Applying Artificial Intelligence to Seismic Data for Enhanced Earth Modeling

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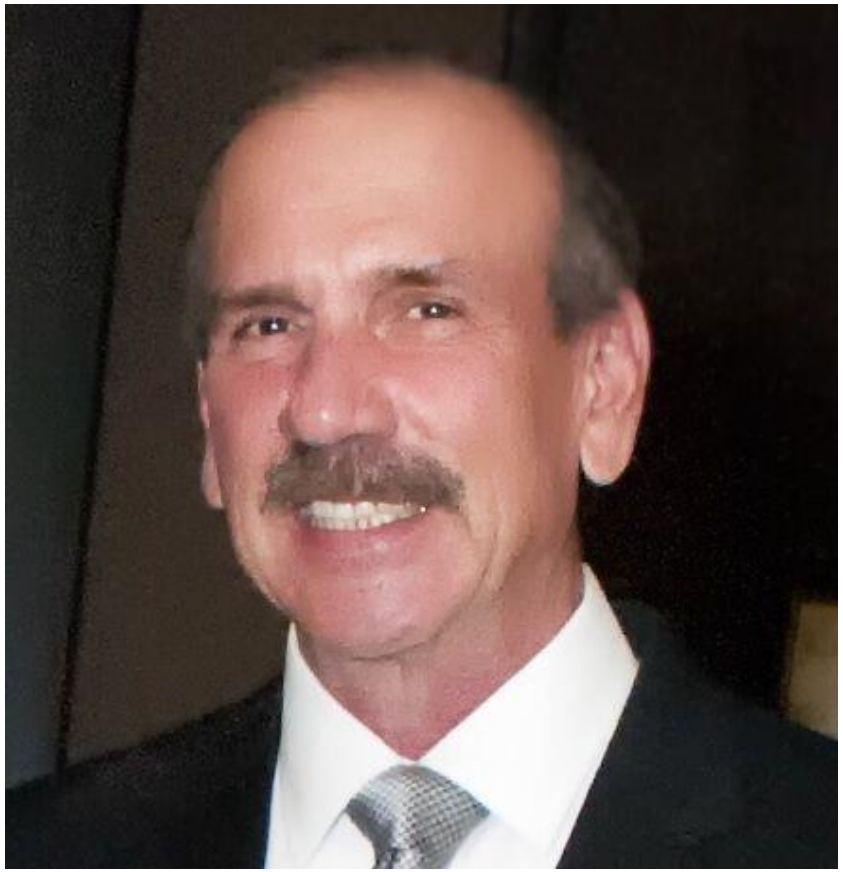
Mr. Koseluk is COO at Quantico Energy Solutions, responsible for all aspects of the company operations in the application of AI and ML for the subsurface. Mr. Koseluk expertise includes over 30 years of experience in management, oil and gas exploration and production, operations management, asset reserve evaluation, acquisition and divestitures, technology design strategy, technology development and commercialization, computer software design and implementation, hardware/ software integration. Mr. Koseluk started his career working for Pennzoil as geophysicist where he worked in international exploration and development. In 1988, Mr. Koseluk formed the Woodlands Geophysical Group, which specialized in seismic data management and later sold the company to PGS. During his tenure at PGS he was responsible for business development establishing PetroBank centers worldwide. Mr. Koseluk was VP of Operations for Tekoil and Gas which included the acquisition and operations of brown oil and gas fields in Galveston Bay. Mr. Koseluk was a Business Development manager at Landmark Graphics. Mr. Koseluk was President and COO of Fusion Petroleum Technologies, then director of sales Worldwide at Global Geophysical, before starting Lumina Reservoir, Inc. an integrated reservoir services company.



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Energy Solutions

Subsurface Intelligence for Success

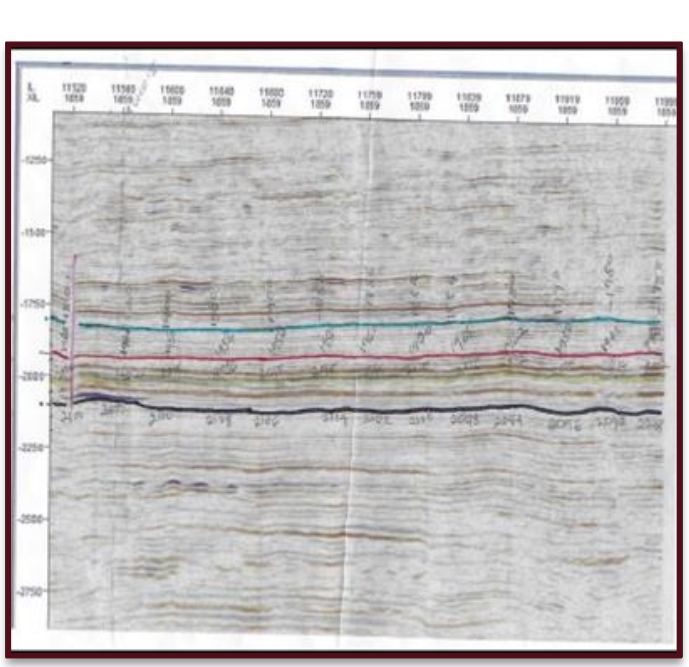
Applying Artificial Intelligence for Synthetic Logs and Enhanced Earth Models

