Government of **Western Australia**
Department of **Mines and Petroleum**

A magnetotelluric (MT) survey across the Albany Fraser Orogen, Western Australia

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THE UNIVERSITY OF WESTERN AUSTRALIA

Moombarriga Geoscience

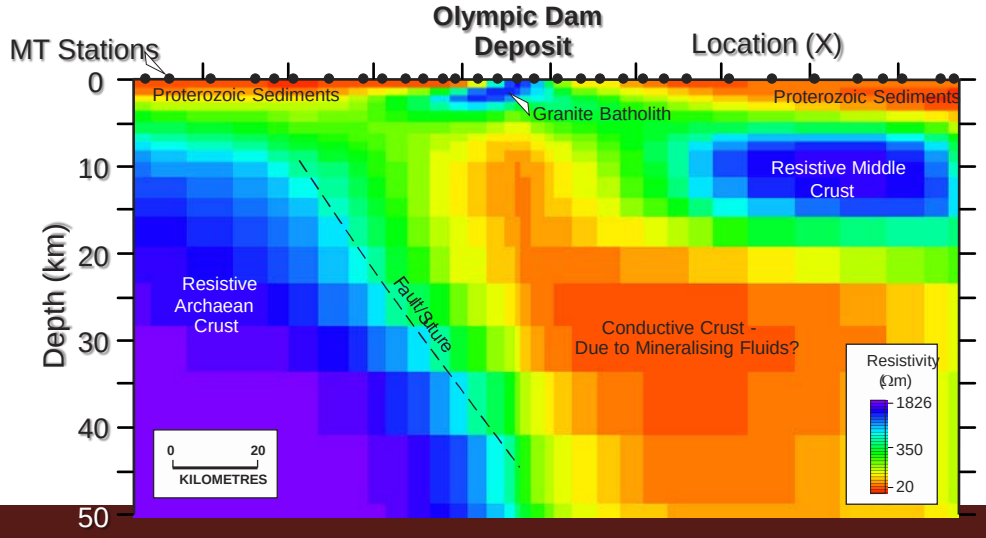
ROYALTIES FOR REGIONS
EXPLORATION INCENTIVE SCHEME

Centre for EXPLORATION TARGETING

Geological Survey of Western Australia

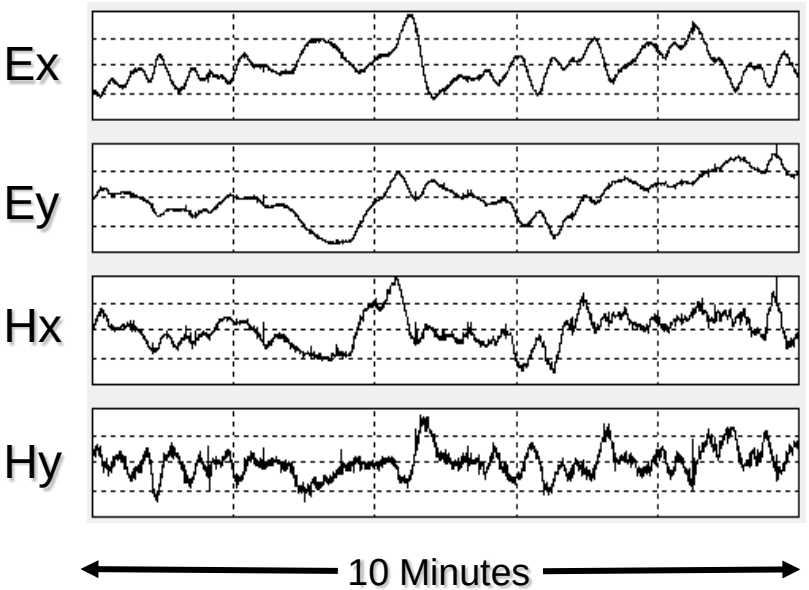
Magnetotellurics

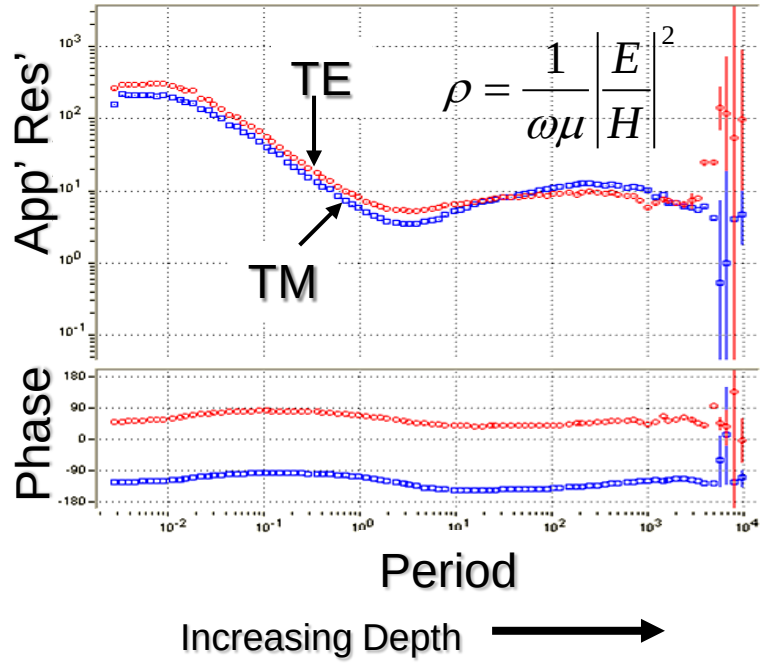
- Passive, frequency domain, electromagnetic method.
  - Maps electrical conductivity (conductance).
- Deep penetrating.
  - Depth penetration depends on recording time.
  - Routinely used to map entire lithosphere.
- Established ‘academic’ tool, emerging exploration applications
  - ☺ Cheap.
  - ☺ Can see deep.
  - ☹ Limited resolution.
  - ☹ Controls on deep cond’ poorly understood.



Magnetotellurics

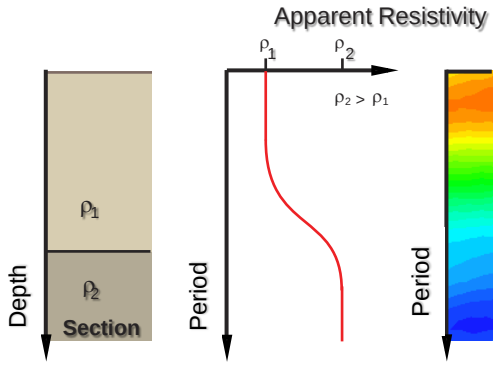
- Record a time series – electric (E) and magnetic (H) fields.
- Convert to frequency dependent apparent resistivity and phase (Ex and Hy; Ey and Hx).
- Combine data from multiple stations.

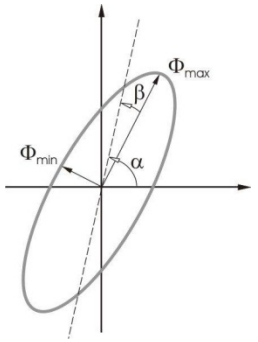


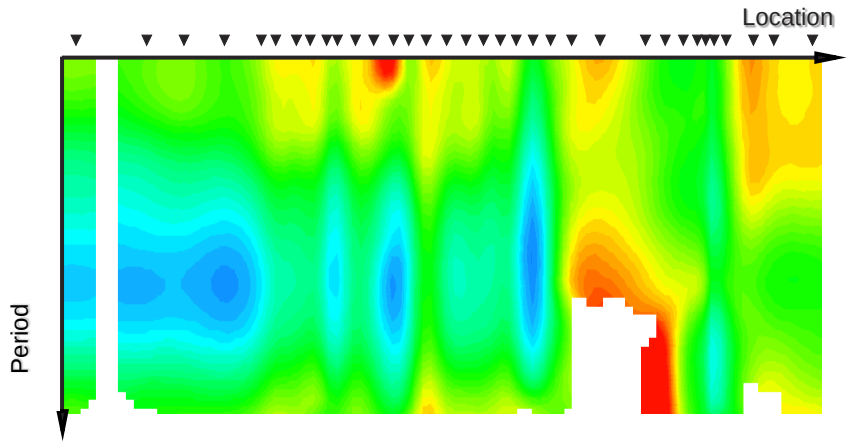


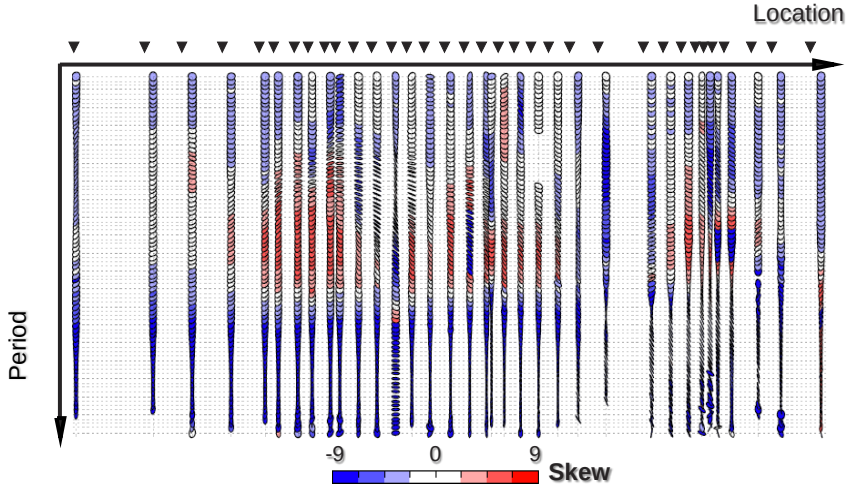
Magnetotellurics

- Stn data used to create pseudo, para and cross sections.
- Dimensionality, strike direction crucial for 2D modelling.



