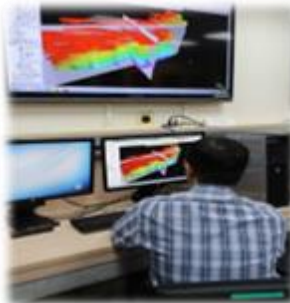




Petro-physical Characterization of Sedimentary Environments Using Collaborative New Method in Wireline logs Interpretation

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3. Schlumberger, Digital & Integration



Content

- Background and object
- Reservoir evaluation and Field develop plan
- Preliminary results of QI Machine Learning
- Concluding Remarks



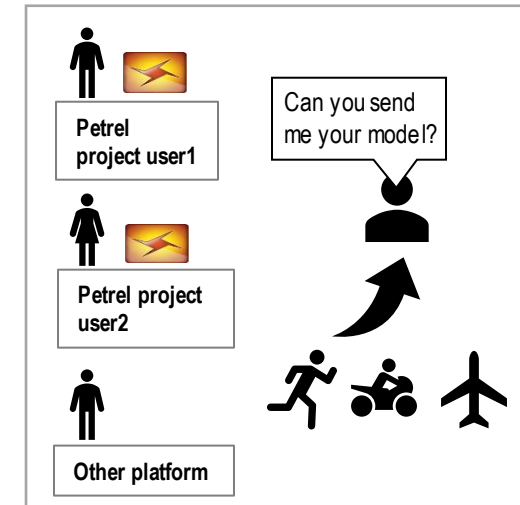
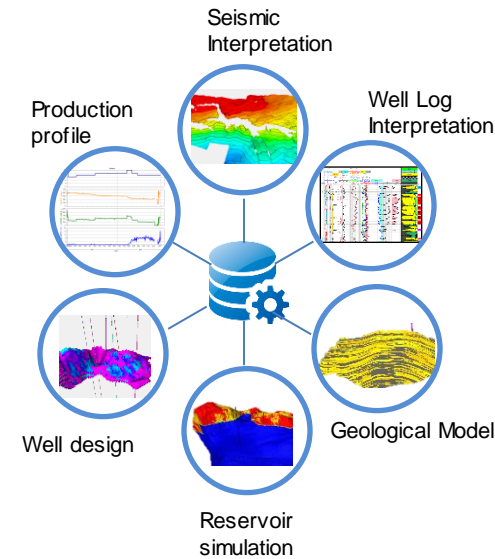
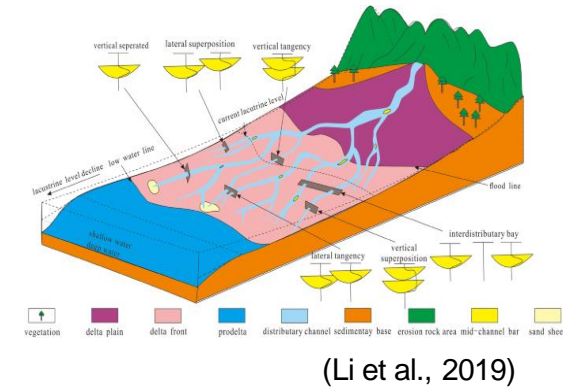
Purpose of the project

Target

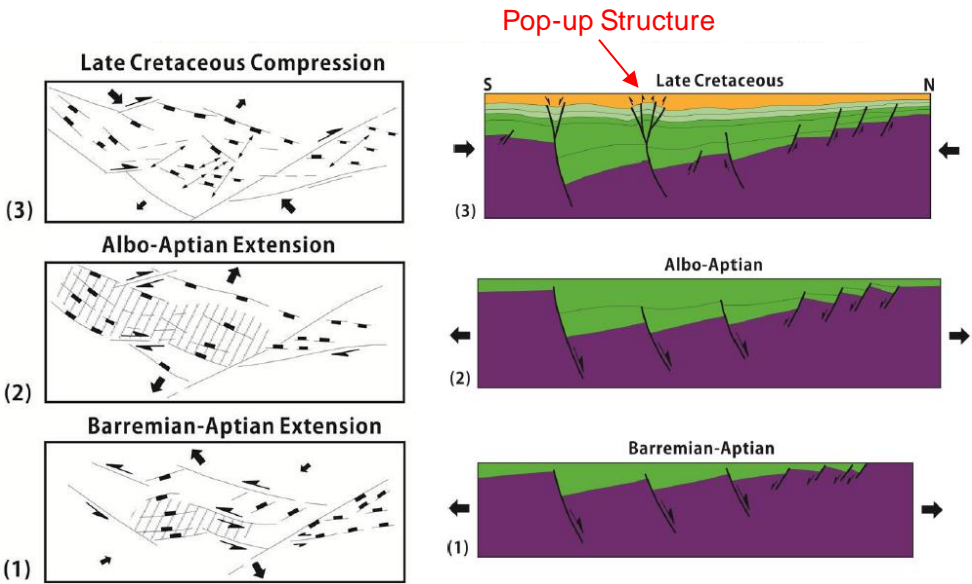
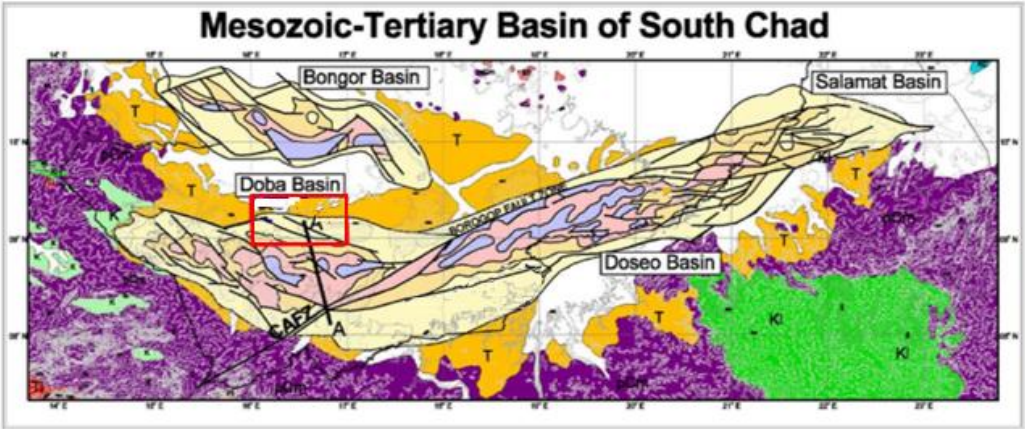
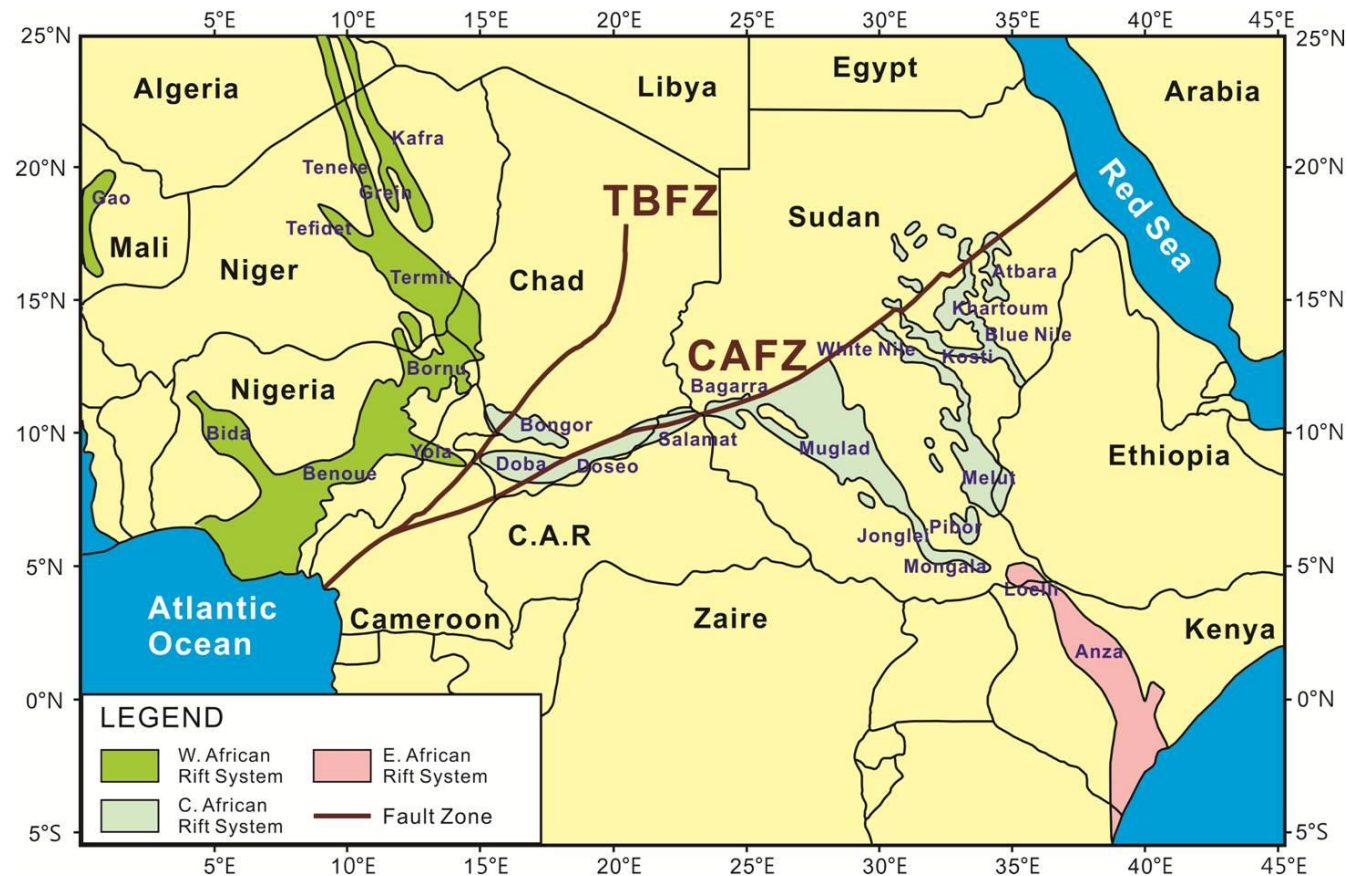
- Reservoir Characterization
- Field development Plan
- Data management
- E&P collaboration

