Australian Government

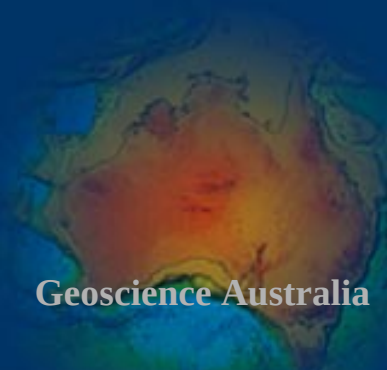
Geoscience Australia

Australian Diamond Exploration 2006: Where are the Greenfields?

Lynton Jaques
Minerals Division
Geoscience Australia

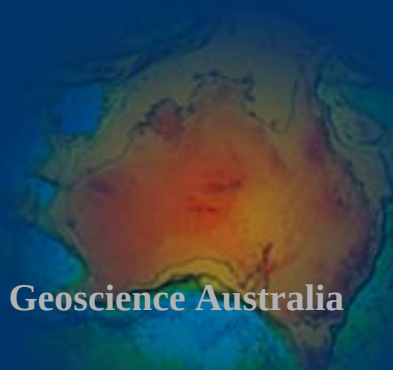
World Diamond Conference,

Perth November 2006



Outline

- Current state of diamond exploration
- Exploration highlights for 2006
- Trends and issues
- Australia's diamond potential
- Concepts for regional scale targeting and area selection



Exploration Record

First generation surveys 1960s-1970s

- Regional stream sediment surveys, airborne magnetics
- Discoveries:
  - Ellendale, Argyle lamproites
  - Kimberlites in North Kimberley, East Kimberley, Gawler, and alkaline ultramafic bodies at Carnarvon Basin and in SE Australia

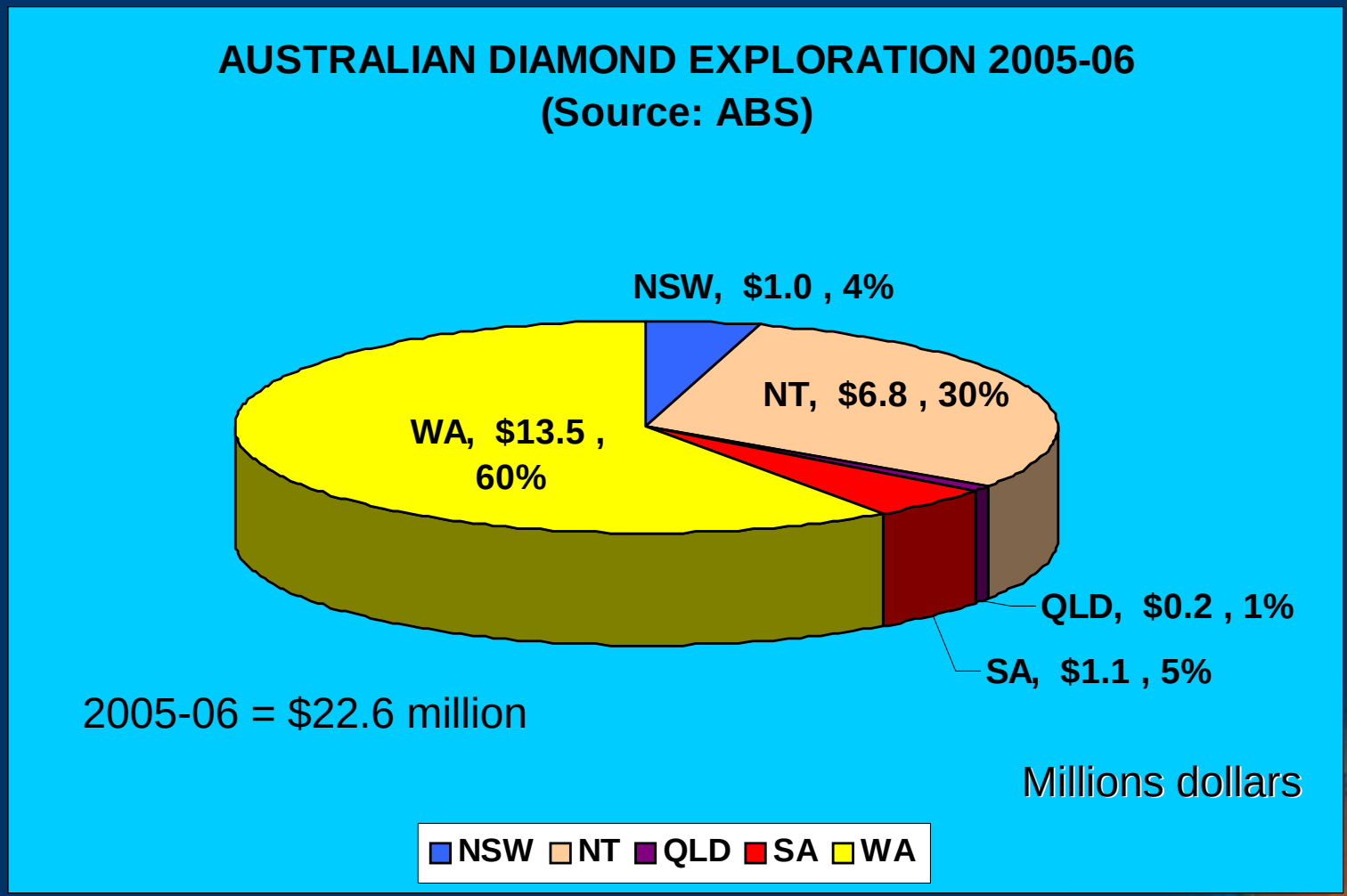
Second generation surveys 1980s-1990s

- Detailed & regional diamond indicator surveys, increased use of geophysics, HR aeromag, gravity, AEM
- Discovered Merlin pipes, Aries, Beta Creek-Ashmore, Forest River, Nabberu, Yilgarn

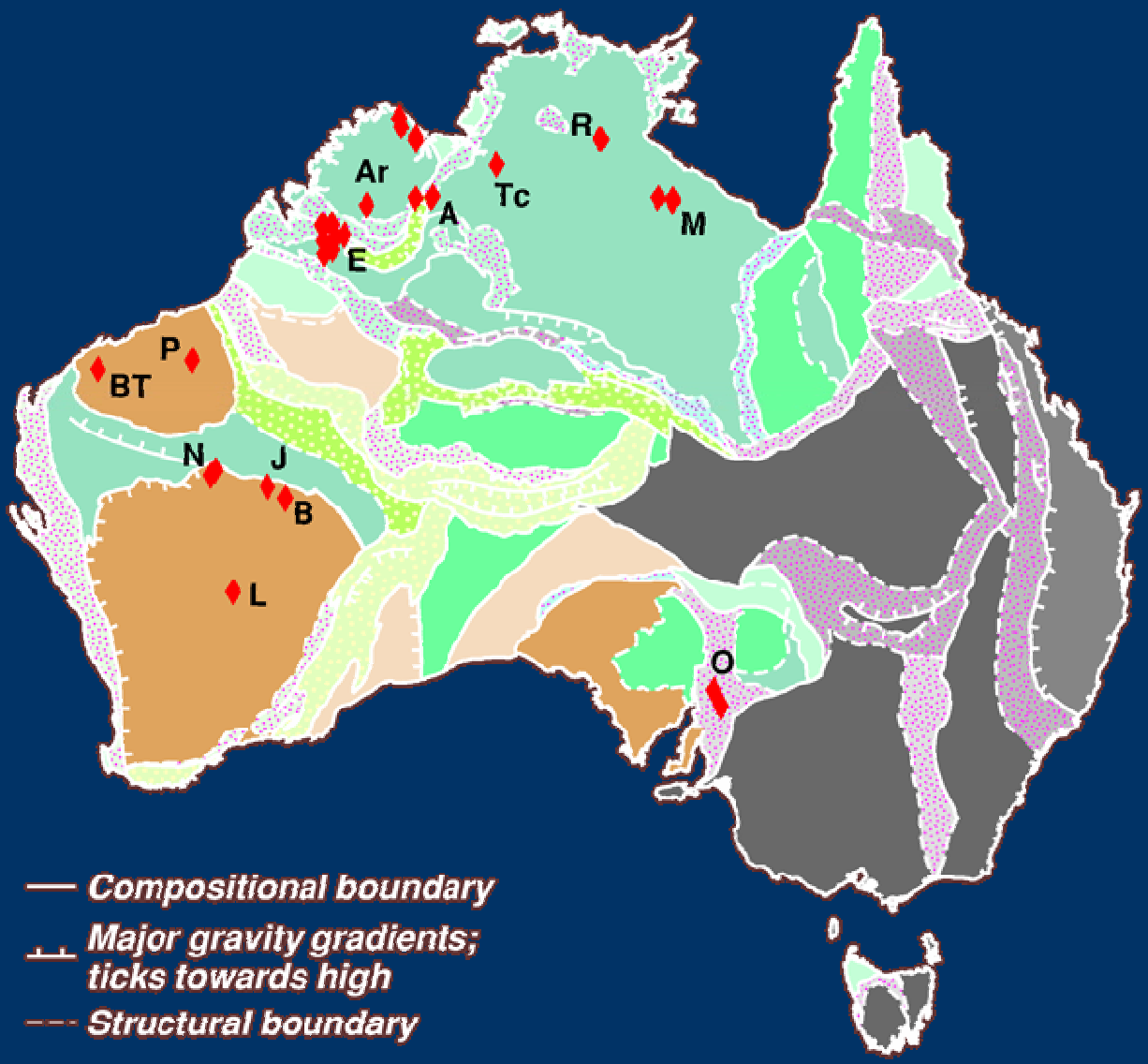
Current

- Detailed follow-up surveys, VHR aeromag, AEM and gravity surveys, airborne gravity gradiometry
- Focus: Ellendale, Merlin, Flinders Ranges, Pilbara, (Seppelt)

