HiSeis

BETWEEN, BEYOND, BELOW

Building 3D Rock Models from Seismic at the Tropicana Gold Mine

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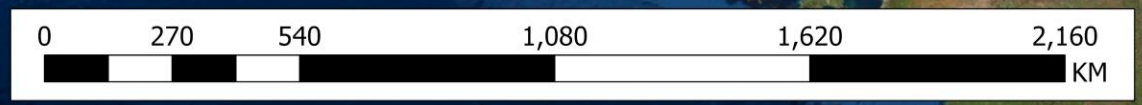
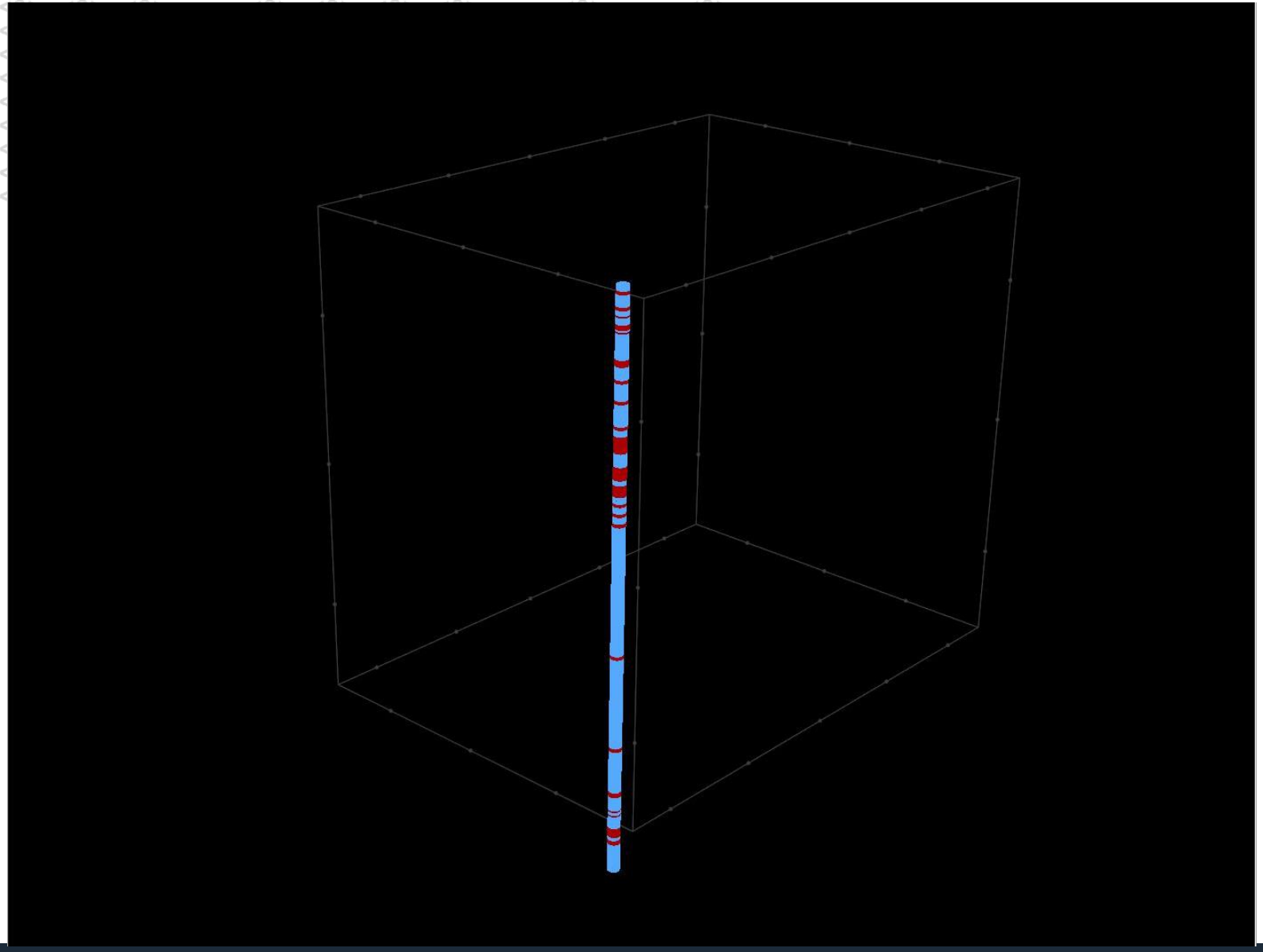
24-Nov-2021

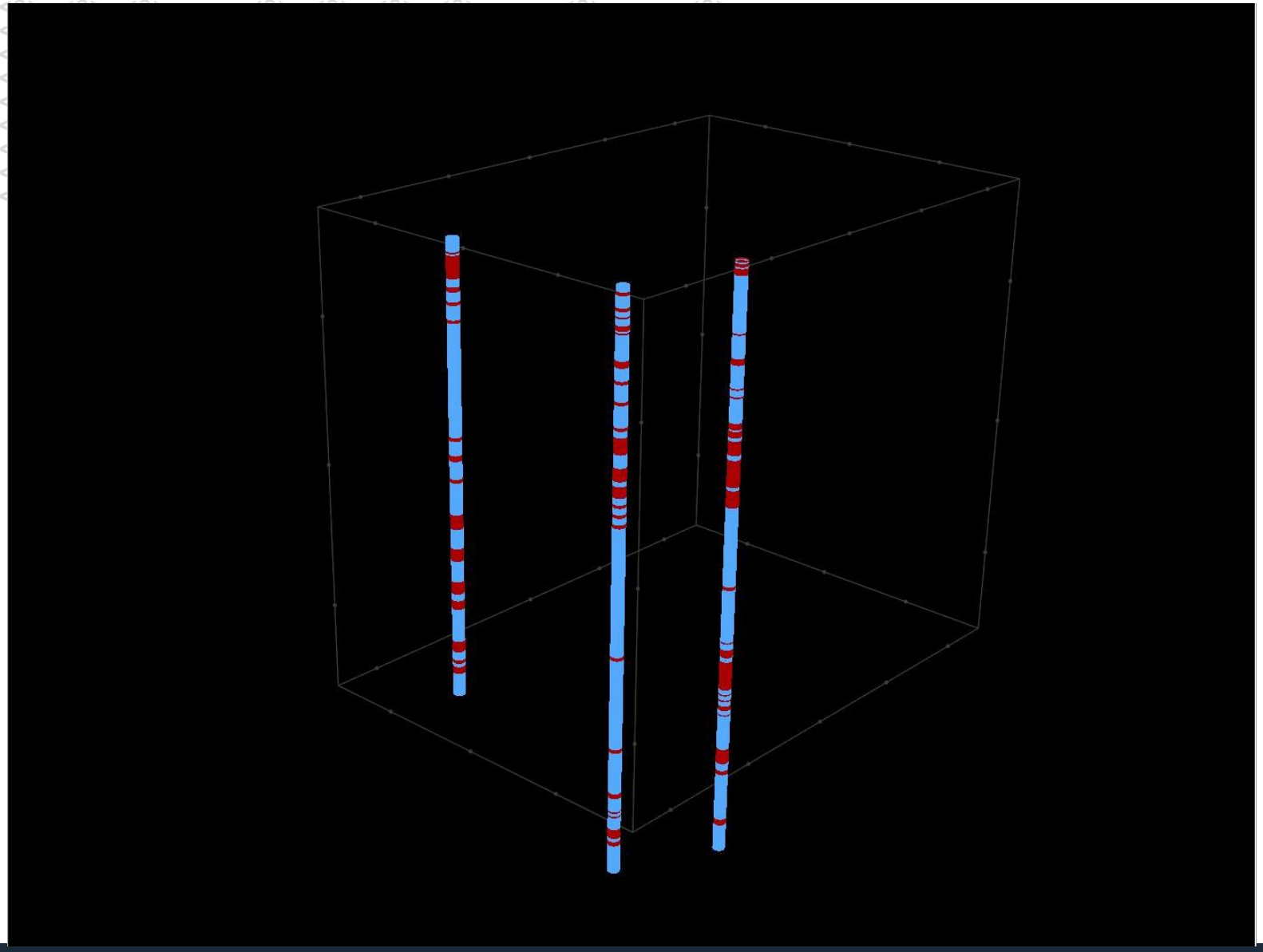


Intro: The earth sampled with 1 drillhole



Vertical variations in rocks can be identified

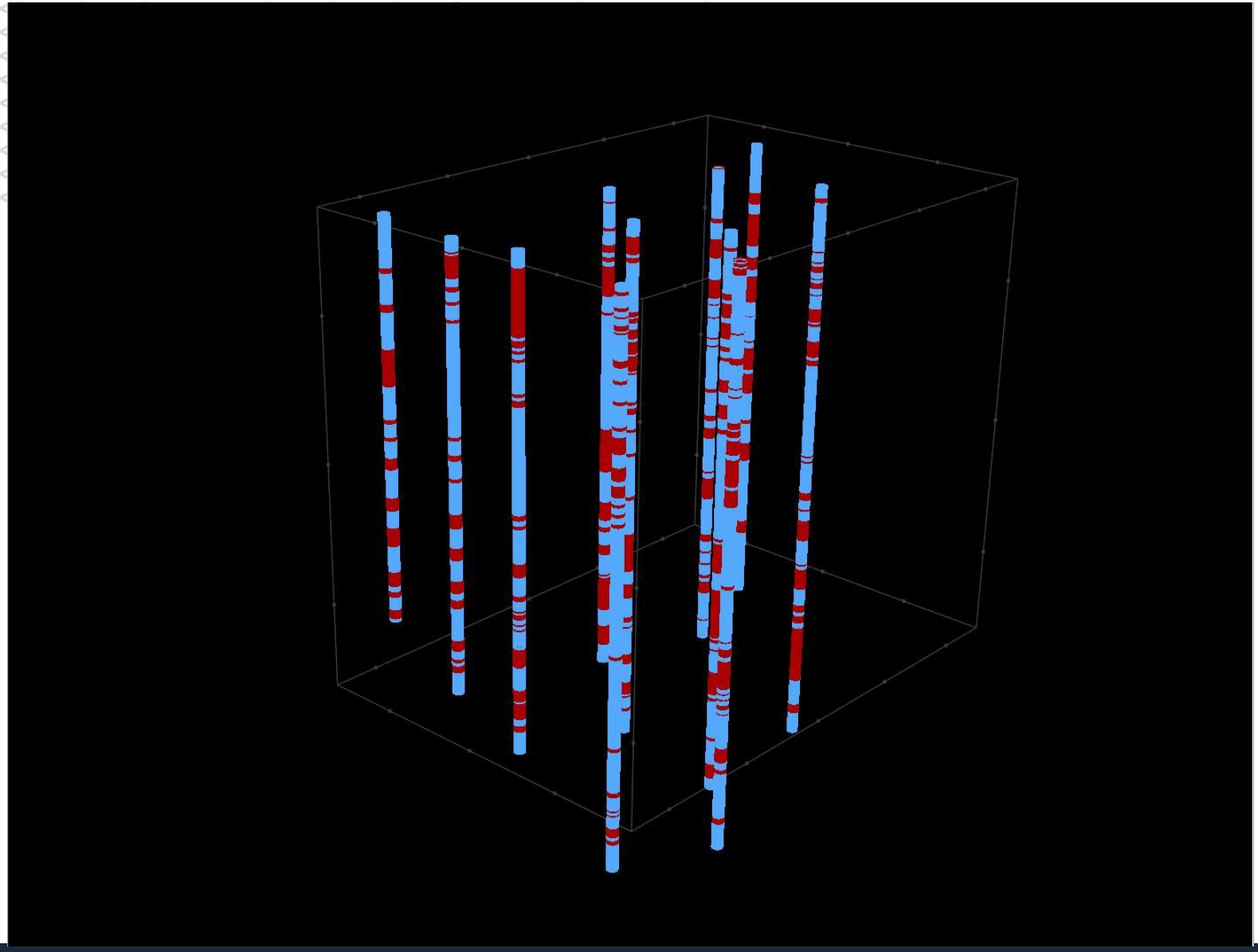
Intro: The earth sampled with 3 drillholes



