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Reservoir and porosity prediction using statistical rock physics and simultaneous inversion: a case study, onshore Ukraine.

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Contents

Study Background

- **Basin**: Dnieper-Donets (~99,000 km^2).

- **Source**: Visean red bed mudstone and coals.

- **Reservoir**: Lagoonal, fluvio-deltaic sheet sands with some shallow marine sands

- **Seal**: Intra-sand shales.

- **Trap**: Anticline with gently dipping flanks.

- **Field**: The Semyrenky gas field, operated by DTEK.

- **Production**: at 5,500 m, encountering very high pressures (3,475.6 psia) and temperatures (128º C).
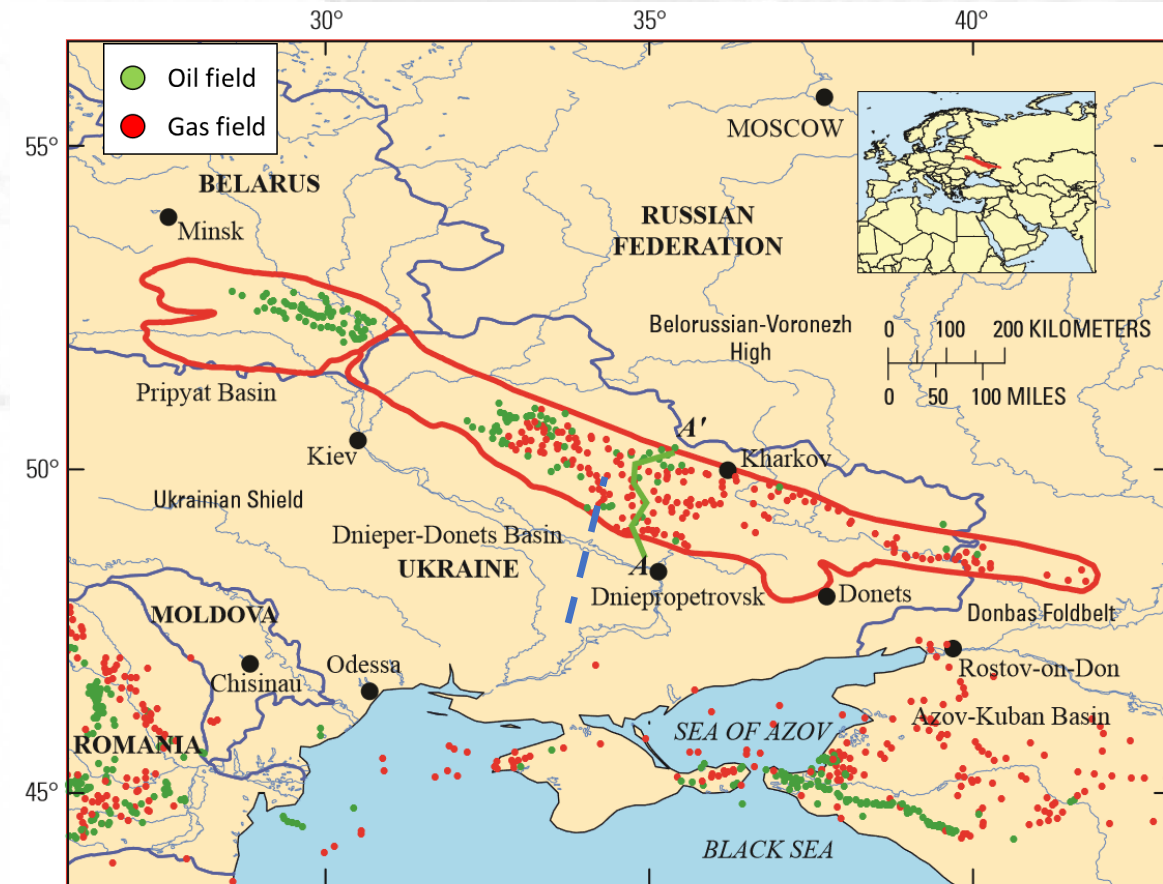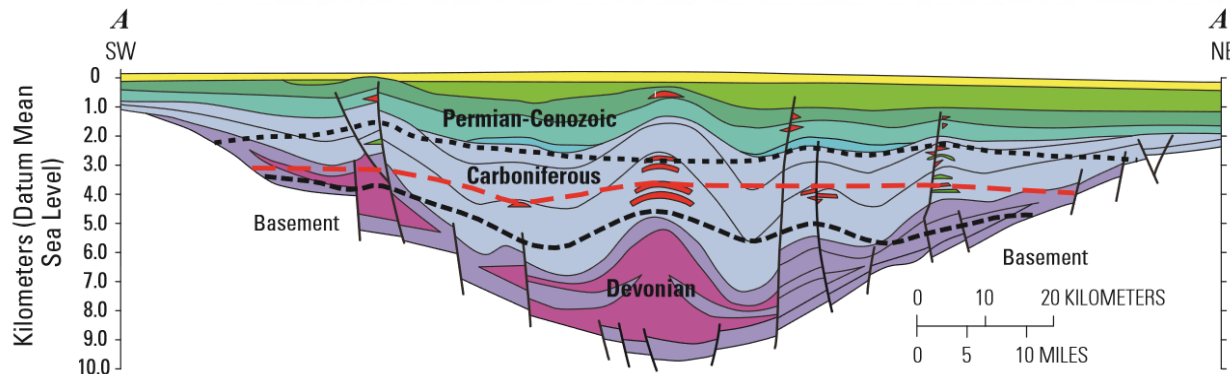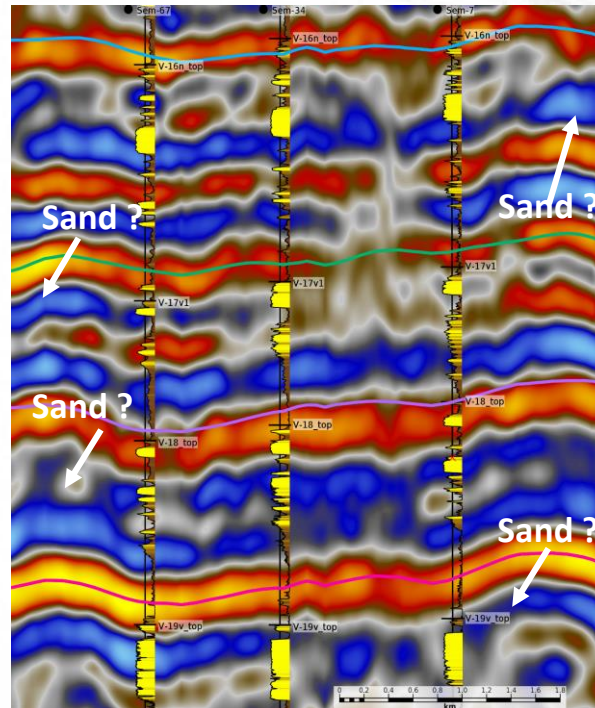
Field Development Challenges
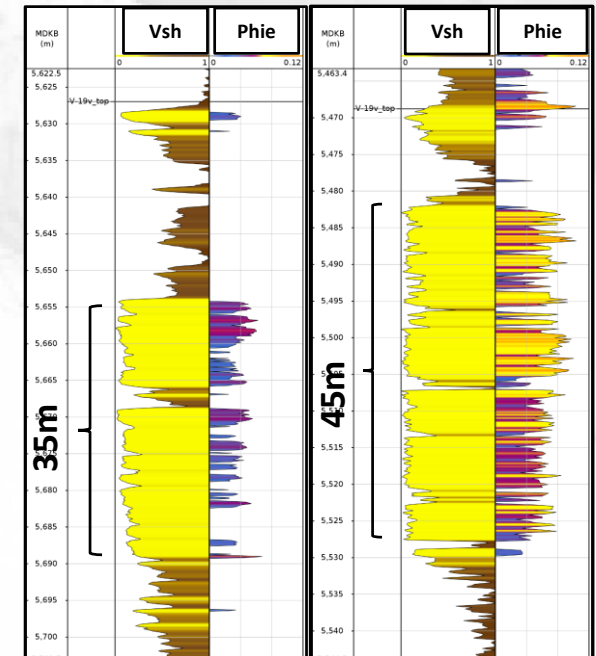

Noisy and discontinuous seismic events
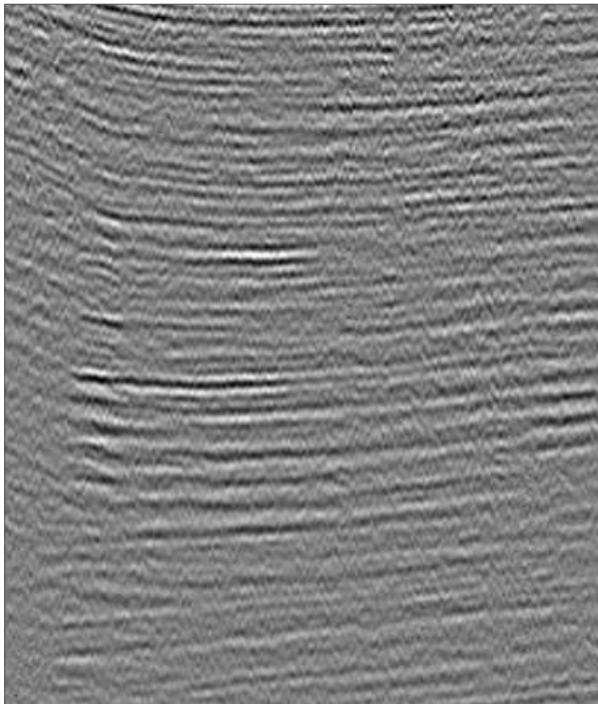
Identifying and mapping sands on seismic

Sand ?

