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Passive seismic for drill-hole optimisation; from Cretaceous cover to tundra thickness

Andrew Fitzpatrick and Clinton Keller
Chief Geophysicist

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Passive Seismic

- Tromino Unit
- 3 component geophone
- Combined Data Logger
- Other versions have GPS and radio telemetry
- Battery operated

$$f = \frac{V_s}{4h}$$

f = resonant frequency
V_s = Shear wave velocity
H = layer thickness

Outline

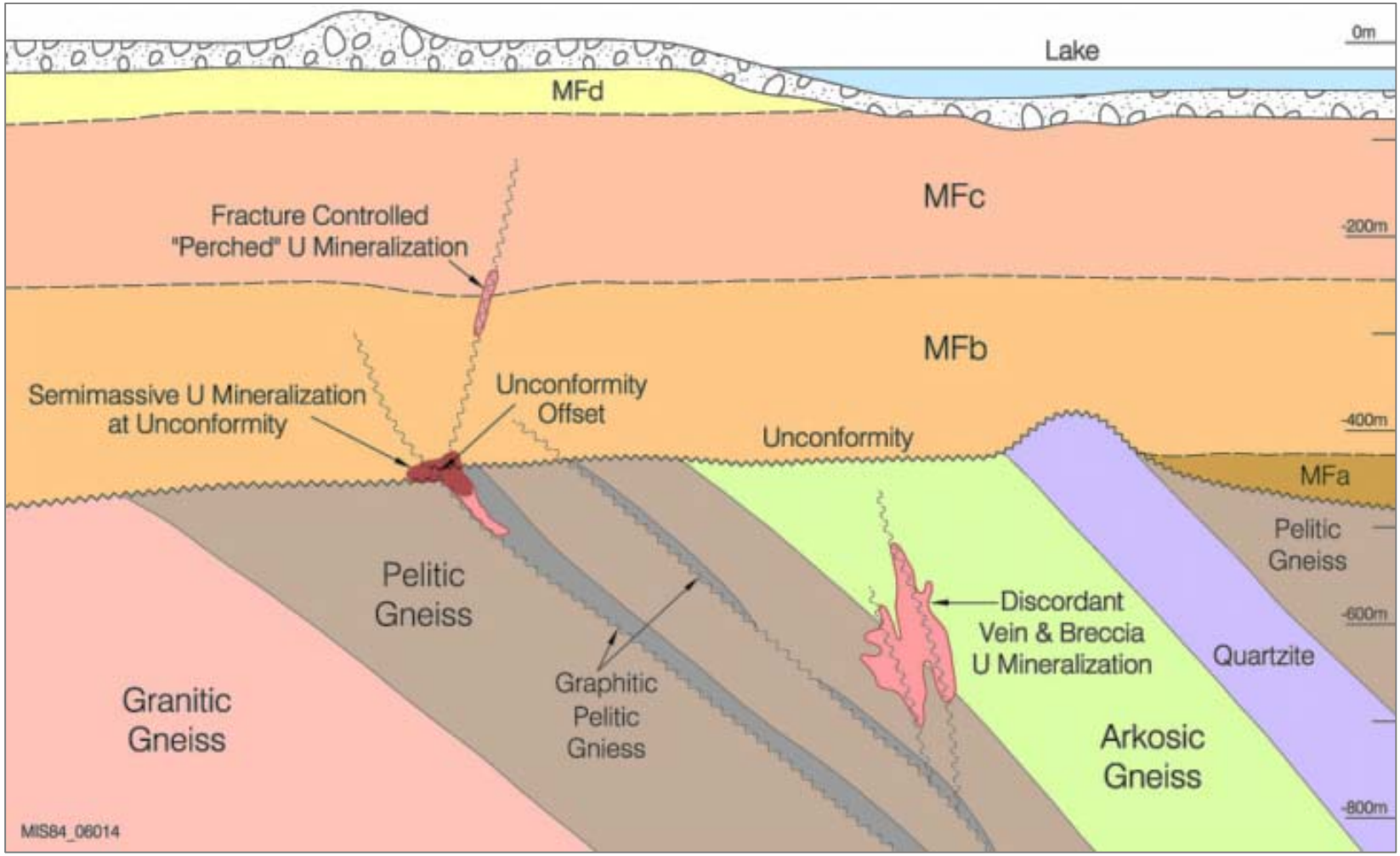
Case Study #1

- **Tillite thickness in Athabasca Basin, Canada**

Case Study #2

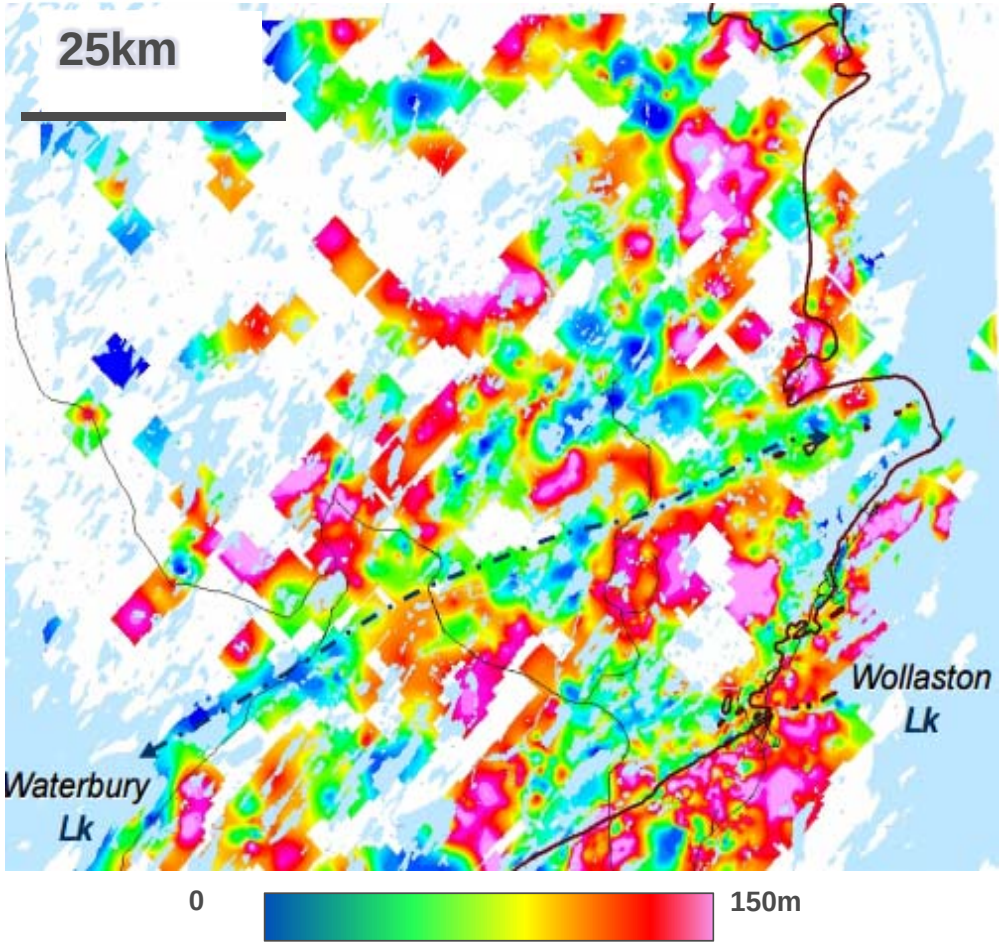
- **Cretaceous cover thickness Arnhem Land, Australia**

Unconformity Uranium model (Athabasca)



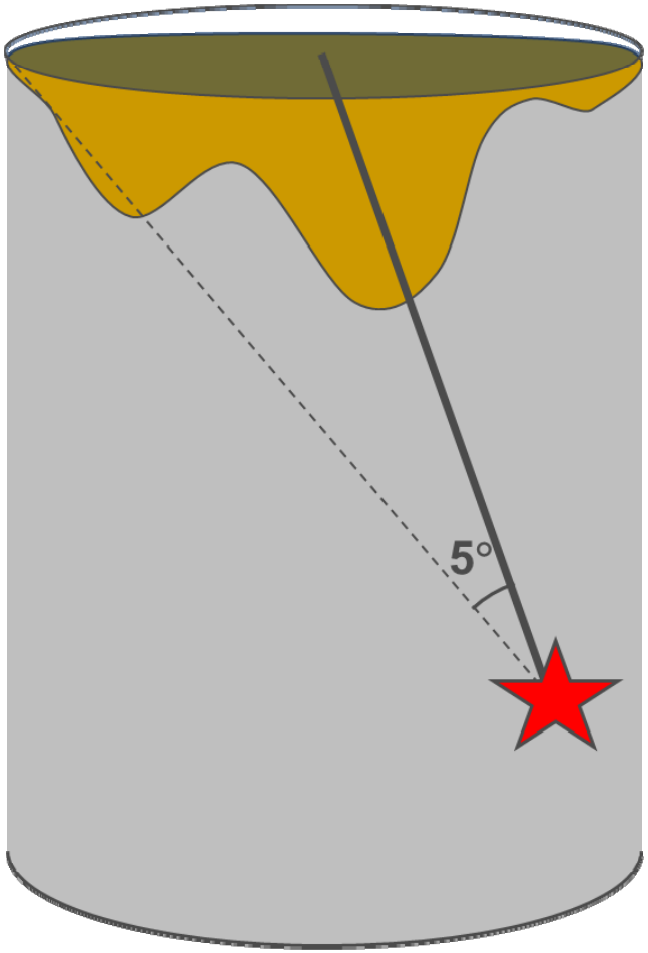
Issues arising from till

- **Major "troughs" in overburden pose logistical difficulties, increased costs, and higher risks when attempting to drill**
  - production rates reducing to approximately 20 metres per day, and drilling costs reaching $250 to $300 per metre of overburden.
- **Varies form 0 to 200m**
- **Amplitude and wavelength of gravity signature due to alteration in sandstones are comparable with that of variable thickness of glacial sediments.**
- **Mapping the overburden thickness can help constrain overburden stripping in geophysical inversion**