Lateral variations in rocks can be identified

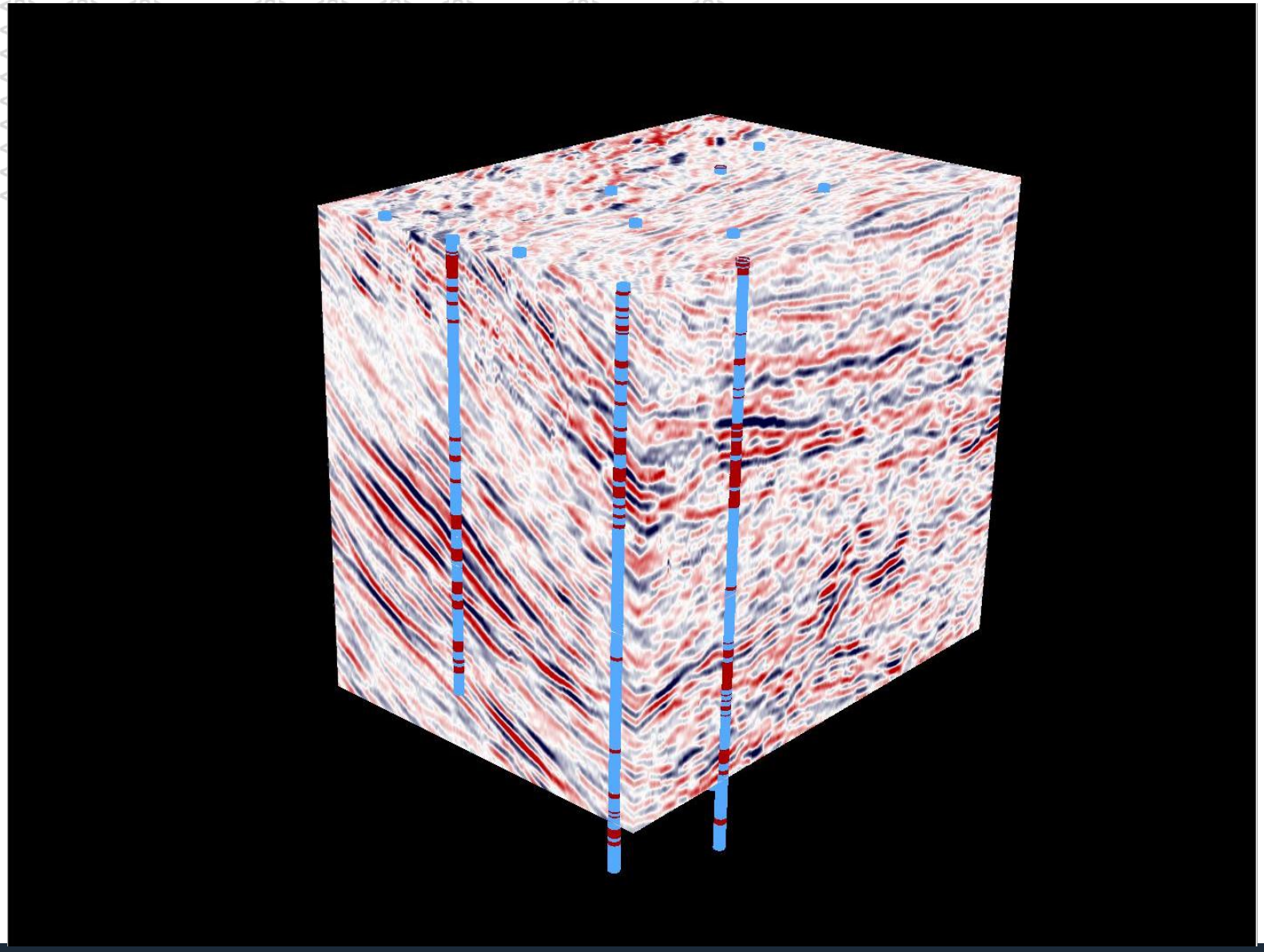
Not really sure how to correlate between DHs

Intro: The earth sampled with 11 drillholes



Additional DHs complicate the picture even further

Intro: Acquiring Seismic to “fill in the gaps”

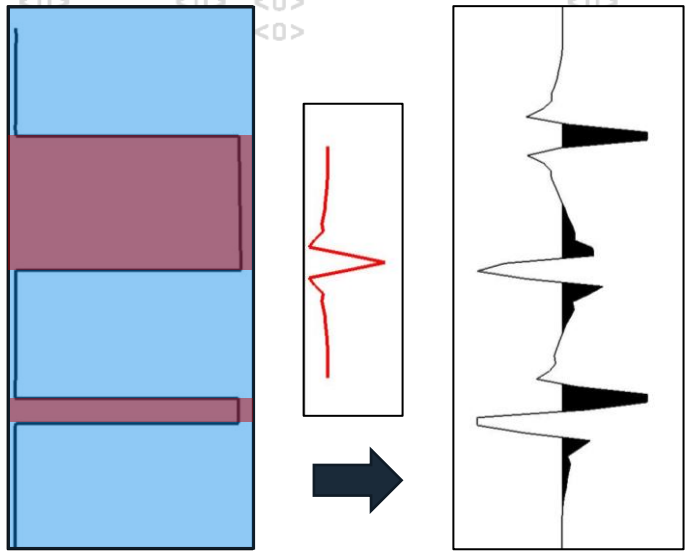


The seismic is a volume that connects the suite of DHs

A rough correlation can be made between the higher amplitudes and the different rock types

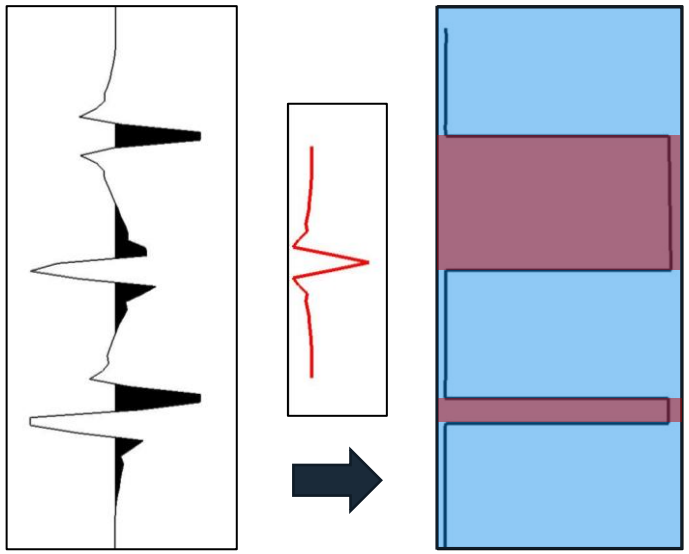
Seismic Inversion – Converting the seismic into something more meaningful

Seismic Experiment



When adjacent rock properties are different enough the processed seismic shows a distinctive signal at each interface

Seismic Inversion



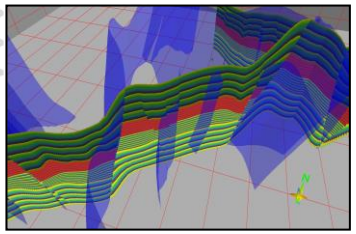
Seismic inversion starts with the seismic and attempts to recover the rock types and their properties