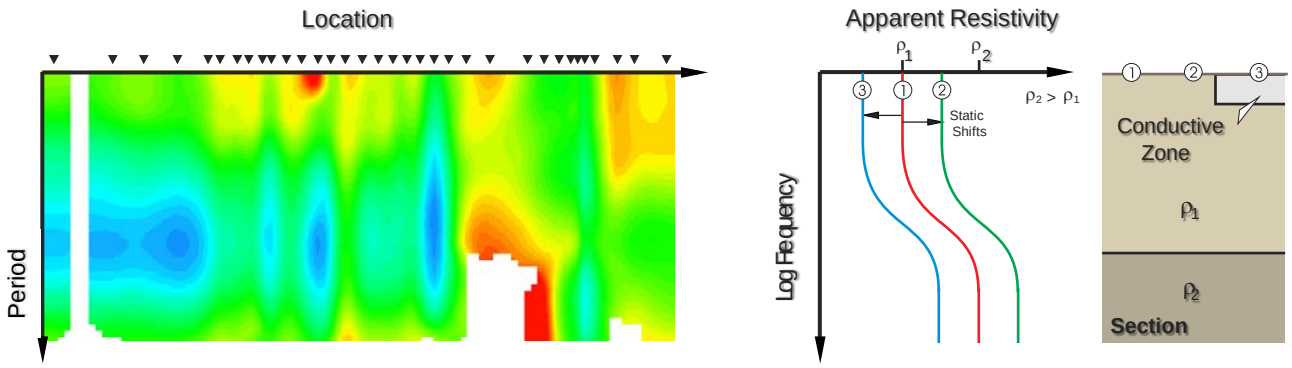






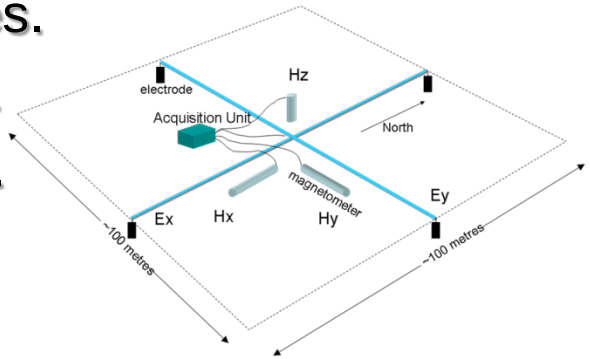
Magnetotellurics

- Station data are used to create pseudo, para and cross sections.
- Static effects.
  - Conductivity variations in the near surface.
- Modelling ⇒ sub-surface electrical conductivity distribution.
  - Forward modelling (Model ⇒ data) – manual.
  - Inverse modelling (Data ⇒ model) – semi-automated.
  - 2D routine, 3D now generally available.

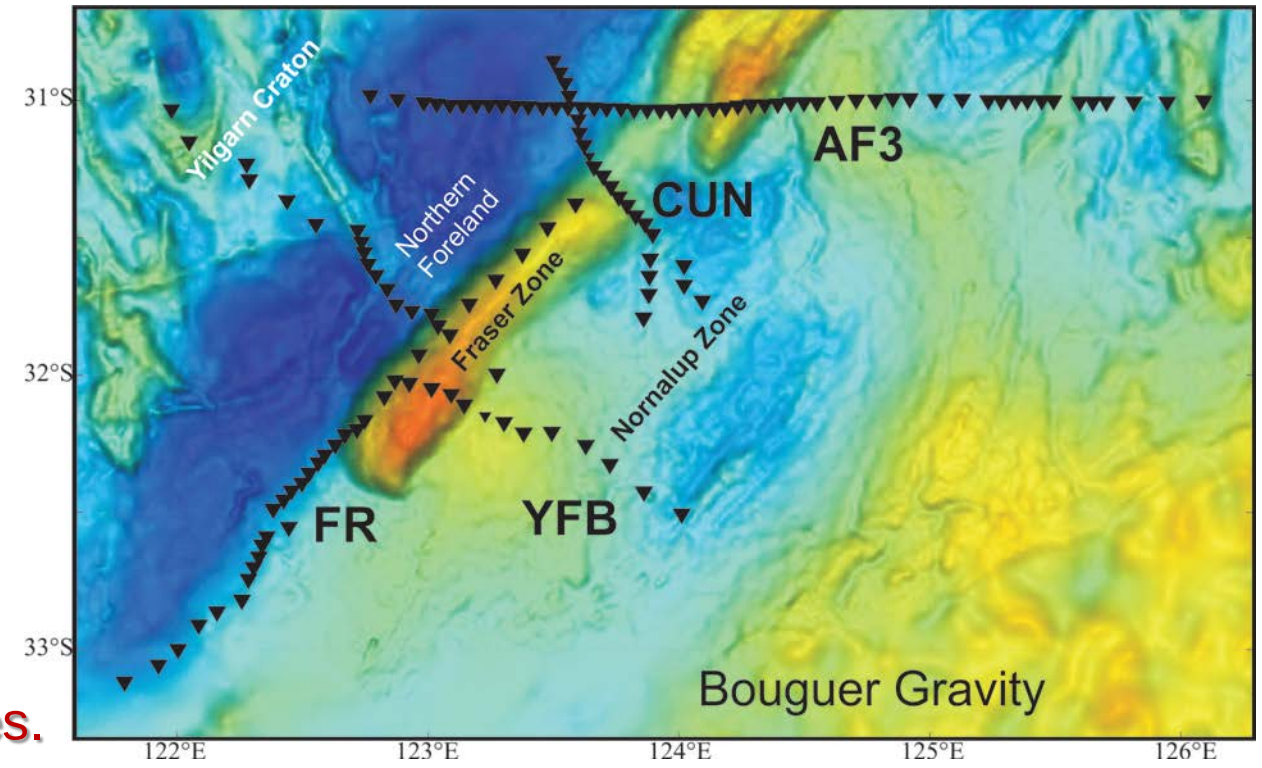


MT Deployment

- Broadband MT.
  - 100 m electric dipoles.
  - Hx-y-z B field (coils).
  - 5-20 km stn spacing.
  - ~40 hrs recording.
- (Long period MT.)
  - 50 m electric dipoles.
  - Hx-y-z B field (magnetometers).
  - 20-50 km stn spacing.
- Time-domain EM.
  - Soundings to measure static shift.

