

Integrated Seismic & Well log interpretation for reservoir characterization

Course: Reservoir Geophysics & Deep Water Imaging(GPD-510)

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Objective

- Perform interpretation of well log & seismic data
- Estimate petrophysical & geomechanical properties from the well log data
- Identify probable reservoir sections from well log data
- Development of sedimentary model based on understanding of interpretation & demonstrate it through proper sketching
- Uncertainty analysis
- References

Preliminary Inventory of Available Well & Seismic Data

3D Seismic Data: Time Domain

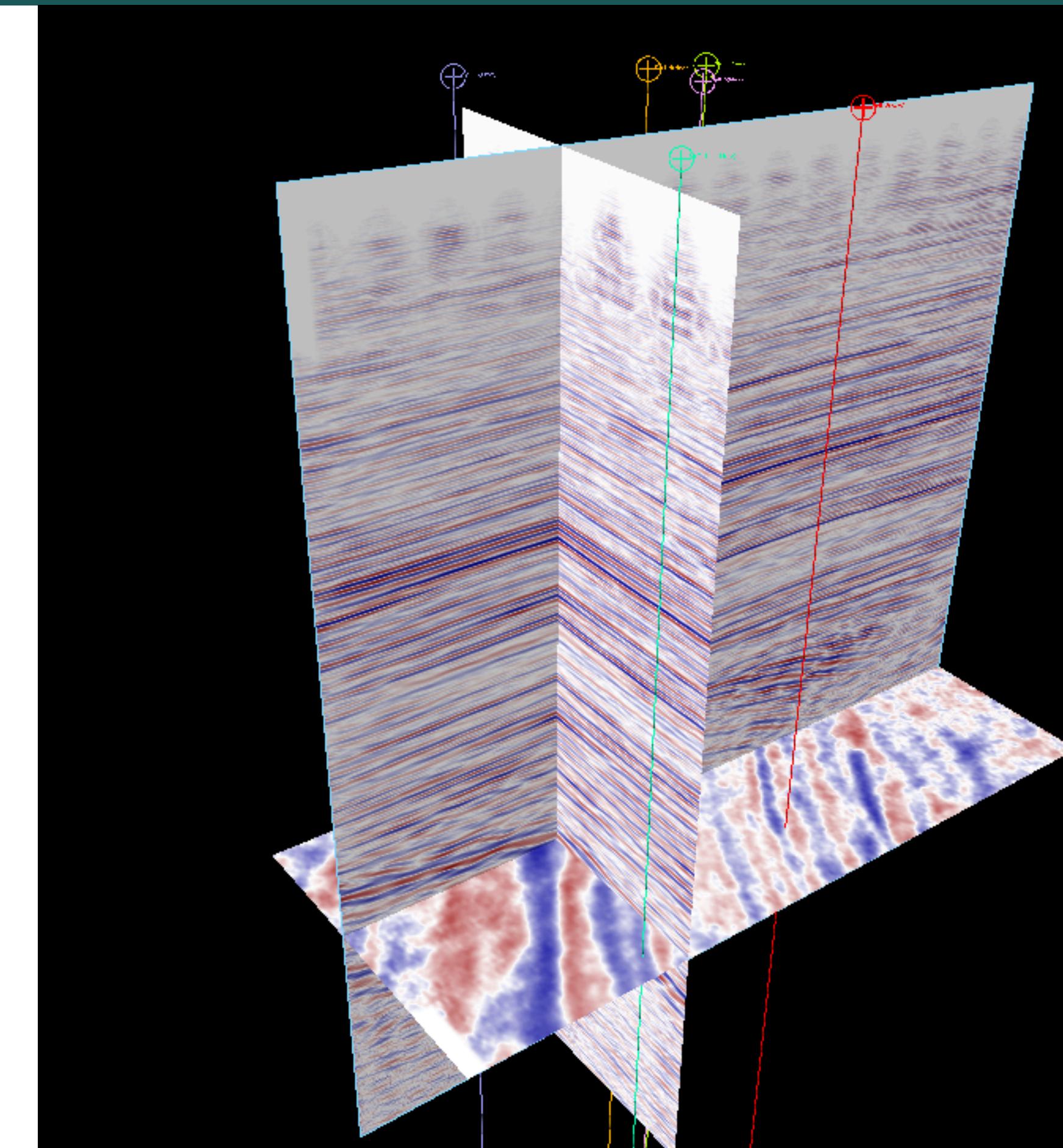
Check Shot Data

Inline No: 2 -102

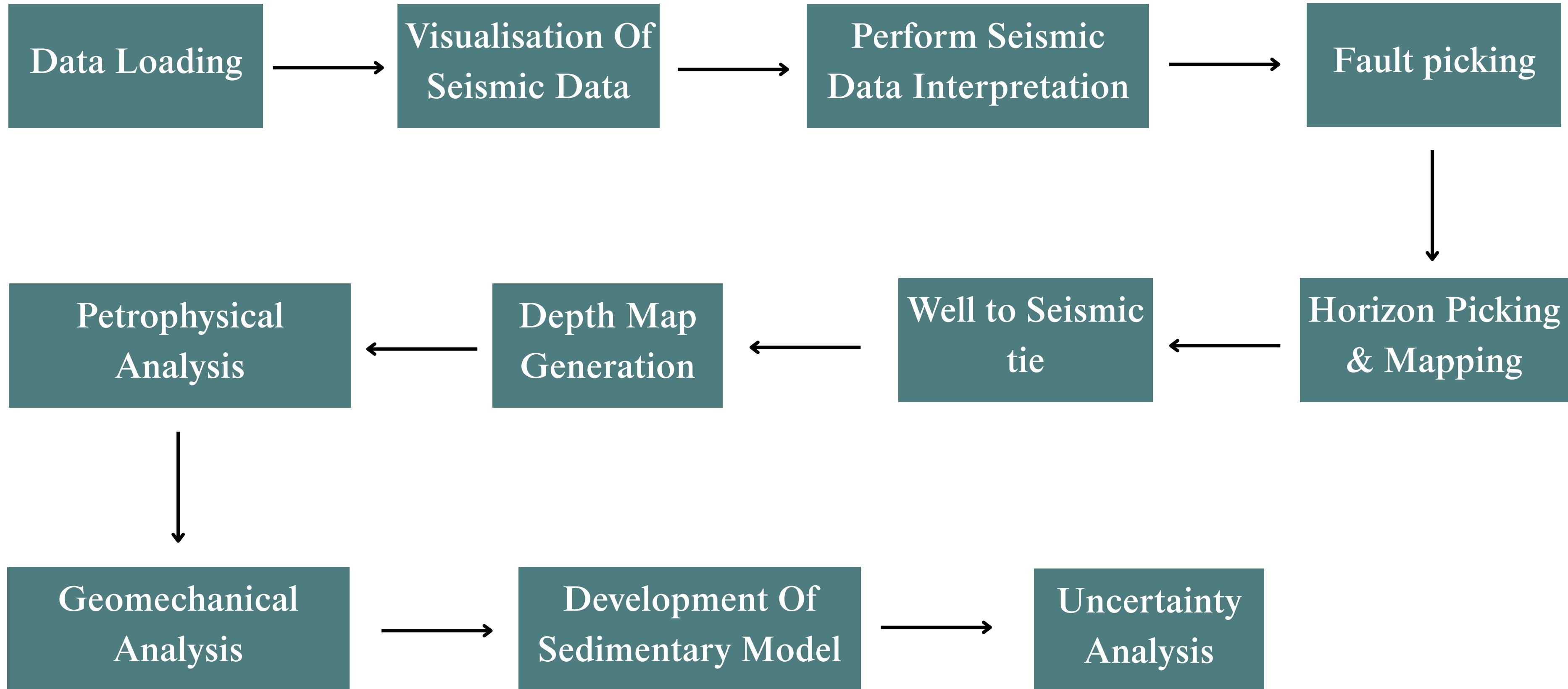
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Available Wells: 06