GeoStatistical Inversion

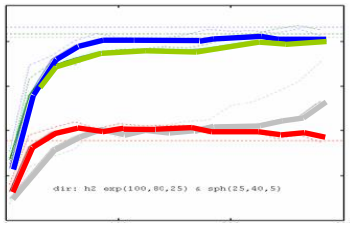
DATA ASSUMPTIONS

Geology

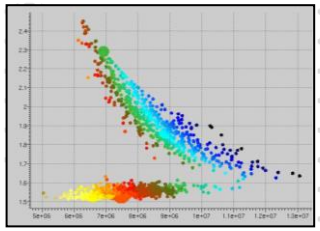
Stratigraphic grid



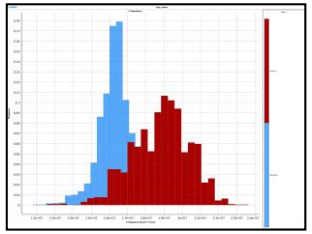
Geostatistics



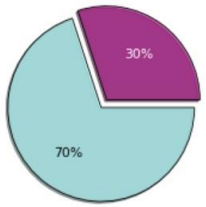
Rock physics



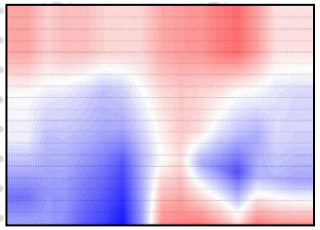
PDFs



Lithology proportions

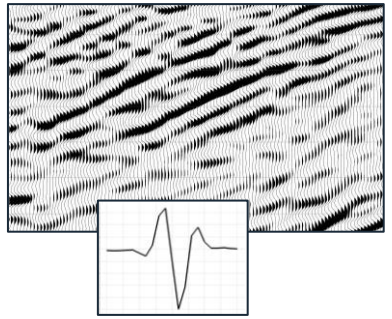


Seismic noise

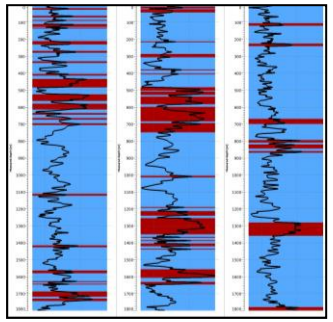


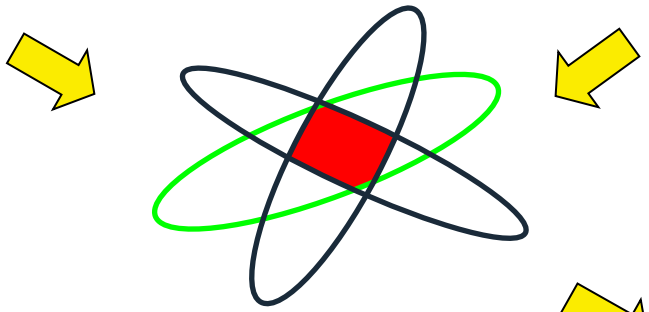
DATA

Seismic data & wavelet



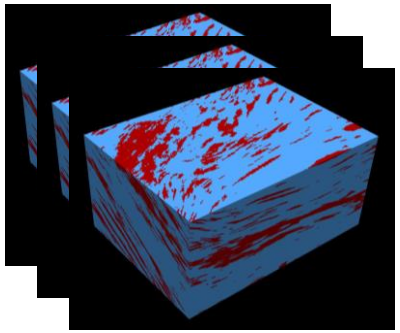
Drillhole logs





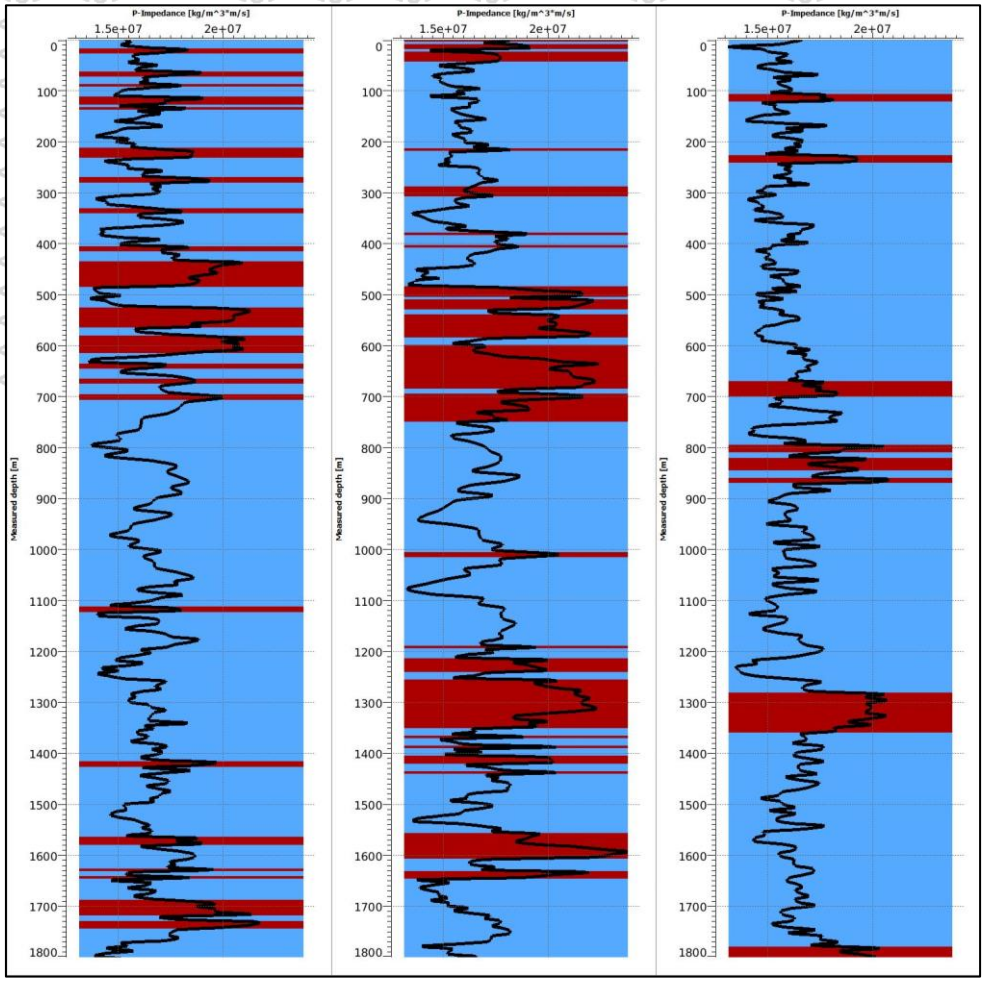
The Bayesian inversion process integrates all available data types and data assumptions to build the plausible geologic models

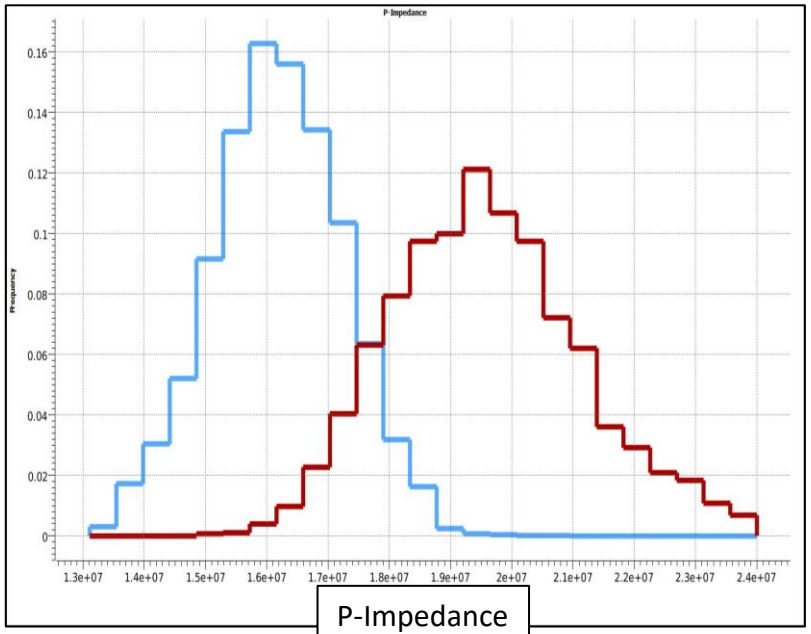
PLAUSIBLE GEOLOGY



Intro: Elastic Log Property Summary (Synthetic Example)

The key rock property of interest for seismic is P-Impedance which is the product of P-Velocity and Density.

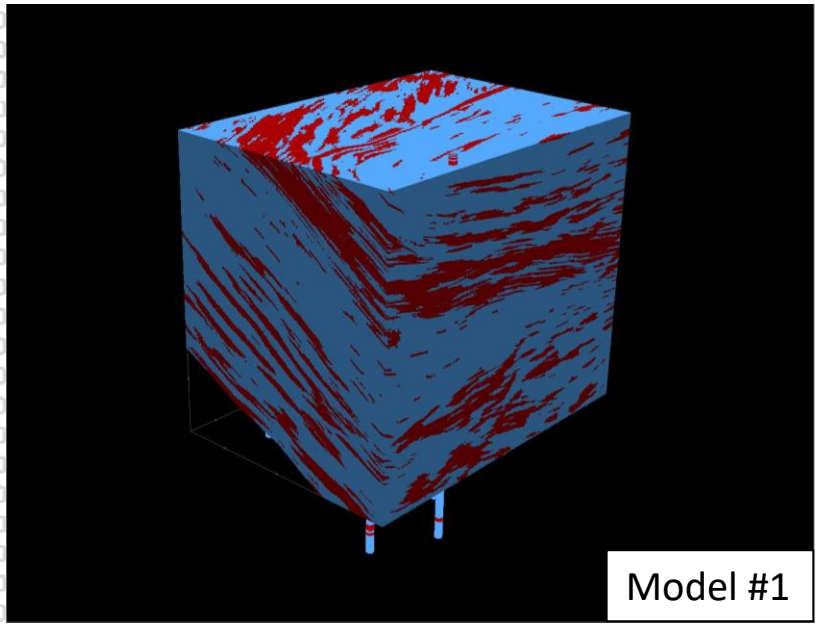


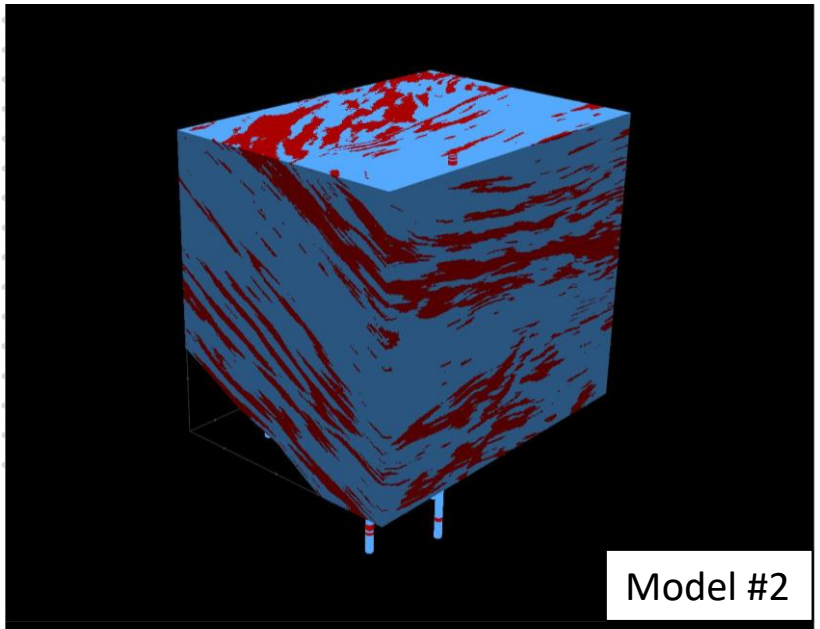


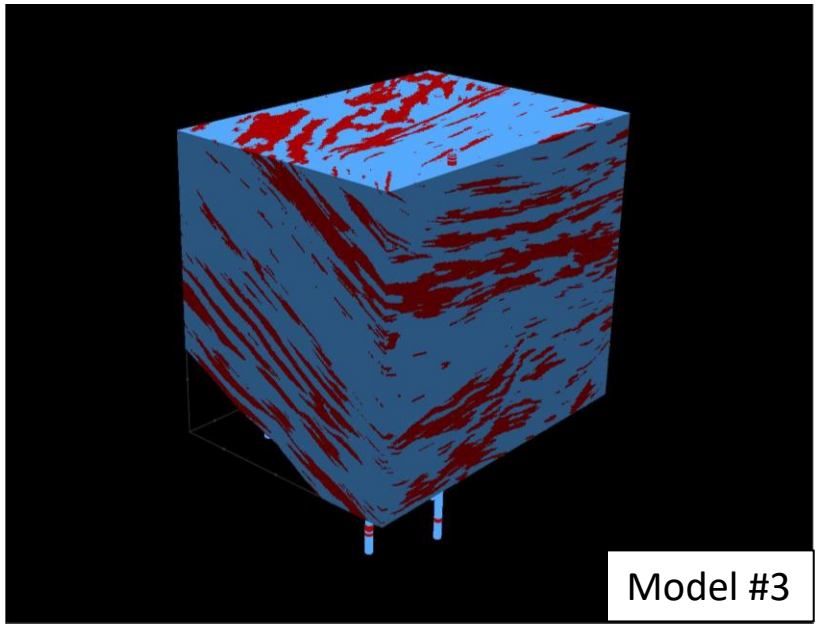
P-Impedance

The P-Impedance logs show varying rock properties but there are some rocks (in red) with generally higher P-Impedance than the others.

