The Implications of the Mineral System Concept for Geophysical Exploration: A Perspective

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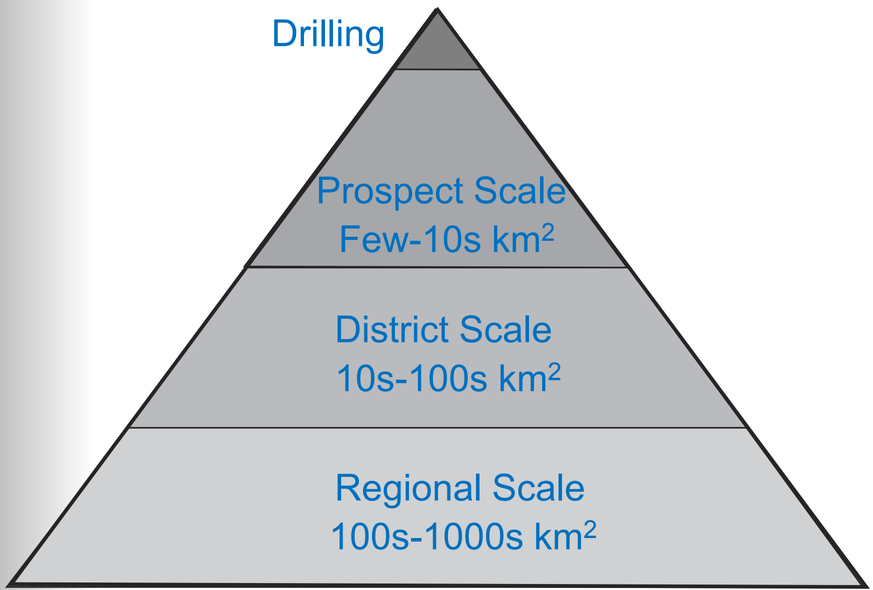
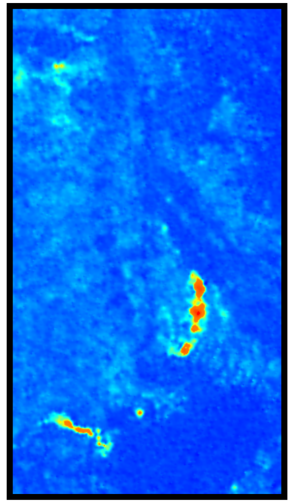
‘Traditional’ geophysical exploration strategy:

- Mapping and targeting form end members of a continuous spectrum

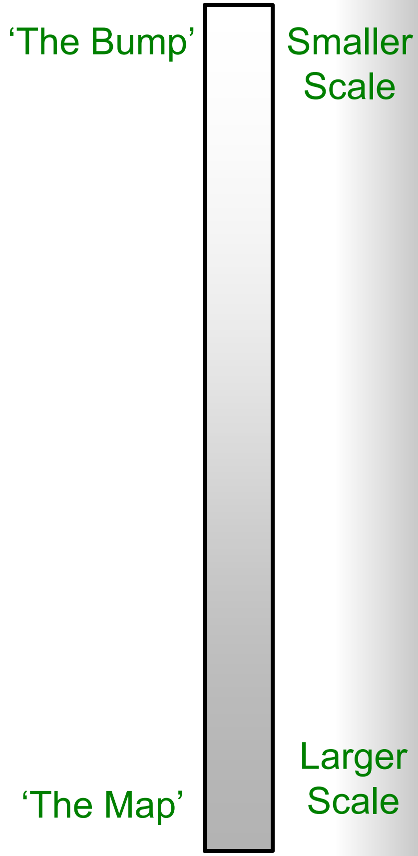
Later Stages of Exploration

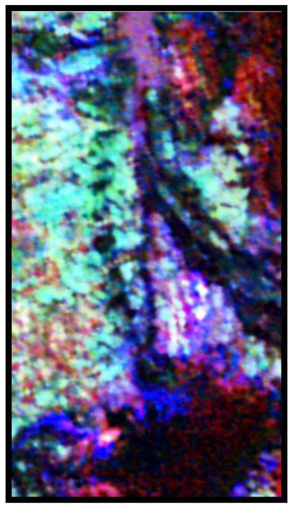


Earlier Stages of Exploration



Greater emphasis on responses from the immediate mineralised environment





Radiometric data, Ranger area, NT

Greater emphasis on mapping geology

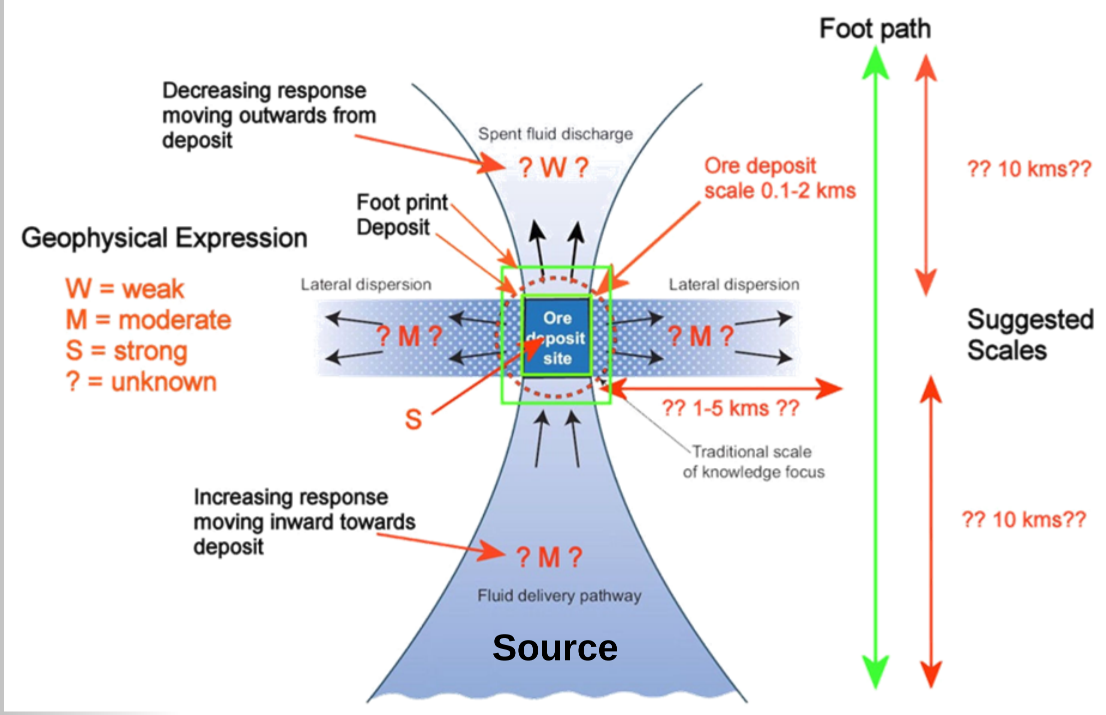
Mineral Systems

" … all geological factors that control the generation and preservation of mineral deposits" (Wyborn et al., 1994)

- Source-pathway-trap(physical throttle-chemical scrubber)

A whole new set of targets!

- Source-pathway as well as the trap
- What will these look like – associated with alteration?



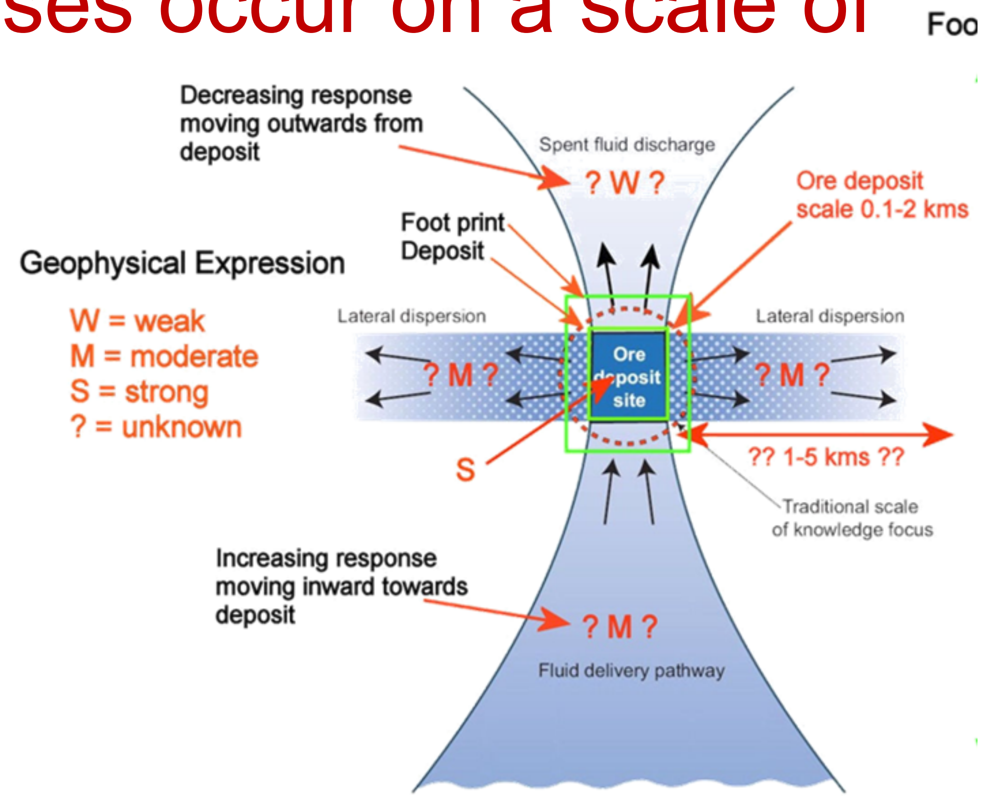
"… the major change that is required is a shift from … direct targeting … to a staged process … where geophysical approaches are used initially to help define the pathways …. that carried mineralizing solutions …"