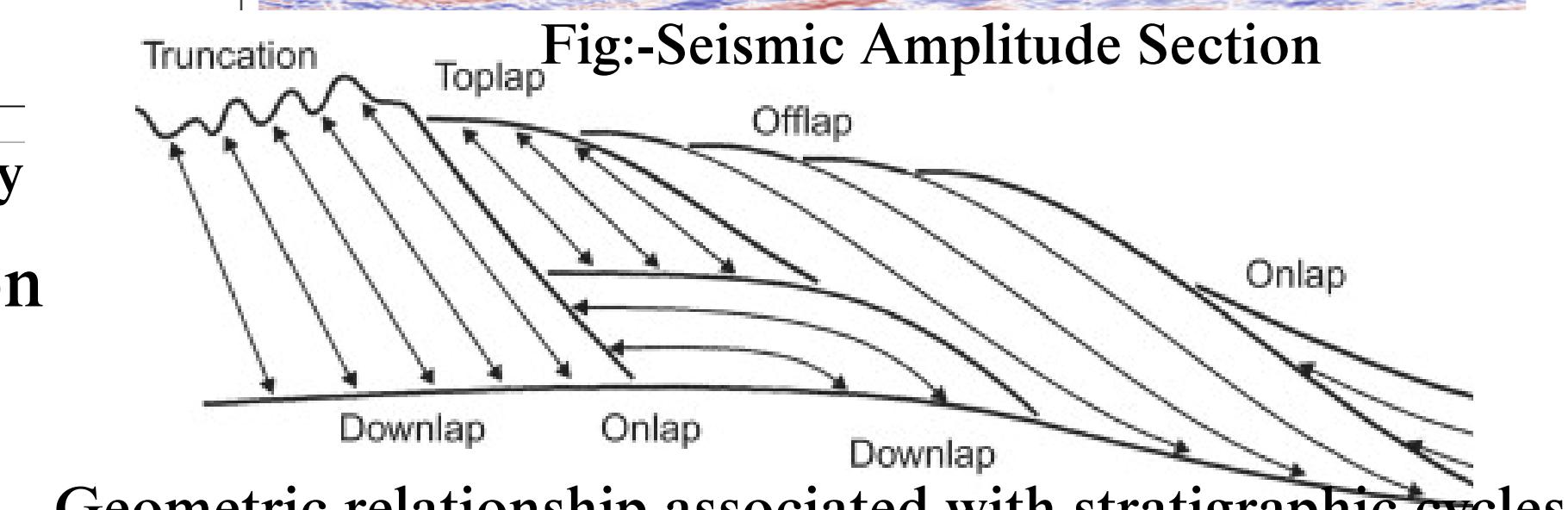
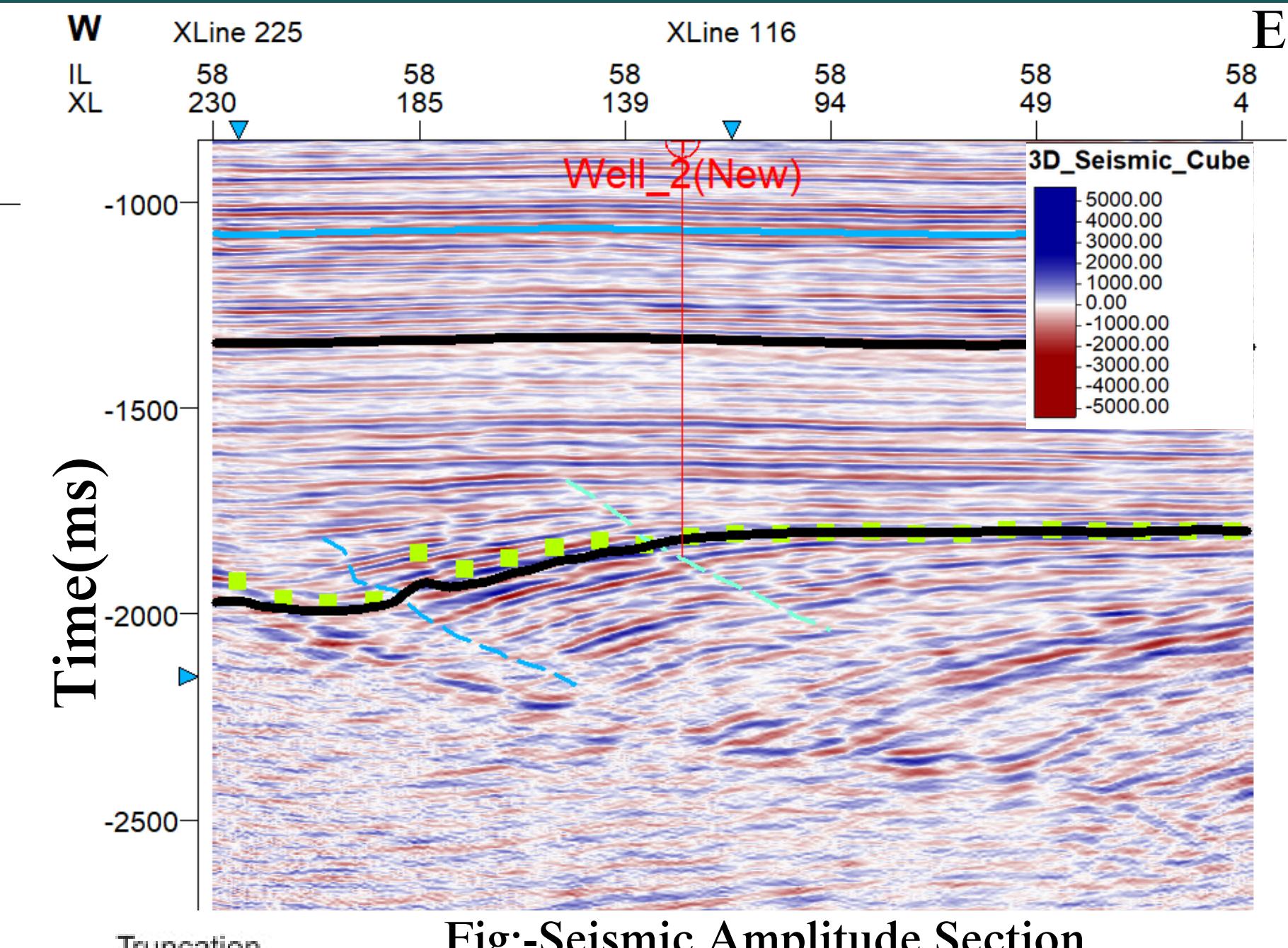
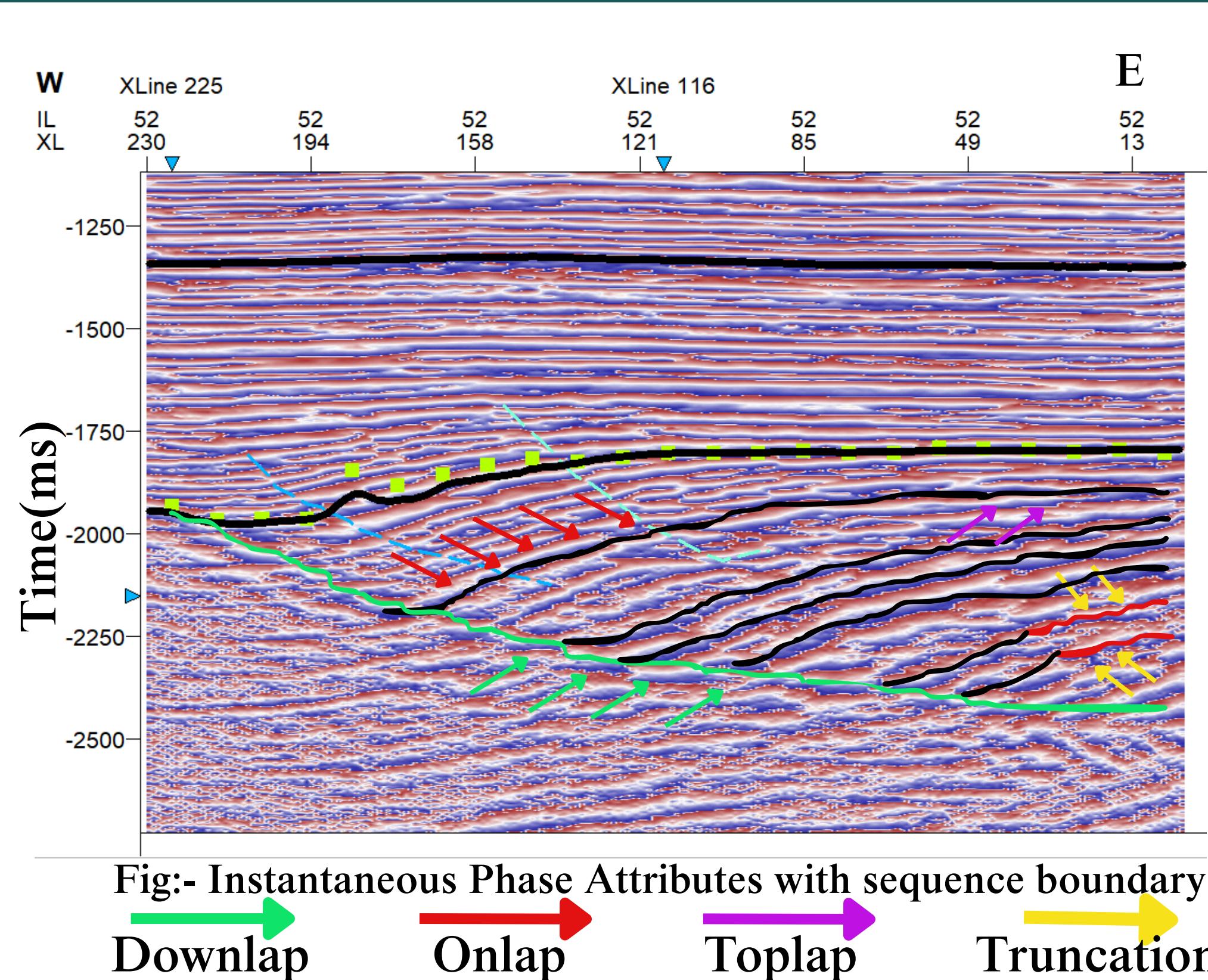
Available Well logs: Sp (Self Potential),
SN(Shallow Resistivity), LN(Deep
Resistivity), GR log(Well 6)



Methodology



Seismic Data Interpretation



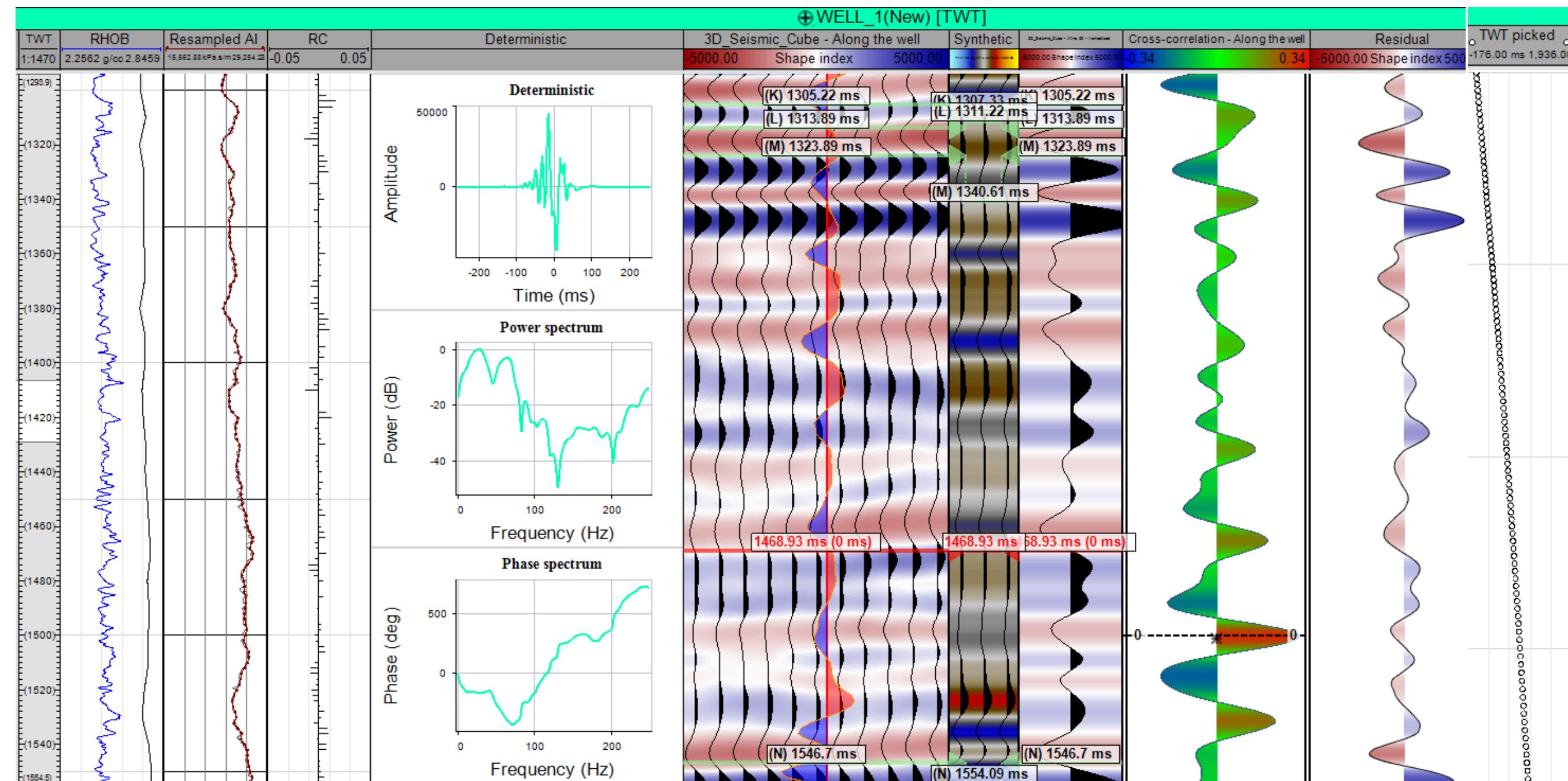
Geometric relationship associated with stratigraphic cycles