Challenges

- Complex Geologic environment
- Significant vertical heterogeneity
- Data collection & QC
- Dispersed platform projects



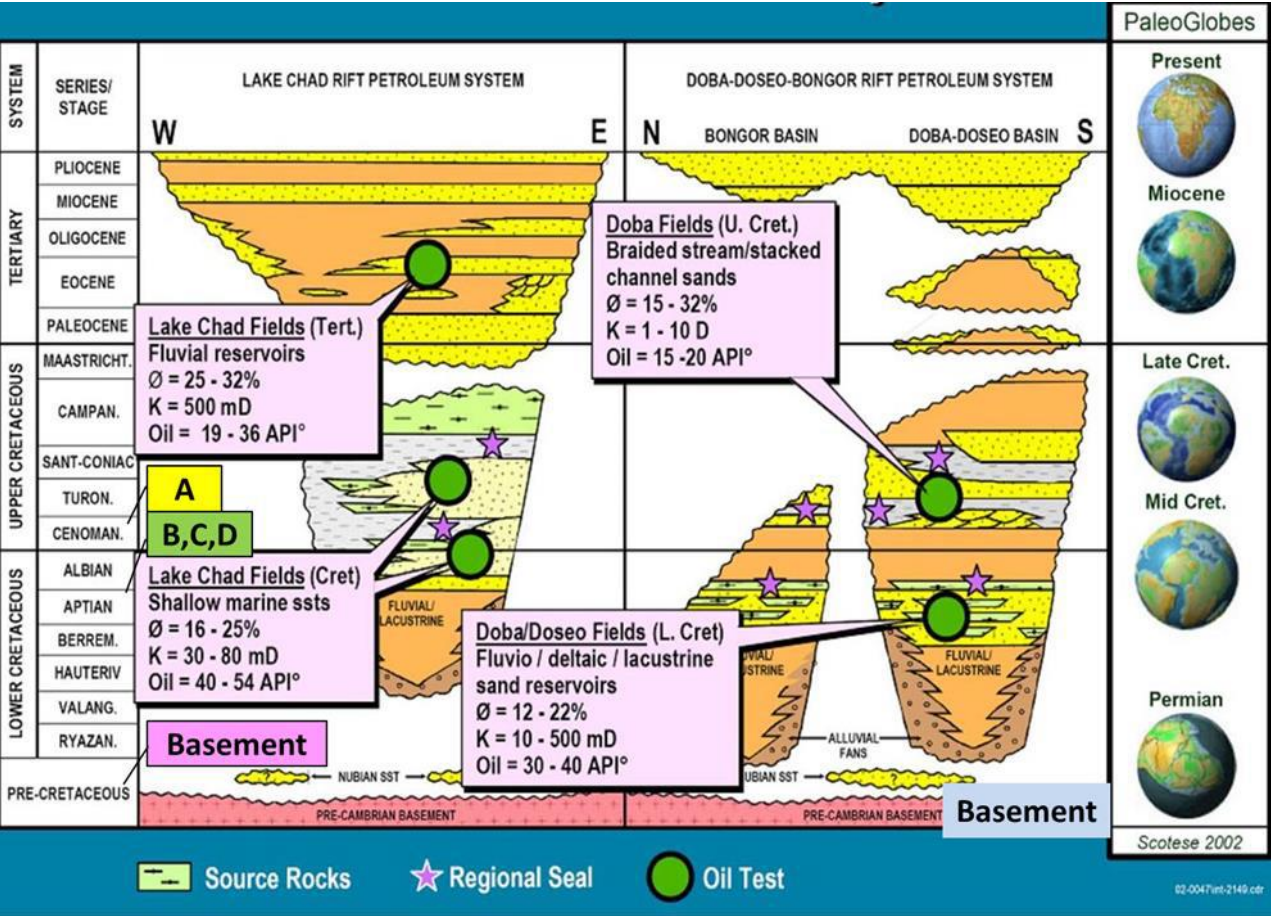
General Geology



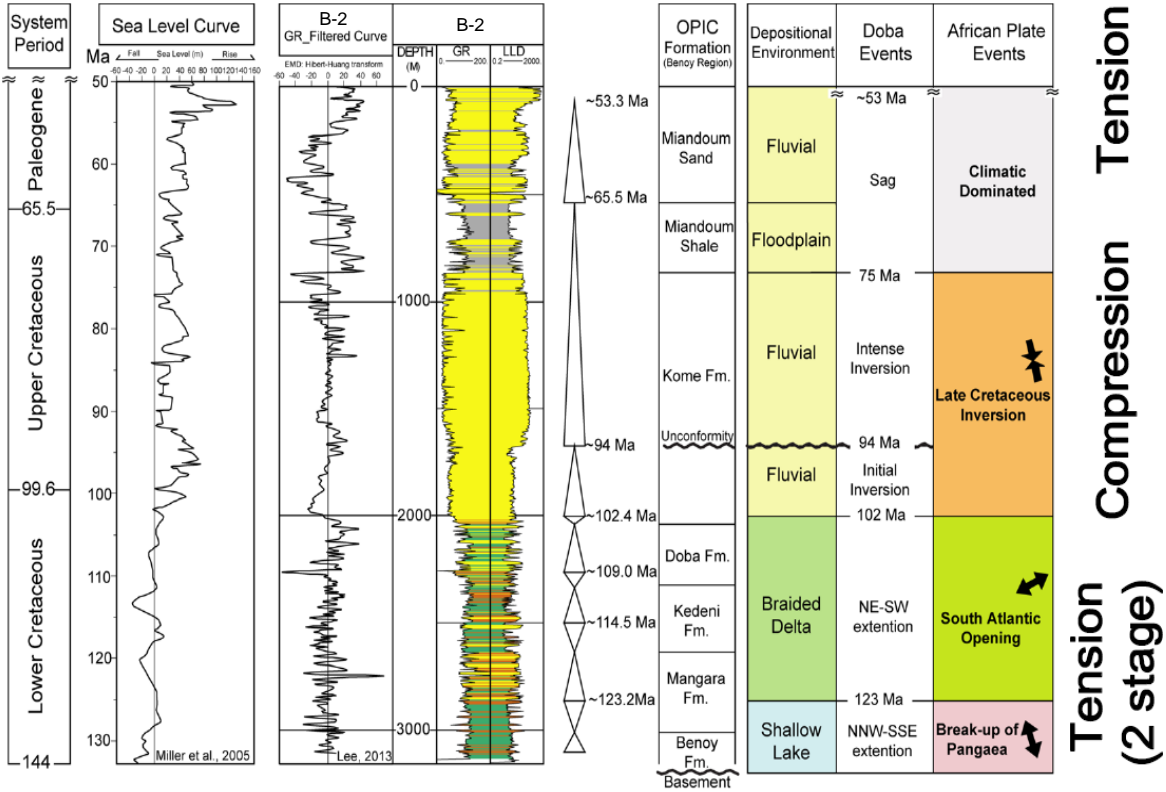
(After Genik, 1993)