Source: Witherly (2014)

Mineral Systems

Mineral systems processes occur on a scale of 100s to 1000s of km^3

- Need geographically widespread datasets
- Scale is such that these are only likely to come from Government/ Geological surveys



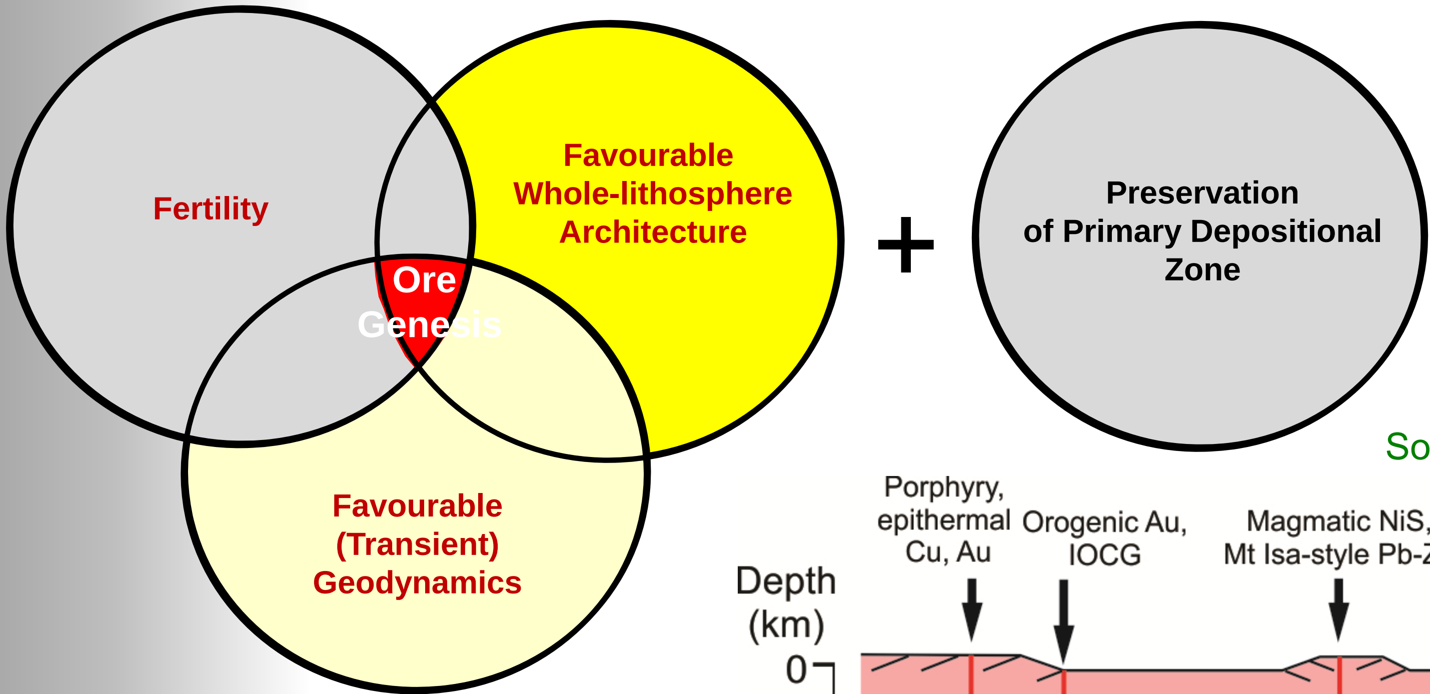
Need geophysical methods that can image source/pathway/(trap) at kms to mantle depths

- 'Academic' methods

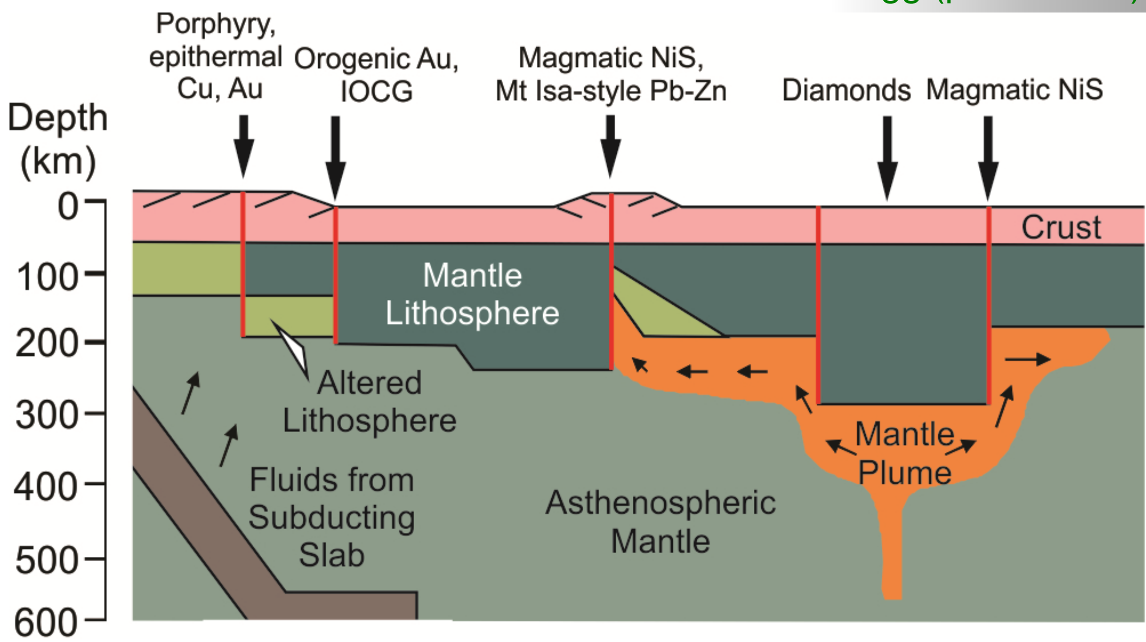
Mineral Systems

Critical elements in a mineral system

Source: McCuaig and Hronsky (2014)



Source: G Begg (pers comm)



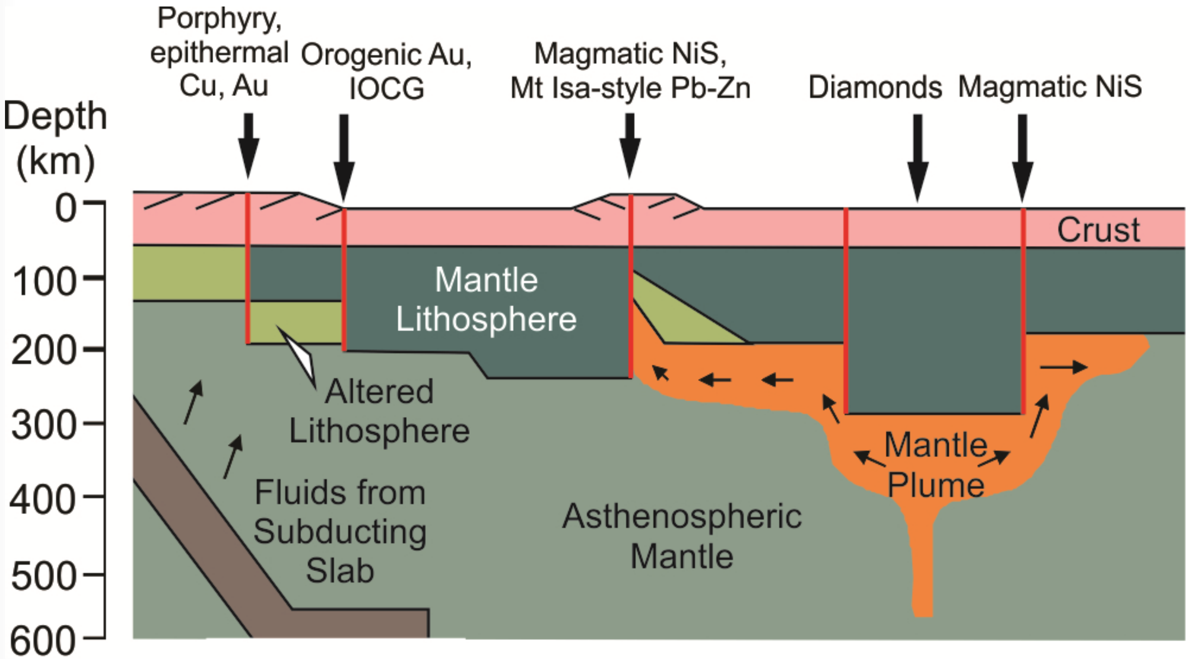
A whole new set of targets!

