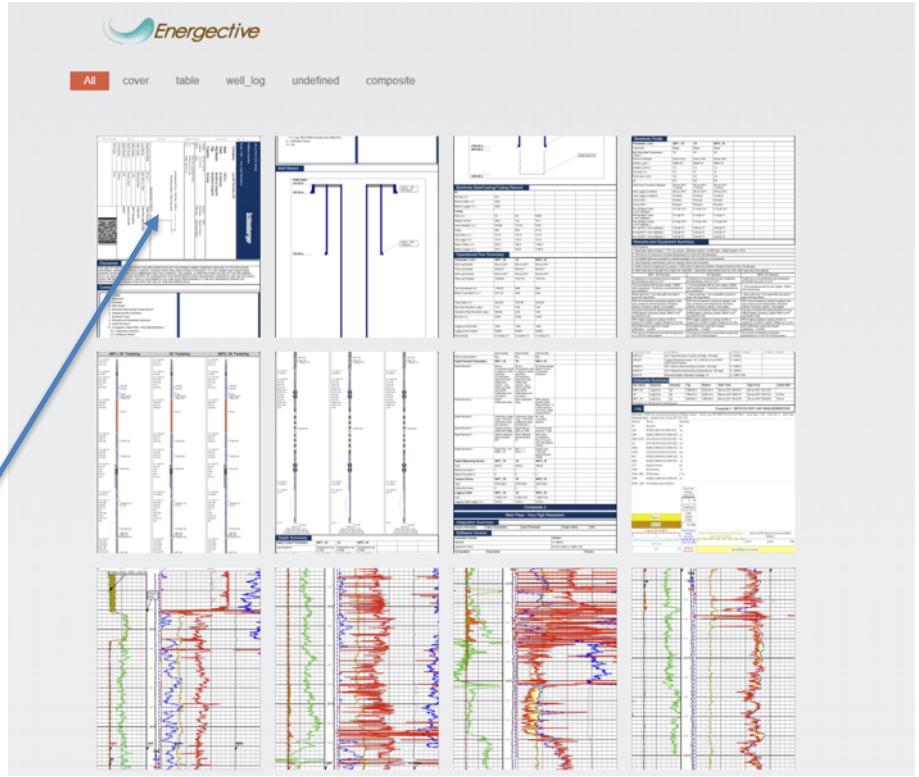
Energective QEDFinder Zooming Into User-Selected Area of Interest





Energective QEDLogFinder Showing Selected Logs



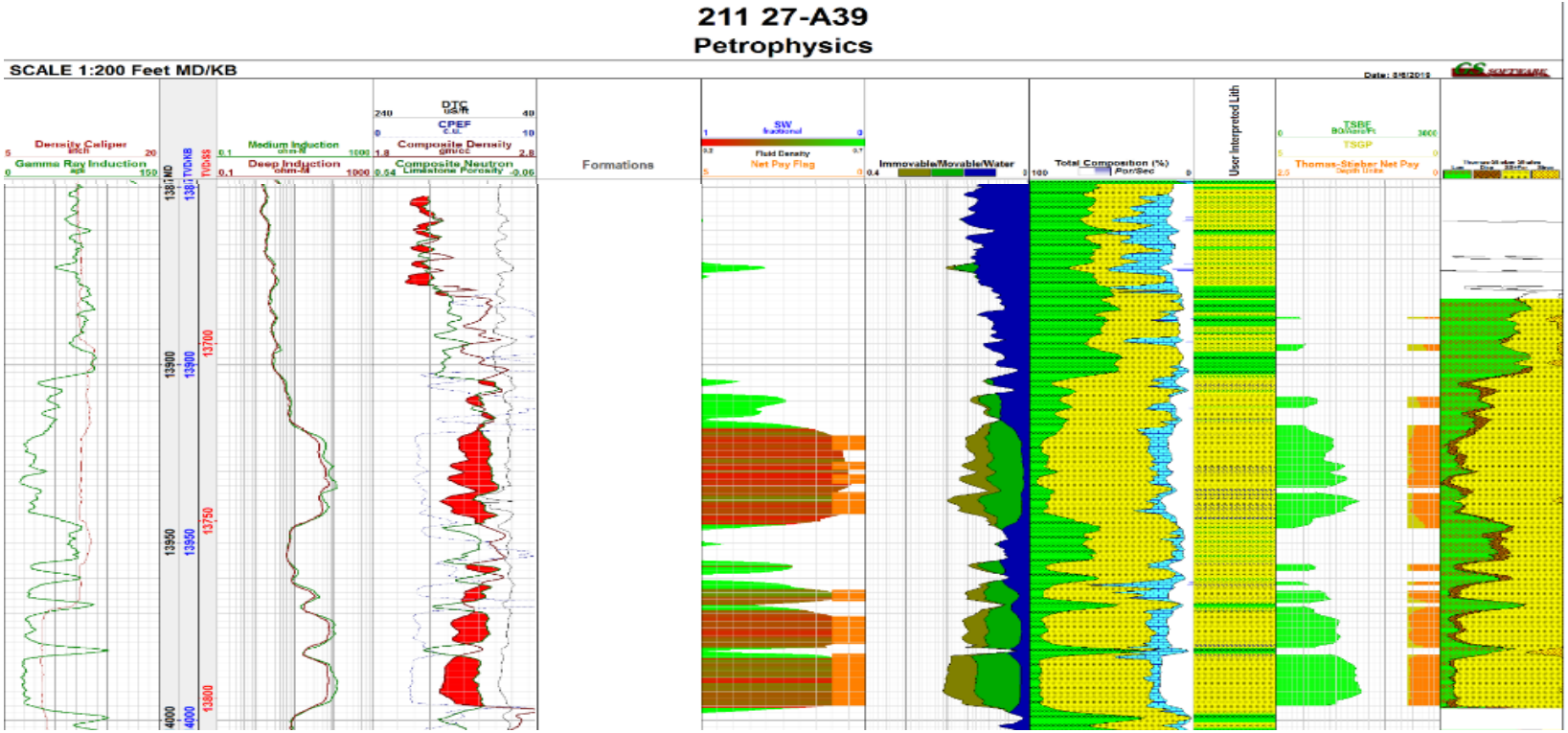


- All discernible alphanumeric and handwritten content searchable
- Log Header Metadata Specifically Auto-Tagged
- Provenance to source, incl. originating box for physical
- Projectable to any user defined folder taxonomy

Technical Progress Update

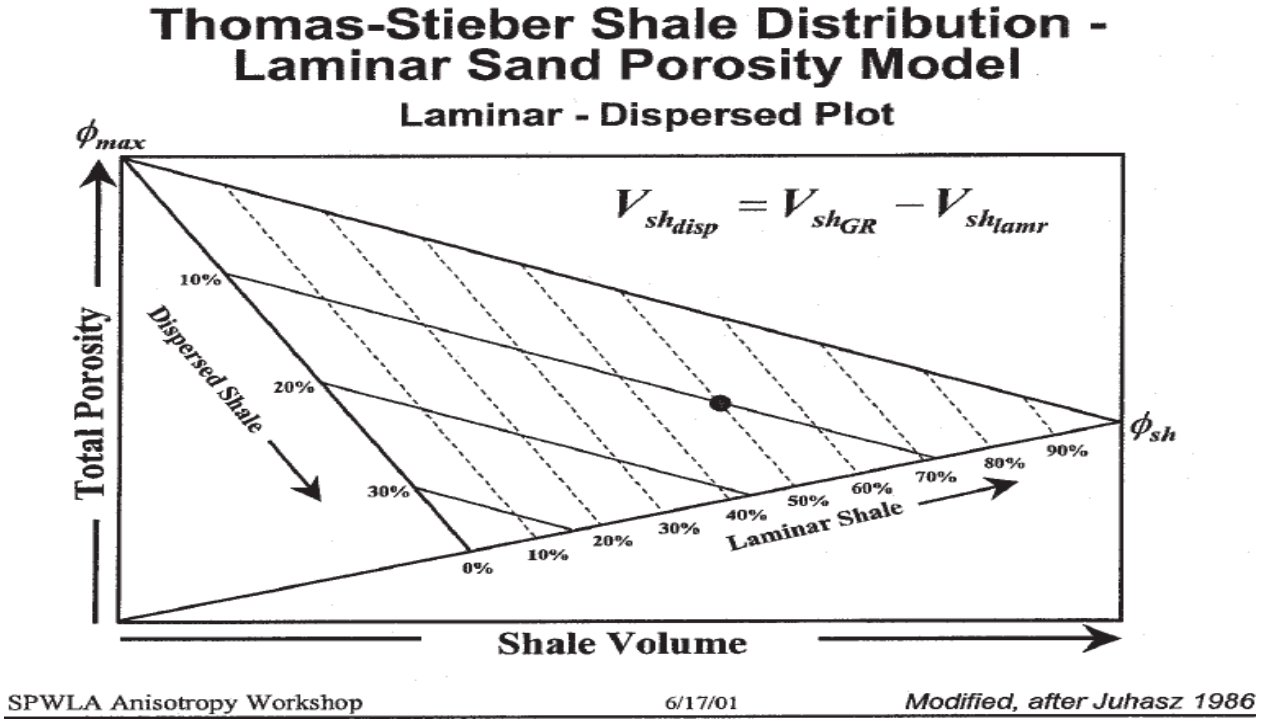
- E2A continuous process optimisation
- Petrophysics
  - Petrophysical Evaluation
  - Thomas Stieber Evaluation
  - Geophysical Prediction
- Sequence Stratigraphy
- Tops picking