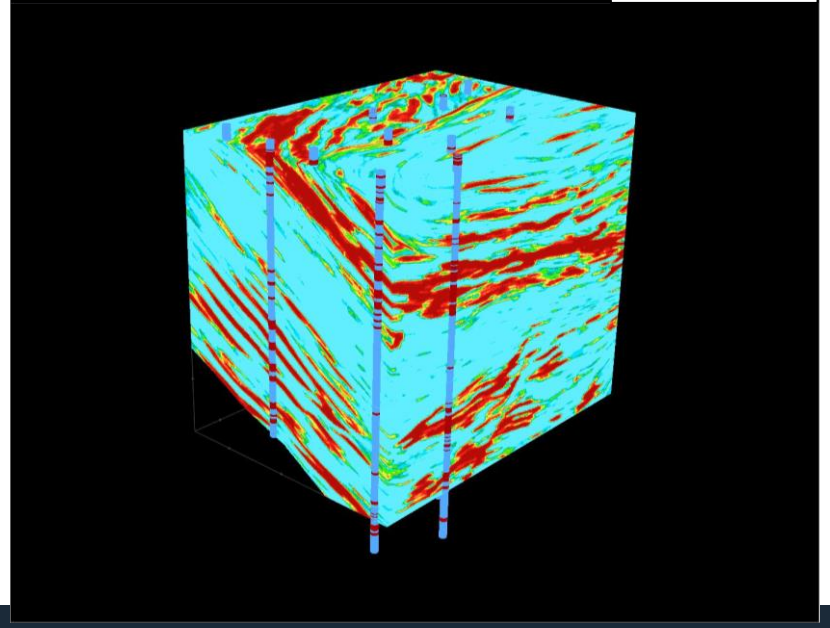
Outputs from Geostatistical Inversion (Synthetic Example)







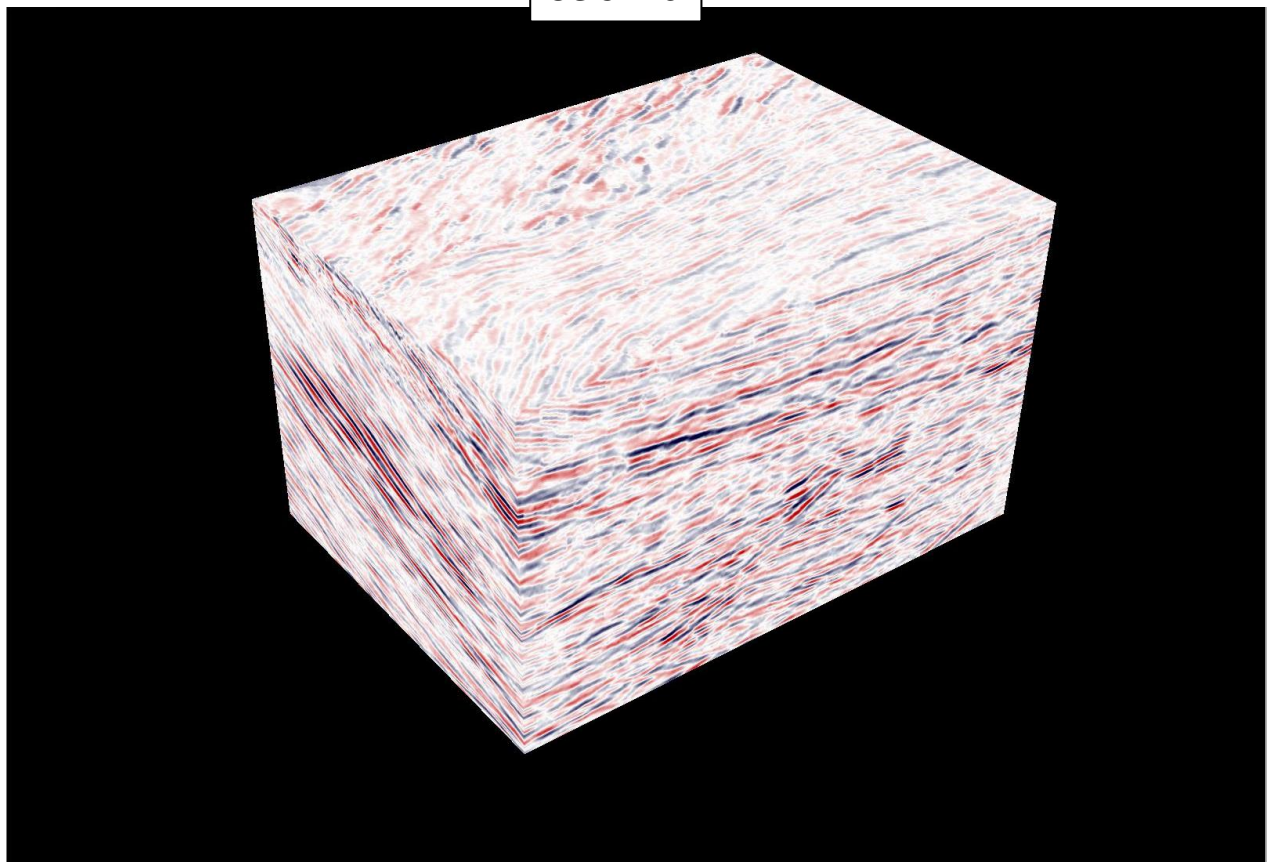
Multiple models are output from the inversion and each one matches the seismic input equally. Due to the constraints and the strong, coherent seismic amplitudes, the models are very similar.



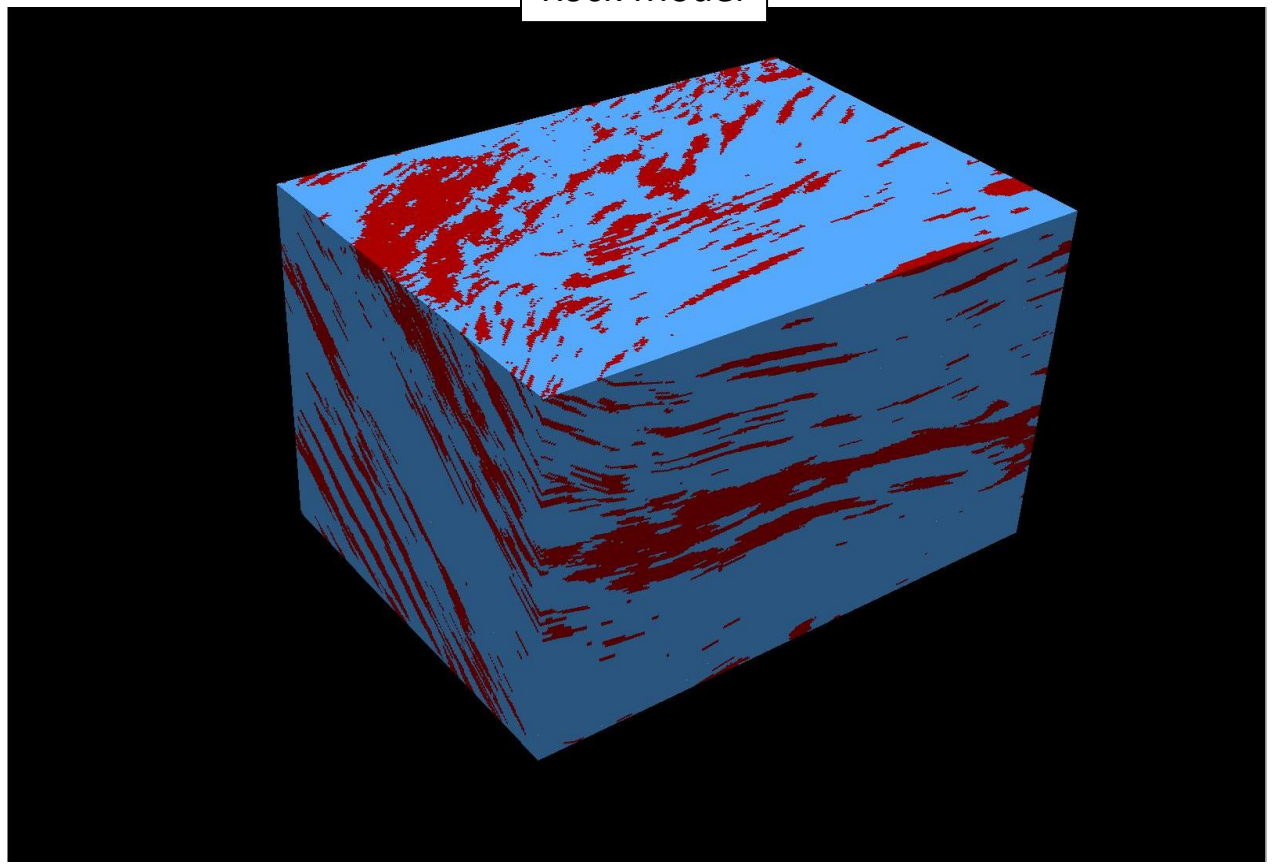
Lithology Probability based on an averaging of all lithology models (9 in this case)

Seismic Inversion provides intuitive models of the earth (Synthetic Example)

