



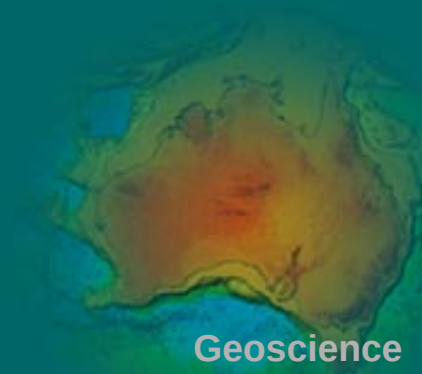
Australian Government

Geoscience Australia

**3 billion years of granite
magmatism:
Palaeo-Archaean to Permian
granites of Australia**

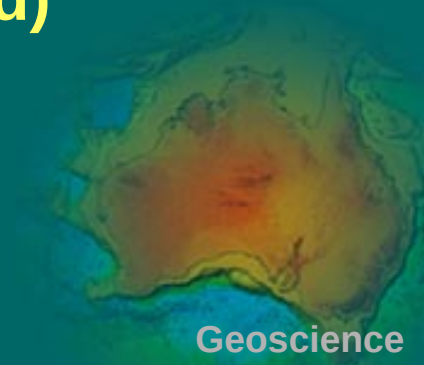
D. Champion & R.H.Smithies

**Geoscience Australia, Geological Survey
of Western Australia**



Outline

- **Australia through time – overview**
- **Archaean magmatism: 3.5 to 2.6 Ga**
 - **Pilbara, Yilgarn**
 - **secular trends**
- **Proterozoic magmatism: 1.9-1.5 Ga**
 - **characteristics**
 - **Archaean-Proterozoic changes**
- **Palaeozoic magmatism: 0.5-0.22 Ga**
 - **eastern Australia (esp. north Queensland)**
- **Secular changes**
- **Discussion**



Australia regions and ages

Major periods of (intermediate-) felsic magmatism occur throughout the Archaean, Proterozoic and Palaeozoic