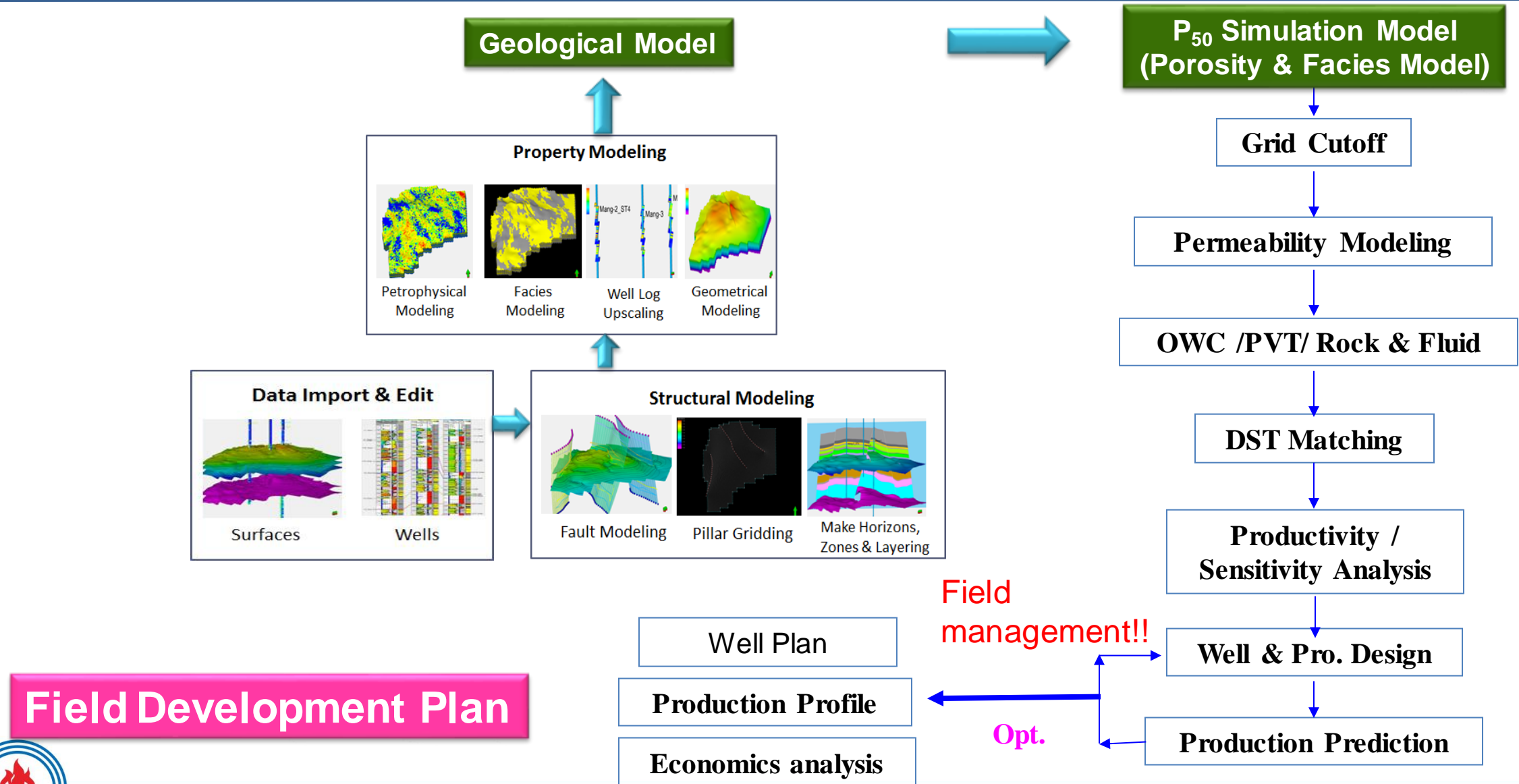
General Geology



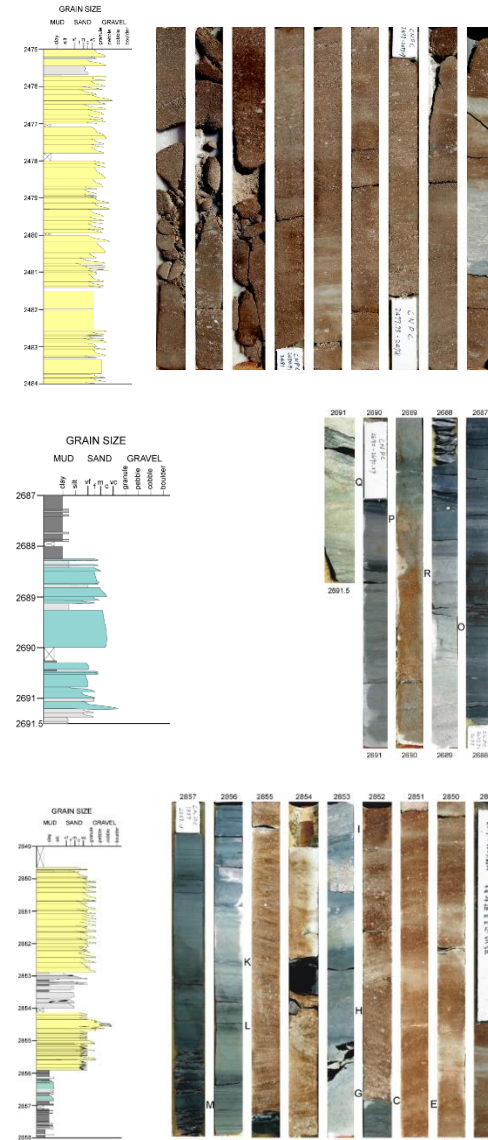
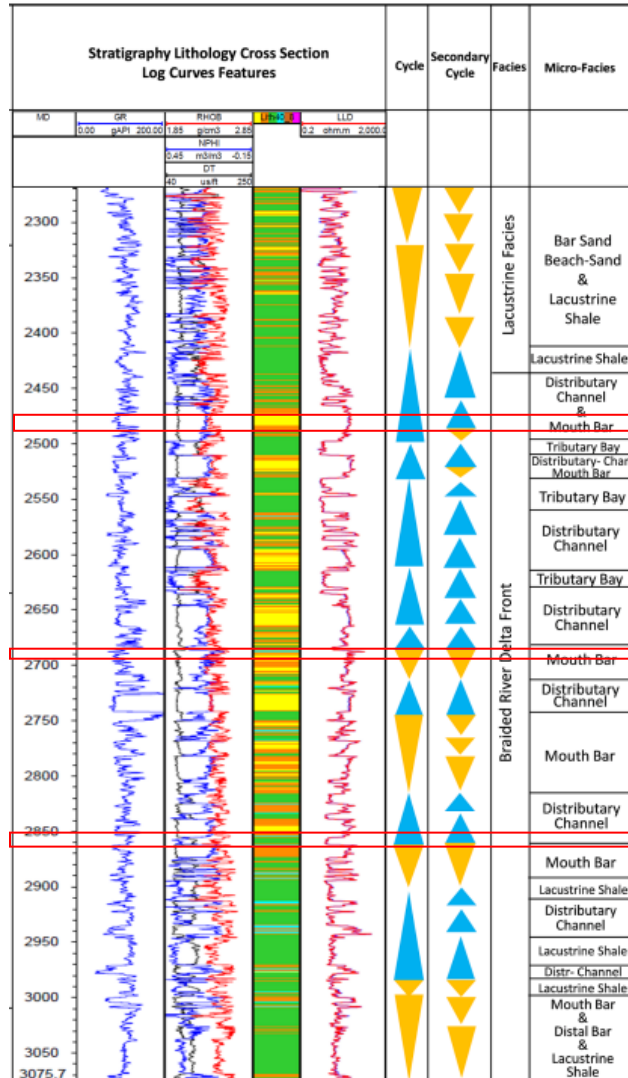
(IHS Energy Group, 2001)



Field Development Plan Optimization



Lithology Characterization and sedimentary facies



A



B



C



D

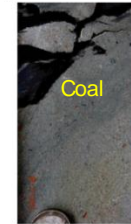


E

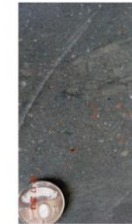
- (1) Clastic-supported
coarse sand to granule
subaqueous distributary channel



F



G



H

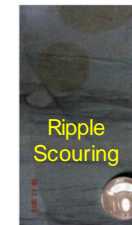


I



J

- (2) Matrix-supported
Coarse sand to granule
Debris flow;
interdistributary channel