Seismic

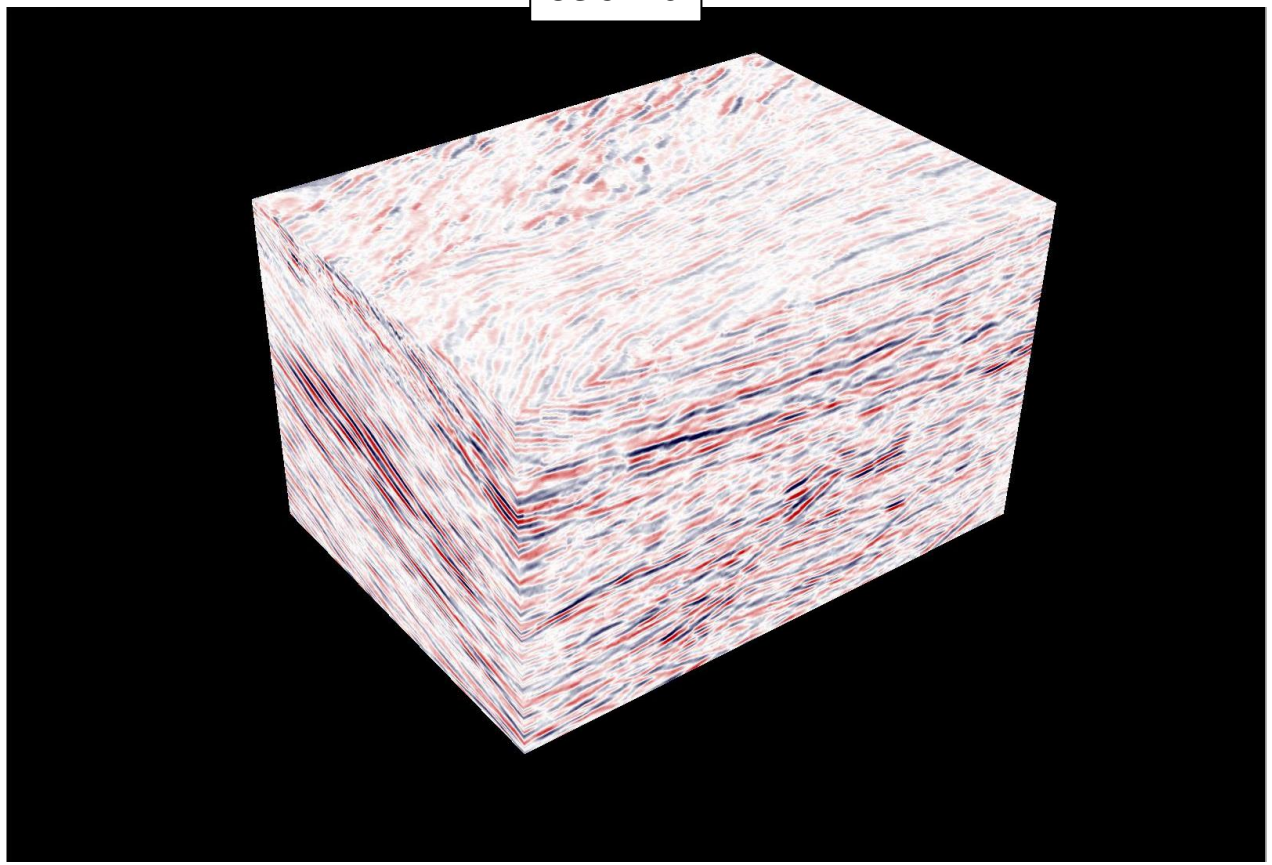


Rock Model

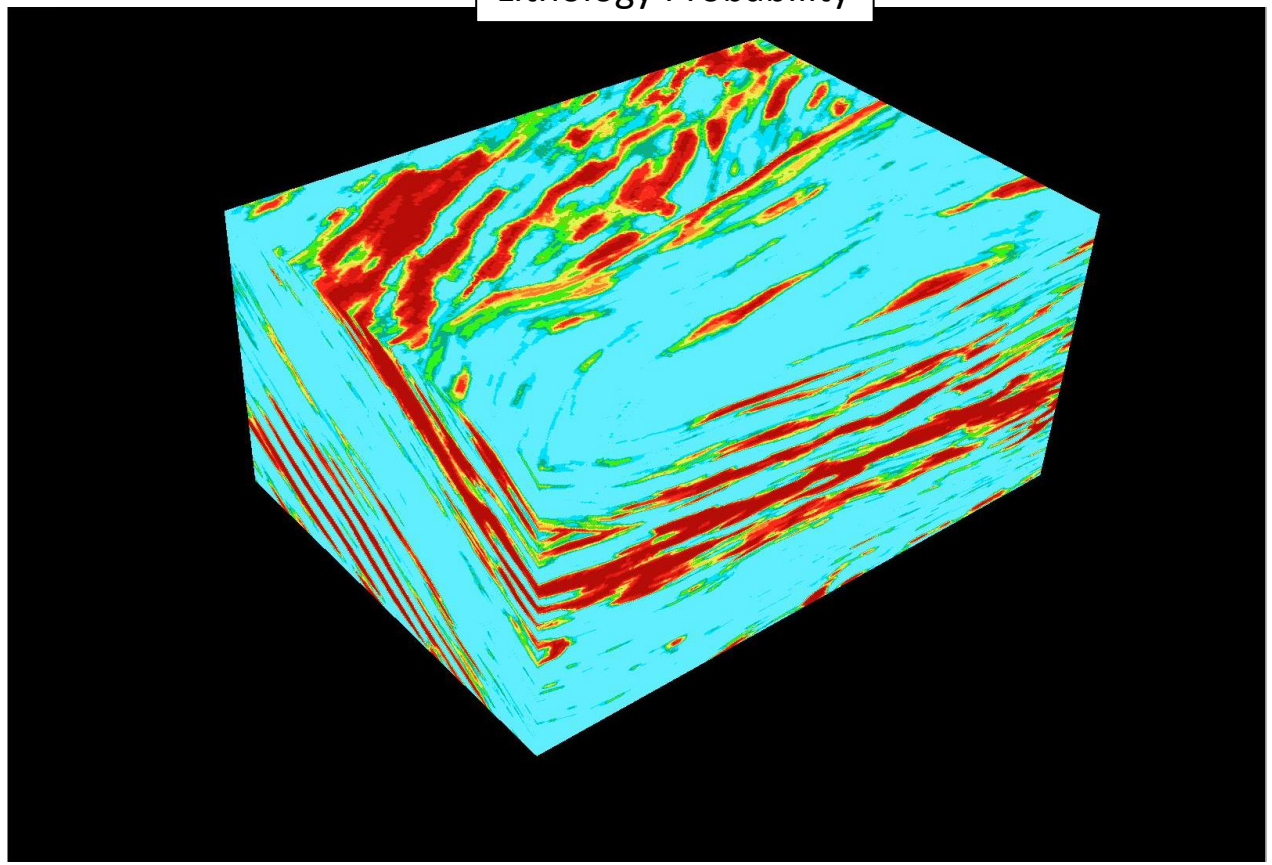


Seismic Inversion provides intuitive models of the earth (Synthetic Example)

Seismic

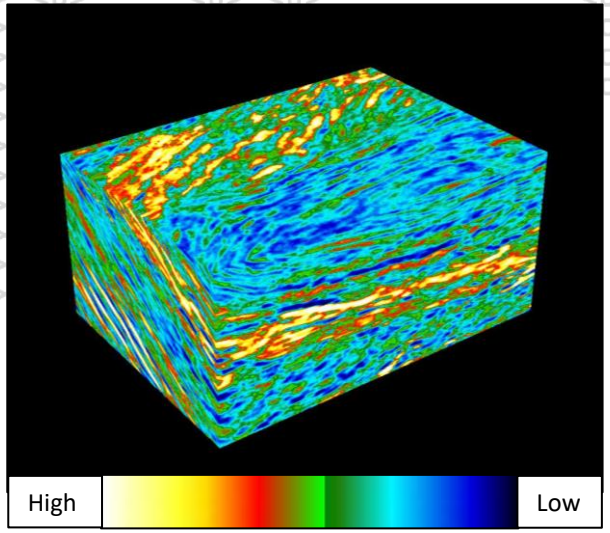


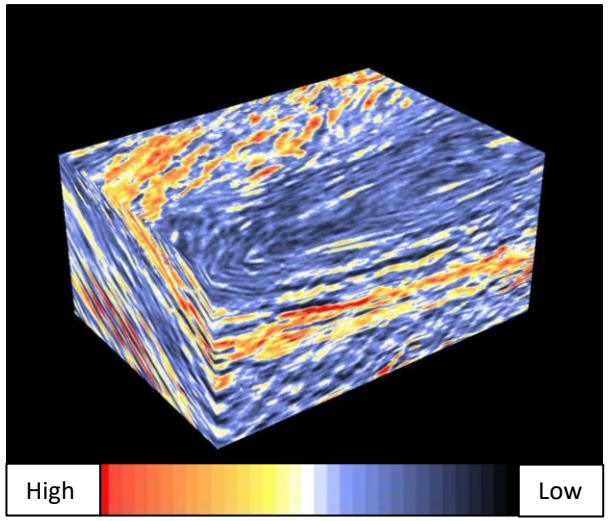
Lithology Probability



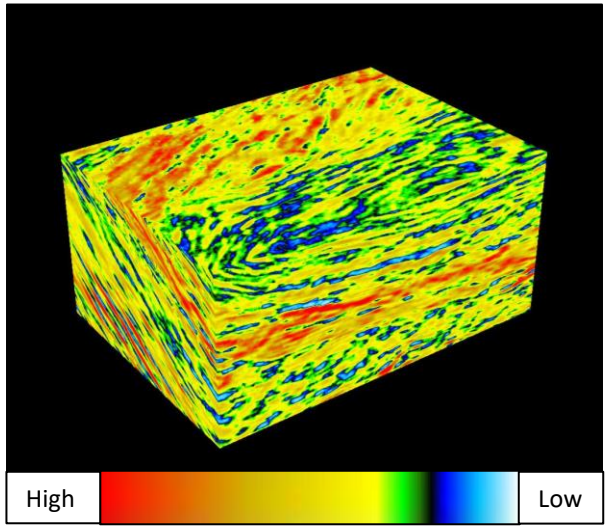
The continuous properties from seismic inversion can be used to derive other key rock properties (Synthetic Example)