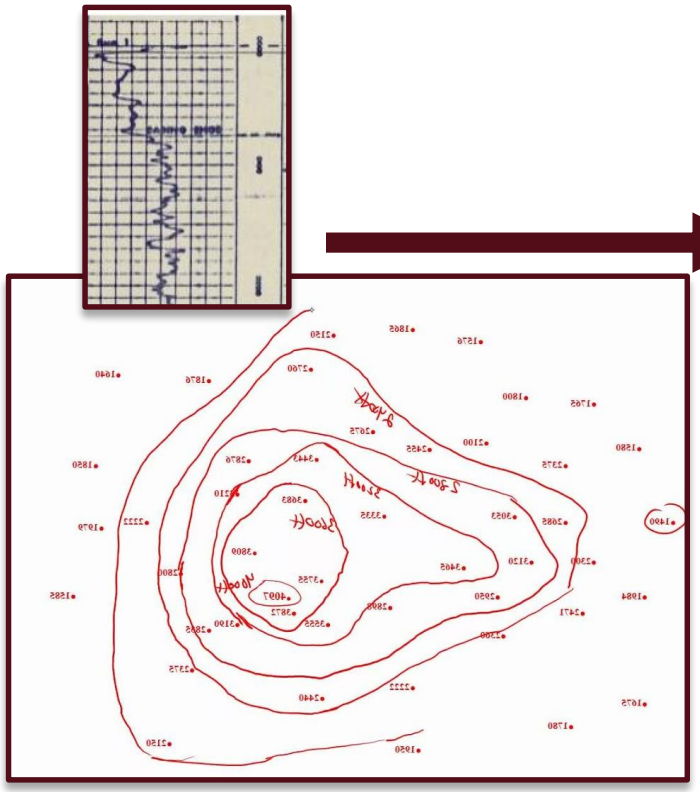
Richard Koseluk

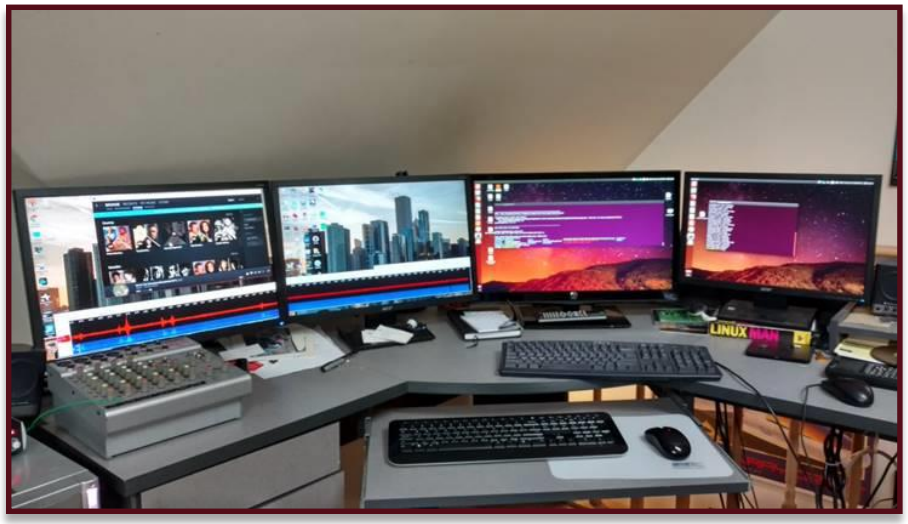
Outline

- Introduction
- Workstation – AI Analog
- Neural Networks
- Synthetic Logs
- High Resolution Earth Models
- Examples
- Conclusions

