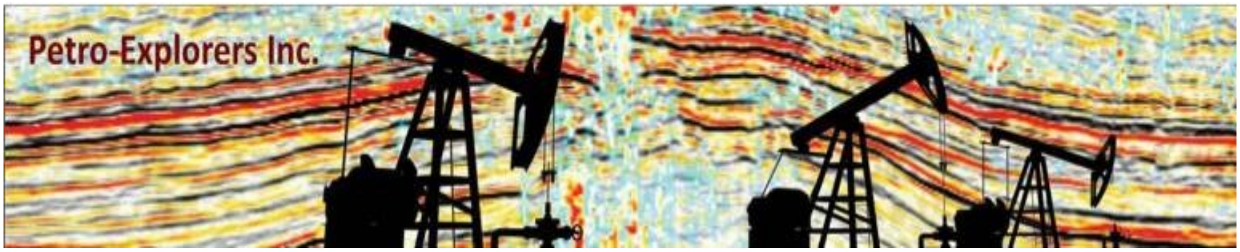


Rock Physics Analysis and AVO Modeling

Rock Physics and Elastic AVO modeling is the key to unravel almost every play in the exploration playbook. It is integral part of all reservoir characterization work.

Considerable time is put toward well data QC and conditioning in order to ensure that there is "Quality In, Quality Out". This preliminary stage of workflow is considered to be so crucial to the success of any project that Petro-Explorers Inc. will perform a full review of all data available prior to commencing analysis.

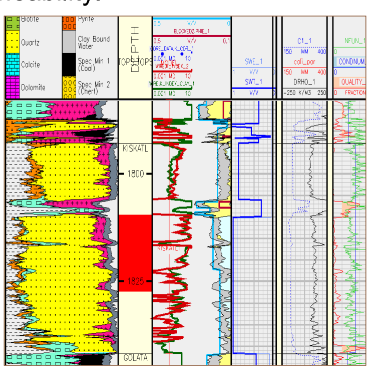
Well Data Loading and QC

Well logs are read from LAS files, reviewed, QC'd and edited as appropriate. Tops, strip logs and other related data are reviewed and loaded. For unconventional shale plays, mineral composition log can help define elastic and anisotropic properties of the shale units. Directional core analysis and/or FMI logs are used to evaluate fracture density, etc.

LAS log data are to be compared with raster data to ensure its accuracy.

Petrophysical Analysis

Primary goal of petrophysical log analysis is to depth match logs, apply check shot corrections, and predict the best representative lithology to prepare logs for rock physics input. For carbonates this also means separating bound porosity and predicting permeability.

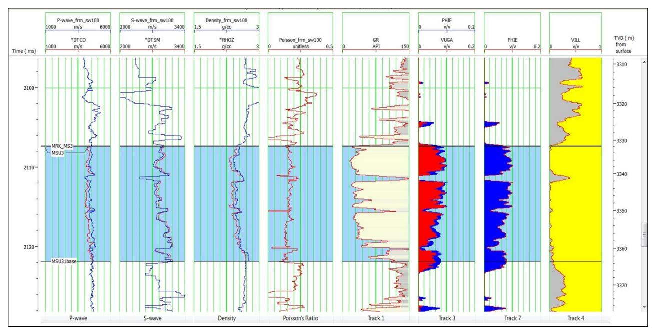


Multi-min petrophysical analysis of log data using Quartz, Calcite, Dolomite and Biotite with 4 other minerals.

Log analysis is focused primarily on geophysical well log analysis while honouring and applying petrophysical rules. In the presence of existing volumetric logs, this step can be optional.

Generation of Shear Sonic, Saturation and Porosity Logs

If it is deemed necessary to generate additional Vs, Sw and porosity logs, it is done using industry-standard empirical equations, providing that existing log data is suitable. Minor editing and log splicing may be required at this point to reduce existing log problems.

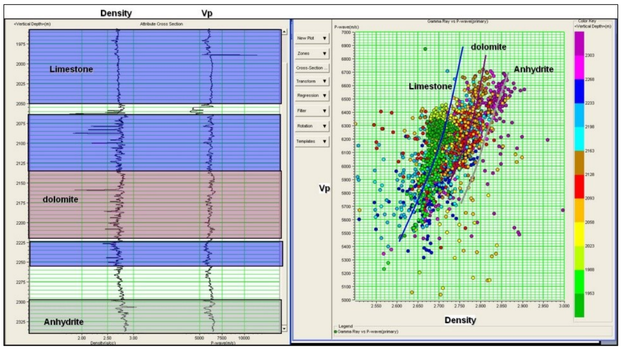


Investigate Log Based Rock Physics Relationships

Using cross plot tools, determine relationship between Zp, Zs, PR, Vp, Vs and rock properties such as N:G, Porosity, saturation, shale content, brittleness.