Exploration Focussed in the North Australian Craton



Distribution of Diamondiferous Intrusions



CRUSTAL ELEMENTS

Relative Age

Palaeozoic
Neoproterozoic
Mesoproterozoic
Palaeoproterozoic
Archaean

Standard
Highly magnetic
Geophysically overprinted

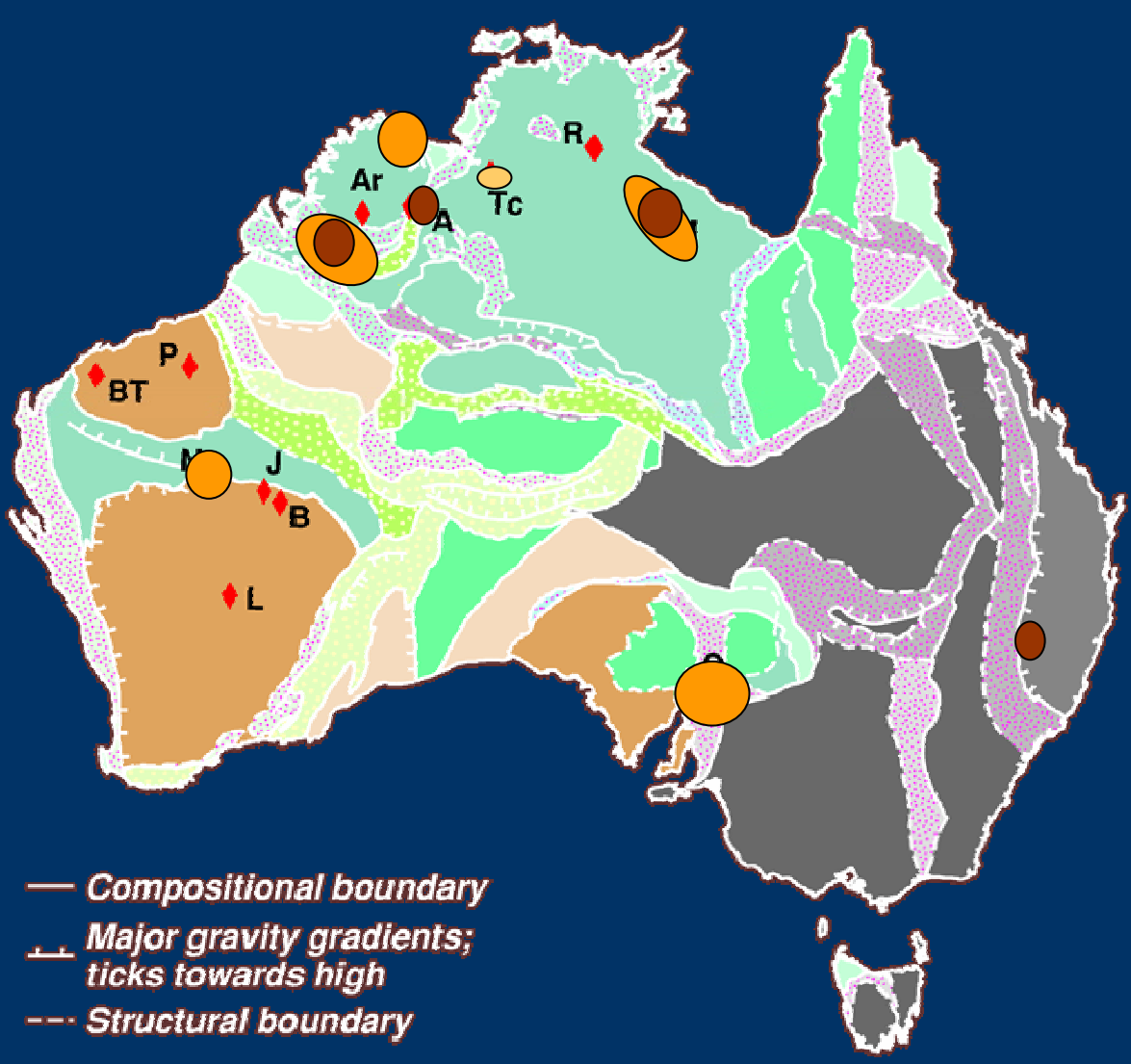
Diamond-bearing

Compositional boundary

Major gravity gradients; ticks towards high

Structural boundary

Exploration Highlights 2006
- Focus on known (brown) fields



CRUSTAL ELEMENTS

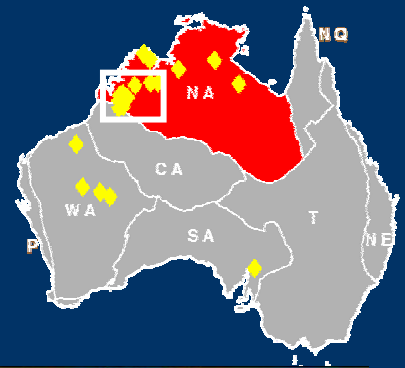
Relative Age

- Palaeozoic
- Neoproterozoic
- Mesoproterozoic
- Palaeoproterozoic
- Archaean

Standard | Highly magnetic | Geophysically overprinted

Diamond-bearing

Ellendale Field



Kimberley Diamonds NL

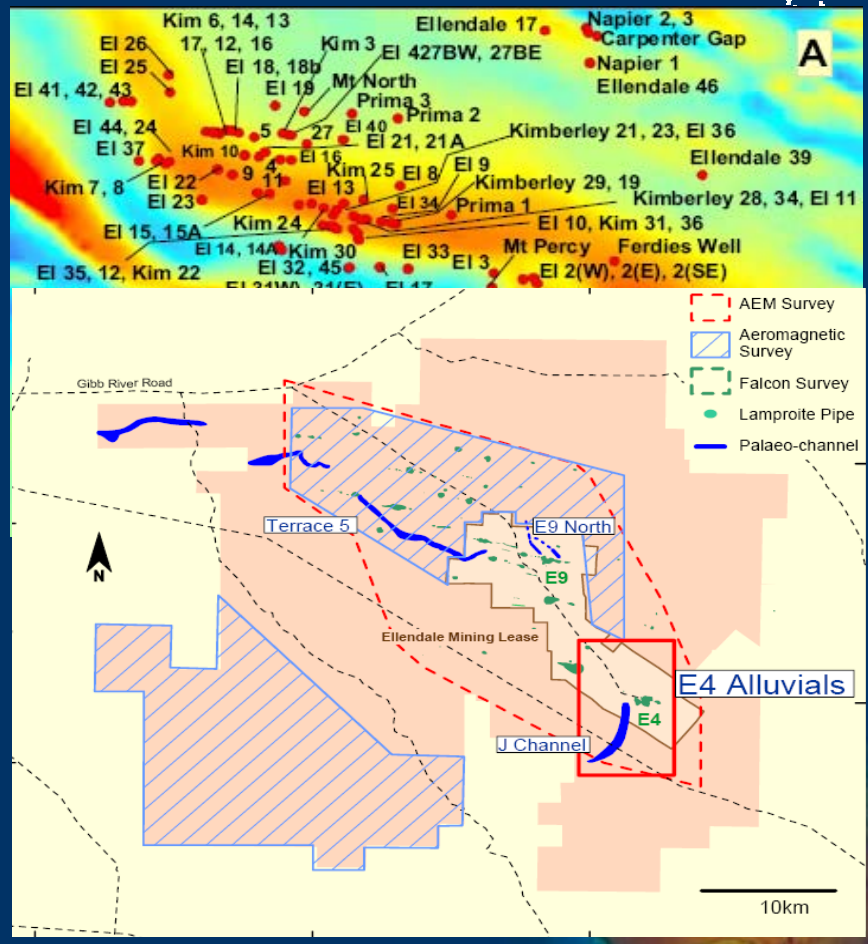
- Increased mine production Ellendale 9,Ellendale 4S commenced production
- WD drilling of Ellendale 7, 11

Blina Diamonds

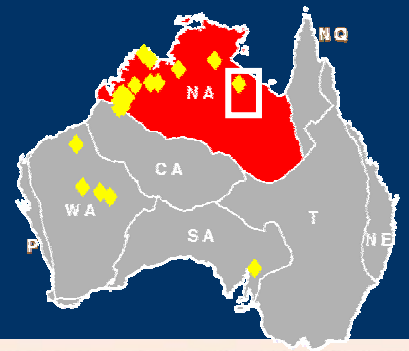
- Large EL holding
- Ellendale 9 western channel
- Terrace 5 alluvial system

Other players

- Resource & Investment NL/Caldera Resources Ltd in Ellendale E and S
- United Kimberley Diamonds



Merlin Field



North Australian Diamonds

- Production from tailings and weathered kimberlite
- New (small) high-grade diamondiferous diatreme (Perceval)
- Exploration of anomalies in Merlin Field
- Borroloola alluvials

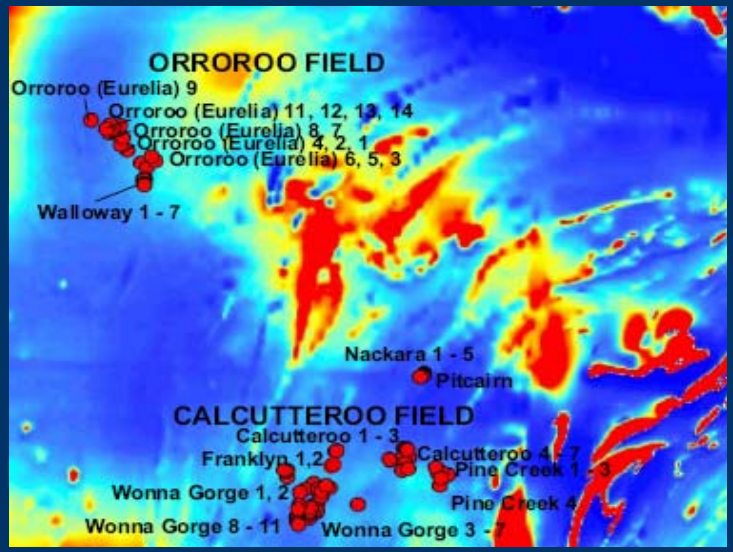
weathered kimberlite from Ywain pipe.

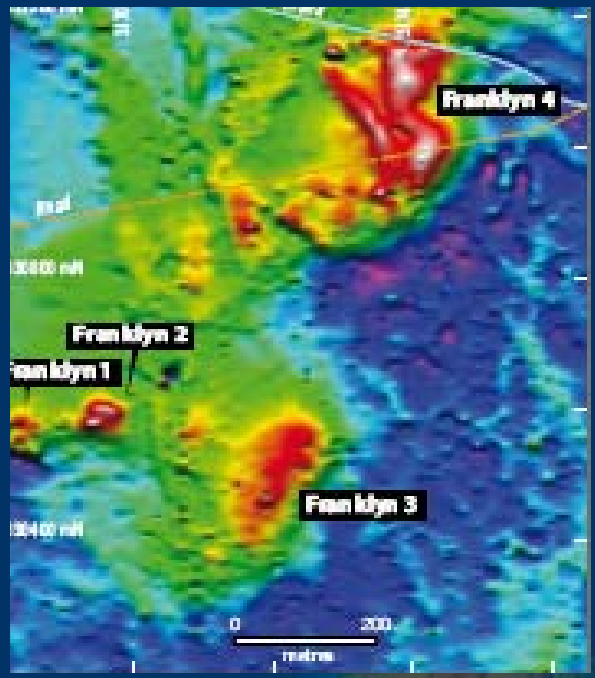
10.6ct stone recovered from Gawain.