Conventional Formation Evaluation

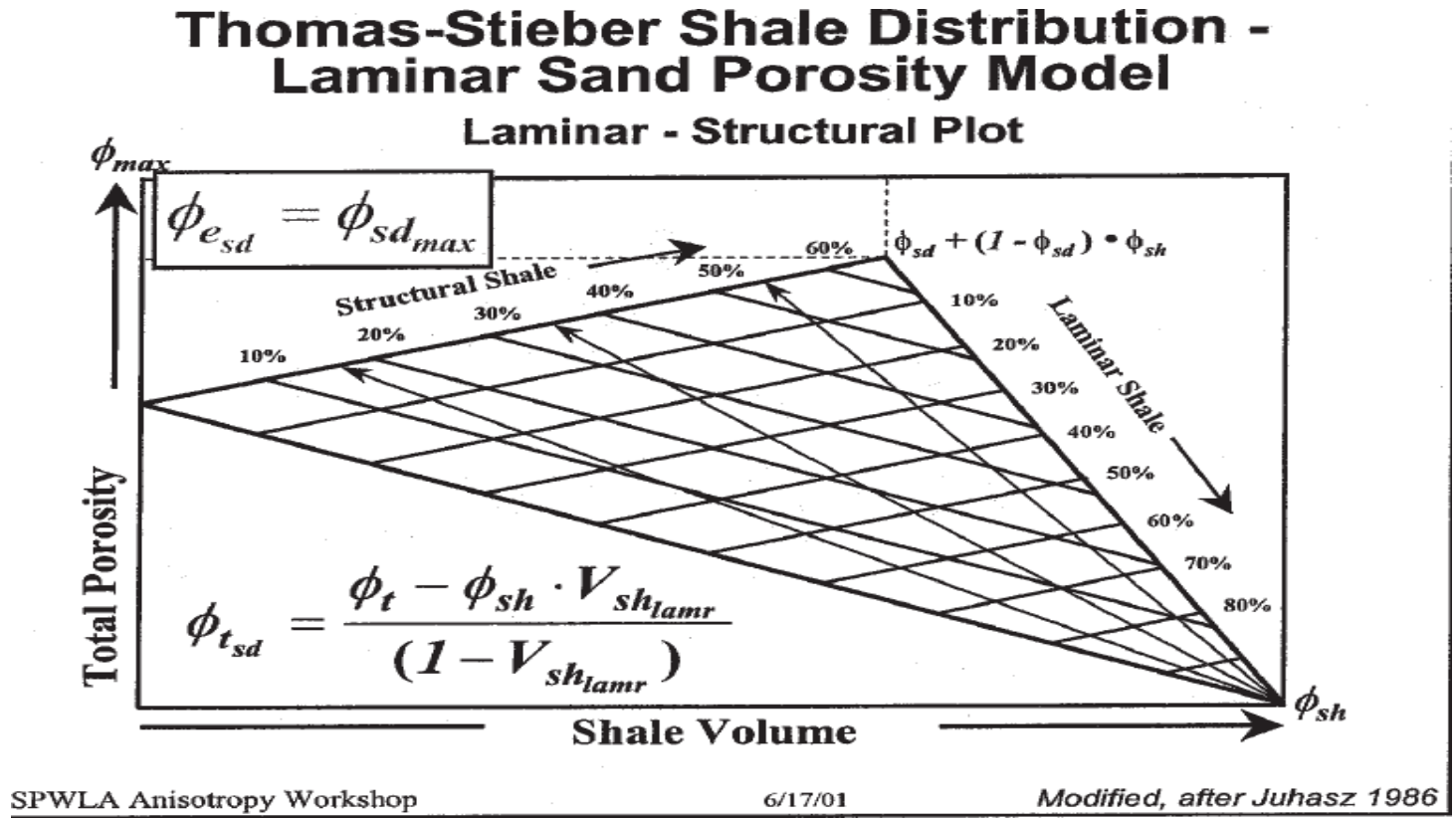


Thomas, E. C., and S. J. Stieber, 1975, The distribution of shale in sandstones and its effect upon porosity: 16th Annual Logging Symposium, SPWLA, Paper T.