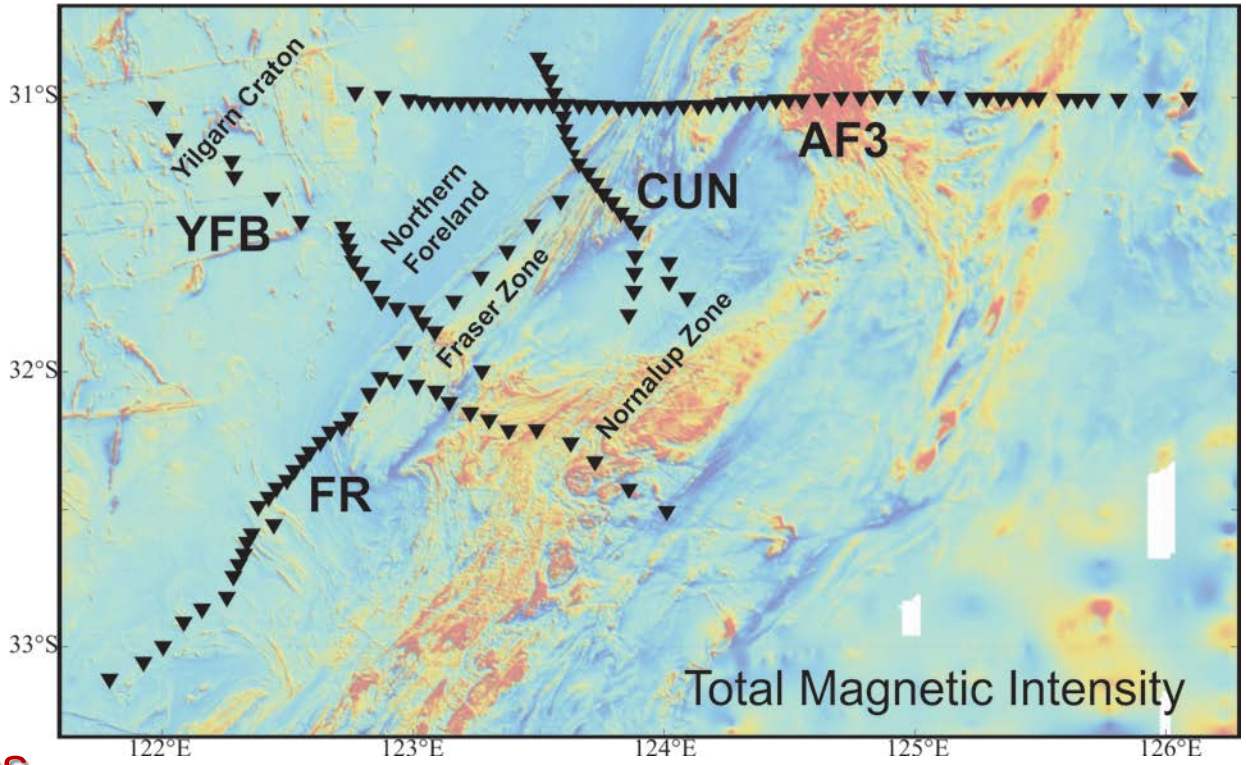


Fraser MT Deployment



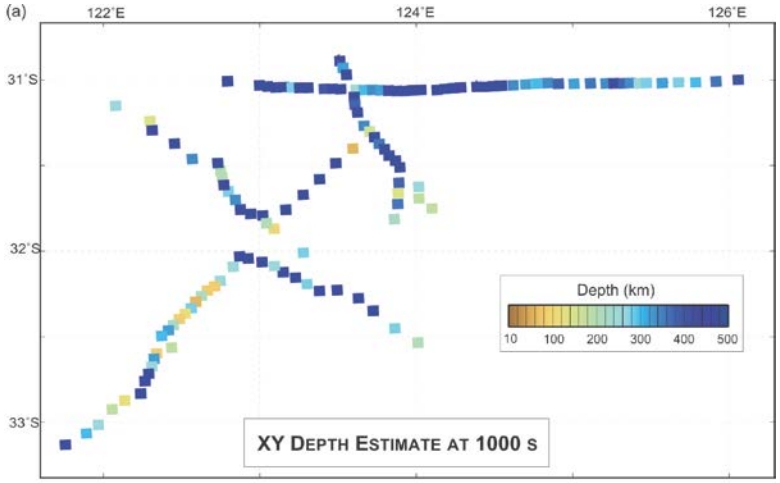
- 4 regional profiles.
  - AF3 – coincident with the seismic line.
  - YFB – based on earlier transect.
  - FR – strike-profile, crosses SW edge of the Fraser Complex.
  - CUN – completes network.

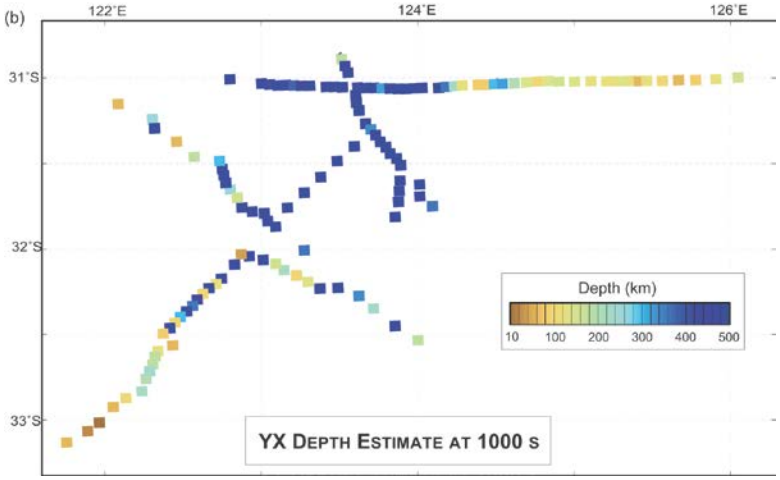
Fraser MT Deployment

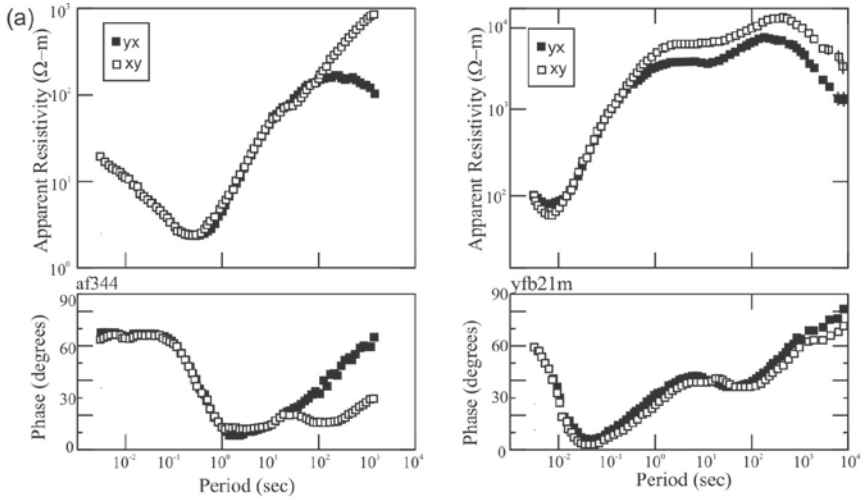


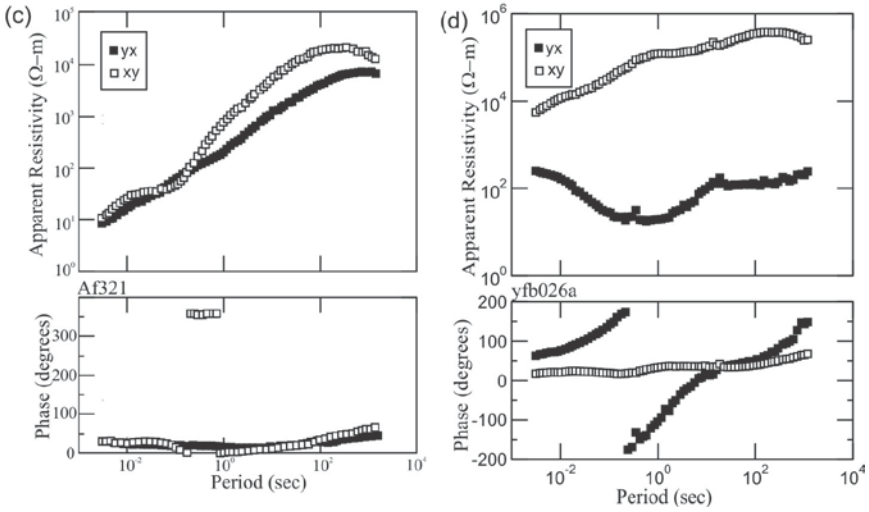
- 4 regional profiles.
  - Three strike profiles.
  - Along with FR profile allow along-strike variations in structure to be detected.
- T1 - Tropicana

Depth Penetration (estimates)



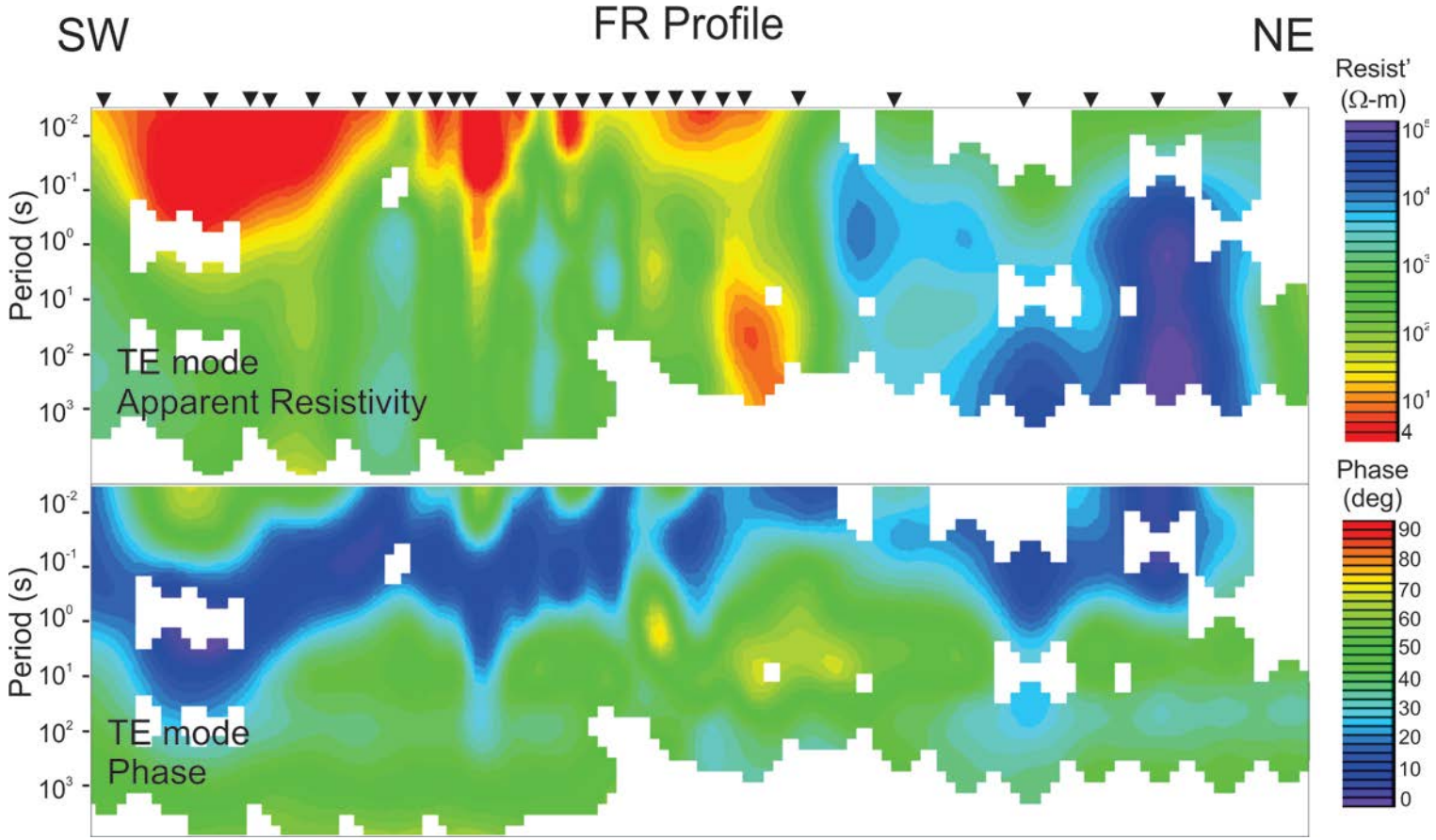






Processing and Modelling

- Fraser profile as an example – pseudosections.