K



L



M

- (3) Thin lamination of Ss&Sh/
Shale
Turbidity current;
lacustrine



N



O



P



Q

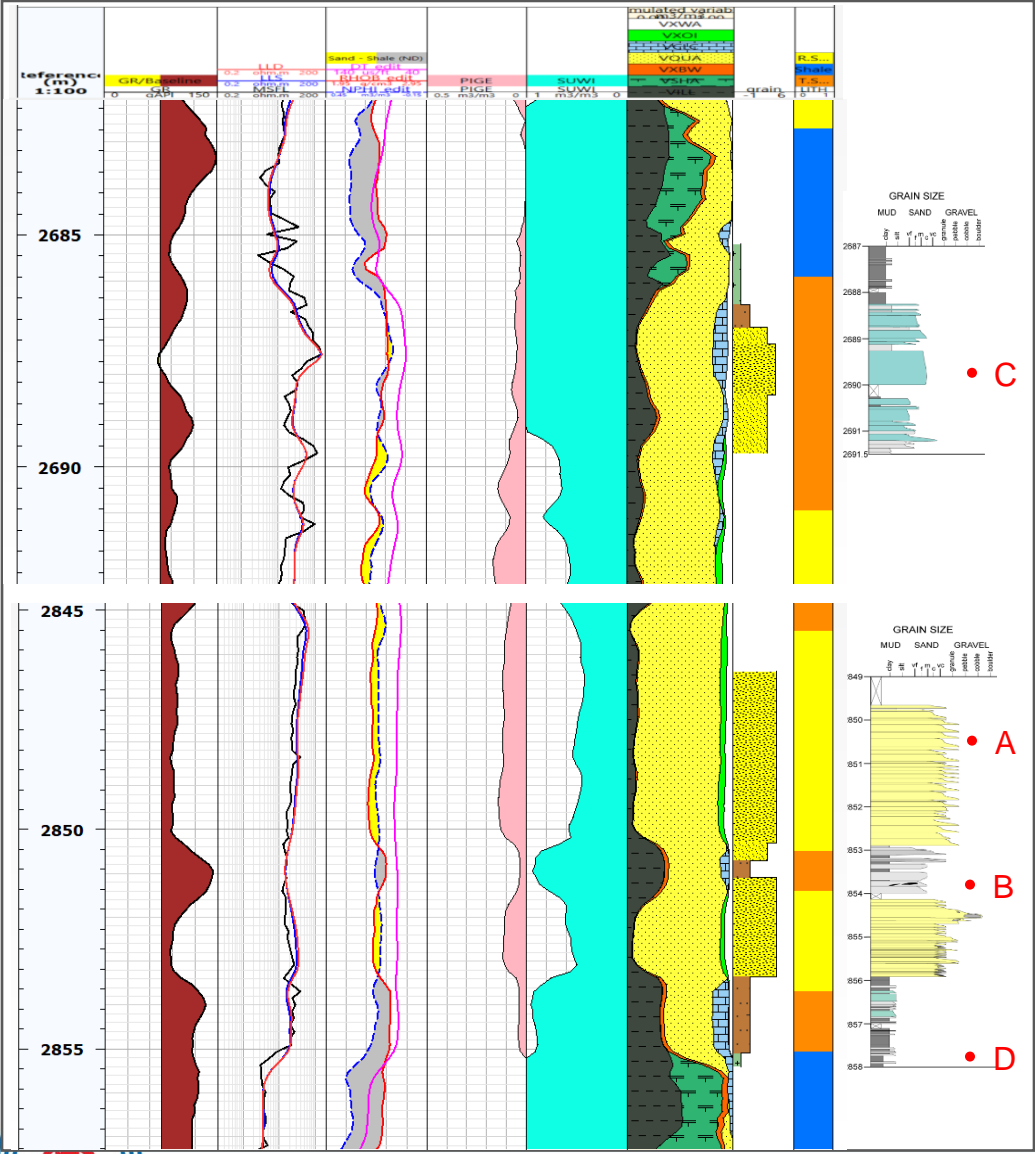


R

- (4) Calcareous sandstone
Distal sandbar



Core-Log lithofacies integration



Reservoir Sand

Log: GR is around 90 gAPI, lower density, lower neutron, high Sonic velocity, higher resistivity; porosity>10%; shale content<40%.

Core: Fining up medium grained, minor coarse grained, occasionally very coarse grained, moderately sorted, clear cross bedding, good porosity, heavy oil odor.



A

Tight Sand

Log: GR>100 gAPI, higher density, higher neutron, lower resistivity; porosity<10%; shale content<60%.

Core: Siltstone with very fine sand stripes in part, common argillaceous matrix, poor porosity, no shows.



B

Calcareous Sand

Log: Lower GR, high density, density>2.5, high resistivity; porosity<10%; calcite content>10%, shale content<60%.

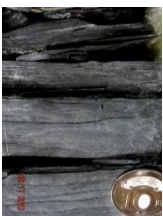
Core: Medium grained, trace very coarse grained, sub-angular to sub-rounded, moderately sorted, trace kaolinitic cement, calcareous cement.



C

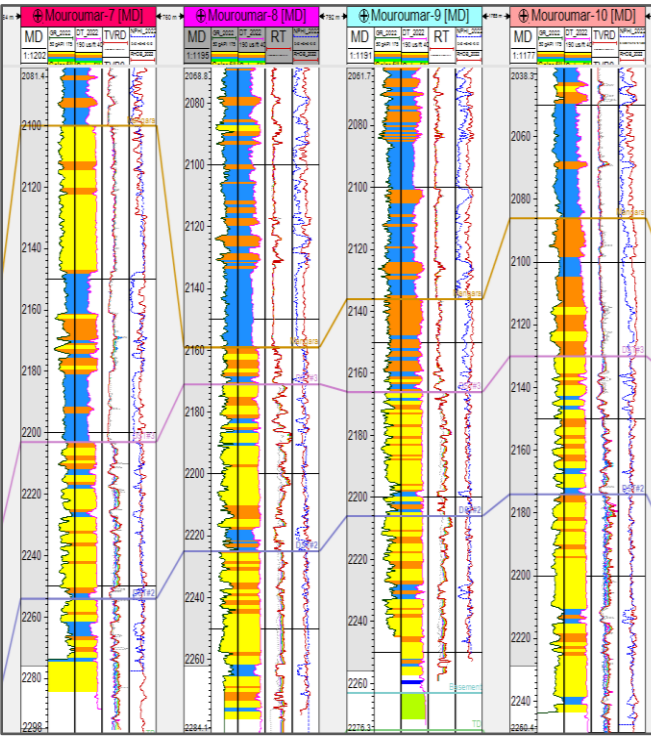
Shale

Log: Higher GR, wide neutron-density cross, low Sonic velocity, lower resistivity, shale content>60%.

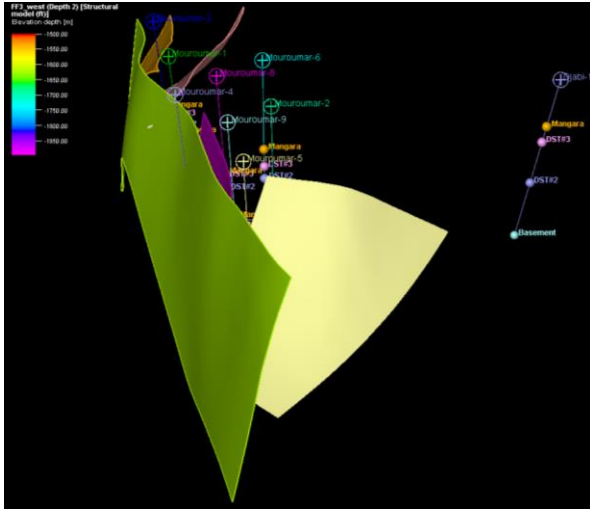


D

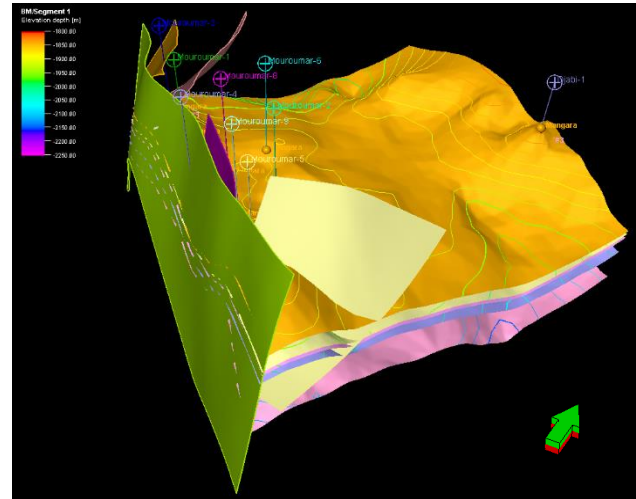
Clay Volume (Vcl)	Porosity (Φ)	Density (ρ)	Calcite Volume (Vclc)	Lith Classification
Vcl ≤ 0.4	Φ ≥ 0.1	/	/	Reservoir Sand
	Φ < 0.1	/	/	Tight Sand
0.4 < Vcl < 0.6	Φ ≥ 0.03	/	/	
	Φ < 0.03	p > 2.5	Vclc > 0.02	Shale
Vcl ≥ 0.6	/	/	/	