Gawler Craton

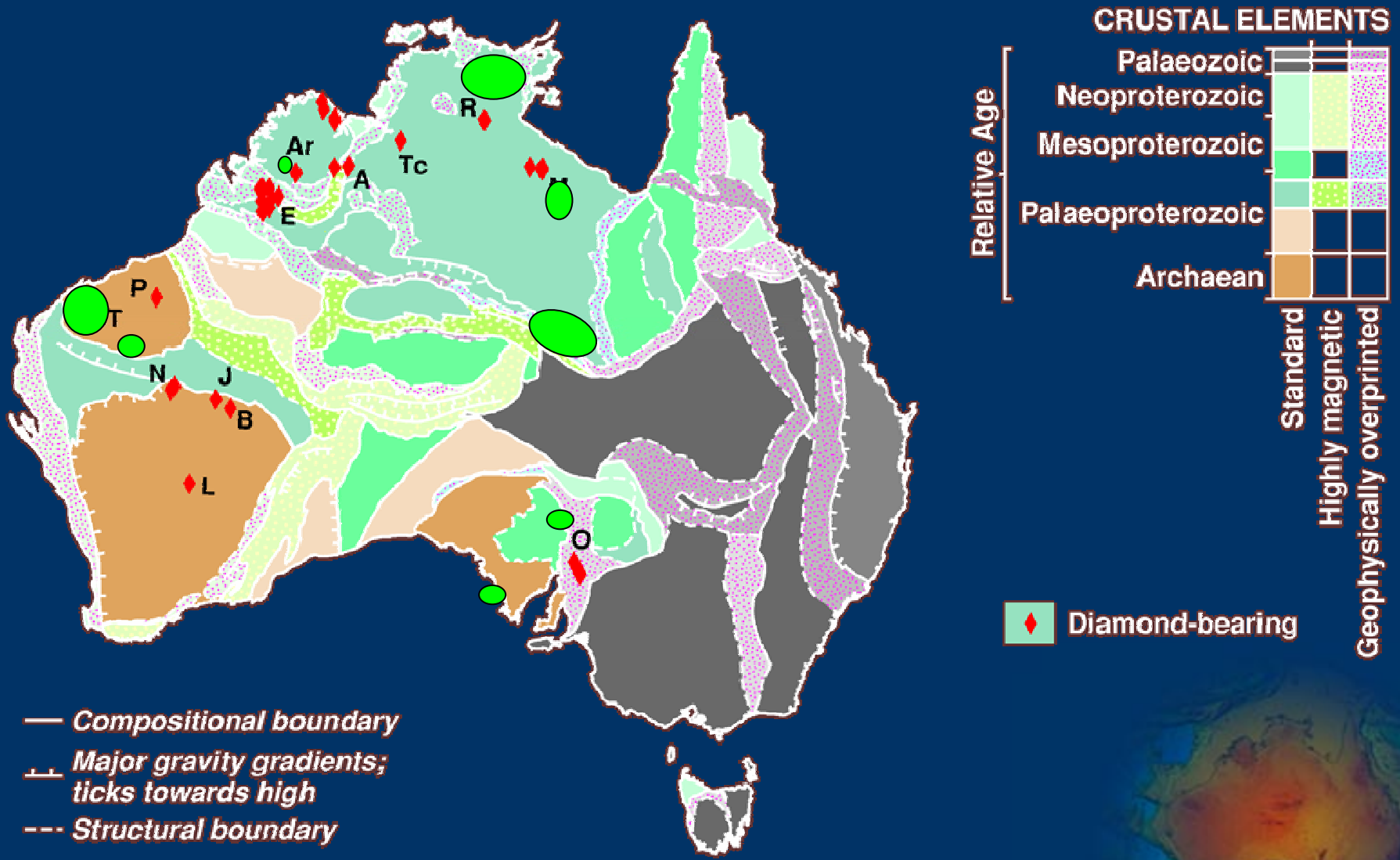
Flinders Diamonds Ltd

- ~40 kimberlites discovered
- Bulk sampling of kimberlite dykes with microdiamonds near Euralia produced macros in 3 dykes (grades reported not commercial)
- Franklin 1 and 2 pipes discovered

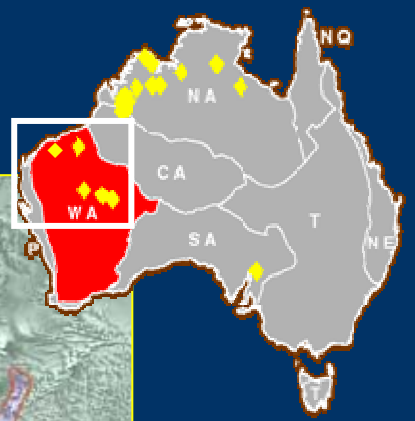




Greenfields Highlights 2006



Pilbara Craton

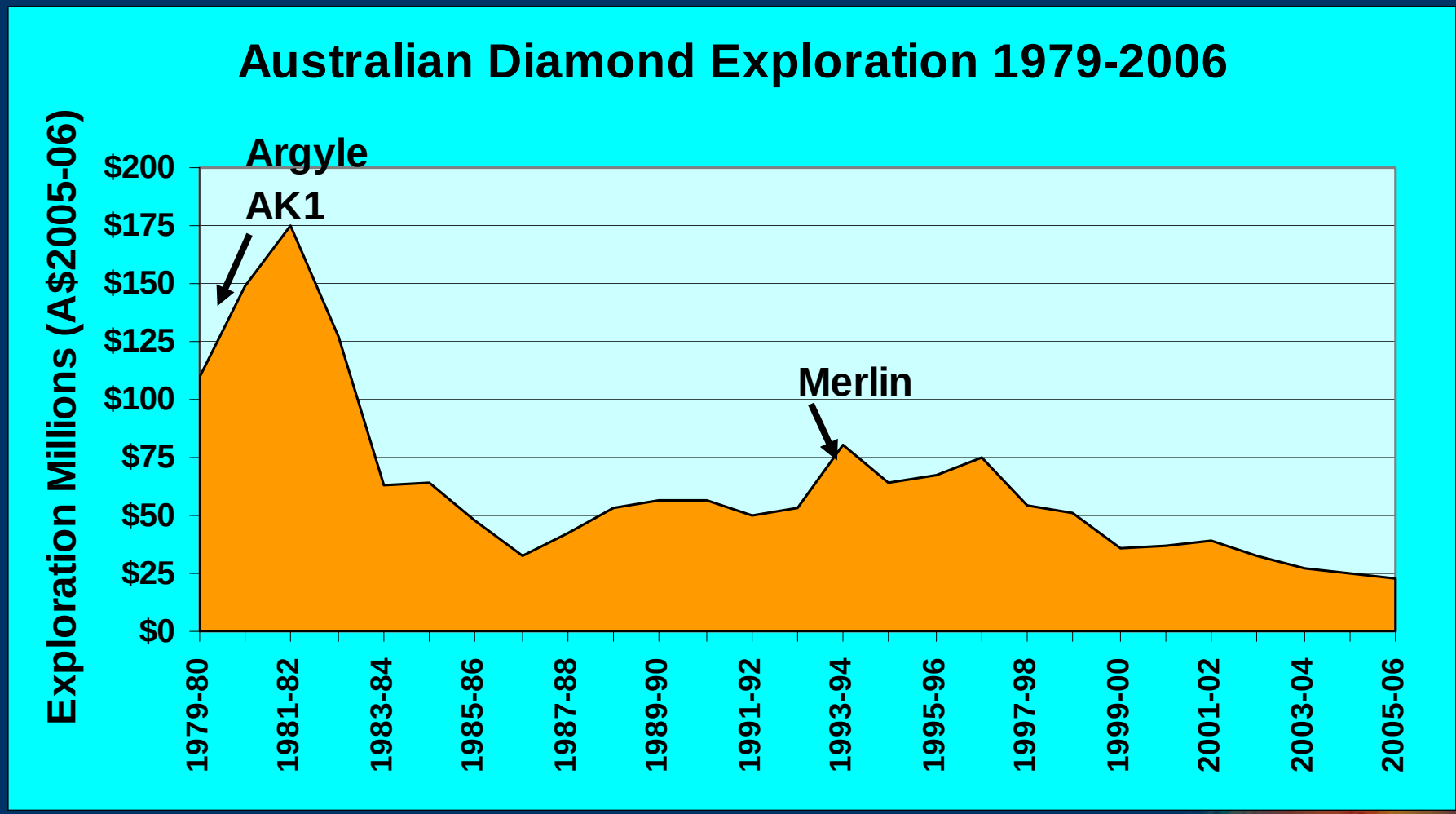


Tawana Resources NL /De Beers Australia Exploration Ltd

- Diamonds recovered from Black Top kimberlite in West Pilbara
- NE-trending sub-parallel kimberlite fissures
- Other companies active in area


Diamonds Recovered from Blacktop. Scale in millimeters

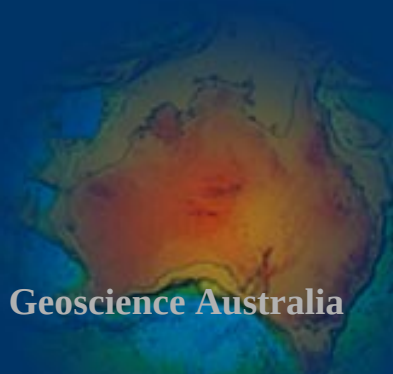
Australian Diamond Exploration Expenditure



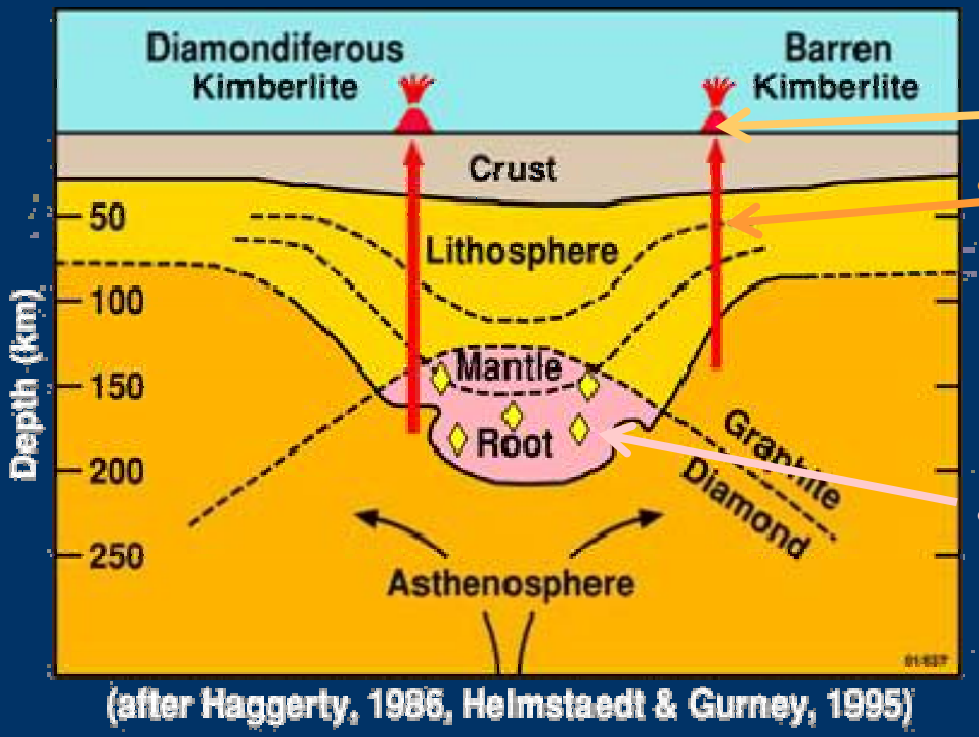
Source: ABS

Implications

- Diamond exploration effort in Australia continuing to decline
- Argyle underground development means continued importance of Australia as diamond producer
- KDC (and NAD) increasing production and playing important role in exploration
- Small number of junior explorers and JVs with majors
- Negative perceptions regarding Australia's diamond potential and discovery record
- We need a significant (greenfields) discovery