Archaean

- Yilgarn
- Pilbara

Proterozoic

- W, N & S Aust. Cratons; many provinces

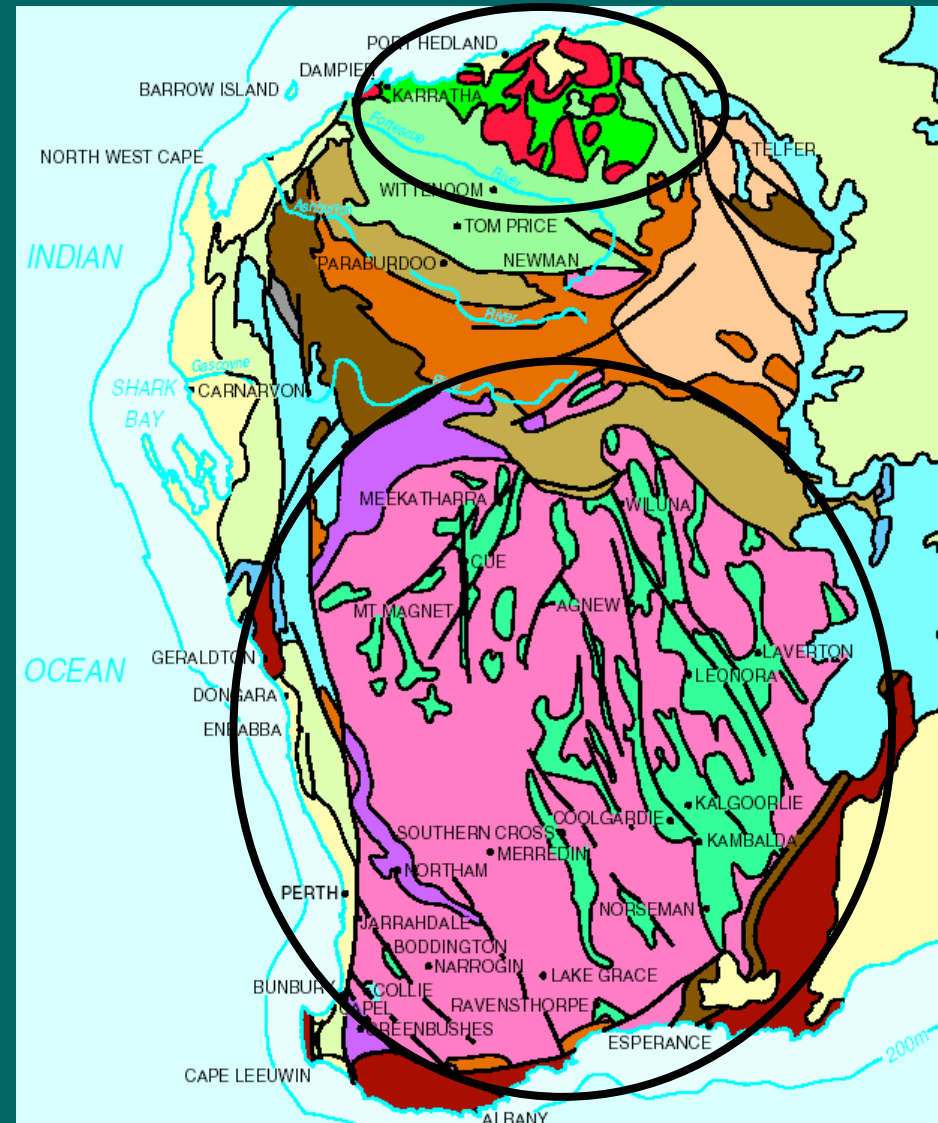
Palaeozoic

- Tasmanides



Archaean

- **Pilbara & Yilgarn**
- look at Yilgarn in some detail
- **early sodic granites & younger potassic granites**
- variety of other types



Pilbara & Yilgarn Cratons

Pilbara

Palaeo- to Mesoarchaeon

- mostly 3.52 to 2.85 Ga

Yilgarn

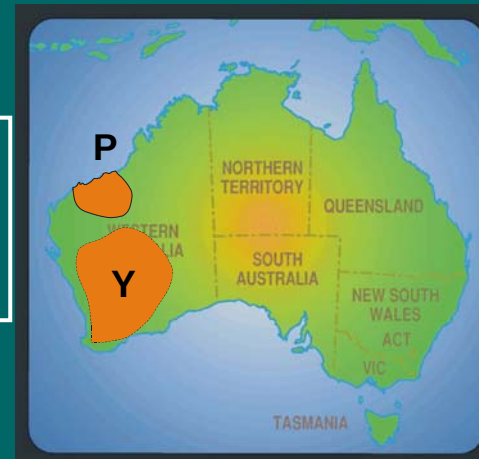
Meso- to Neoarchean

- mostly ~3.0 to 2.6 Ga

Typical Archaean granite-greenstones

- **subdivided - geological terranes & superterranes**
e.g., Swager, 1997; Barley et al., 2002; Van Kranendonk, 2006