Workstation AI Analog



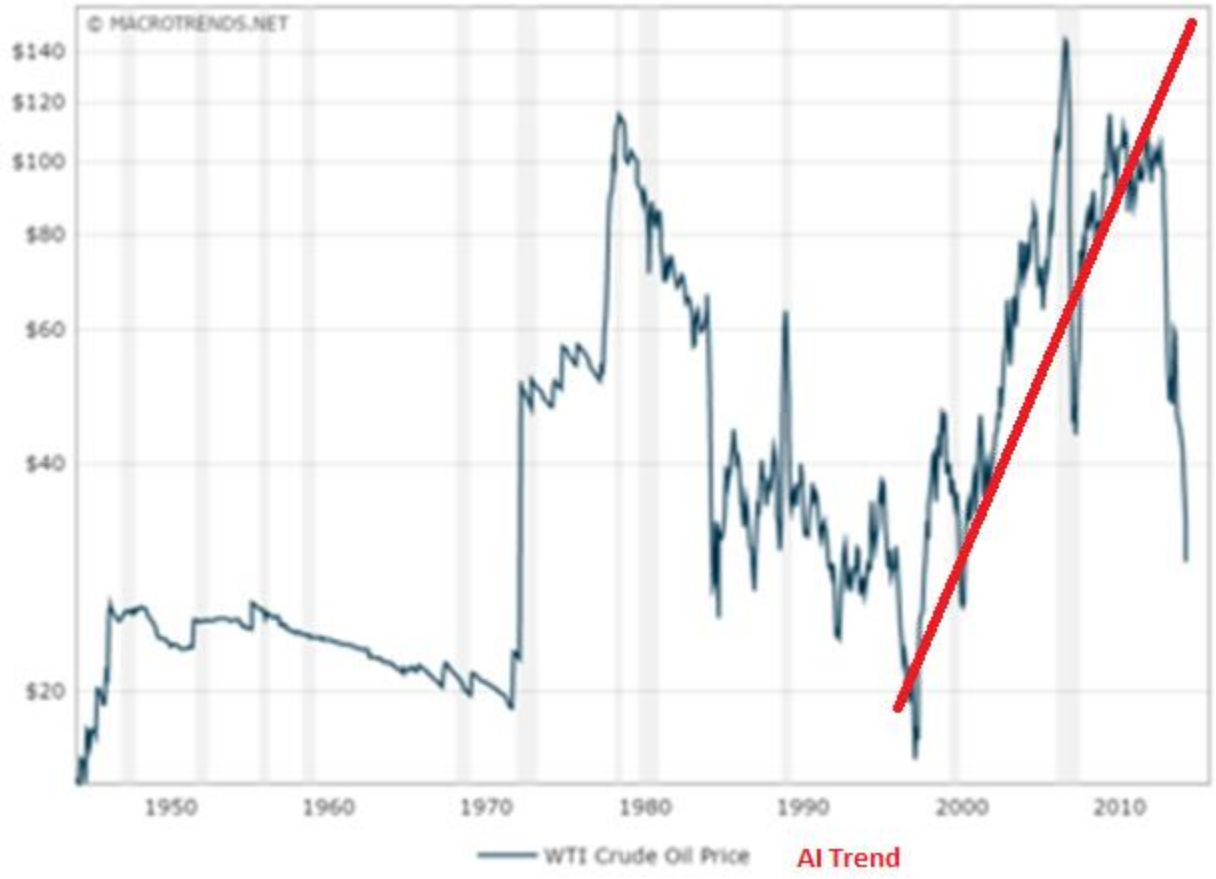




- Workstations changed the way we worked
- Similarly AI and ML will change the way we work

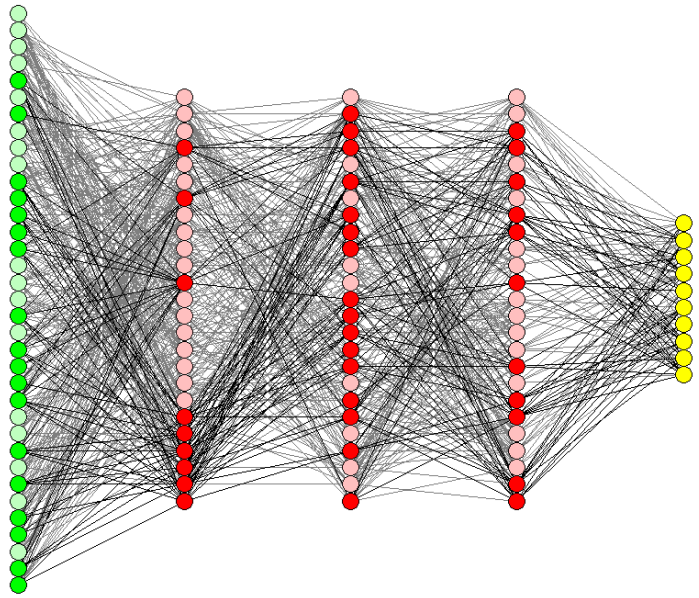
Oil Prices and AI trend

- Oil Price amplitude and frequency have both increased dramatically in recent years
- Similarly the trend in ML and AI has increased at a record pace in every aspect of our lives



Neural Networks

- Neural Networks have been around for years
- In our industry they have been shallow NN due to lack of training data
- We have developed physics based methods for generating more training data which allows for deep learning neural networks
- QRes has a proprietary neural network technique that handles sparse data. This allows for an inversion with limited well data. The well data is not strictly temporally or spatially constrained. However, with more complex geology, well data for the different geologic trends is required.

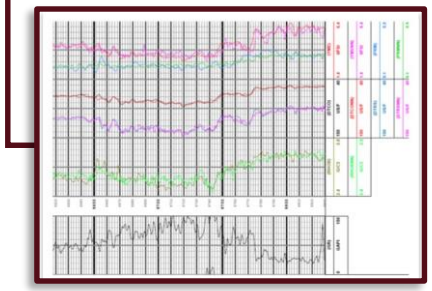


AI Enabled Synthetic Logs

Training Data

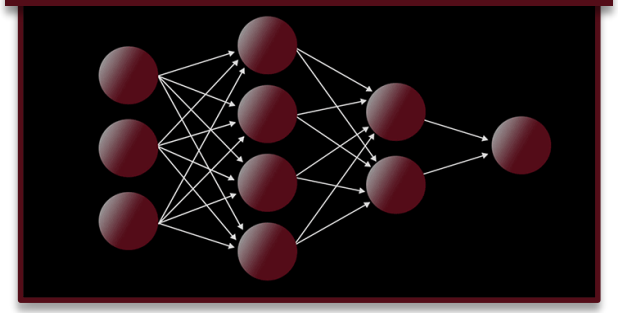
Train model using conventional logs obtained from nearby wells of similar well trajectory