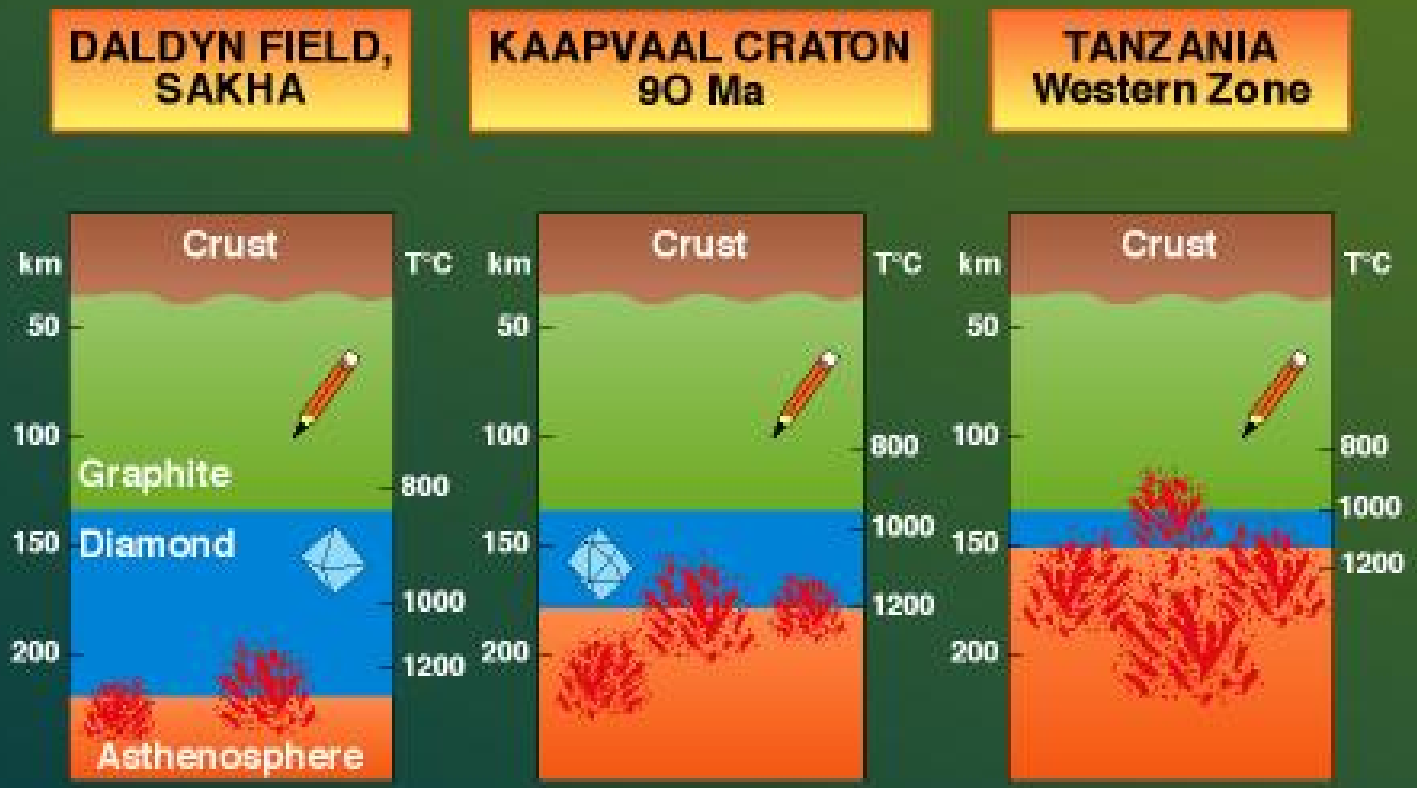


Diamond Mineral System
- Cratonic Diamonds



- Preservation (erosion levels)
- Emplacement mode
  - Controlling structures
  - Form (pipe, dyke etc)
- Transport (kimberlite, lamproite, rare others)
  - Tap diamond stability field
  - Rapid eruption
  - Pathways
- Diamond source regions (mantle)
  - Cold, old, thick (150 km) refractory craton roots
  - Diamond preserved
    - No major mantle metasomatic, melting events

Diamondiferous Lithosphere can Be Eroded/Destroyed



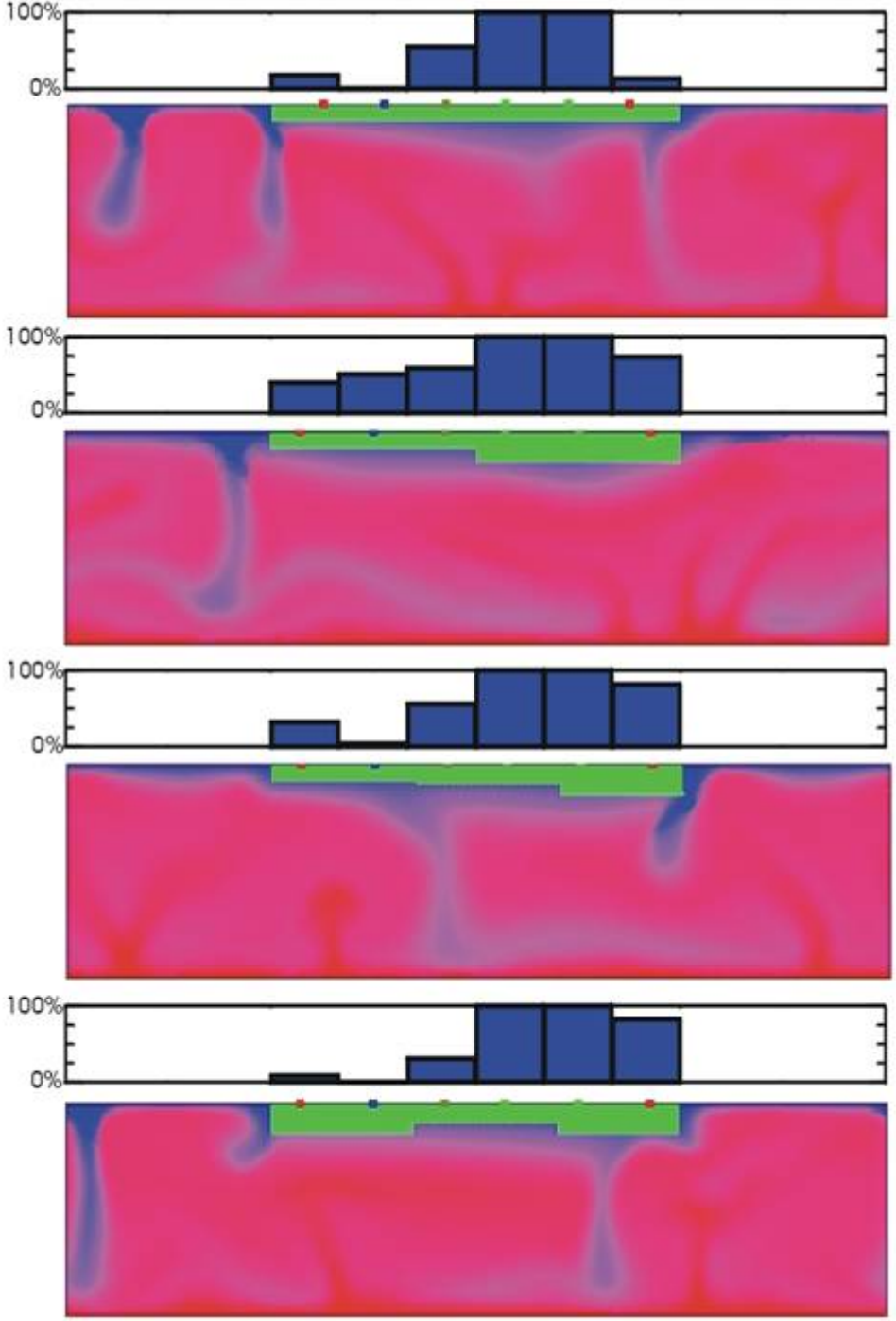
GEMOC, Griffin & O'Reilly

Geotherms Not Fixed

Time craton roots spend in diamond zone depends on:

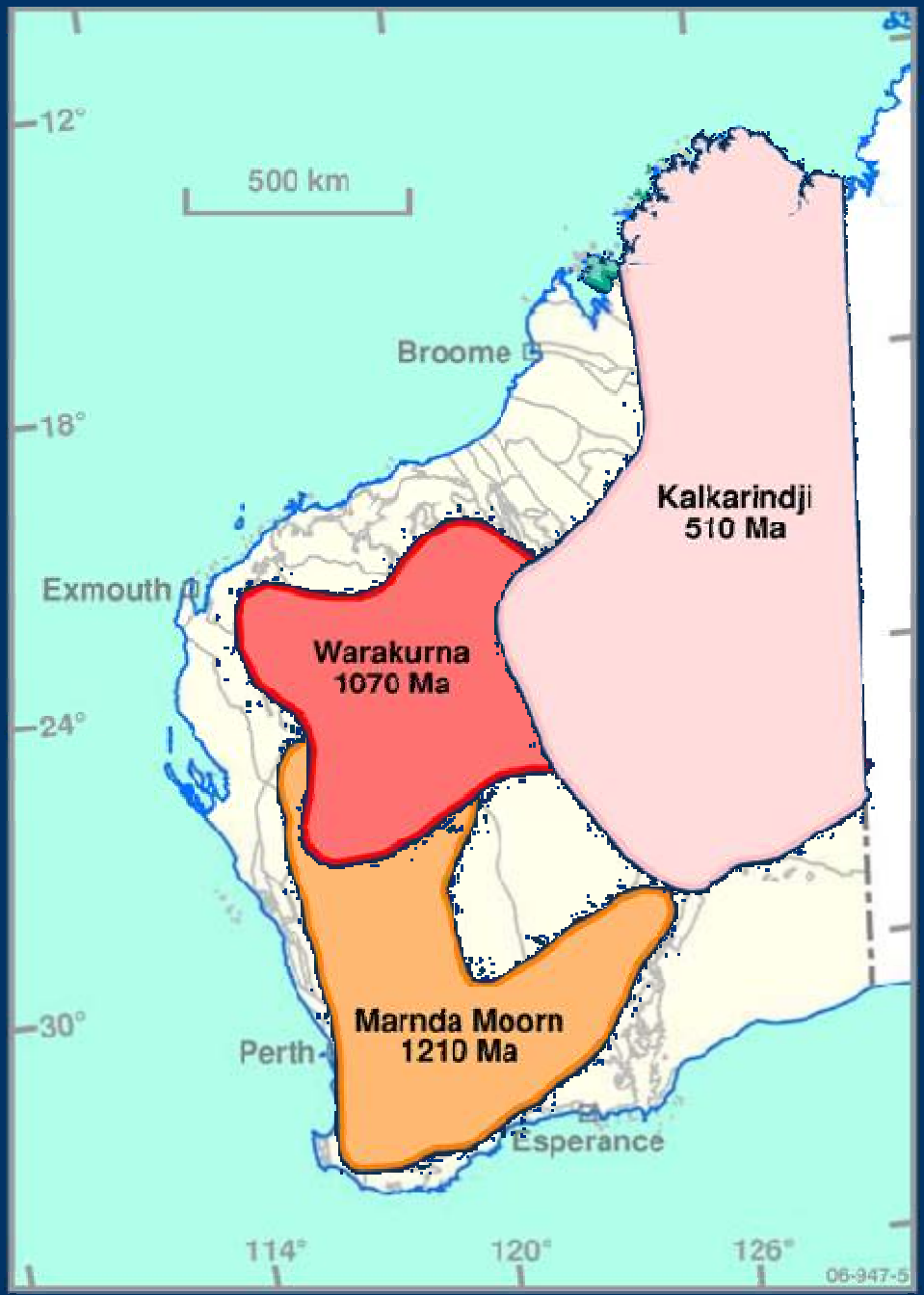
- **shape of root zone**
- **location wrt root zone**
- **adjacent lithosphere**
- **distance to cont-ocean boundary etc**

(O'Neill, Moresi & Jaques, Tectonophysics, 2005)



Large Igneous Provinces (LIPS)

Large volumes of coeval mafic magmas (giant dyke swarms, flood basalt-sill provinces, layered intrusions); mantle-plume origin



~510 Ma Kalkarindji (ME 15)

~1070 Ma Warakurna (ME 12)

~1210 Ma Marnda Moorn (ME 11)

~1790 Ma Hart - Carson (ME 8)