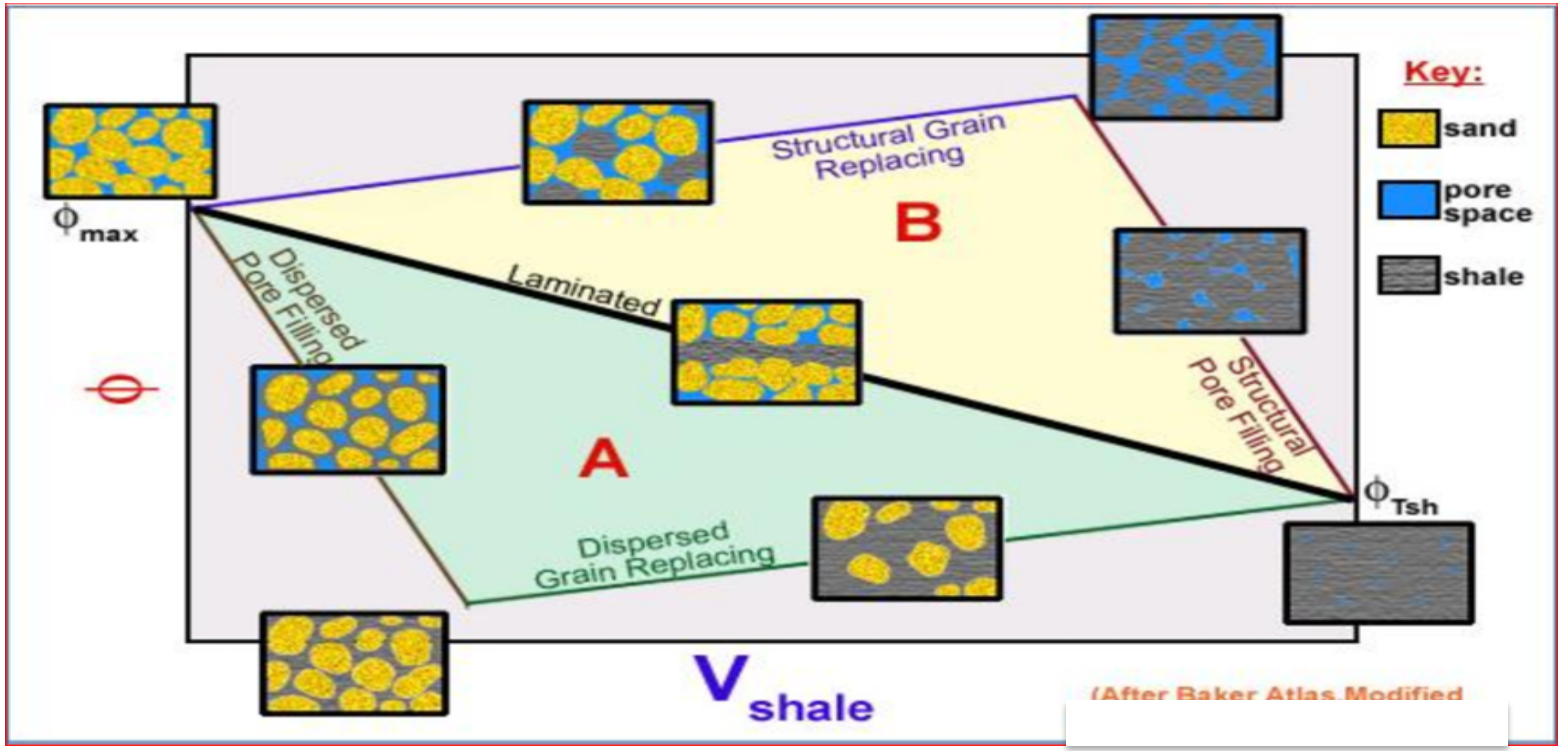
Laminar vs Dispersed Clays



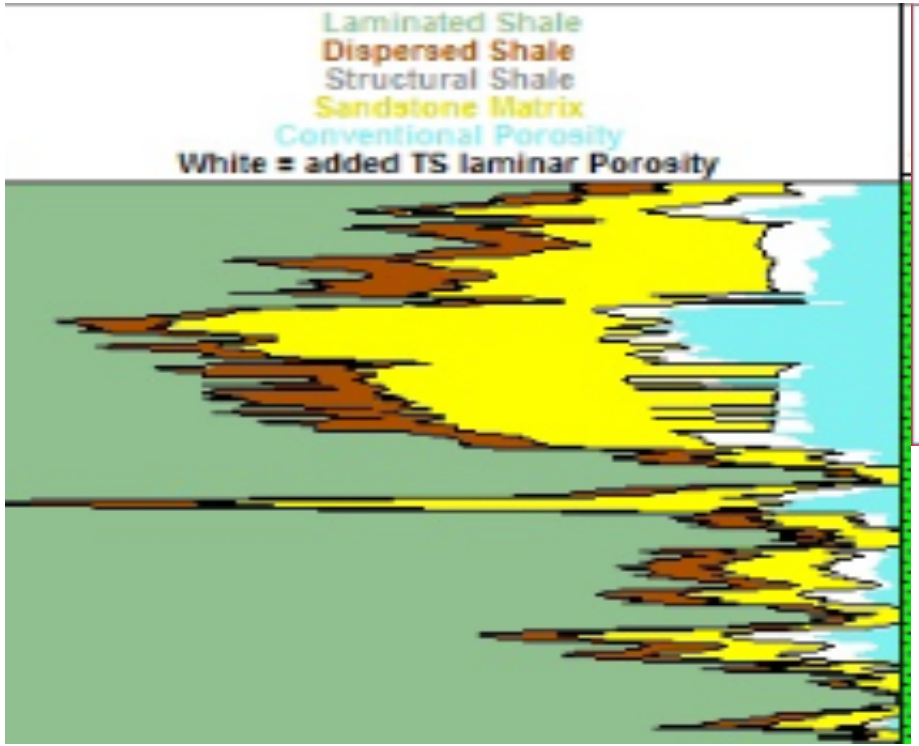
Laminar vs Structural Clays

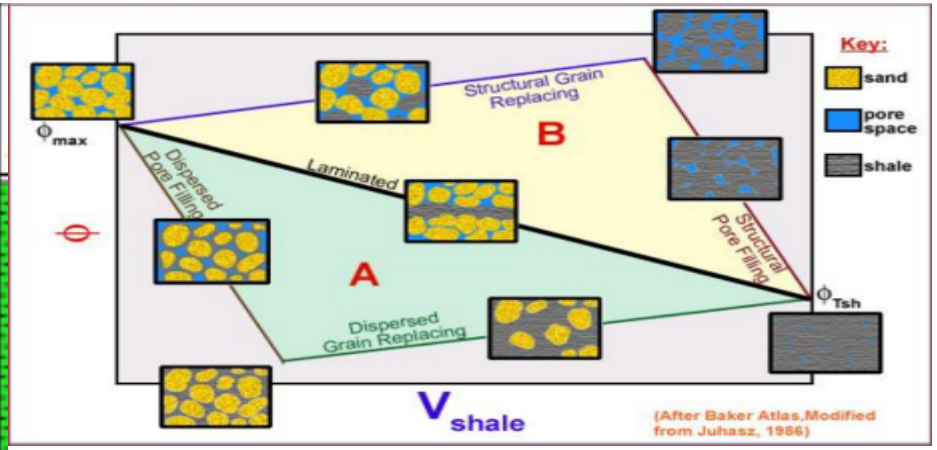


Thomas Stieber Methodology



Thomas Stieber Clay Volumes





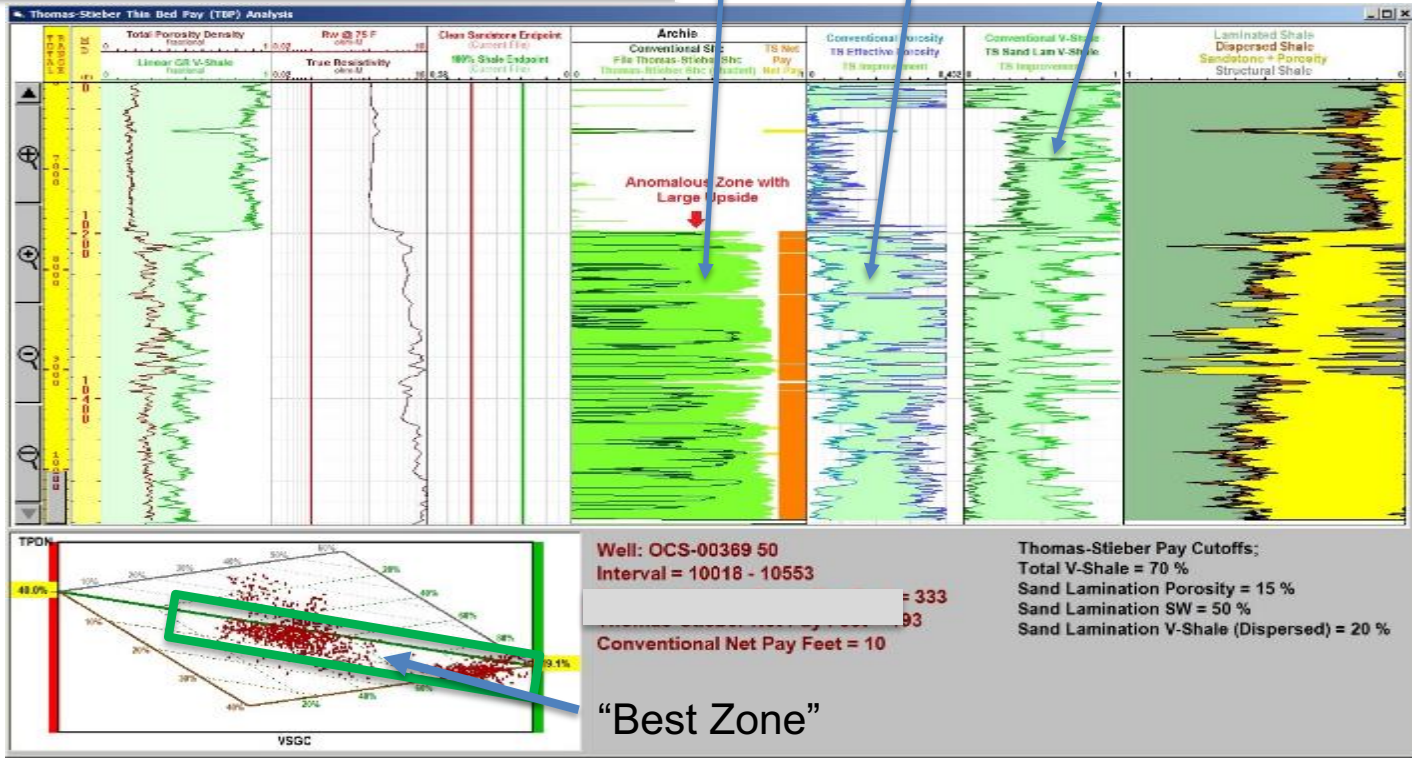
Thomas Stieber Thin Bed Analysis Resource Potential (~300 MM bbl risked) behind pipe

HIGHLIGHTS

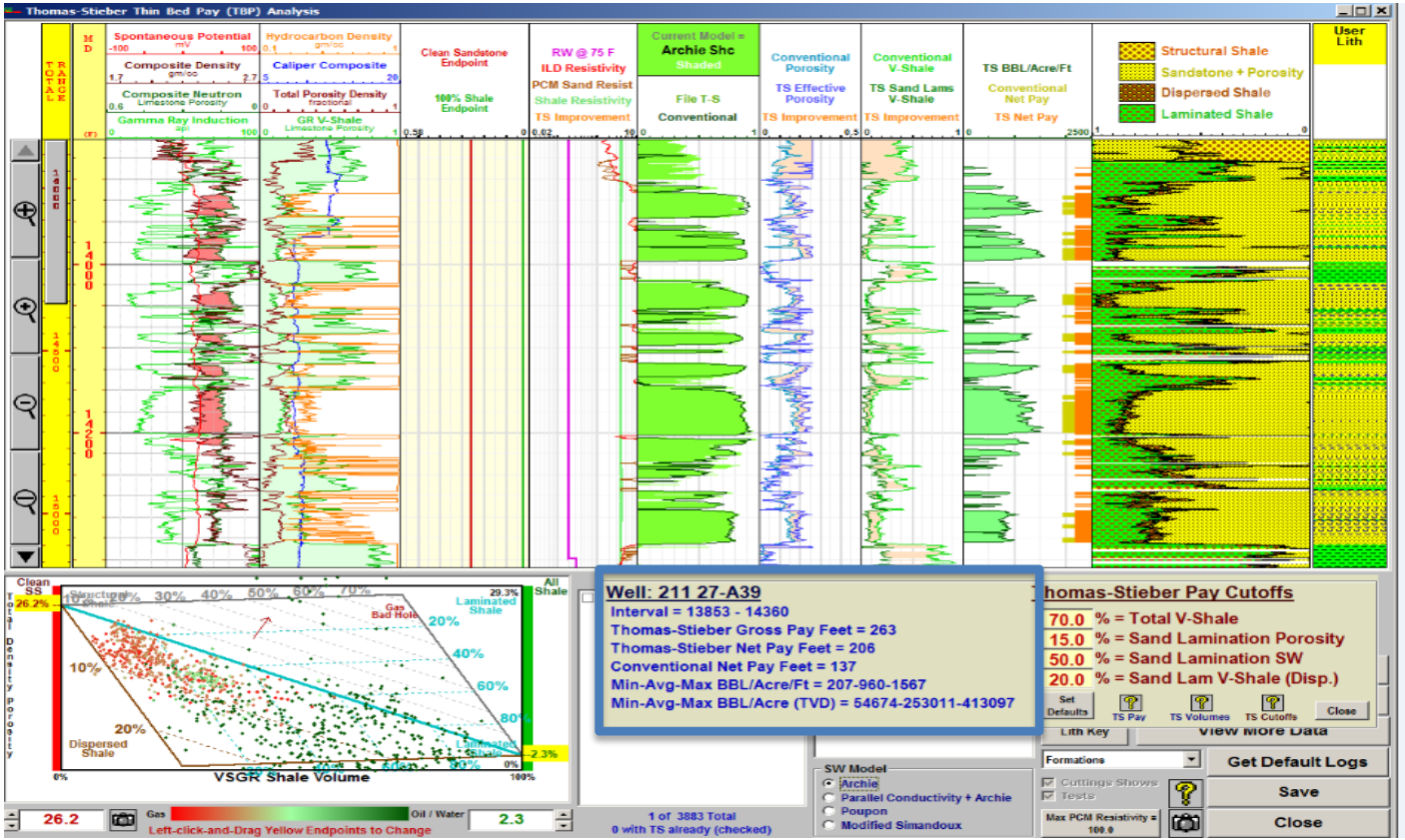
- 17 wells have very high POS with AVERAGE thin bed add of **76** ft of pay
- 28 wells have good to fair to good
- 18 % of wells have Thin bed pay behind pipe potential out of 256 wells

GREEN: potential added pay zone
BLUE: potential added porosity
Teal: potential improved reservoir

Well	Effective New TS Pay (ft) added
OCS-00369 76ST01BP01	37
OCS-00386 EE13	39
SL-1366 56	85
SL-1367 22	99
SL-1367 23	78
SL-1367 33	58
SL-1367 35	49
SL-1367 45ST1	15
SL-1367 52	68
SL-1365 77	93
SL-1365 87ST01	43
SL-1366 76	59
SL-1367 22ST03	35
SL-1367 30	53
SL-1367 49	118
SL-1486 25	103
Total for 16 wells	1225



Thomas Steiber analysis example (211 27a-39)



Geomechanical Characterization - Rock Quality Assessment

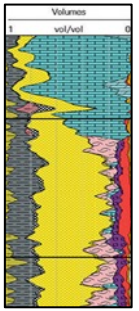
"Rock Fabric" Brittleness: Over-consolidation Ratio: B_7=OCR ^{b}

- $OCR=(s_{V(max)} / s_V)$
- $(s_{V(max)}\ (Mpa))= 8.6C_0(Mpa)^{0.55}$
- $C_0(Mpa)=0.77V_p(km/s)^{2.93}$