Pilbara & Yilgarn both have cratonic
'nuclei' & marginal terranes

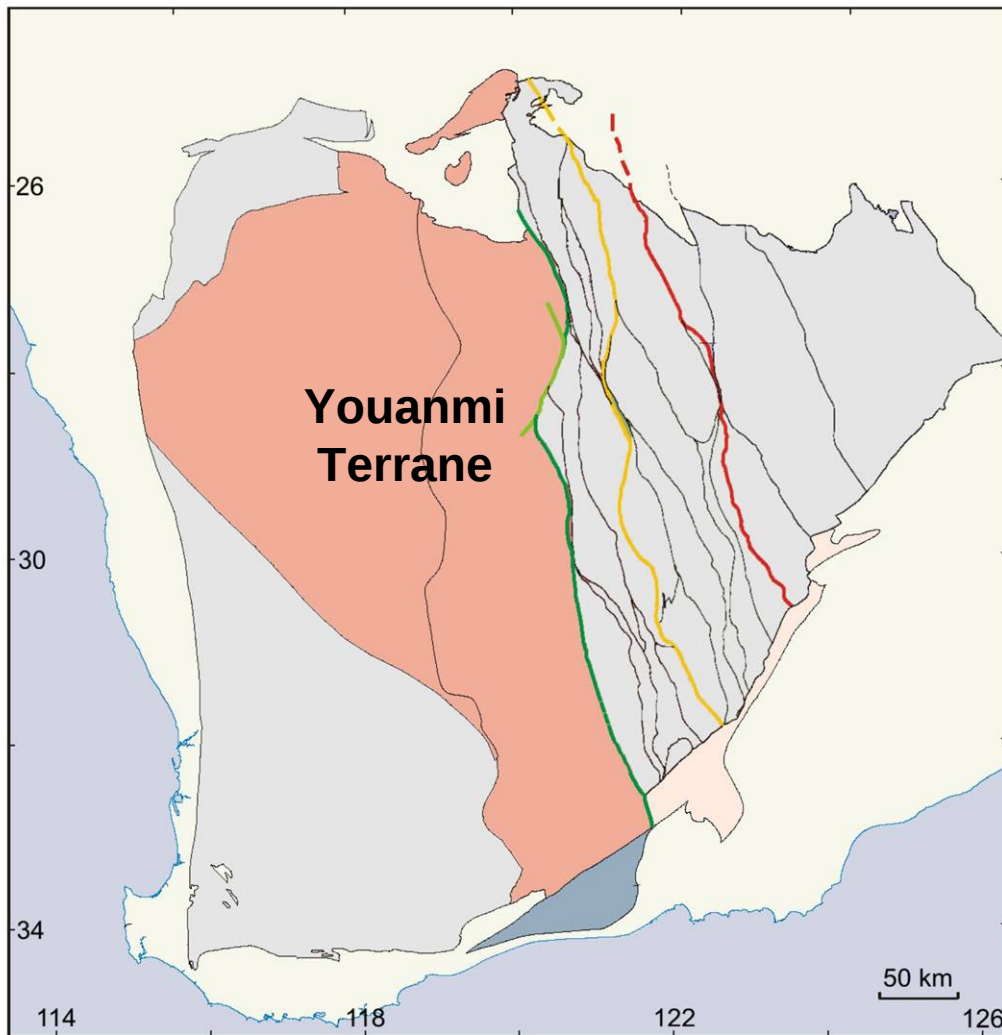


Yilgarn

Youanmi Terrane:

- >3.0-2.6 Ga craton nucleus

- oldest greenstones **ca. 3.0-2.92 Ga**
- oldest granites **ca. 3.0-2.92 Ga** (rarely preserved)
- peak of felsic magmatism 2.73-2.68 Ga