Latitude/Longitude, Survey
LWD Gamma (optional: Resistivity)
Drilling dynamics

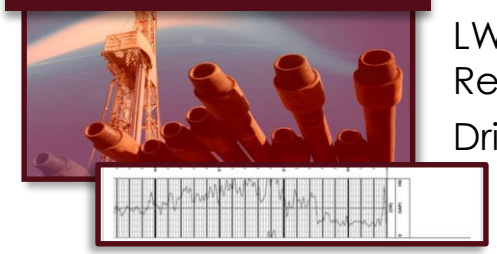


LWD Gamma (optional: Resistivity)
Compressional, Shear
Density
Neutron-porosity

Machine Learning Software

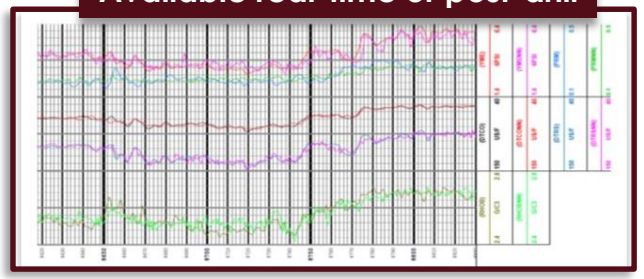


Input Data



Latitude/Longitude, Survey
LWD Gamma (optional: Resistivity)
Drilling dynamics

Synthetic Logs
Available real-time or post-drill



Compressional, Shear
Density
Neutron-porosity

Data QC	+	Well Database	+	Rock Type	+	Calibration
• Remove bad data • Ingest mis-calibrated or missing data		Drilling Dynamics Logs Core		Standard plus proprietary methods		Standard plus proprietary methods

QLog

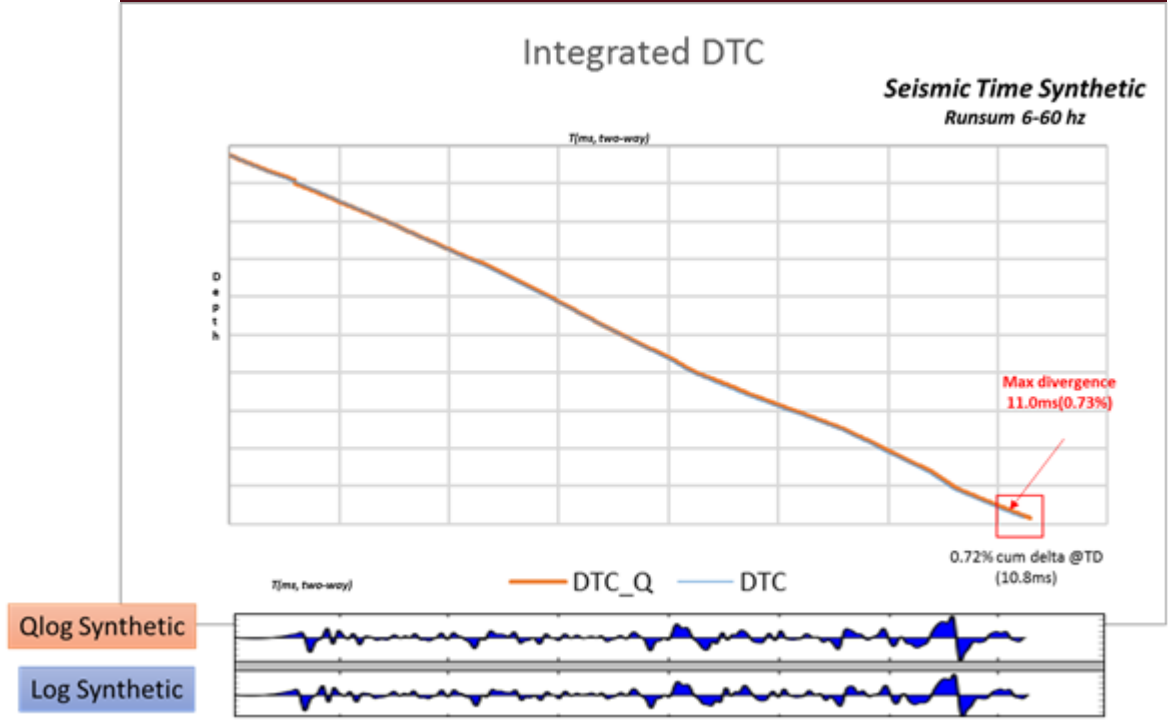
Real time or post-drill synthetic logs DTC, DTS, RHOB (Patented)

- Can be done in real time or after the fact in both conventional and unconventional horizontal wells
- Quality is as accurate as a well log rerun
- Better Geosteering – stay in the sweet spot
- Update Earth Models for rock properties
- Calculate rock properties for better fracking
- Backup or replacement of LWD tools and traditional wireline logging
- Non-invasive – no tools or sources (nuclear) in the hole
- Can be used to add more well control in traditional inversions