+

"Rock Composition" Brittleness: Weatherford (Walles, 2010)

$$\frac{(1.3)\text{Quartz} + \text{Feldspar} + \text{Plagioclase} + (1.2)\text{Carbonates}}{((\text{numerator} + (2)V_{\text{mixed I/S}} + (1.5)V_{\text{I + chl + kao}}) + \text{Others})(1 - \text{TOC}_{\text{pd}})) + \text{TOC}_{\text{pd}}}$$



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Rock Quality Index

Geophysical Logs Construction

Compressional velocity

$$Vp = \sqrt{\frac{K + \frac{4}{3}\mu}{\rho}}$$

Shear velocity

$$Vs = \sqrt{\frac{\mu}{\rho}}$$

K = Bulk modulus

μ = Shear modulus

ρ = Density (specific gravity)

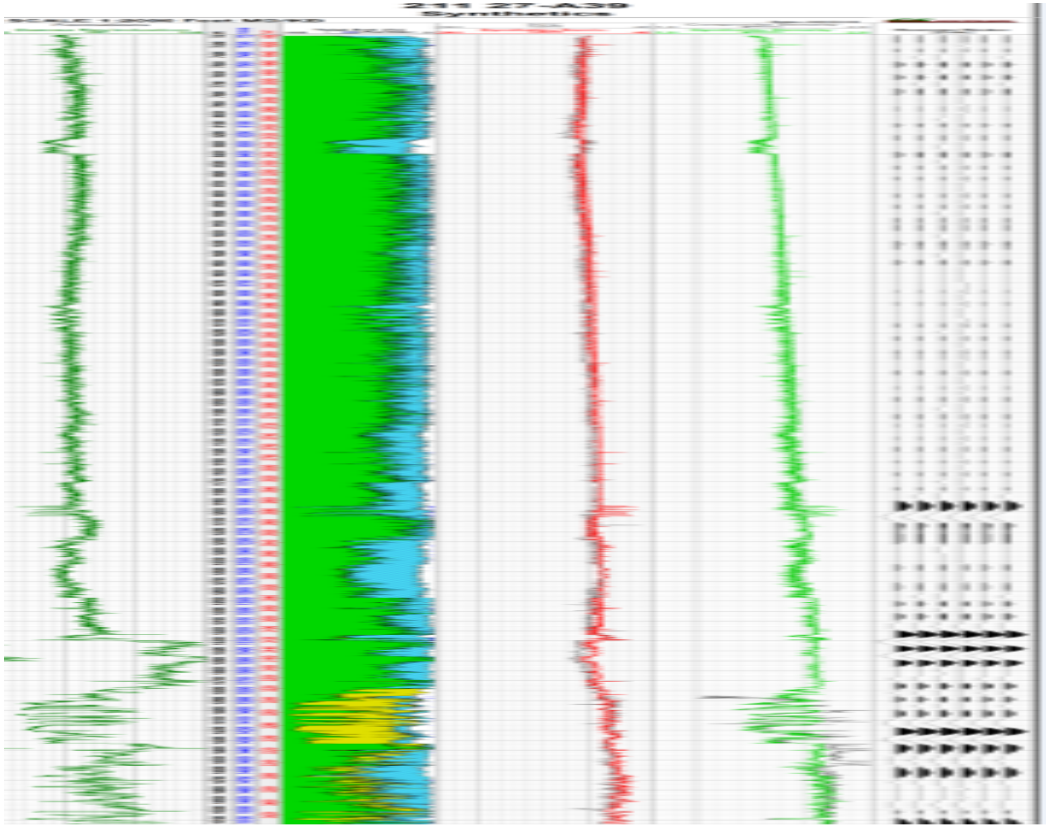
- We “build” a rock physics Database as we go along to determine these exact values

Clays	K	M	den	VP	VS
smectitie	17.5	7.5	2.58	3.263315	1.704986
illite	39.4	11.7	2.58	4.615486	2.129527
Koalinite	37.9	14.8	2.42	4.878016	2.472995
	12	6	2.42	2.87336	1.574592
Chlorite	95	11.4	2.5	6.638132	2.135416
	160	55	2.8	9.125122	4.432026
	120	82	2.68	9.245007	5.531457
QTZ	37	44	2.65	6.003772	4.074773
Calcite	70	30	2.71	6.368163	3.327178