Province boundary

ME 8 : Magmatic Event 8

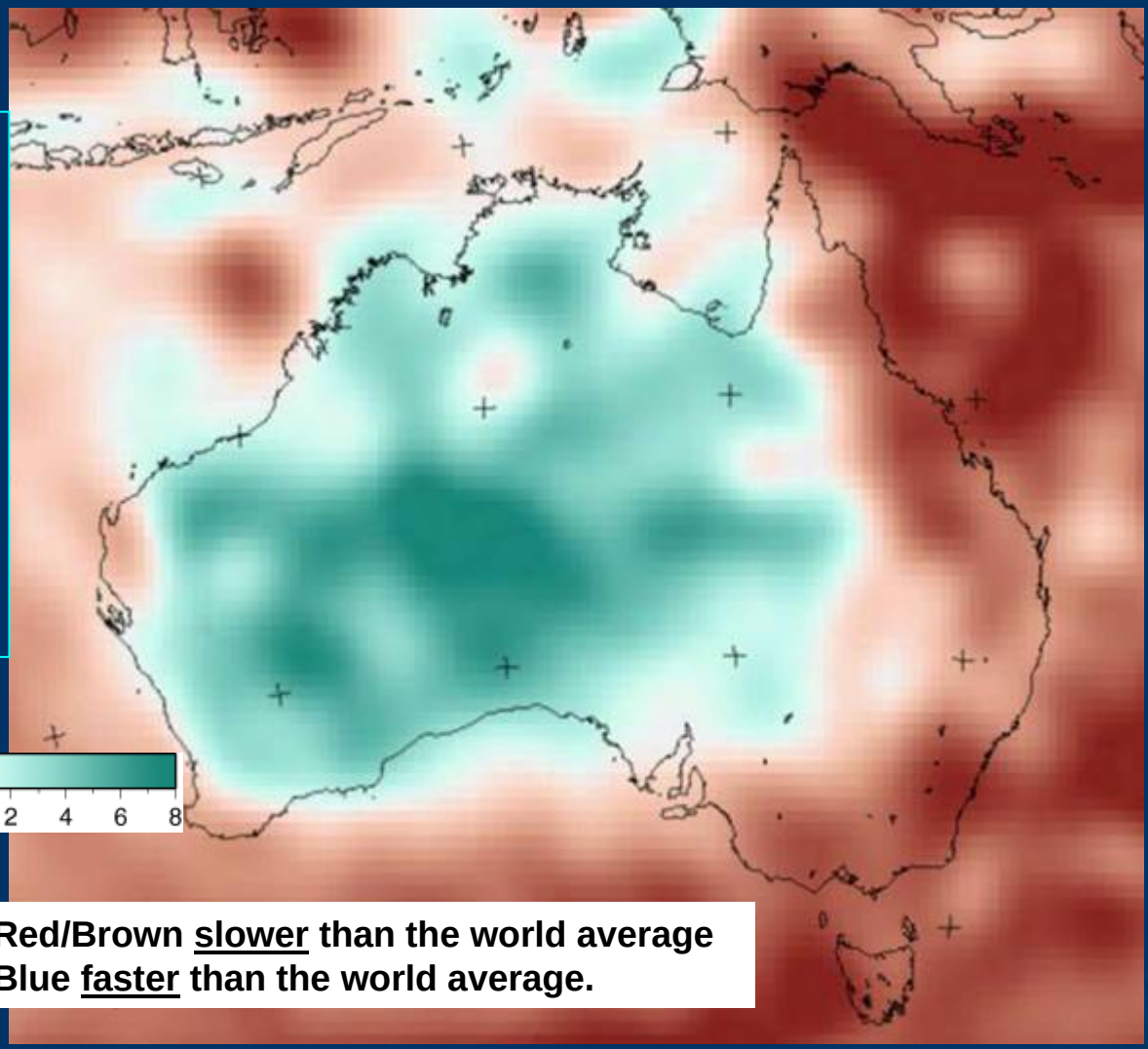
New GA compilation

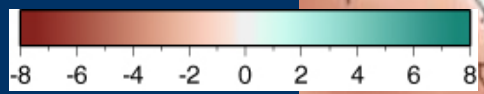
Proterozoic mafic-ultramafic events map

Structure of the Australian Lithosphere

Broad Band Seismic Shear (S) wave velocity at 125 km

West
- fast
- cold
- refractory
- less dense (buoyant)
- dry
- strong



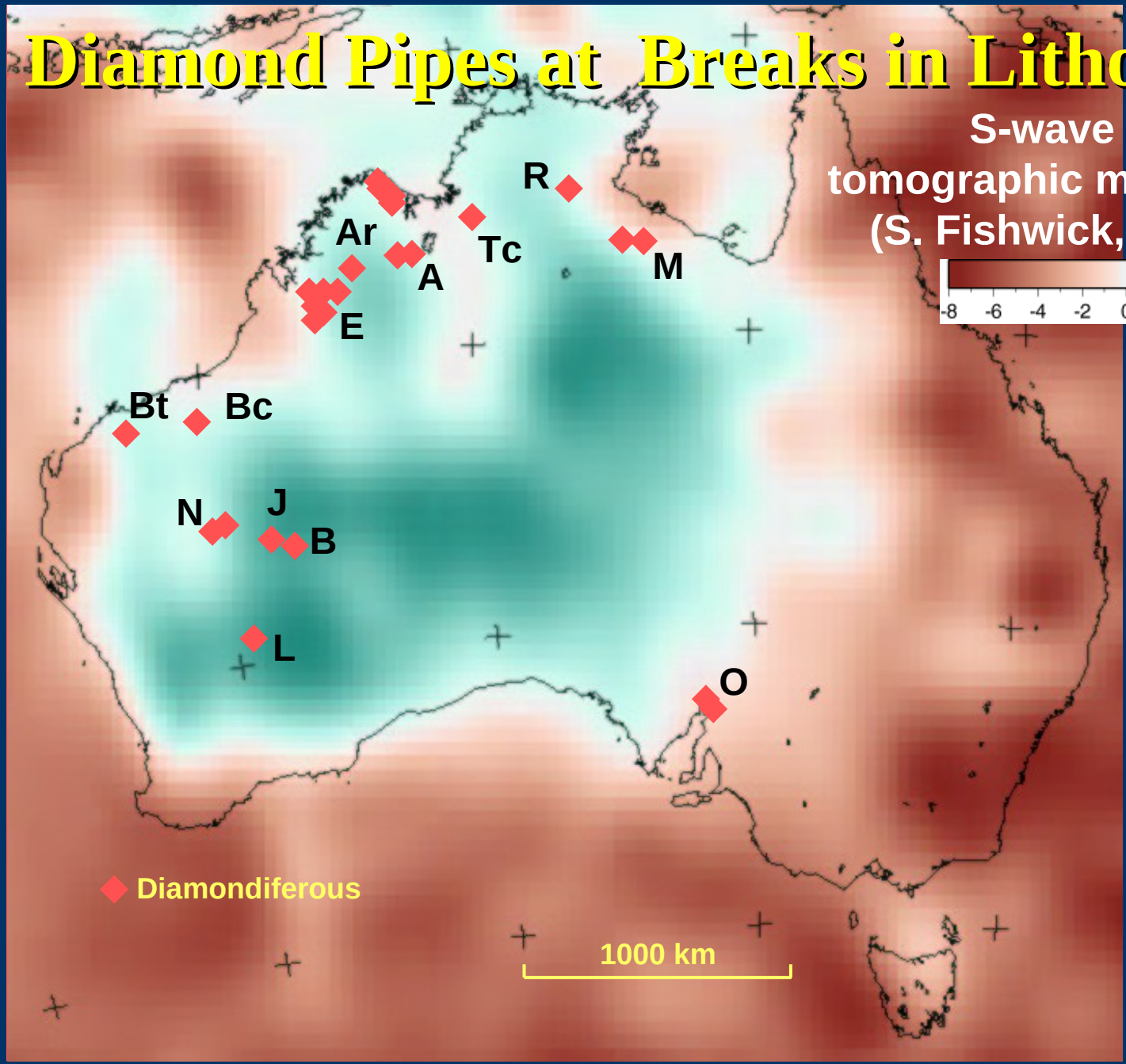


East
- slow
- warm
- fertile
- dense (less buoyant)
- wet
- weak

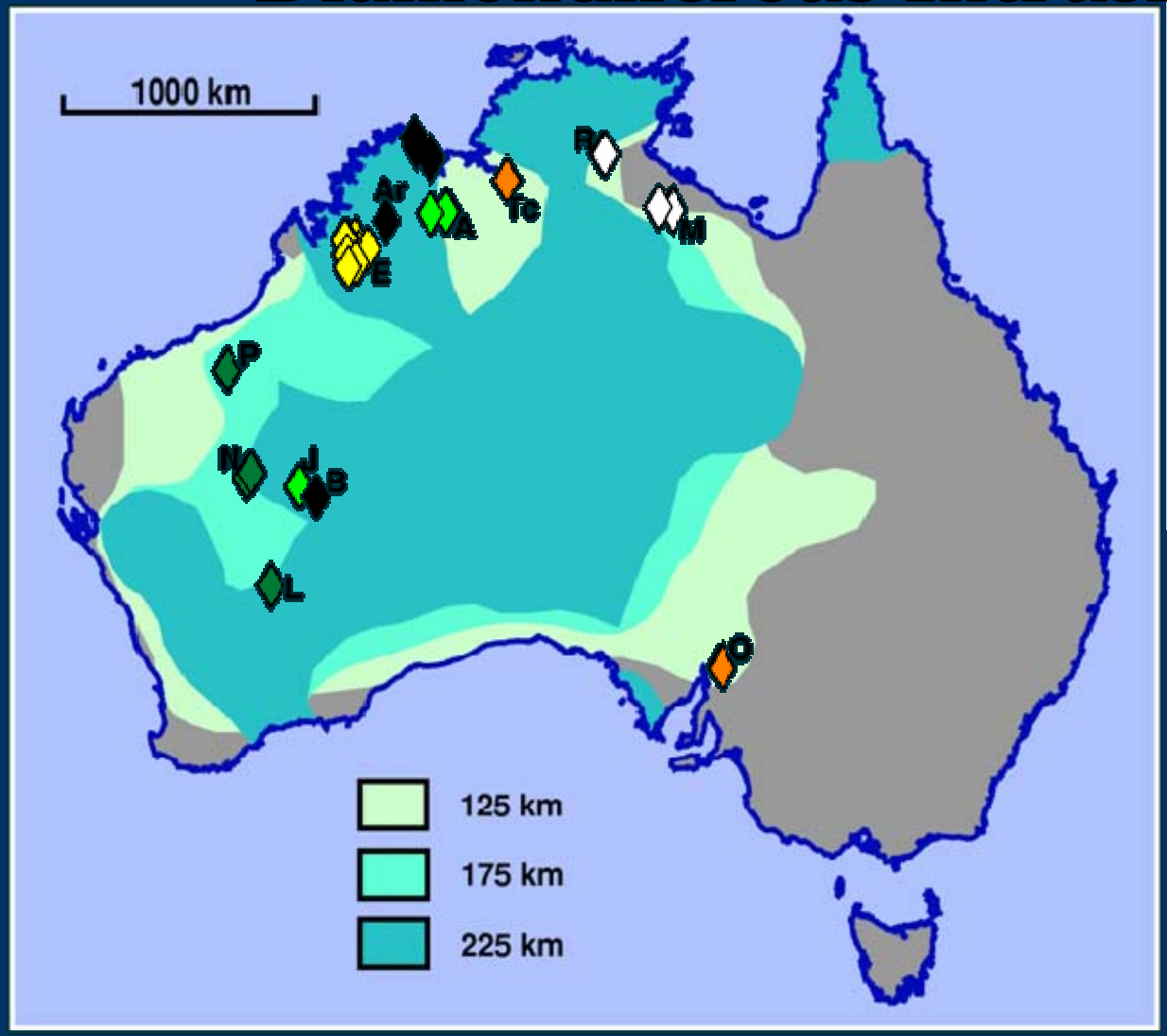
S. Fishwick & B. Kennett, RSES, ANU, 2004

Red/Brown slower than the world average
Blue faster than the world average.

Diamond Pipes at Breaks in Lithosphere



Diamondiferous Intrusions



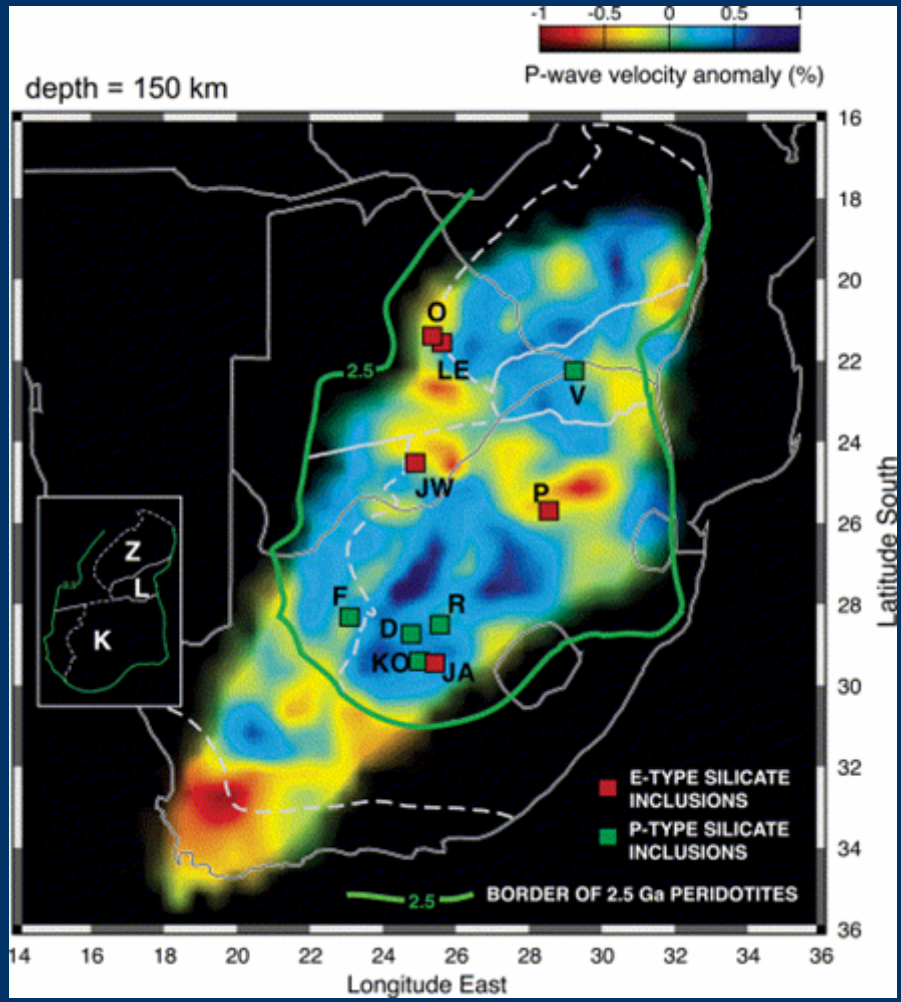
Seismic S-wave tomographic model

Coloured areas have 3D S-waves faster than average mantle at depth slices of 125, 175 and 225 km. Data clipped to coastline.

(S. Fishwick, RSES).

- Miocene (20 Ma)
- Jurassic (180-160 Ma)
- Devonian (380 Ma)
- Neoproterozoic (850 Ma)
- Mesoproterozoic (1300-1200 Ma)
- Palaeoproterozoic (2020-1900 Ma)

Diamond Potential Linked to Craton Evolution

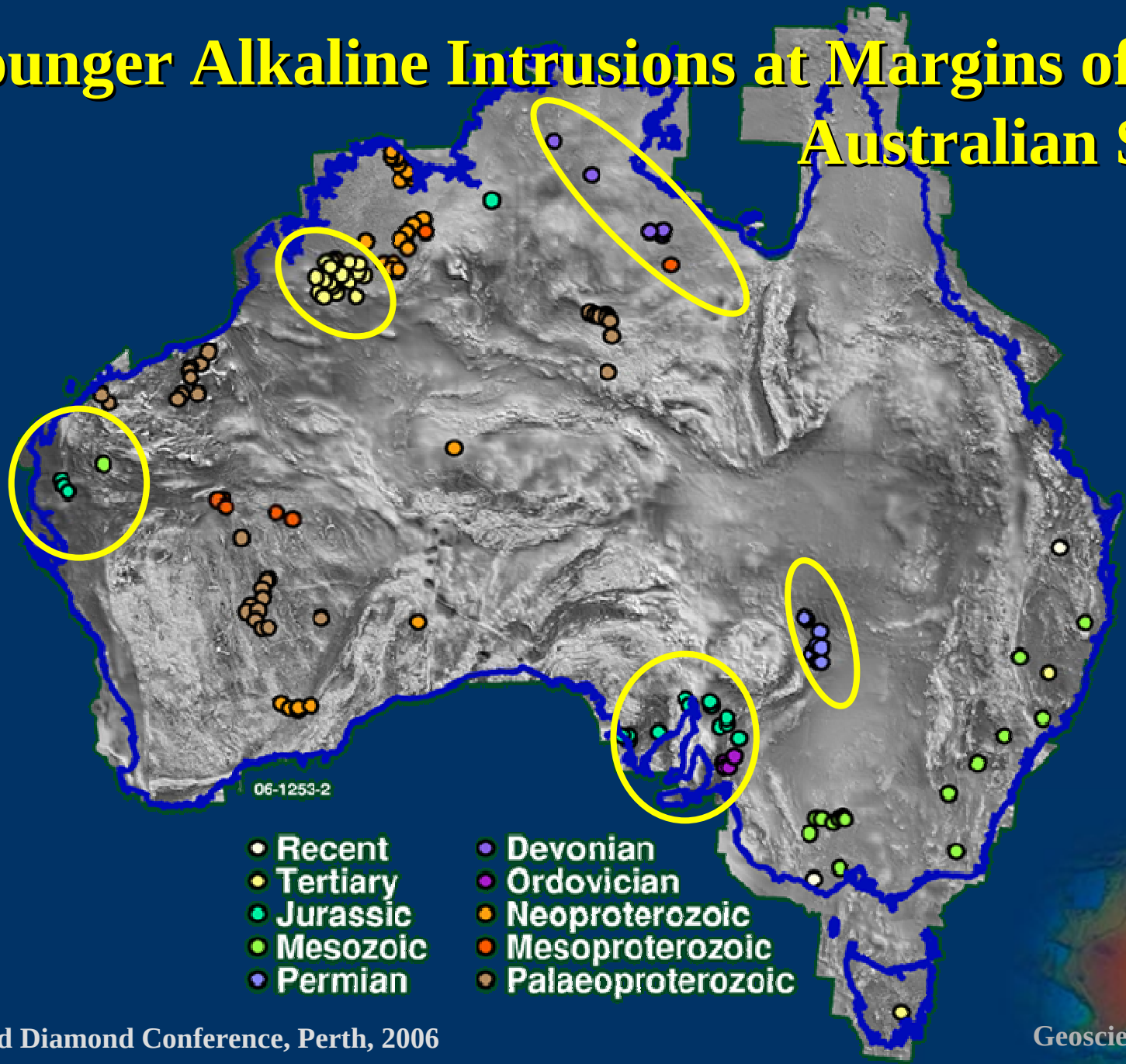


Tomographic image of seismic P-waves at 150 km for Kaapvaal and Zimbabwe Cratons, Southern Africa showing dominant inclusion suite in diamonds (Shirey et al., 8IKC, 2004)