Eastern
Goldfields
Superterrane

Terrane

- Burtville
- Kumalpi
- Kalgoorlie
- Youanmi

Fault system

- Hootanui
- Ockerburry
- Ida
- Waroonga

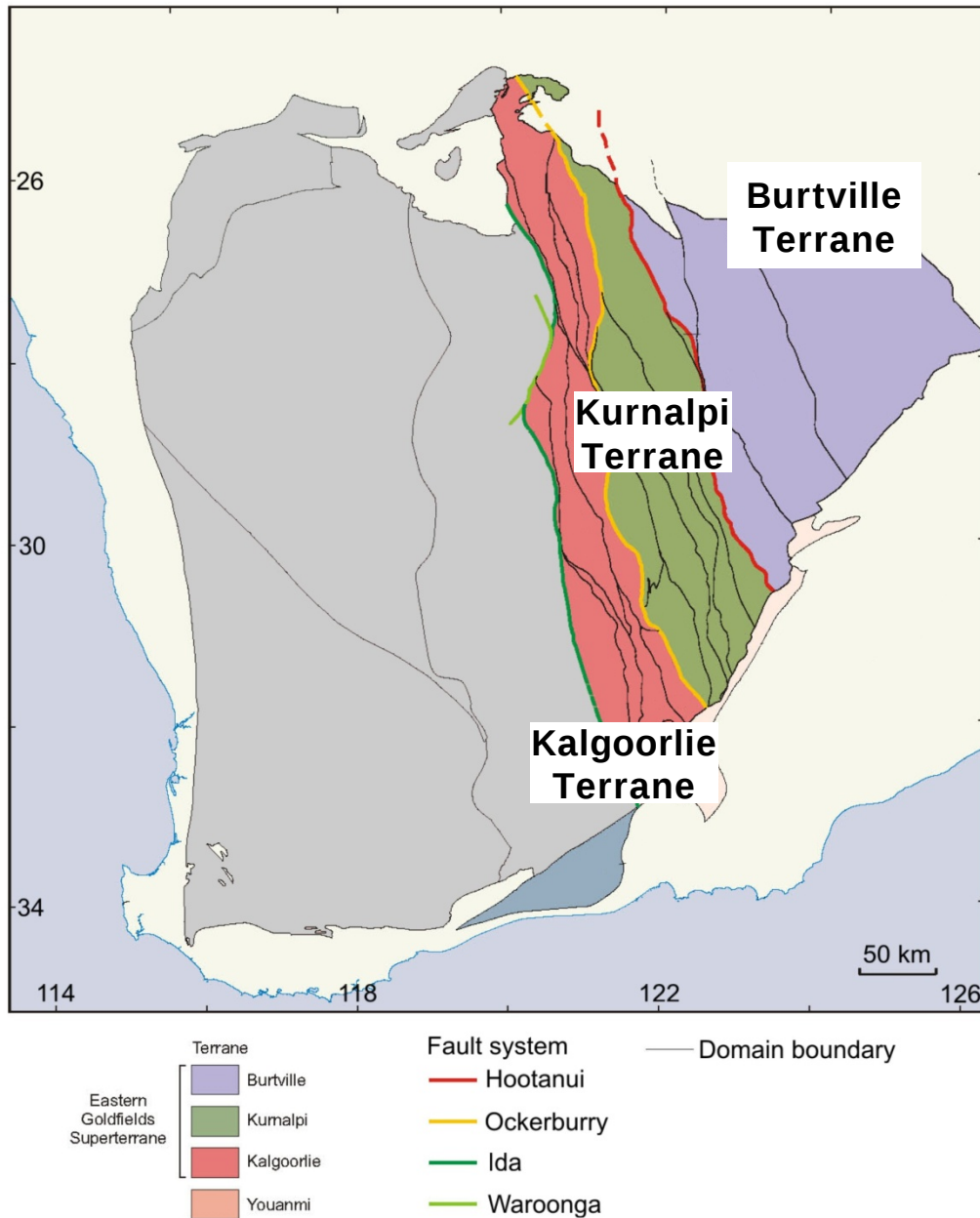


Yilgarn

Eastern Goldfields Superterrane