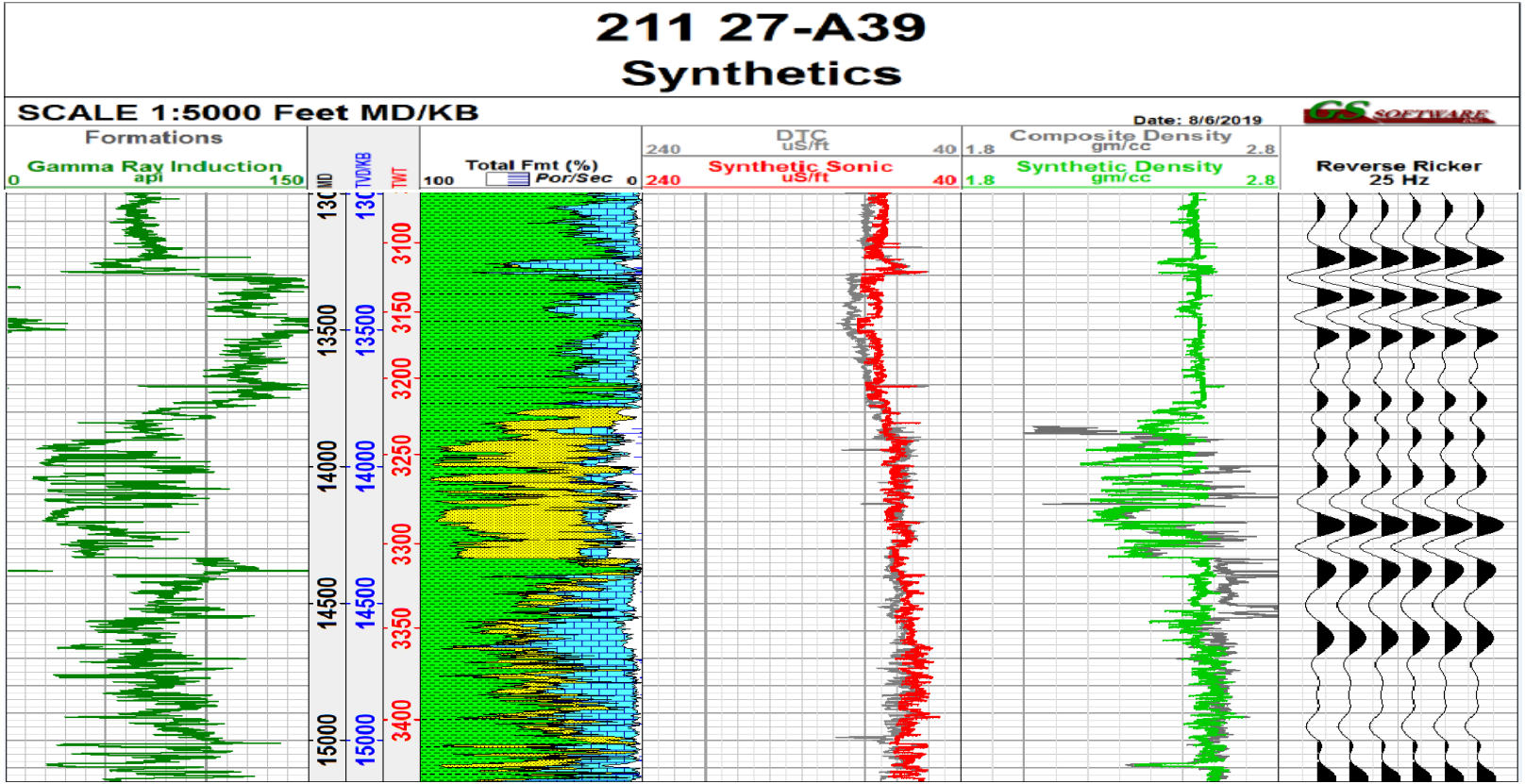
Oil & Gas Authority

Synthetic Logs and Seismogram

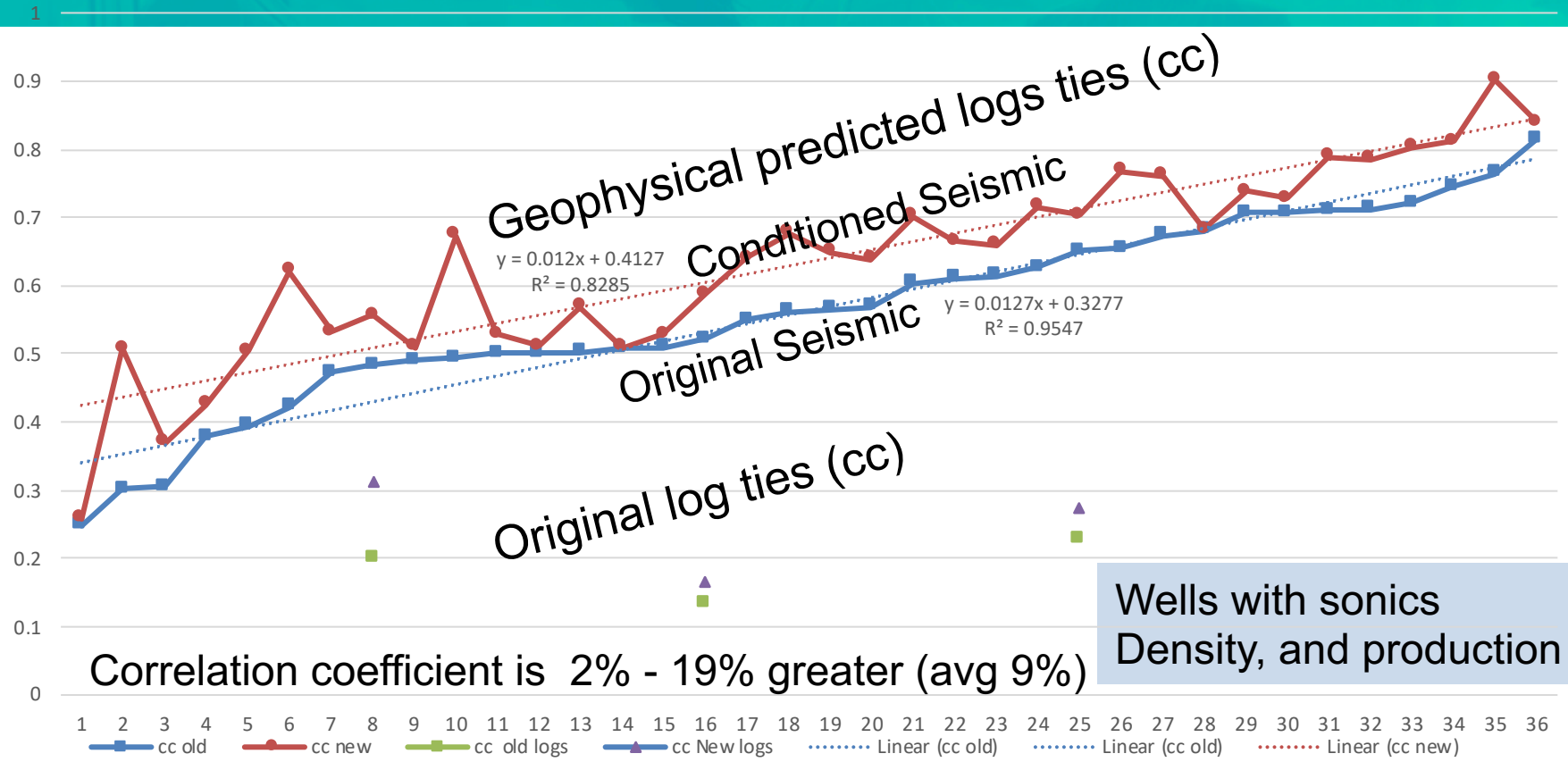
- Low res. image showing full extent of 211-27a-39
- Showing determined volumes of differing shale lithologies



Synthetic Logs and Seismogram



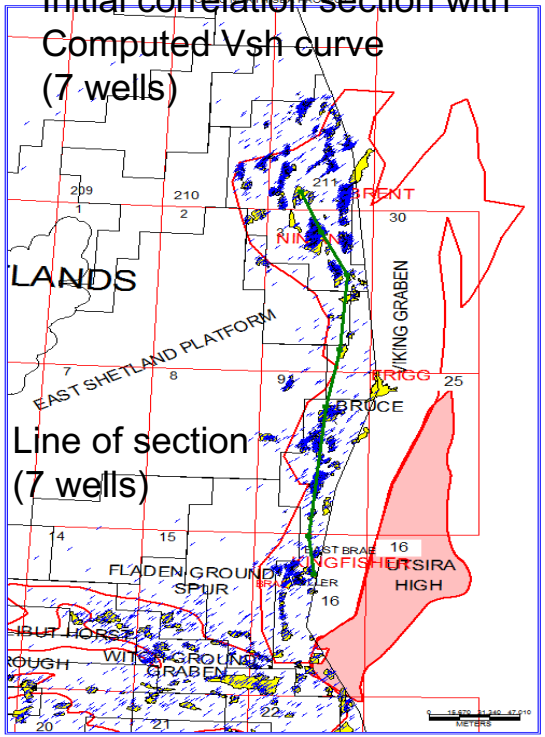
Comparison to Original and Conditioned Seismic Ties

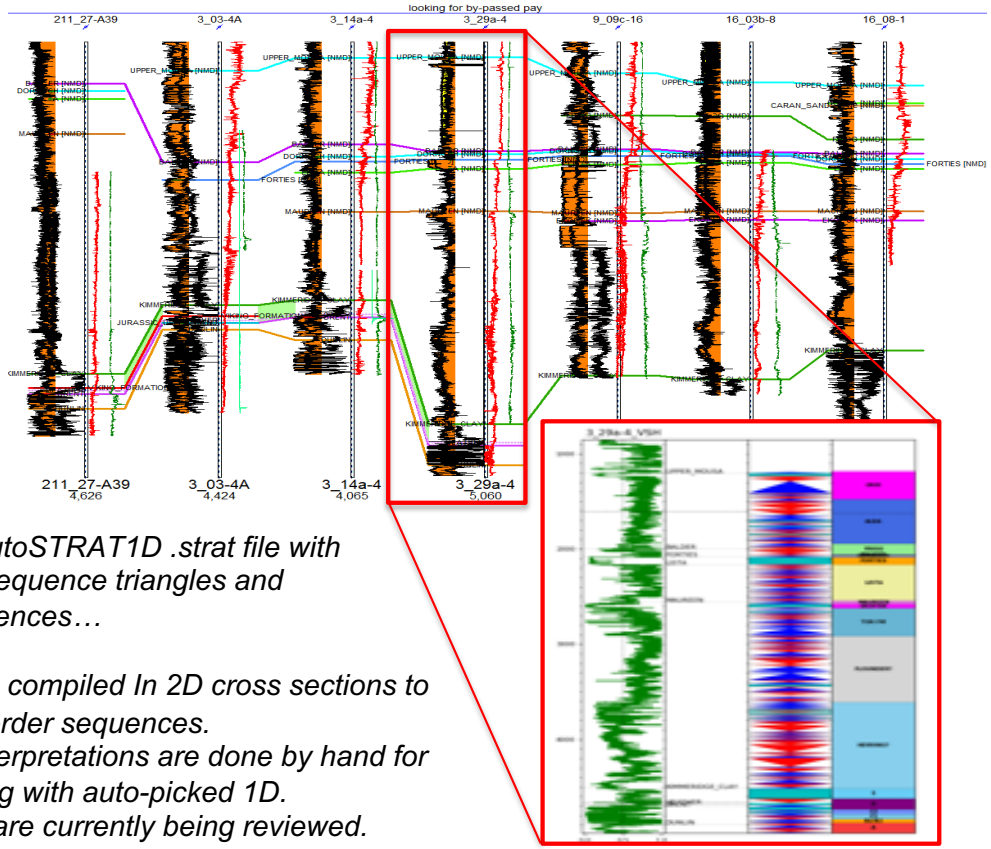


Sequence Stratigraphy

- Started on Sequence stratigraphic framework and tie in
- Building training set for Seq Strat AI
  - Automatic Seq Strat on 20% of wells
- Started off with 79 wells with logs – with curves and some tops, good depth range, relatively straight wellbores
- Extended this subset to 88 wells to use available tops in Millennium Atlas correlation sections
- 26 wells to date with lithostrat or sequence strat tops (Eocene, Paleocene through U. Jurassic) from well files, Millennium Atlas or literature
- 5th order parasequences ‘hand-picked’ and ‘auto-picked’ and compared in 7 well subset; this will be extended to the 26 wells in order to determine 3rd order sequences that corroborate with literature; before extending to greater regional extent

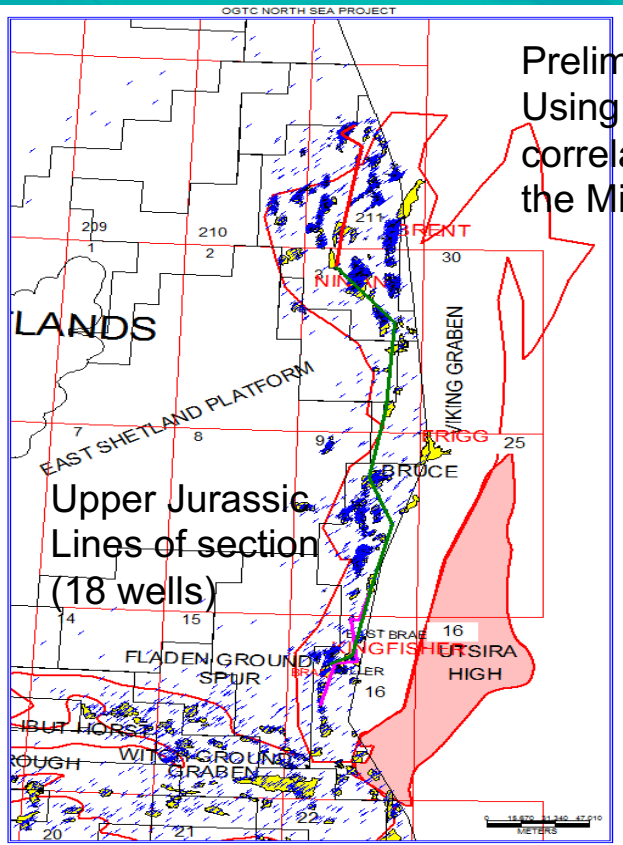
Parasequences





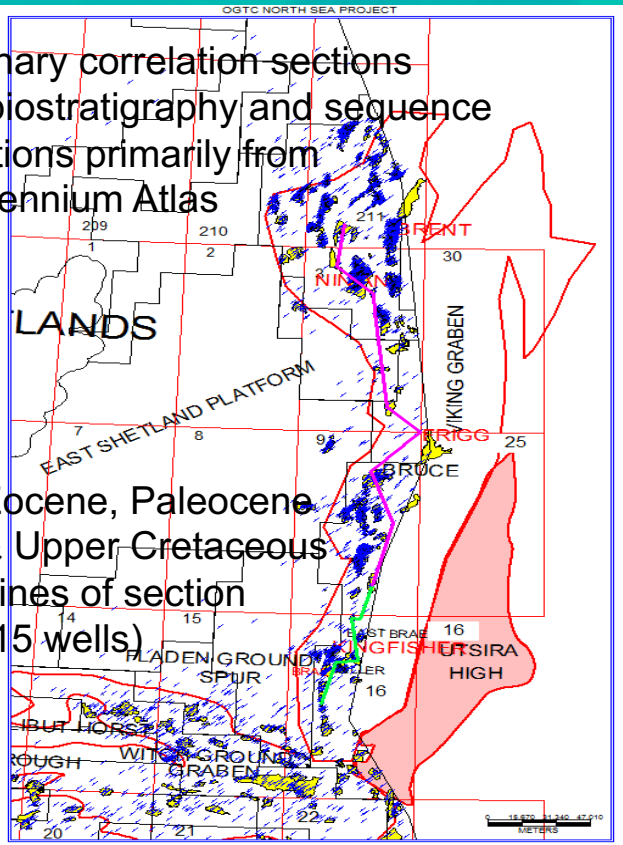
- *Example an AutoSTRAT1D .strat file with*
- *5th order parasequence triangles and*
- *identified sequences…*
- *At this stage:*
  - *1D plots are compiled In 2D cross sections to*
  - *identify 3rd order sequences.*
  - *Initial 1D interpretations are done by hand for corroborating with auto-picked 1D.*
- *These 7 wells are currently being reviewed.*