P-Impedance



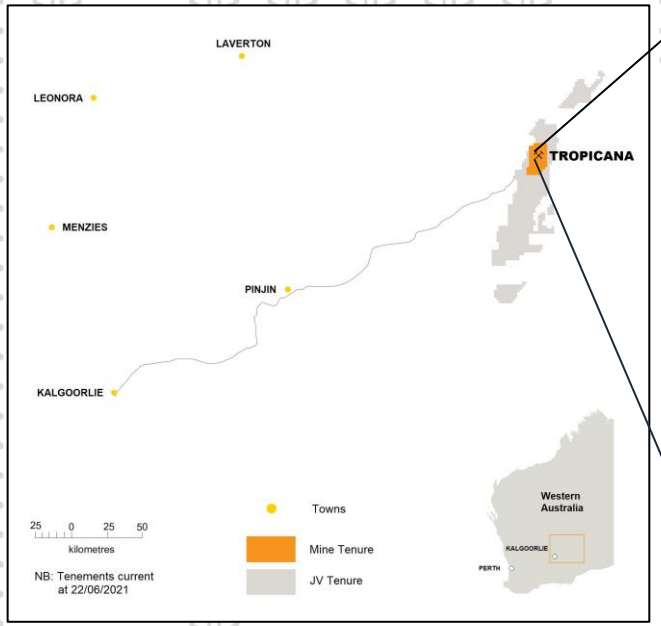


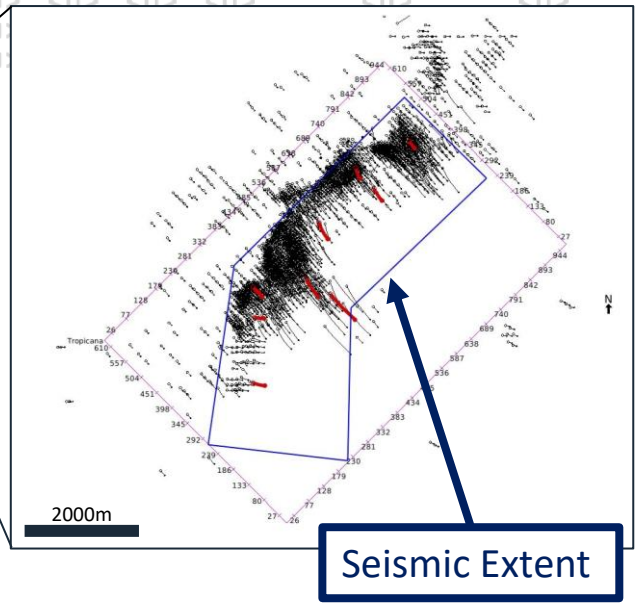
Density



Rock Quality

Intro to Tropicana

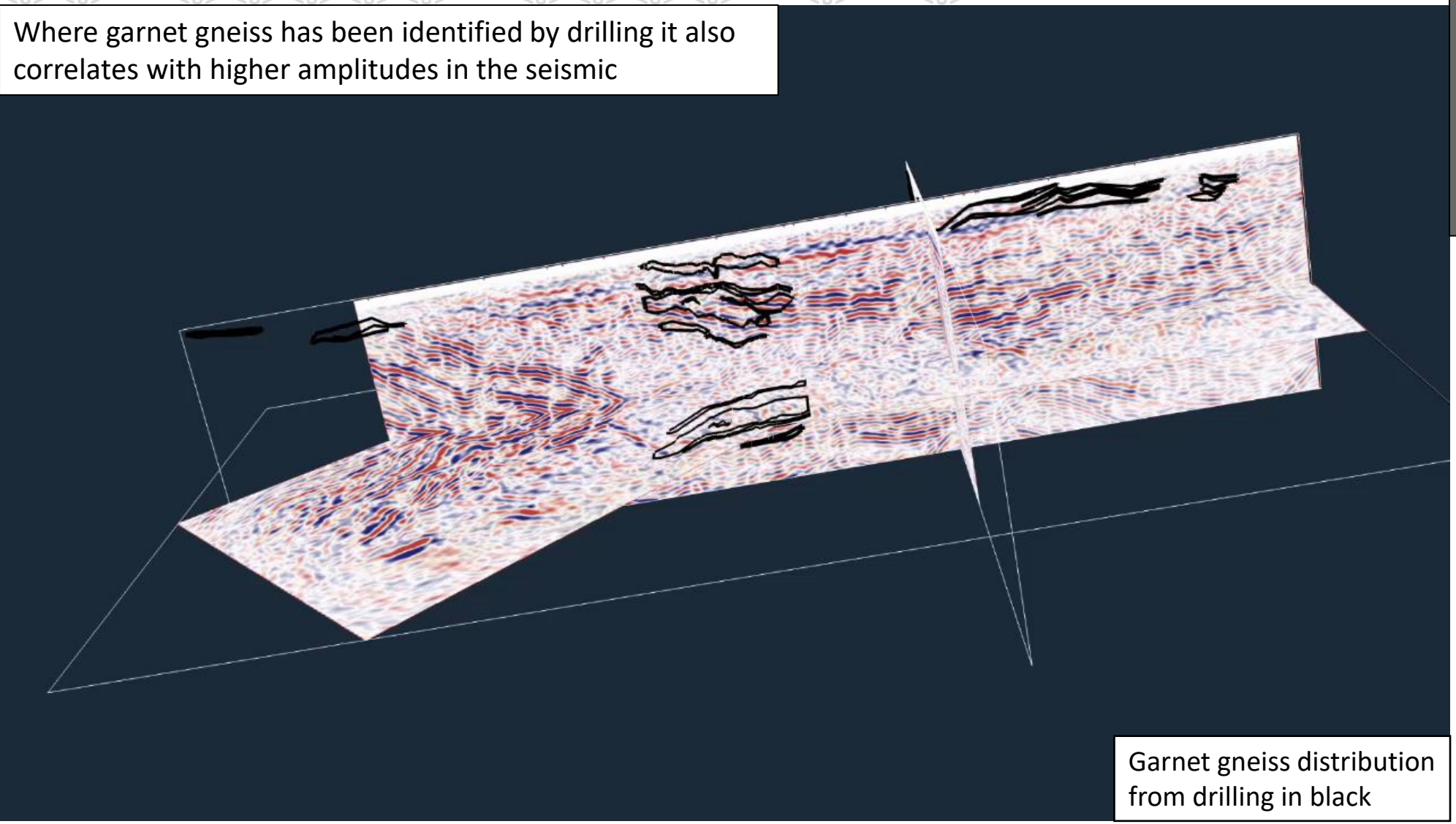




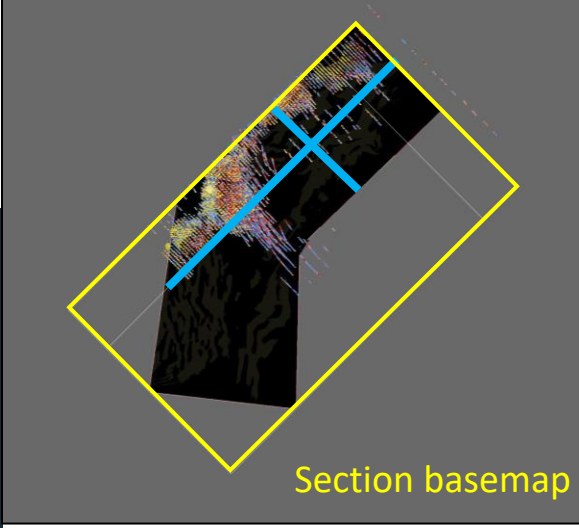
- Tropicana discovered in 2005 following up a gold-in-soil anomaly identified in the 1990s
- 3 deposits identified: Tropicana, Havana and Boston Shaker
- Tropicana Joint Venture Partners: AngloGold Ashanti Australia Ltd – 70% and Manager and Regis Resources Ltd – 30%
- Gold mineralisation hosted in granulite facies quartzo-feldspathic gneiss
- Garnet gneiss in hanging wall of nearby mineralisation so understanding garnet gneiss distribution is key to understanding mineralisation
- 3D seismic surveys acquired in 2014 and 2015, merged and processed as one volume

Tropicana Seismic volume in depth

Where garnet gneiss has been identified by drilling it also correlates with higher amplitudes in the seismic