Sand ?

Sand ?

Unpredictable Well Performance

No production

Good production

35m

45m

Solution = Targeted seismic processing + bespoke rock physics model + seismic inversion

Contents

Project QI Workflow

INPUT
Legacy seismic

SEISMIC REPROCESSING
- Remove multiple
- Improve SNR
- Flatten gathers
- Improve resolution

OUTPUT
Final seismic

INPUT
Raw well logs

PETROPHYSICS
- Log editing
- Synthetic log generation
- Invasion correction
- Vclay, Sw, φ

OUTPUT
Final well logs

ROCK PHYSICS
- Statistical rock physics
- Stochastic forward models
- Depth-dependent interpretation criteria

OUTPUT
Rock physics model

GEOLOGICAL PRIOR
- Horizon interpretations

SIMULTANEOUS INVERSION

Seismic angle stacks

Wavelets

LFMs

IP

Rho

Vp/Vs

OUTPUT
Rock property volumes

INTERPRETATION

Probabilistic Bayesian Classification

Lithology Probability
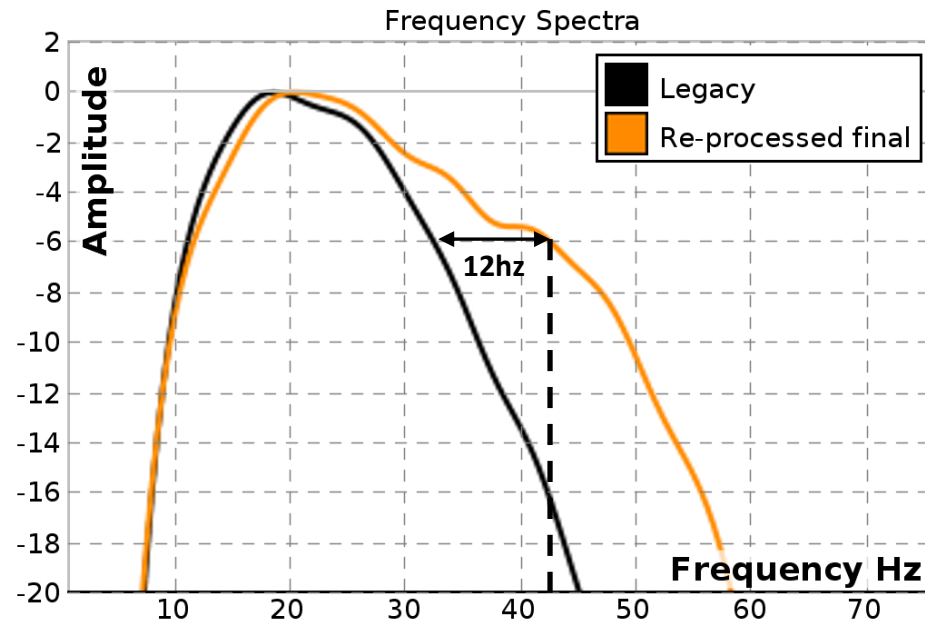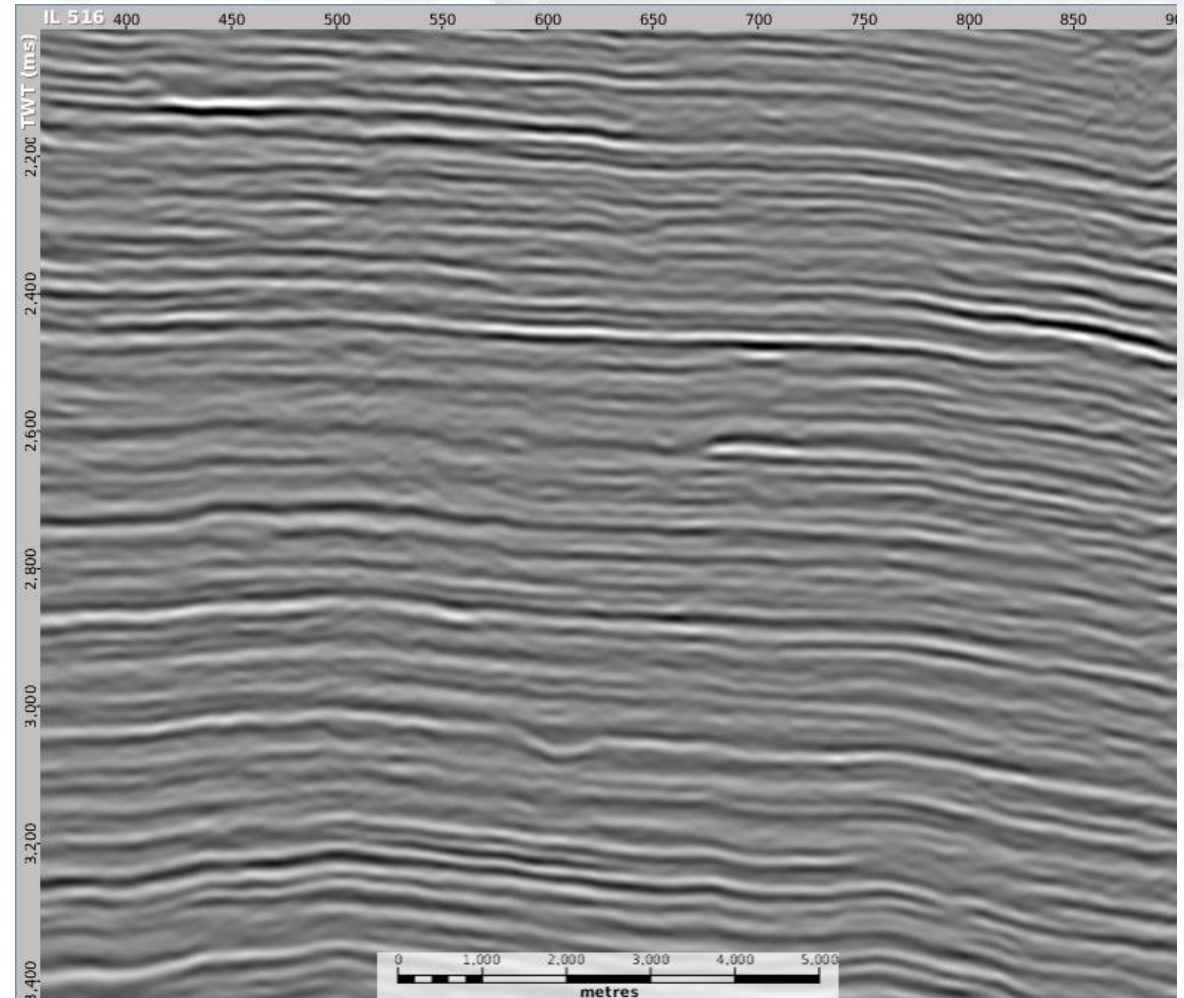
Porosity
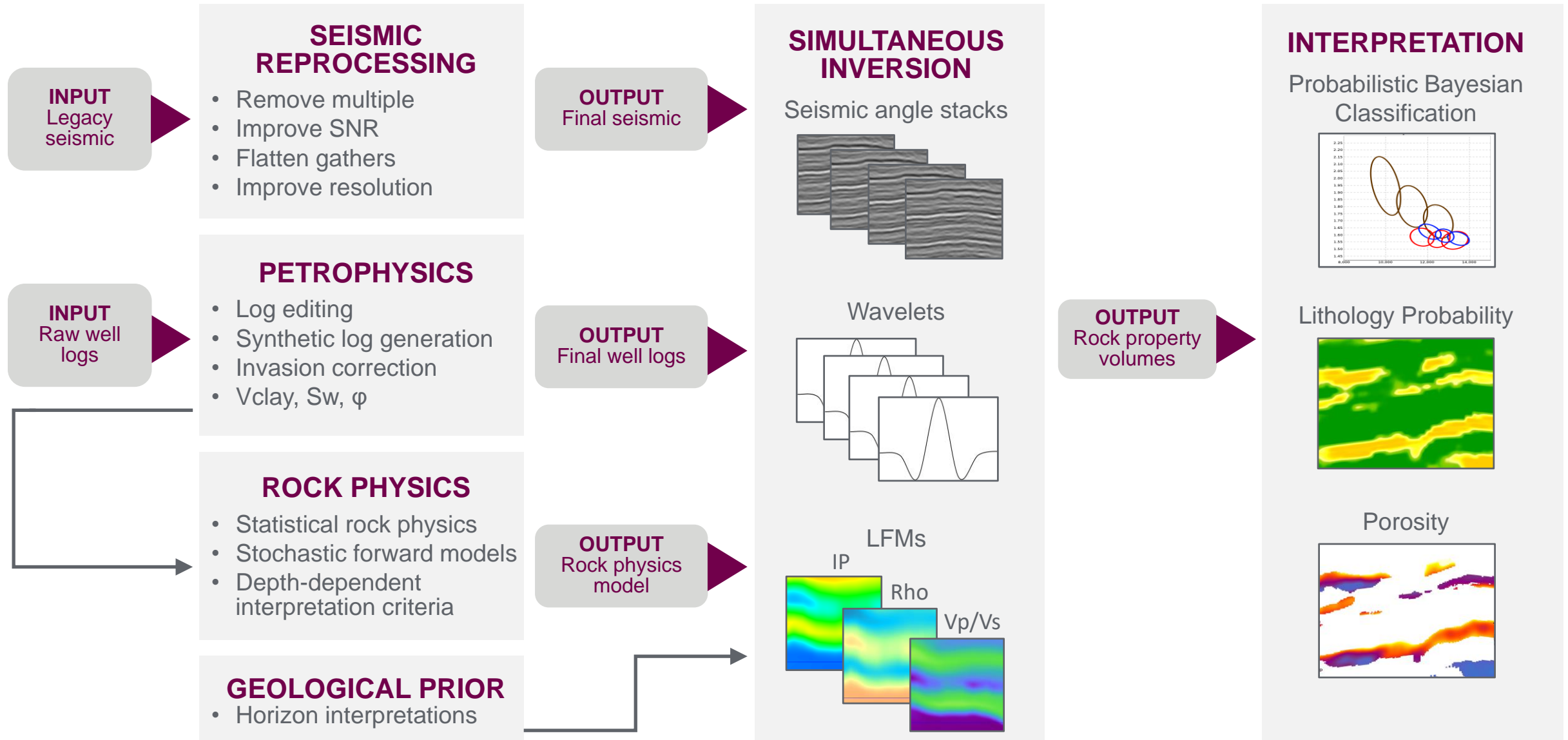
Seismic Re-processing

