Resource Potentials
Mineral Exploration Technologies

Passive seismic surveying for paleochannel mapping with an emphasis on SOP brines, secondary U deposits and alluvial gold deposits

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Why explore for paleochannels?

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- Mapping paleochannels in order to:
  - Find specific mineral deposits (such as secondary U, alluvial Au, potash and Li brines, coal, etc.) contained in paleochannels and shallow sedimentary basins
  - Avoid deep cover and paleochannels when exploring for bedrock mineral targets, i.e. collecting geochemical samples and/or carrying out drilling using a rig that cannot penetrate to the base of the paleochannel deposits

Why passive seismic?

- Other methods commonly used to map paleochannels:
  - EM – probably the most common method, but requires electrical contrast and may not penetrate very conductive layers
  - Gravity – rapid and effective, but depth and geometry can be ambiguous
  - Seismic reflection or refraction – very slow and costly, logistically difficult, and struggles to detect actual depths due to diffractions
  - High resolution magnetics – only where underlying basement rocks are magnetic, and even then depth is ambiguous
  - IP – generally ineffective, slow and expensive, but in moderately resistive settings it can work
  - Drilling!

- Each method can work together to overcome disadvantages

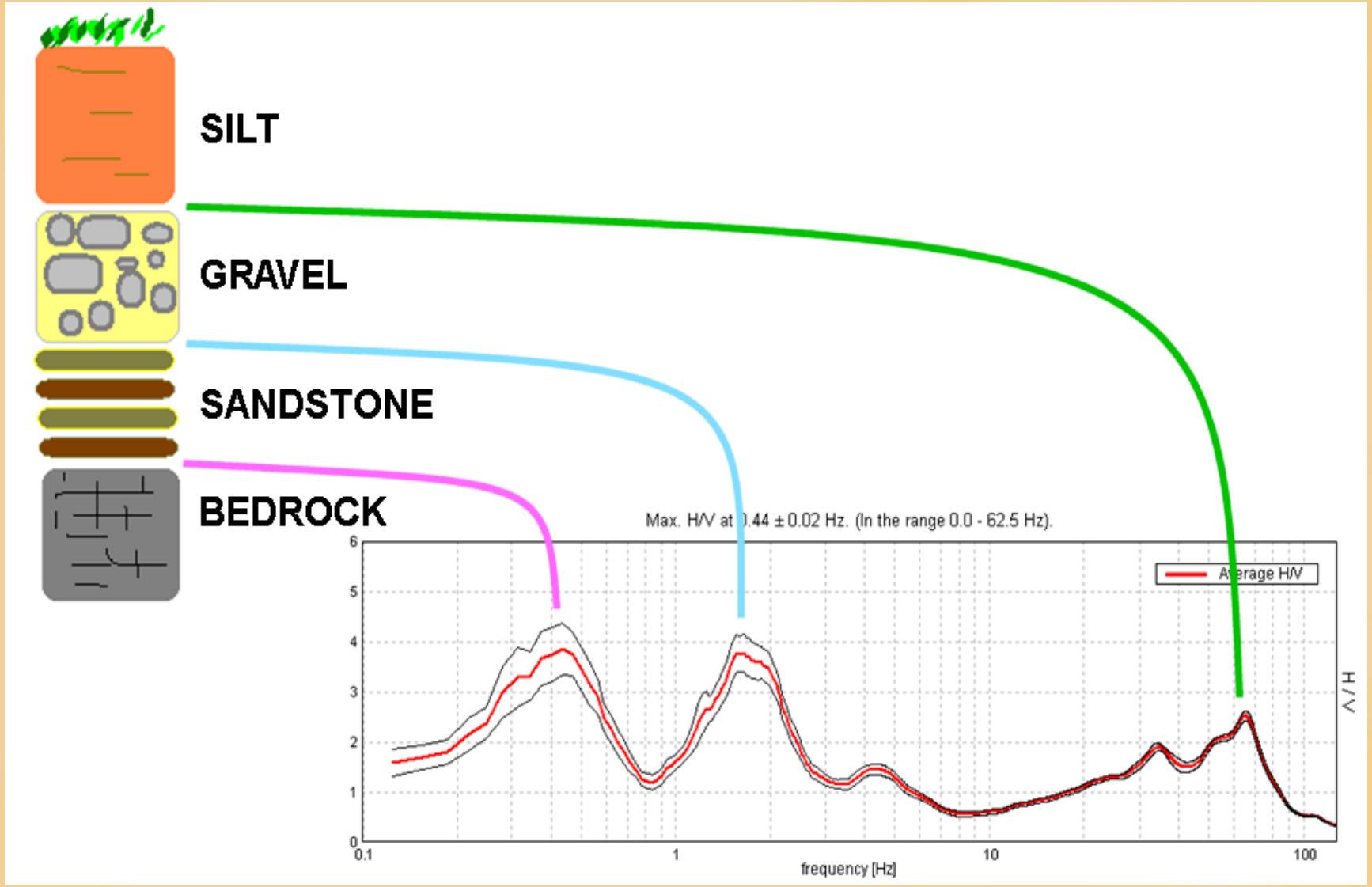
Advantages of passive seismic

- Tromino passive seismic has clear advantages:
  - Fast – easily to acquire up to 80 readings a day with two-man crew, and quick data processing turn around
  - Simple – don’t need to be a geophysicist to use the instrument
  - Reliable – while amplitudes may vary from day-to-day, the peak frequency remains consistent
  - Lightweight – can carry them with you on a plane
  - Powered by 2 AA batteries
  - QC and initial processing software comes with the instrument
  - Cheap!
- Tromino surveying for depth of cover mapping will become a common tool for mineral exploration programs – part of every exploration geologist’s toolkit!

What are we looking for in the PS data?

- Main objective is to detect a high amplitude, low frequency H/V peak corresponding to the paleochannel sediment-bedrock interface

- Multiple H/V peaks are possible, with higher frequency peaks caused by layering within the paleochannel deposit sequence



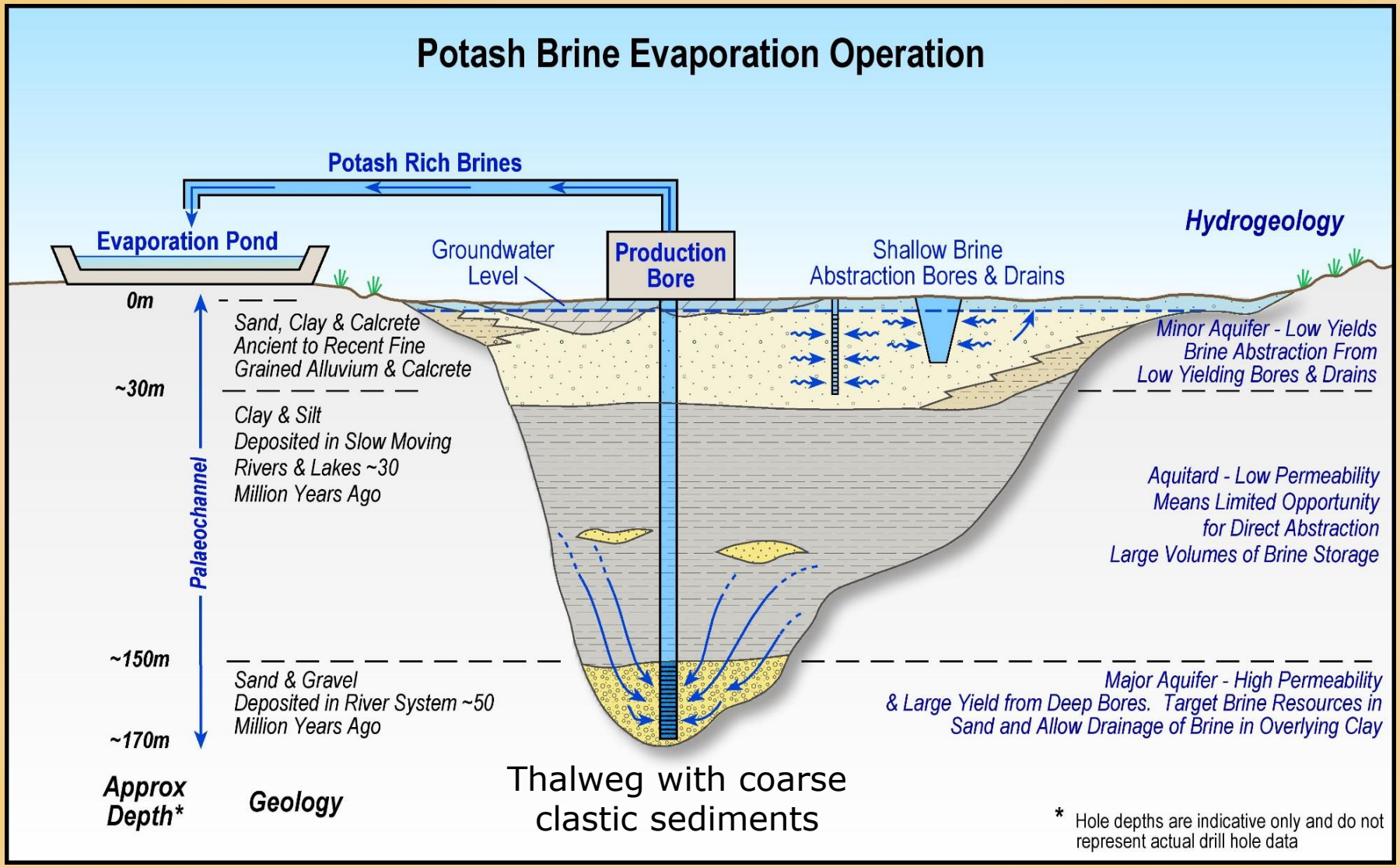
Modelling the data

- 1D velocity modelling is carried out so that the shape of the velocity model roughly matches the measured H/V amplitude vs frequency profile. A model can be manually produced for each field reading, but this is a very slow process and should only be done on a selected number of readings.

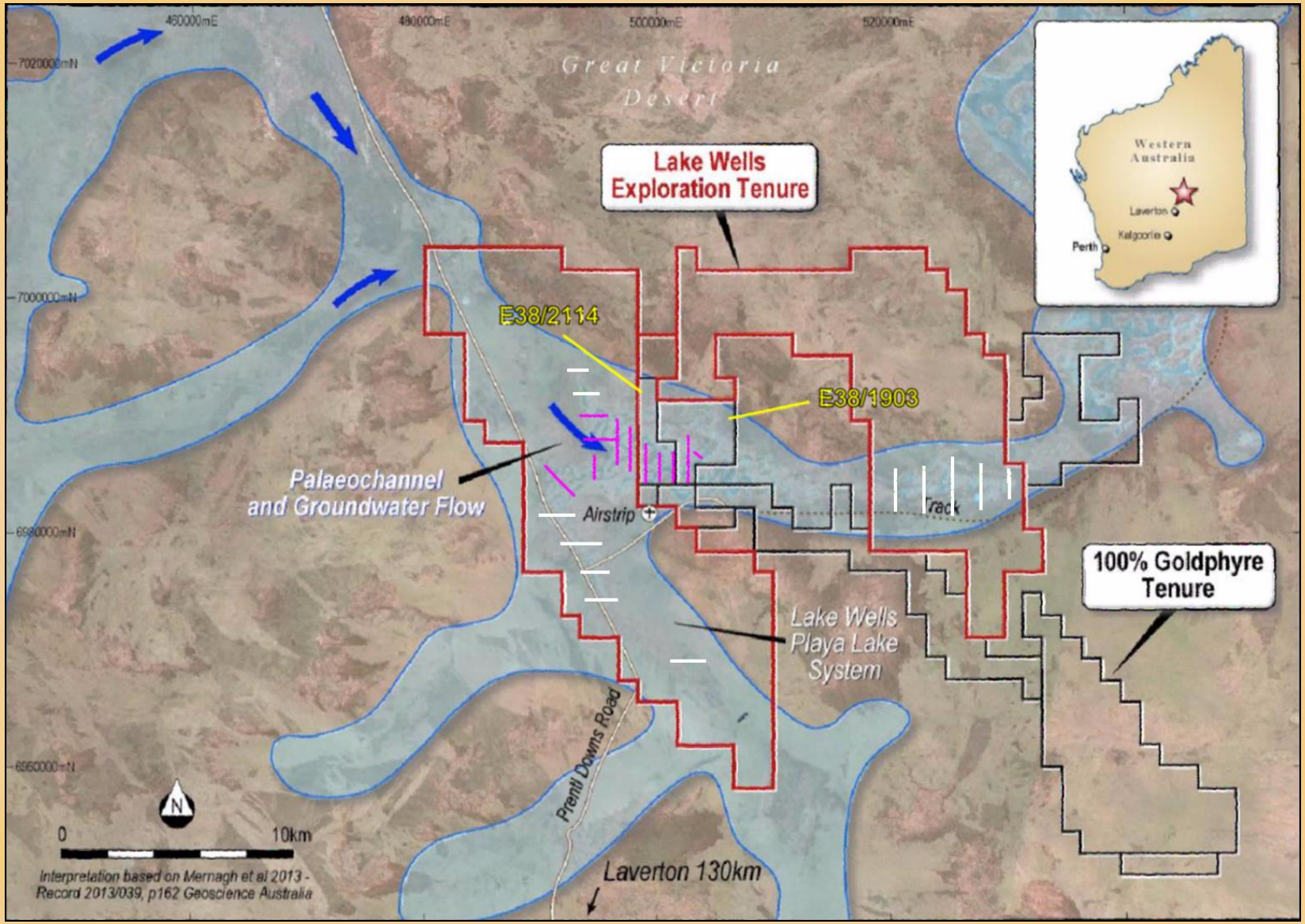
- Taking readings at drillhole locations where the depth to geological horizons are known from DH logs, allows the generation of a power law equation which can then be used for estimating depths away from drillholes