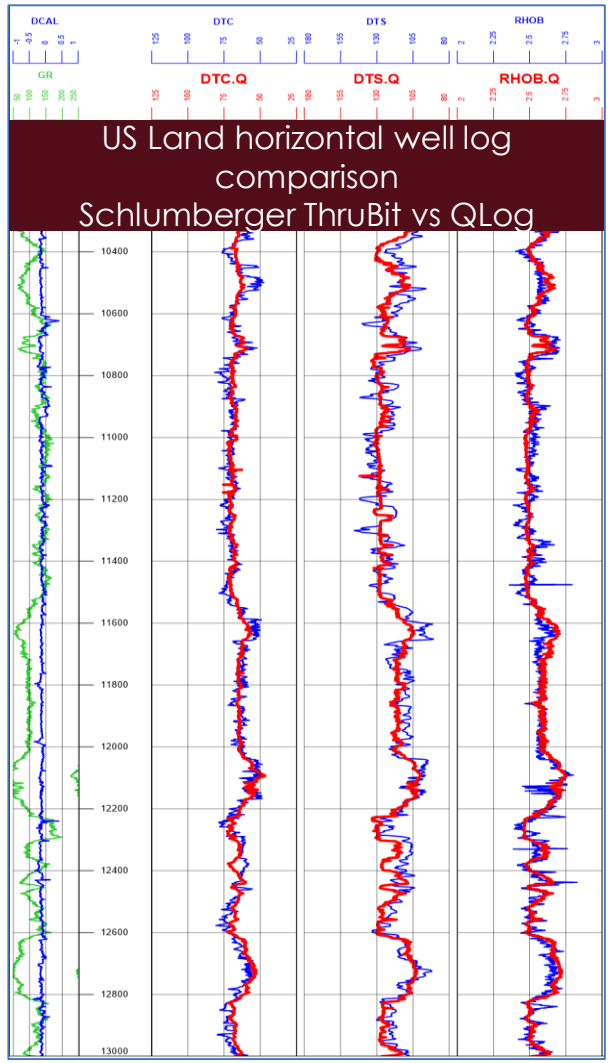
QLog – Synthetic Logs via Drilling Data

Quantico logs have qualified with multiple oil and service companies

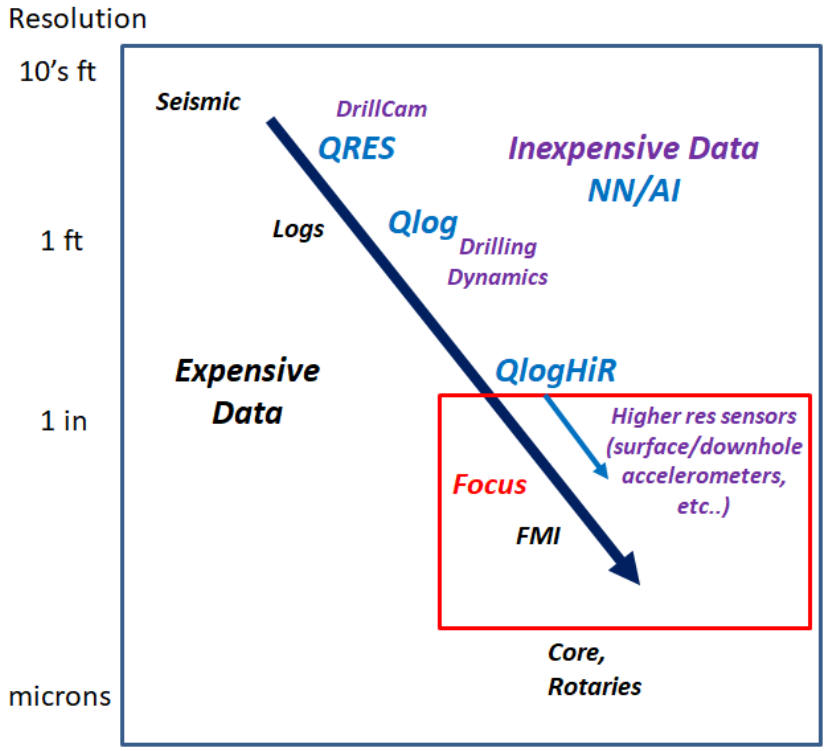
Deepwater depth-time comparison between LWD sonic vs QLog (30,000ft TVD)

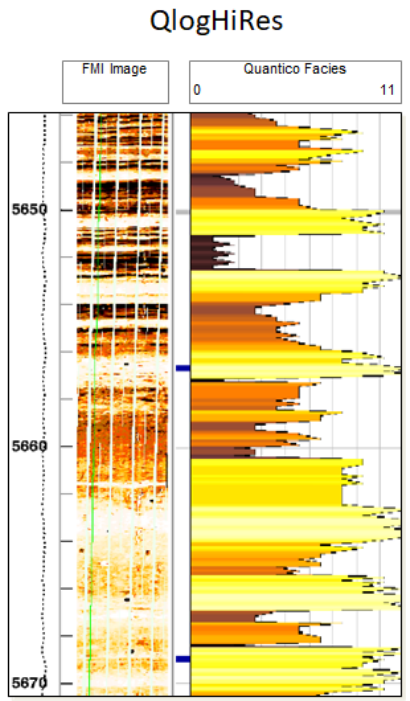


US Land horizontal well log comparison
Schlumberger ThruBit vs QLog



QLog – Moving "down" the Resolution Curve





Benefits

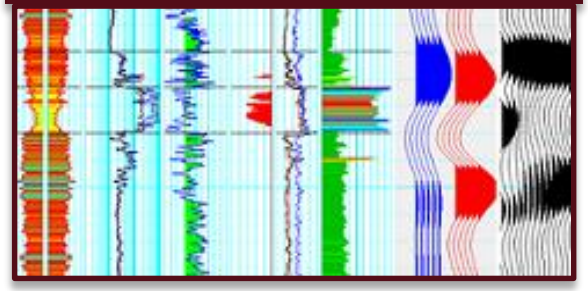
- Use high-frequency data and AI to decipher fine-scale rock properties
- Minimize need for coring/FMI
- Id fine-scale porosity/perm/facies
- High-frequency pay resolution

Elements of Study

- Generate AI/NN workflow on sample wells w. FMI/core
- Additional methods for "downscaling" wireline data