Re-processed seismic shows

- Reduced noise

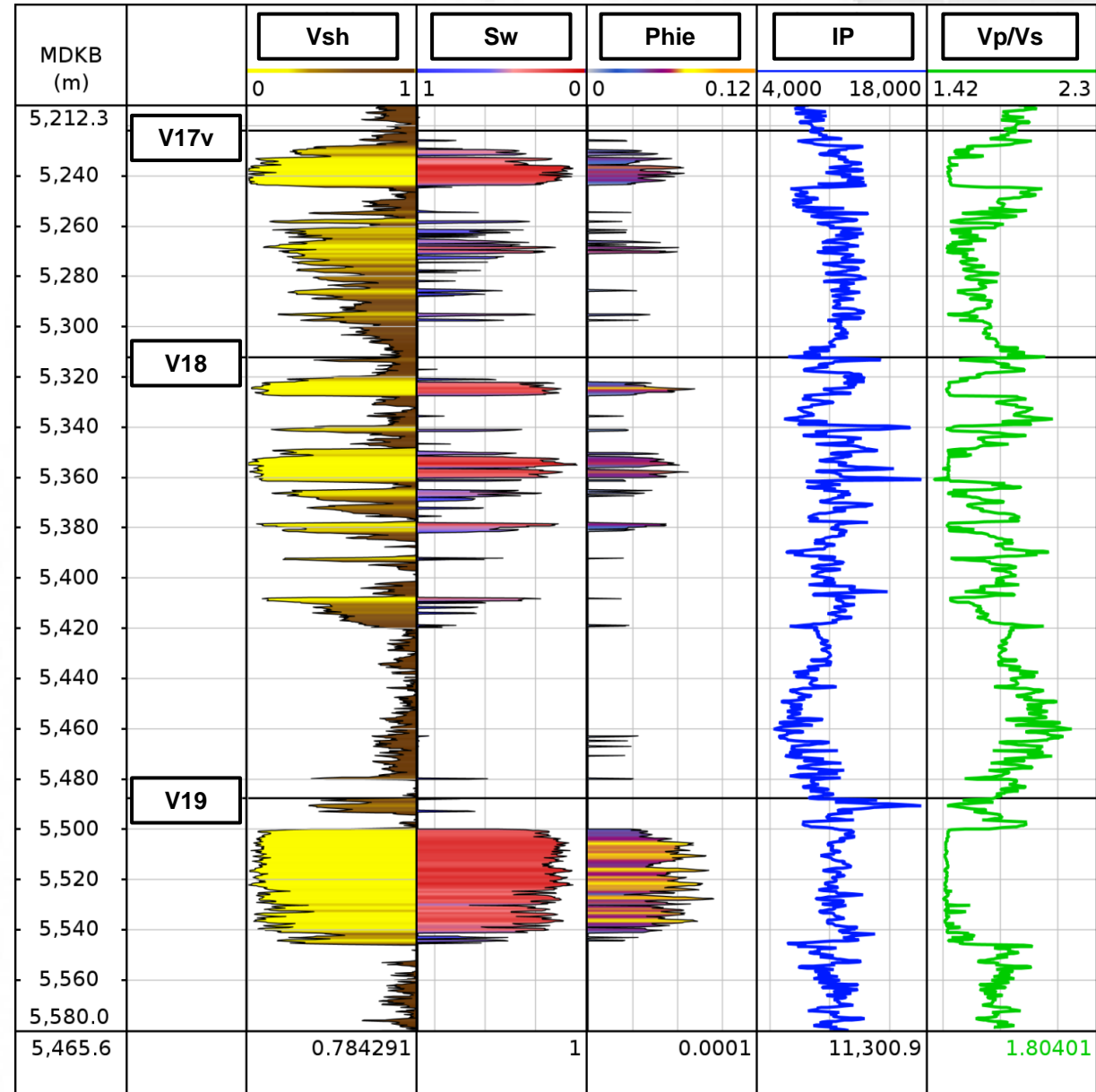- Improved resolution

- Better event continuity
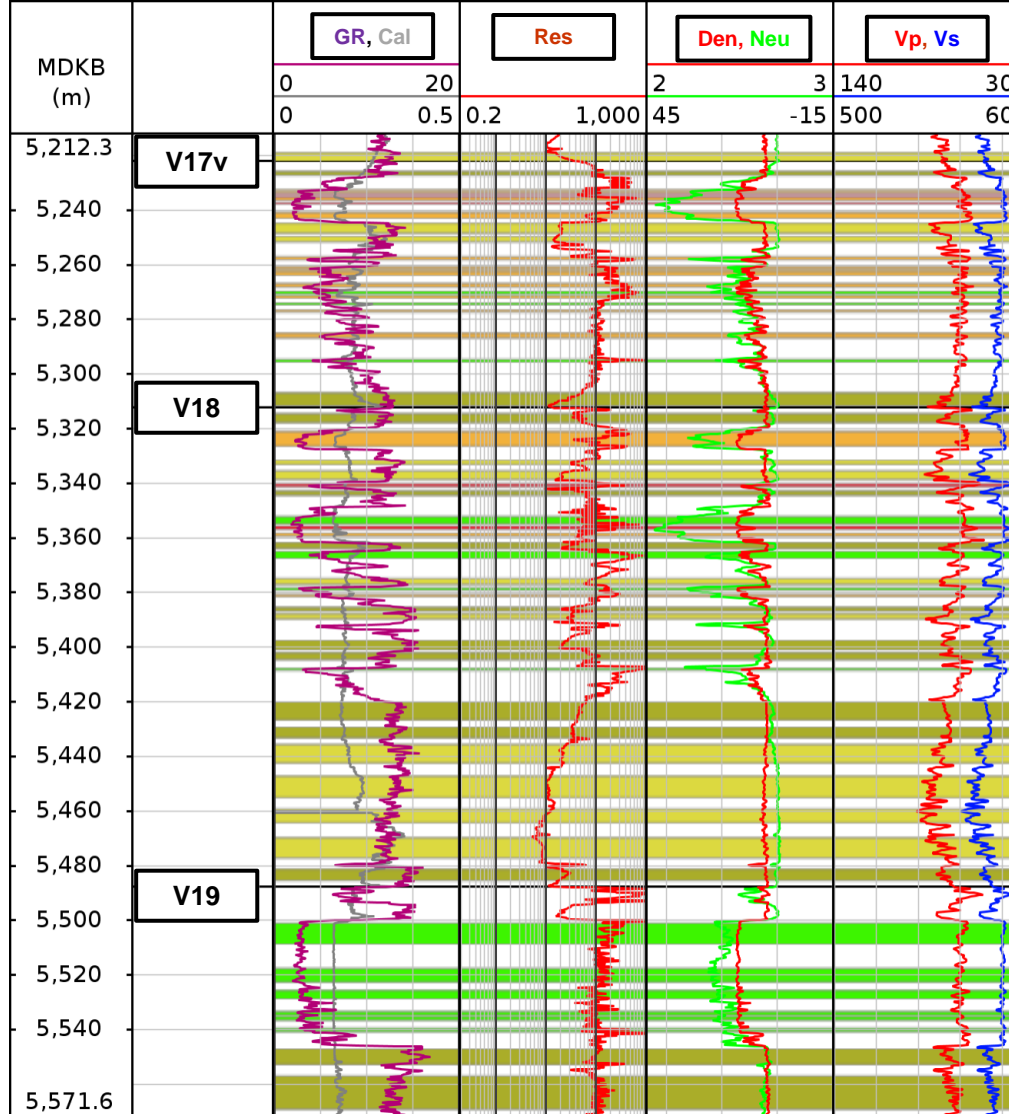

DUG Re-Processing (PSDM in time)