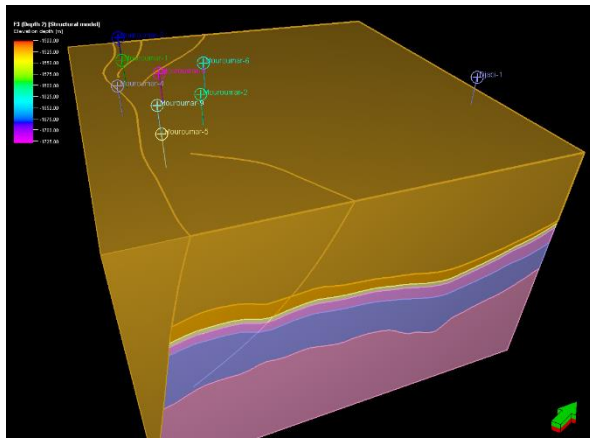
Structure Modeling



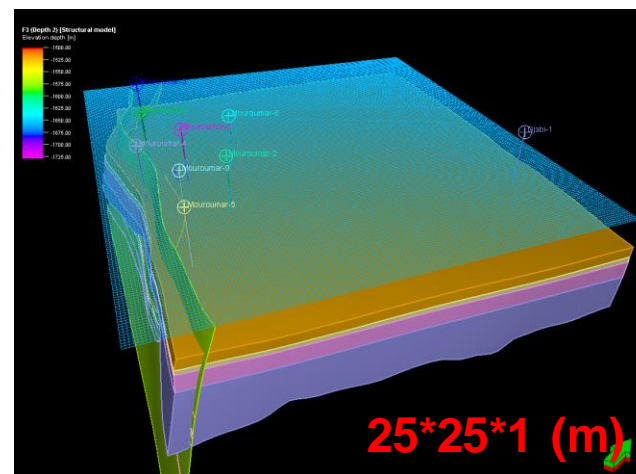
Fault Framework



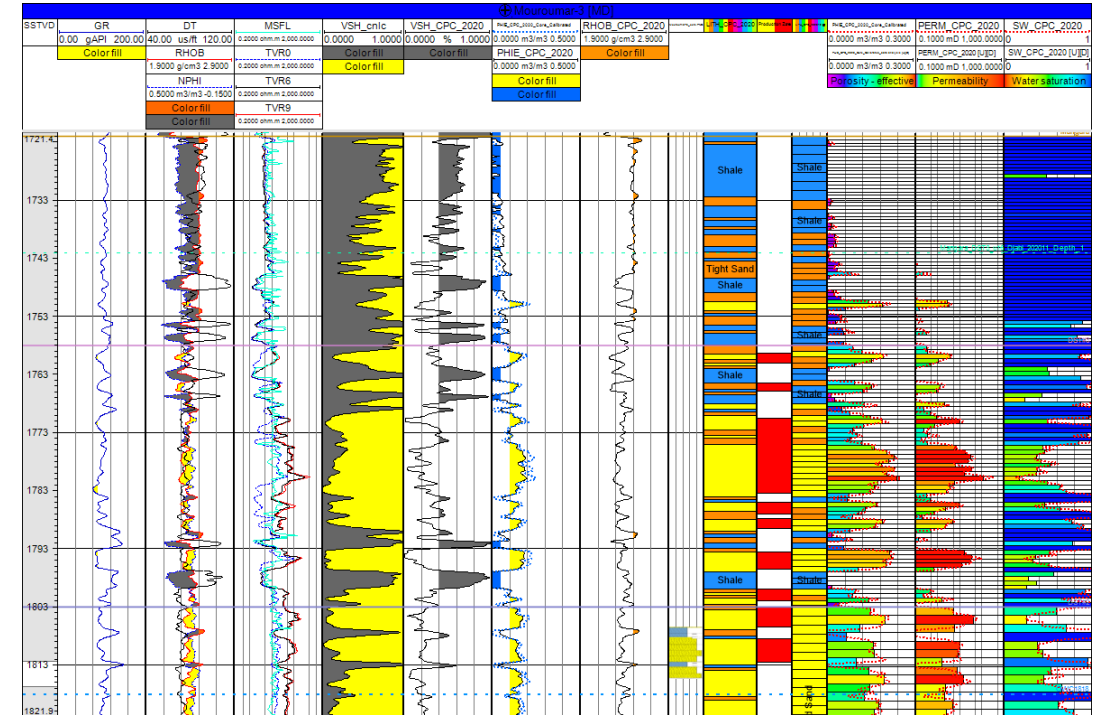
Model Construction



Model Construction



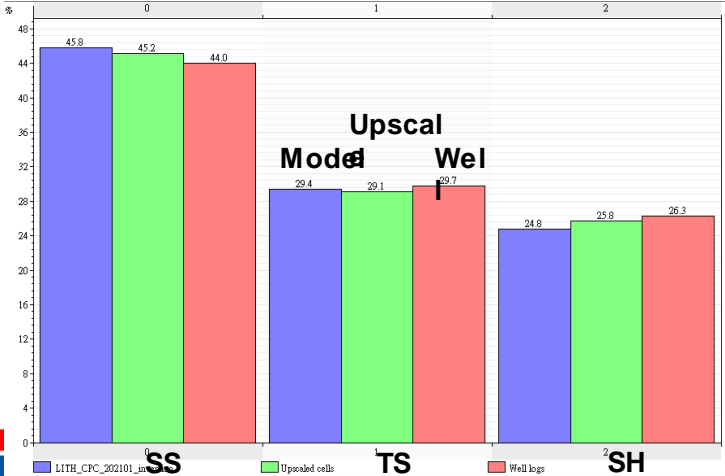
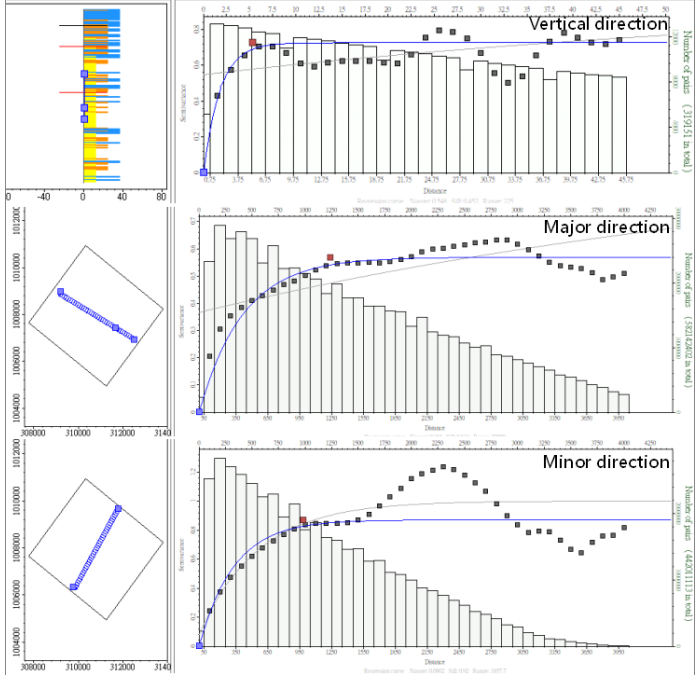
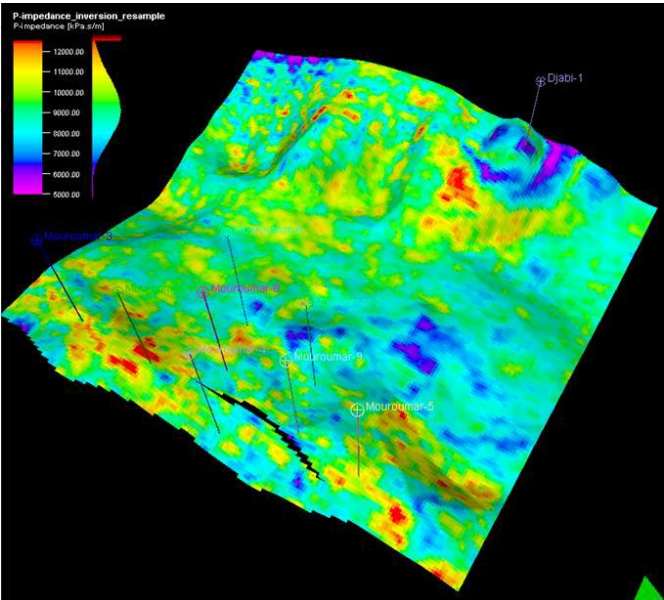
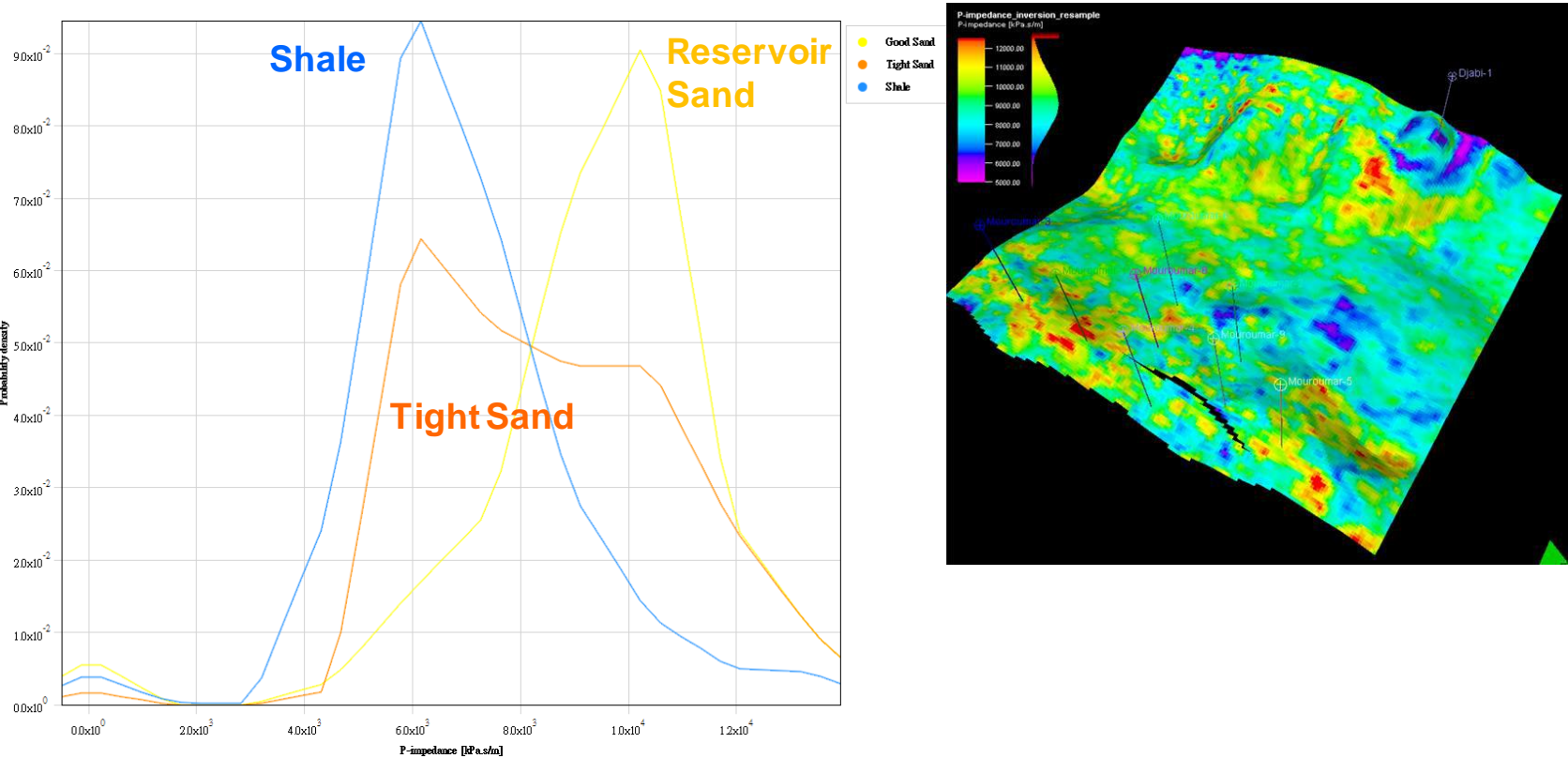
Structure gridding