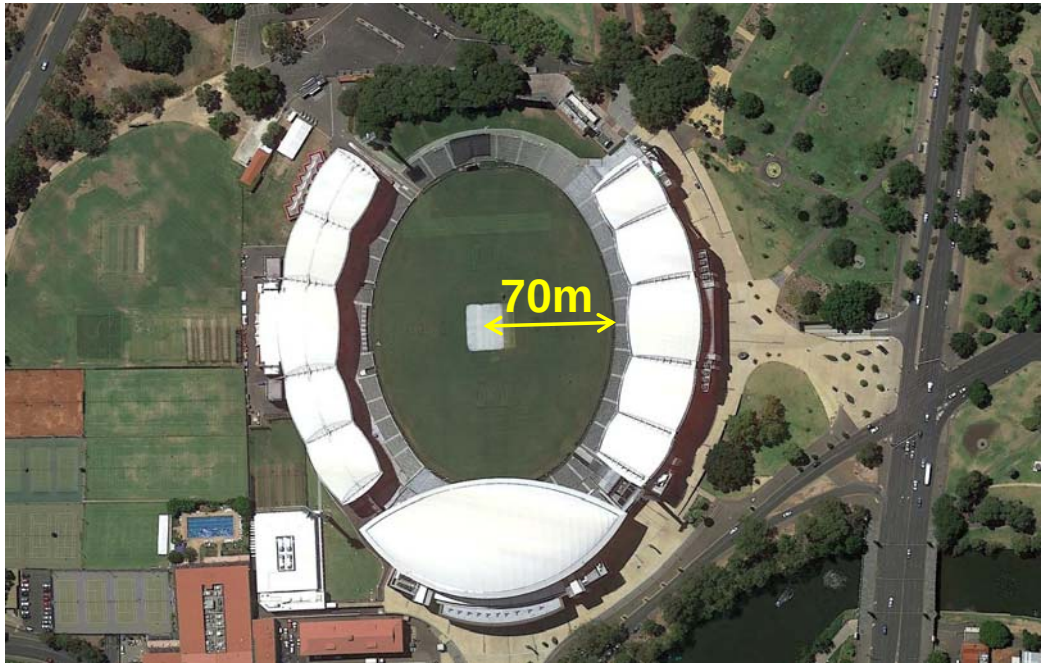


(From Campbell,2007)

Flexibility in collar location



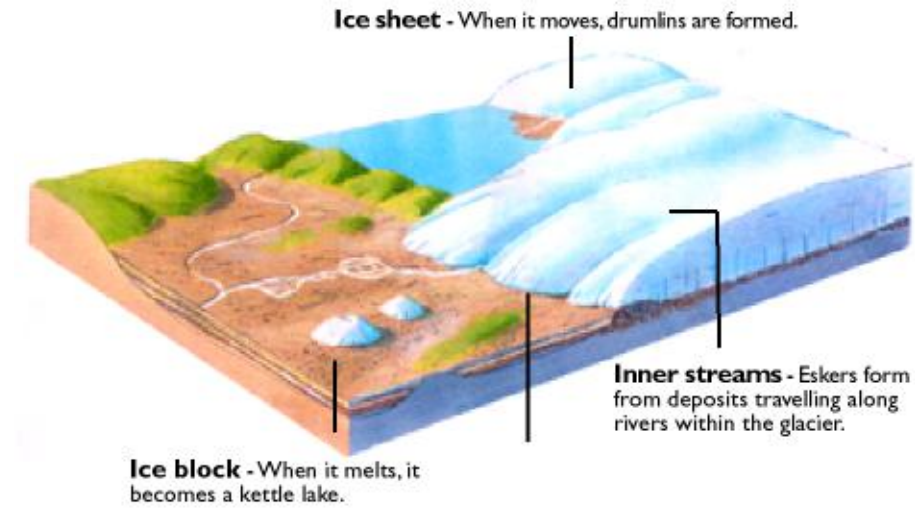
- For an 800 m hole
- 5° variation in dip
- ~70m radius collar footprint

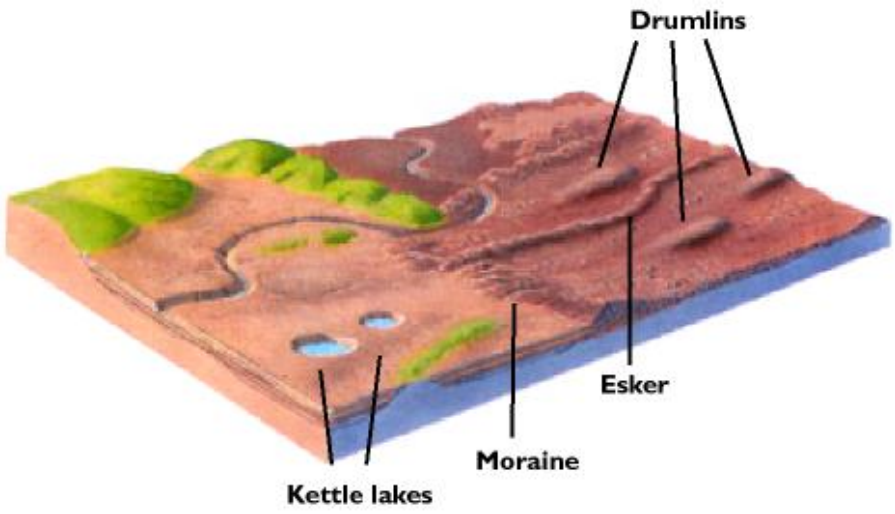


Adelaide Oval

Till formation

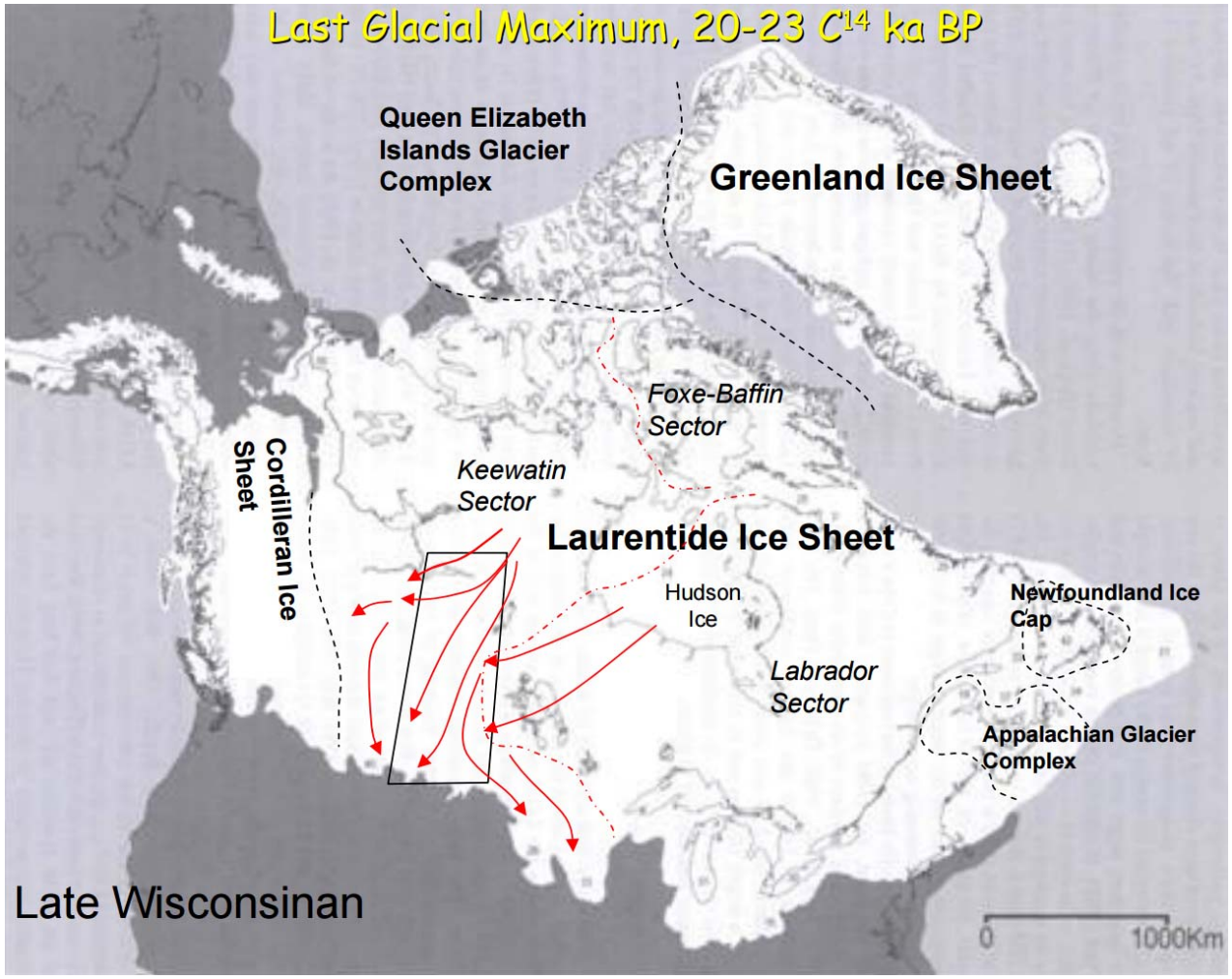
- **Glacial till** is unsorted sediment deposited directly by **glacial** ice. **Glacial till** is a soft rock identified by large angular rock fragments on the surface and within the soil.
- **Multiple glaciations extensive drift cover extensive drift cover**
  - complex glacial history
- **Present day landscape primarily result of last primarily result of last glaciation –Late Wisconsinan**
- **Preservation of older sediments in thick drift and buried valleys**