Petrophysical Evaluation

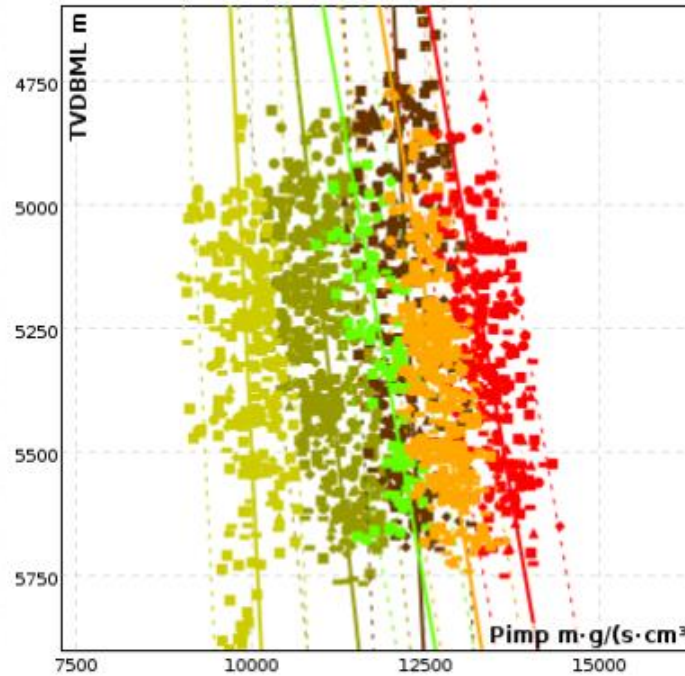The main reservoir is the V19 sandstone:

- A sheet sand present in all wells.
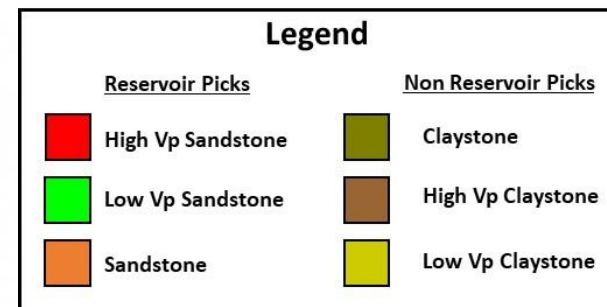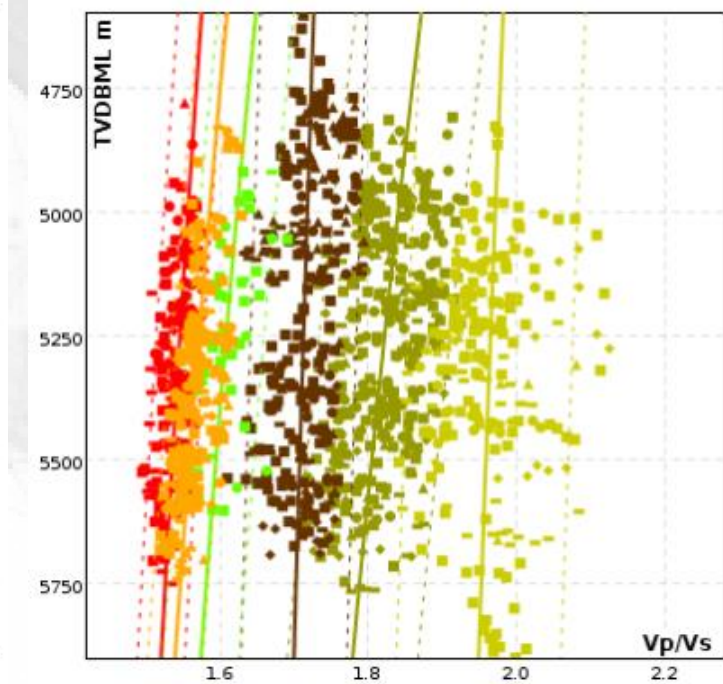- Varies in thickness (12 to 30 m) and in reservoir properties.

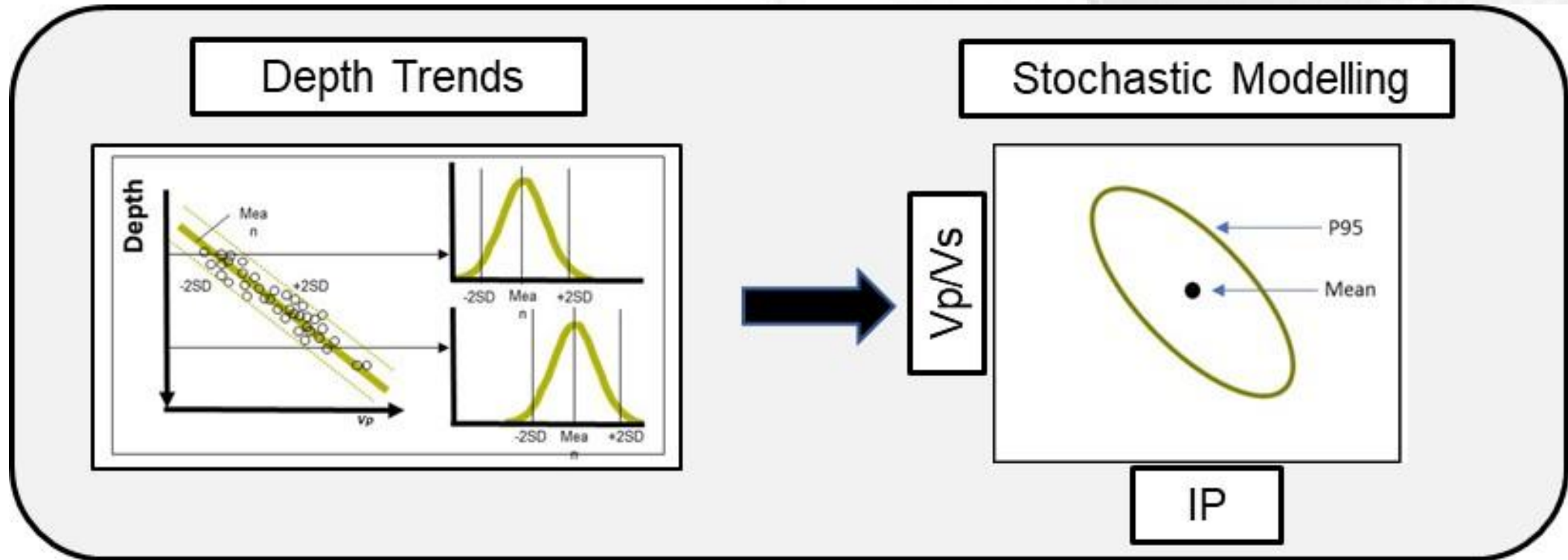# Statistical Rock Physics: End-Member Picks & Trends

- Three types of sands and three types of claystones were identified.
- A rock property to porosity relationship was established for the sands.
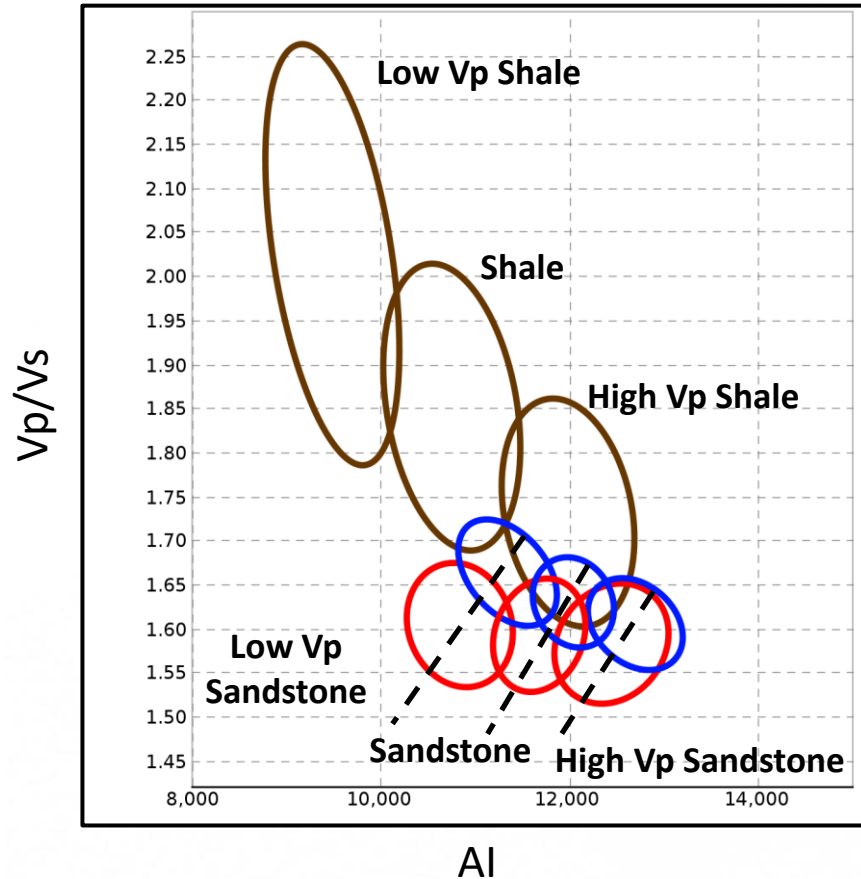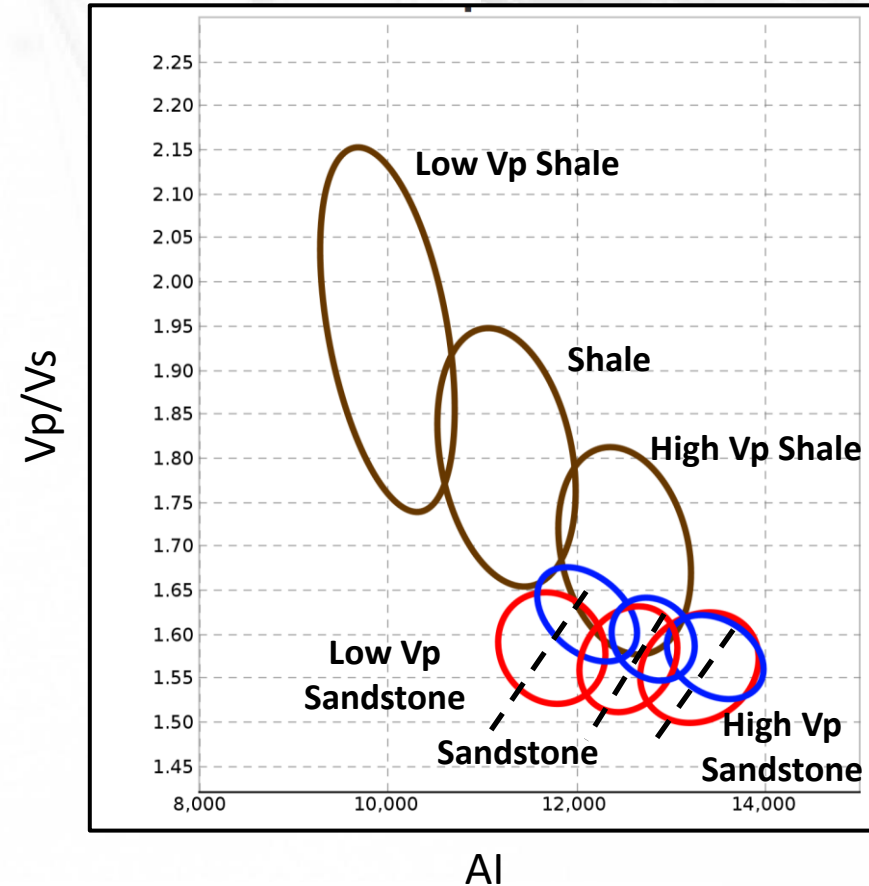
Stochastic Forward Modelling