Well to Seismic tie

Wavelet: Deterministic in nature
extracted from the seismic data
in well location

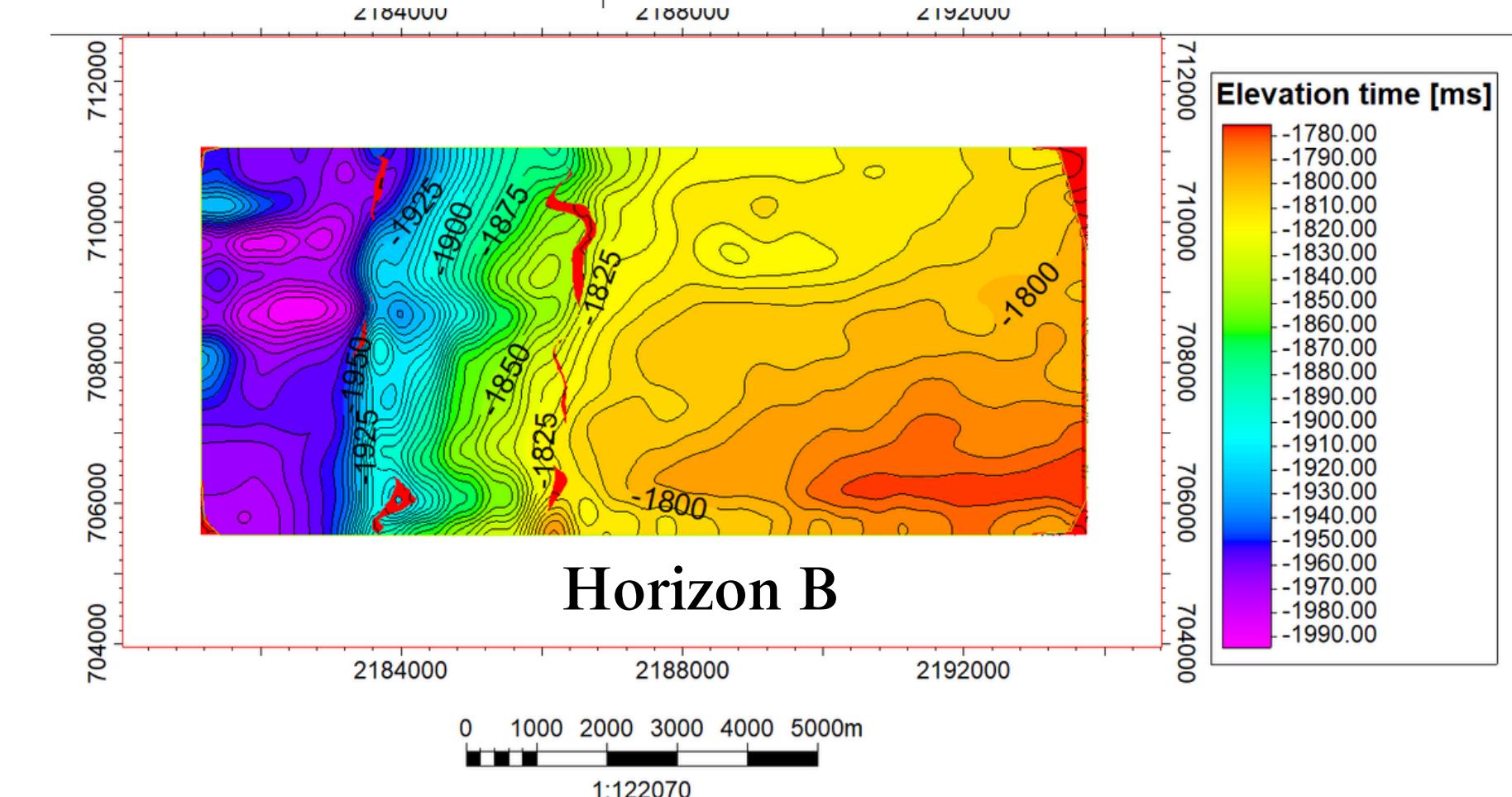
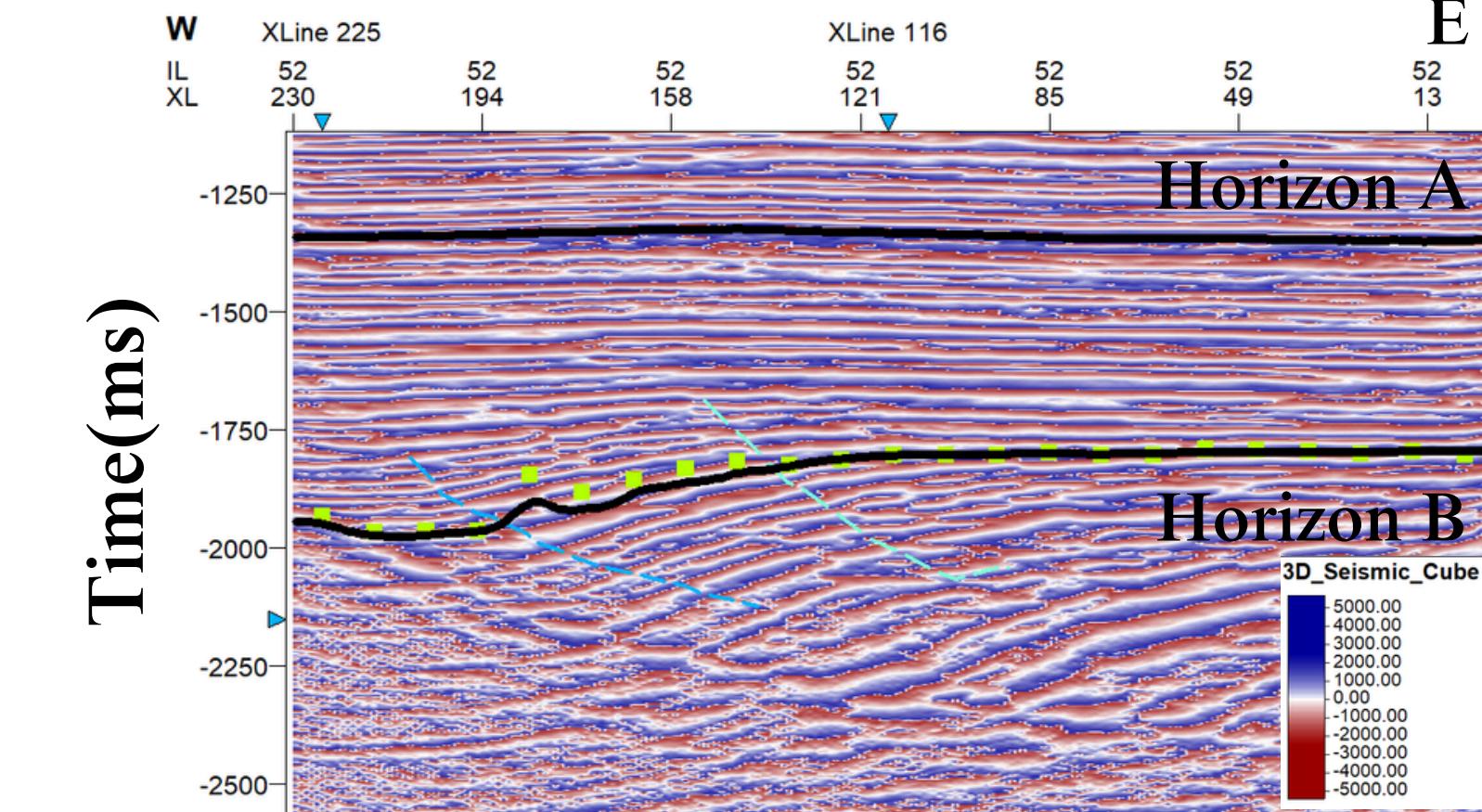
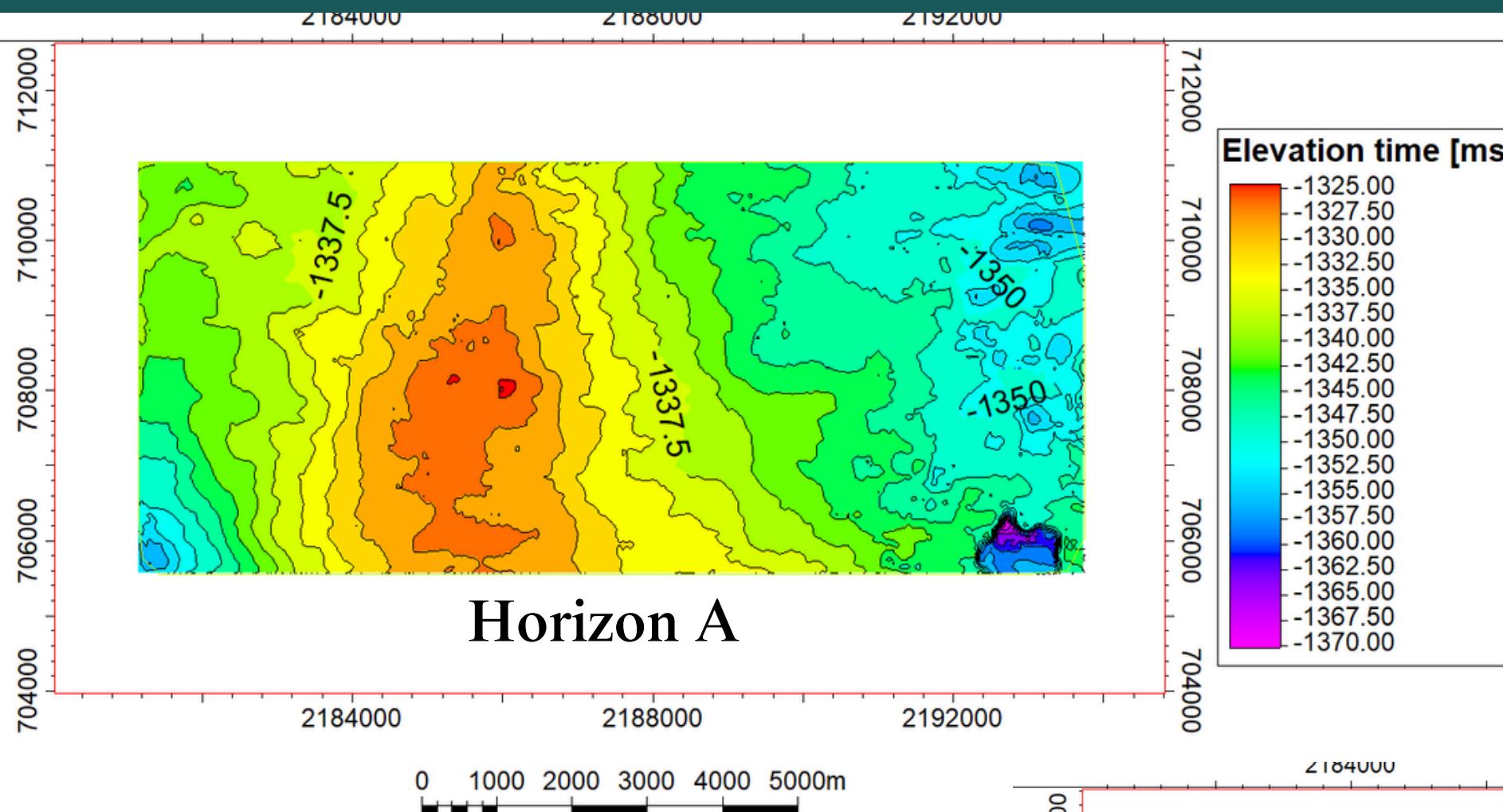
Correlation value: 0.34