- The final result is a depth vs shear wave velocity profile for a particular reading, set of readings forming a survey transect which can be displayed as frequency profiles or preferably as depth cross sections, or a grid of survey transects or readings to generate a subsurface bedrock depth or elevation map which can be contoured to show the paleochannel geometry in 3D

Potash brine model

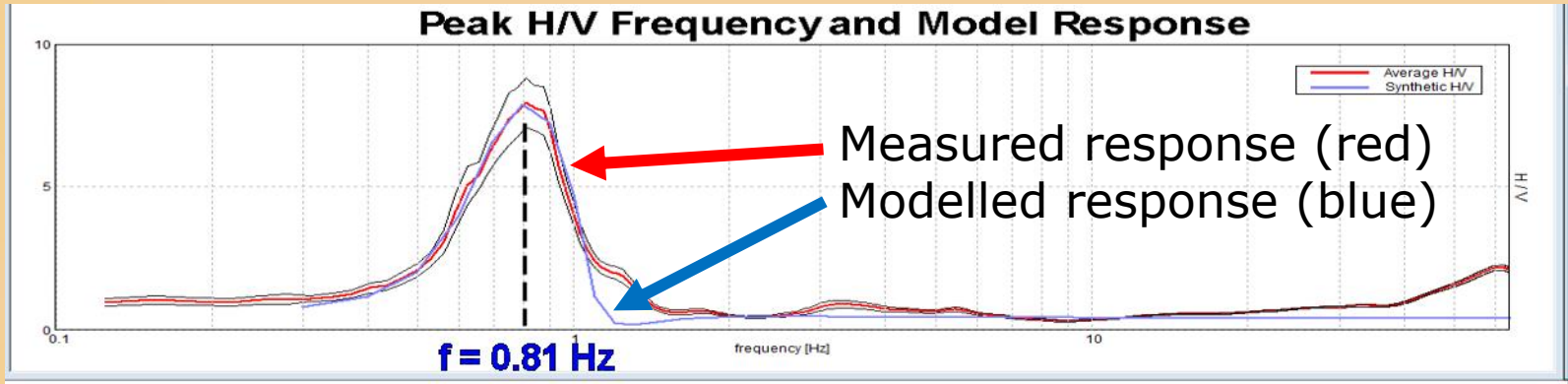


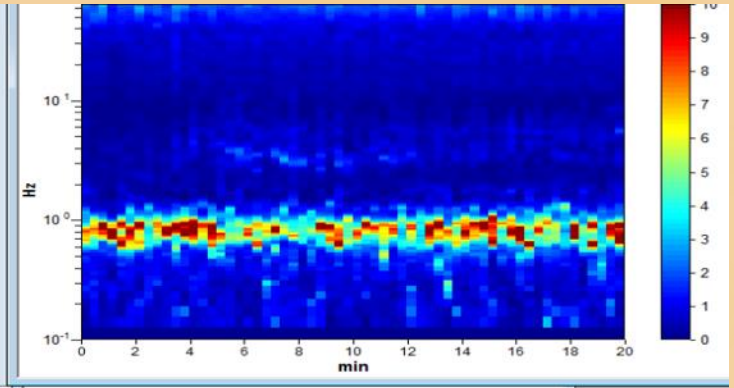
Simplified GA Paleochannels at Lake Wells

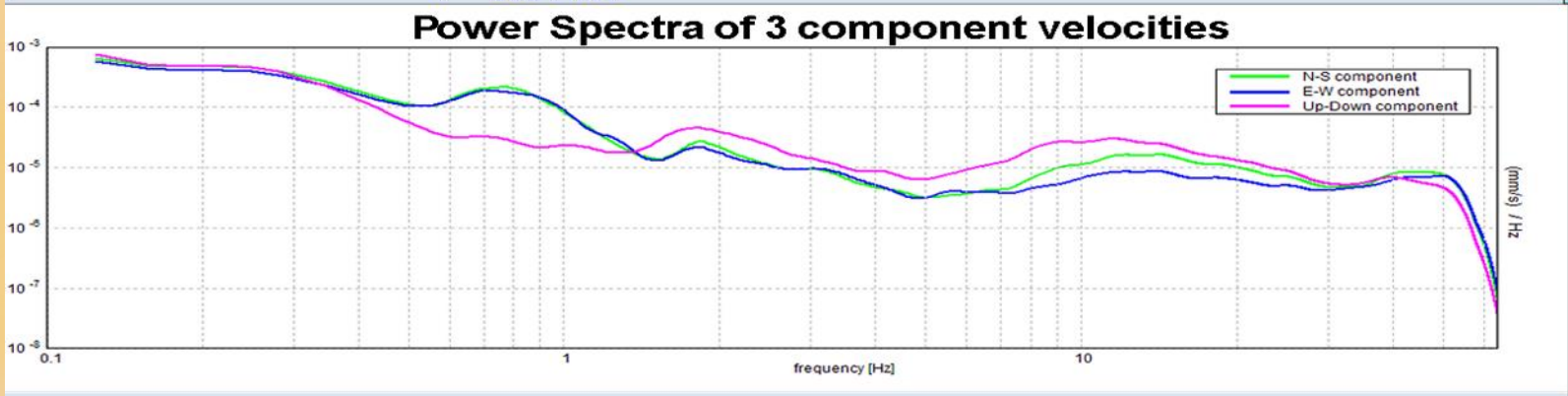


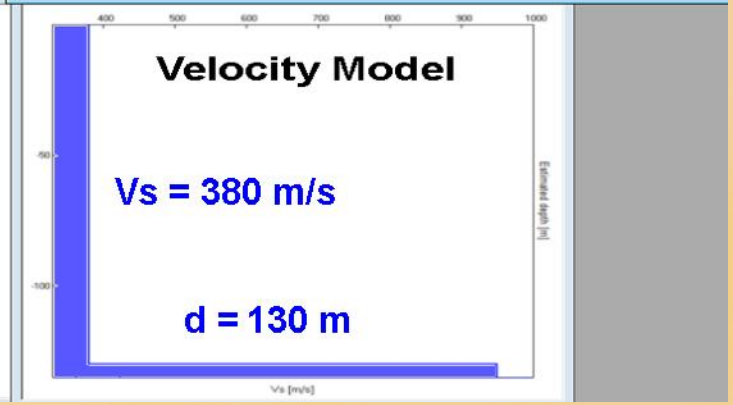
Lake Wells passive seismic survey

- Target is the sediment-bedrock interface beneath a salt lake playa and adjacent alluvial deposits
- A strong impedance contrast gives rise to a high-amplitude peak H/V response
- Modelled depths tied to existing drilling lead to the creation of a depth-to-bedrock map, highlighting deep paleochannel axes (thalwegs) and “pinch-points” where higher water flow rates deposited coarse grained sediment facies