- End-member distributions any depth at any depth are stochastically sampled.
- The realisations are summarized using probability density functions (PDFs).
- PDF characteristics vary with depth.

Depth Dependent PDFs

AI vs. Vp/Vs at 4800 m TVDBML

AI vs. Vp/Vs at 5500 m TVDBML

- Good separation of sand from shale.
- Fluid separation varies with sandstone type.
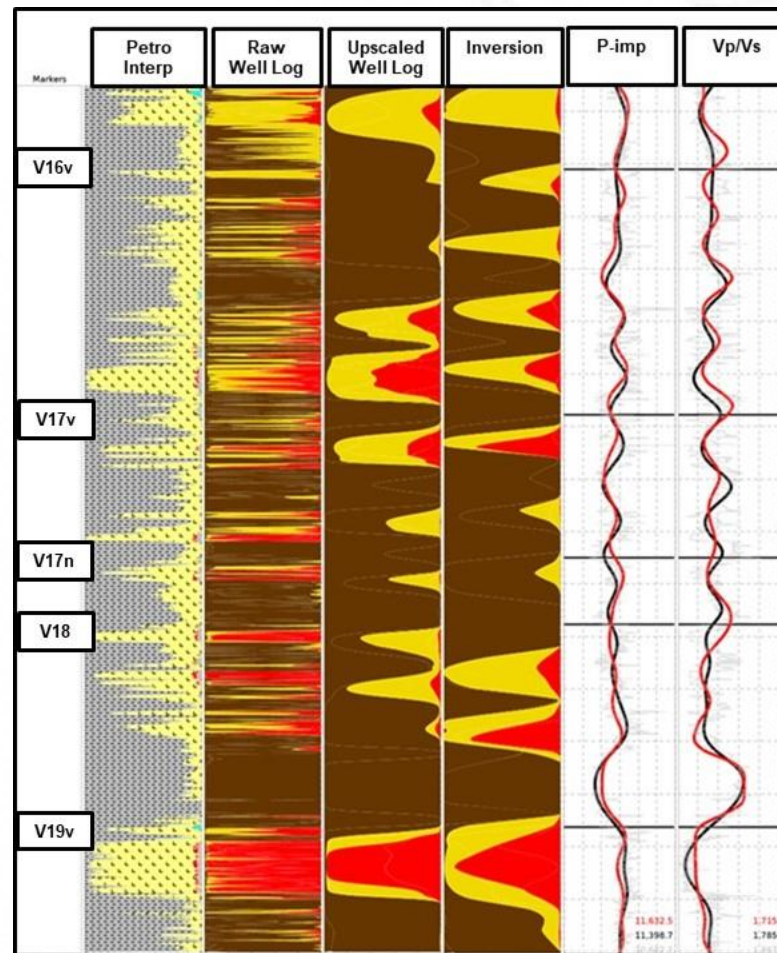- PDF characteristics change with depth.

Contents

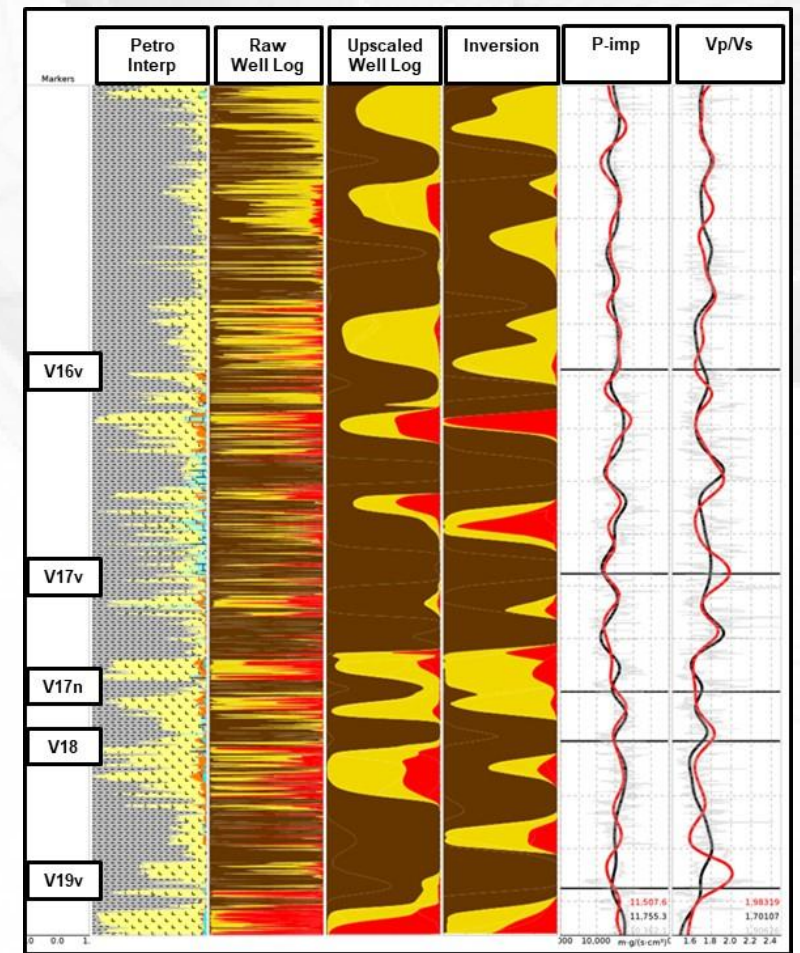# Lithology and Fluid Prediction – Control Wells

Well 52
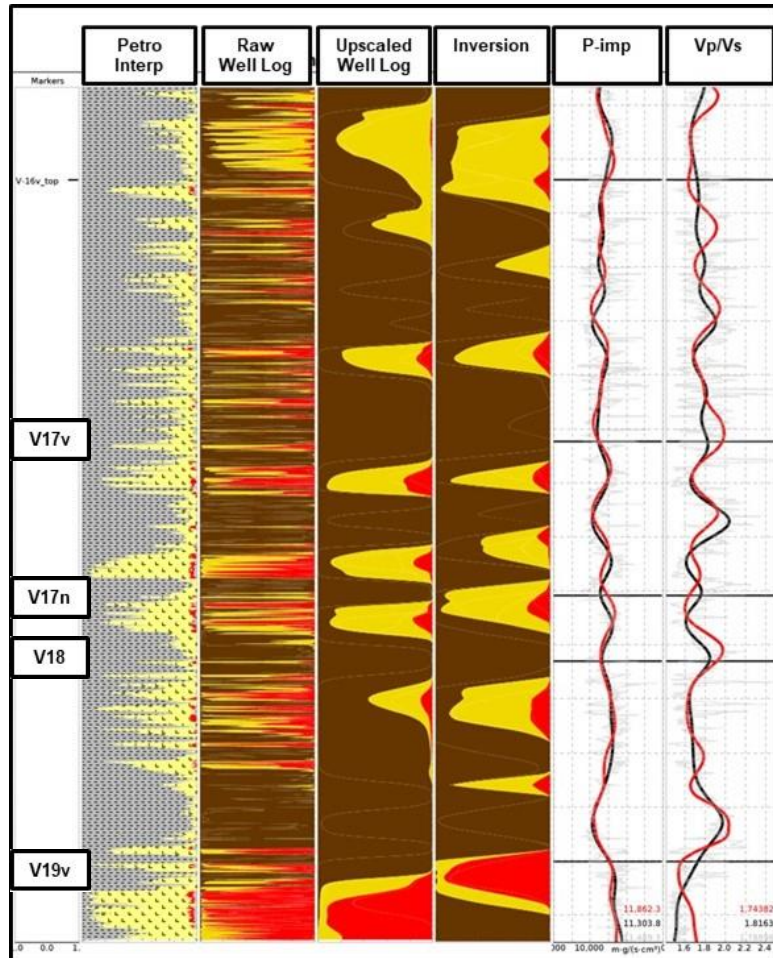
Well 67

Well 73

- Rock properties from simultaneous inversion were compared against depth-dependent PDFs.
- A Bayesian classification scheme was used to derive lithology and fluid probability volumes.
- Interpretations from inversion results agree with well log interpretations.