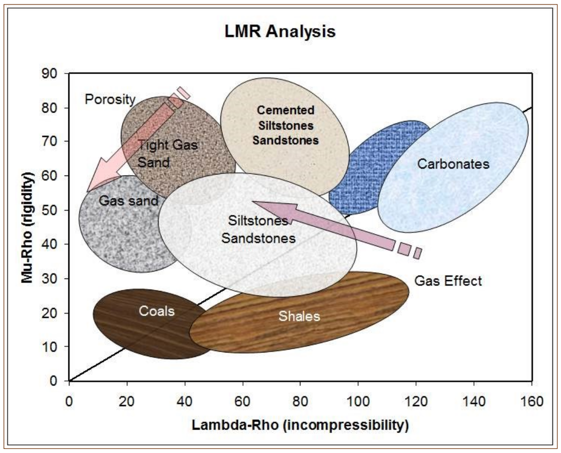
- Log Cross-Plotting: Depth v Attribute, Attrib v Attrib
- Upscale logs to seismic scale (bandwidth) – Backus Averaging
- Repeat Cross-Plotting: Depth v Attrib, Attrib v Attrib
- Generate stack and offset synthetics and observe affects on well to seismic ties (time-depth relationship, wavelet extractions)
- Generate transformed attributes: Ip, Is, lr, mr, EI, fluid factor, pseudo Poisson's ratio
- Determine all required empirical relationships between measured petrophysical (rock) properties (e.g. Vshale, porosity, Sw, etc) and acoustic and elastic log properties (attributes) for each prospect interval. The results are then calibrated against core analysis.
- Carry out fluid replacement modelling (FRM) using various end member scenario.
- Repeat previous four steps with FRM - before and after Backus upscaling
- Produce final set of logs for tuning analysis and generate geomechanical log sets.

ROCK PHYSICS ANALYSES AND AVO MODELING



Differentiation between limestone, dolomite and anhydrite to allow separate parameter selection for Gassman fluid substitution

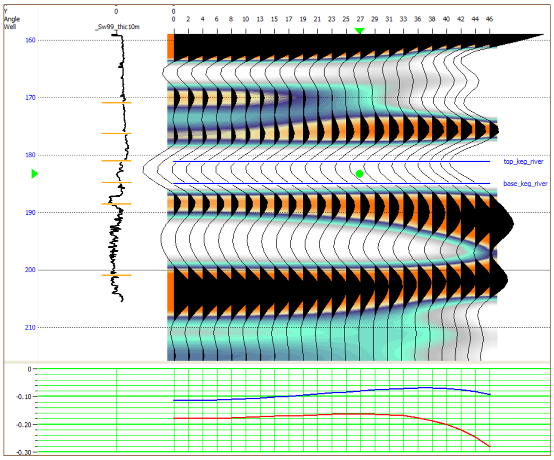
Young's modulus and Poisson's Ratio cross-plots provide direct relationship to the brittleness of shales. These shale properties and zones are then used to understand seismic response. Recent studies have shown that lower Poisson's ratio calibrates to the zones of high brittleness, hence is good for fracture simulation.



LMR characterization of lithology to create Probability Density Functions (PDFs) in LMR space

AVO Synthetic Modeling

Pre-stack synthetic generation and scenario modelling play an important part to understand nature of any play and its AVO attributes. End member of porosity and thicknesses is used to create 3D pre-stack synthetic seismogram. Various frequency options are used to understand the nature of play.

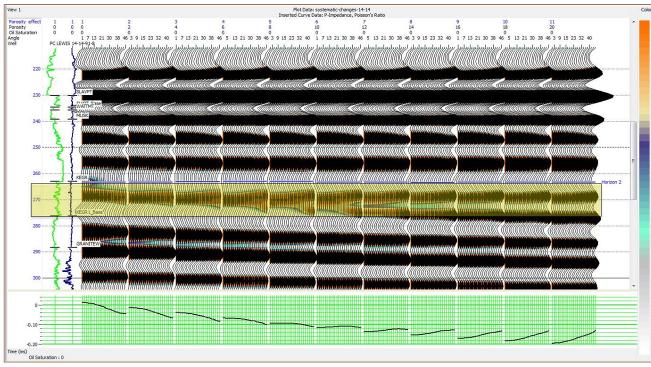


Typical AVO synthetic model to understand amplitude variation using well data and seismic frequencies

Lithological information from existing wells such as strip logs, core and geomechanical analysis etc. is very important at this point. Various models are used to control better lithological substitution parameters. Lithology substitution allows variation of shale type by changing the Poisson's ration and various elastic moduli.

Creating Porosity, Lithology and Fluid Scenario

3D synthetic gathers are generated by changing two properties at the same time. In this scenario we change Porosity on X direction and Water Saturation on Y direction while keeping thickness of unit as the same. Following are gathers from in-line extracted from modelled 3D showing effect of porosity variation while fluid is kept as wet. By using such scenario modeling of actual seismic gather response can be compared and calibrated. It is also important to understand the effect of porosity alone in wet or hydrocarbon zone. For the shale gas plays clay mineral substitution uses elastic moduli of different lithology types to create base rocks. The method can also be called as lithology substitution to create synthetic scenario.



Gathers of inline from modelled 3D with change from Class II to Class IV AVO with only variation in porosity

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