Images from http://members.shaw.ca/len92/geology.htm

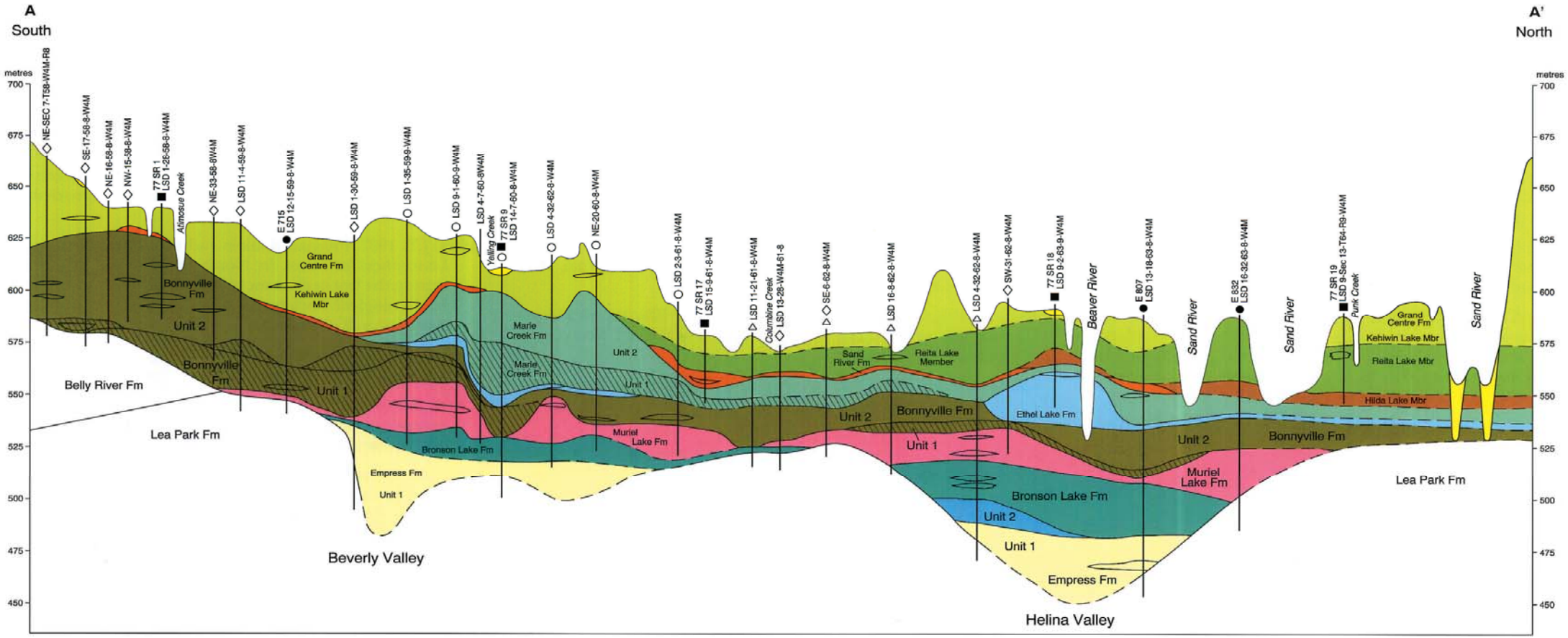
Regional Setting



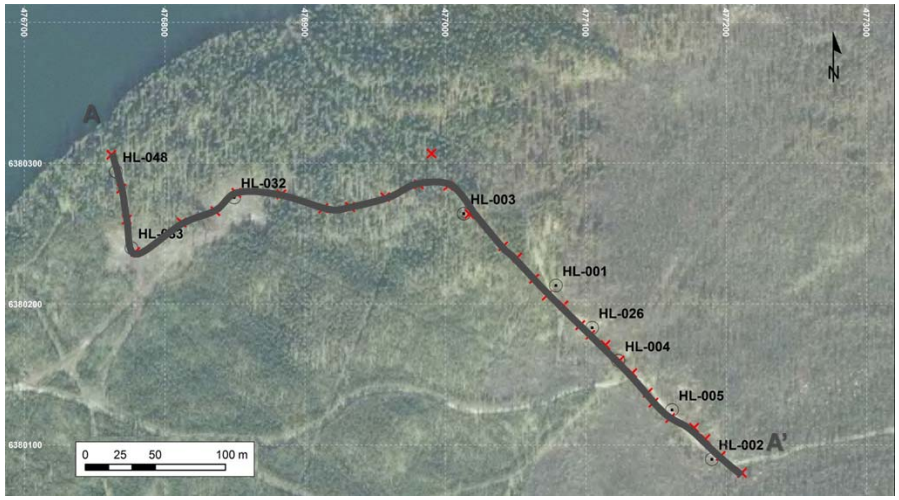
Glacial Maximum (From Campbell,2007)

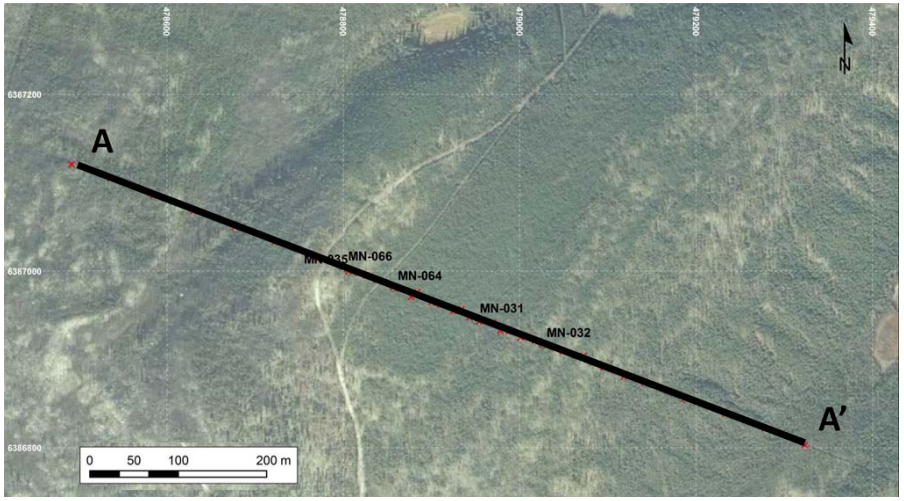
Drumlins (Athabasca)