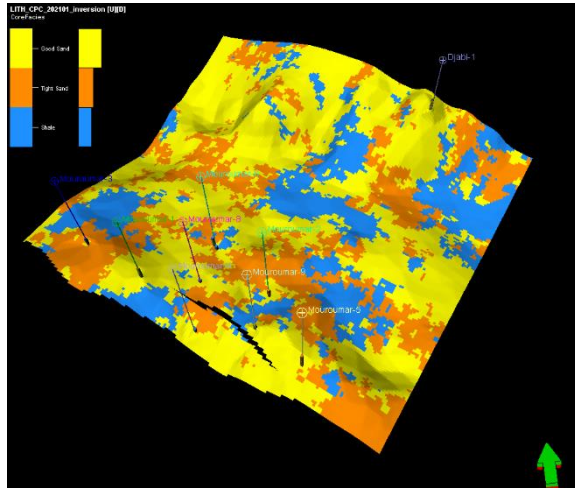
Well data upscaling



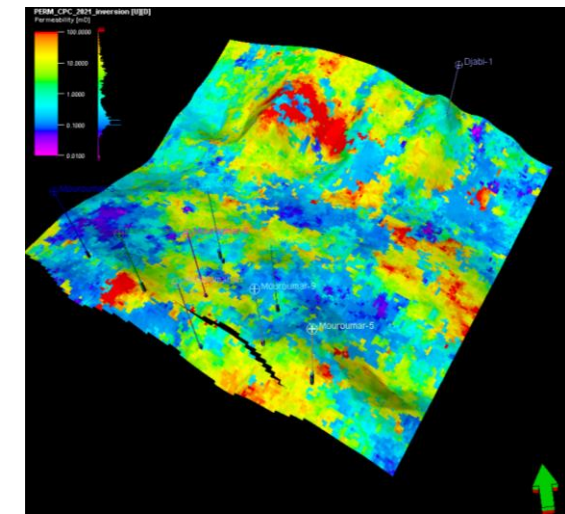
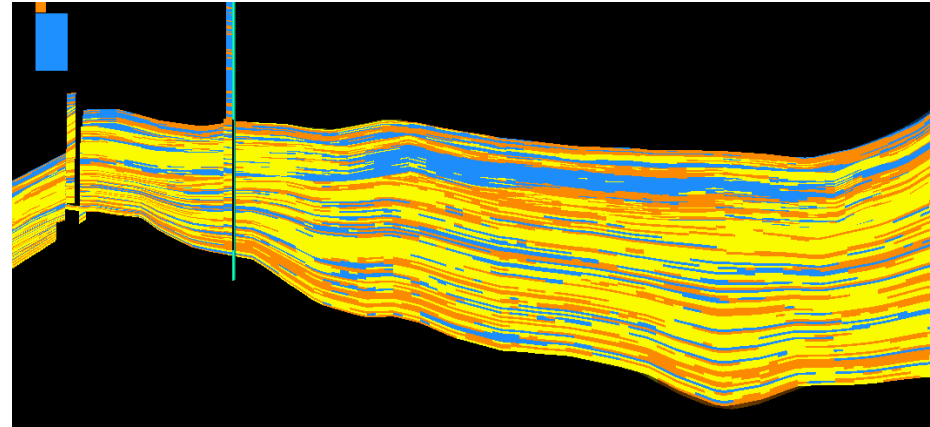
Property Modeling



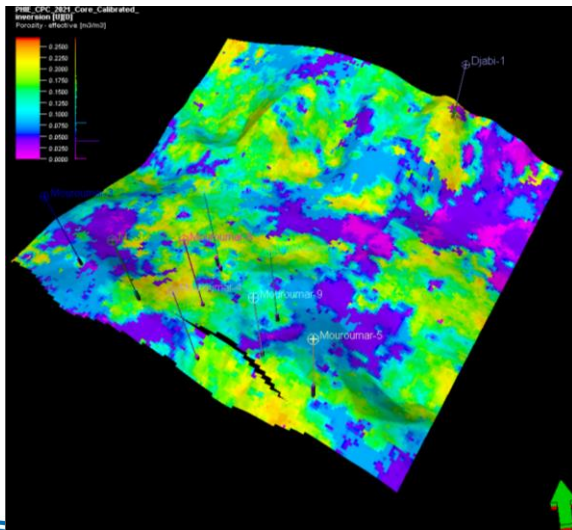
Property Modeling



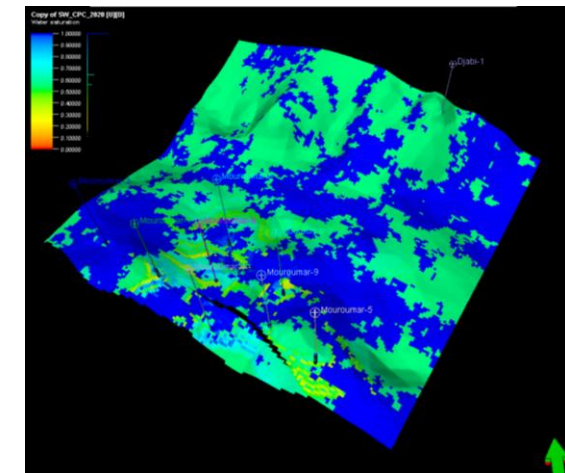
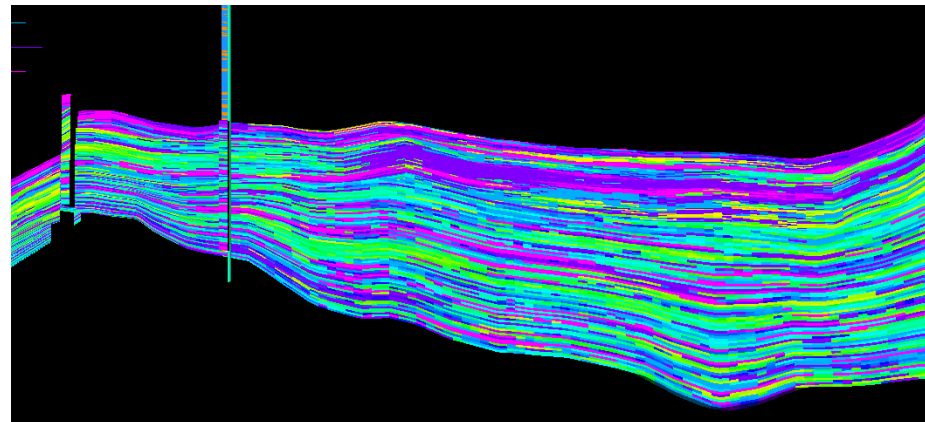
Lithology