Lithology and Fluid Prediction – Blind Wells
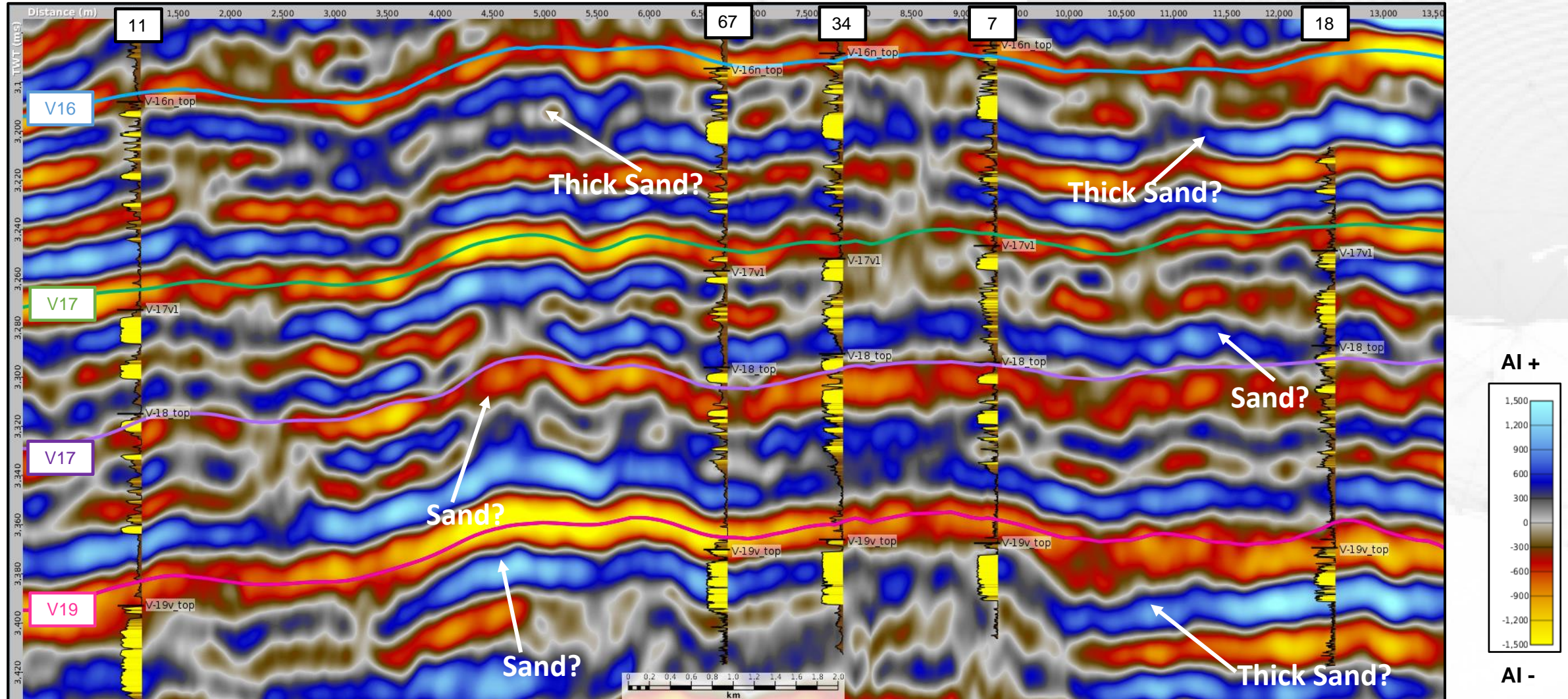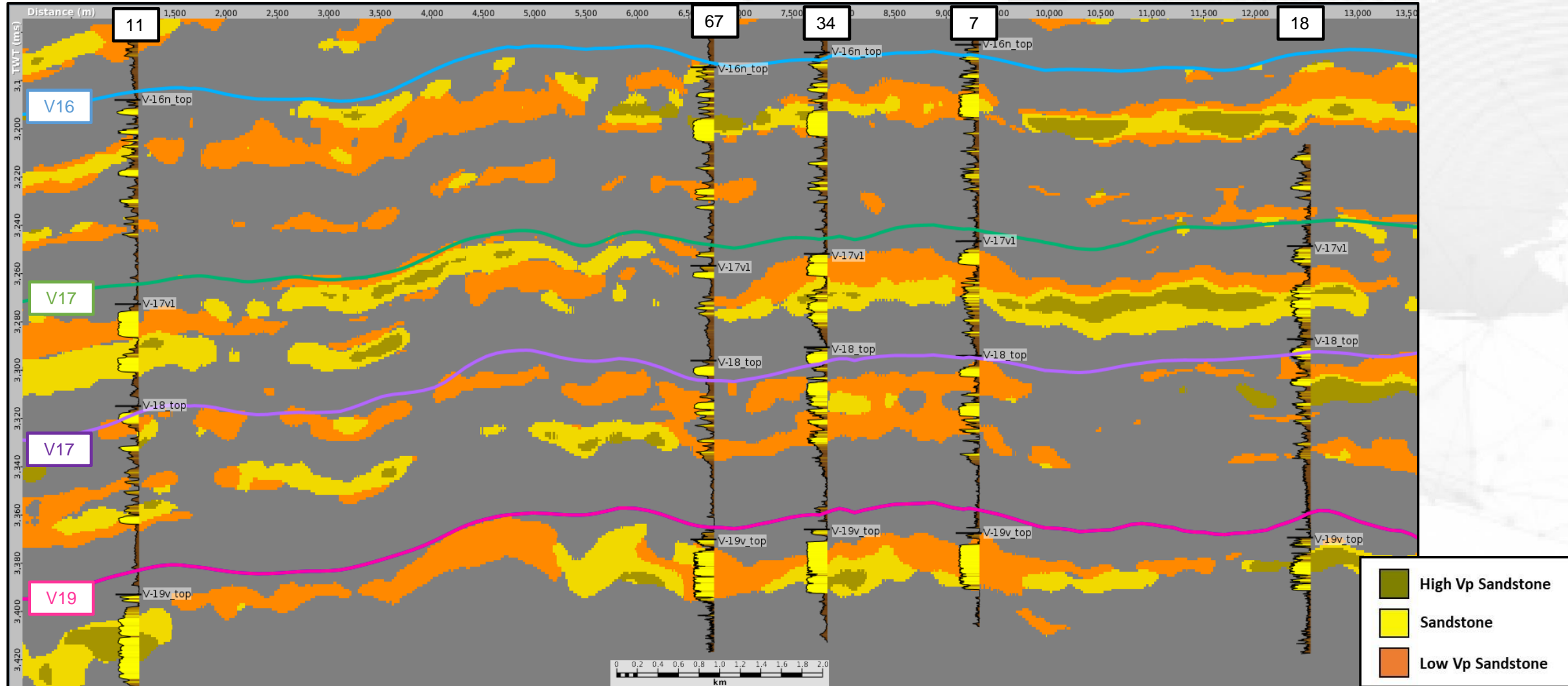