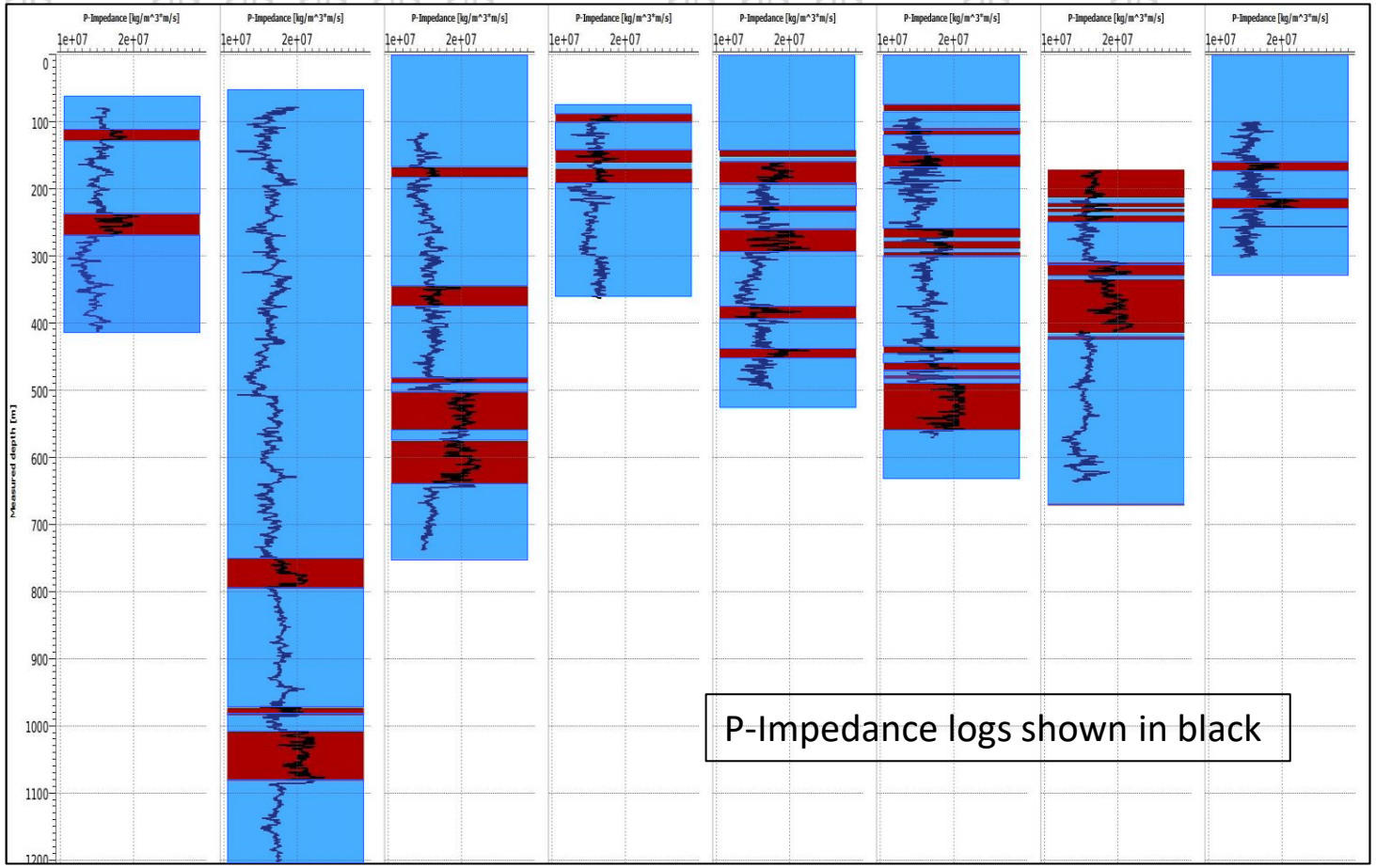


Garnet gneiss distribution from drilling in black

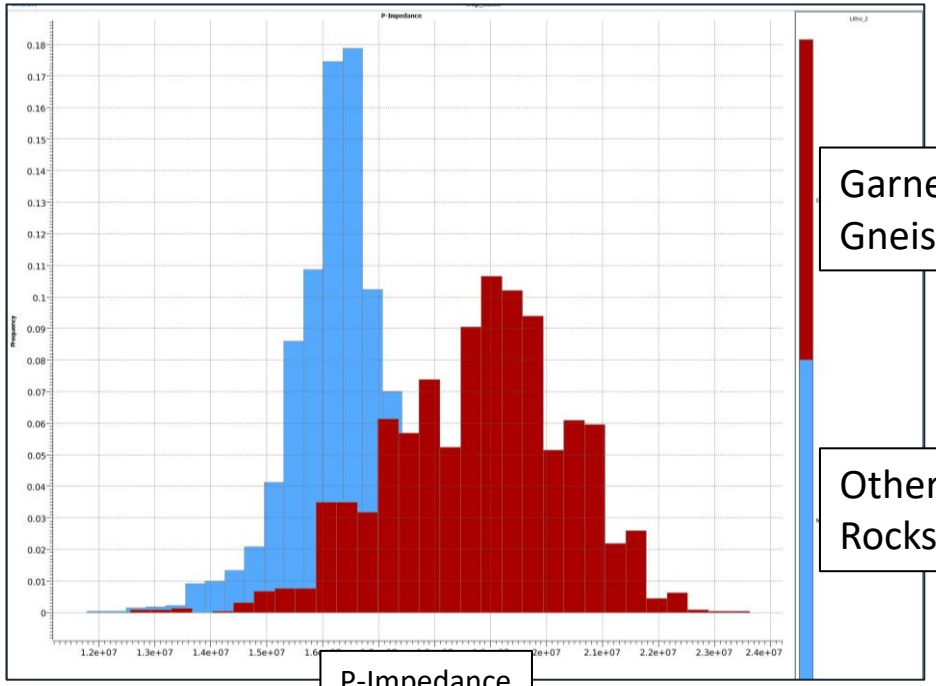


Section basemap

Tropicana Log Properties

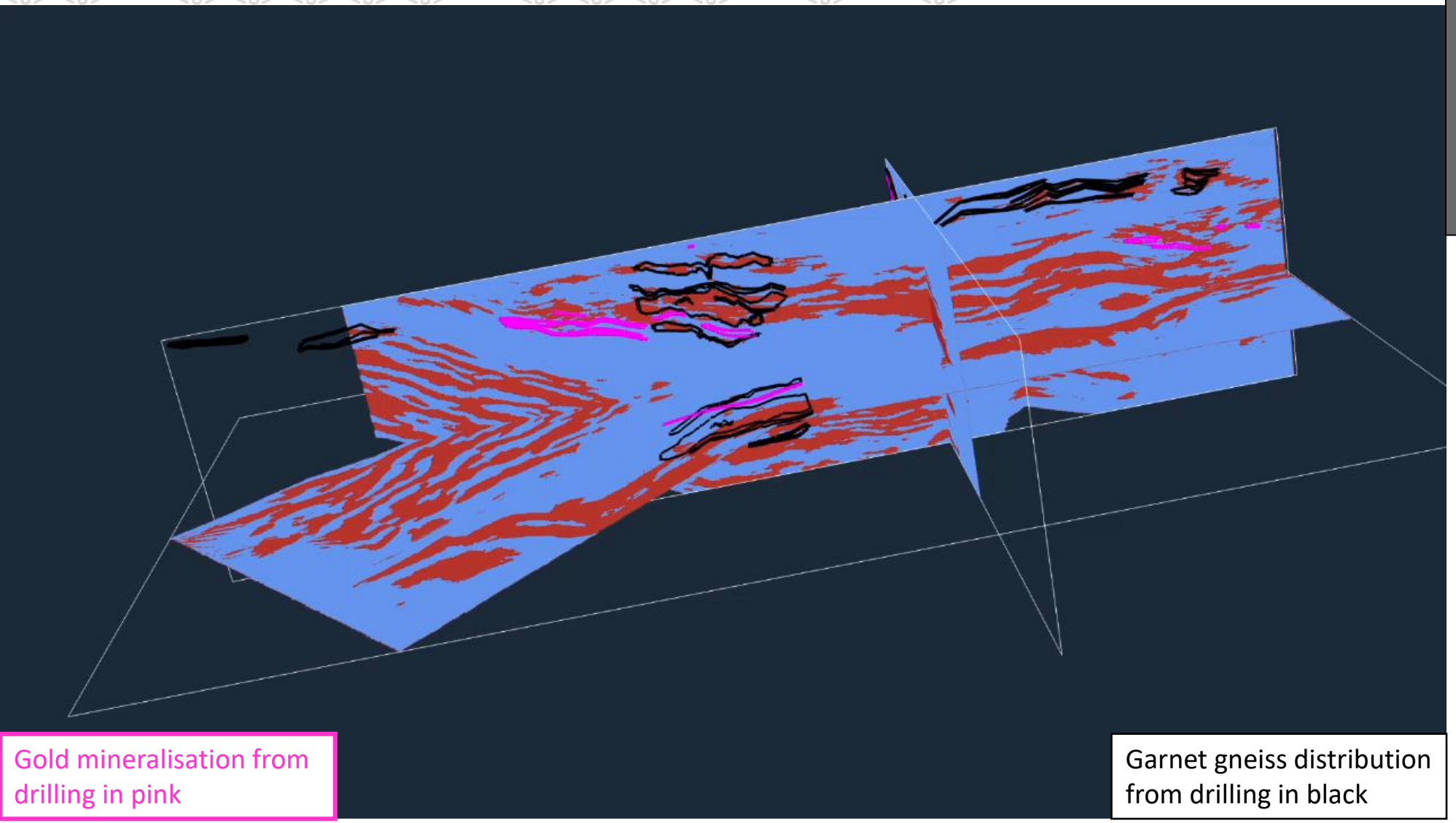


P-Impedance logs shown in black



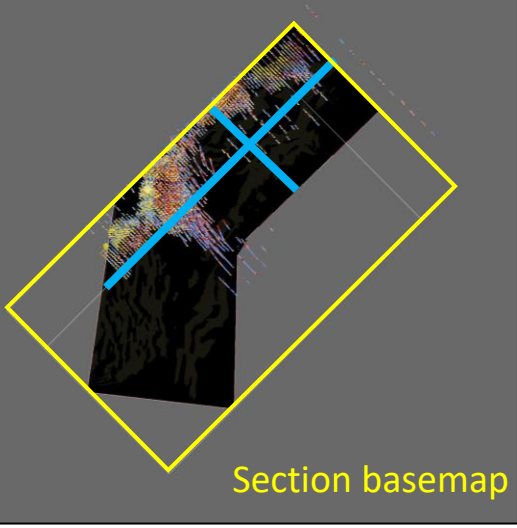
The garnet gneiss has consistently higher P-Impedance than the other rocks.