- Indirect inference of the fluid pathway

Deep Penetrating Geophysics

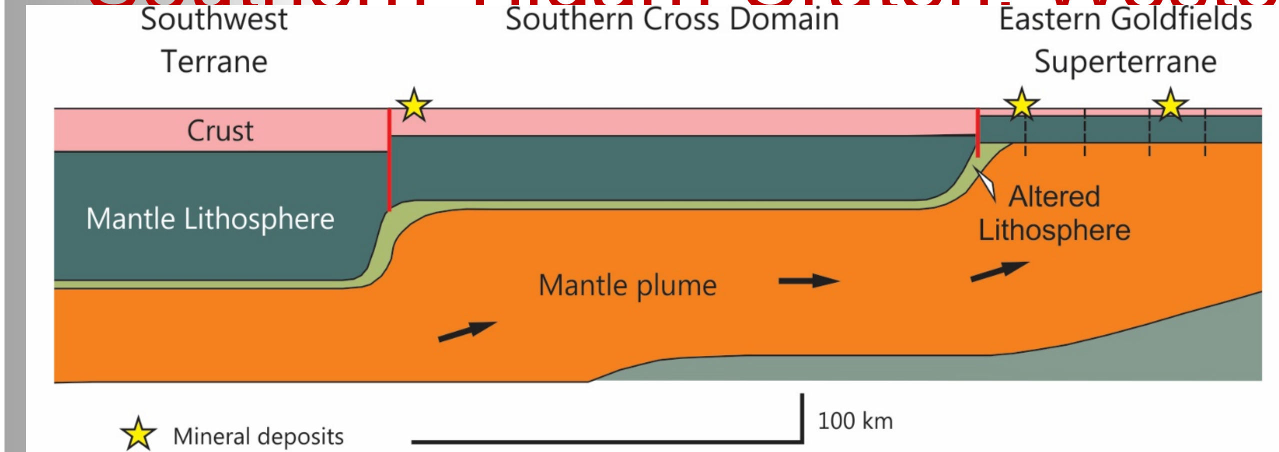
Whole lithospheric architecture: Geophysical options?

- (Gravity)
- Magnetotellurics (MT)
- Active seismic methods
- Passive seismic methods