Bulk Shift: 3.3 ms

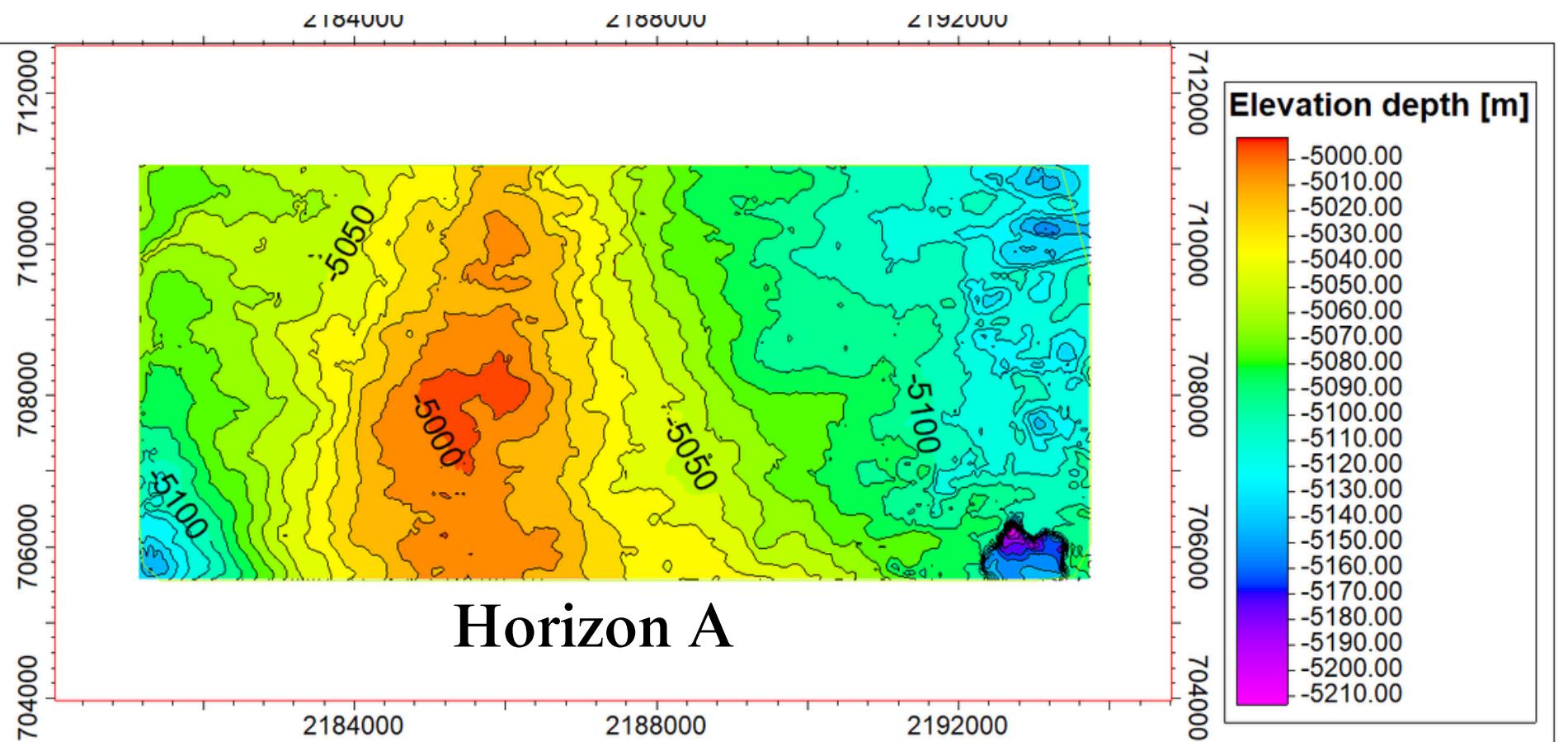


Well to Seismic tie in Well 1

Horizon Picking & Time Contour Mapping



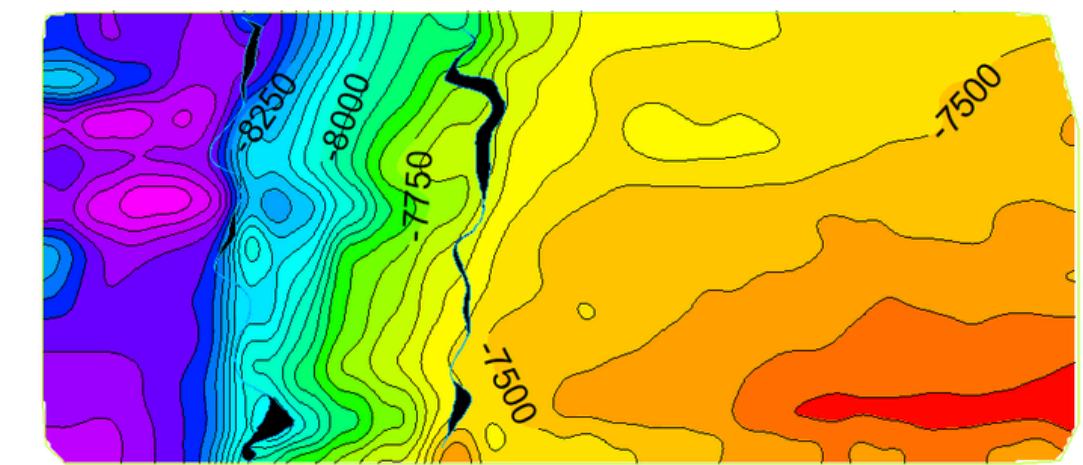
Depth Map Generation



Horizon A

0 1000 2000 3000 4000 5000m
1:122070

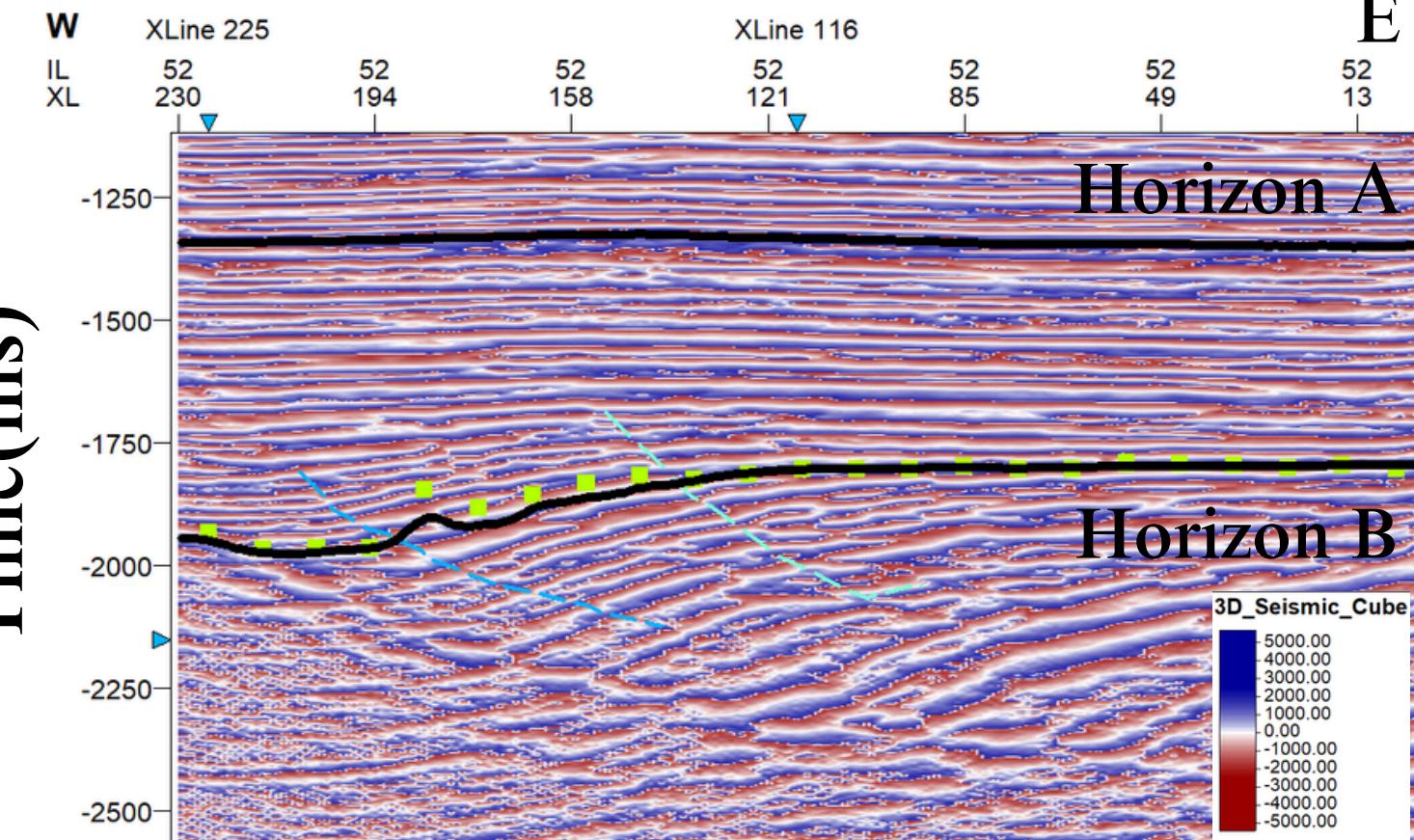
2184000 2188000 2192000



Horizon B

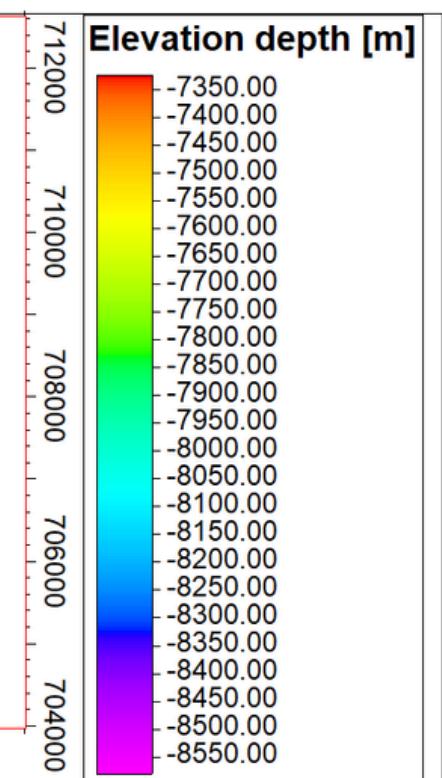
0 1000 2000 3000 4000 5000m
1:122070

Time(ms)