AI Enabled High-Resolution Earth Models

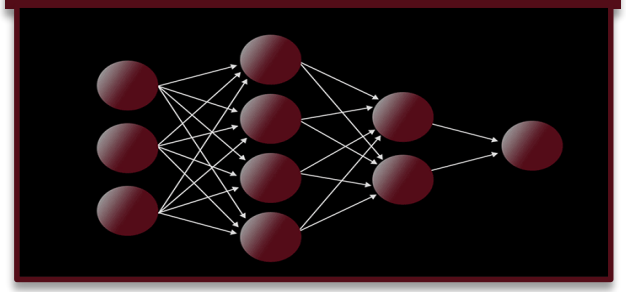
Training Data



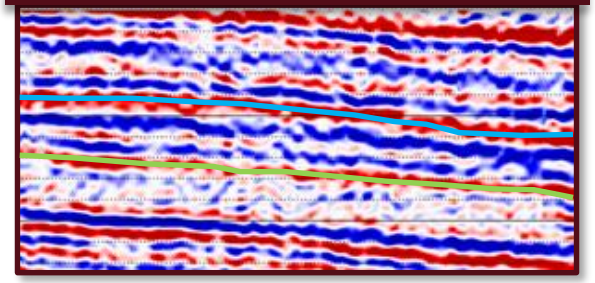
Well Logs (Measured and Synthetic), Pre and Post Stack Seismic data, Horizons/Tops, Maps…

Train model using a matrix of input data

Machine Learning Software

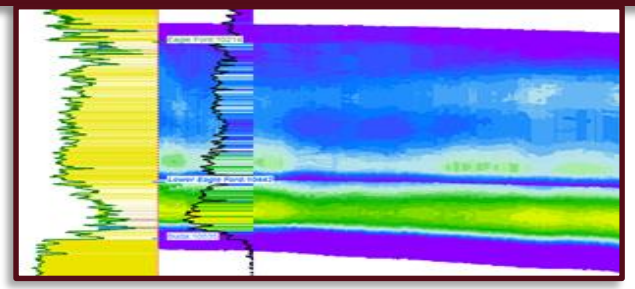


Input Data



3D Seismic data and horizons

High Resolution 3D Earth Model

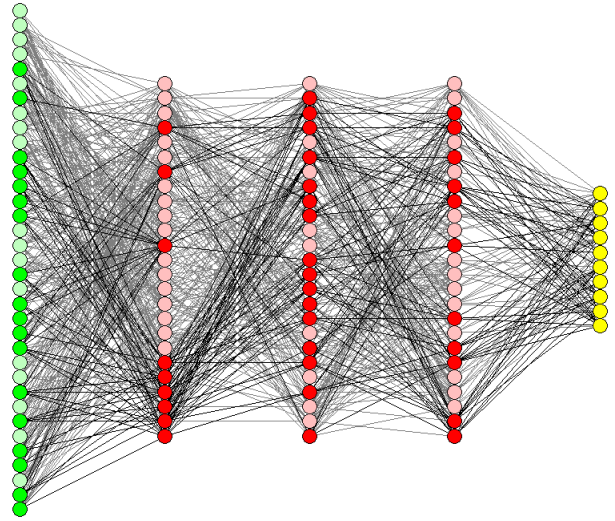


3D Rock property volumes: Compressional, Shear Density, Neutron-porosity, Porosity, SW, GR …

Data QC	+	Training Data	+	Train Model	+	Testing
Condition and scale input data		Physics Based matrix of conditioned data		Generate inverted dataset QC / Iterate		Blind well testing