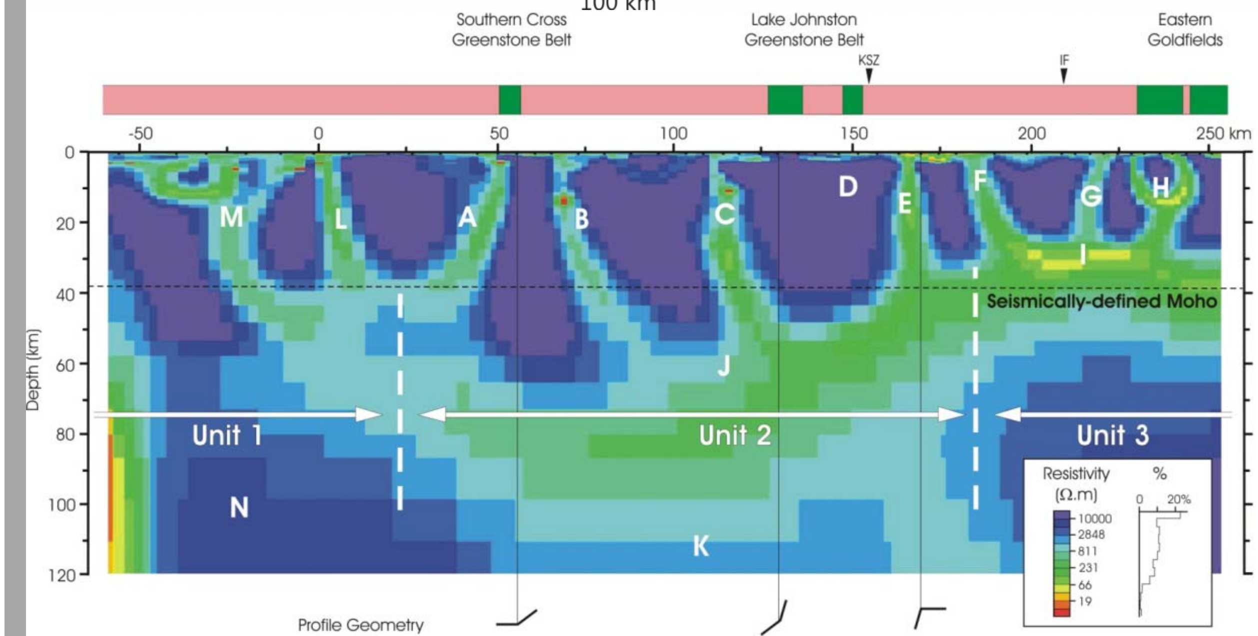


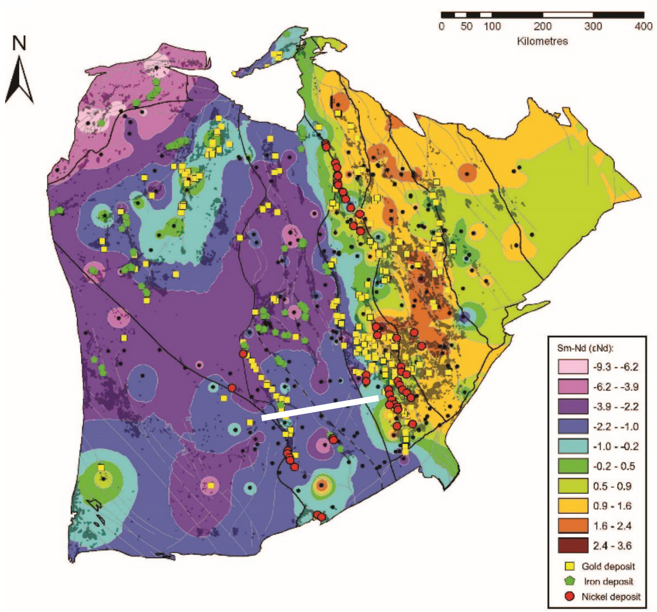
Magnetotellurics

Southern Yilgarn Craton, Western Australia



-cratonic

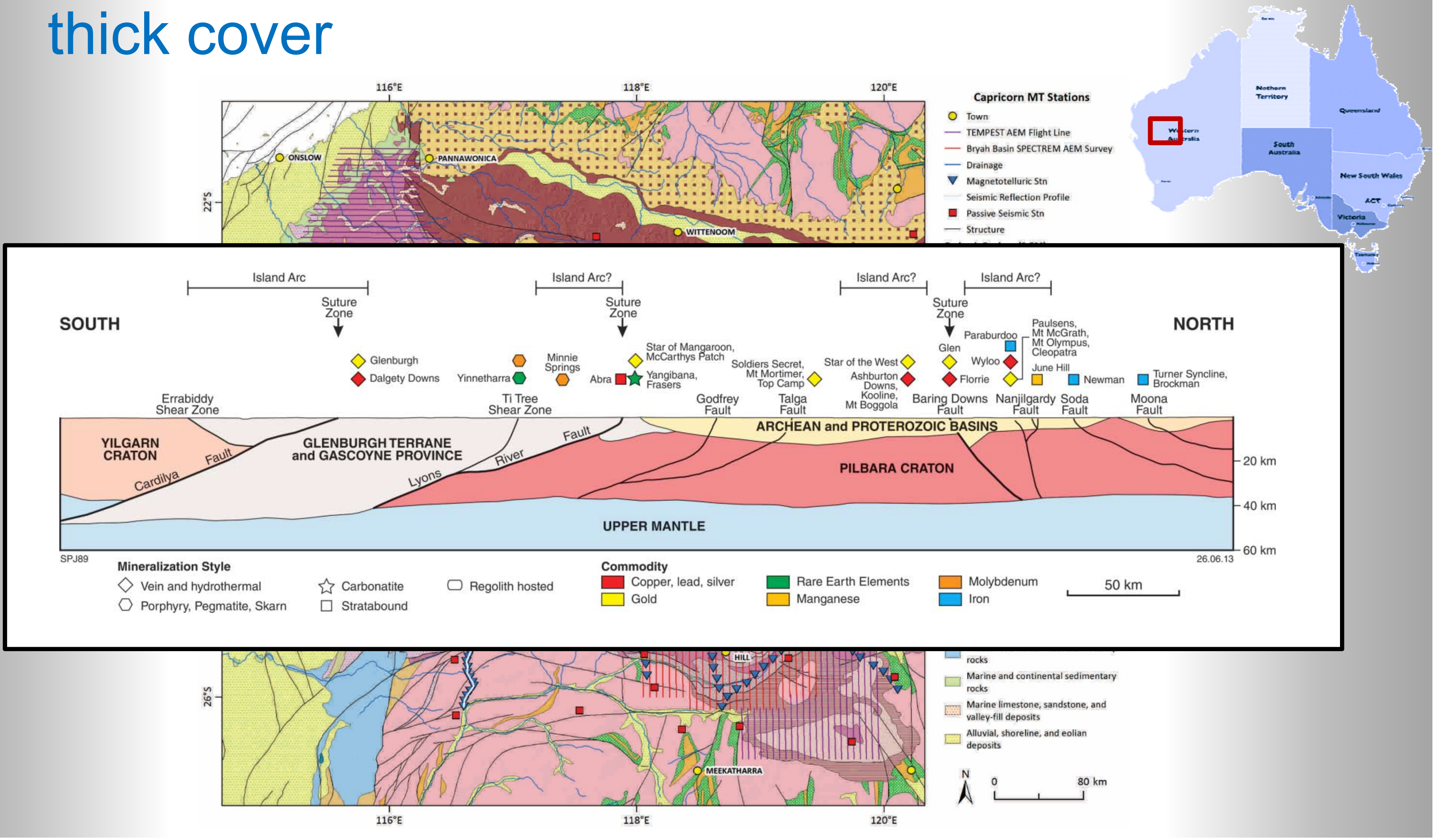




Seismic Methods

Capricorn Orogen, Western Australia

- Mapping cratonic margins/suture zones beneath thick cover



Seismic Methods

Advantages passives surveys

- Do not require expensive artificial sources
  - Drilling of shot holes

Disadvantages passive surveys

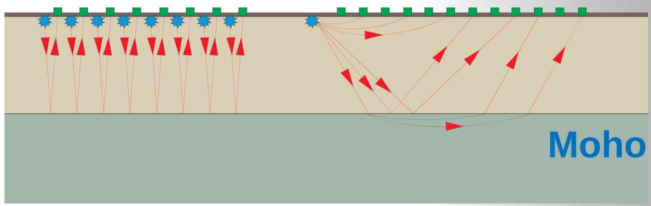
- Lack resolution
- Long deployment times
  - Weeks, months, years

Options

- Ambient noise methods – V_S
- Teleseismic methods – velocity contrasts
  - Receiver functions, body wave tomography, H-k analysis