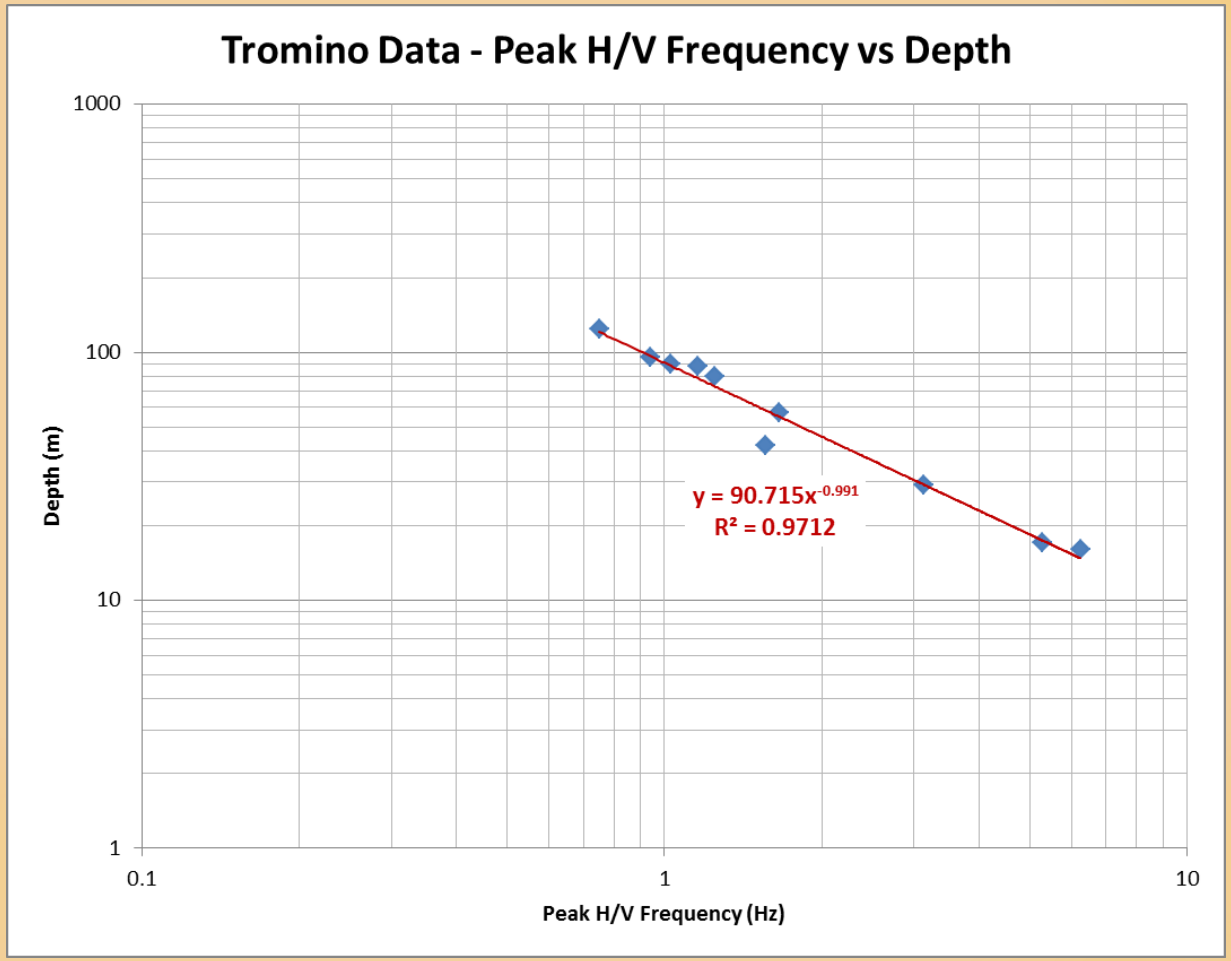






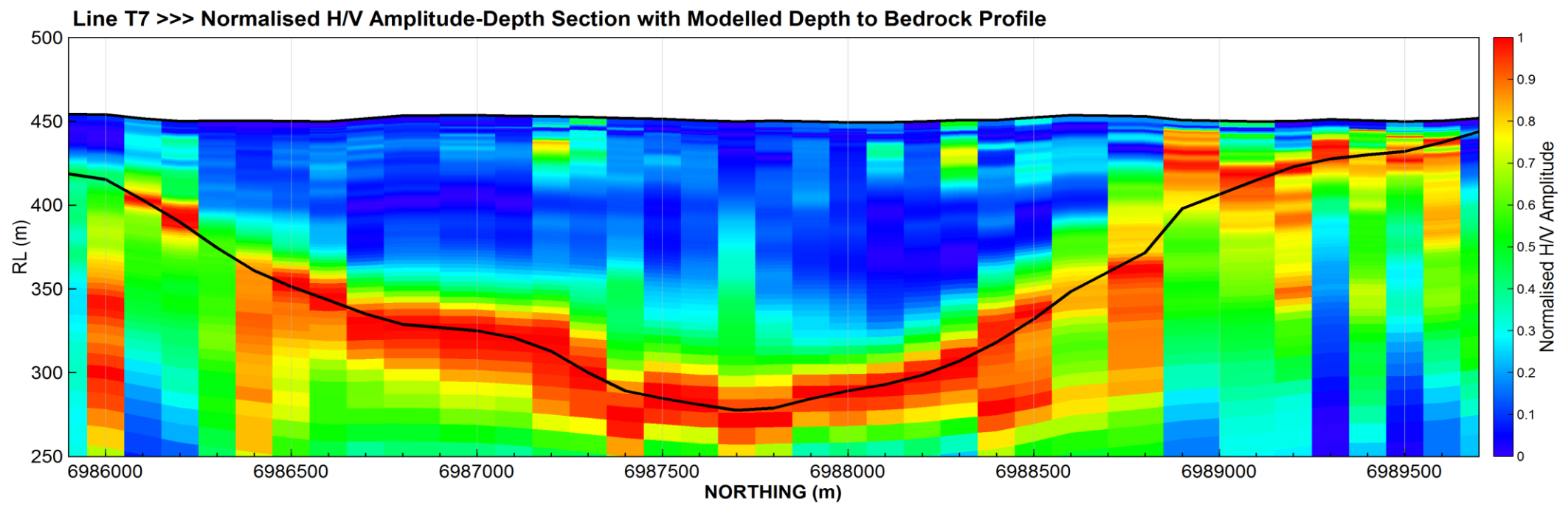
Other Depth Calculations

- Calibration of peak frequency to bedrock depth from drilling
- Equation generated a for depth estimation away from drillholes
- This equation accounts for increasing velocity with depth laterally due to compaction and cementation



Lake Wells paleochannel

- Cross-section plots show distinct shape of paleochannels hidden beneath salt lake playa and adjacent alluvial deposits
- Final depth to fresh bedrock estimate was acquired at a minute fraction of the cost and time it would take to complete a fence of drilling or conventional seismic reflection program, it penetrated conductive salt lake deposits and groundwater where EM and IP surveying would not penetrate, and gravity is ambiguous in terms of depth estimates and channel geometry

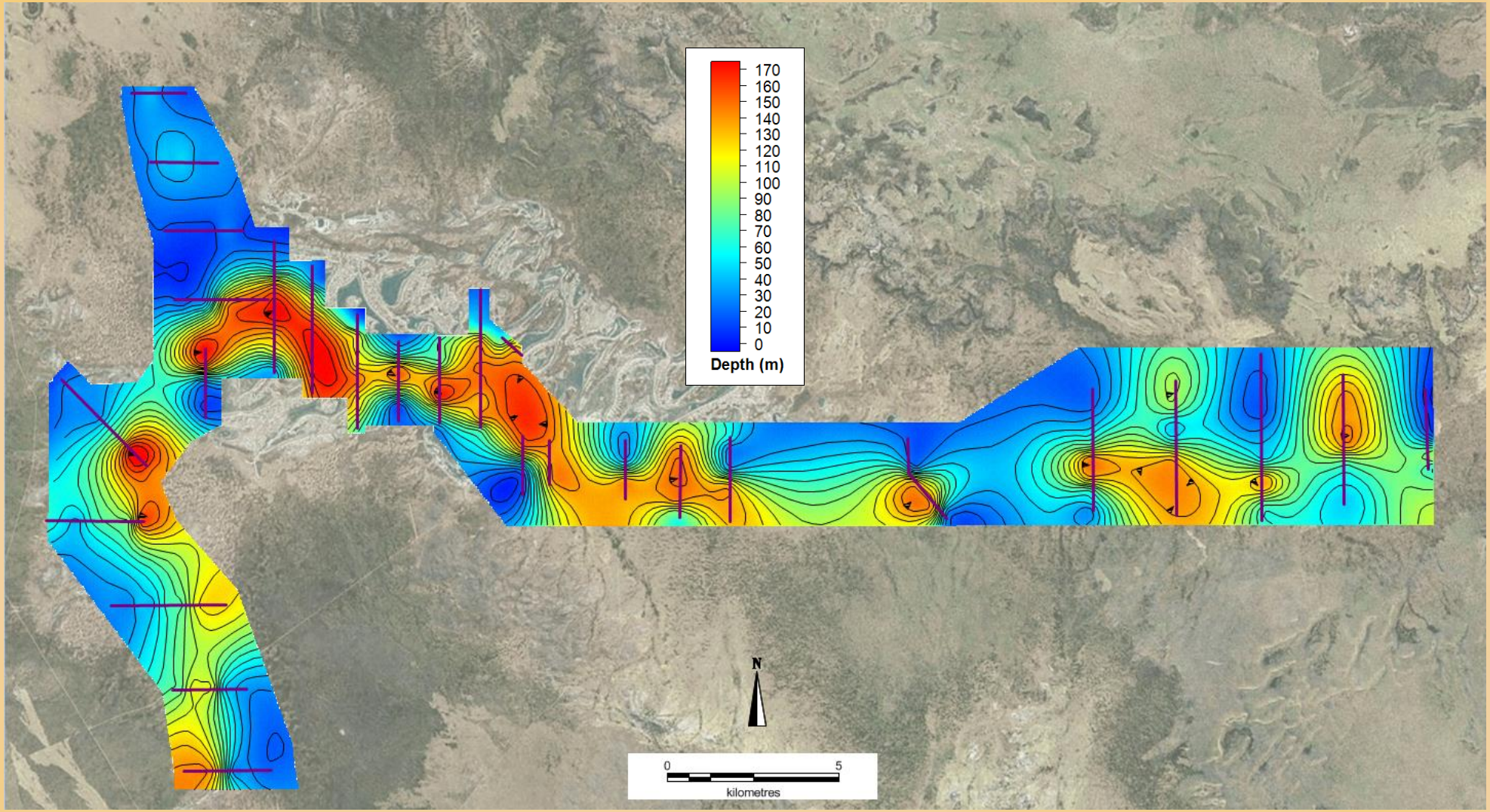


Courtesy of Goldphyre Resources Ltd (ASX: 15/12/2015)

Lake Wells Potash Project

- Mapping deep paleochannel axis below a salt lake

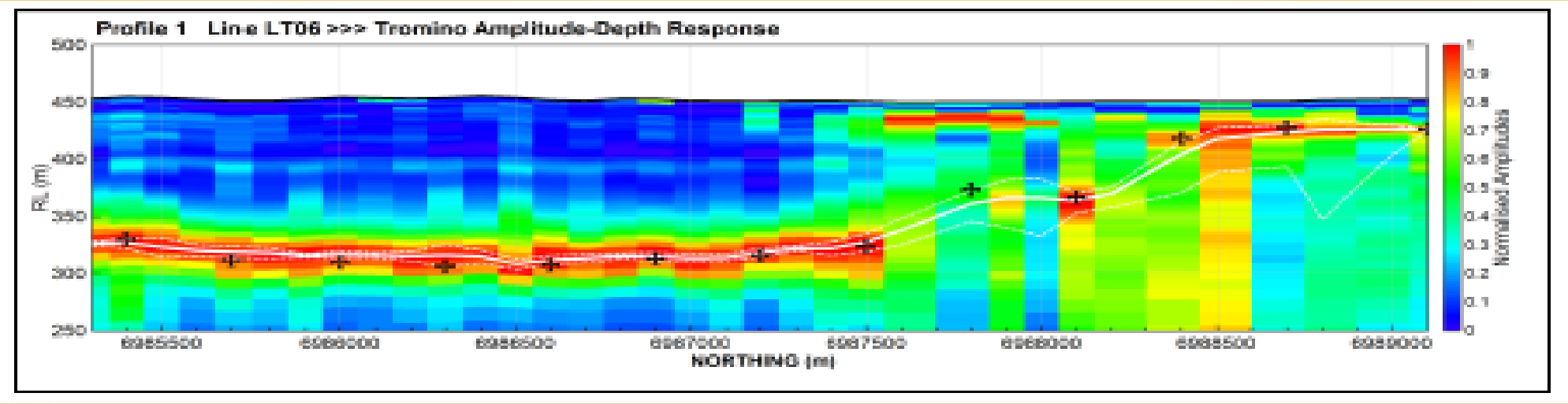
  Applications for alluvial mineral deposits, paleochannel uranium and potash deposits, ground water, lignite deposits, etc.



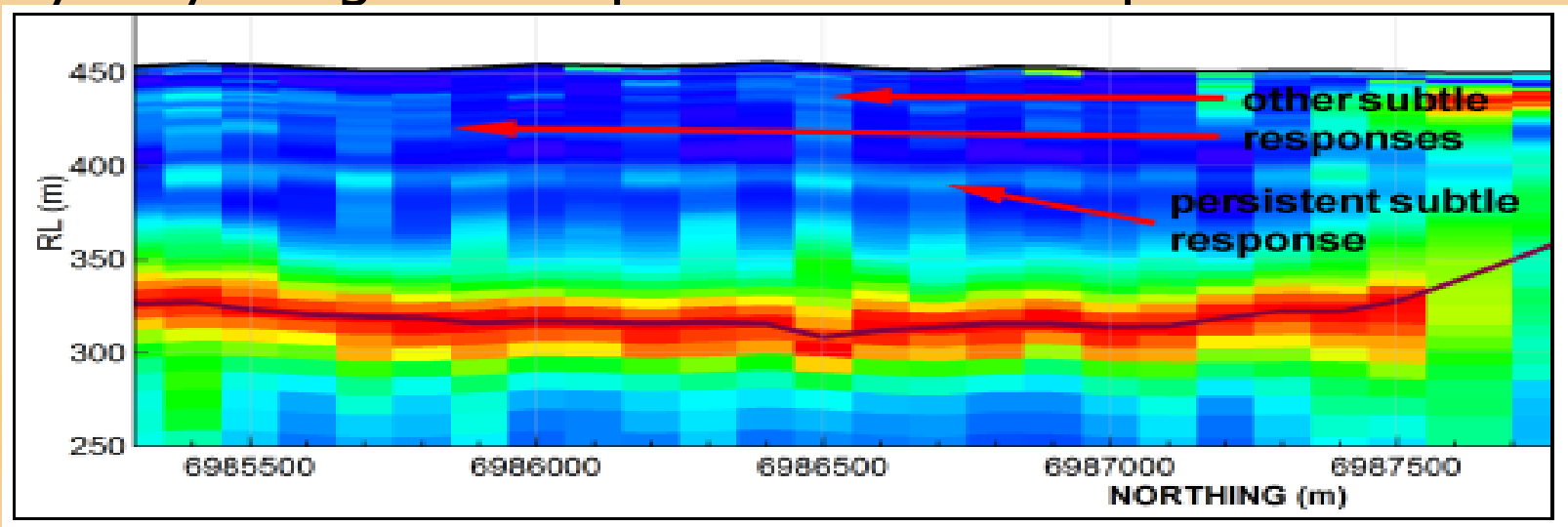
Courtesy of Goldphyre Resources Ltd (ASX: 15/12/2015)