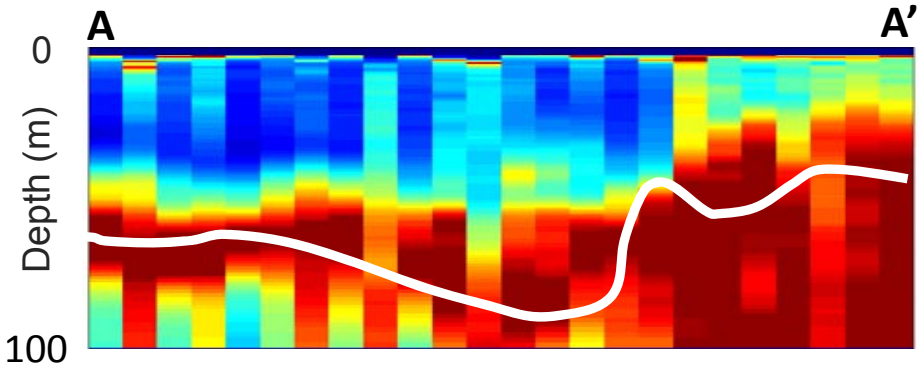
Quaternary overlying Cretaceous units

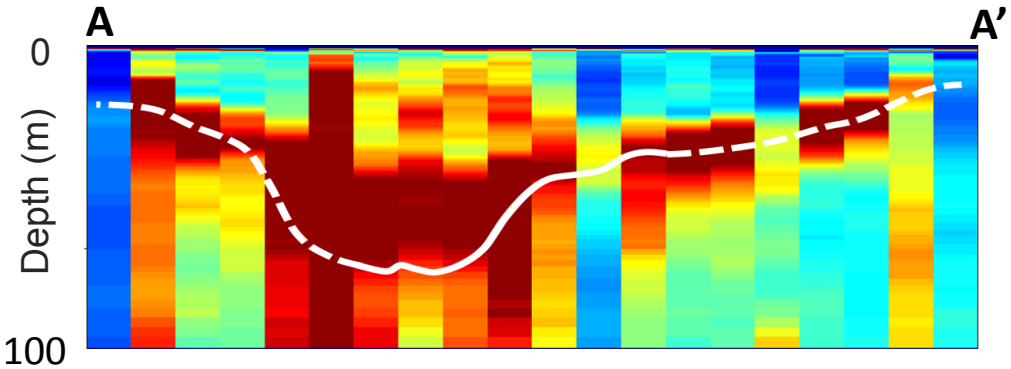


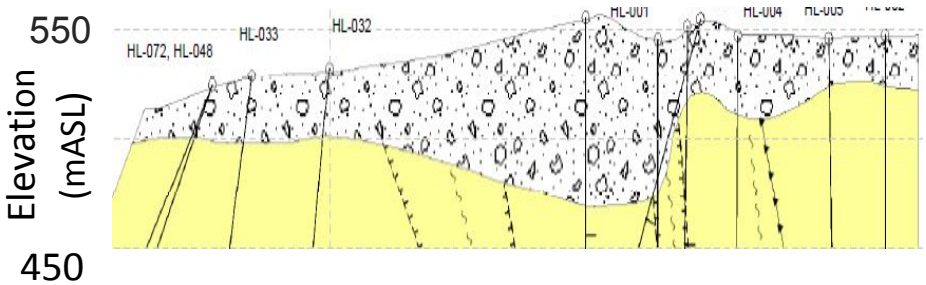
From Andriashek and Fenton, 1989

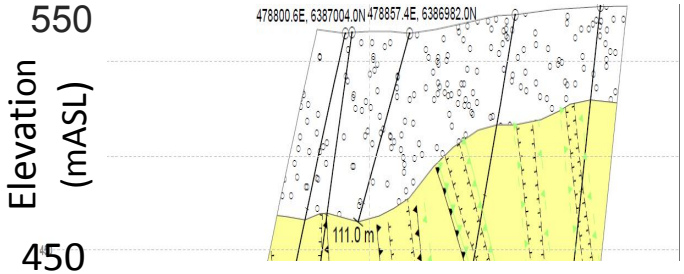

A
HL-048
HL-032
HL-003
HL-001
HL-026
HL-004
HL-005
HL-002
A'
0 25 50 100 m


A
MN-066
MN-064
MN-031
MN-032
A'
0 50 100 200 m

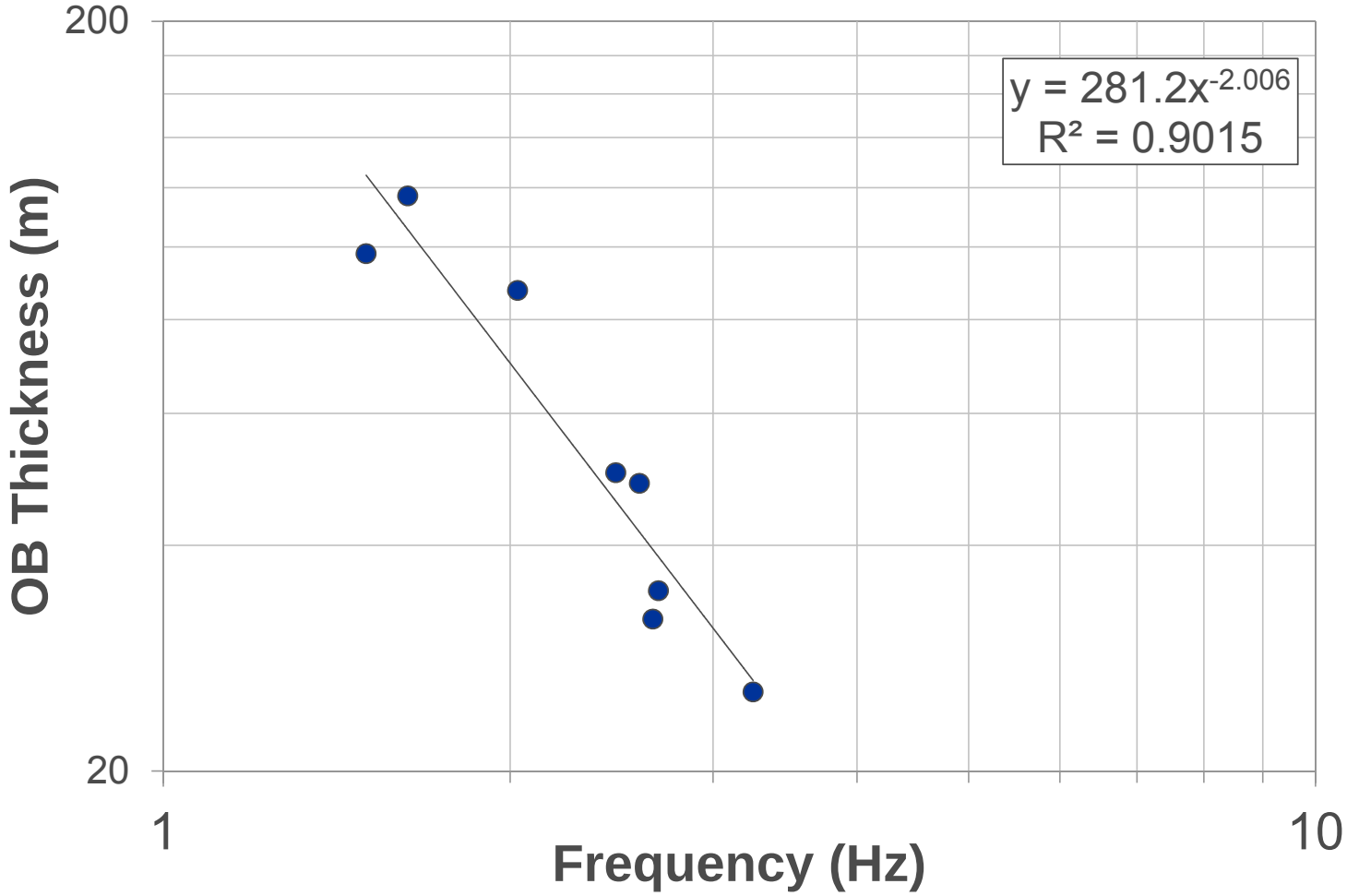

A
A'
0
Depth (m)
100


A
A'
0
Depth (m)
100


550
Elevation (mASL)
450
HL-072, HL-048
HL-033
HL-032


550
Elevation (mASL)
450
478800.6E, 6387004.0N
478857.4E, 6386982.0N
111.0 m