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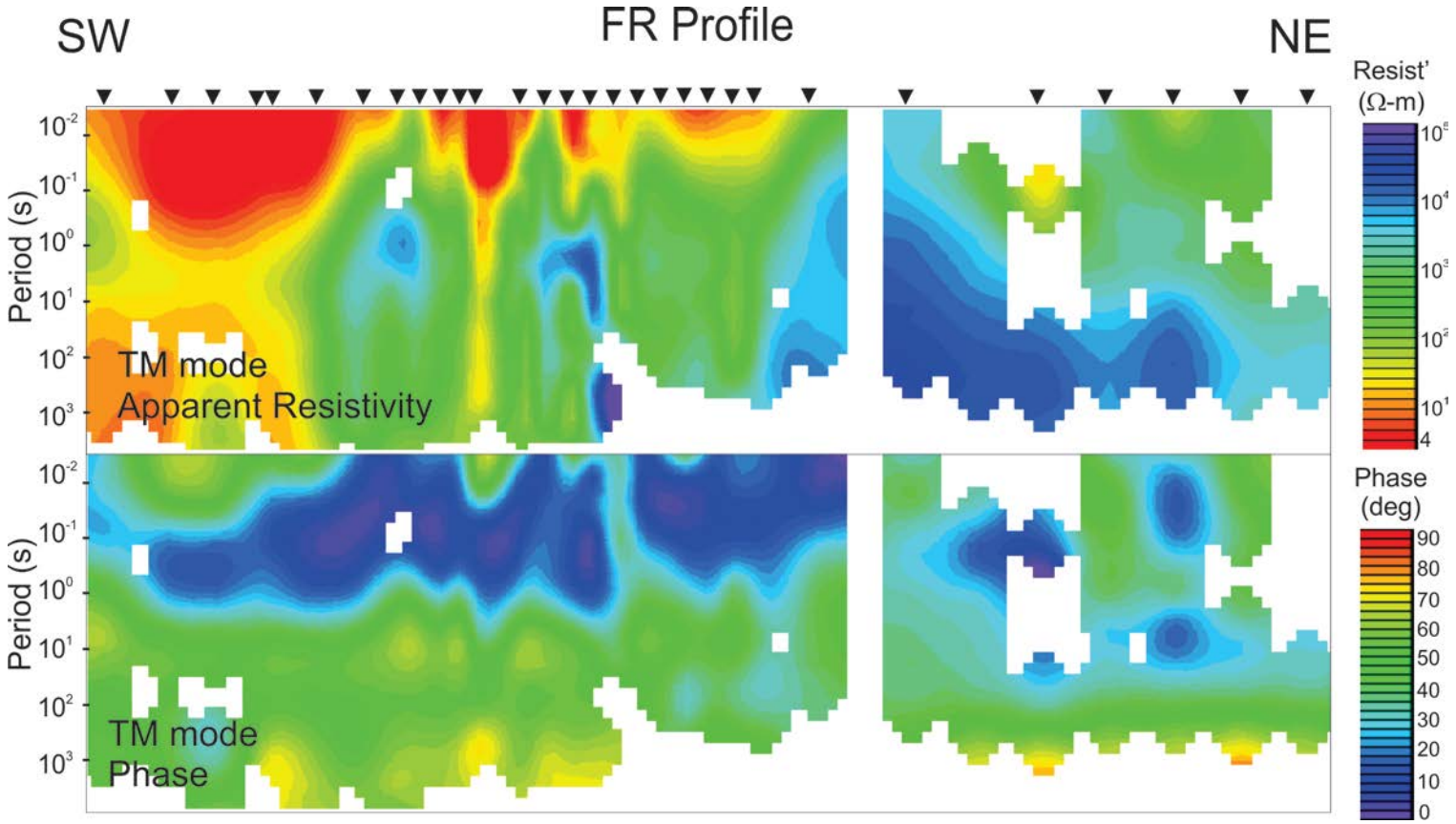
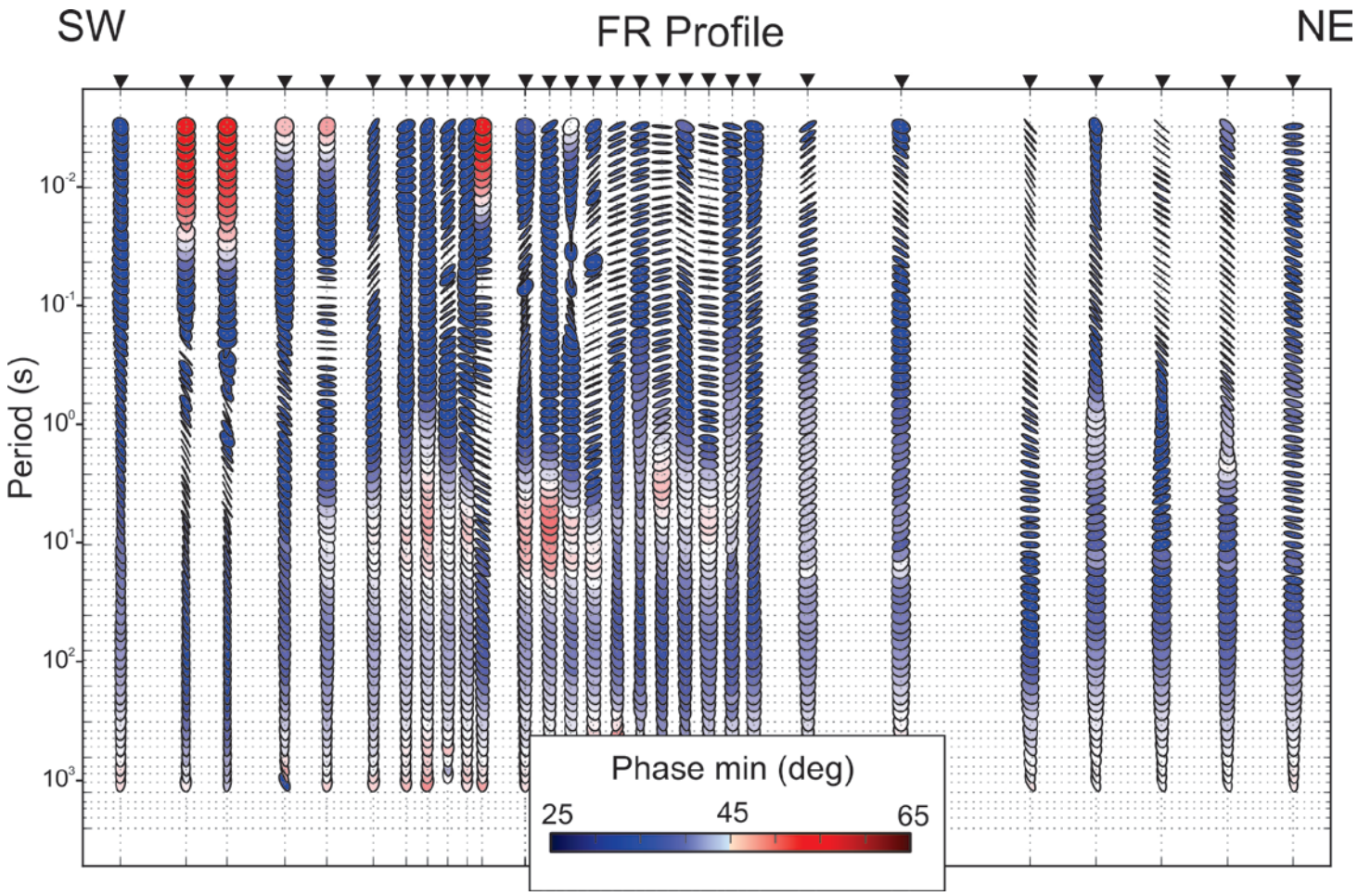
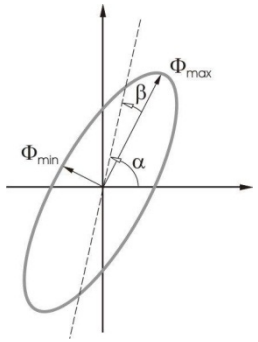