Lake Wells paleochannel

- Different depth estimation methods provide similar results

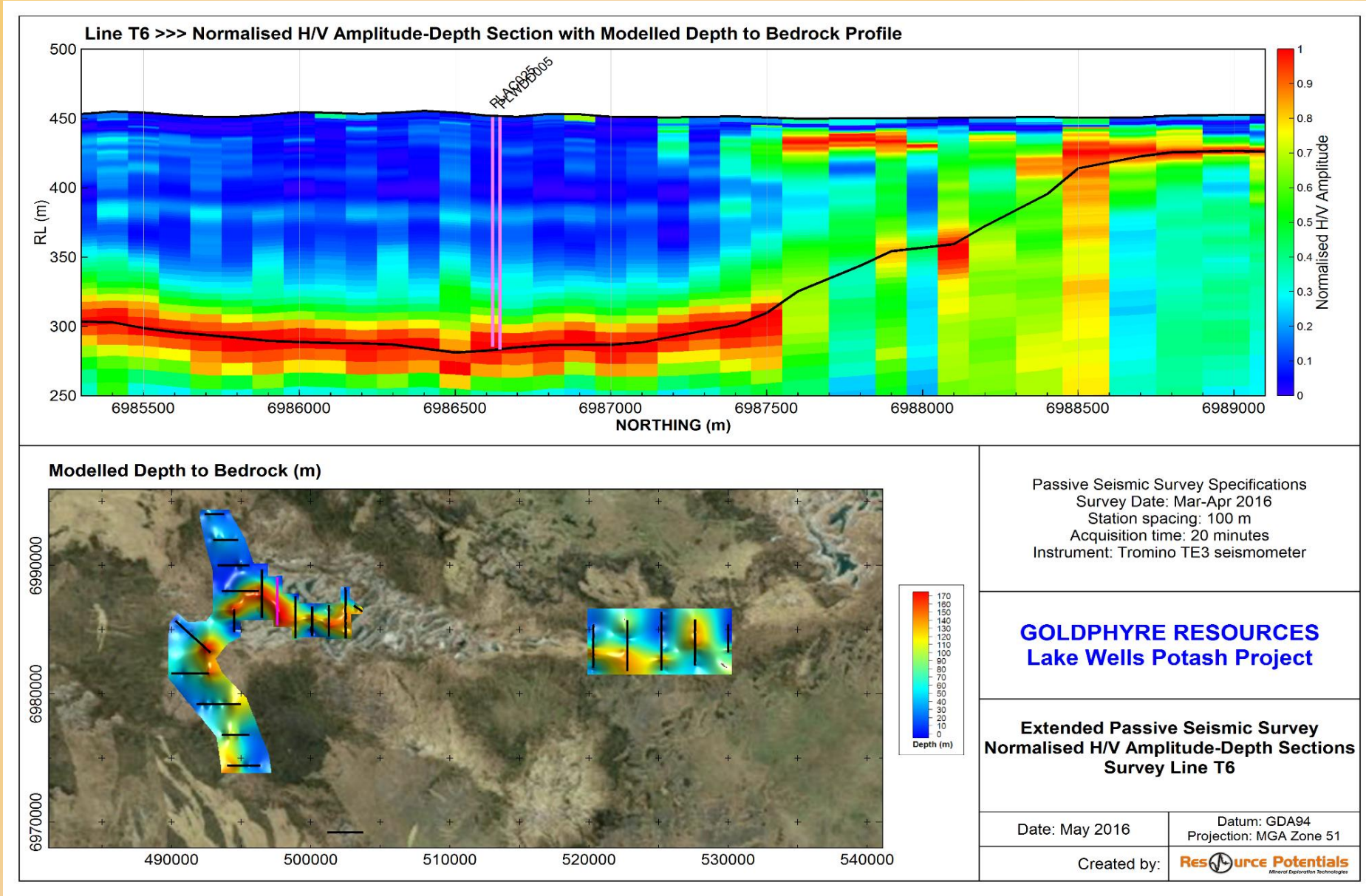


- Cross-section plots with frequency response shows some sedimentary layering within paleochannel deposits



Lake Wells paleochannel

- Then proved with drilling
- Mapping deep paleochannel central axis used to locate new (high cost) rotary mud drillholes
- Coarse grained reservoir hit at the base of two 167 m deep drillholes



Lake Wells paleochannel in 3D

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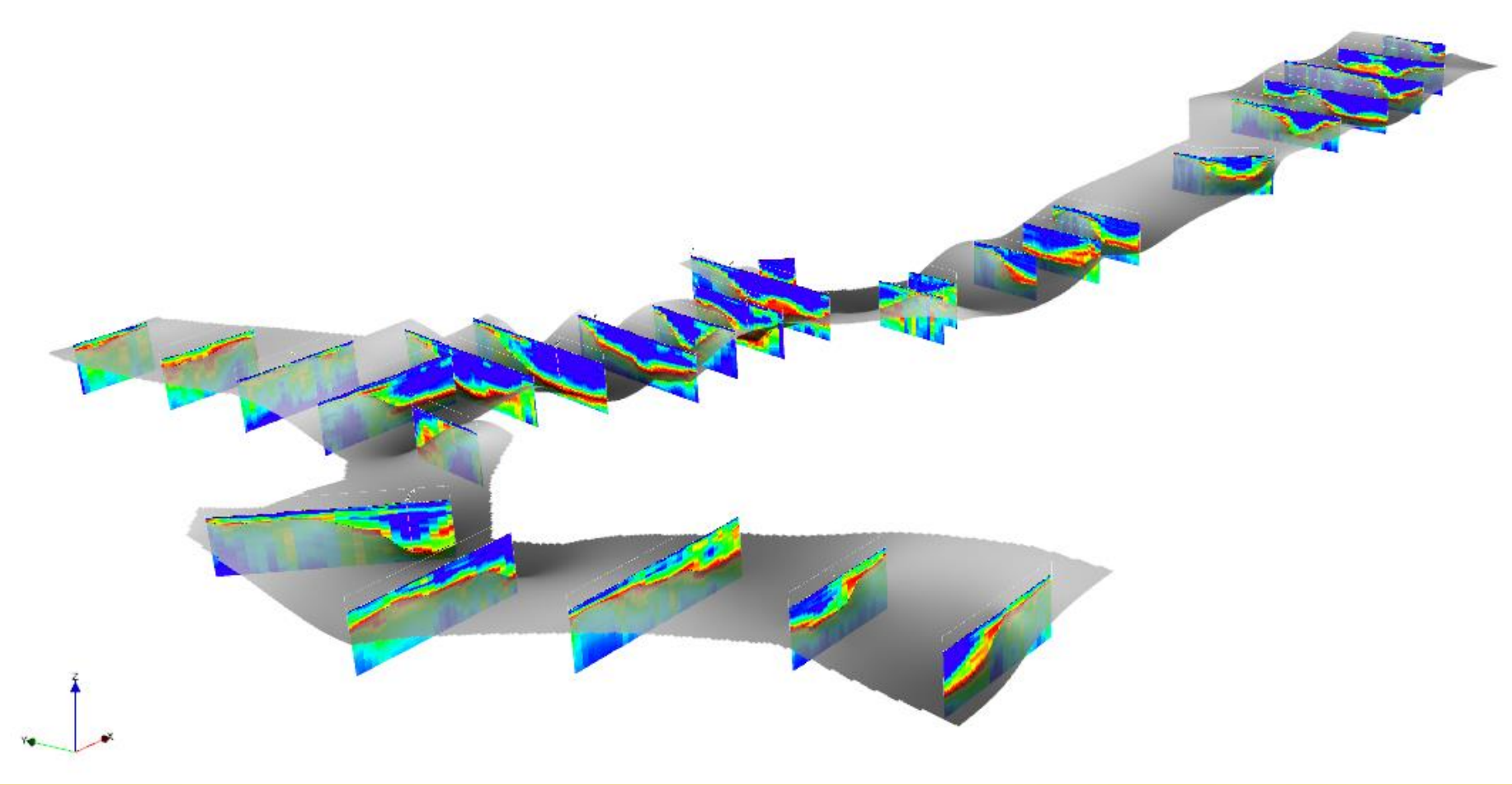
- Paleochannel represented in 3D, with estimated base of channel surface, which can also be used for estimating paleochannel deposit volume and contained pore water volume for brine target estimation



Lake Wells paleochannel in 3D

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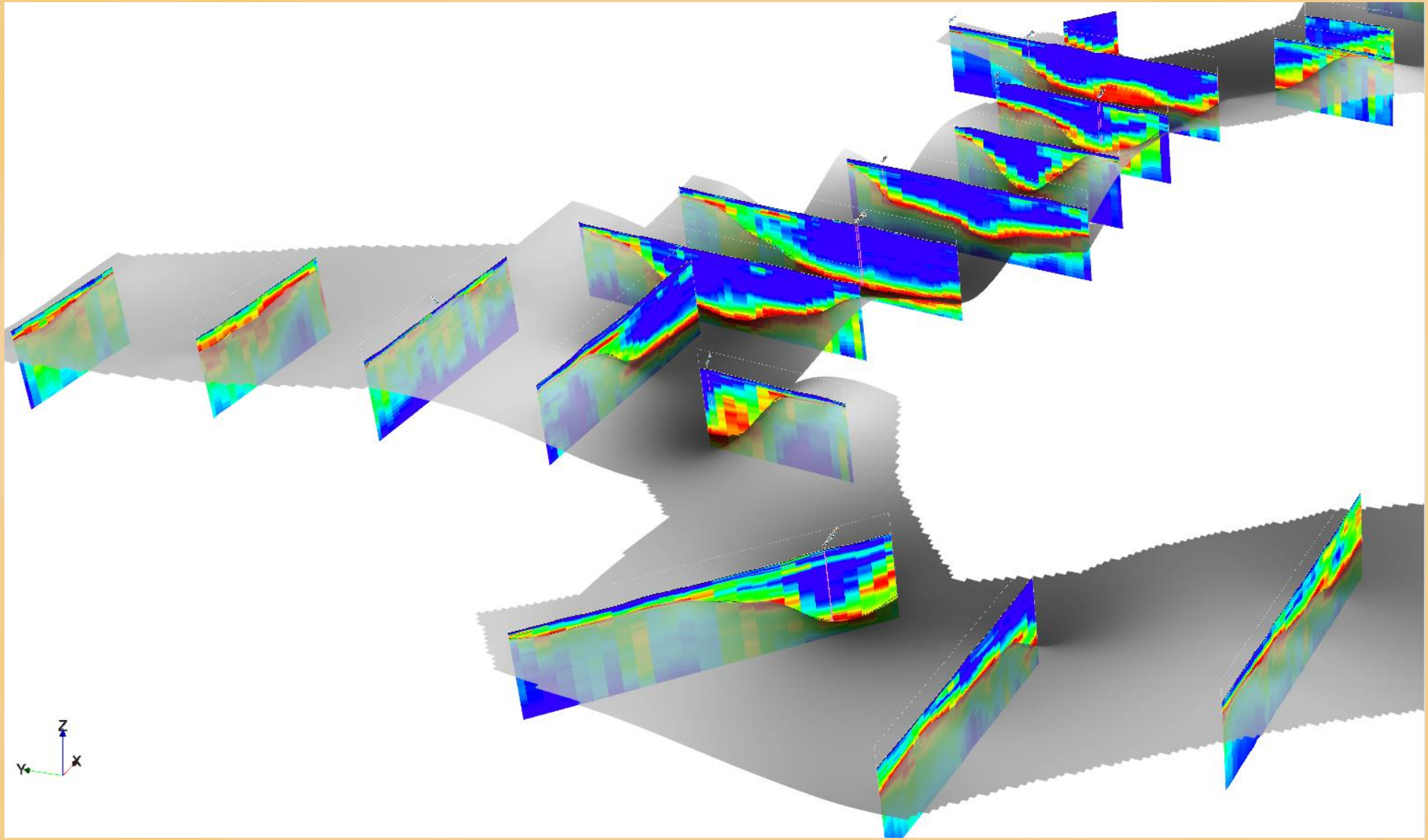