Comprises

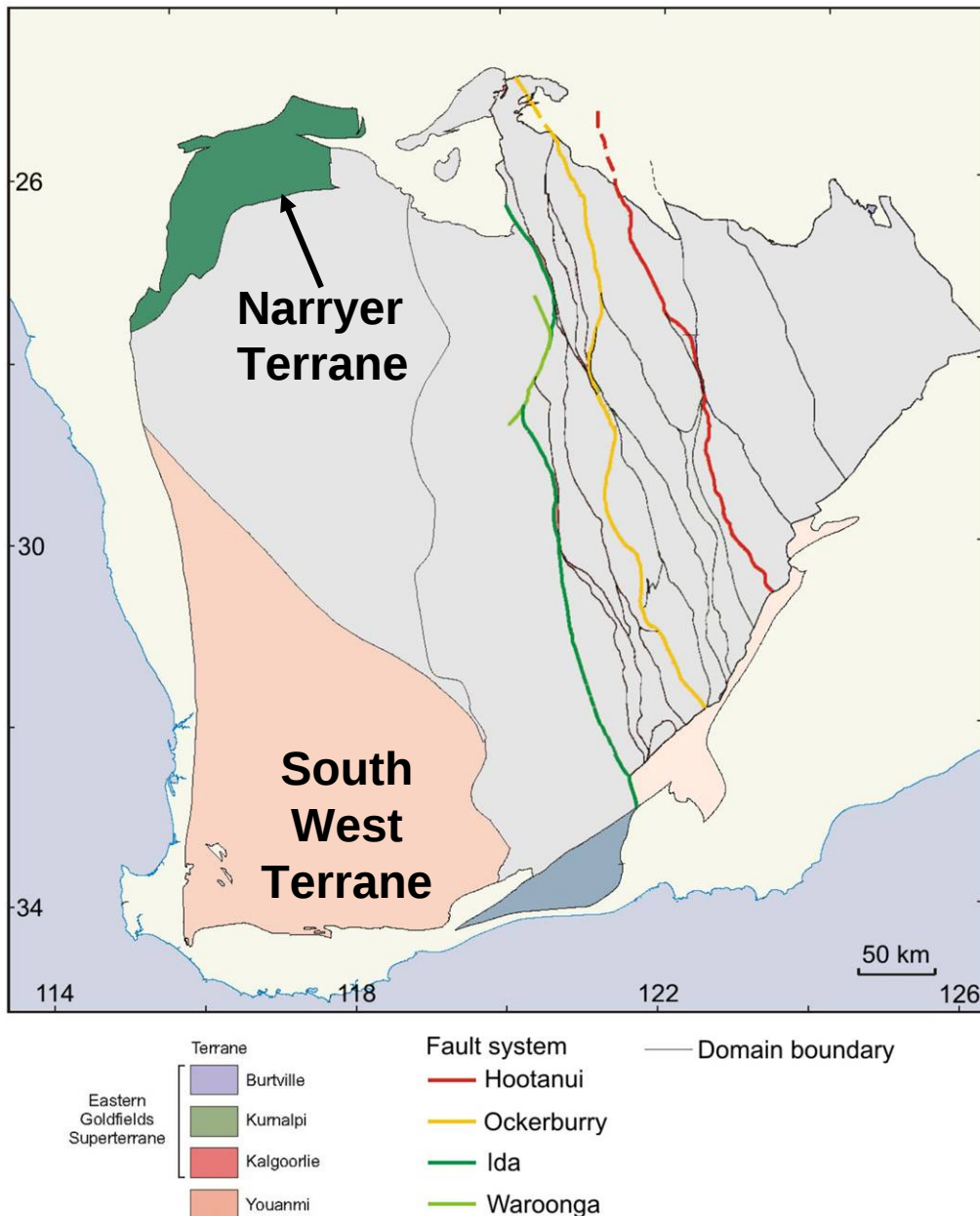
- >2.76-2.63 Ga
Kalgoorlie Terrane
 - ~2.95-2.63 Ga
Kurnalpi Terrane
 - ~2.95-2.63 Ga
Burtville Terrane
-
- peak felsic magmatism
2.68-2.65 Ga