Borehole vs Passive Seismic results



Outline

Case Study #1

- Tillite thickness in Athabasca Basin, Canada

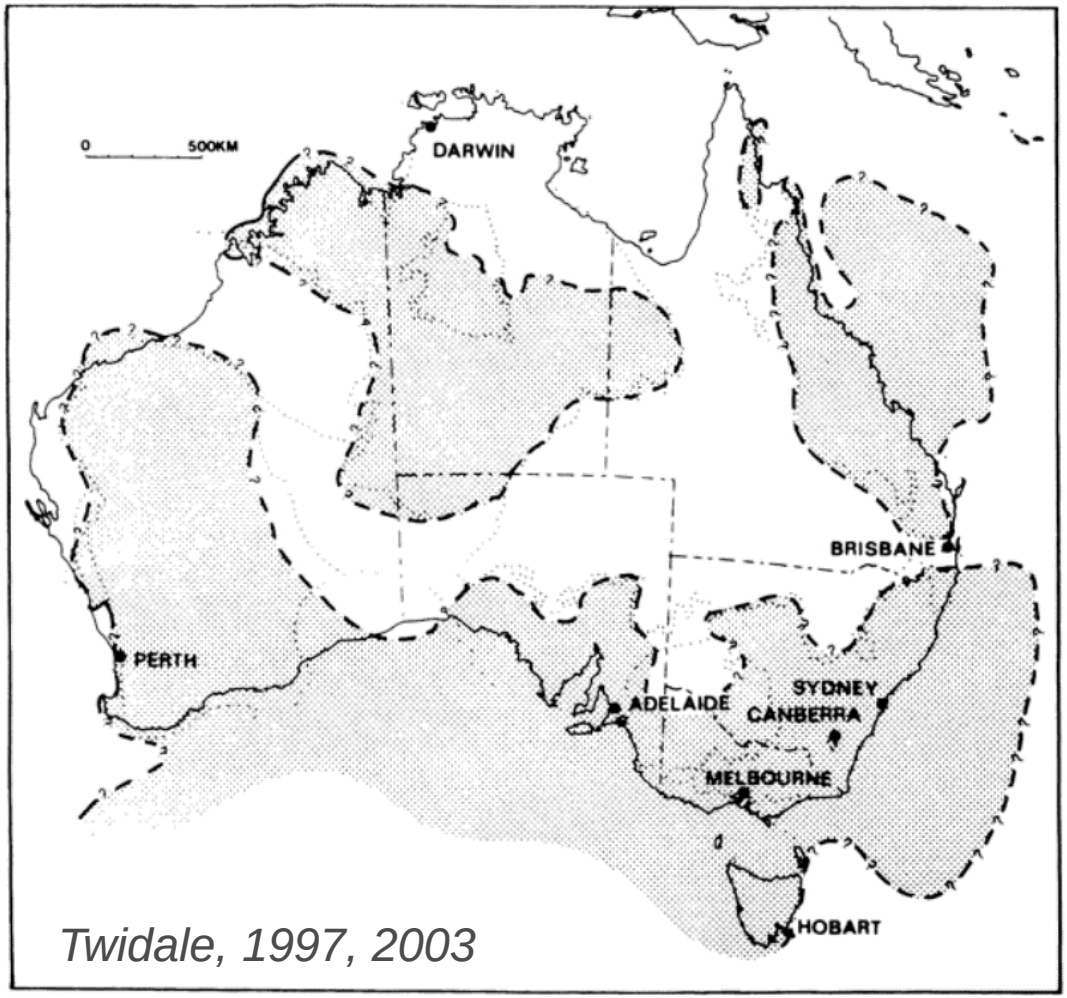
Case Study #2

- Cretaceous cover thickness Arnhem Land, Australia

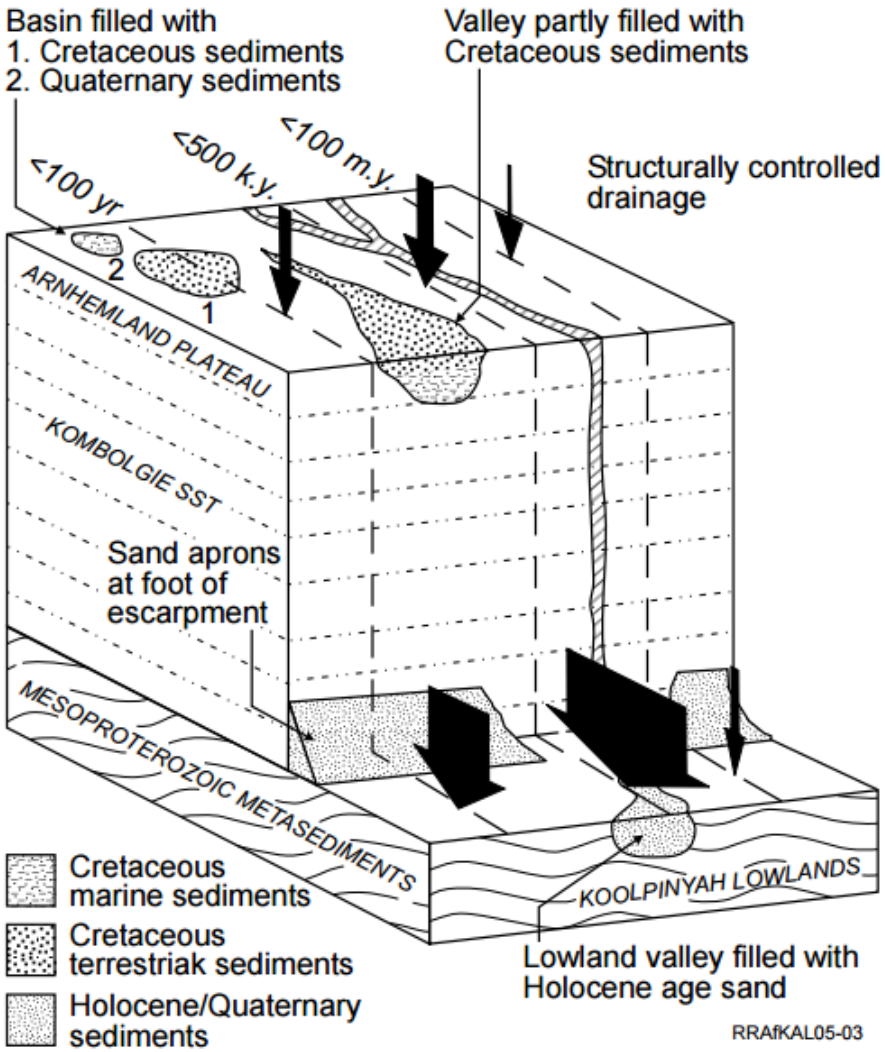
RC Drilling vs Diamond Drilling

- **Positives**
  - Cheaper and faster alternative to diamond drilling
  - Requires less water
  - Could be used for geochemical exploration
- **Negative**
  - Less geological information from sample
  - Depth limitations (250-300m from an efficiency perspective)
  - Difficult to implement in Cretaceous materials >30 m thick