Lake Wells paleochannel in 3D

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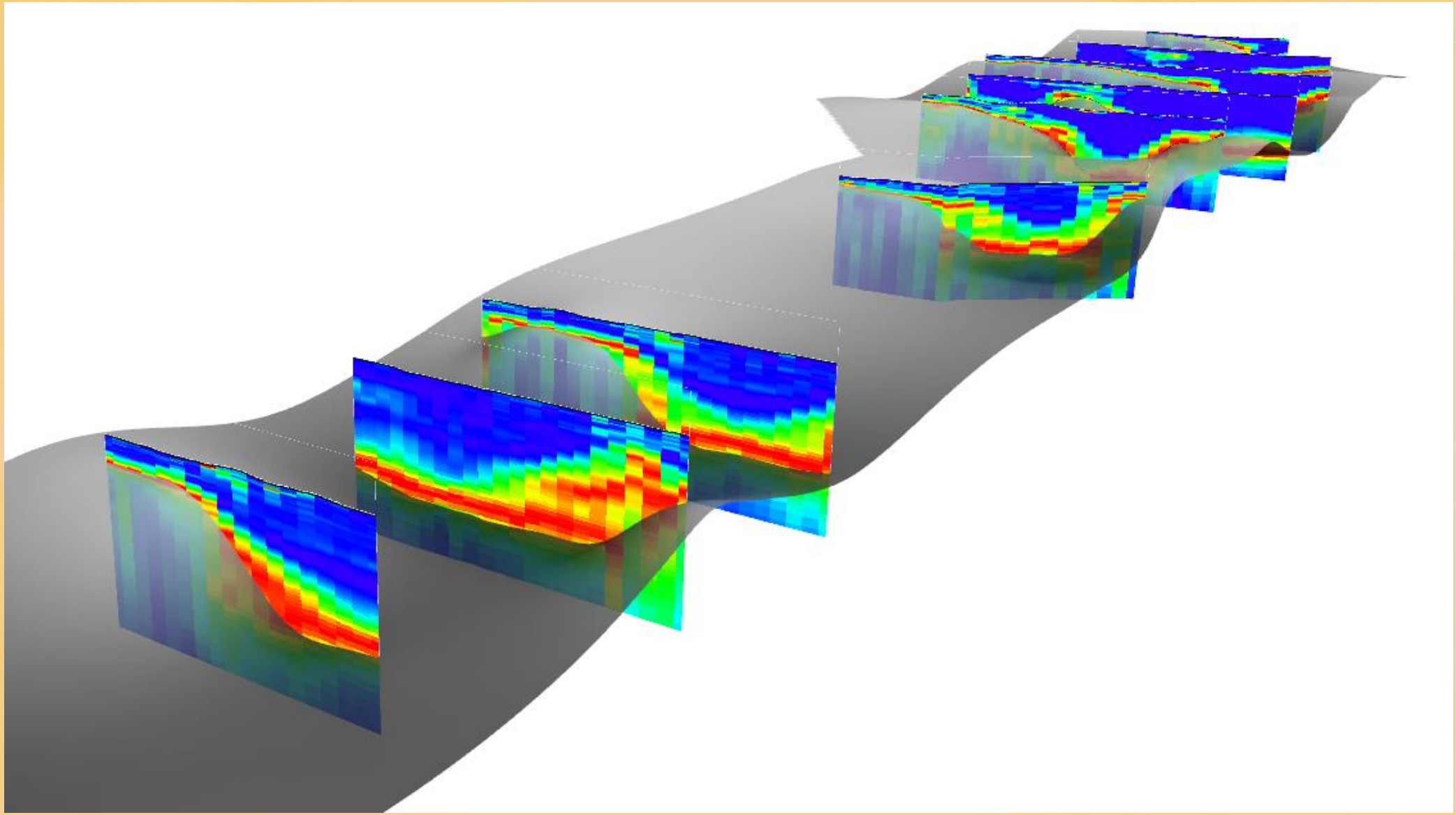

Manyingee secondary U deposit

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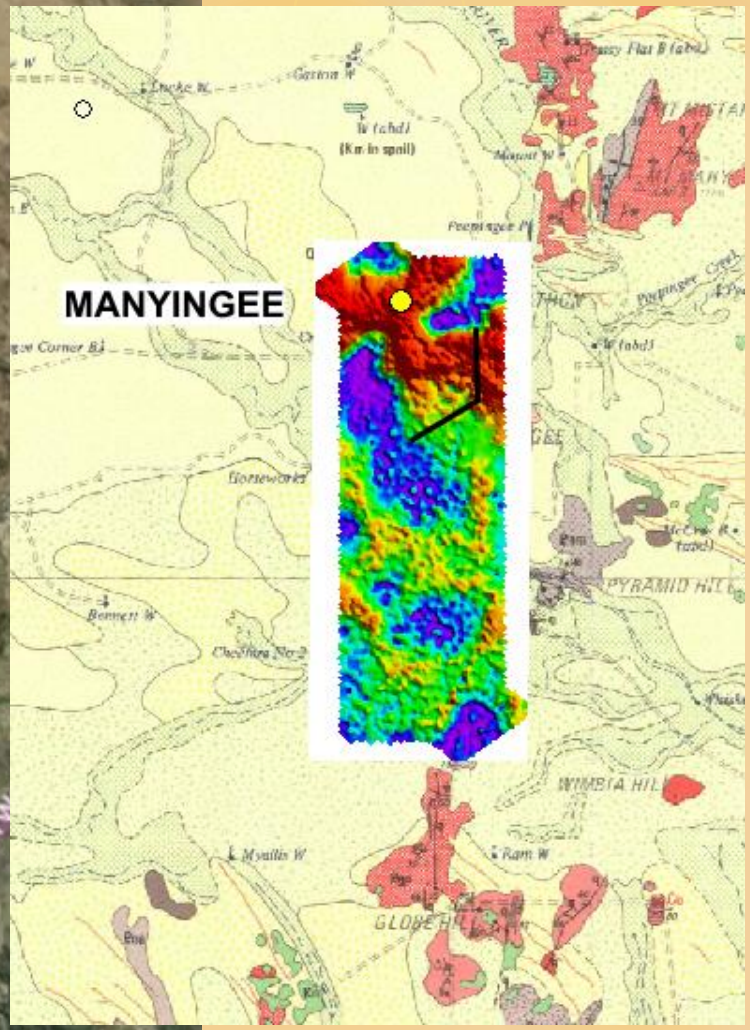
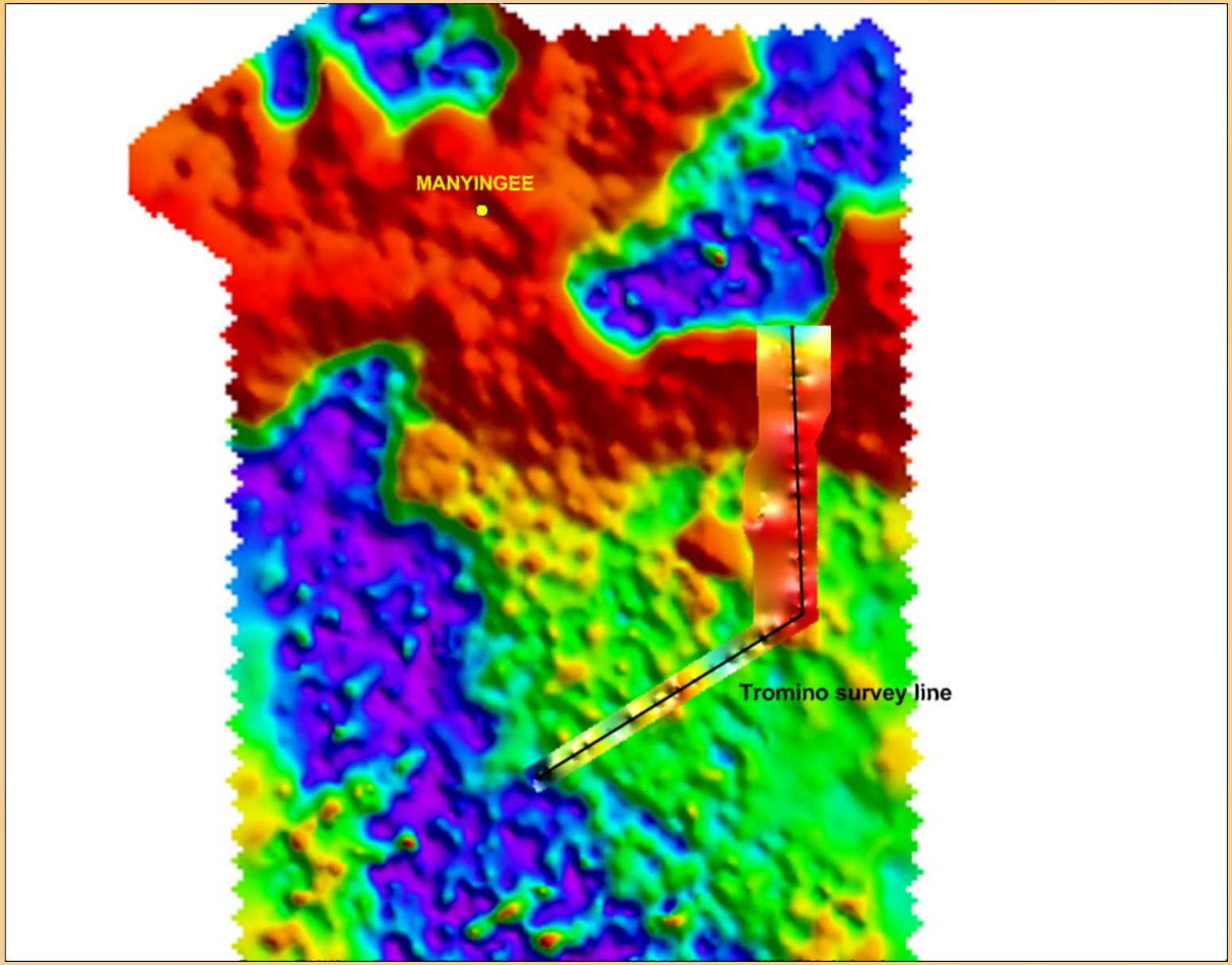


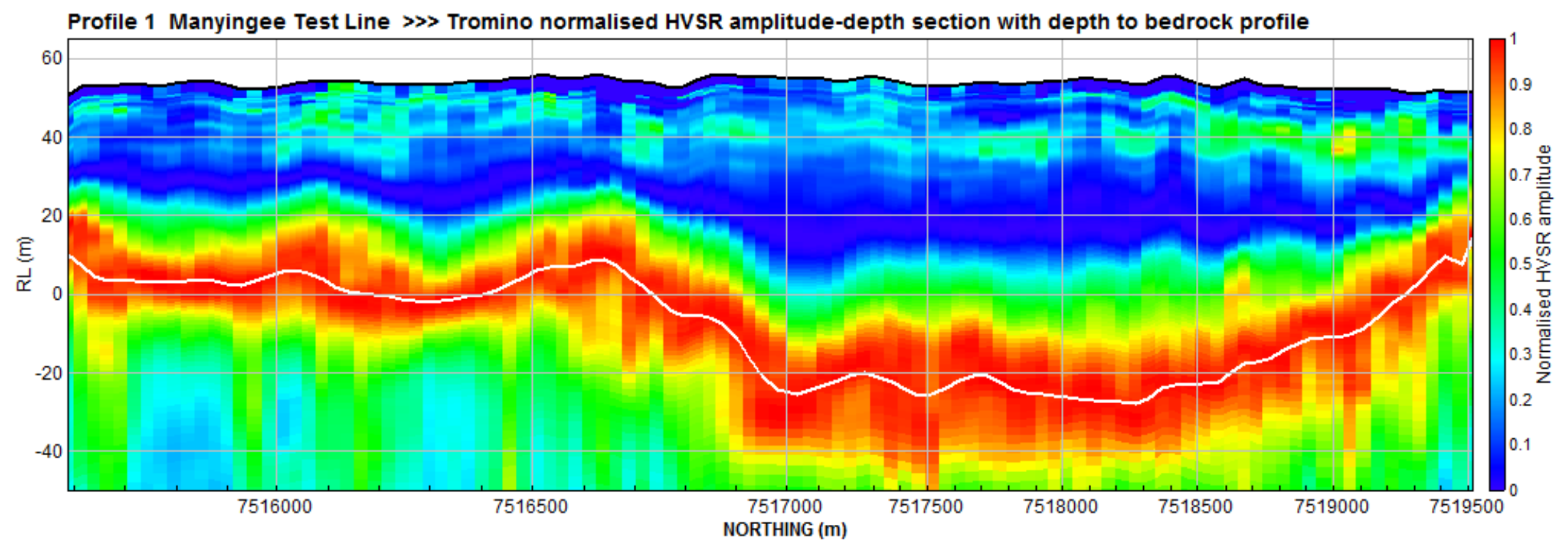
Manyingee Tromino survey

- Airborne EM survey poorly defined the shape of the paleochannel where there is little conductivity contrast due to resistive sediments and less saline groundwater