Well 43 (Blind well)
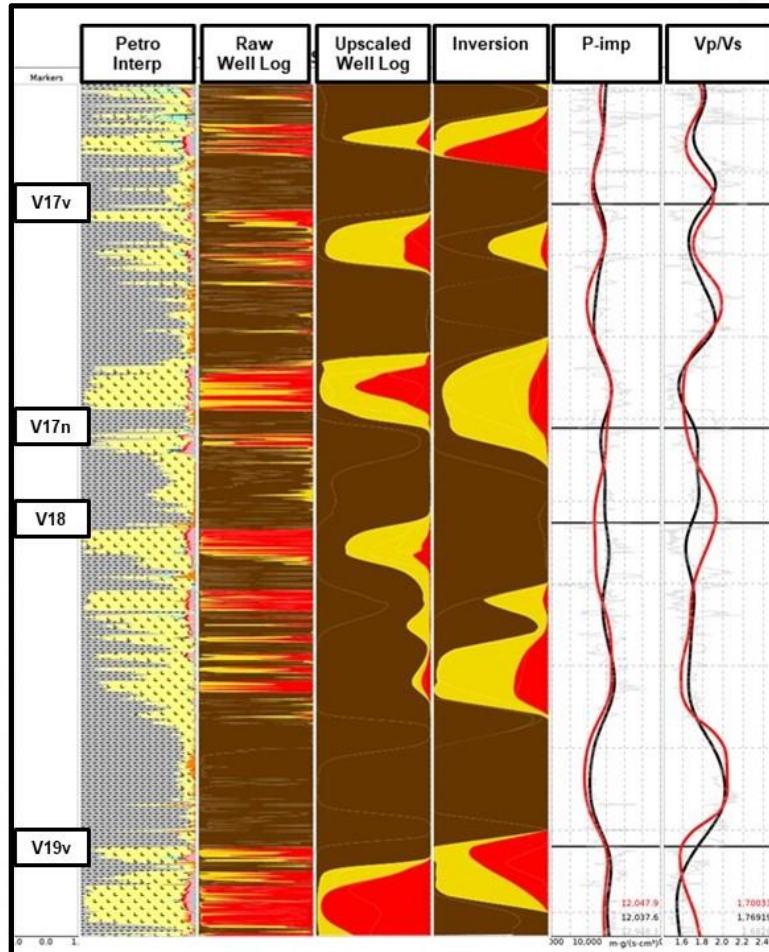
Well 61 (Blind well)
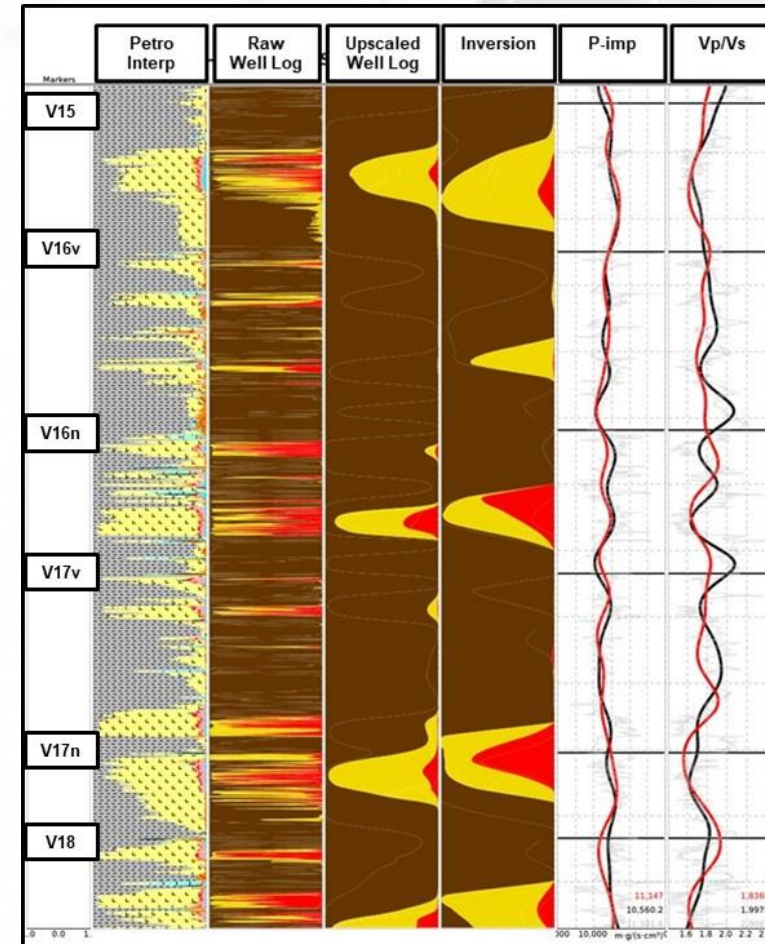
- Inversion results and interpretations also agree with wells that were blind to the project.
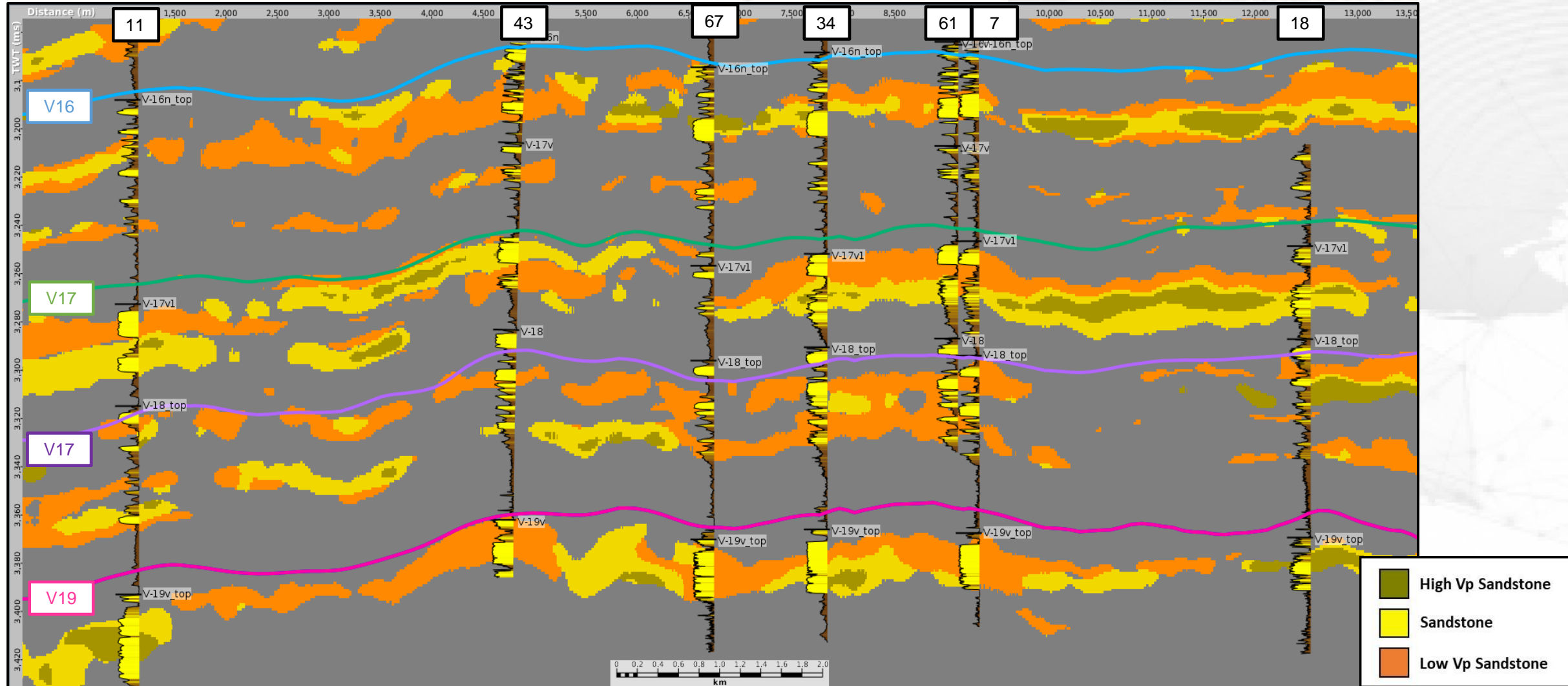
Interpretation: Seismic

- Mapping sands on seismic is ambiguous.
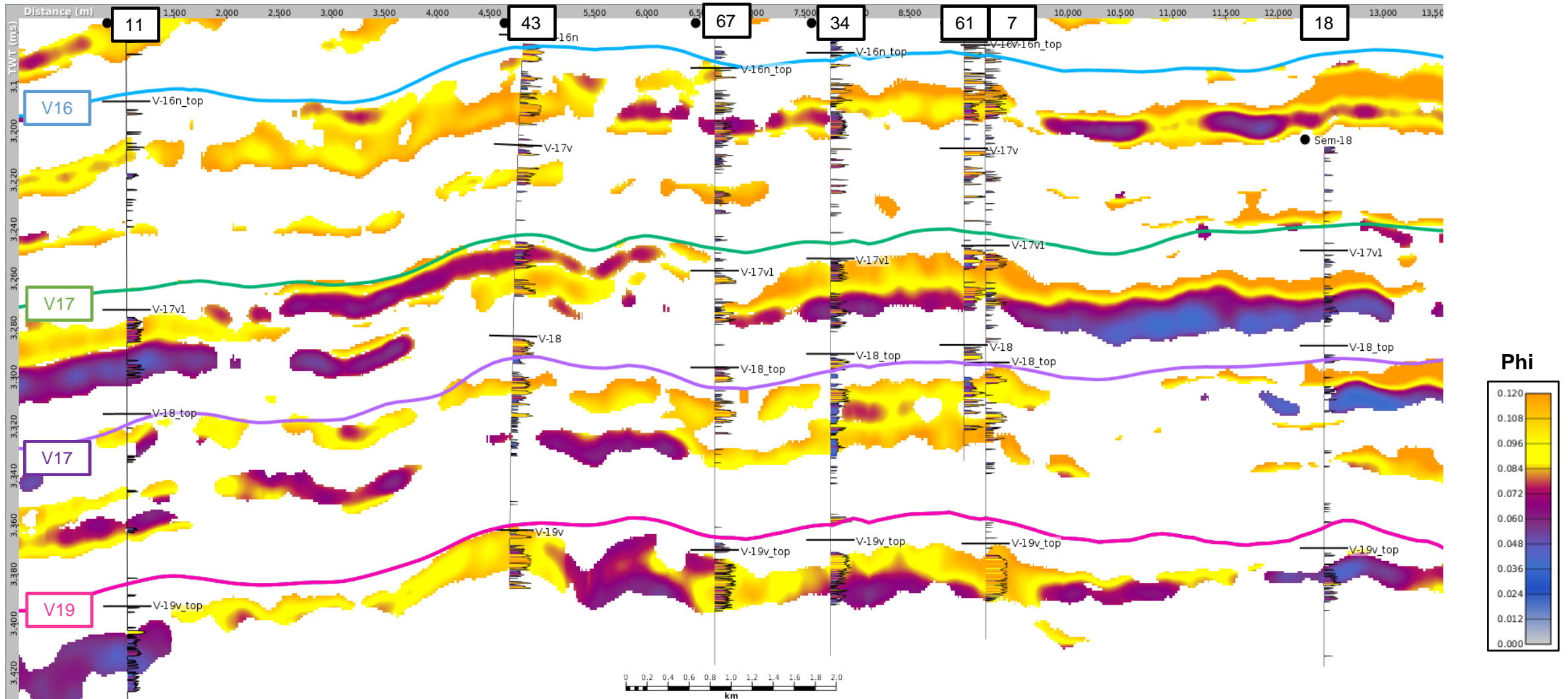
Interpretation: Most Likely Sands