Cretaceous Sediments



Twidale, 1997, 2003

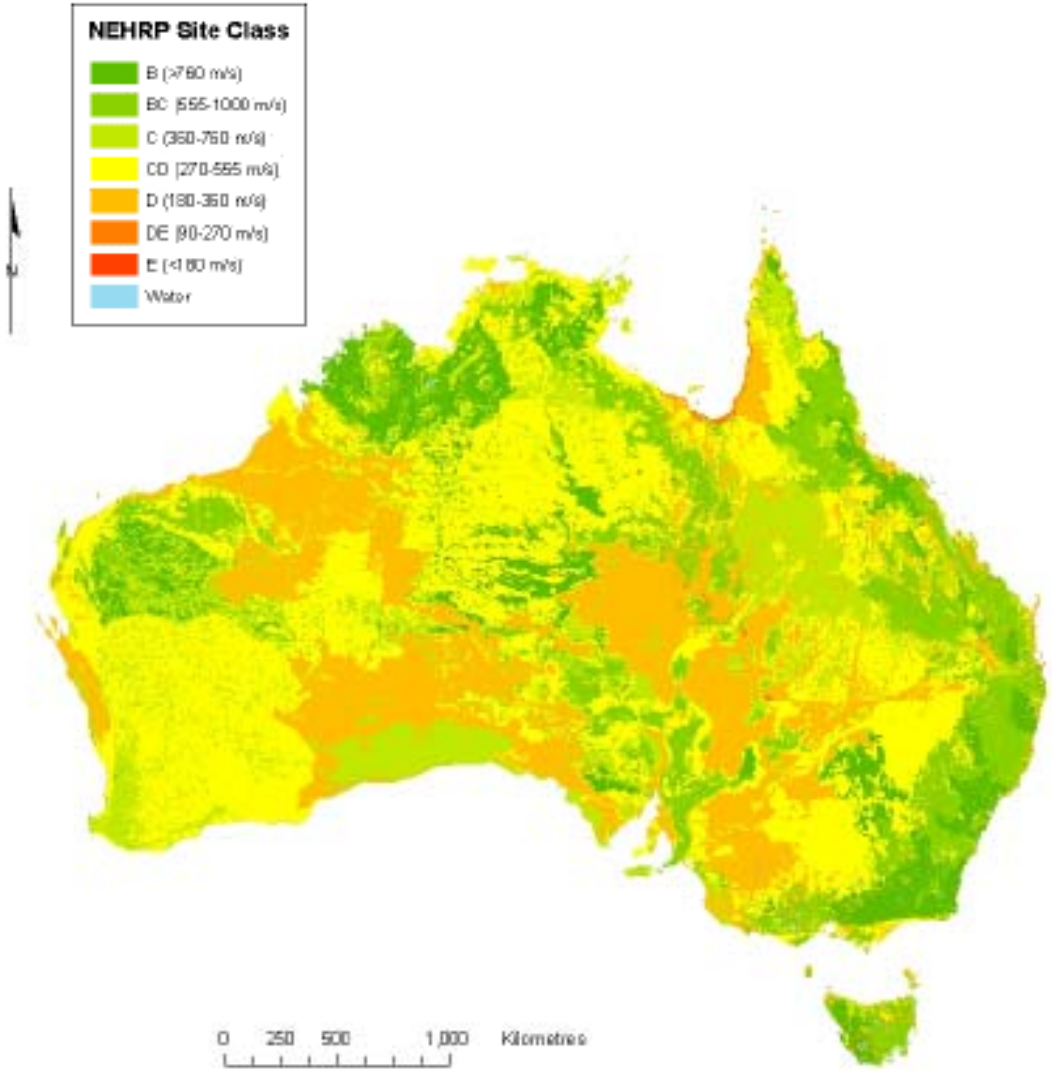


Nott, 2003

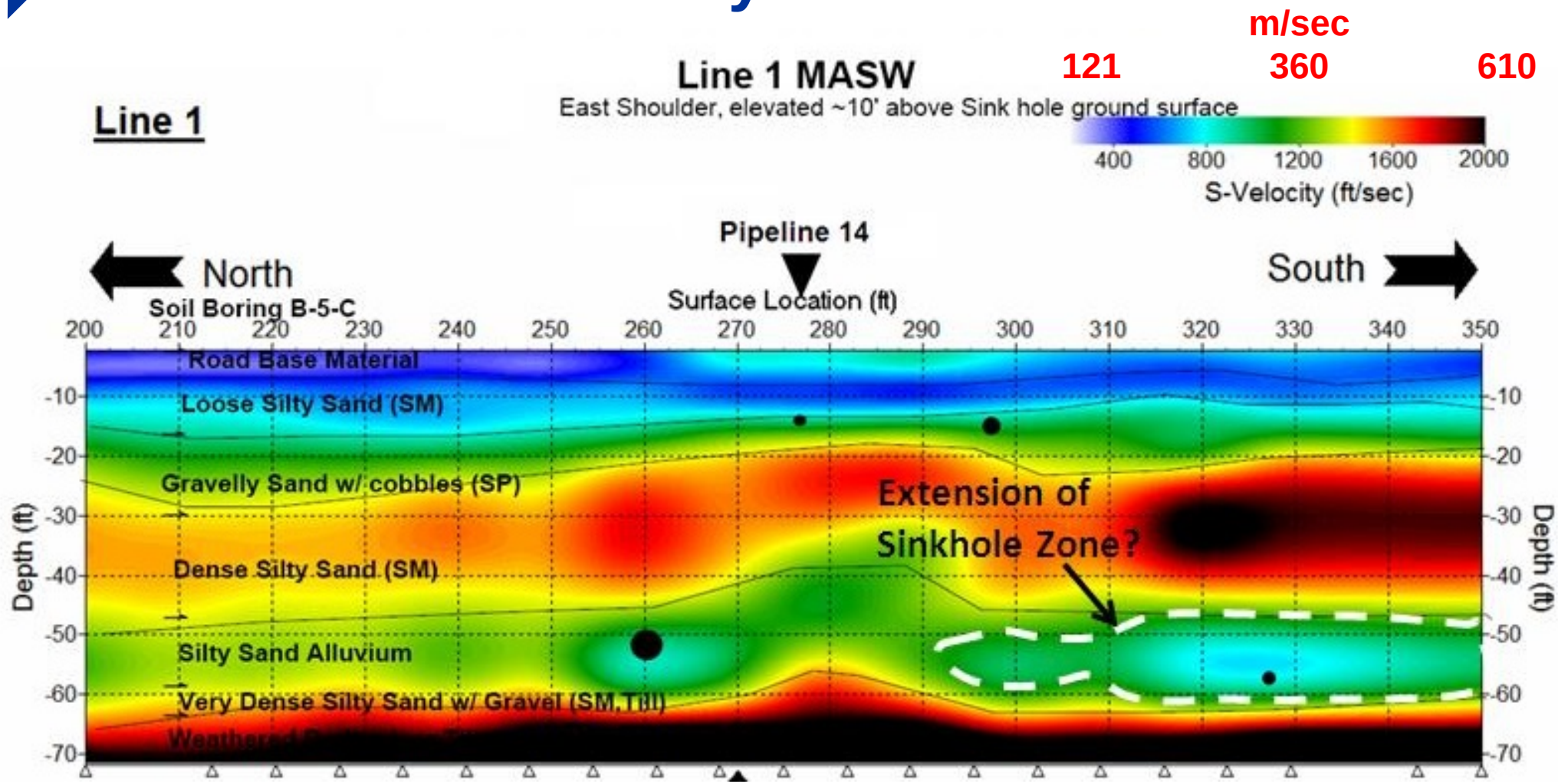
Shear Wave Velocity

Table 1. Modified NEHRP site classes, associated V_s^{30} values and general groupings of geologic units associated with each class, based on 556 measured profiles from California (Wills *et al.*, 2000).

Site Class	V_s^{30} (m/s)	Geological Materials
B	> 760	Plutonic/metamorphic rocks incl. most volcanics; pre-Tertiary sedimentary units
BC	555 - 1000	Cretaceous fine-grained sediments; serpentine; sheared/weathered crystalline rocks
C	360 - 760	Oligocene – Cretaceous sedimentary rocks; coarse-grained younger material
CD	270 - 555	Miocene fine-grained sediments; Plio-Pleistocene alluvium; coarse younger alluvium
D	180 - 360	Holocene alluvium
DE	90 - 270	Fine-grained alluvial/estuarine deposits
E	< 180	Inter-tidal mud