Horizon A

Horizon B



E

Petrophysical Property Analysis

EQUATIONS USED

$$\text{Porosity } (\phi) = \frac{\text{matrix density}(\rho_{mat}) - \text{bulk density}(\rho_b)}{\text{bulk density}(\rho_b) - \text{fluid density}(\rho_f)}$$

Faust Equation

$$\text{P wave velocity } (V_p) = 657.07 \times (\text{true resistivity} \times \text{depth})^{1/6}$$

$$\text{Bulk density } (\rho_b) = 0.31 \times (V_p)^{1/4}$$



Gardner Equation

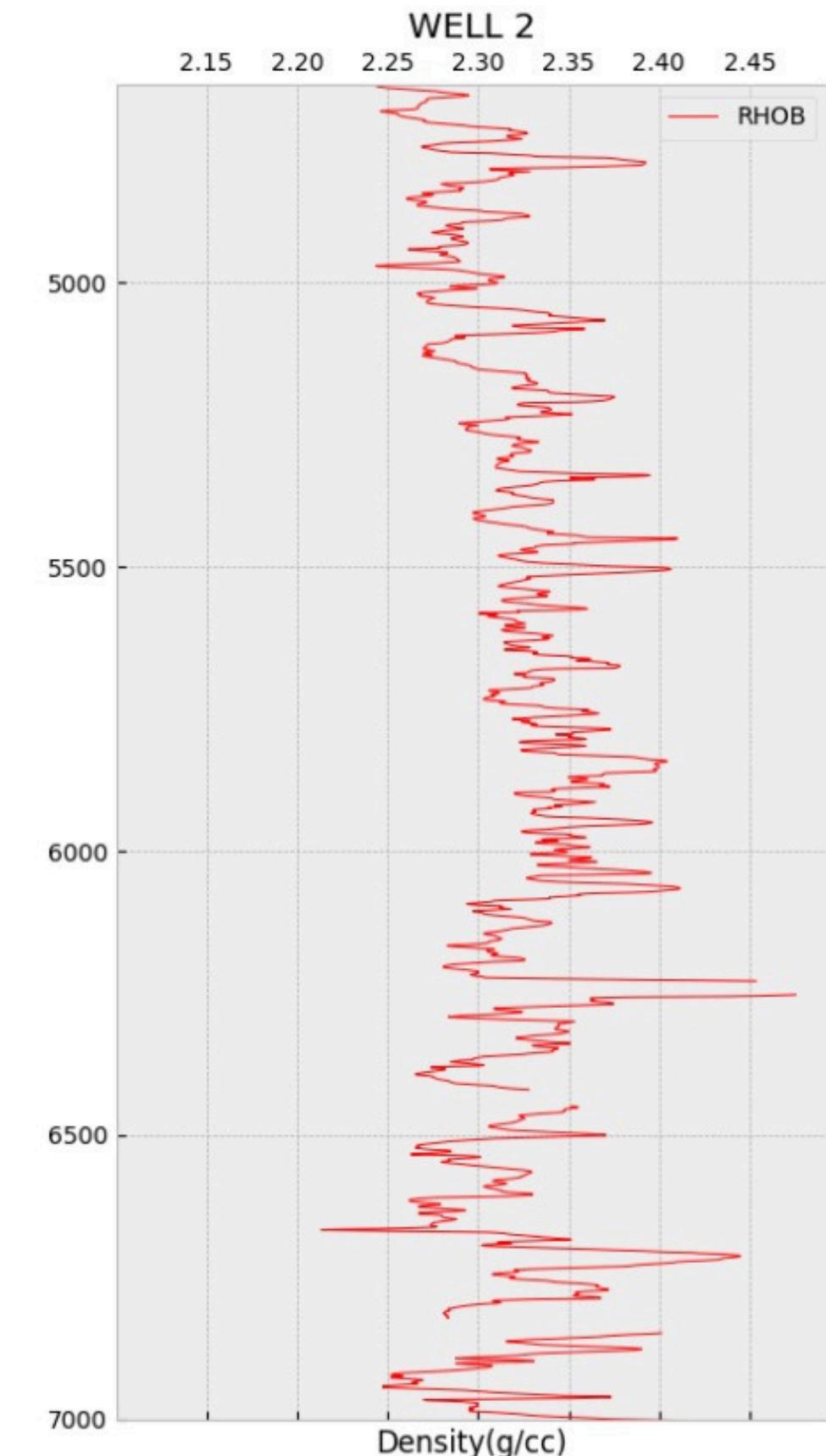
$$\text{Water Saturation } (S_w)^2 = \left(\frac{a * R_t}{\phi^m * R_w} \right)$$



Archie's Equation

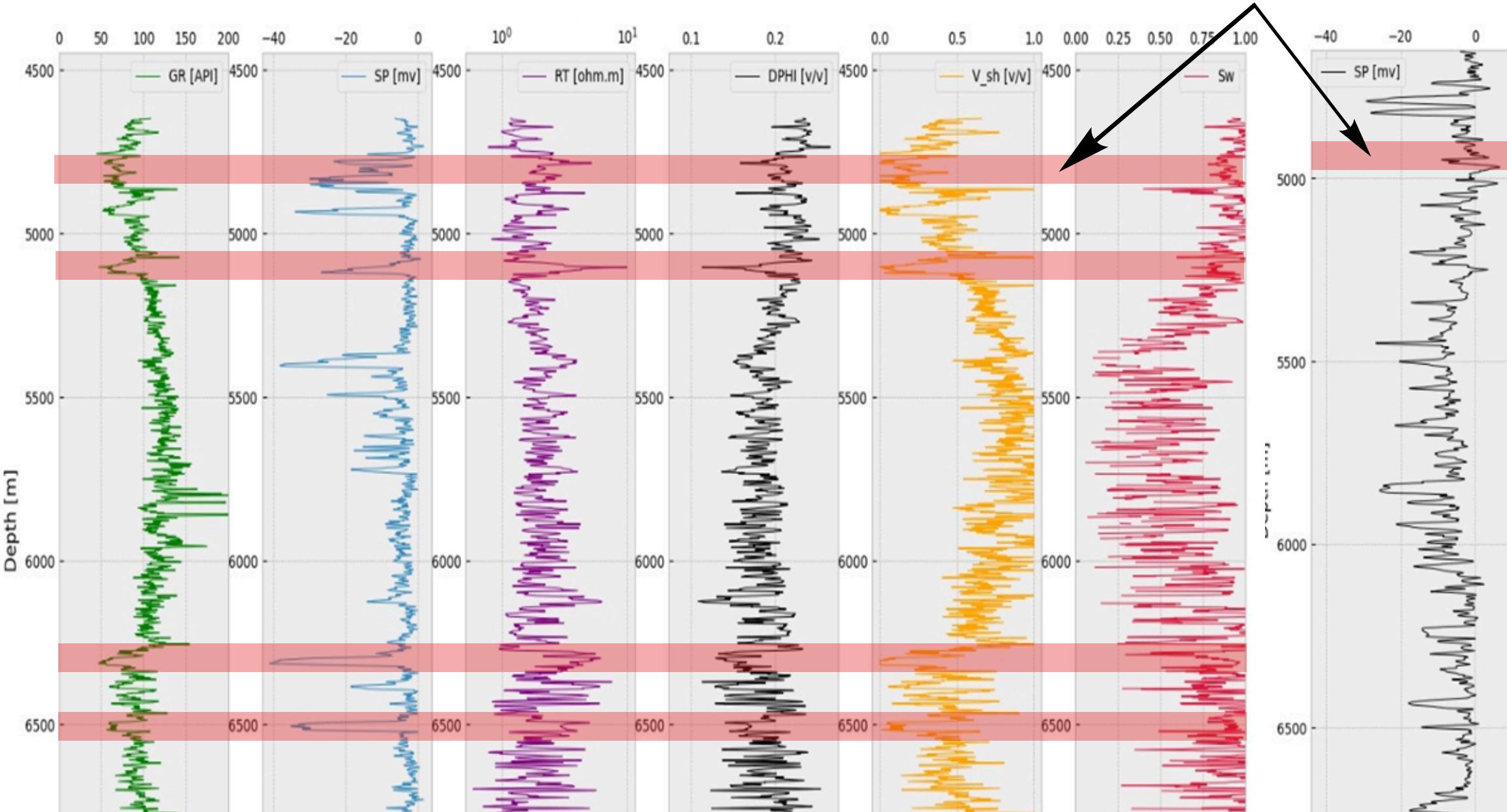
$$\text{Shale volume } (V_{sh}) = \left(\frac{GR - GR_{min}}{GR_{max} - GR_{min}} \right)$$

$$\text{Shale volume } (V_{sh}) = \left(\frac{SP - SP_{sh}}{SP_{cs} - SP_{sh}} \right) = \left(1 - \frac{PSP}{SSP} \right)$$