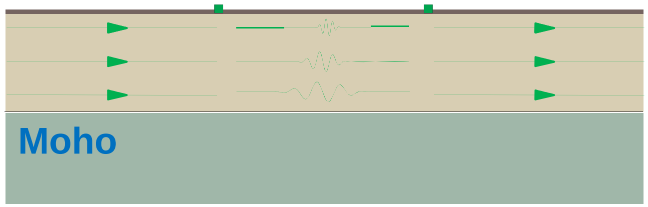
Active Source Data

Source: Local explosion/ vibration

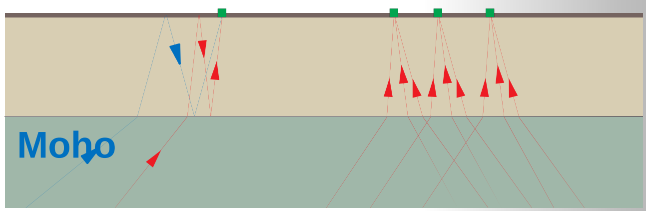


Ambient Noise Data

From Distant Micro Seismic Events



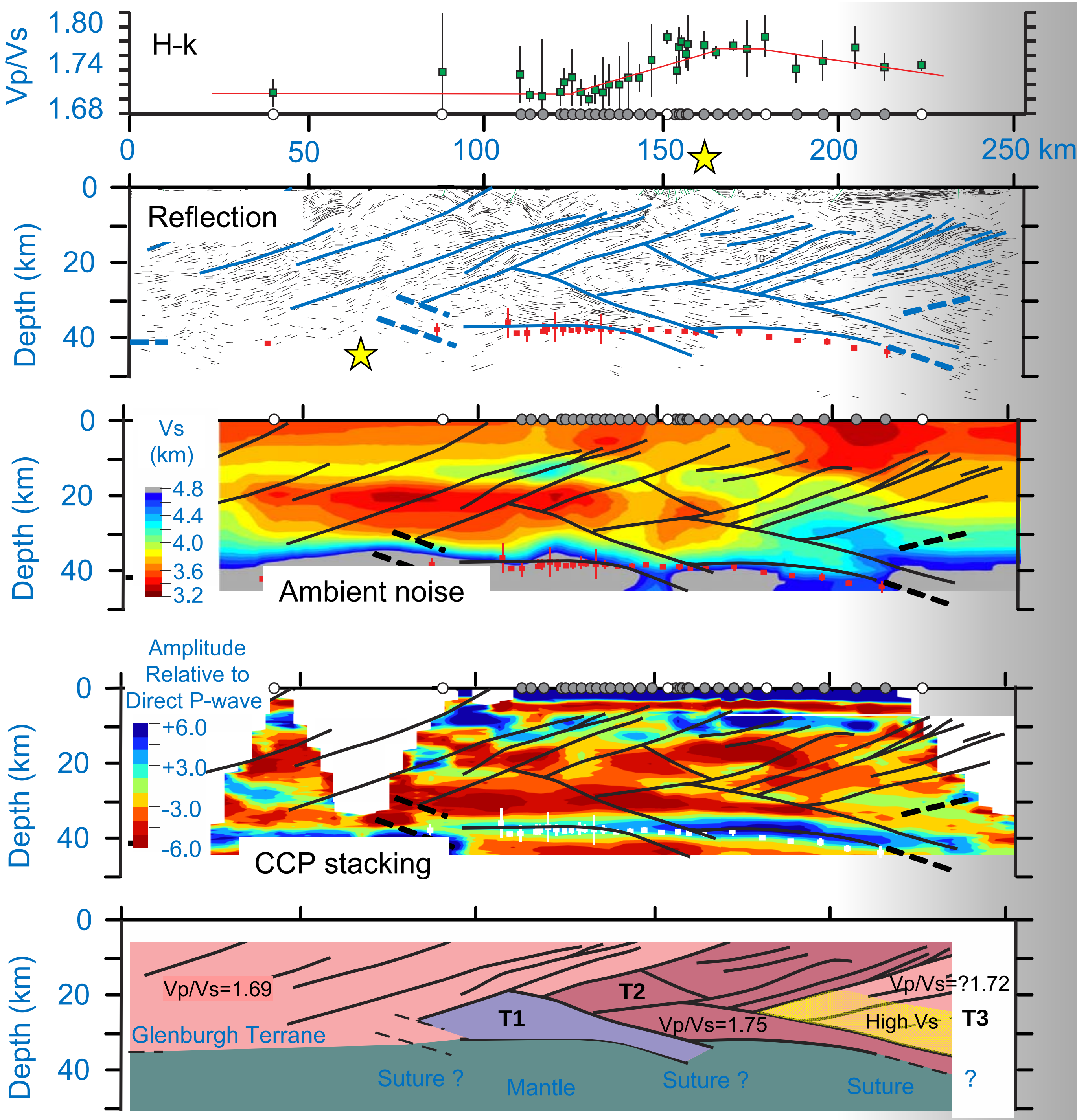
Teleseismic Data



From Distant Earthquakes

Mapping basement under thick cover

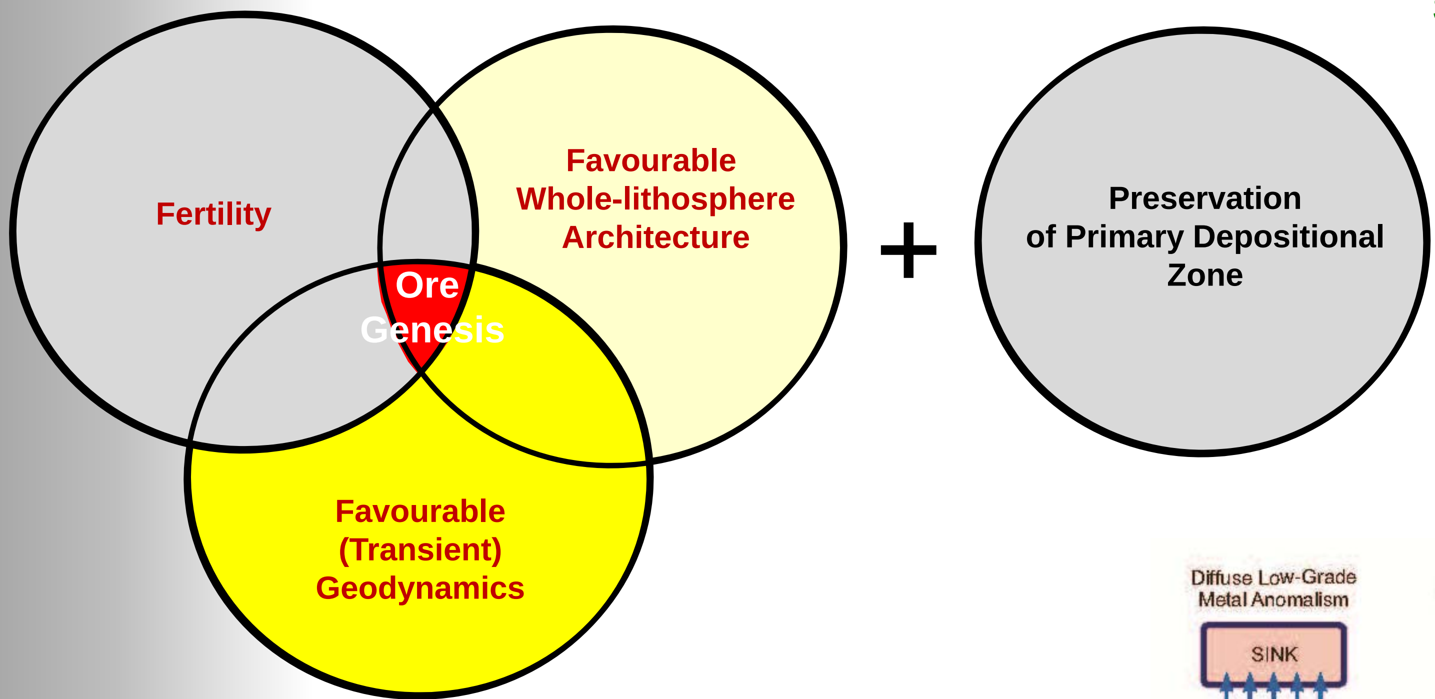
- H-k analysis of teleseismic arrivals
- Ambient noise derived Vs
- Common-conversion-point stacking of teleseismic arrivals



Mineral Systems

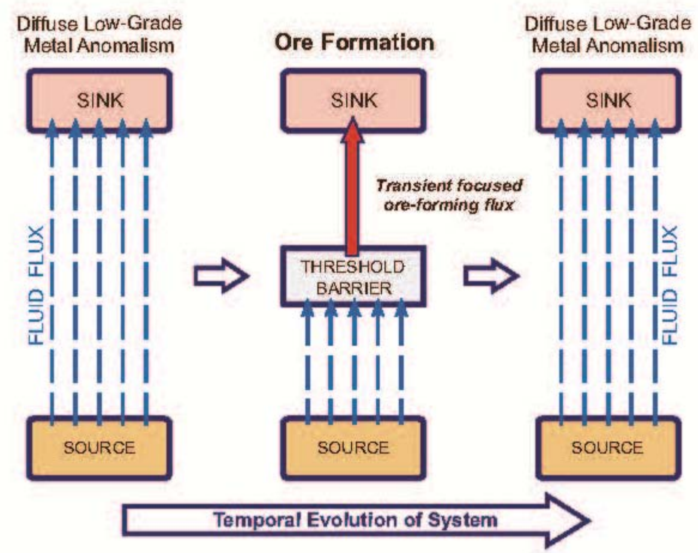
Critical elements in a mineral system

Source: McCuaig and Hronsky (2014)



Transient dynamics?

- Reservoir of over-pressured fluids below an impermeable barrier
- Barrier is periodically breeched (transient stress event) allowing fluid flow from the reservoir and deposition of metals



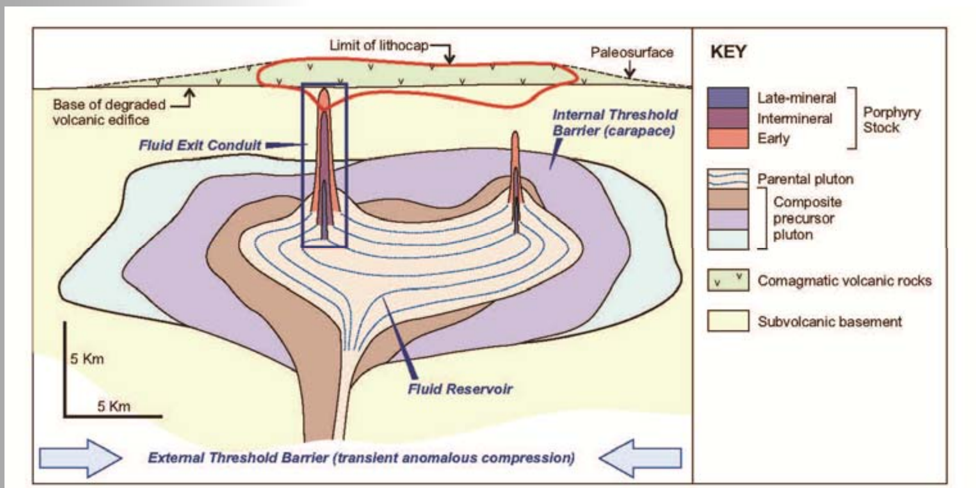
Palaeo-Reservoirs

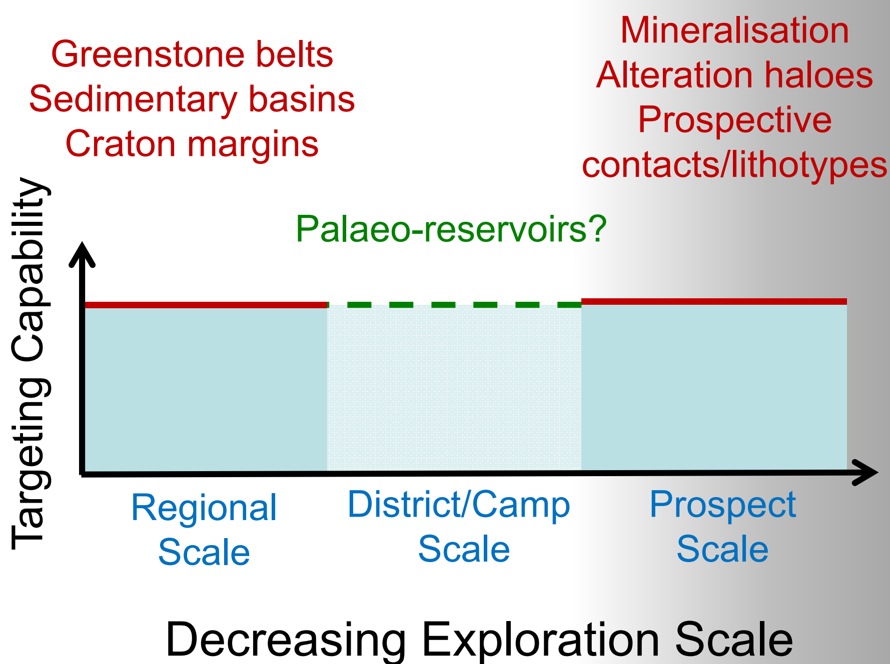
Reservoirs – a useful camp-scale target?

- Relatively large and shallow targets

  Expect extensive and intensive alteration

- Allow detection-based exploration strategies in the gap between regional- and prospect-scale?