Manyingee Tromino survey

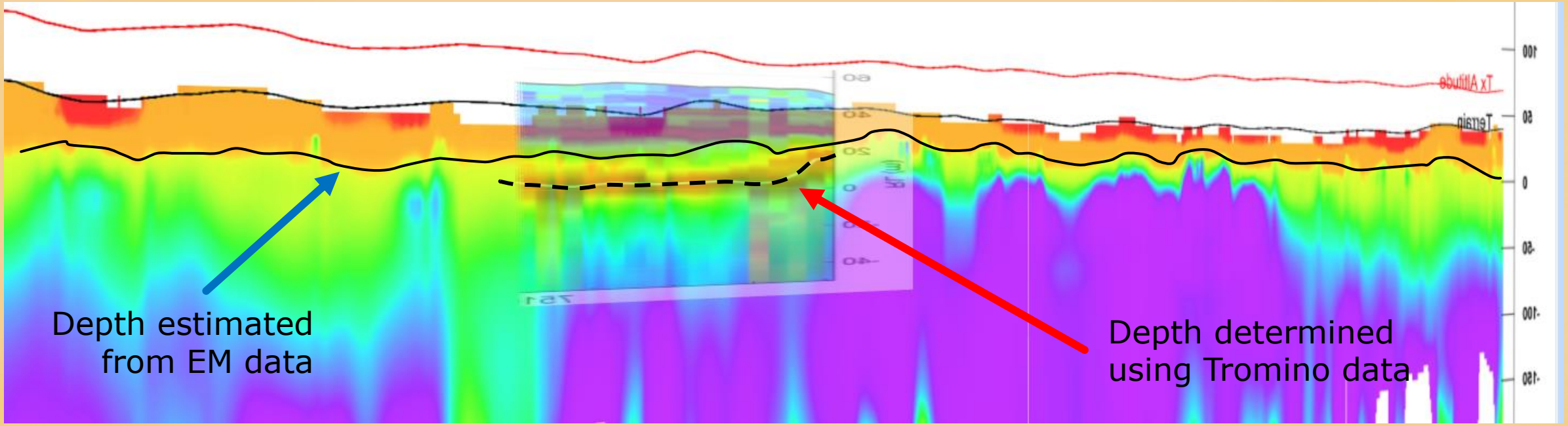
- Cross-section plot showing distinct shape of paleochannel
- An airborne EM survey was previously flown over the area



Courtesy of Energy Metals Limited (ASX: 28/10/2015)

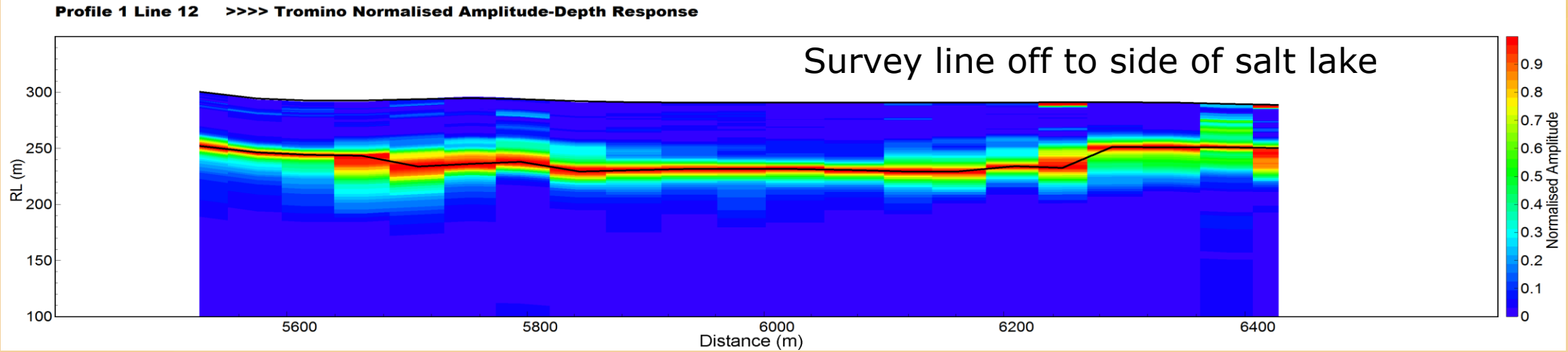
Manyingee Tromino survey

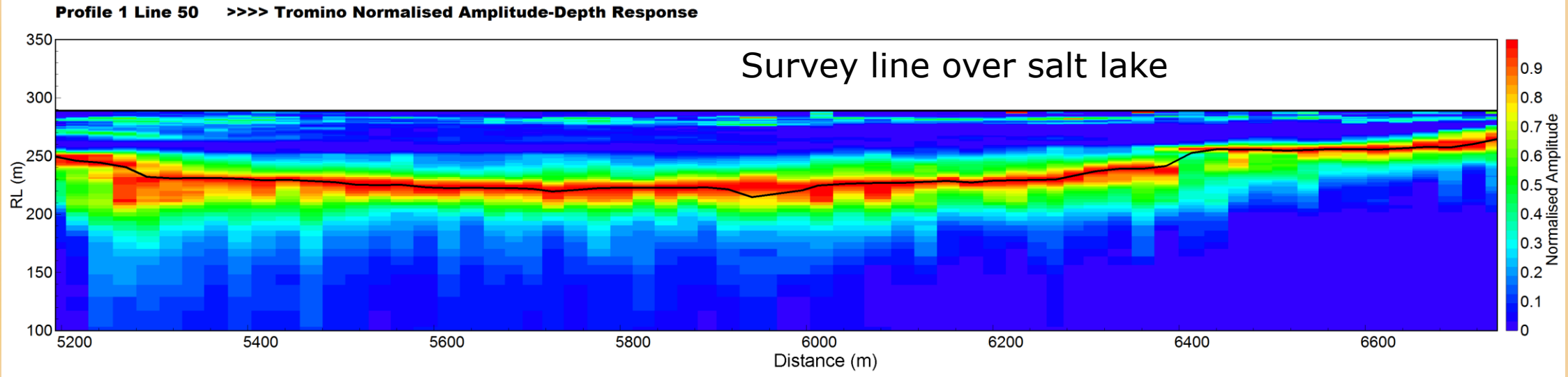
- Airborne EM survey also poorly defined the depth of the paleochannel



Paleochannel gold over greenstone in WA

- "Proof of concept" survey for major gold producer in the Kambalda area
- Tromino survey lines easily mapped paleochannel both on and off a salt lake
- EM survey worked quite well, but was slow and expensive, and dangerous due to currents





Comparison of methods at Yarrie

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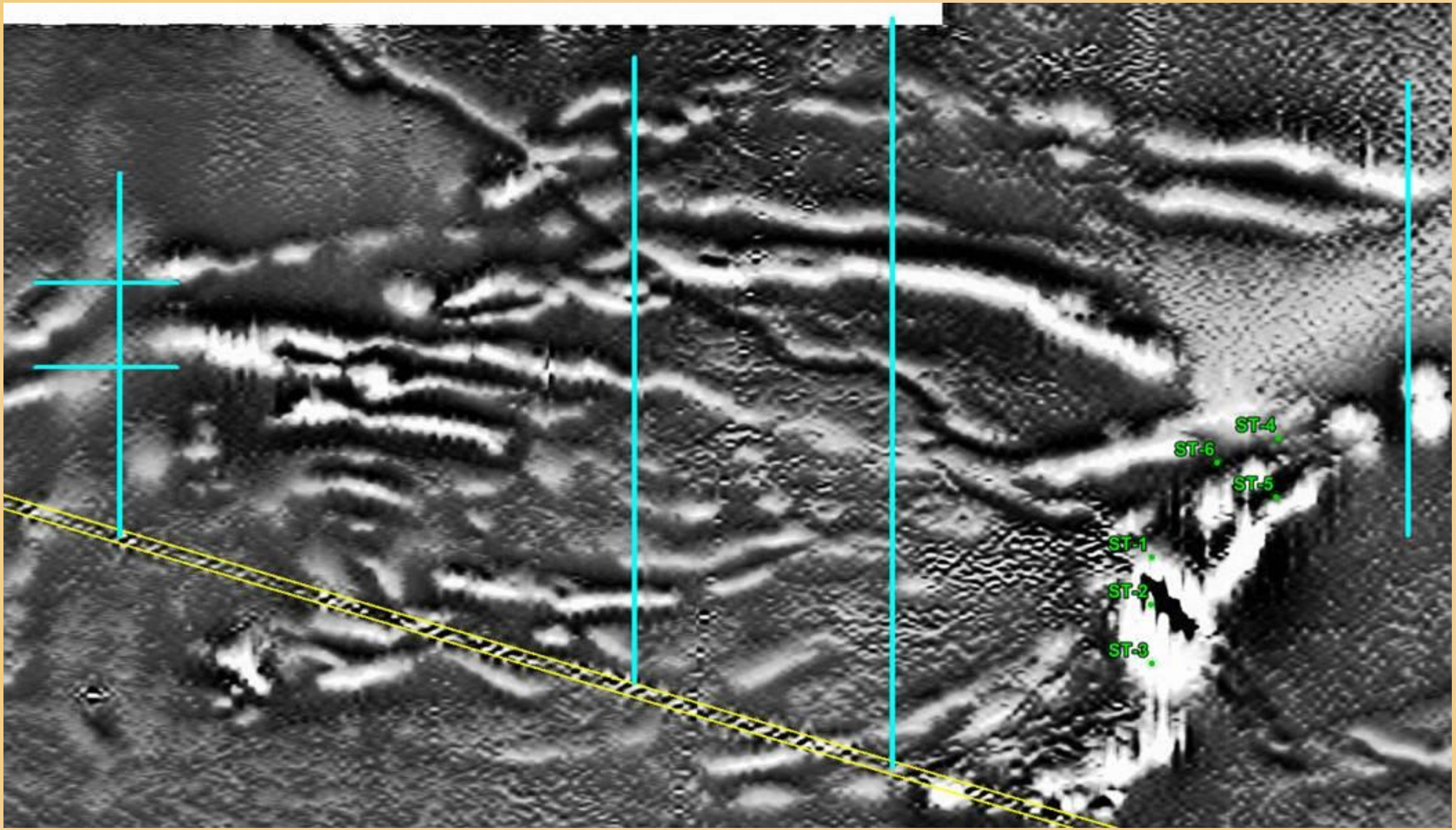

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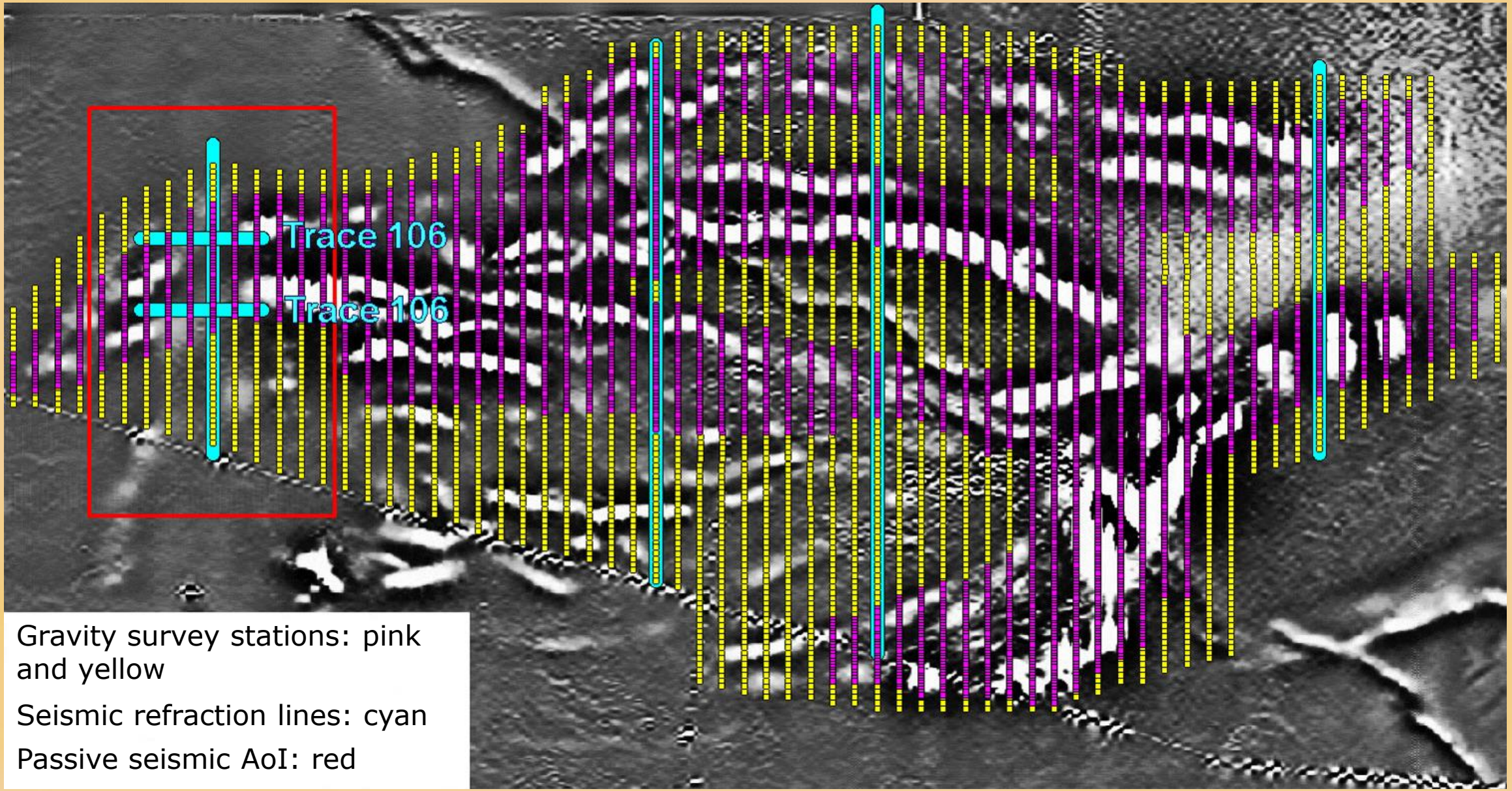