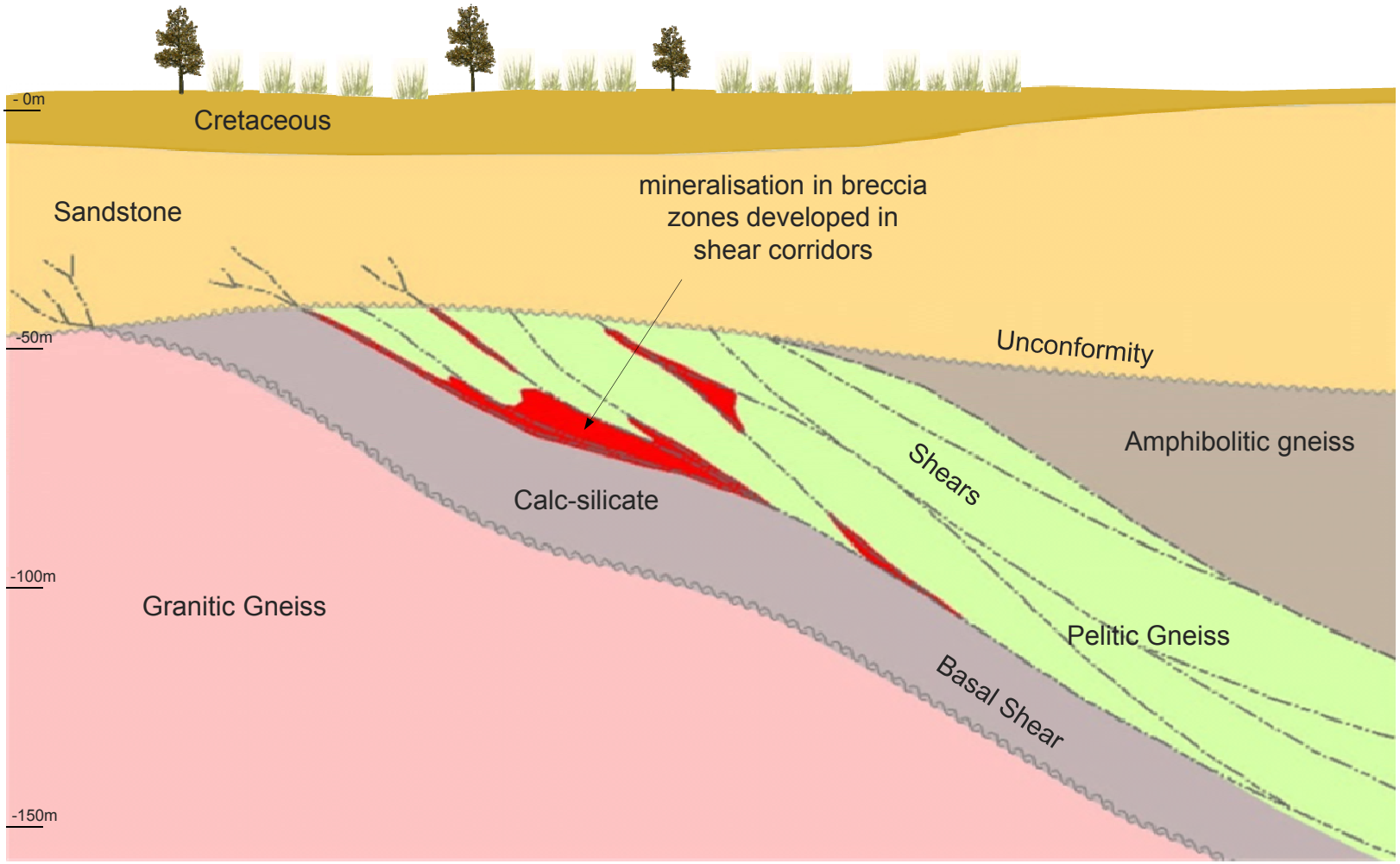


Shear Wave variability



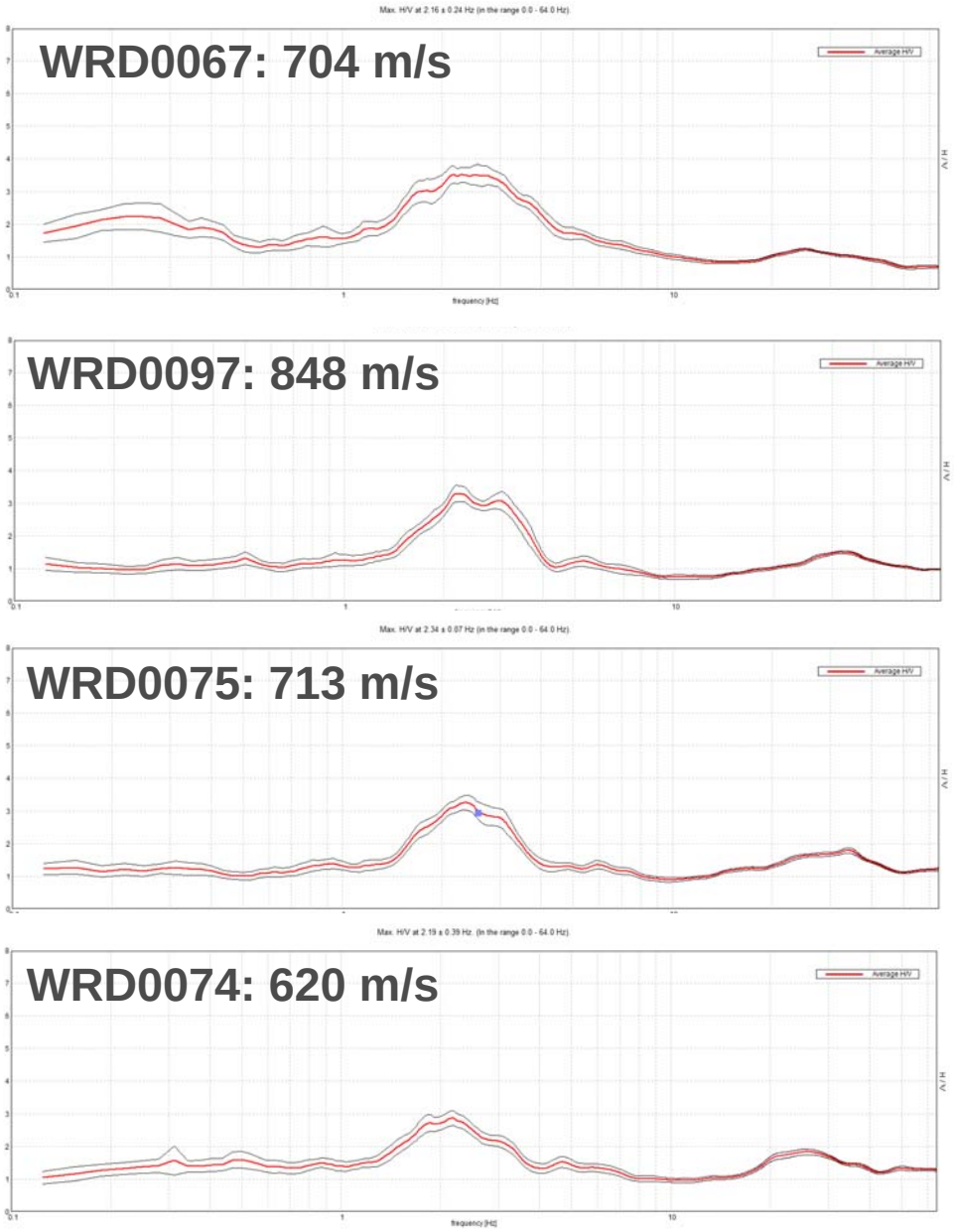
From Parkseismic.com

Unconformity Uranium model (Australian Setting)



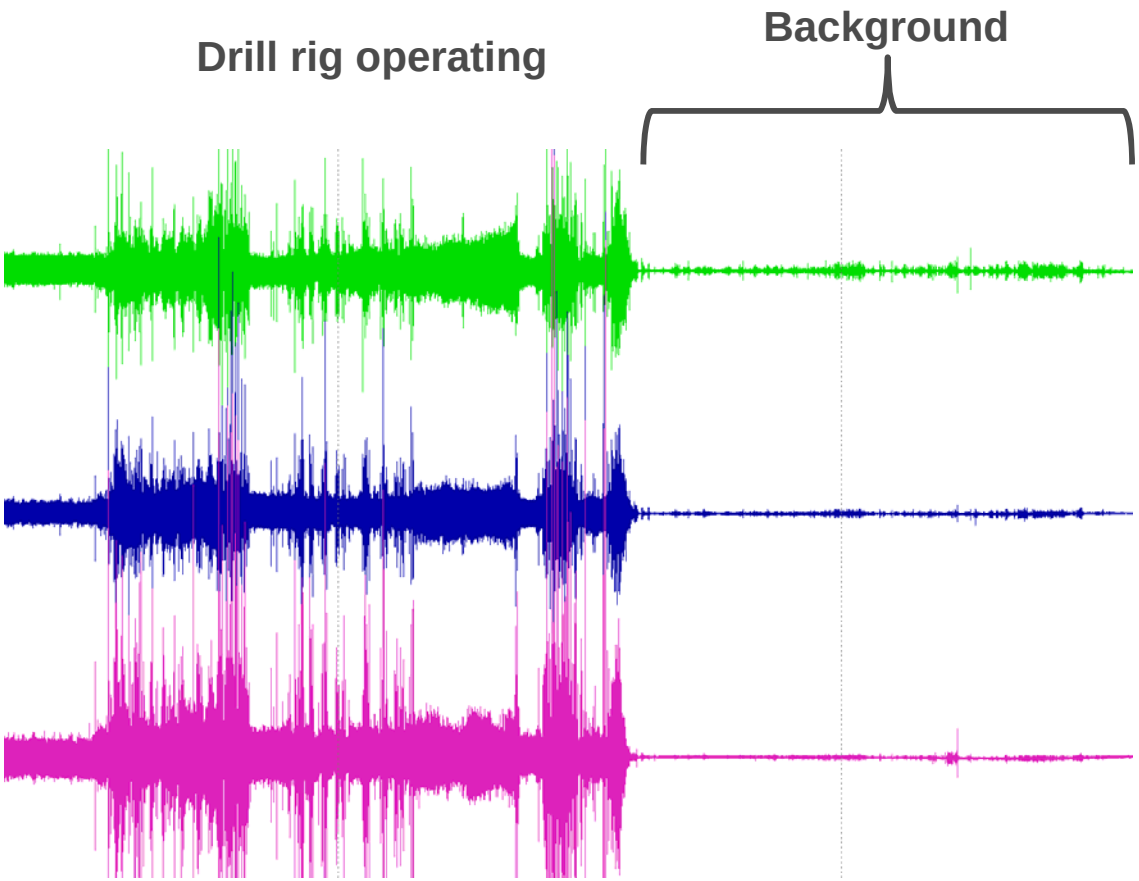
Estimating Velocity

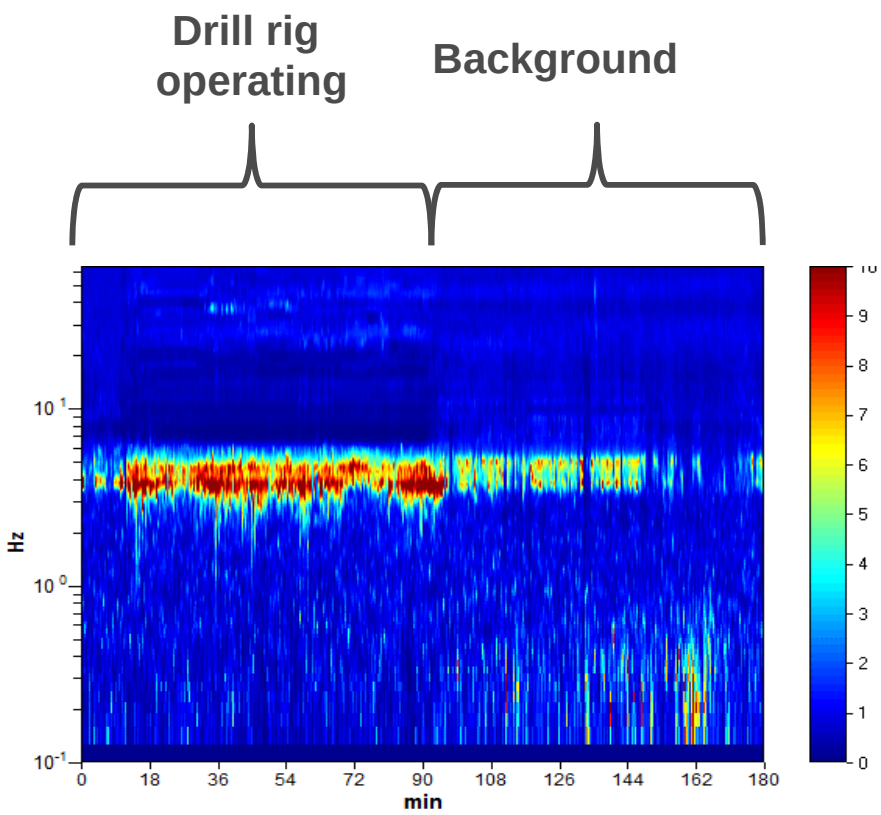
Average 702 m/s
Std.Dev 60 m/s



Testing near operating drill rigs

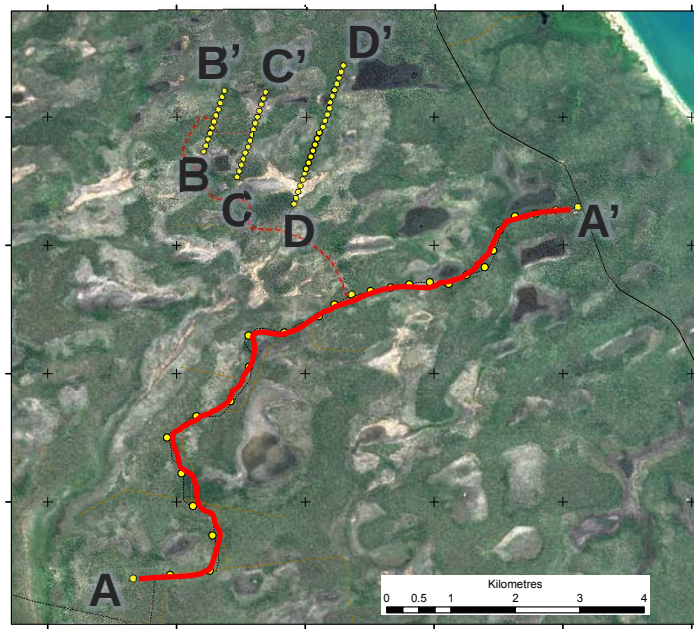
- Increase amplitude of signals but doesn't provide any benefit in measurement