Electrical Strike and Dimensionality





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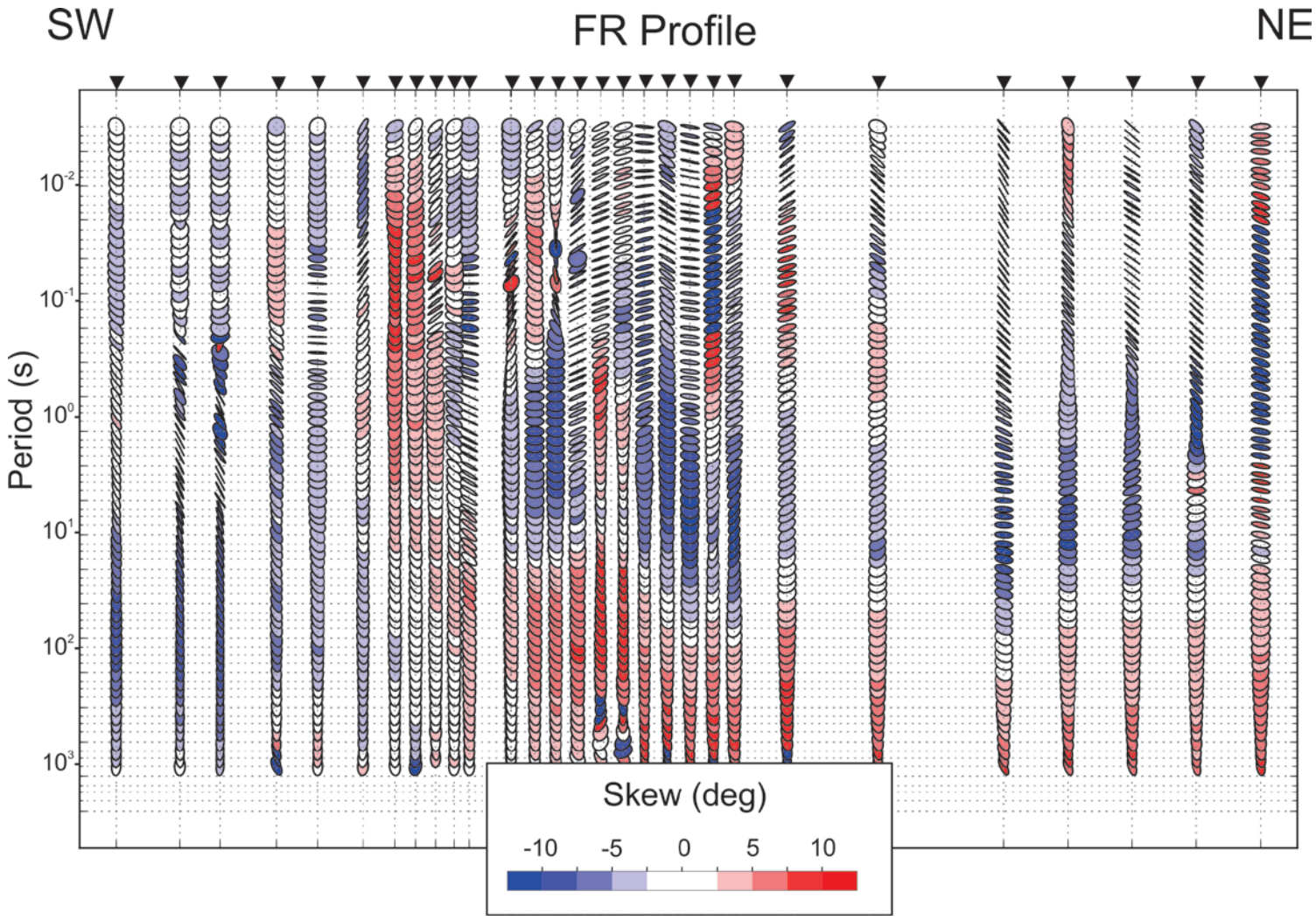
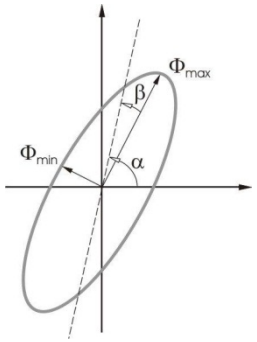
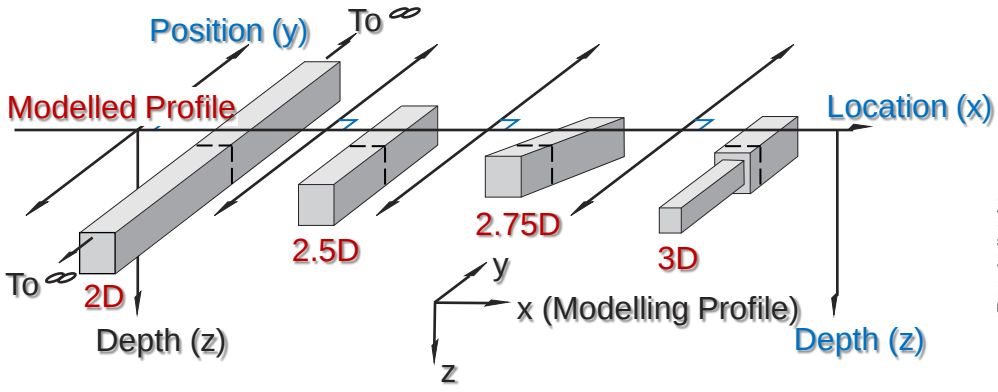
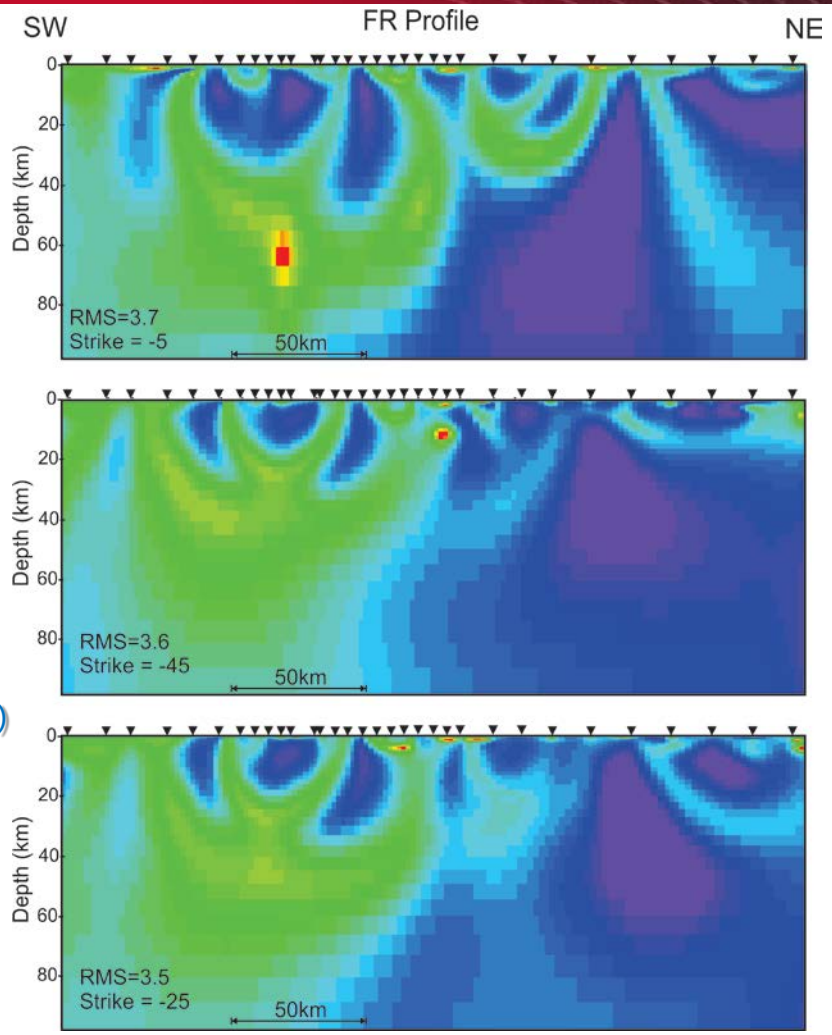




Strike Variation

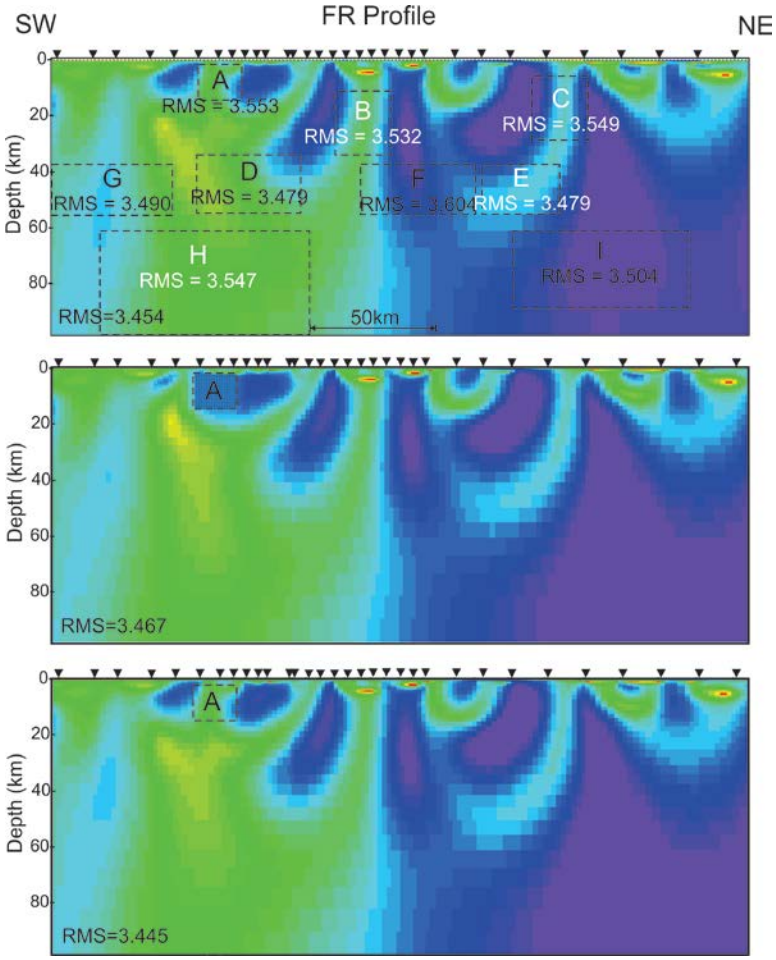
- Inverse modelling: Winglink package.
  - Have to discard '3D' responses.
  - Strike direction is a critical variable.
  - Geoelectric strike is period and spatially variable.