Chronostratigraphy Sequence and Lithostratigraphic Top Picks



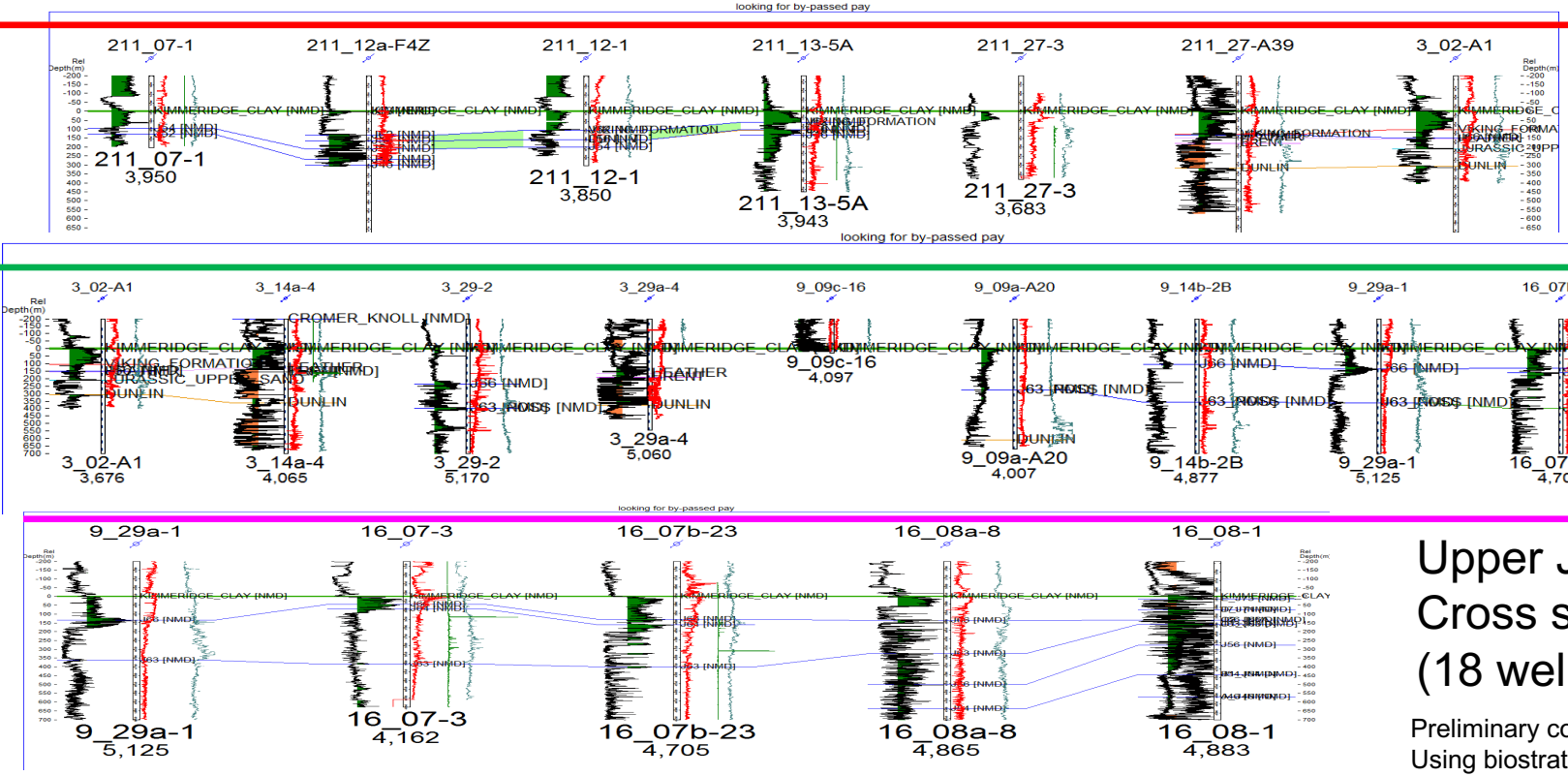
Upper Jurassic
Lines of section
(18 wells)

Preliminary correlation sections
Using biostratigraphy and sequence correlations primarily from the Millennium Atlas



Eocene, Paleocene & Upper Cretaceous
Lines of section
(15 wells)

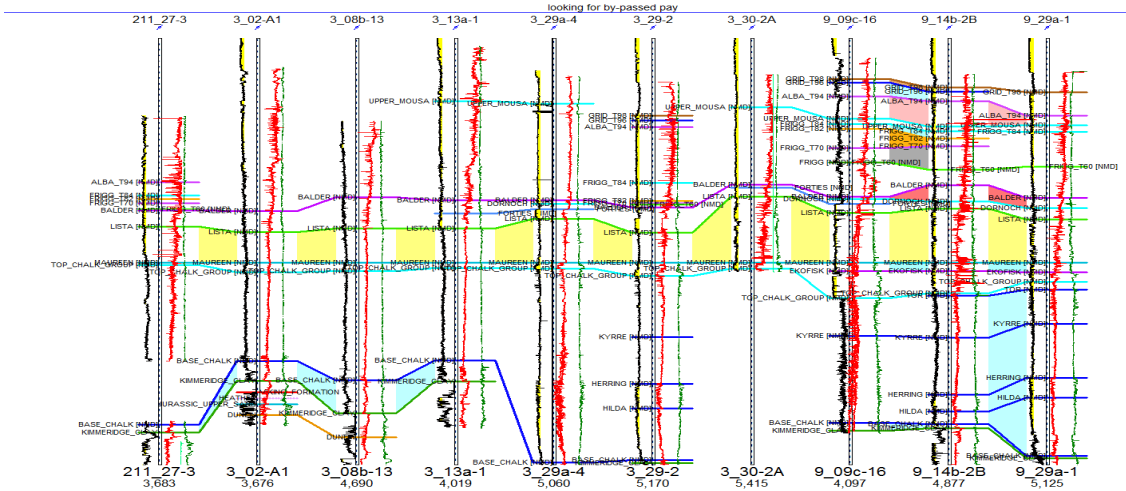
Biostratigraphic Sequence Correlations

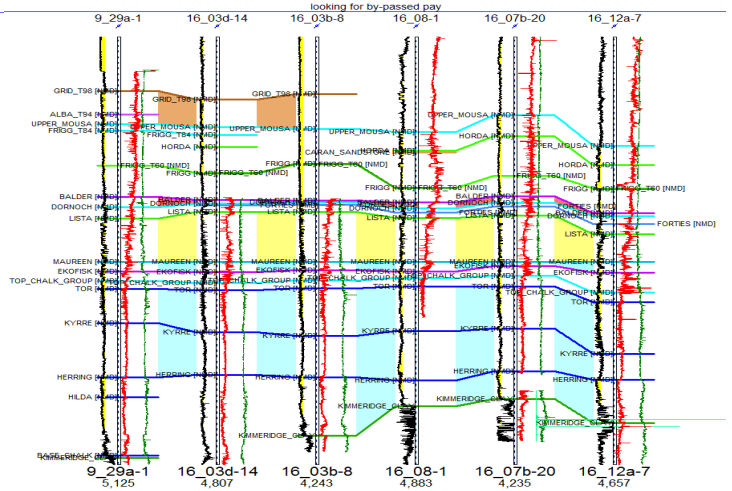


Upper Jurassic Cross sections (18 wells)

Preliminary correlation sections
Using biostratigraphy and sequence correlations primarily from the Millennium Atlas