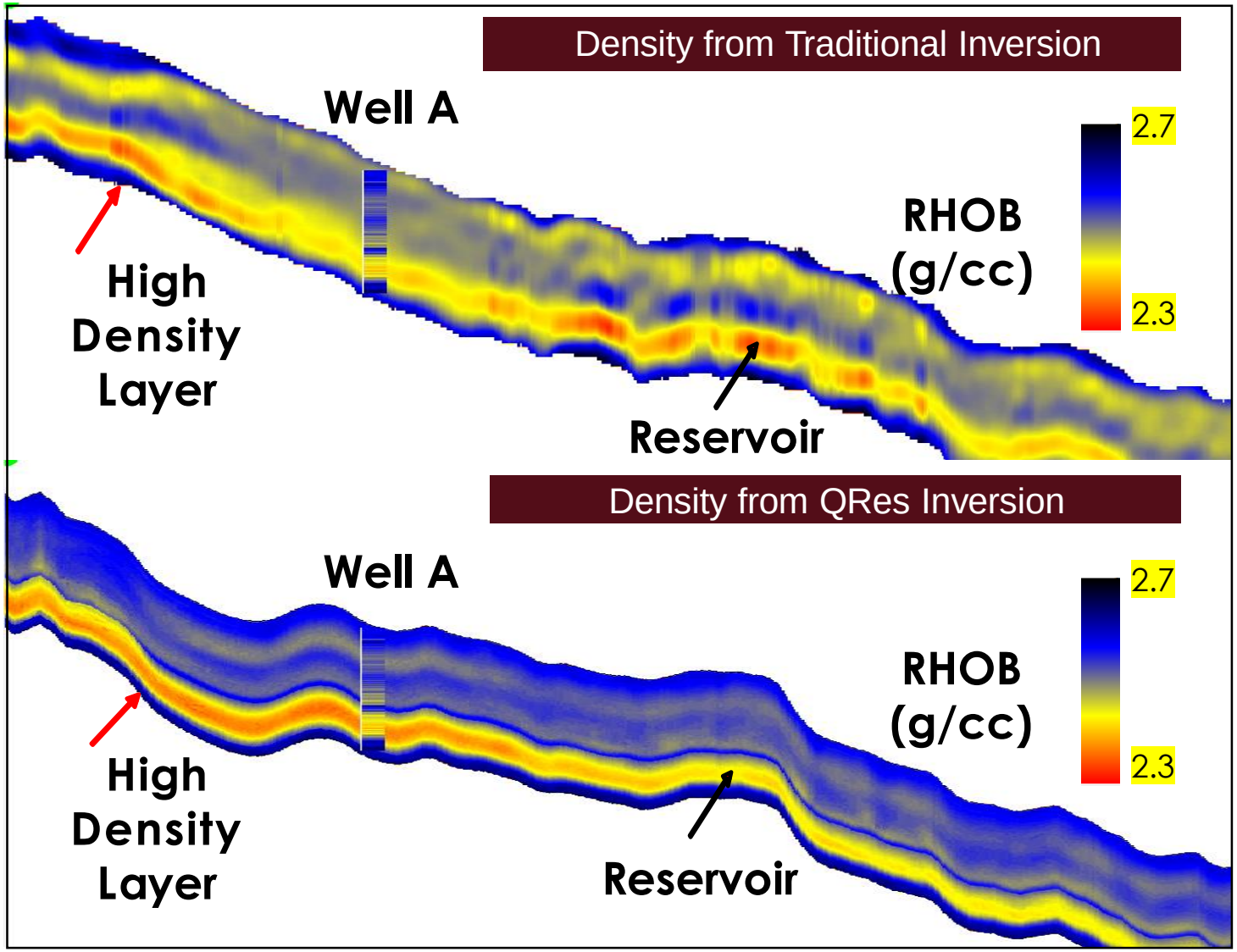
QRes Data Input / Output

- Training Data can Include:
  - All types of input well logs – GR, sonic, density, resistivity, image etc.
  - Pre and post stack data – amplitude, Lambda-Rho/Mu-Rho etc.
  - Horizons, isopach maps, depth maps etc.
  - Synthetic / partial logs



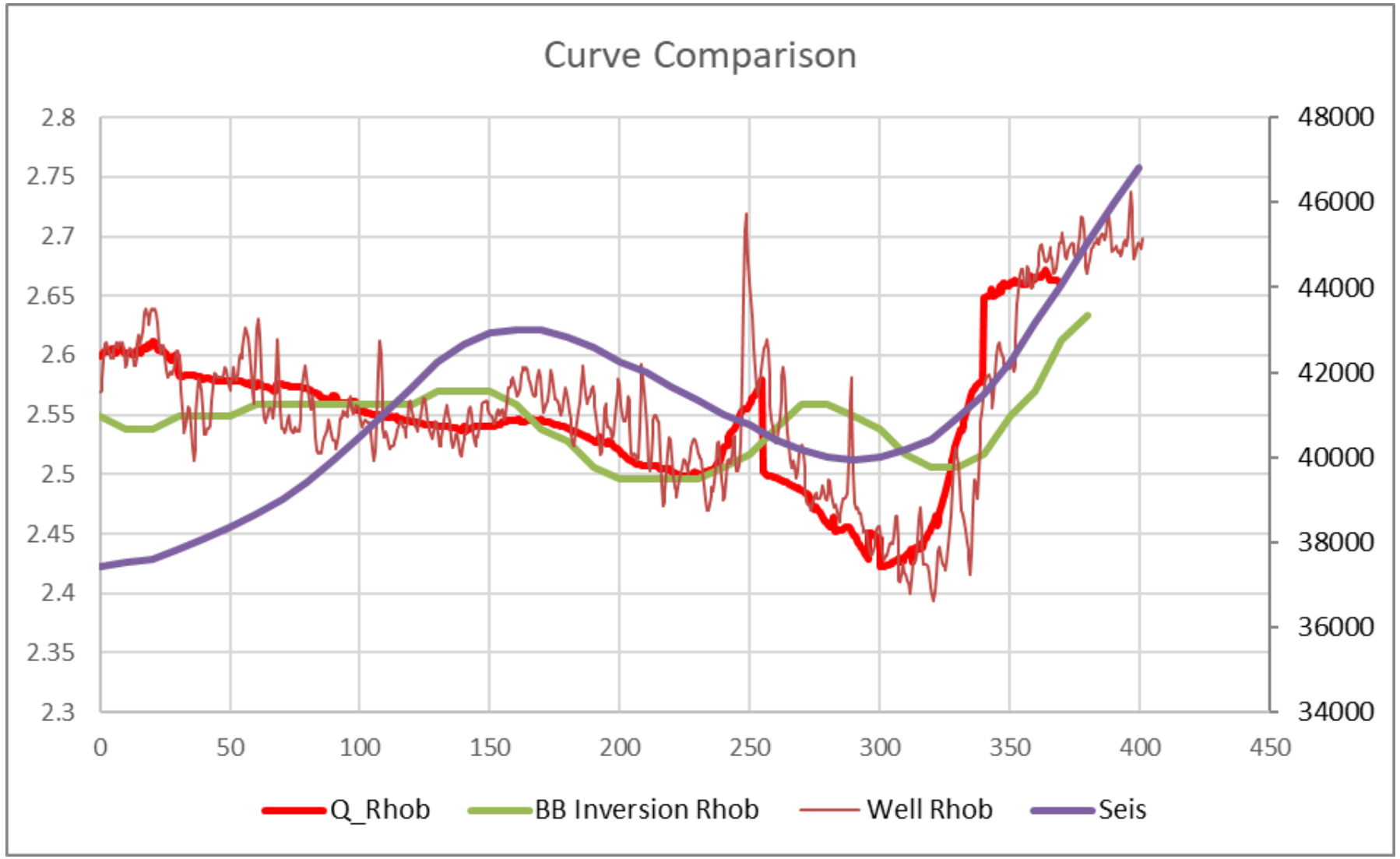
- Output Data can include:
  - Acoustic impedance, Vp, Vs, RHOB, GR, Porosity, Sw etc.
  - SEGY Format – GeoCellular in the works