Most Probable Rock volume in depth



Gold mineralisation from drilling in pink

Garnet gneiss distribution from drilling in black

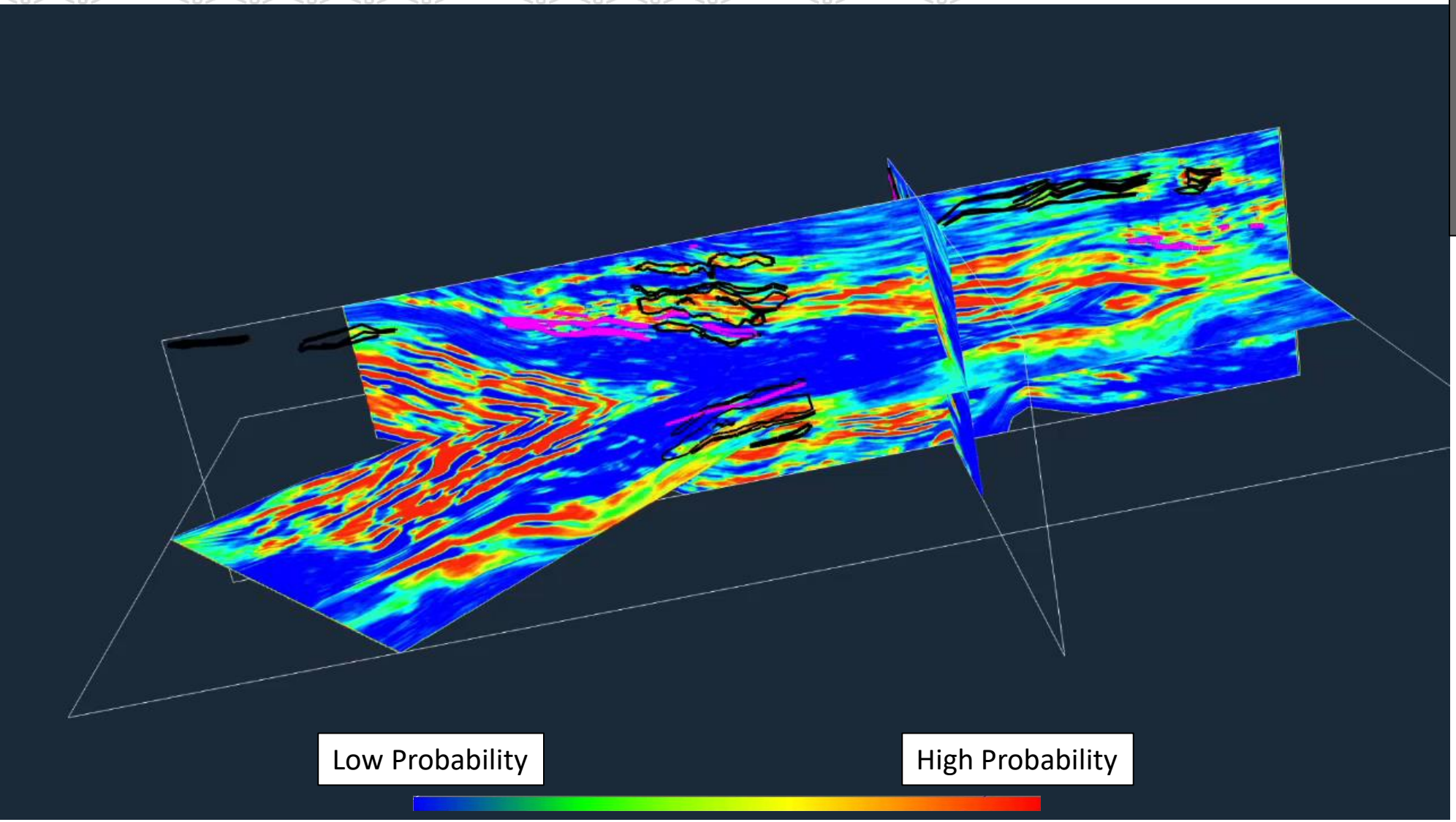


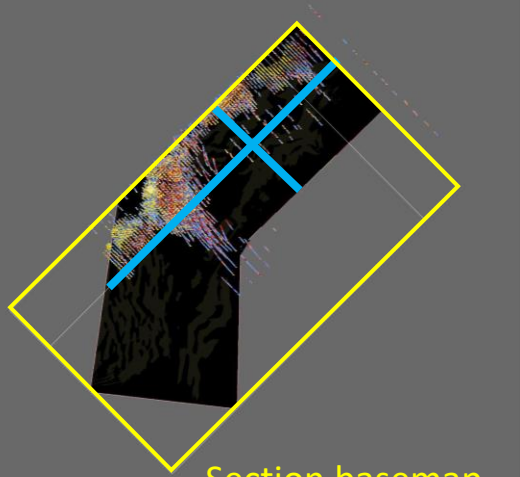
Section basemap

Garnet Gneiss

Other Rocks

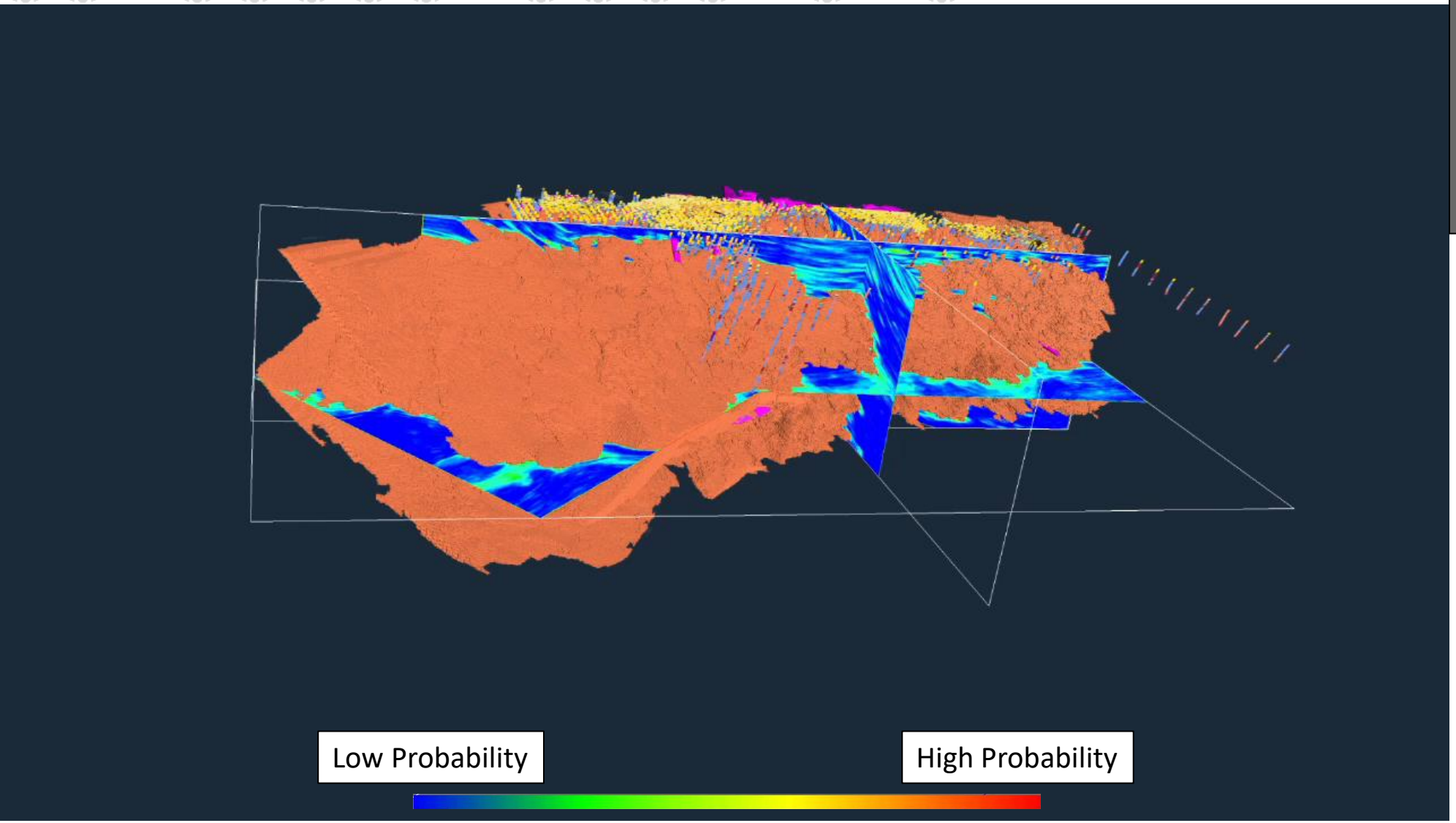
Garnet gneiss probability volume in depth

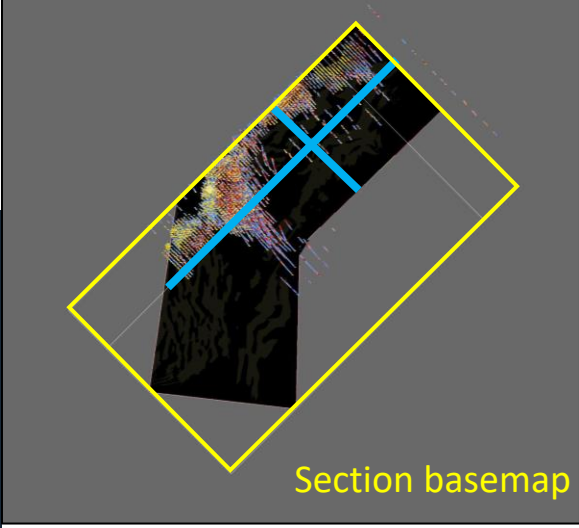




- Garnet gneiss from drilling in black
- Gold mineralisation from drilling in pink
- Garnet gneiss probability volume shows probable occurrence of garnet gneiss in warmer colours
- The volume honours drillhole control and informs between and beyond the drillhole

Garnet gneiss probability volume in depth





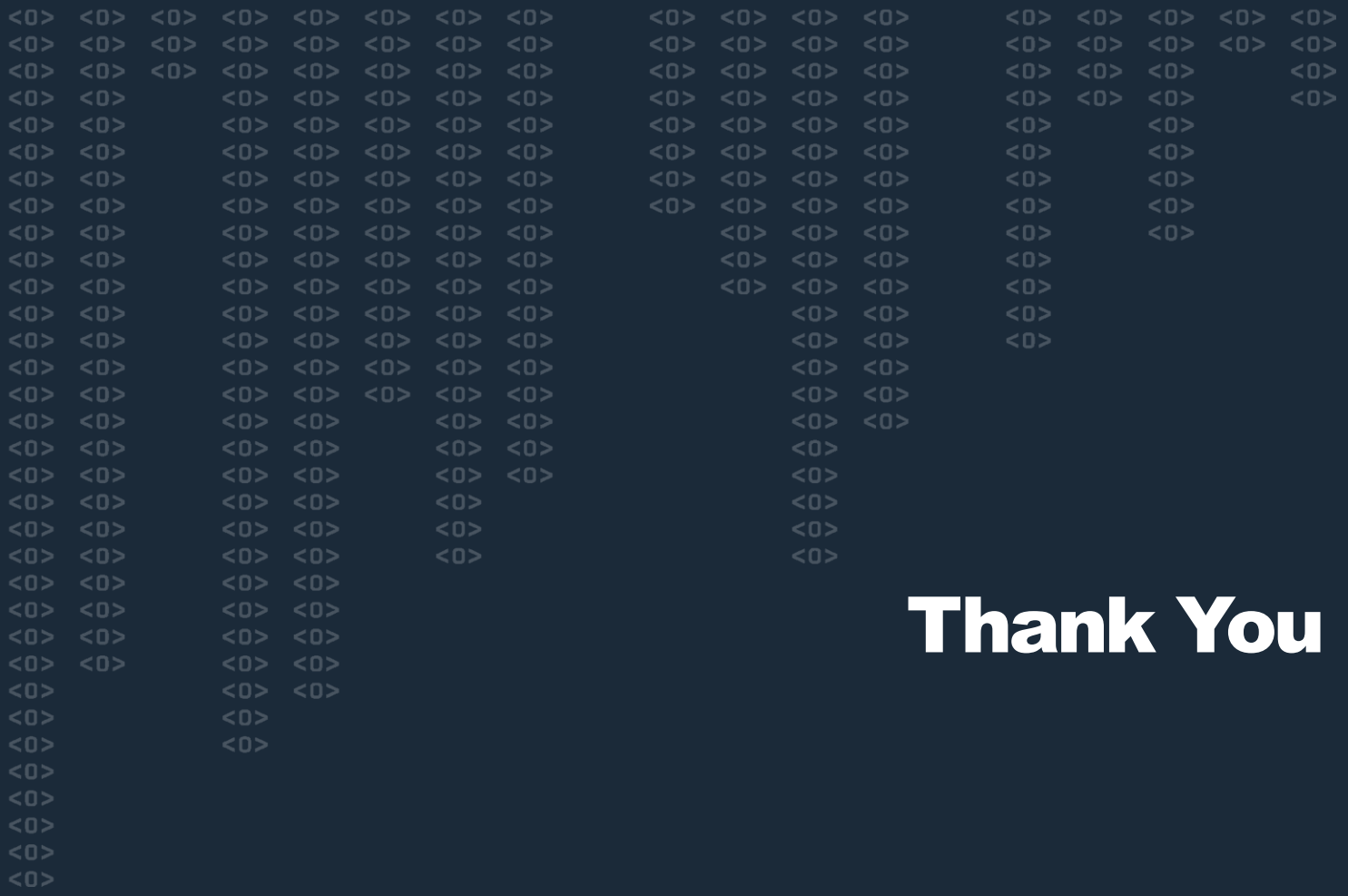
- Gold mineralisation from drilling in pink “shells”
- The brown “shell” represents a cutoff of 0.5 on probability volume

The value of seismic inversion for mining

- The distinctively high P-Impedance of the garnet gneiss enables the creation of detailed data driven rock models, honoring all existing data
- The outputs are continuous volumes of data infilling zones with sparse drilling
- The results enhance the understanding of rock type distributions and spatial variability providing a better understanding of controls on mineralisation and future drill targets
- The inversion results have the potential to influence prediction of geotechnical properties.

Acknowledgements

- The Tropicana Joint Venture Partners (AngloGold Ashanti Australia Ltd – 70% and Manager and Regis Resources Ltd – 30%) gave us access to the extensive Tropicana Gold Mine dataset (seismic and drillhole).
- CGG GeoSoftware provided the software used for this work



Thank You