Upward Progression from Third Order Sequences

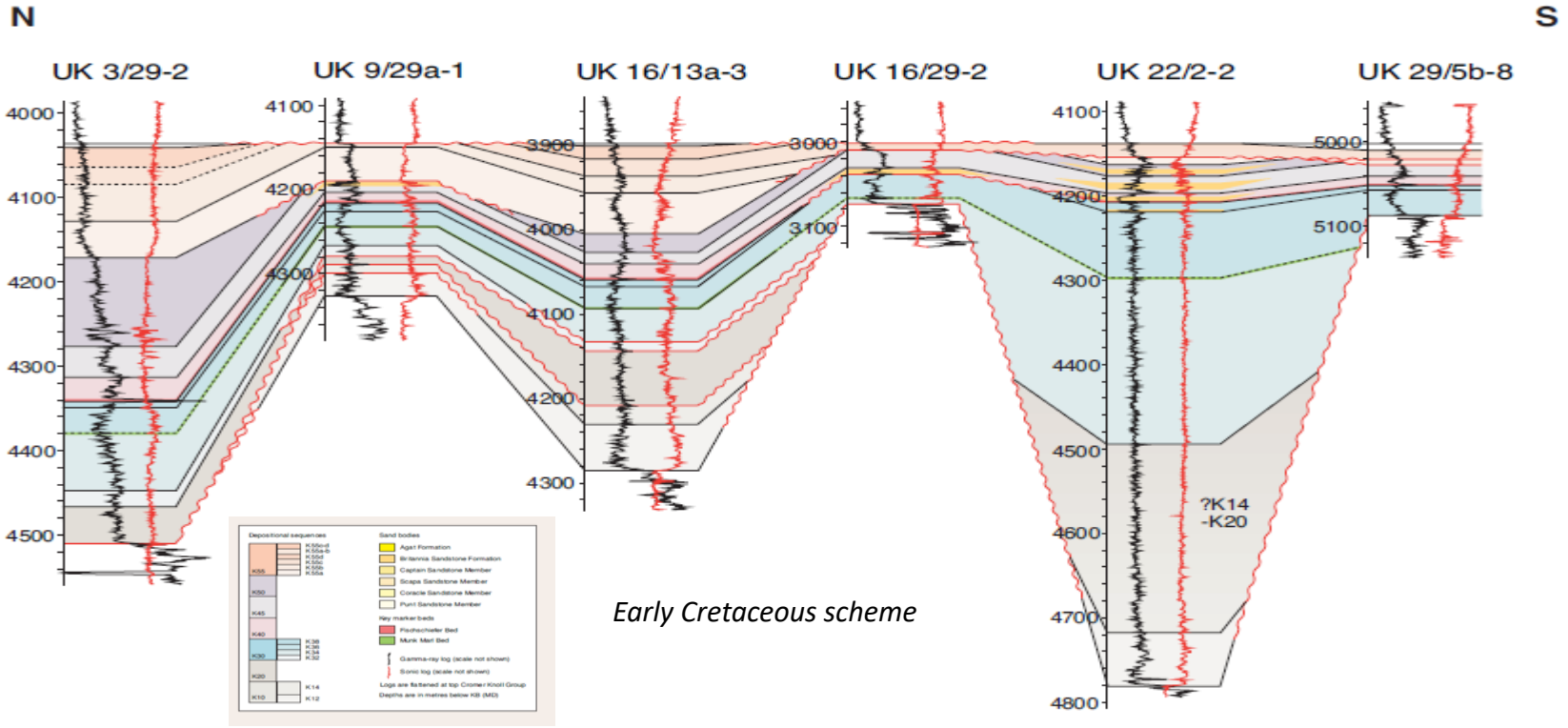




Eocene, Paleocene & Upper Cretaceous Cross sections (15 wells)

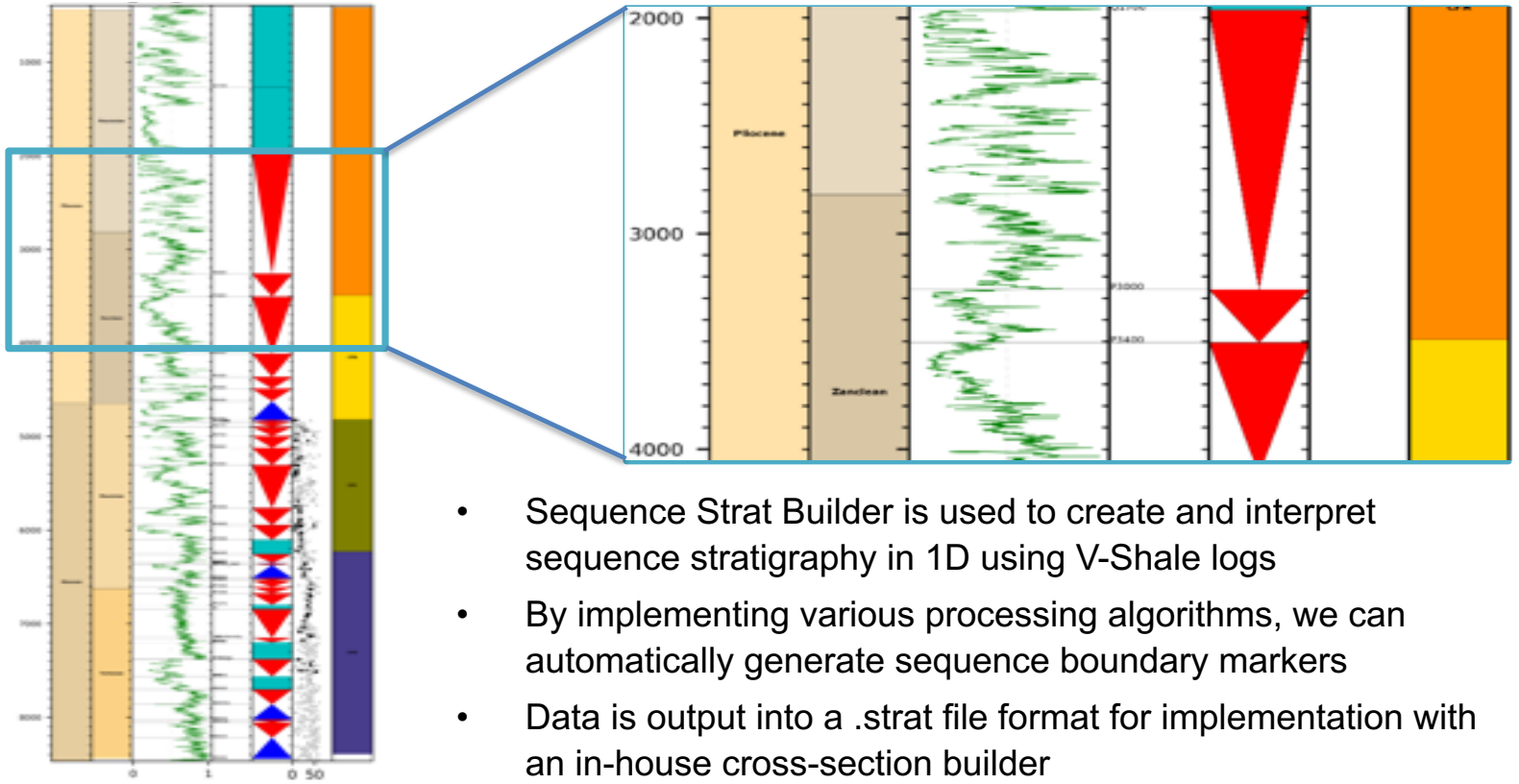
Preliminary correlation sections Using biostratigraphy and sequence correlations primarily from the Millennium Atlas

Corroboration with Fifth and Third Order Sequences



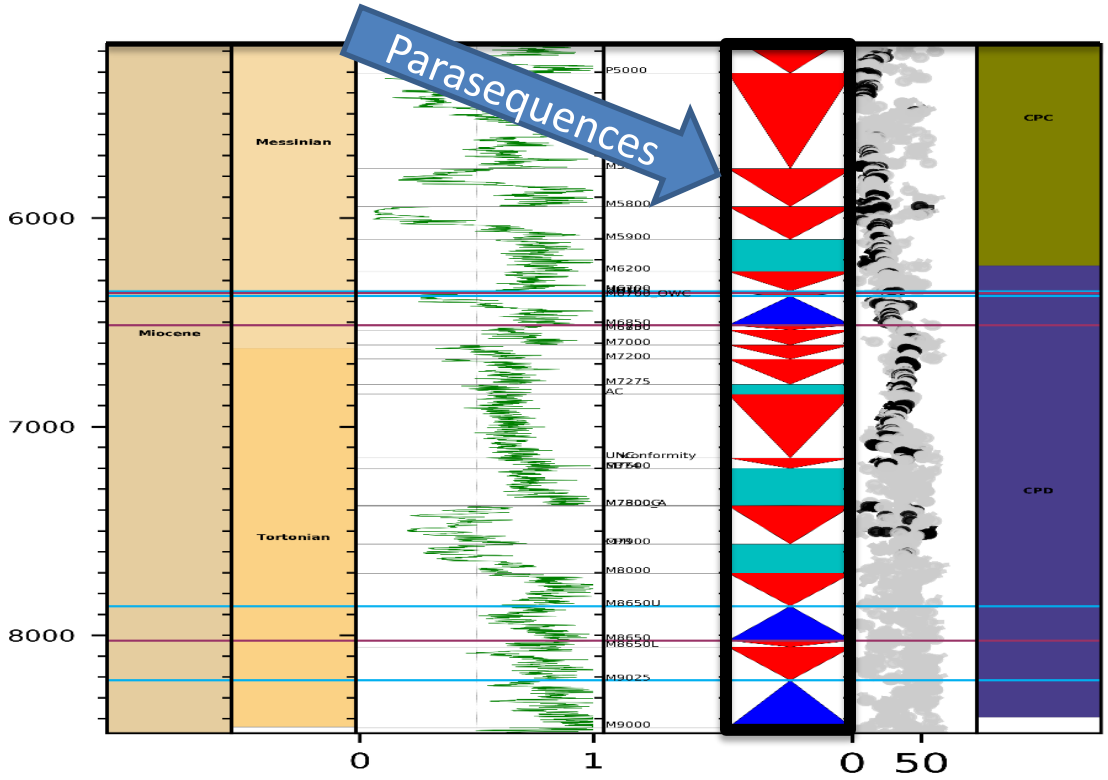
Early Cretaceous scheme

Sequence Strat Builder



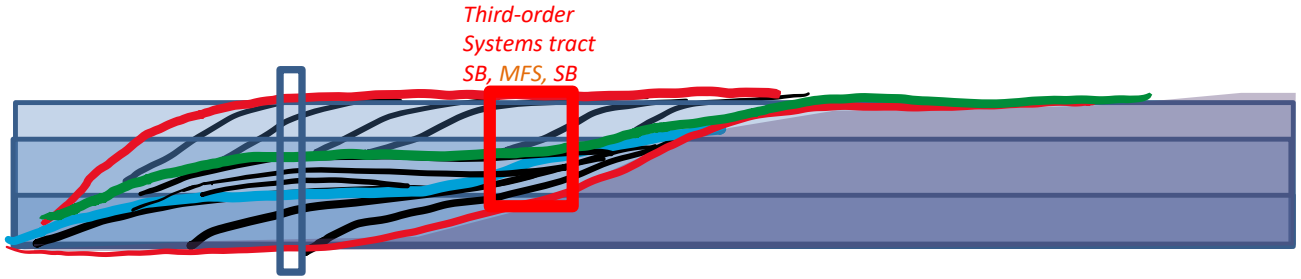
- Sequence Strat Builder is used to create and interpret sequence stratigraphy in 1D using V-Shale logs
- By implementing various processing algorithms, we can automatically generate sequence boundary markers
- Data is output into a .strat file format for implementation with an in-house cross-section builder