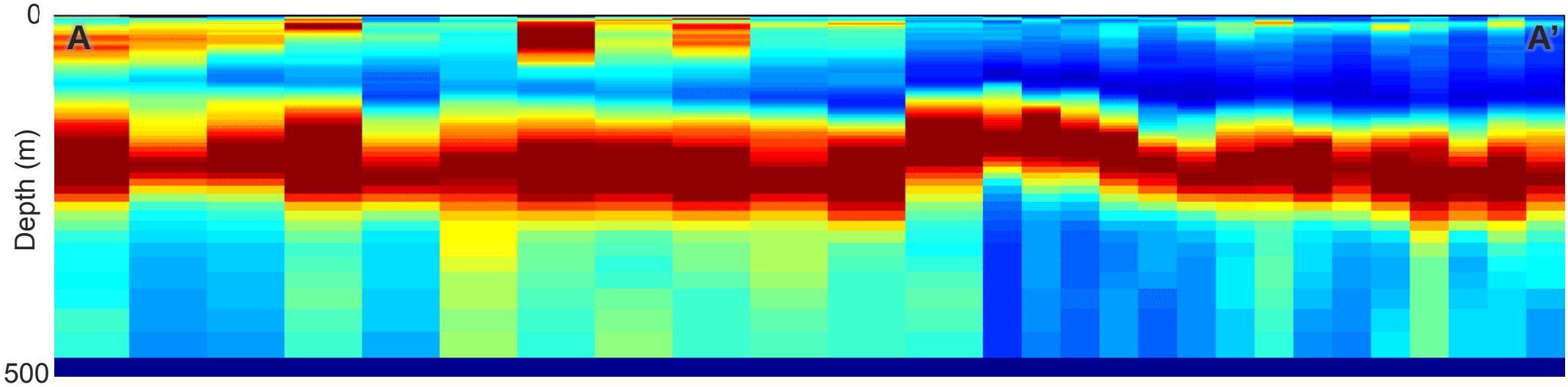




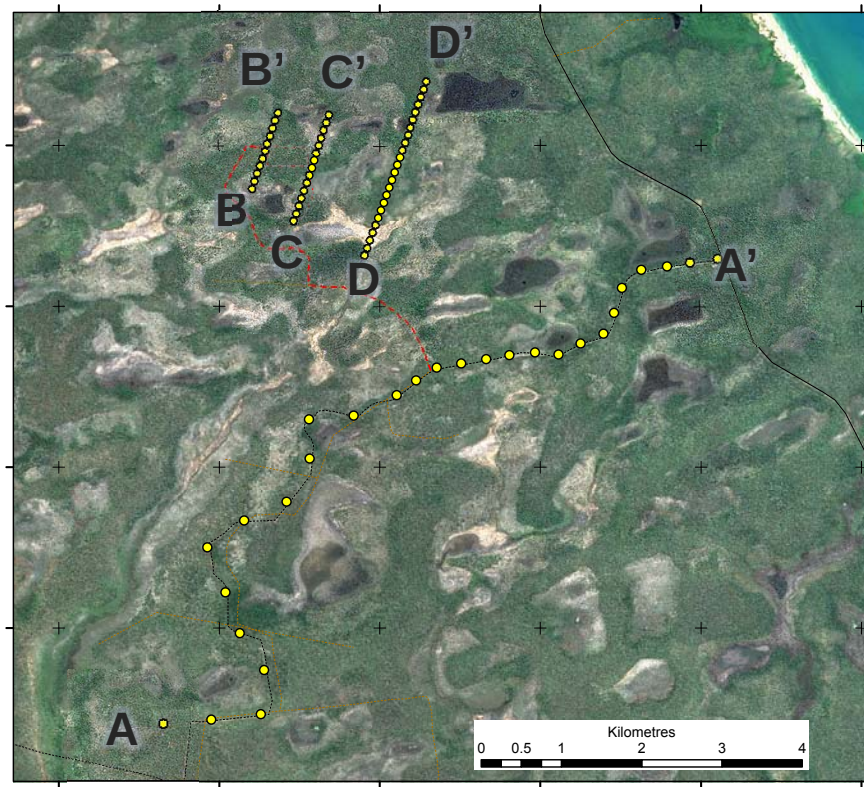
Profiles

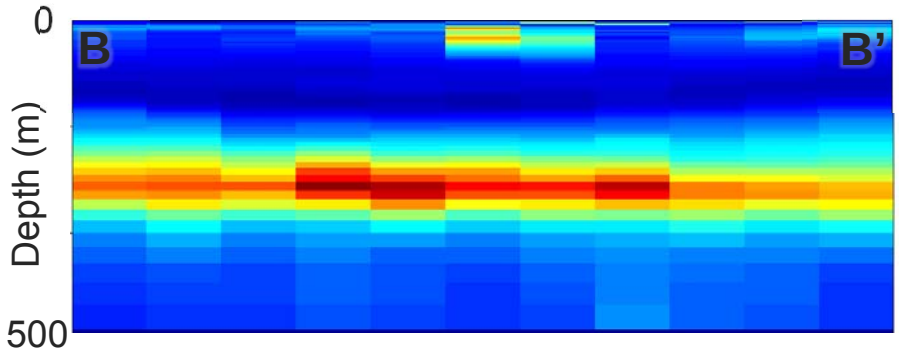
- **15 Minutes record**
- **Station spacing:**
  - 3 Transects @ 100m
  - 1 Regional transect @ 300 and 600m

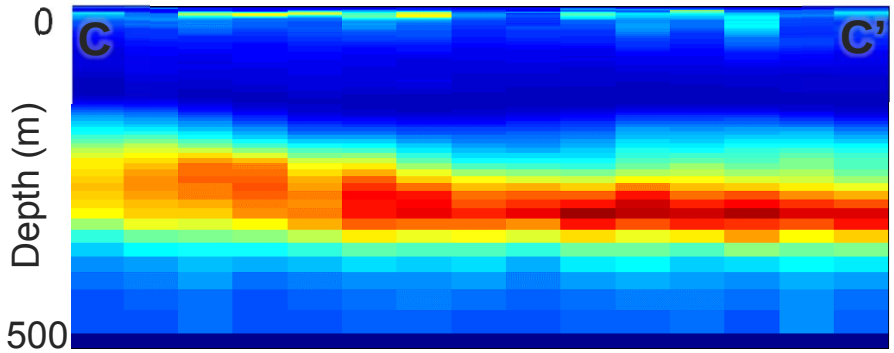


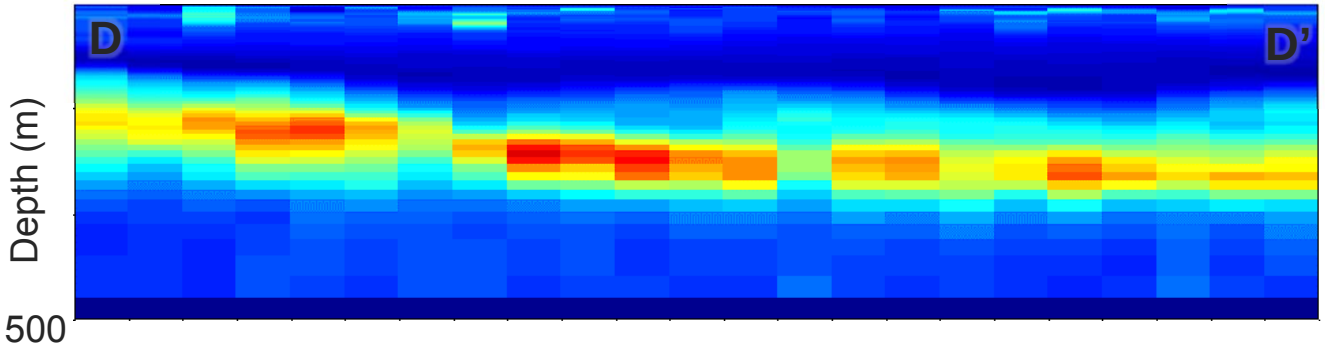


Profiles


B'
C'
D'
B
C
D
A'
A
Kilometres
0 0.5 1 2 3 4


0
B
B'
Depth (m)
500


0
C
C'
Depth (m)
500


D
D'
Depth (m)
500

Conclusions

- **Passive seismic is successful in mapping overburden**
  - Glacial till sediments
  - Cretaceous Sediments
- **Assumptions are the geological materials have consistent velocities. Any errors are directly proportional to the estimation of thickness.**
- **Existing drilling can be used to calculate layer velocities.**
- **Using active sources did not lead to significant improvement in measurement (may be limited bandwidth).**
- **Useful for determining appropriate drilling techniques for pre-season planning**
- **Provides additional constraints for geophysical modelling**
- **Methodology is cheap to deploy and requires minimal training for field acquisition**

Questions

Andrew_Fitzpatrick@cameco.com

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