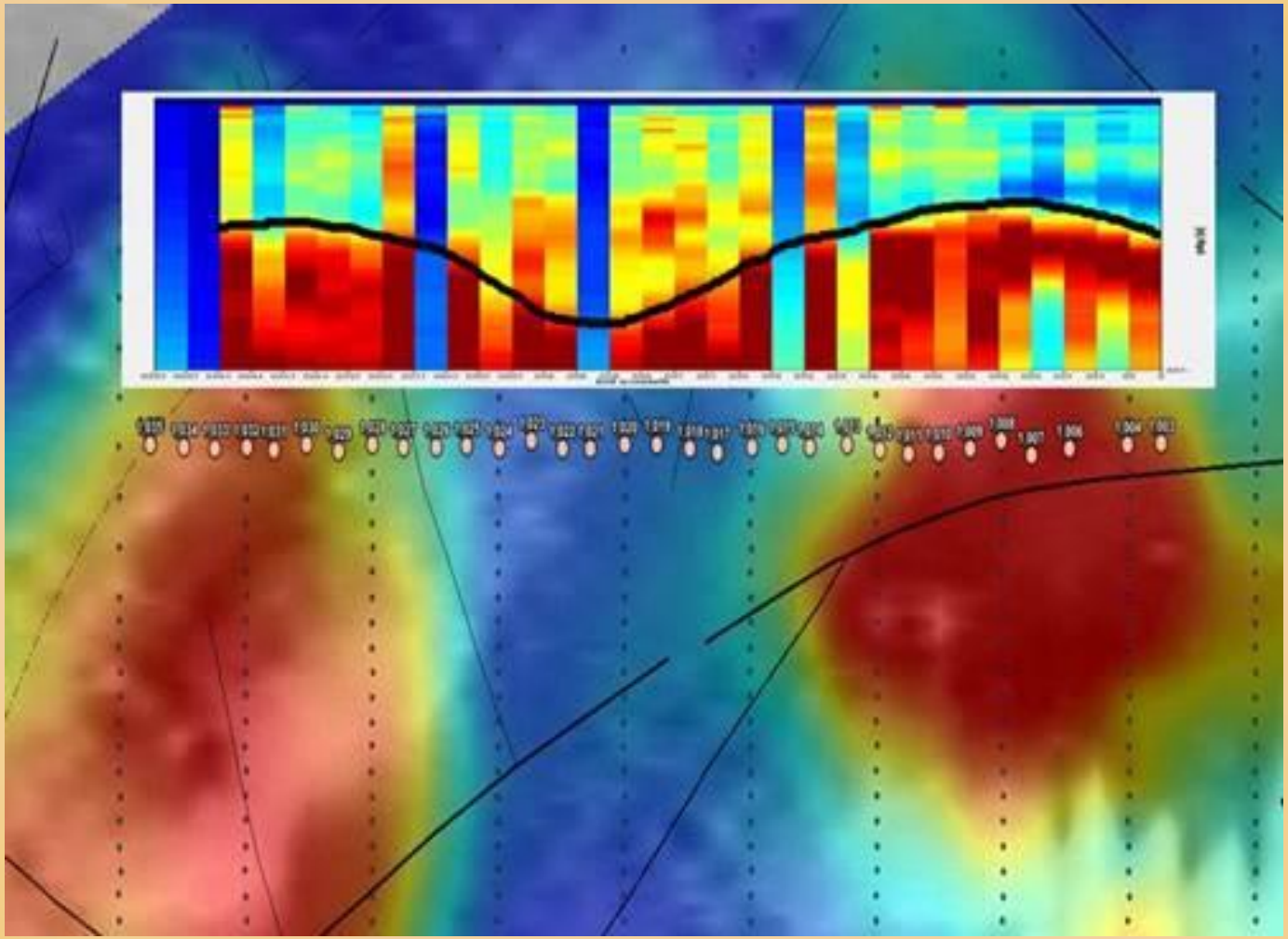
Gravity survey stations: pink and yellow

Seismic refraction lines: cyan

Passive seismic AoI: red

Yarrie U-shaped valley

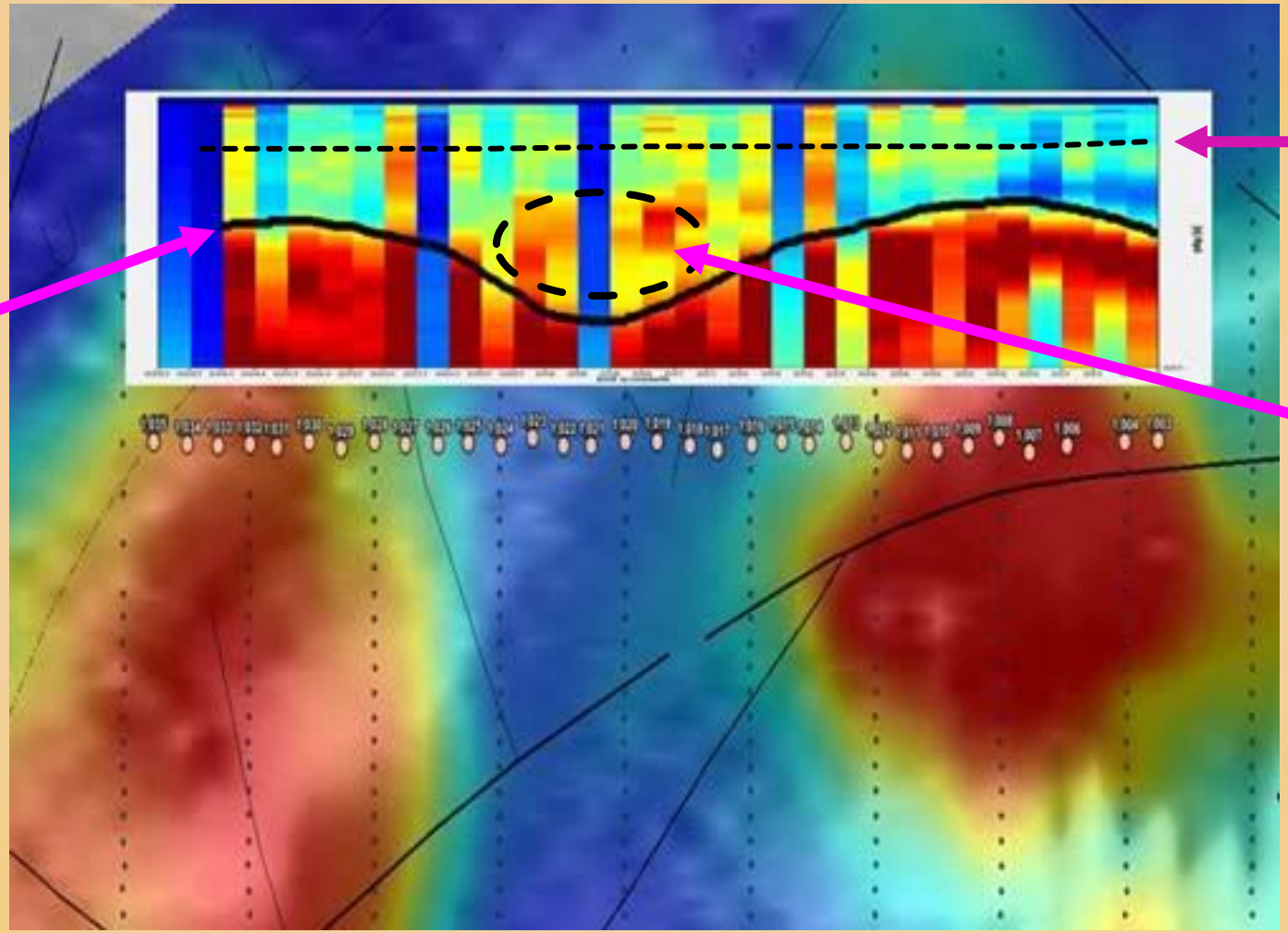
- Passive seismic clearly mapped the U-shaped paleovalley, including steep sides



Yarrie U-shaped valley

- And features within the paleovalley

Interface between paleochannel sediments and bedrock detected by passive seismic

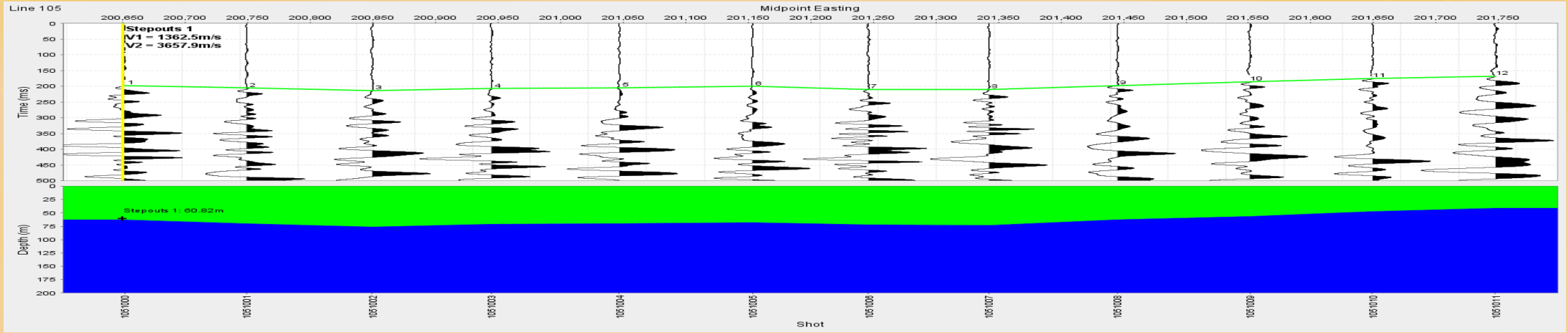


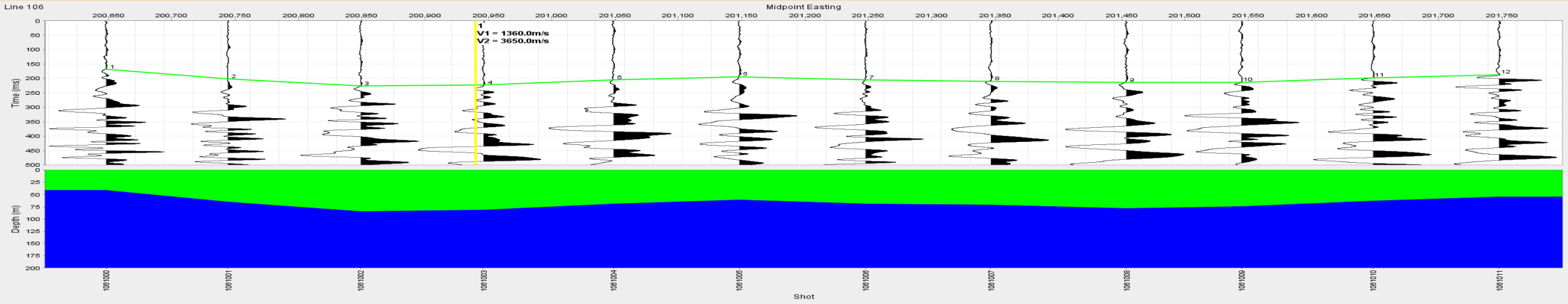
Layering in Mesozoic-Cainozoic cover deposits