Permeability



Porosity

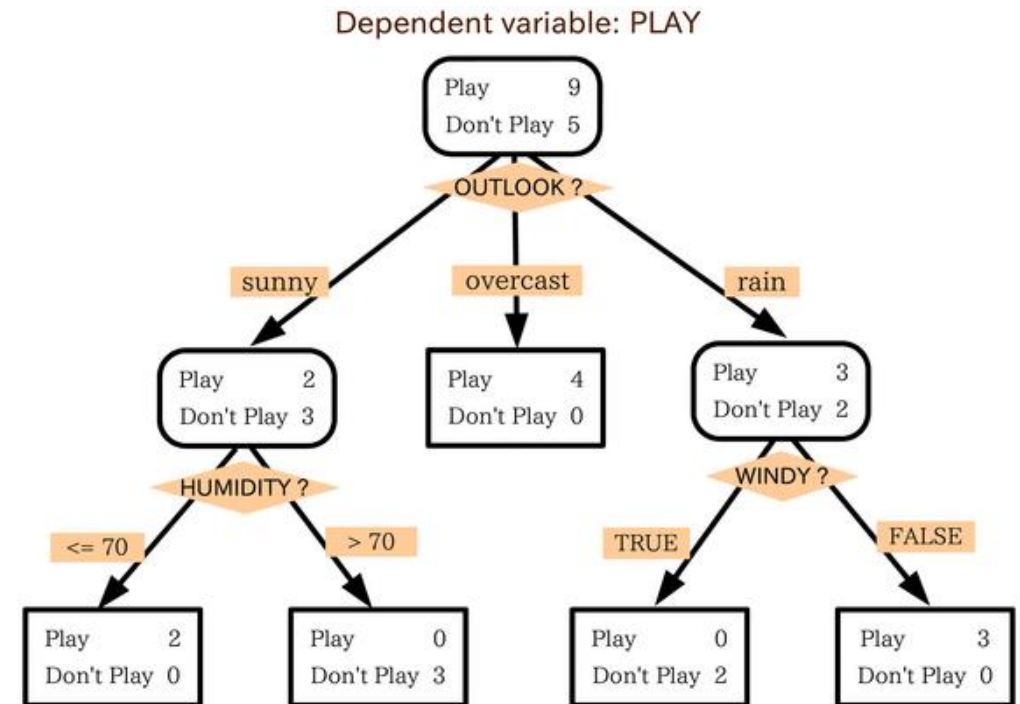


Water Saturation



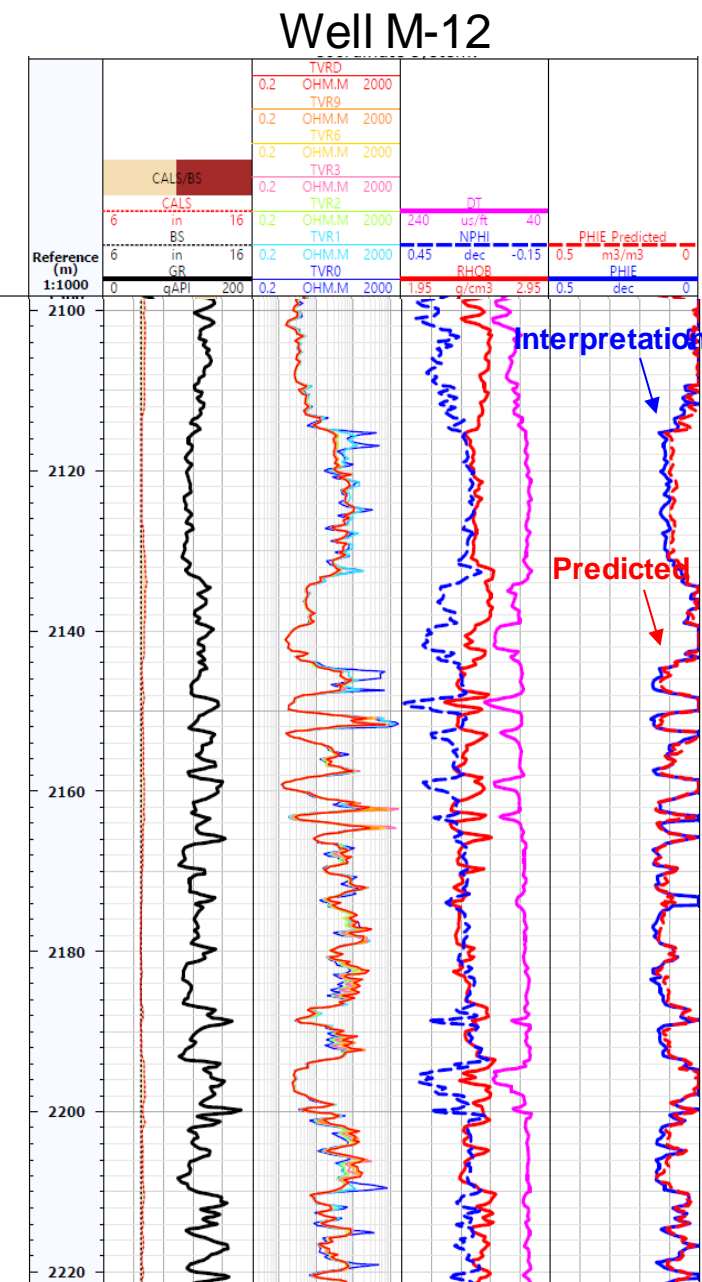
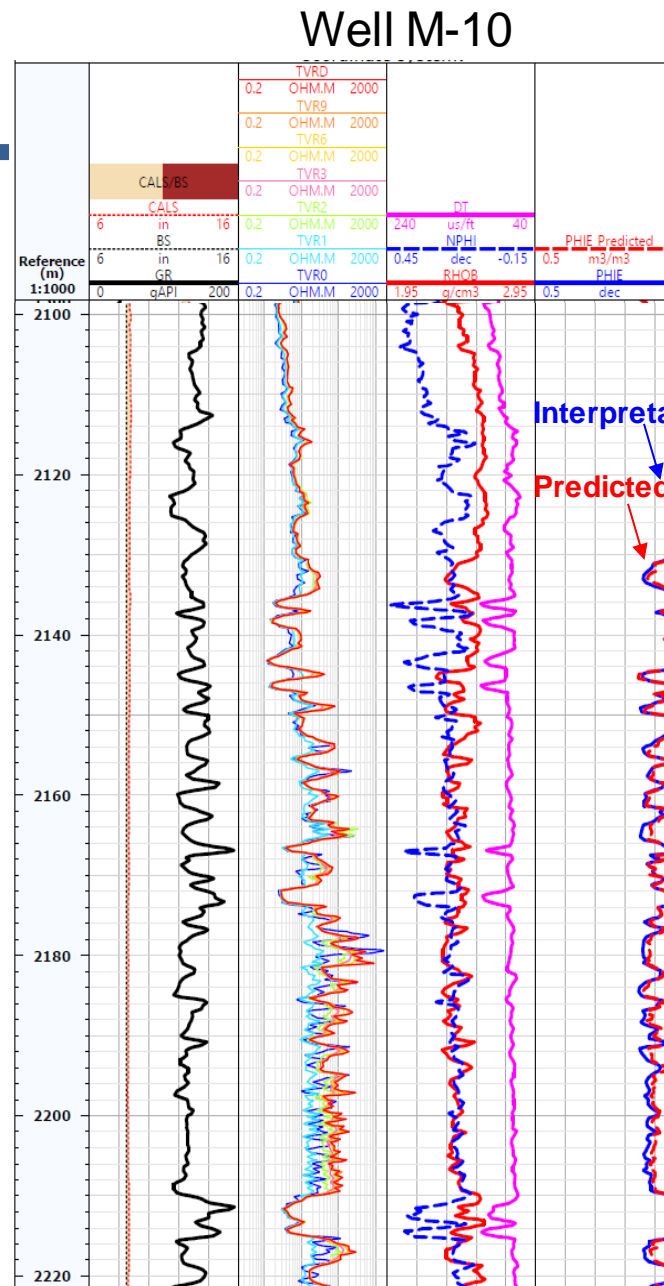
Decision Tree

- Machine Learning Module in Petrel
- Case Study
 - Porosity curve prediction
 - Shear wave curve prediction
 - porosity cube prediction