Yilgarn

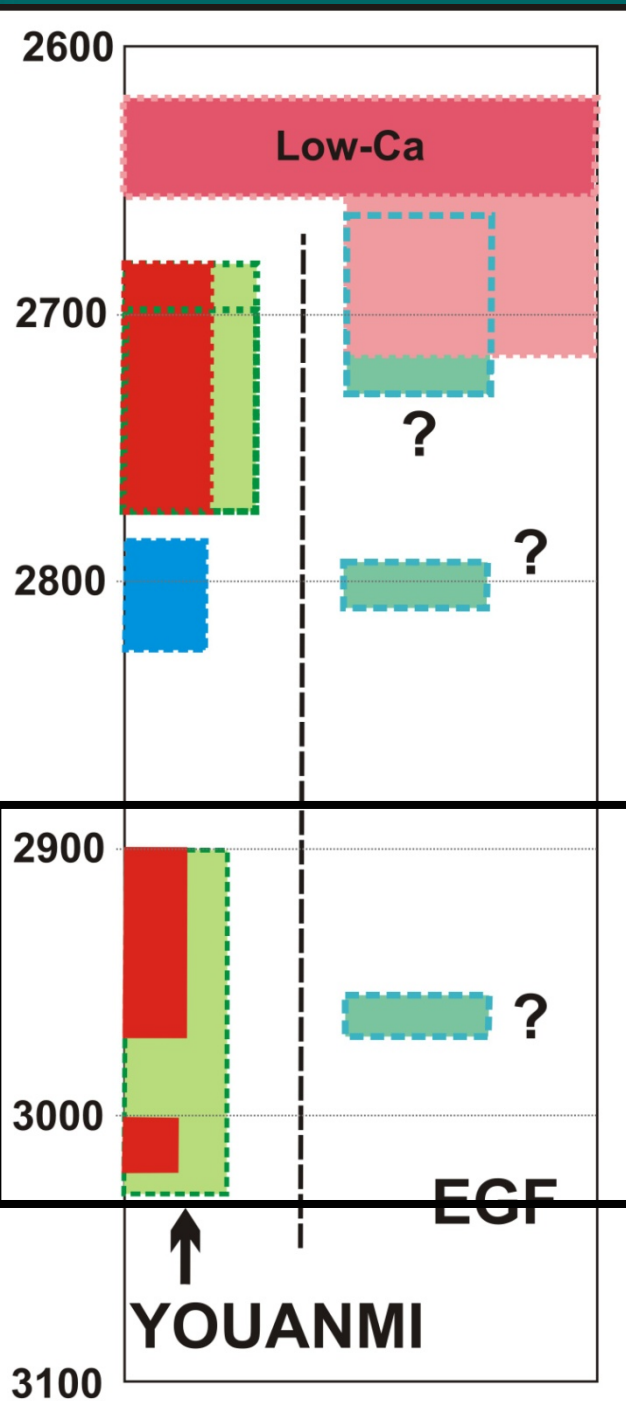
Narryer & South West terranes:

- >3.3-2.6 Ga
- include oldest known parts of Yilgarn & Jack Hills Conglomerate
- accreted(?) onto Youanmi Terrane
- South West Terrane boundary - poorly defined