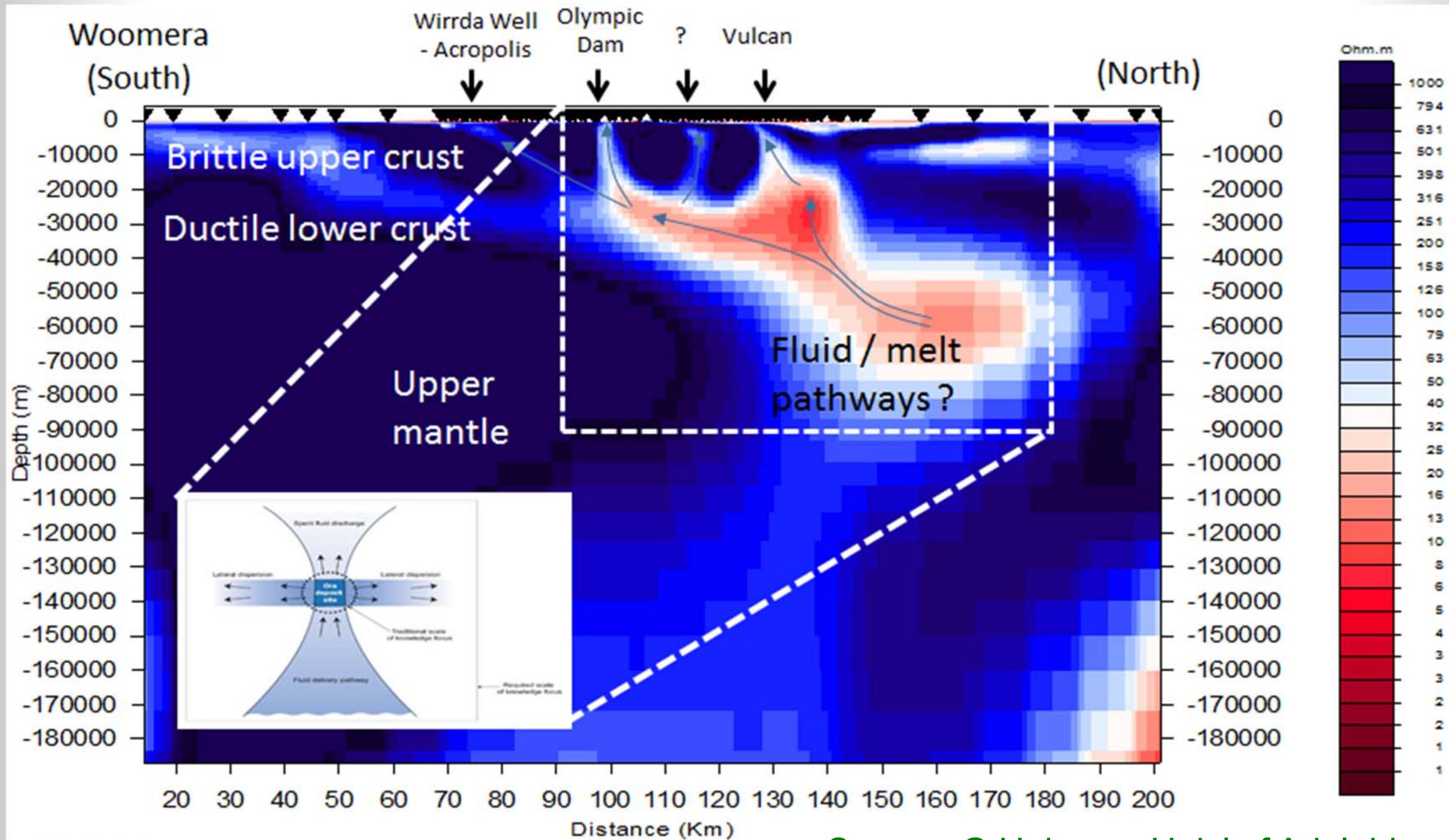


Source: McCuaig and Hronsky (2014)

Palaeo-Reservoirs

Olympic Dam IOCG deposit

- Cu-U-Au-(Ag-REE-Fe)



Source: G Heinson, Univ' of Adelaide, pers comm

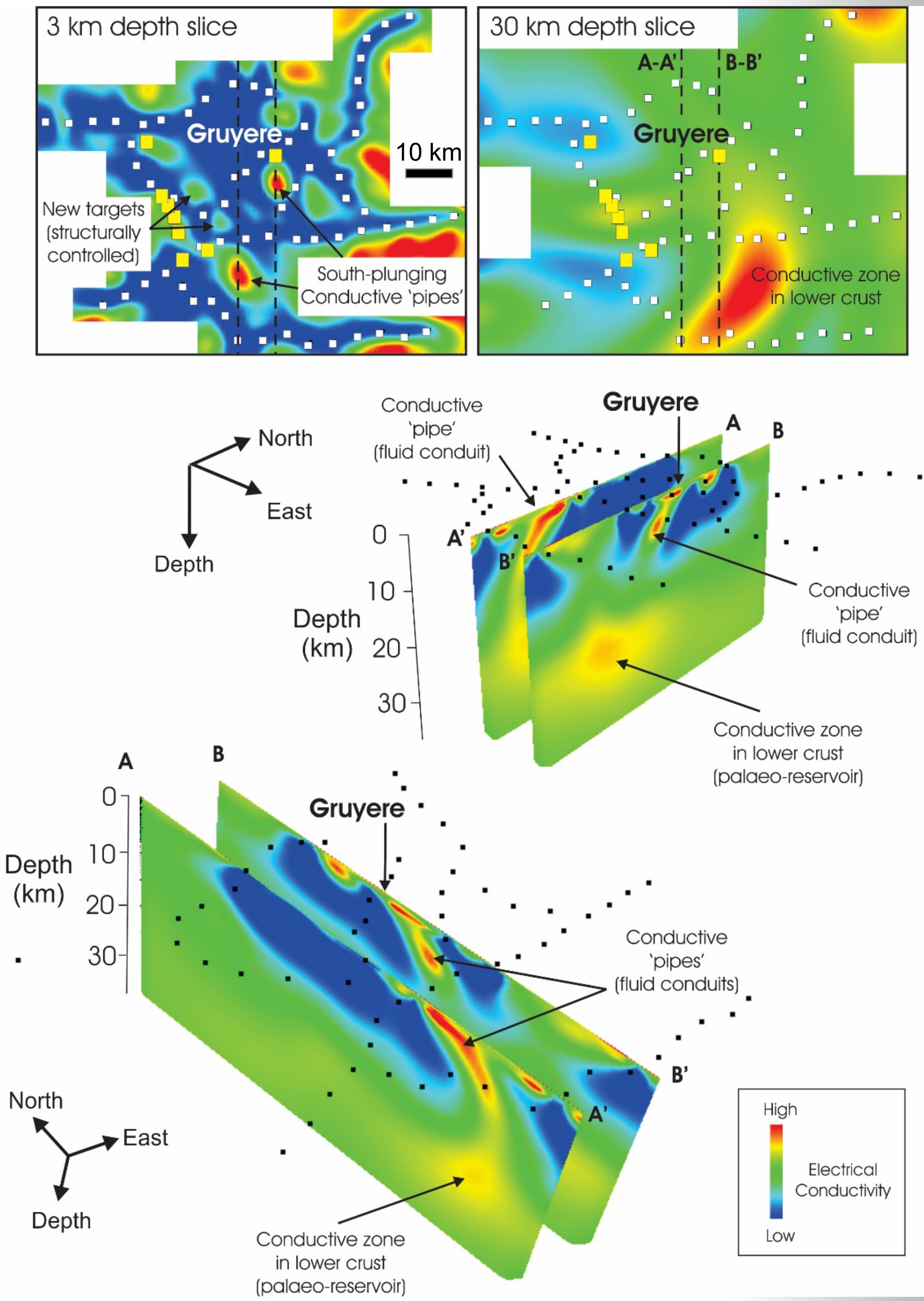
Palaeo-Reservoirs

Gruyere deposit

- Orogenic gold

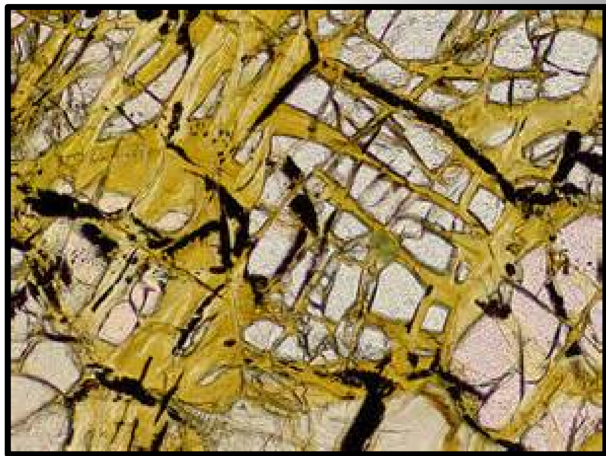
MT modelling by Jessica Spratt

Slide courtesy of Gold Road Resources Ltd, Minerals Research Institute of Western Australia, Geological Survey of Western Australia



Mineral Systems: Petrophysics

What do mineral system components actually look like?