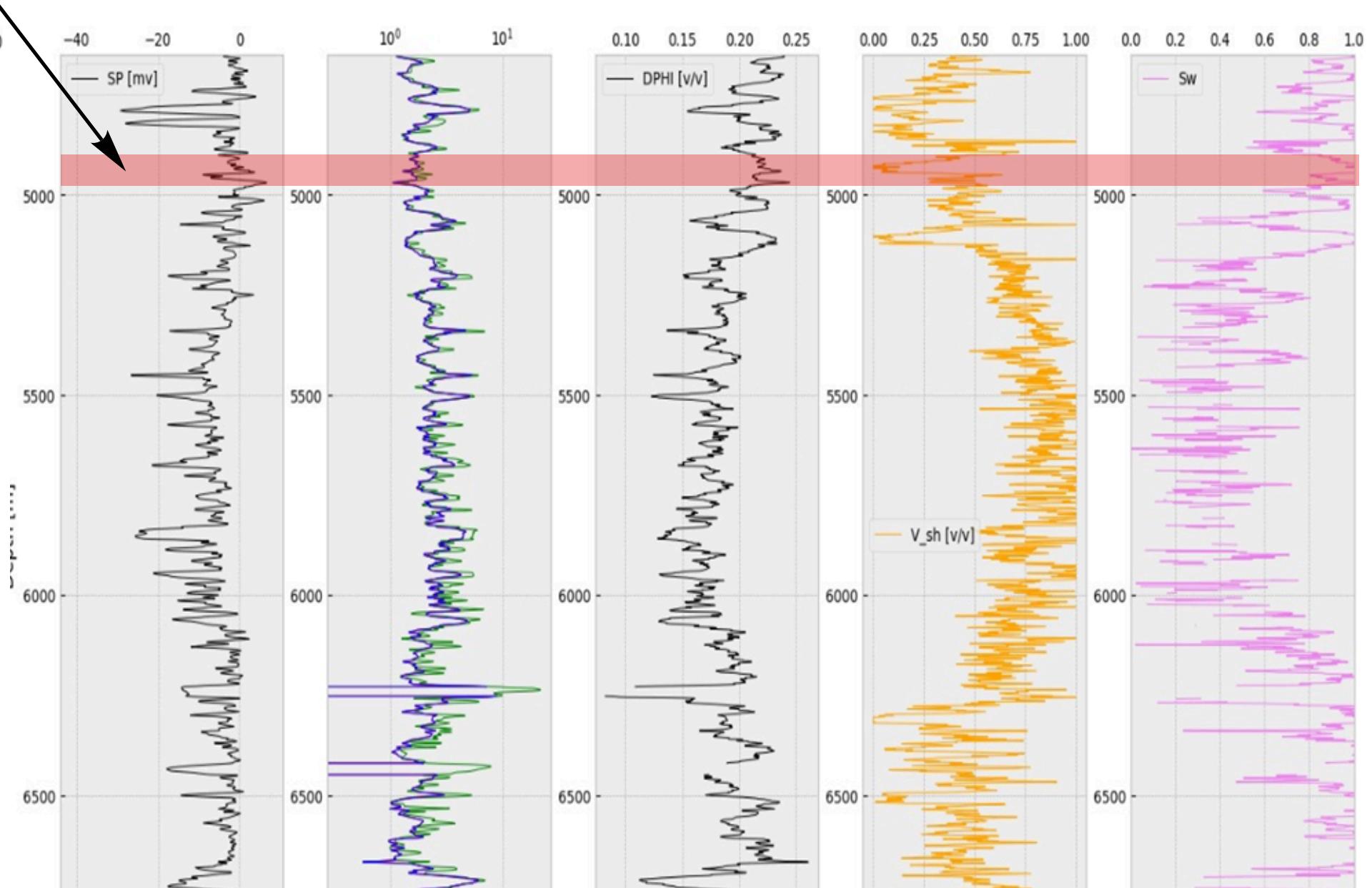
Petrophysical Property and Reservoir Zone Detection

Well 6



Reservoir Zone

Well 2



Geomechanical Property Analysis

EQUATIONS USED

$$P_p^{\text{hyd}}(z) = \int_0^z \rho_w(z) g dz \approx \bar{\rho}_w g z_w$$

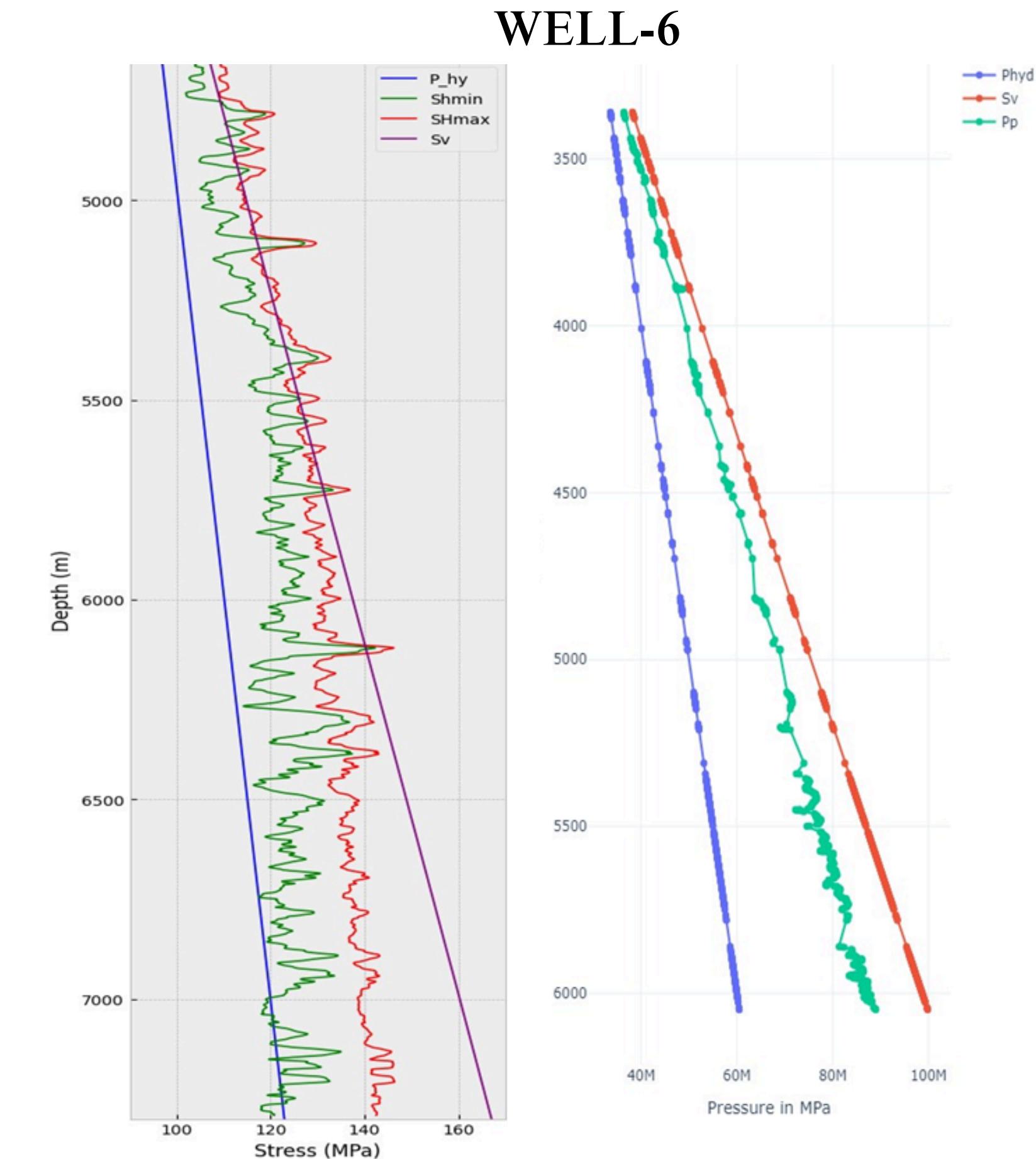
$$S_v = \int \rho(z) \cdot g \cdot d(z)$$

$$P_p = S_v - (S_v - P_n) \cdot \frac{\ln \Phi_0 - \ln \Phi}{\beta z}$$

$$S_{h\min} = 0.32 \cdot (S_v - P_p) + P_p$$

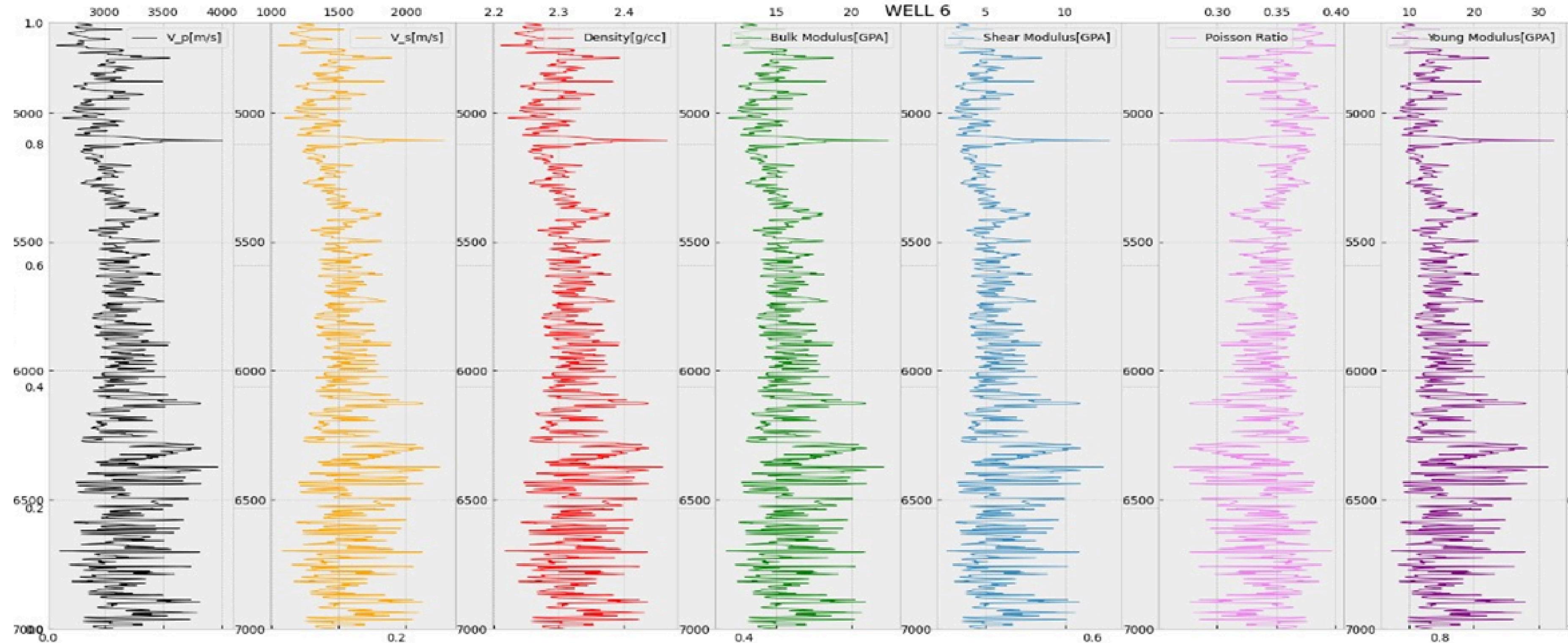
$$SH_{\max} = \left(\frac{\nu}{1-\nu} \right) S_v - \left(\frac{\nu}{1-\nu} \cdot a + a \right) \cdot P_p$$