QRes – AI-based Seismic Inversion (Example: Density)

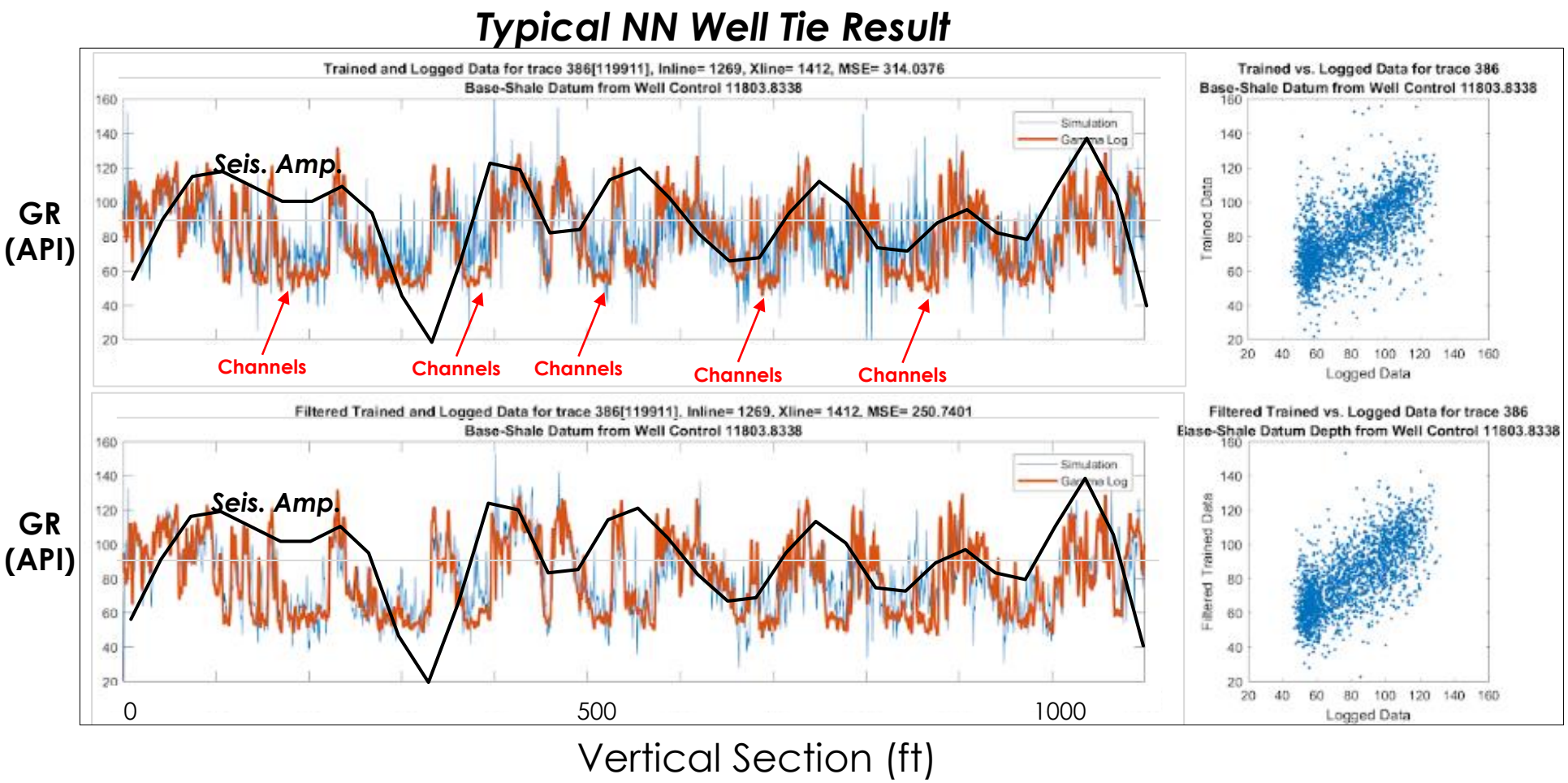


- RHOB is used to calculate YM, PR, Stress, Pore Pressure, Porosity, TOC.
- Its hard to obtain RHOB using Traditional Elastic Inversion and needs wide range of seismic offsets. The final output is within ~ 50 ft resolution.
- QRes uses post-stack seismic and the output is within (10 ft) resolution
- QRes density tied explicitly to well logs
- QRes uses well control based on conventional logs or AI driven logs (QLog).
- Swiftly generate and update model (focus)

QRes – Blind Well RHOB Comparison



Seismic Amplitude and Corresponding Well



Seismic Amplitudes do NOT resolve fluvial channels; while Neural Network inversion of seismic DOES

Conclusions