- Fluid source regions
- Fluid flow conduits (pathways)
- Fluid reservoirs

All are expected to be regions where there is fluid-rock interaction

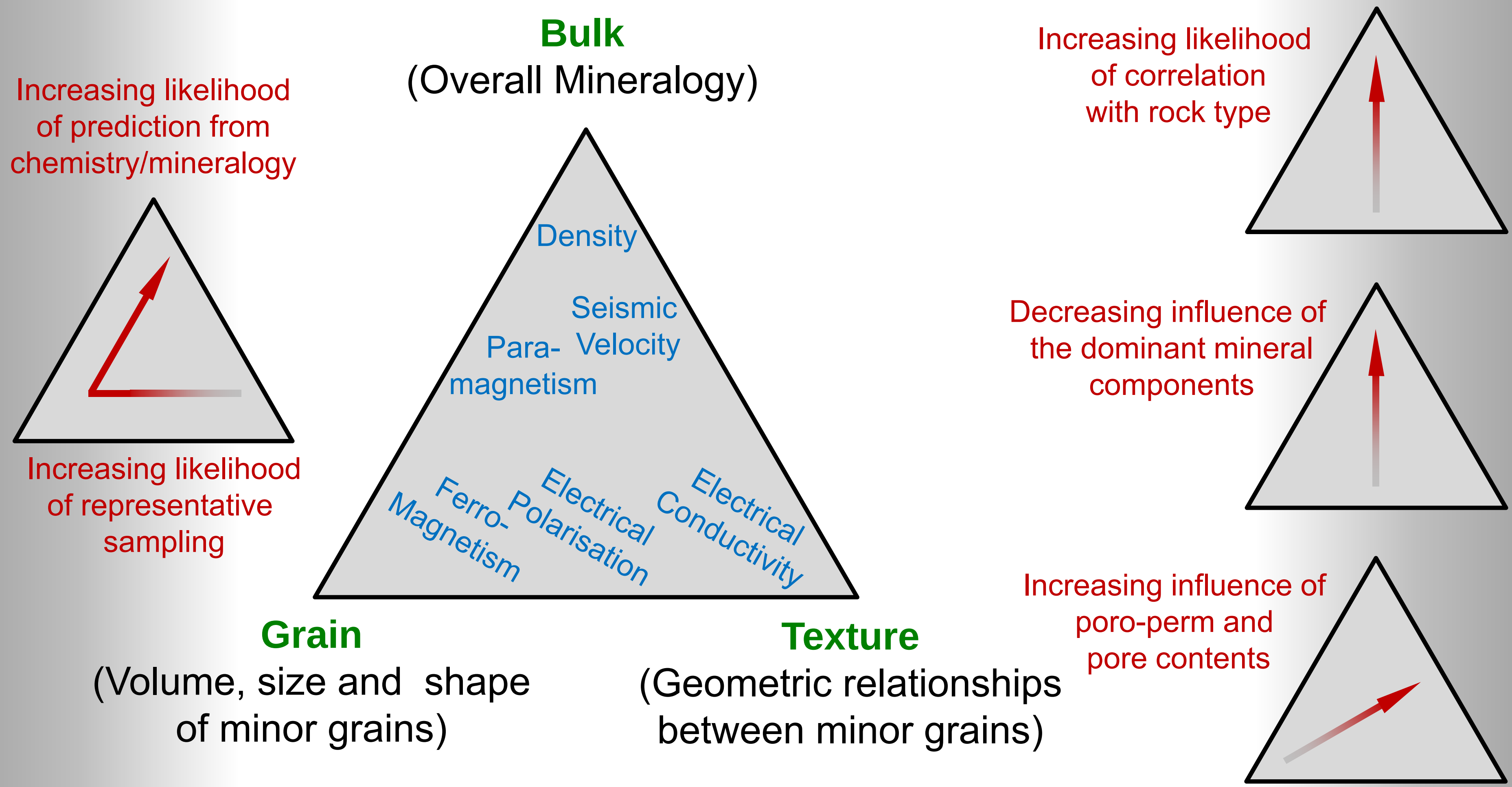
- Petrophysical databases organised by lithology
- What are the petrophysical consequences of the alteration?

  Detectable physical property contrasts?
- Develop a predictive capability – petrophysics first not last?

Mineral Systems: Petrophysics

Towards a conceptual framework to understand geological controls (lithology+) on physical properties – prediction!

- Recognise end-member ‘behaviour’ of the petrophysical properties
- Need to treat different types of petrophysical data in different ways

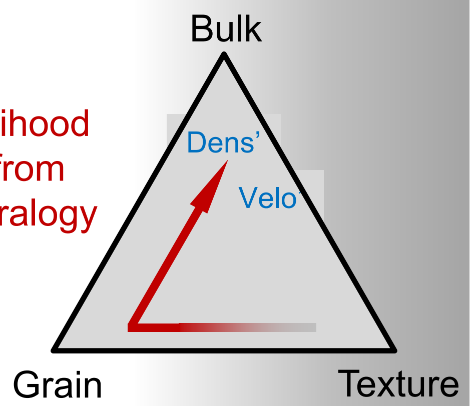


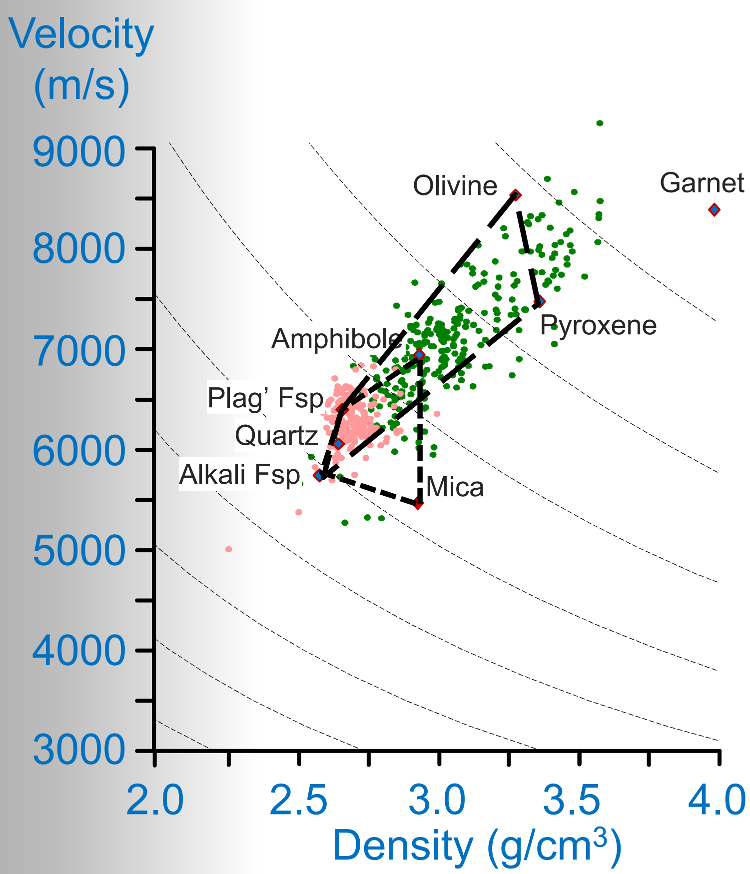
Petrophysics & Alteration

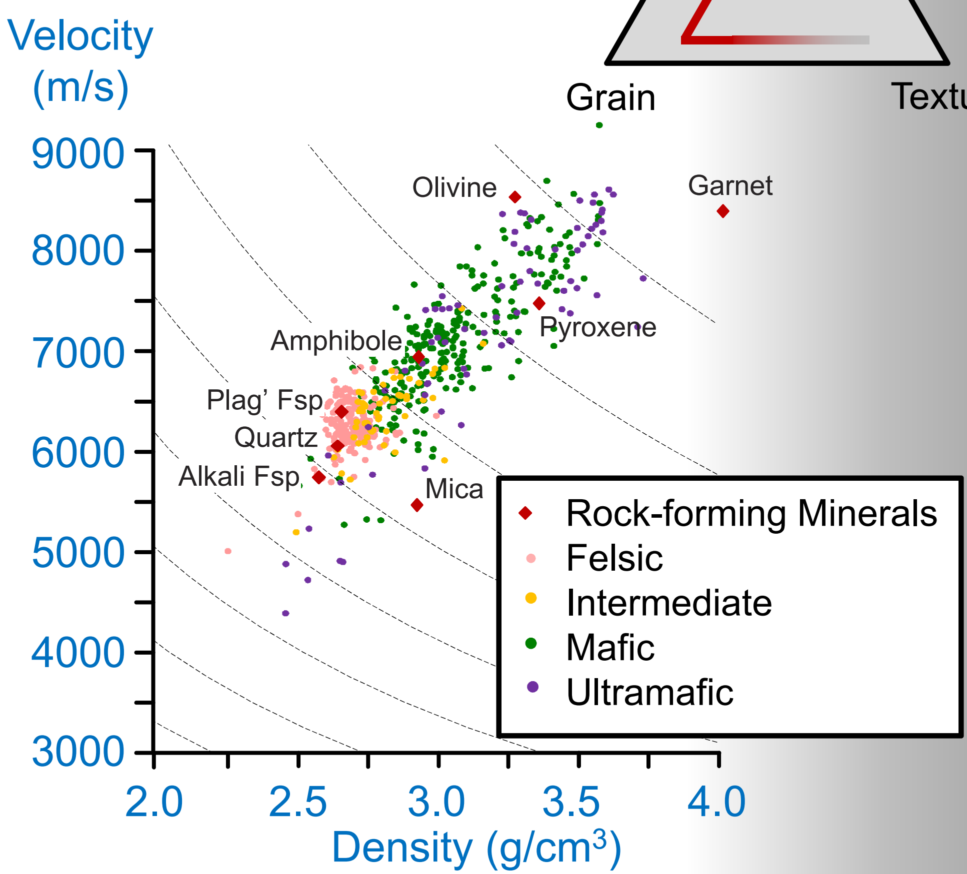
Lithology and seismic properties)