$$\nu = \frac{\frac{1}{2} (\nu_p / \nu_s)^2 - 1}{(\nu_p / \nu_s)^2 - 1}$$



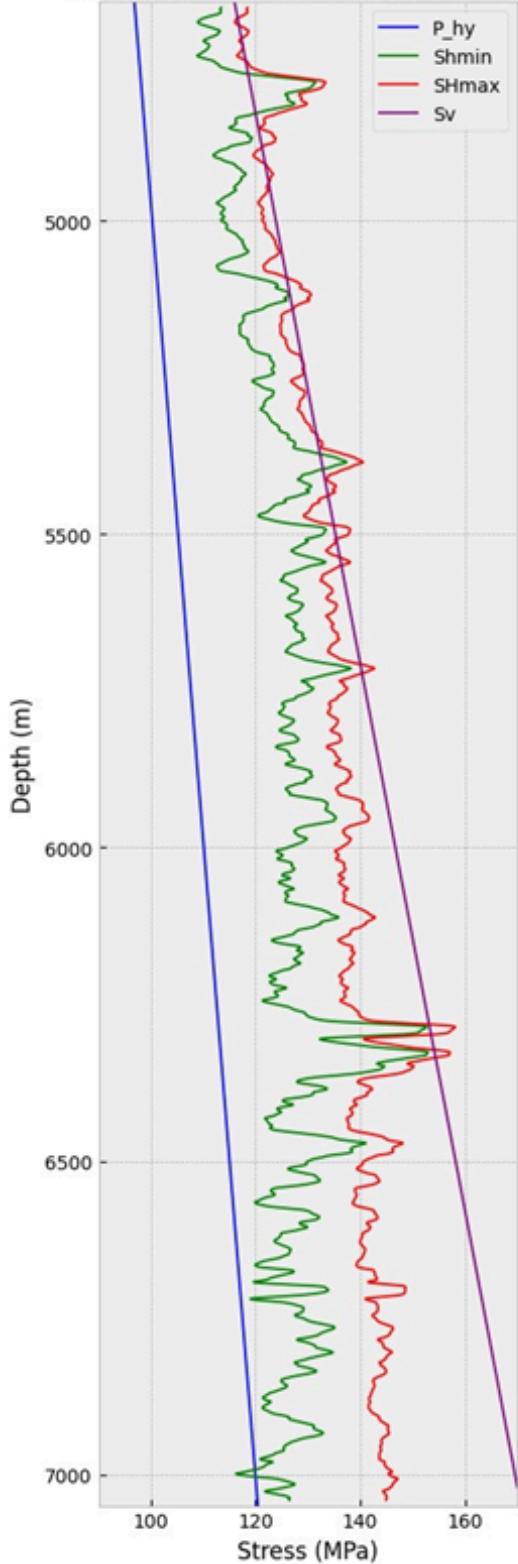
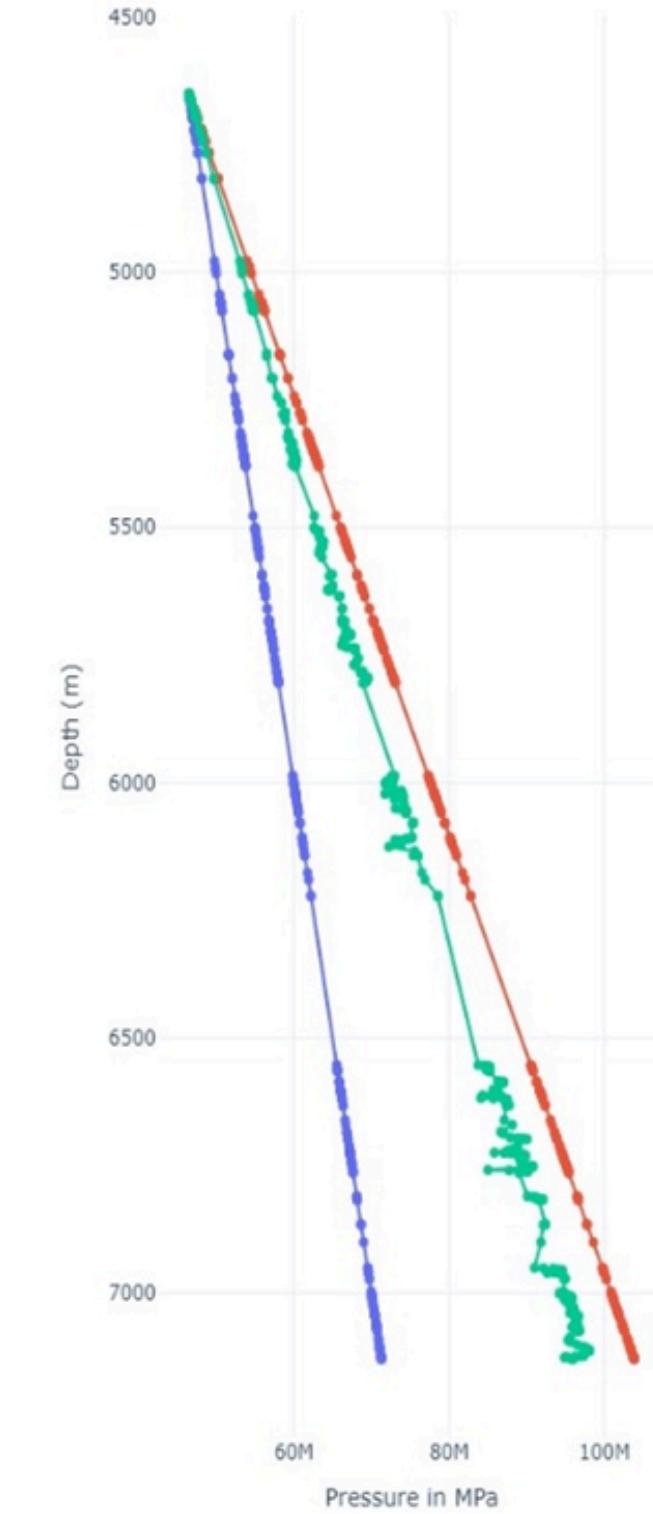
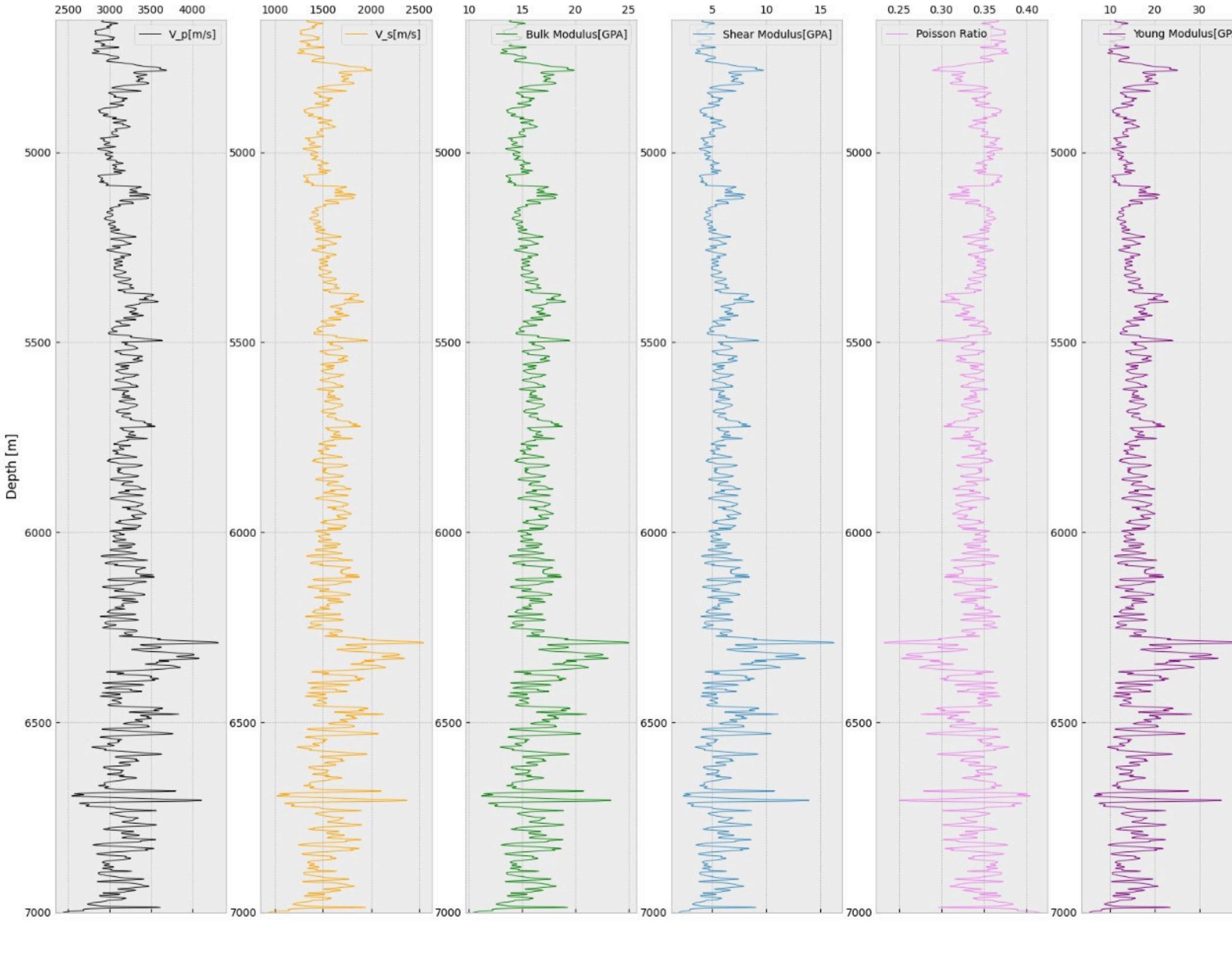
Geomechanical Property Analysis