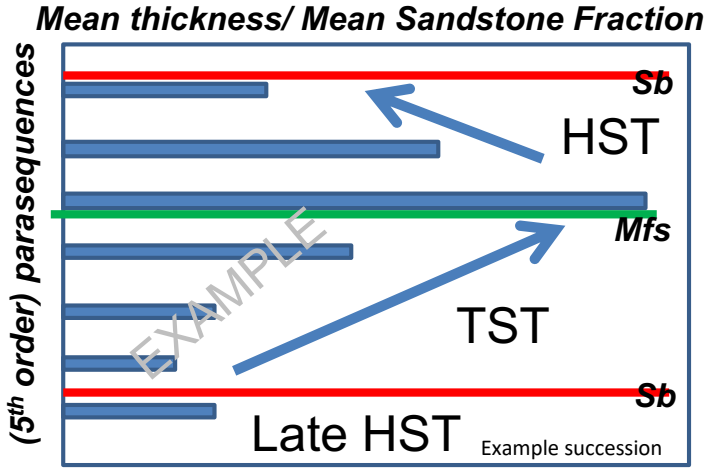
Auto Seq. Strat Interpretation (Deep Learning Neural Network)



- One processing method for automatically generating parasequences uses a deep learning neural network.
- Results are shown in the highlighted column to the left

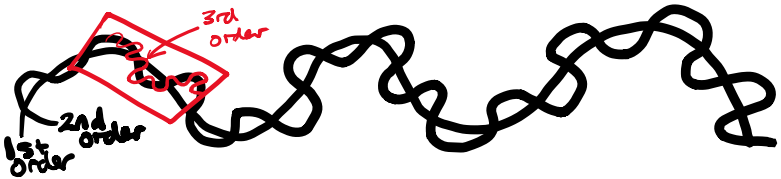
Quantitative Sequence Stratigraphy (QSS) Concept



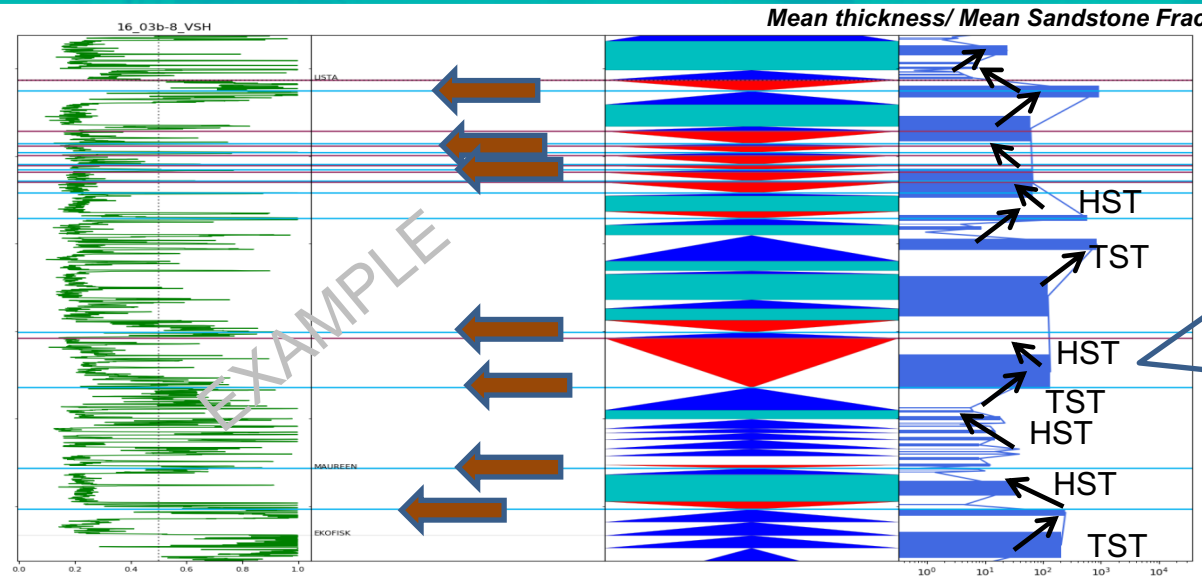


AUTOMATIC
QUANTITATIVE SEQUENCE STRATIGRAPHY
ANALYSIS WITH MULTIWELL CROSS SECTIONS TO DETERMINE
3RD ORDER SEQUENCES

In multiwell cross section QSS will identify 3rd order stratigraphic sequences



Quantitative Sequence Stratigraphy (QSS) Concept



Quantitative Sequence Stratigraphy (QSS):
TSF analysis= T/SF
T= parasequence thickness, SF = ss fraction

T/SF value for each cu/fu/aggrading int. 5th order sequence
Lower the value the richer the sand content
Next steps:
resolve 5th order sequences to 3rd order

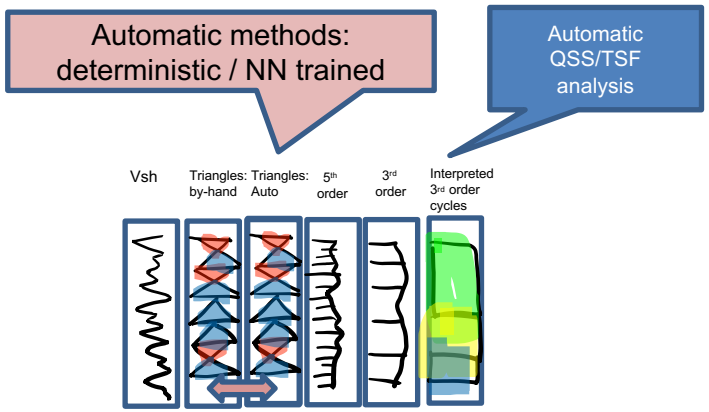
Example succession
& preliminary interpretation of
possible surfaces and
systems tracts
(ITERATE WITH SEQUENCE STRATIGRAPHY FROM ATLAS/LITERATURE)

AUTOMATIC then edited/vetted TRIANGLE PICKING

AUTOMATIC QSS: Including MULTIWELL CROSS SECTIONS to determine 3RD ORDER SEQUENCES

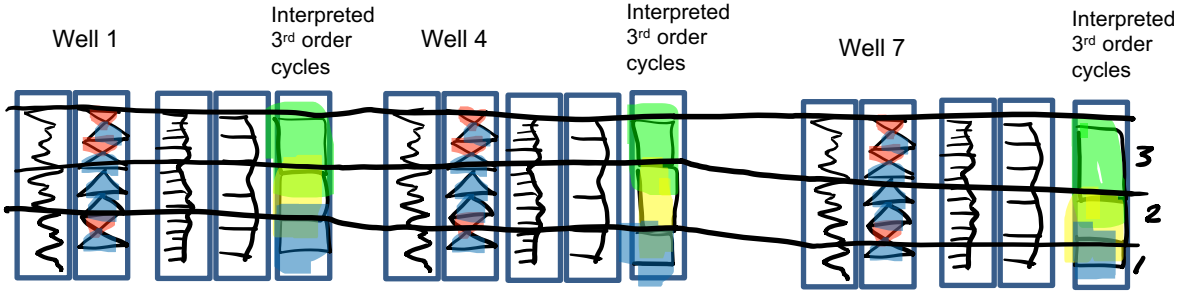
- High gamma ray:
  - flood/MFS,
  - reduced sediment,
  - tectonic subsidence or uplift
- Flood Sequence boundary SB

Quantitative Sequence Stratigraphy (QSS) Concept



Compare triangles by-hand with automatic triangles

AUTOMATIC QSS:
Includes MULTIWELL CROSS SECTIONS
to determine regionally extensive
3rd ORDER SEQUENCES
iterated with known sequence stratigraphy -
and leading to PLAY FAIRWAYS



Summary

- **Petrophysics:**
  - Loading/editing/QC 100 % complete 8 weeks ahead of schedule
  - Building Lithology training set (mudlogs / Visual) 5%
  - Building Vclay training set 33%
  - Loading header info (scan)
  - Building training and Petrophysical models for AI Formation Eval
- **Sequence Stratigraphy:**
  - Started on Sequence stratigraphic framework and tie in
  - Building training set for Seq Strat AI
    - Automatic Seq Strat on 20% of wells
  - Started off with 79 wells with logs – with curves and some tops, good depth range, relatively straight wellbores
  - Extended this subset to 88 wells to use available tops in Millennium Atlas correlation sections
  - 26 wells to date with lithostrat or sequence strat tops (Eocene, Paleocene through U. Jurassic) from well files, Millennium Atlas or literature
  - 5th order parasequences picked in 7 well subset; this will be extended to the 26 wells in order to determine 3rd order sequences that corroborate with literature; before extending to greater regional extent
- **On schedule** and expect to finish **under budget or on budget**

Deliverables

- Composited logs for 3486 wells
  - Composited as 1 set of curves
  - Depth tied
  - QC and Edited
  - Full petrophysical evaluation where logs exist
- Thomas Stieber (thin Bed analysis) on selection of 446 wells that satisfy the criteria of:
  - Vertical or near vertical well bores < 20 degrees deviation
  - Large stratigraphic and geologic interval represented
  - Cover entire geographic area of study
  - Good quality and availability of logs types
  - Any value adding information (core, test, dipmeters)
- Geophysical Logs on all wells from above
  - Rock physics based constructed (VP, VS and density)
  - Synthetic seismogram in depth and time
- Play fairway maps by zone (dependent on info from above work)
  - Thomas Stieber analysis will drive where new and additional reserves can be prospective behind pipe or in new areas.

What's Next – Where do we go from here?