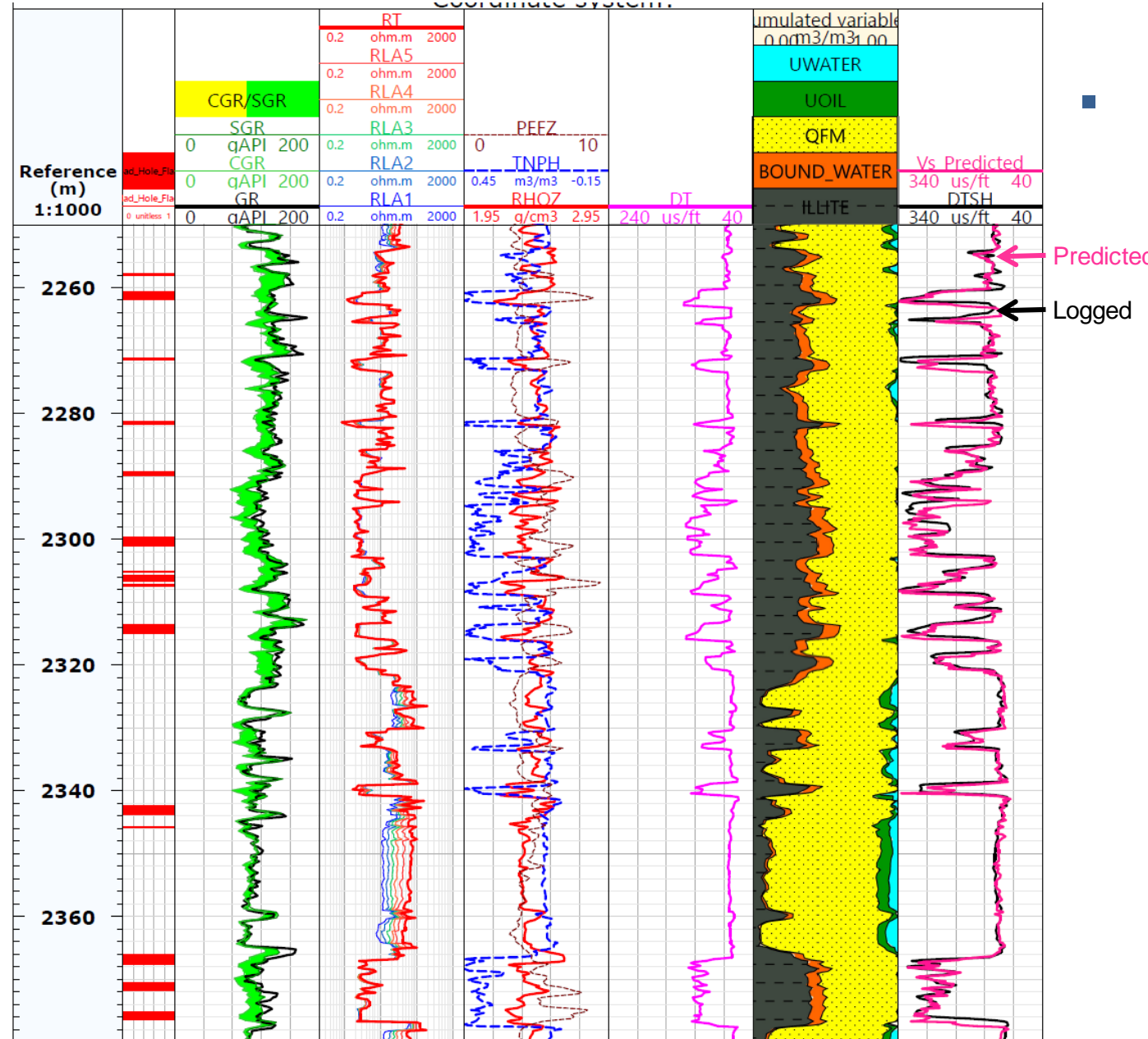
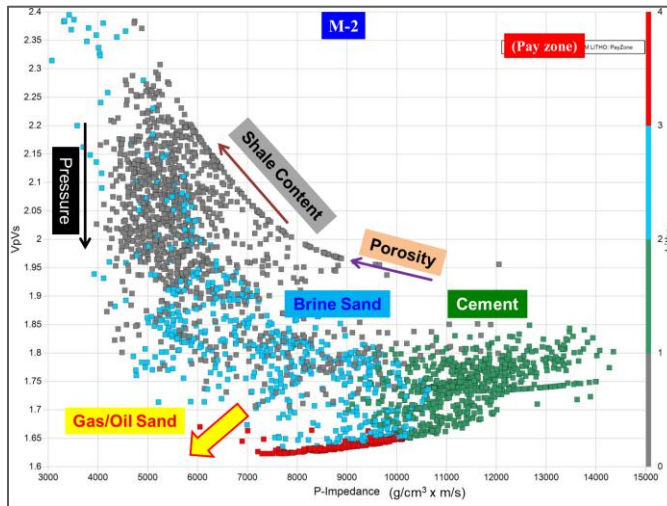
Porosity Log prediction

- Conventional logging curves of 8 wells are used for training
 - Gamma Ray (GR), Deep Resistivity (RT), Medium Resistivity (RLA3), Invaded Formation Resistivity (RXOZ), Density (RHOZ), Neutron (TNPH), Sonic (DT), photoelectric effect (PEFZ)
- Target: Effective Porosity (PHIE)
- Results curves are mostly consistent with manual interpretation



Shear wave prediction

- Conventional logging curves are used for training
 - Gamma Ray (GR), Deep Resistivity (RT), Density (RHOZ), Neutron (TNPH), Sonic (DT)
- Target: Shear Slowness (DTSH)
- The predicted curve matches well with actual logged curve.
- discrimination of reservoir fluid



Porosity Cube prediction

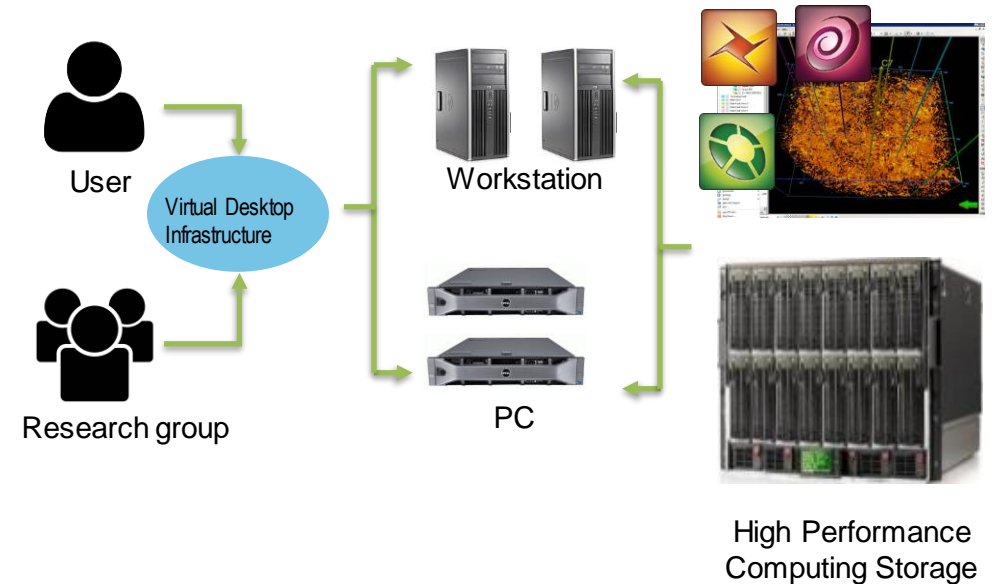
- Training model:
- Prediction:
 - Input: P-impedance, Density and Vp/Vs cube.
 - Output: Porosity Cube
- Result
 - Match well with actual logging curve



Data integration & collaboration

Challenges:

- Data storage in PC or external disk
- Time-consuming for data searching, preparation and transfer.
- Human errors in data import (CRS, datum, units)
- Duplicated Data
- Research result display (color bar, template, well-section, workflow)



Workflow

- Data index, search, access
- Data share, collaboration
- Data filtering and management
- Resource evaluation workflow, reservoir simulation workflow
- Play Chance Mapping

Background

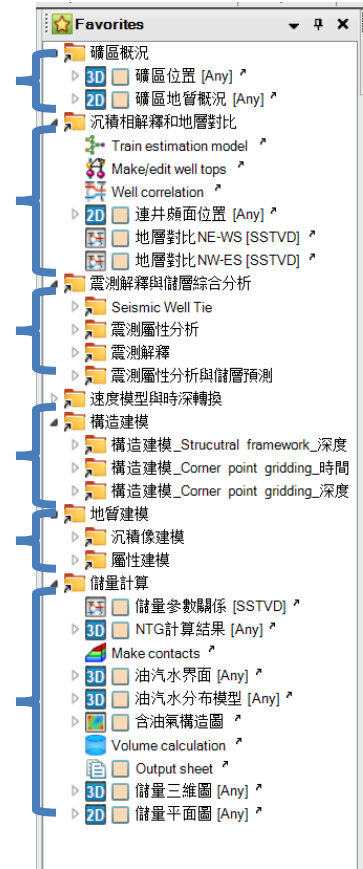
Sedimentary Facies; well correlation

Seismic Interpretation; seismic well tie; Attribute analysis

Velocity Model; Structural geological models

Face model; Property models

Volume calculation; Reports & Graphs



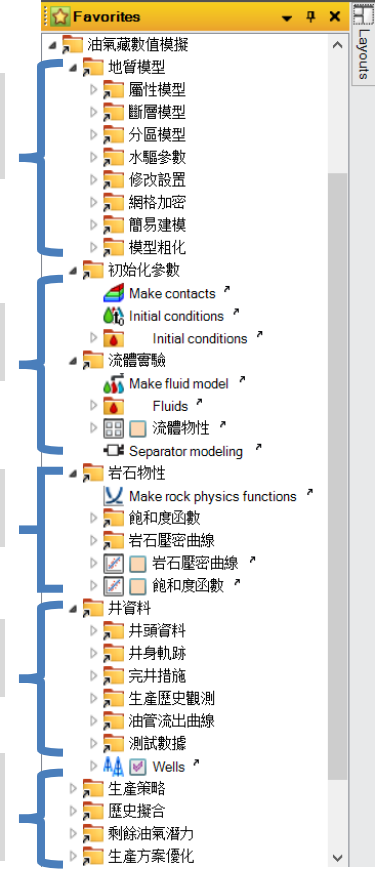
geological models: Property models, fault analysis, water drive, water drive parameters, grid

Fluid Properties, fluid model, initial conditions

Rock physic functions, relative permeability, capillary pressure

Well head; Well path; Completion design; observed data, VFP

Development strategy & simulation, History matching, Uncertainty and Optimization



Concluding Remark

- The sedimentary facies and reservoir characterization was analyzed by core-Log lithofacies integrating.
- The resource evaluation and field development plan were completed based on the geological model from deterministic inversion.
- Case study of QL Machine Learning suggested the predicted porosity and shear wave match well with manual interpretation and actual log data, respectively.
- The Petrel E&P platform and Studio improved efficiency in data management and collaboration among researchers.



Thank you for listening