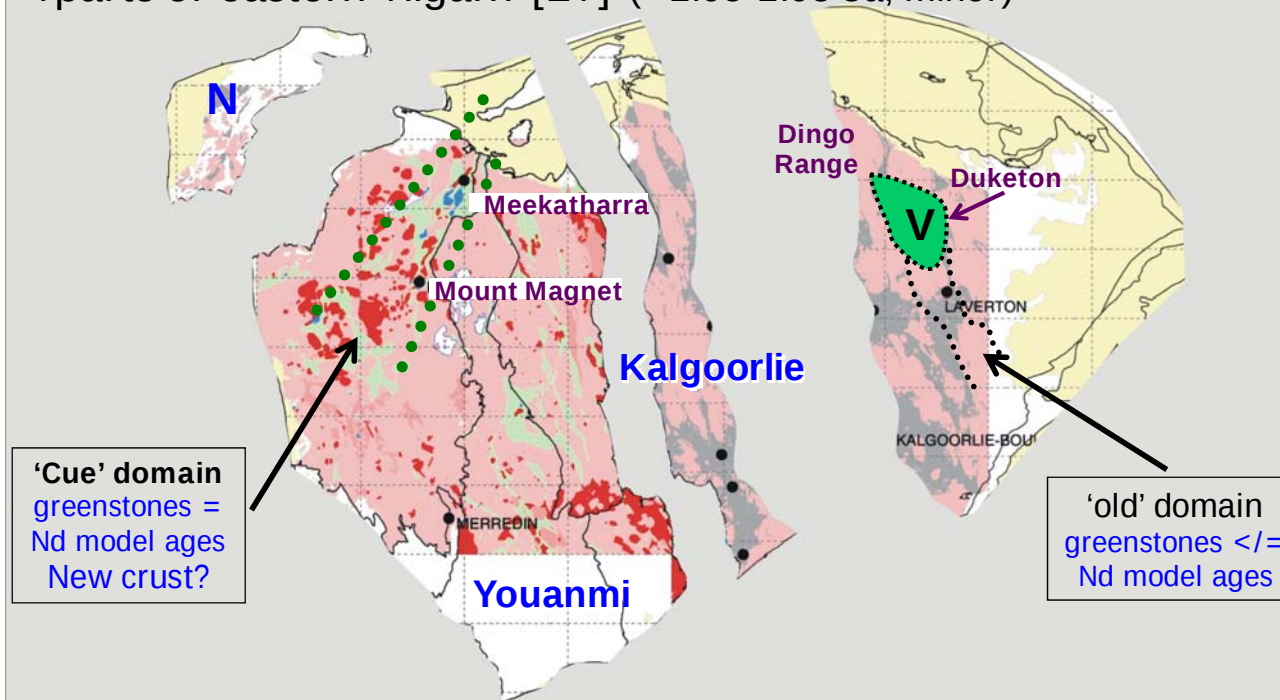
3.01-2.9 Ga

**Sodic granites: mostly high-Al
TTGs, Also high-HFSE granites**



ca 3.01, 2.97-2.9? Ga

greenstone deposition, granites – Youanmi (~3.01, 2.97-2.9? Ga),
?parts of eastern Yilgarn [EY] (~2.95-2.93 Ga, minor)