- Using inverted rock properties can help sand mapping between wells.

Interpretation: Most Likely Sands

- Blind wells Post-inversion increase confidence in the sand prediction.
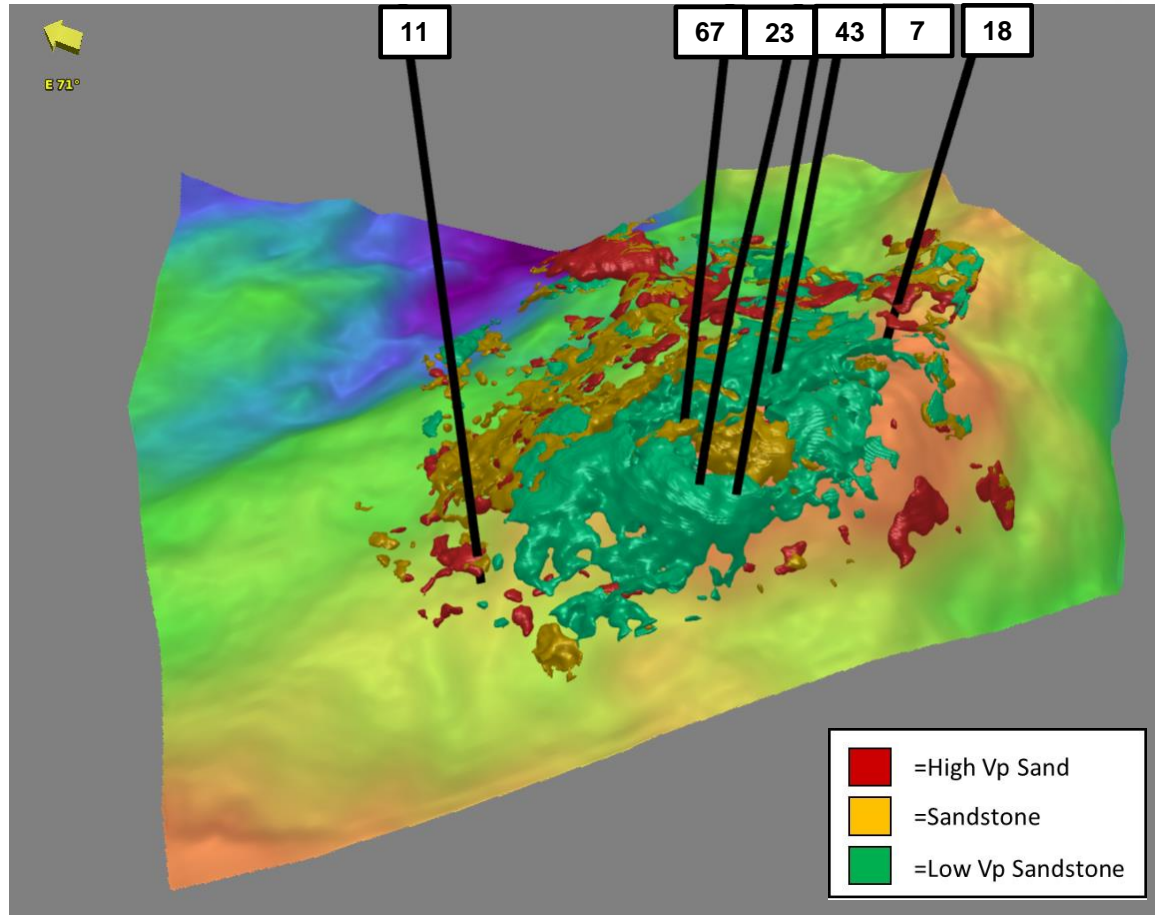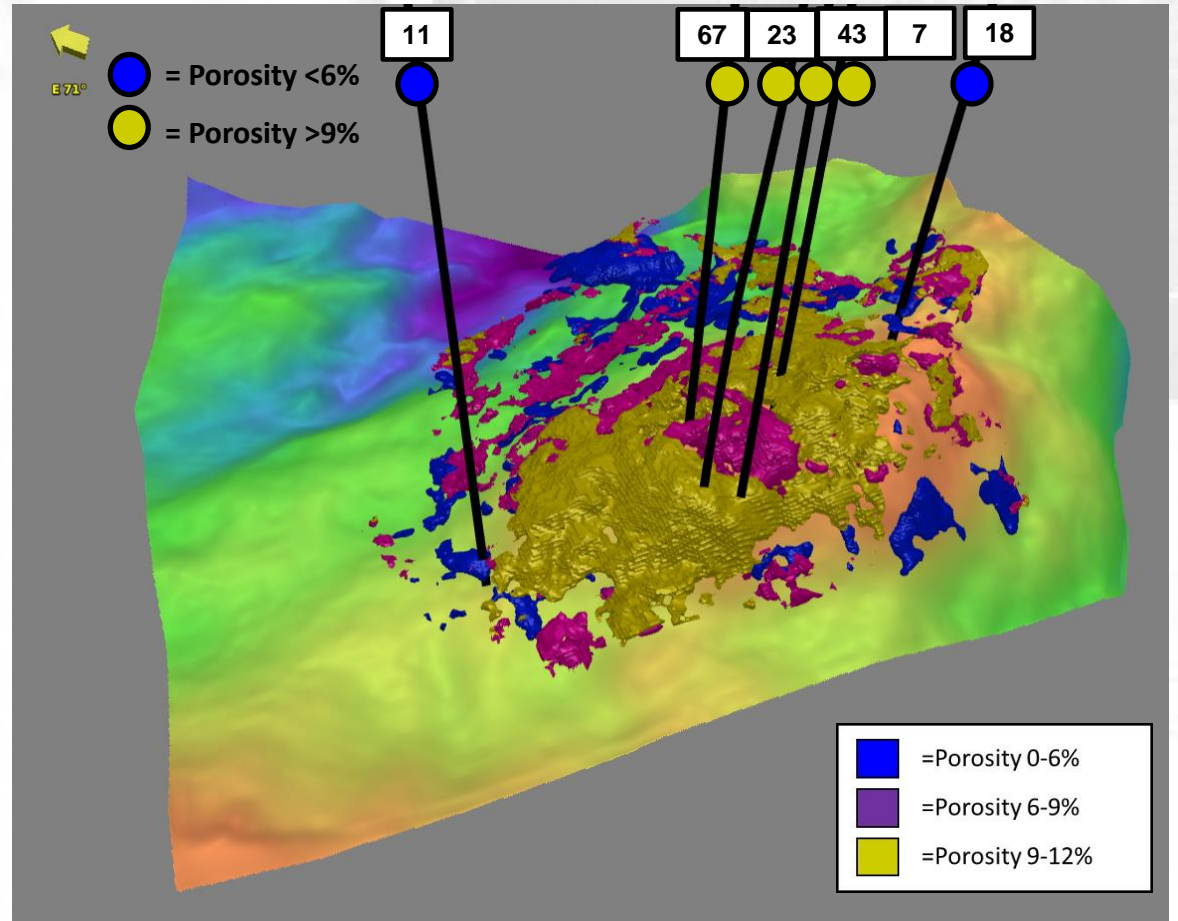
Interpretation: Porosity

- Different sands have different porosities which can affect production.

Interpretation: V19 sand

Sand Type Classification

Sand Porosity Prediction

- High Vp sands are seen on the periphery of the field with low porosities.
- Well 11 and 18 have poor V19 production.
- Wells drilled in the center of the field have good V19 production.

Conclusions

In the Semyrenky gas field:

- Seismic re-processing has reduced noise and improved event resolution and continuity.

- Three types of sands have been mapped using simultaneous inversion results.

- Interpretations are validated by wells that were blind to the study.

- Production is controlled by sand type distributions and porosity.

Acknowledgements / Thank You / Questions

- DUG QI, Petrophysics and Processing Teams

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  Anne Locke

- All thanks to DTEK for allowing DUG to present this case study and RPS for their ongoing technical support.