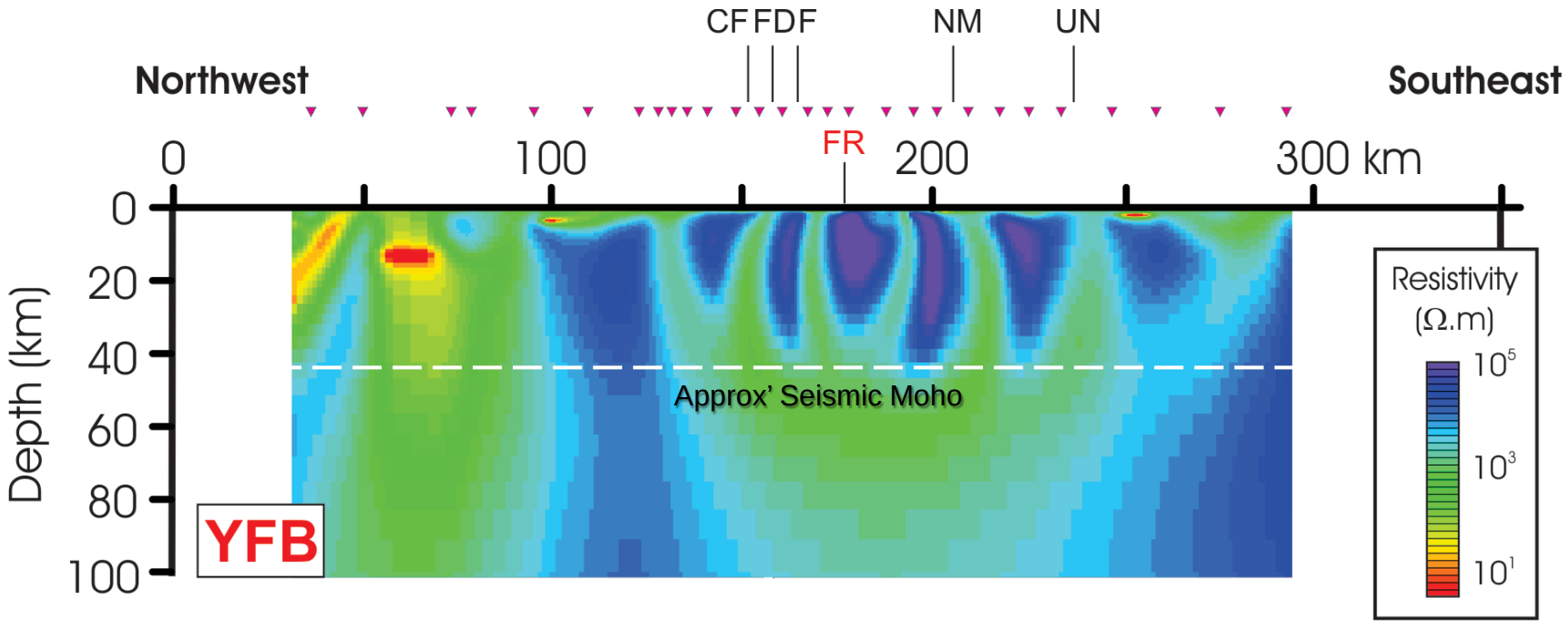


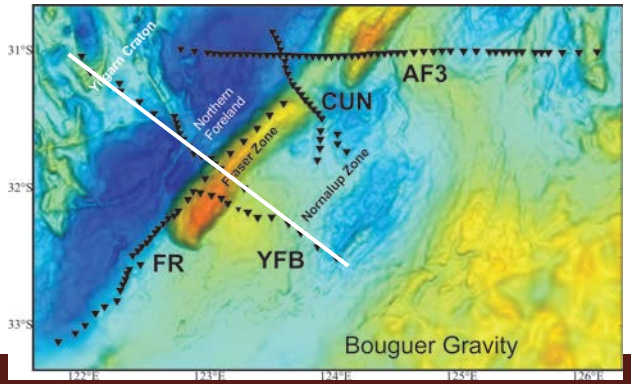
Feature Testing

- Systematically test to see whether some feature in the model is ‘needed’.
  - Freeze the feature.
  - Remove the feature.
  - Compare the RMS fit to the data.