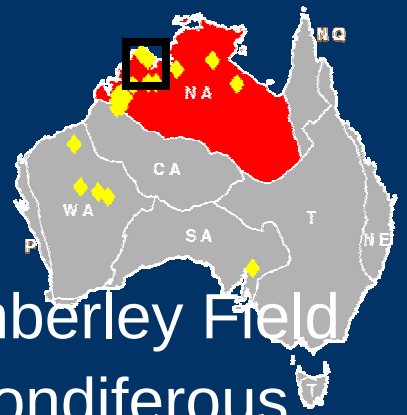
Key messages

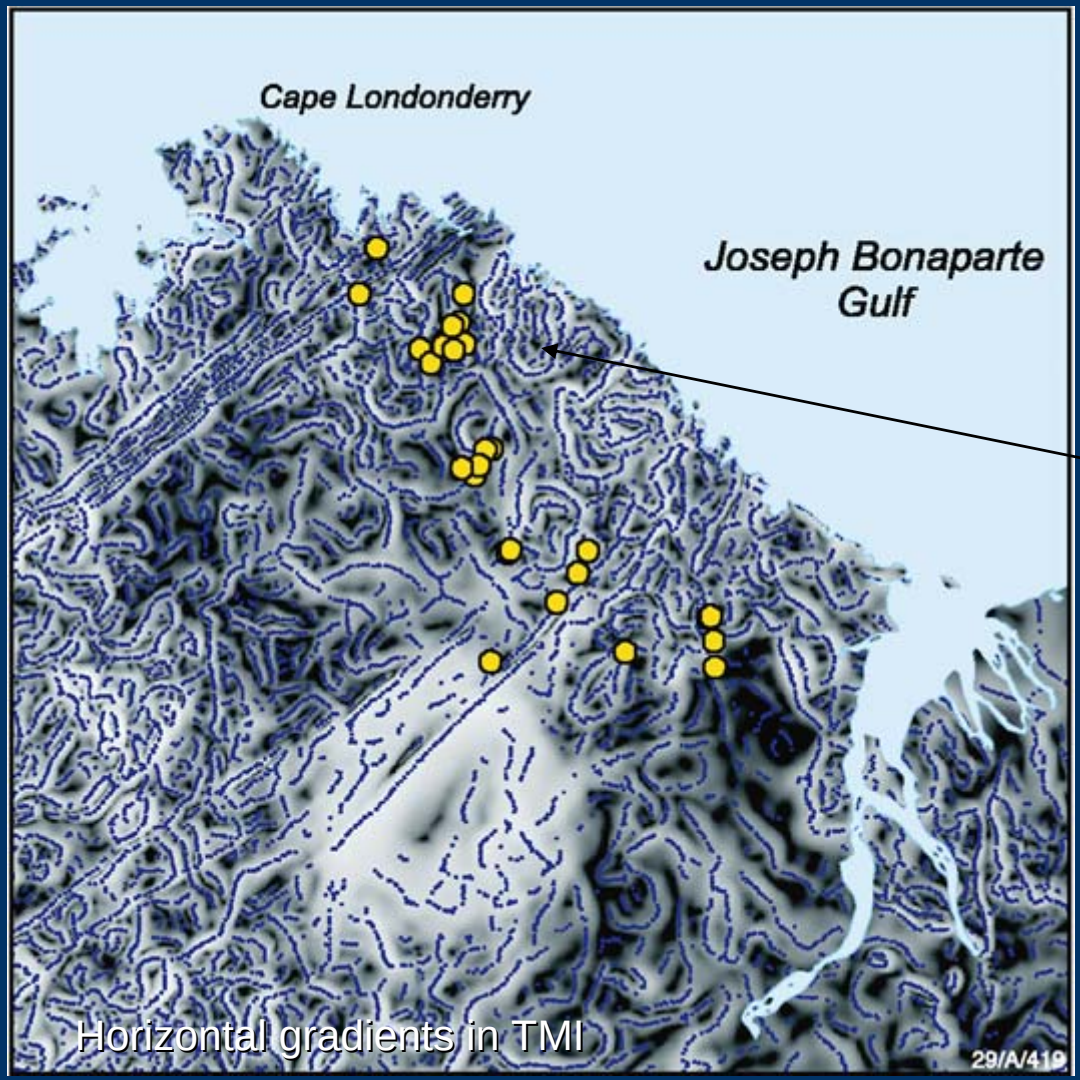
- Diamond potential linked to craton elements and craton evolution
- Eclogitic diamond suites linked to subduction events at craton margin