Well 6



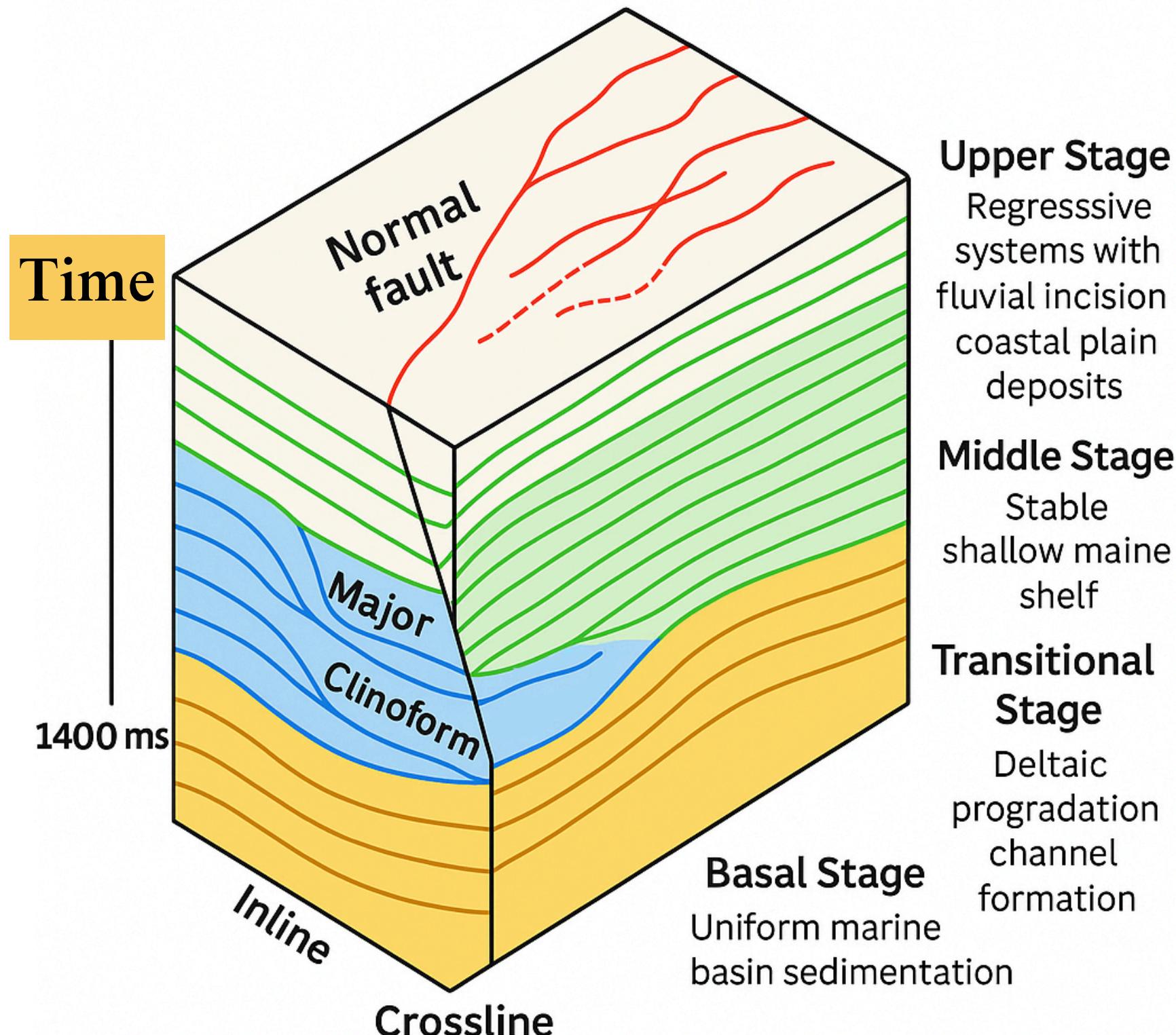
Geomechanical Property Analysis

WELL-2



Development Of Sedimentary Model

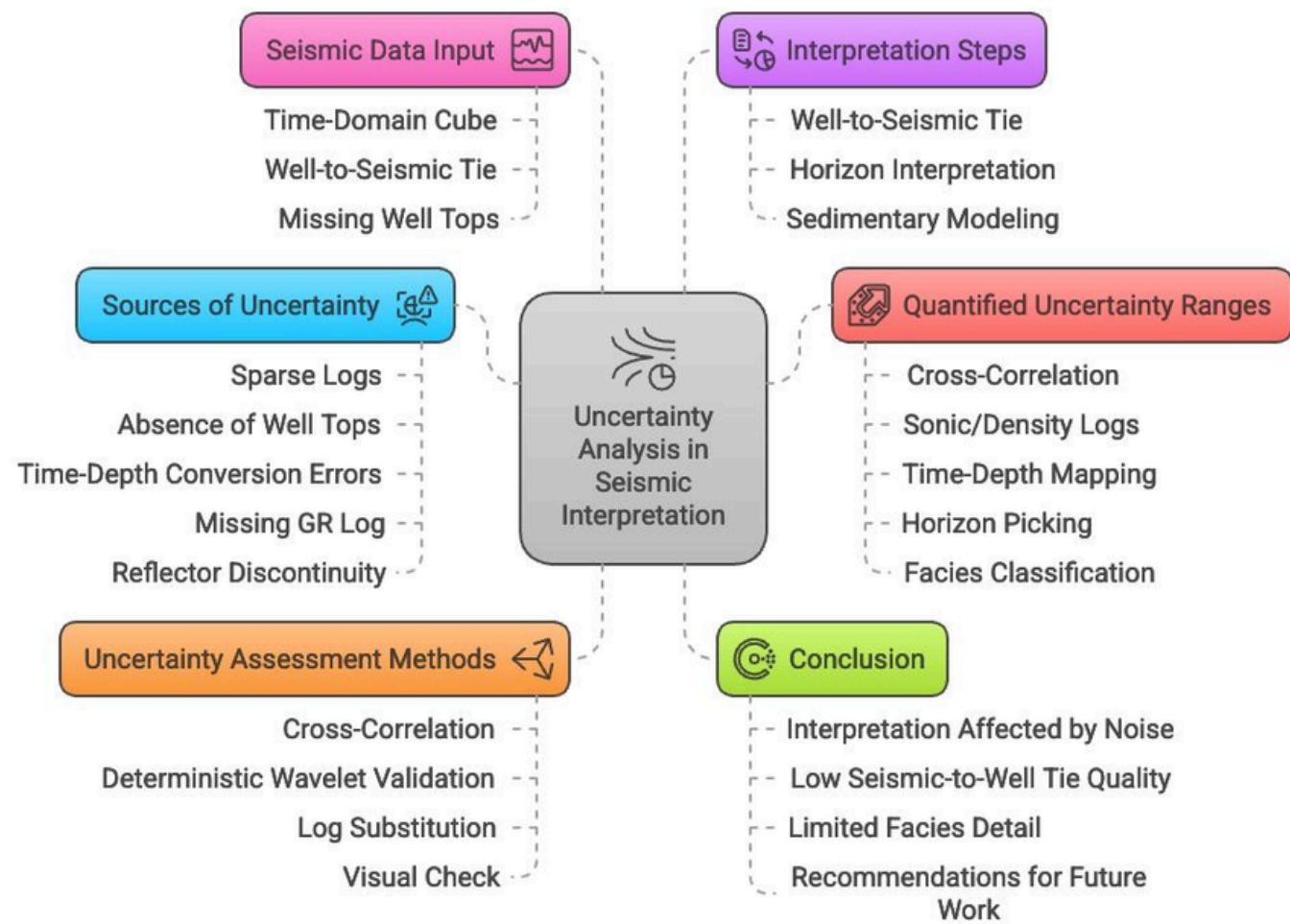
Sedimentary Model



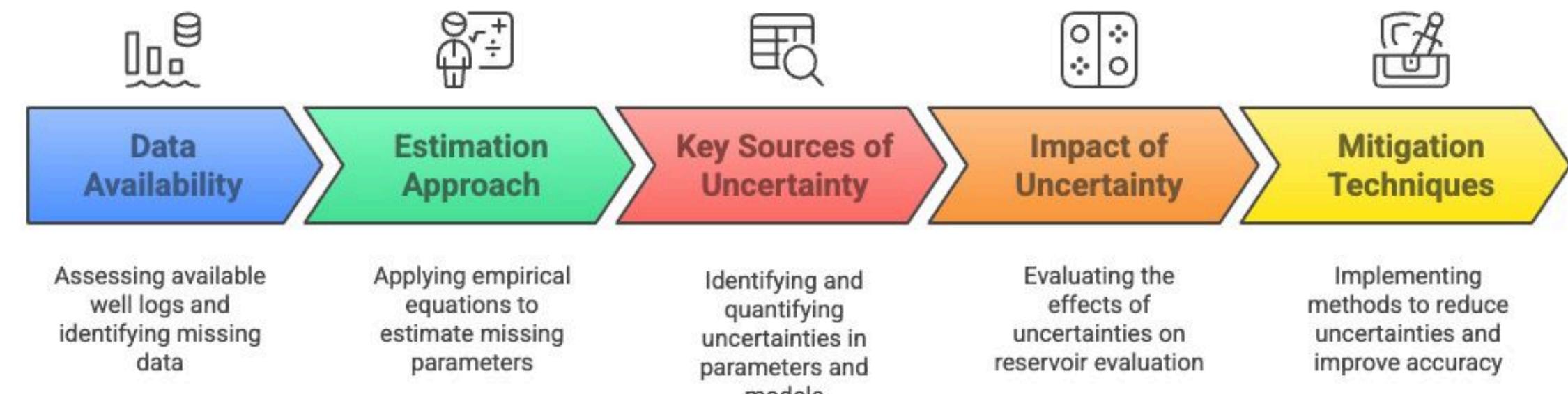
- **Upper Sequence (0–600 ms)**: Parallel, continuous reflectors indicate stable shelf deposition with minimal tectonic disturbance.
- **Middle Sequence (600–1000 ms)**: Variable reflections and clinoforms suggest deltaic or shoreline progradation in a transitional environment.
- **Lower Sequence (1000–1400 ms)**: Discontinuous, high-amplitude reflectors with channel features and erosional surfaces point to dynamic deposition and significant lithological boundaries.

Uncertainty Analysis

Uncertainty Analysis in Seismic Interpretation



Uncertainty Analysis Workflow for Petrophysical Data



References

1. Seismic Data Interpretation and Evaluation for Hydrocarbon Exploration and Production by N.C.Nanda
2. Sedimentary model for mixed depositional systems along the Pacific margin of the Antarctic Peninsula: Decoding the interplay of deep-water processes
3. Global Overview of Deep-water Exploration and Production. Paul Weimer and Henry S. Pettingill
4. Petrophysics MSc Course Notes by Paul Grover
5. Reservoir Geophysics & Deep Water Imaging Class Notes provided by Prof. Saurabh Datta Gupta
6. Seismic Hydrocarban Exploration by Hamid N. Alsadi
7. SEG Wikipedia
8. Software used Petrel, Opendtect and Python for code.

Contribution

1. Arpan Pan: Seismic Data Interpretation & Presentation
2. Amrit Krishn: Well to Seismic Tie & Presentation
3. Rohit Banerjee: Seismic Horizon Picking and Mapping & Presentation
4. Raj Sahu: Development Of Sedimentary Model & Presentation
5. Sk Abu Samad, Arijit Chell, Gokul K: Petrophysical and Geomechanical Property Analysis & Presentation
6. Saikat Dey: Uncertainty Analysis & Presentation

THANK YOU