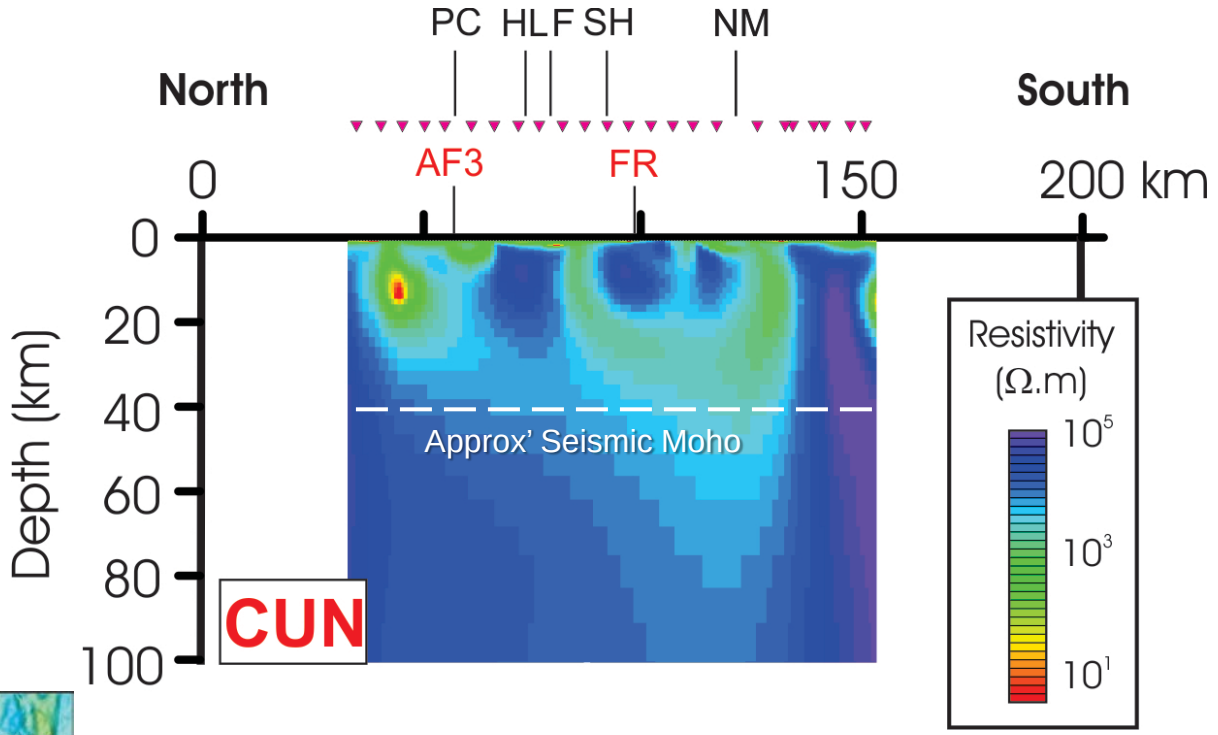


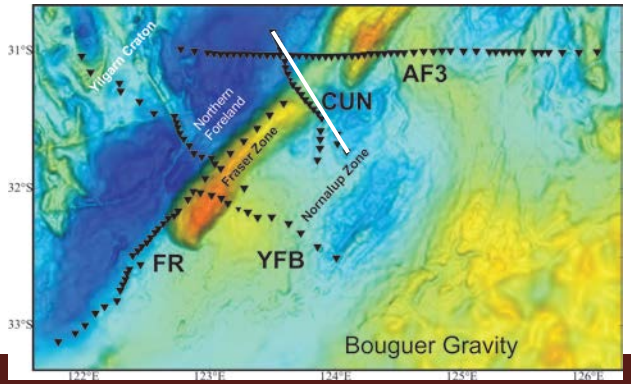
2D Results - YFB



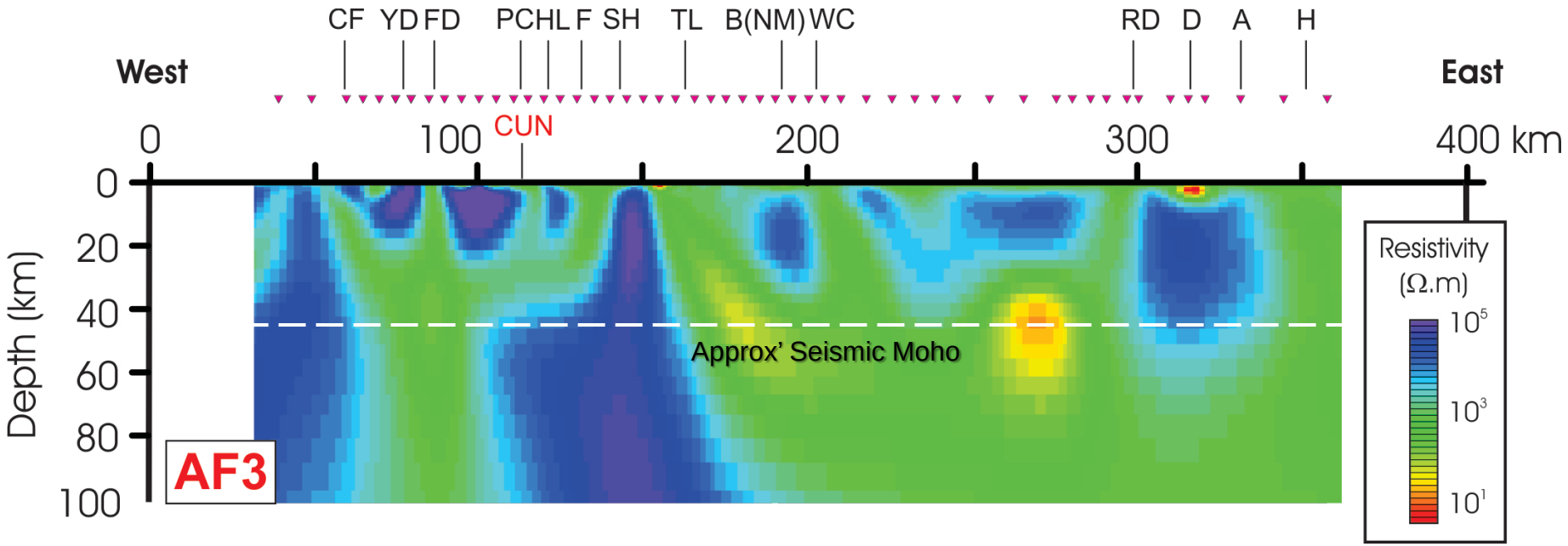


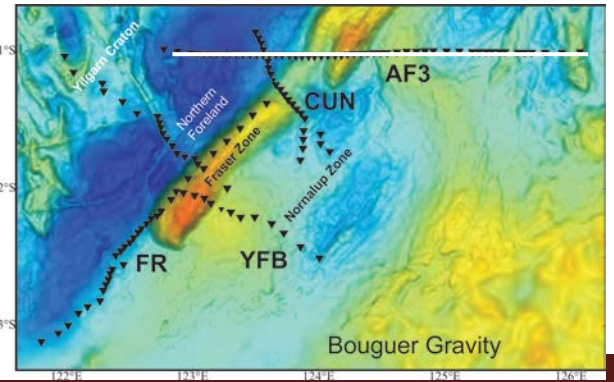
2D Results - CUN



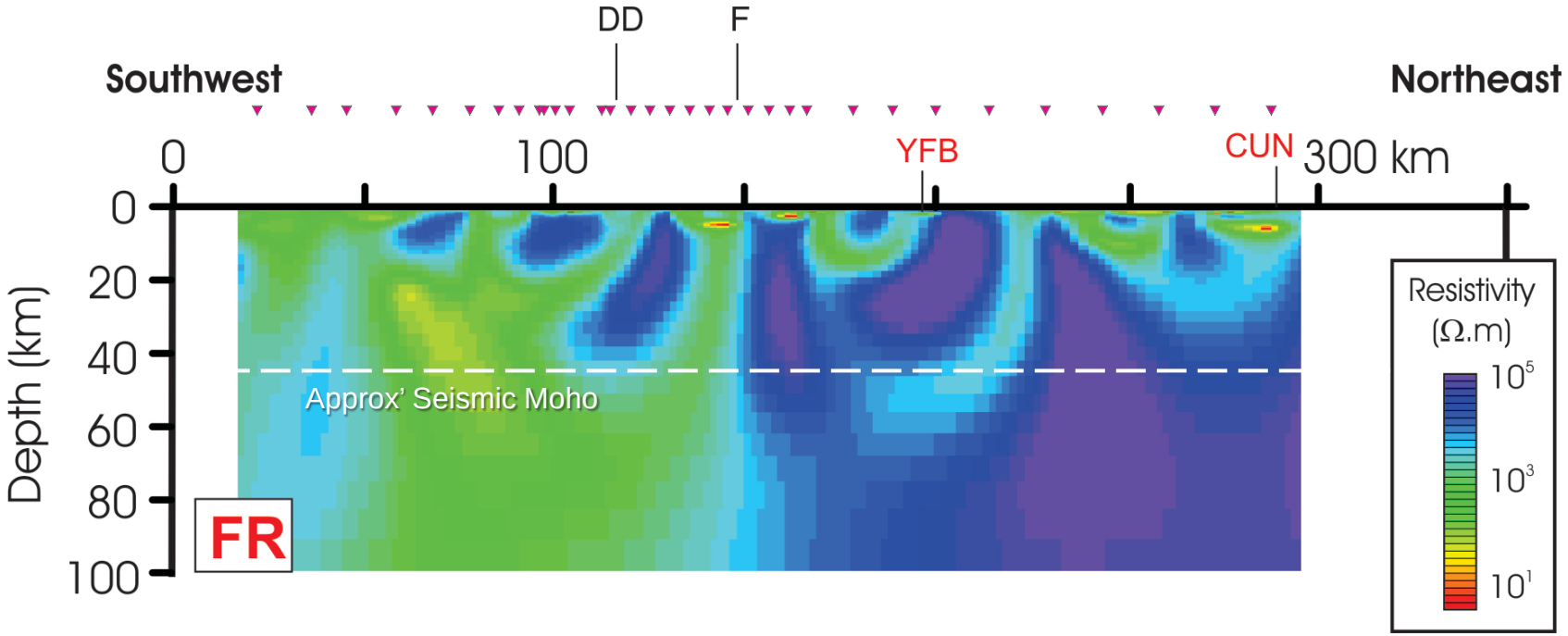


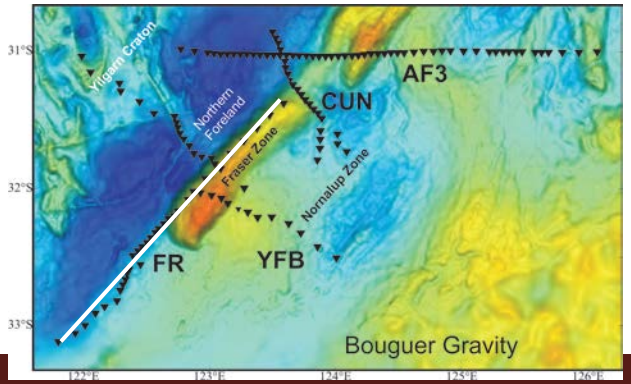
2D Results – AF3

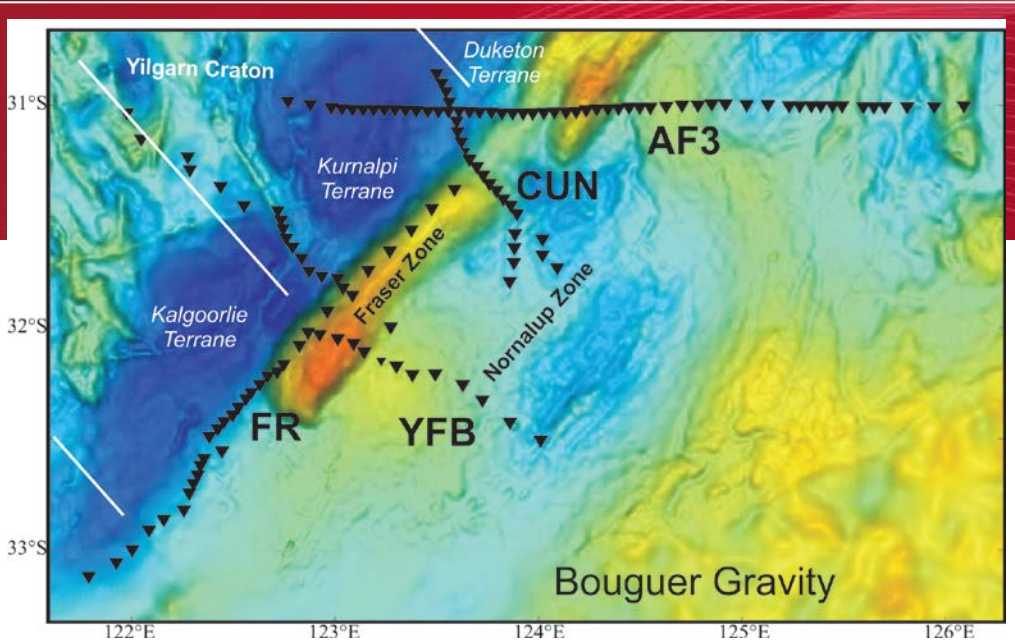


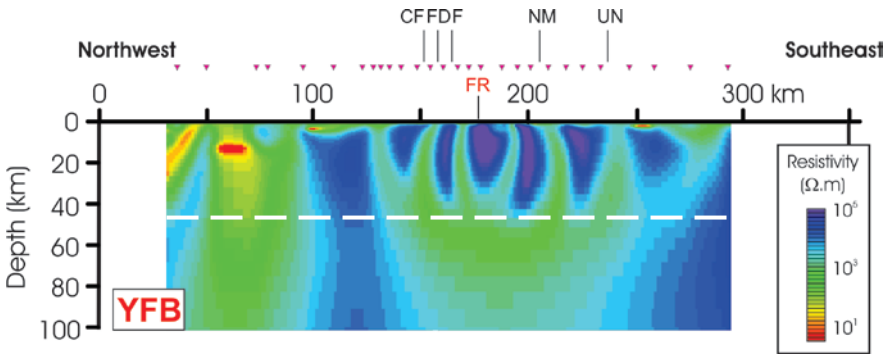


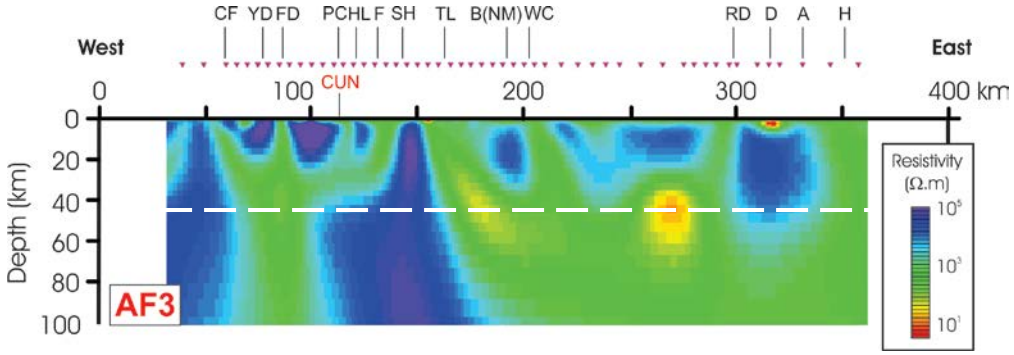
2D Results - FR

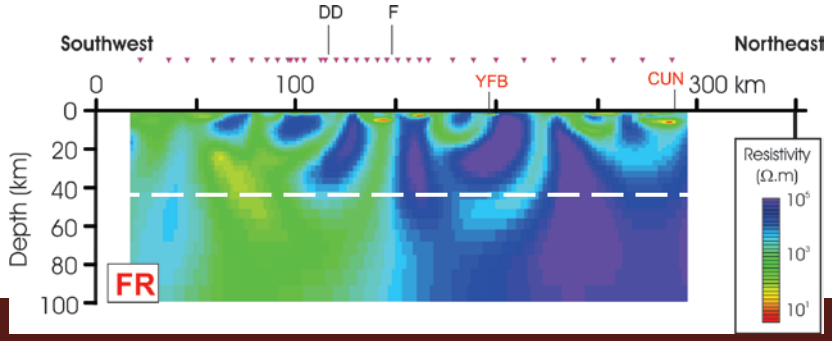


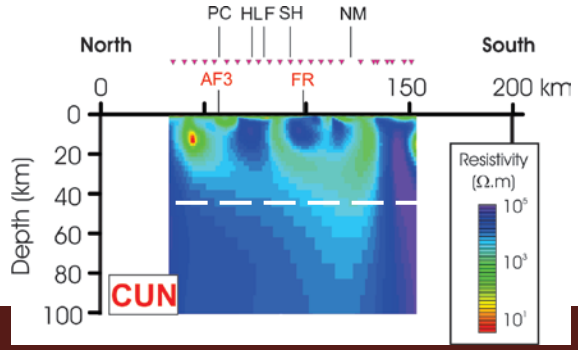



Yilgarn Craton
Duketon Terrane
Kurnalpi Terrane
Kalgoorlie Terrane
Fraser Zone
Nornalup Zone
AF3
CUN
FR
YFB
31°S
32°S
33°S
122°E
123°E
124°E
125°E
126°E
Bouguer Gravity


Northwest
Southeast
CF FD F
NM
UN
FR
0
100
200
300 km
Depth (km)
0
20
40
60
80
100
YFB
Resistivity (Ω.m)
10⁵
10³
10¹

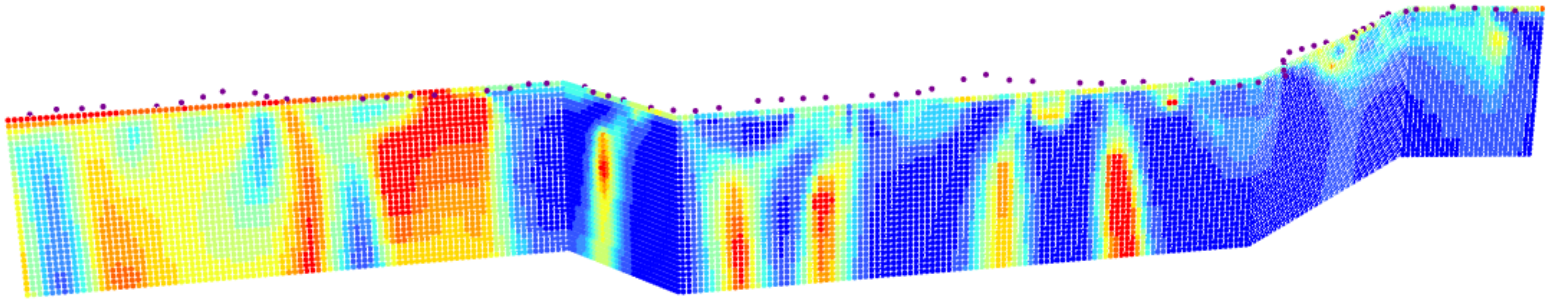

West
East
CF YD FD
PC HL F SH
TL
B(NM) WC
RD
D
A
H
CUN
0
100
200
300
400 km
Depth (km)