- Ultra-mafic, mafic, intermediate, felsic

Increasing likelihood of prediction from chemistry/mineralogy





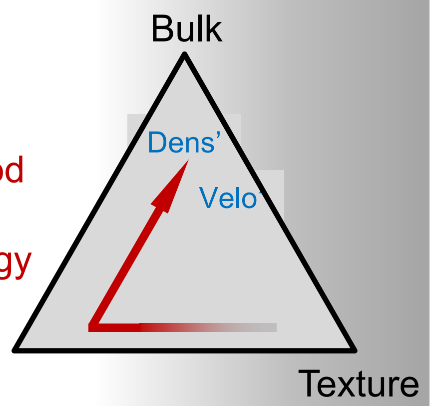


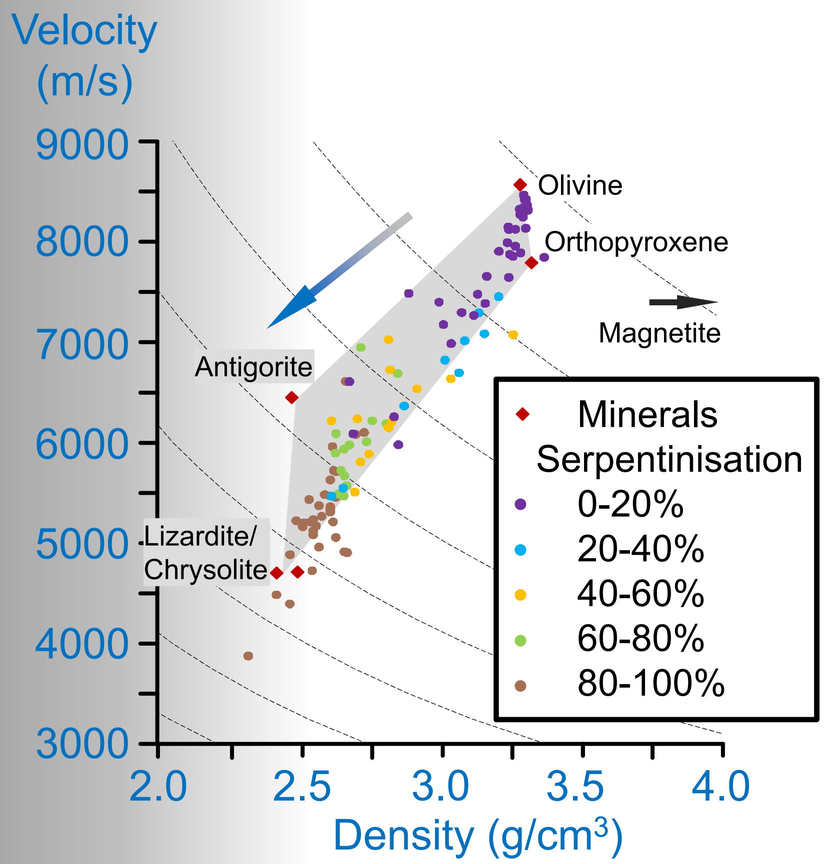
Petrophysics & Alteration

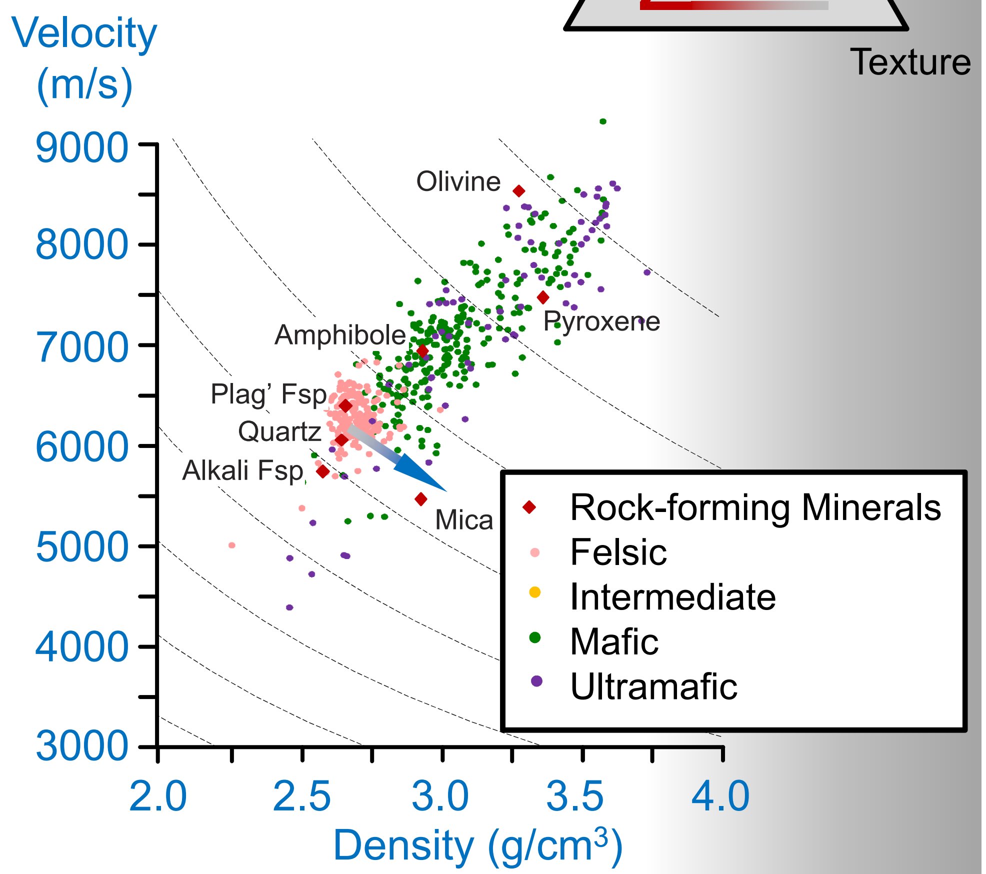
Alteration and seismic properties

- Olivine or Opyx → Serp’ group minerals + mg (Serpentinisation)
- K Feldspar → Muscovite or sericite

Increasing likelihood of prediction from chemistry/mineralogy



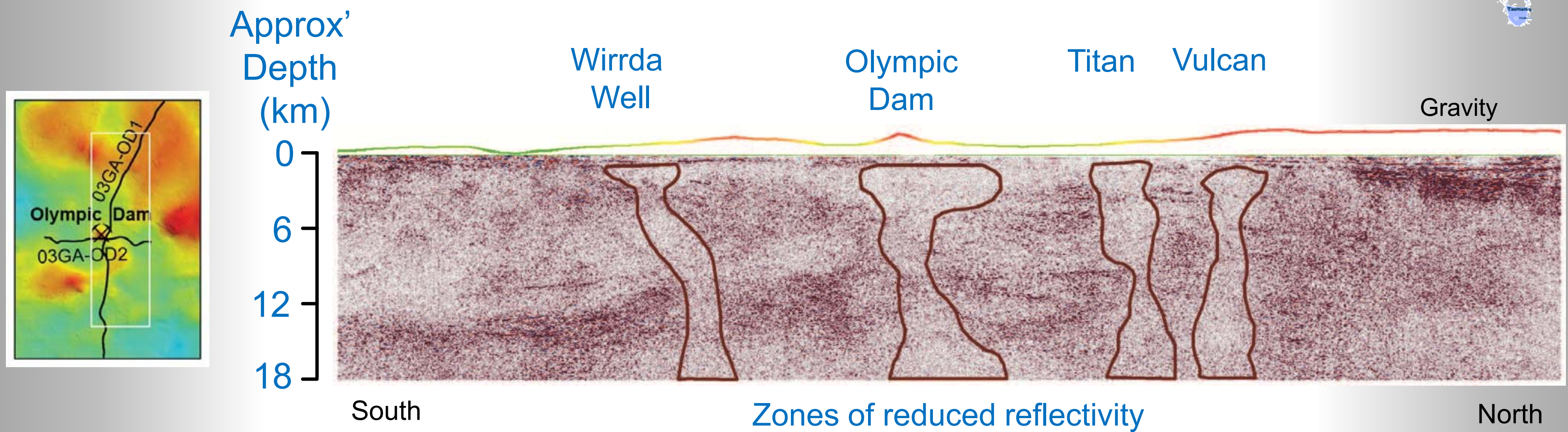




Petrophysics & Alteration

Seismically transparent zones – Stuart Shelf, South Australia

- Alteration by mineralising fluids?
- Probable they are due to alteration of mafic components of the country rock



Zones of reduced reflectivity
In seismic section

Source; Wise, et al., 2015

Min' Systems & Geophysics

A role for deep-penetrating geophysical methods

- Passive seismic methods, MT

Need a better understanding of the 'new' mineral system targets

- Palaeo-reservoirs and camp-scale targets?
- Need for research in petrophysics
  - More than just a constraint for modelling
  - Need to think beyond variation with lithology and include alteration
  - Collect these data 'early' and with good geological context

Exploring for mineral system components under cover

- Need to develop a predictive capability

Thankyou !

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