Permian gravels

Comparison of methods at Yarrie

- Two lines from the refraction survey. “U-shape” is subdued owing to diffraction on flanks

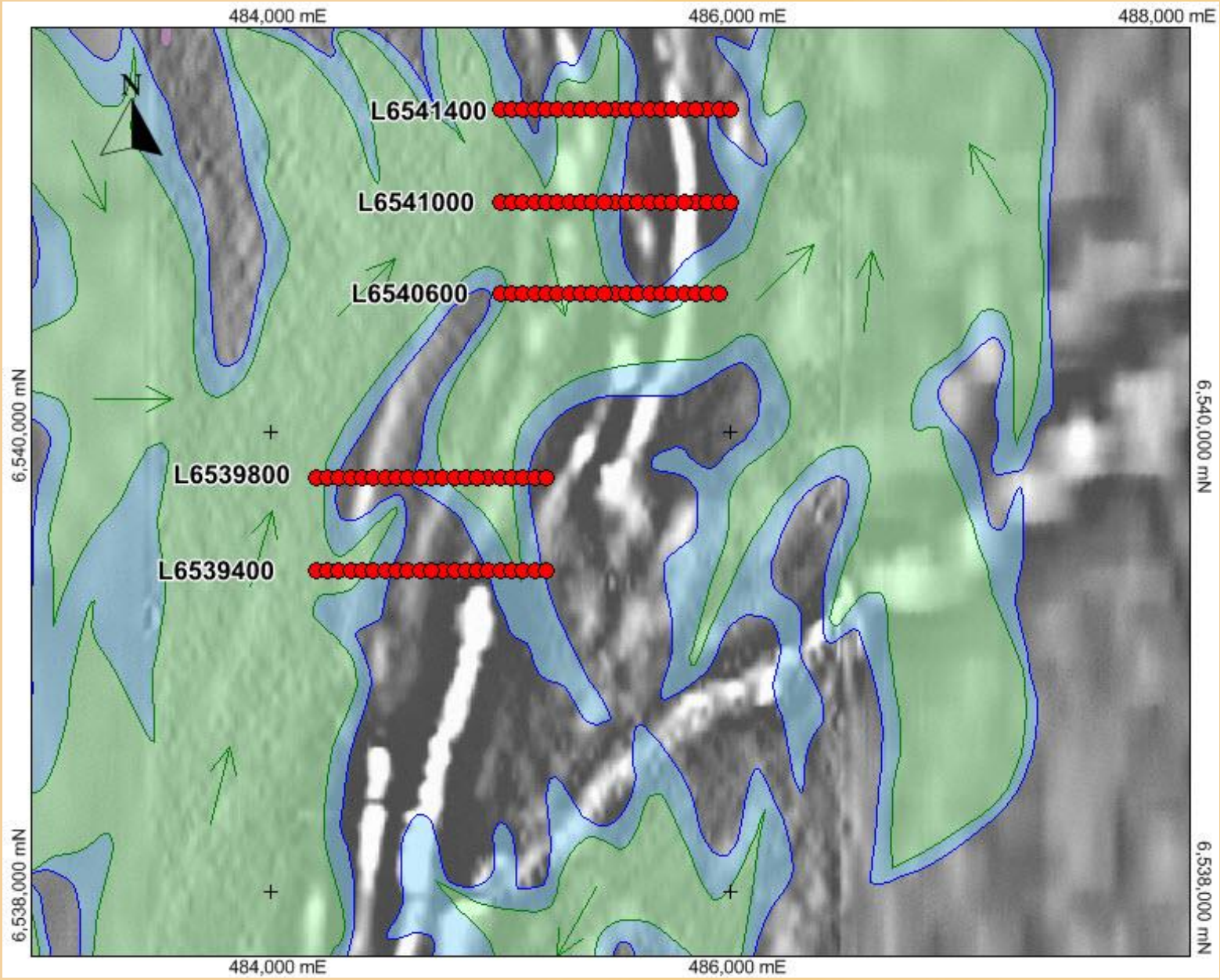




Tromino survey lines at Erayinia

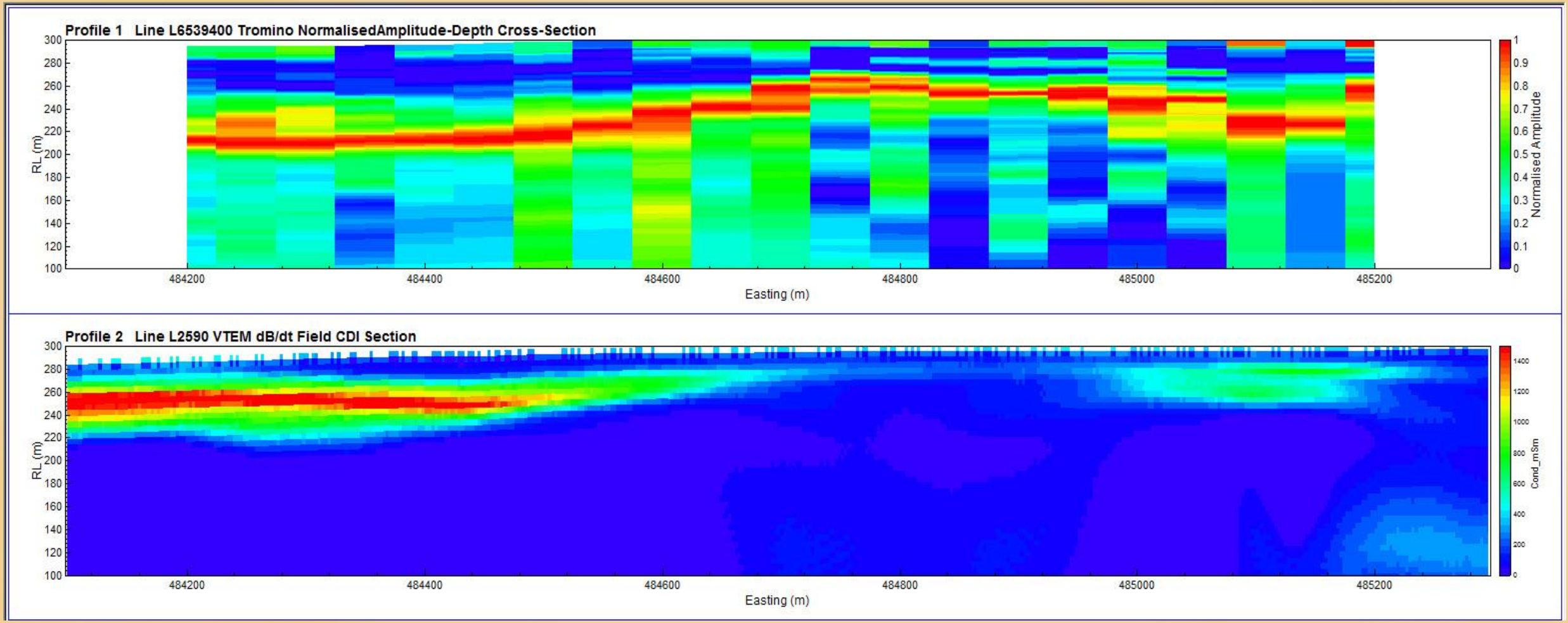
- Two lines from the Tromino survey compared to EM CDI sections

- Regolith cover interpreted from VTEM airborne EM survey flown in 2013:
  blue = shallow
  green = deep



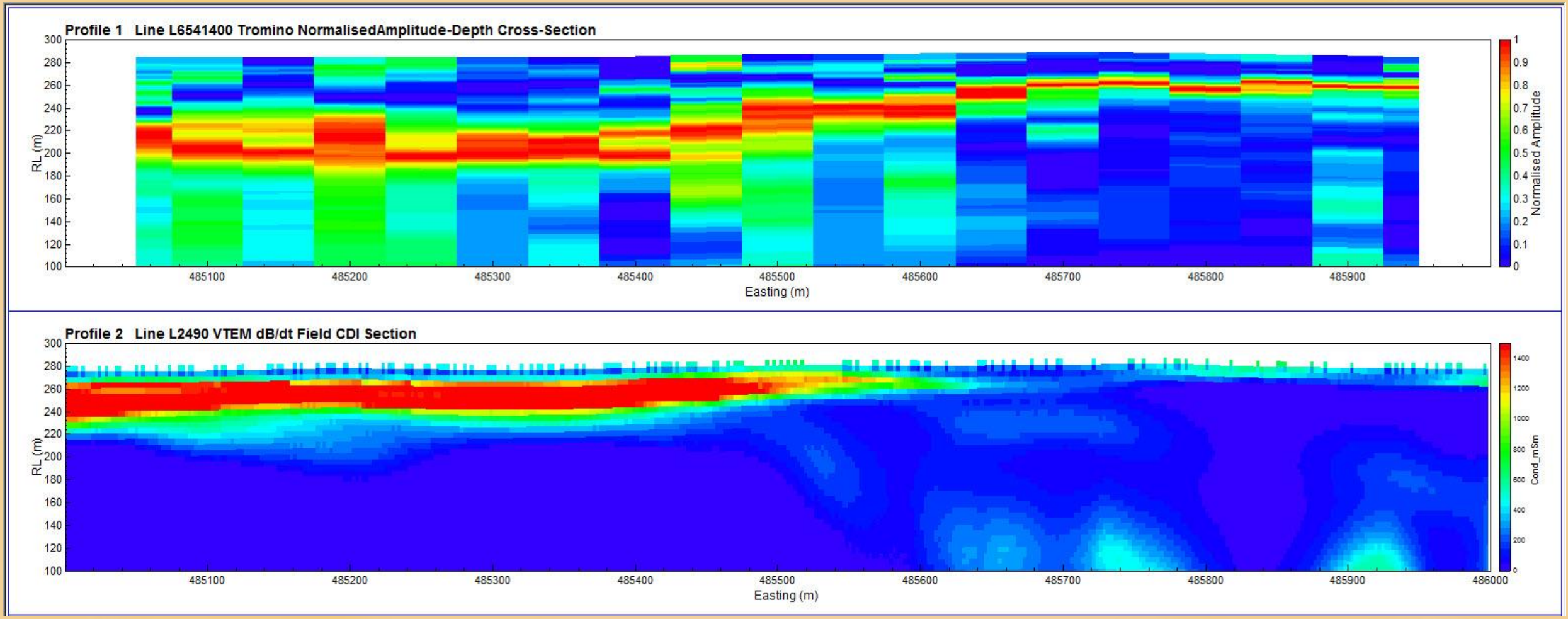
Tromino survey lines at Erayinia

- Line 6539400 from the Tromino survey compared to coincident CDI section



Tromino survey lines at Erayinia

- Line 6541400 from the Tromino survey compared to coincident CDI section



The future...

- The passive seismic method is an innovative adaption of existing technology that will impact on the future of exploration in regolith covered areas, and for direct detection of paleochannel and other shallow basin-related mineral deposits

- Tromino seismometers are small, lightweight, fully self-contained, easy to use, two units can leap-frog during surveying to collect up to 40 stations per day per field operator, data processing can be carried out by field operators using Grilla software which comes with the Tromino, but it is recommended that specially trained geoscientists be contracted for final data processing and assisting with interpretation

- The Tromino instrument and software package is the only miniaturised, self-contained, sensitive for purpose, and “industry ready” passive seismic system available

Acknowledgements

- The author would like to thank the following people and companies for making their passive seismic data available for this presentation:
  - Brenton Siggs and Australian Potash Limited
  - Gold Fields Australia Pty Limited
  - Black Raven Mining Pty Ltd
  - Coziron Resources Limited
  - Energy Metals Limited