0
20
40
60
80
100
AF3
Resistivity (Ω.m)
10⁵
10³
10¹

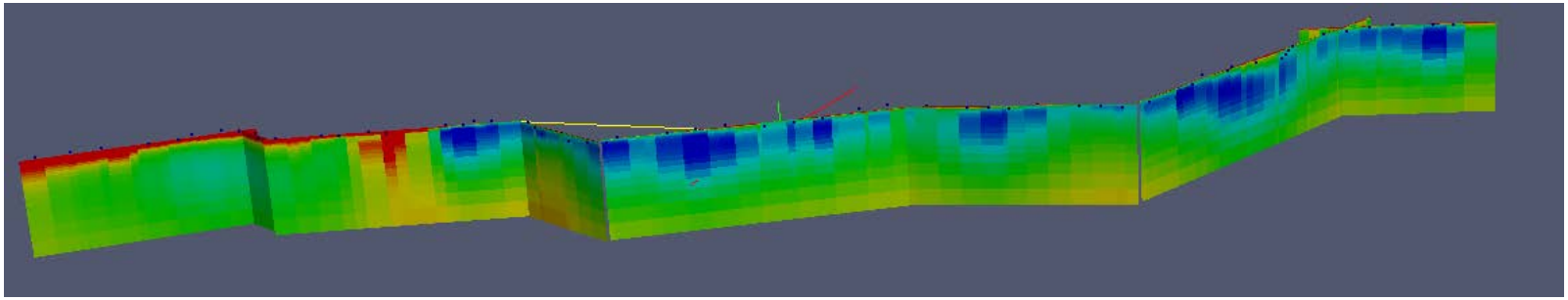

Southwest
Northeast
DD
F
YFB
CUN
0
100
300 km
Depth (km)
0
20
40
60
80
100
FR
Resistivity (Ω.m)
10⁵
10³
10¹

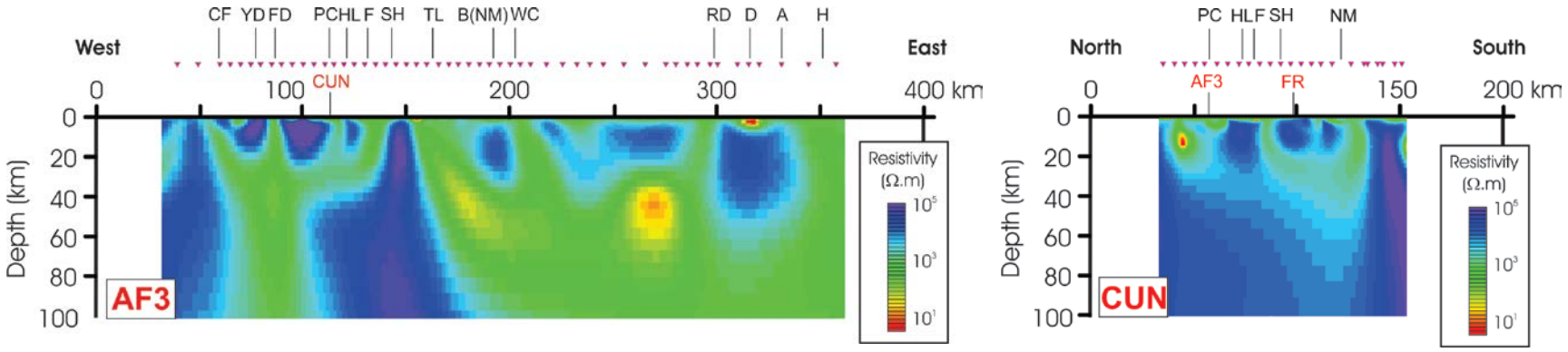

North
South
PC HLF SH
NM
AF3
FR
0
150
200 km
Depth (km)
0
20
40
60
80
100
CUN
Resistivity (Ω.m)
10⁵
10³
10¹

Results so far

- Even by Western Australian standards the Fraser survey is highly ‘3D’.
- Experience, for example in the Capricorn Orogen has shown significant improvements when modelling in 3D.
  - Time consuming, and requires the iVec super computer.
- A similar story seems to apply to data from the Fraser area – Tropicana line.





Results so far

- Map many ‘conductive’ features in resistive background – faults?
- Conductivity of the lower crust is variably conductive, as is the upper mantle.
- Are we seeing Archean features that continue under the Fraser Orogen?
- 3D modelling to come ...