Younger Alkaline Intrusions at Margins of Australian Shield

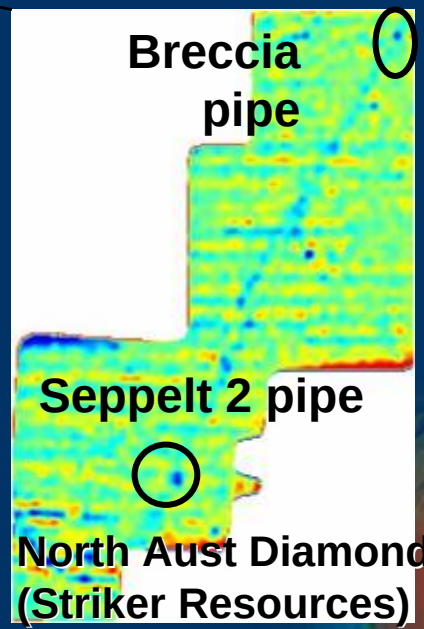


Structural Controls on Kimberlites

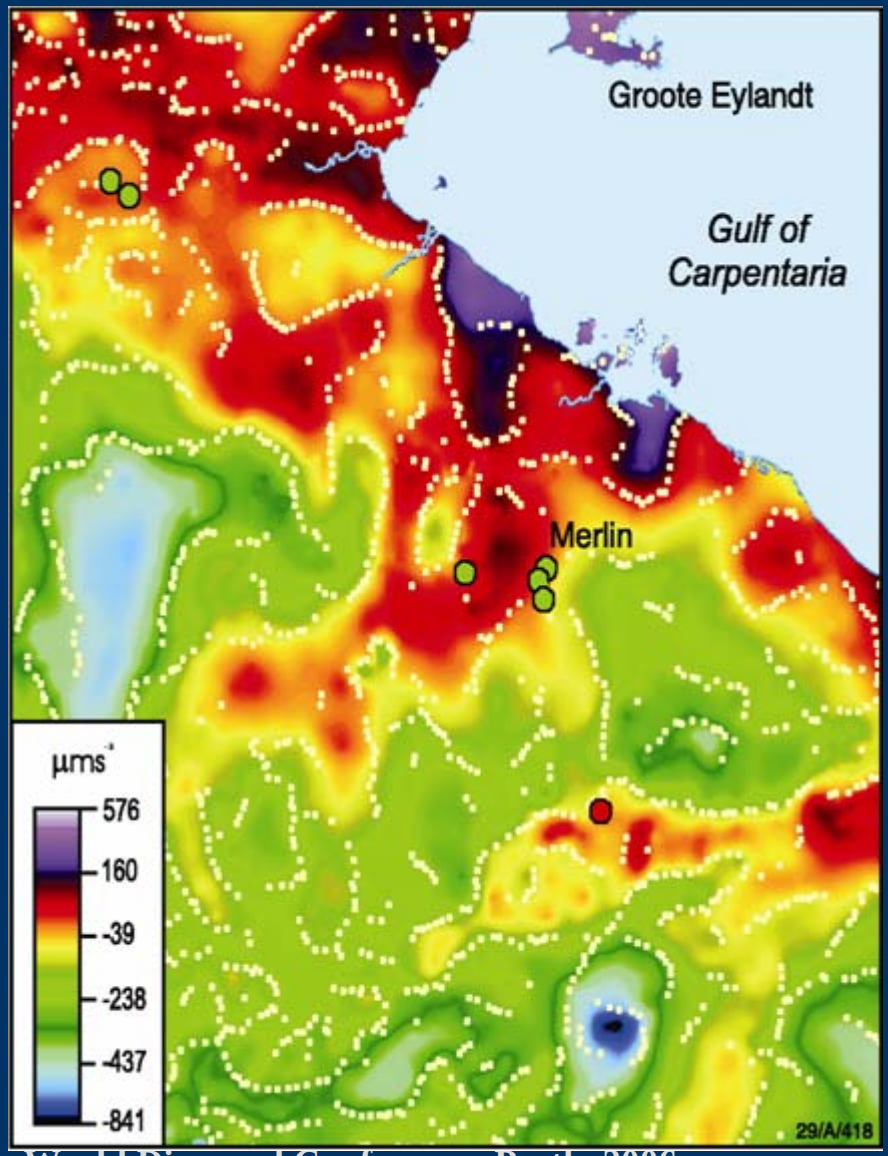


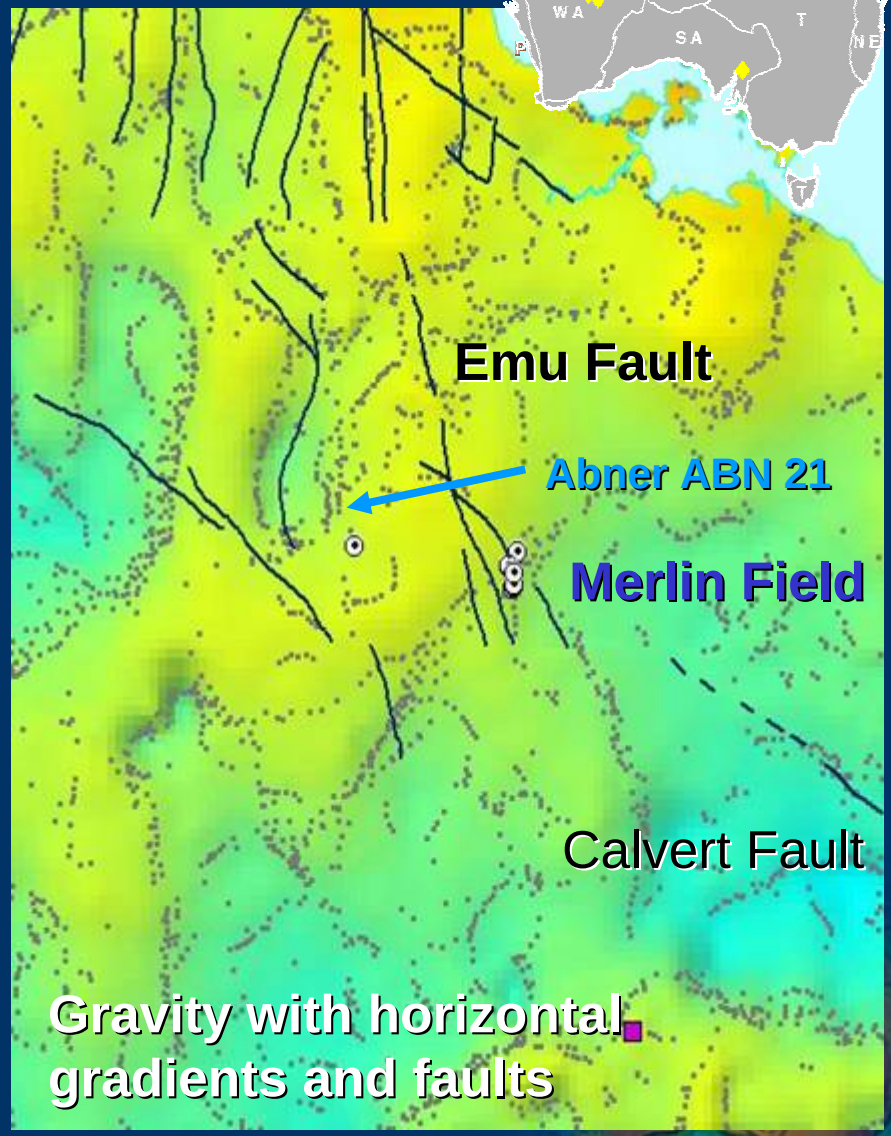


- North Kimberley Field
- >20 diamondiferous kimberlites
- NE control on NW gravity high (corridor)



Structural Control on Merlin Kimberlites

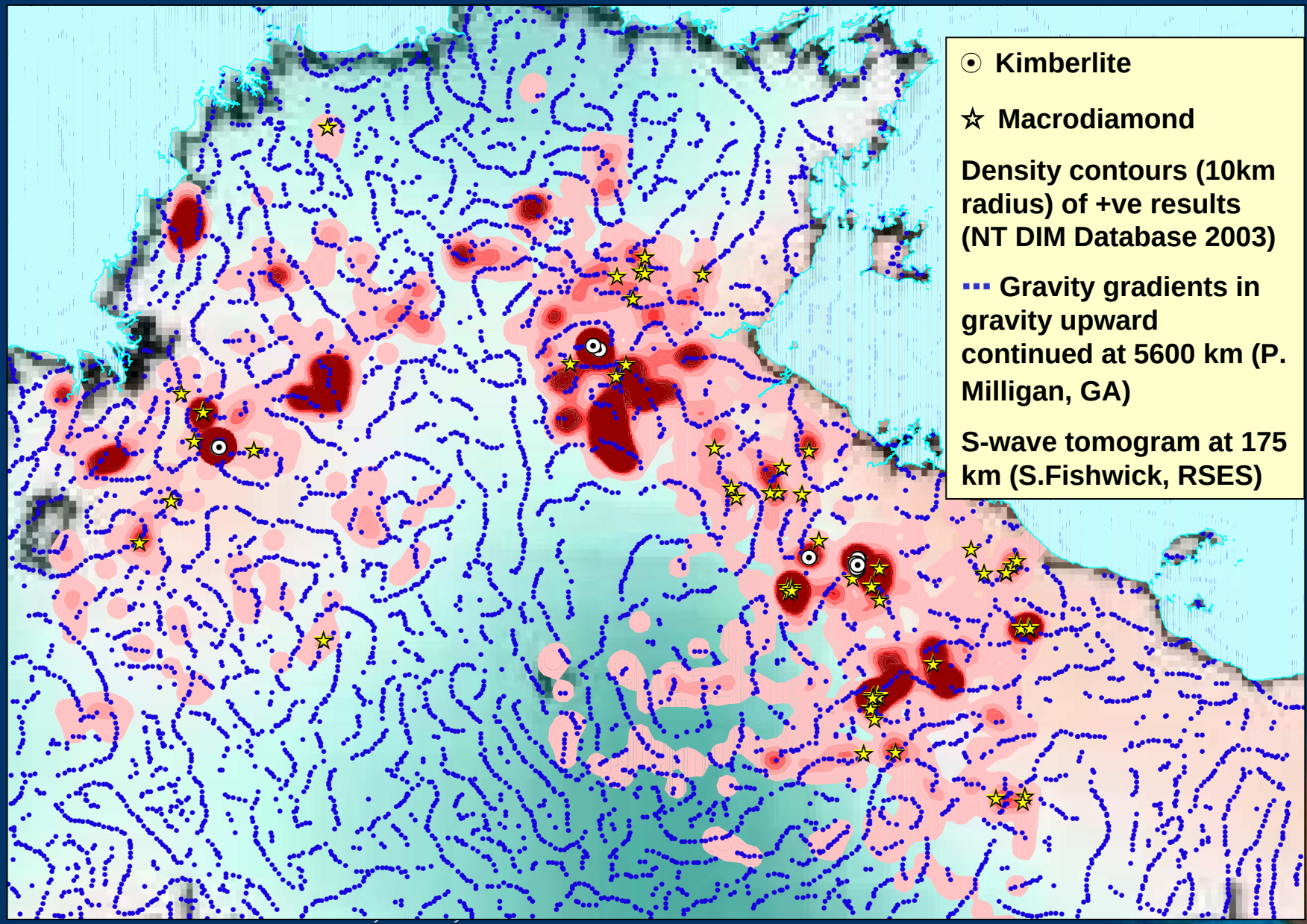




Requirements for Improved (Conceptual) Targeting

- Continental-scale geophysics can help define fertile source regions (mantle roots) and identify favourable tectonic zones/corridors
- Diamond pipes located at boundaries/breaks in lithosphere and crustal domains
- Kimberlites/lamproites commonly show structural control
  - Structures commonly evident in potential field data (horizontal gradients of upward continued gravity and magnetic data)
  - Multi-scale approach needed (fine & coarse scale structures)
- Need improved seismic tomographic models of the Australian lithosphere for substantial improvement in targeting
- Better understanding of geodynamic evolution of continent

(Empirical) Prospectivity Mapping Approach



GA's 2006 Energy Security Initiative

- $134M energy security package
  - New impetus for exploration
- $75M over 5 years to expand GA's "Big New Oil" program through pre-competitive data acquisition
  - Acquire new data to attract exploration for petroleum in under-explored frontier offshore basins
- $59M over 5 years for onshore minerals and petroleum
  - New data acquisition using latest geophysical imaging /mapping in onshore basins and mineral provinces

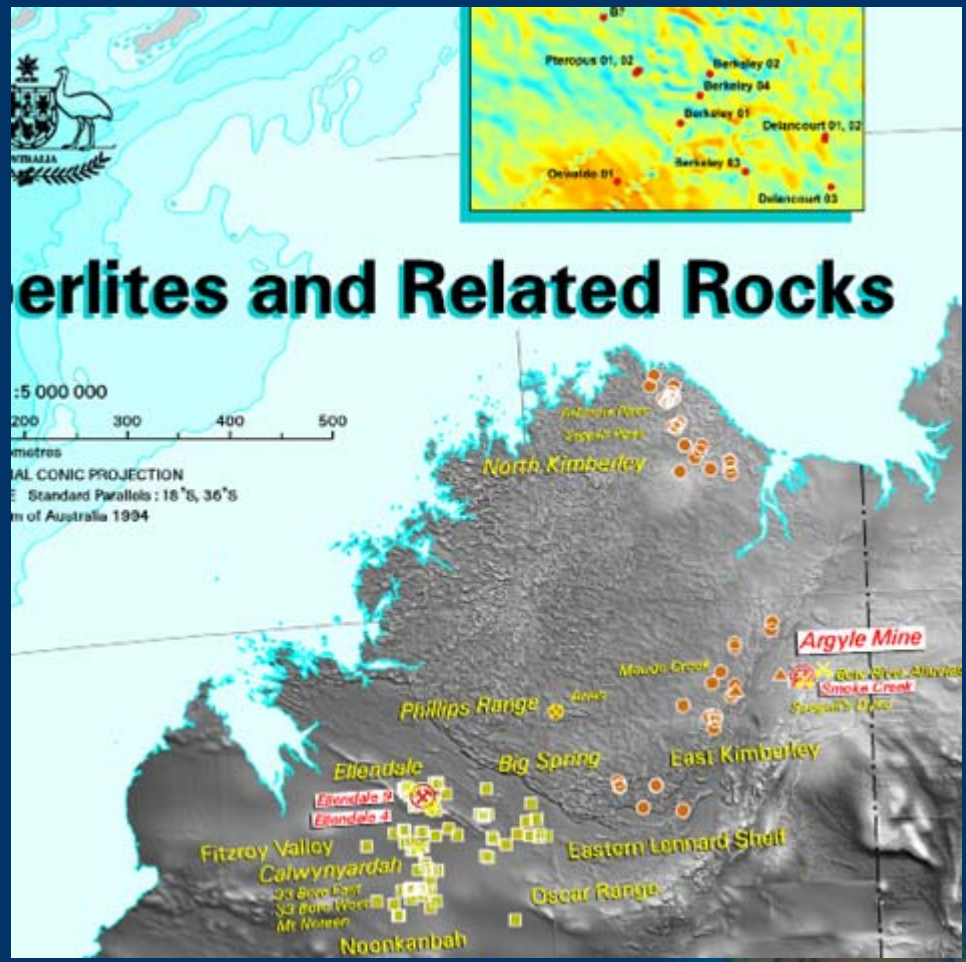
Conclusions

- Diamond exploration mostly focussed in brownfields areas mostly on NAC
- West Pilbara is new diamondiferous field
  - significance and extent yet to be determined
- Much of the Australian Shield has deep old roots and is prospective
  - locally impacted by thermal/metasomatism
- Exploration difficult
  - regolith/cover
  - poor survival and erratic distribution of indicators
- **Improved targeting needed to identify greenfields provinces**

New release

Australian Diamond Deposits, Kimberlites and Related Rocks 1:5M map 2006

Thank you



www.ga.gov.au/image_cache/GA8872.pdf