2.76-2.73 Ga

**Sodic granites: mostly high-Al TTGs,
Also high-Mg diorites, high-HFSE
granites**

ca 2.76-2.73 Ga

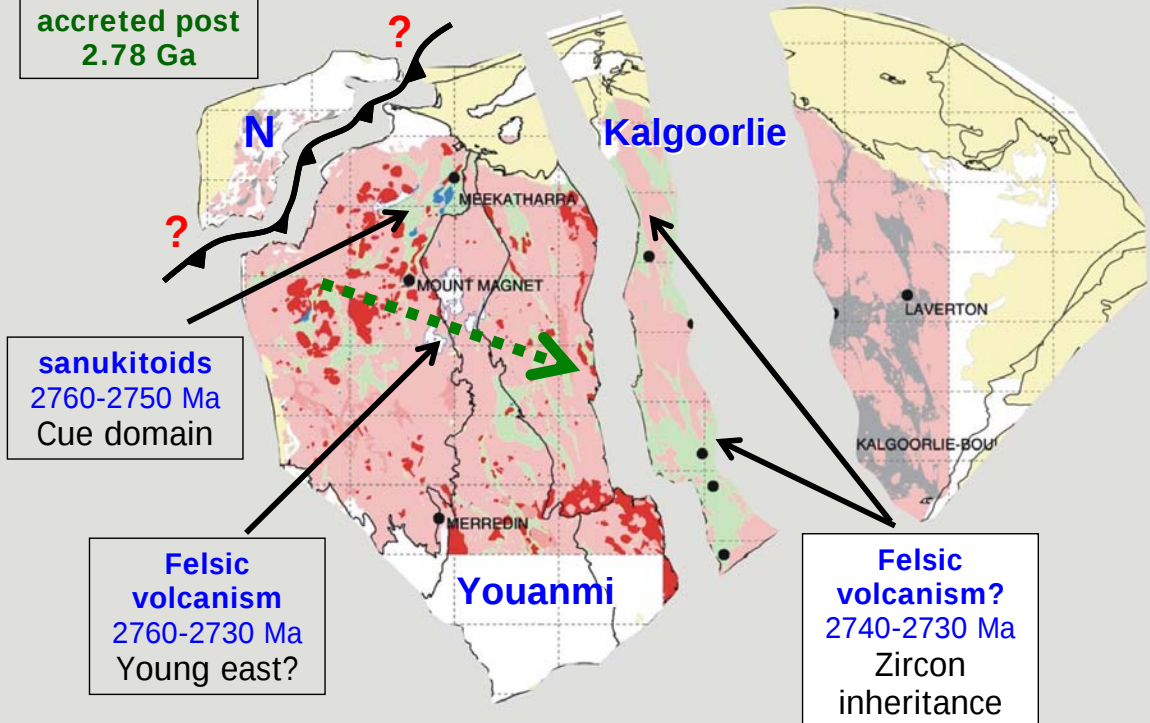
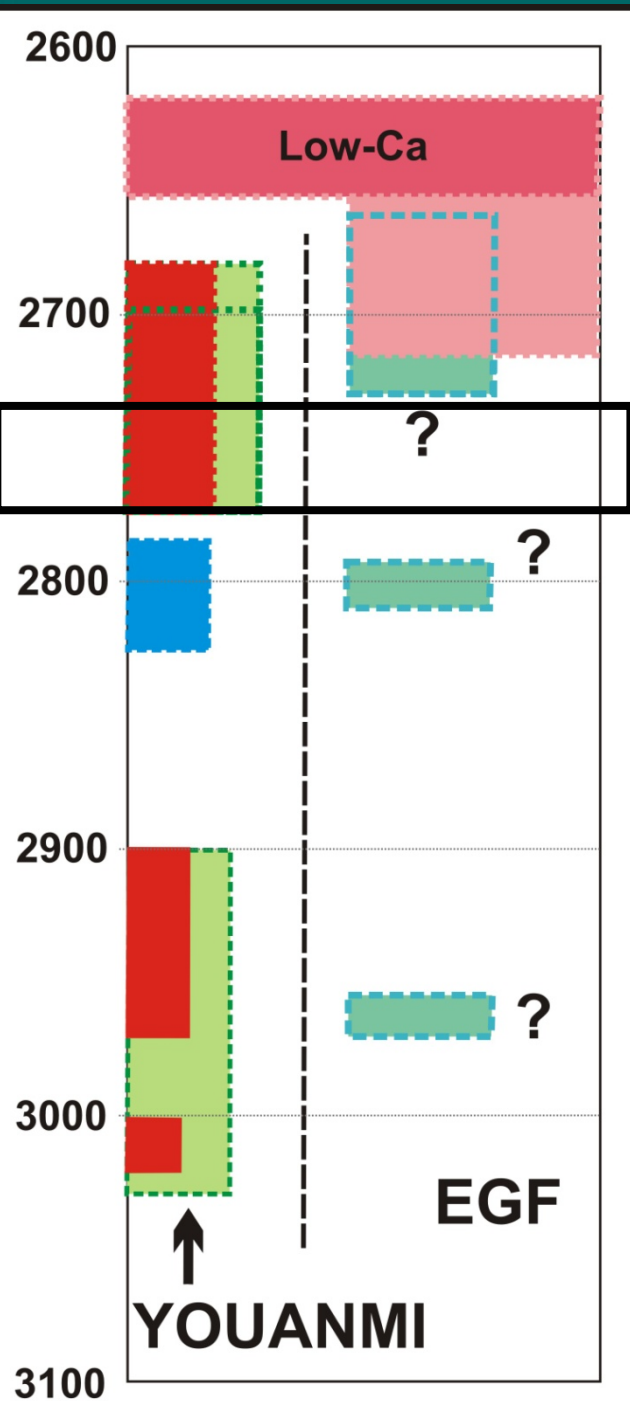
granite-greenstone (young to east) – Youanmi; Kalgoorlie (minor)

accreted post
2.78 Ga

sanukitoids
2760-2750 Ma
Cue domain

Felsic
volcanism
2760-2730 Ma
Young east?

Felsic
volcanism?
2740-2730 Ma
Zircon
inheritance

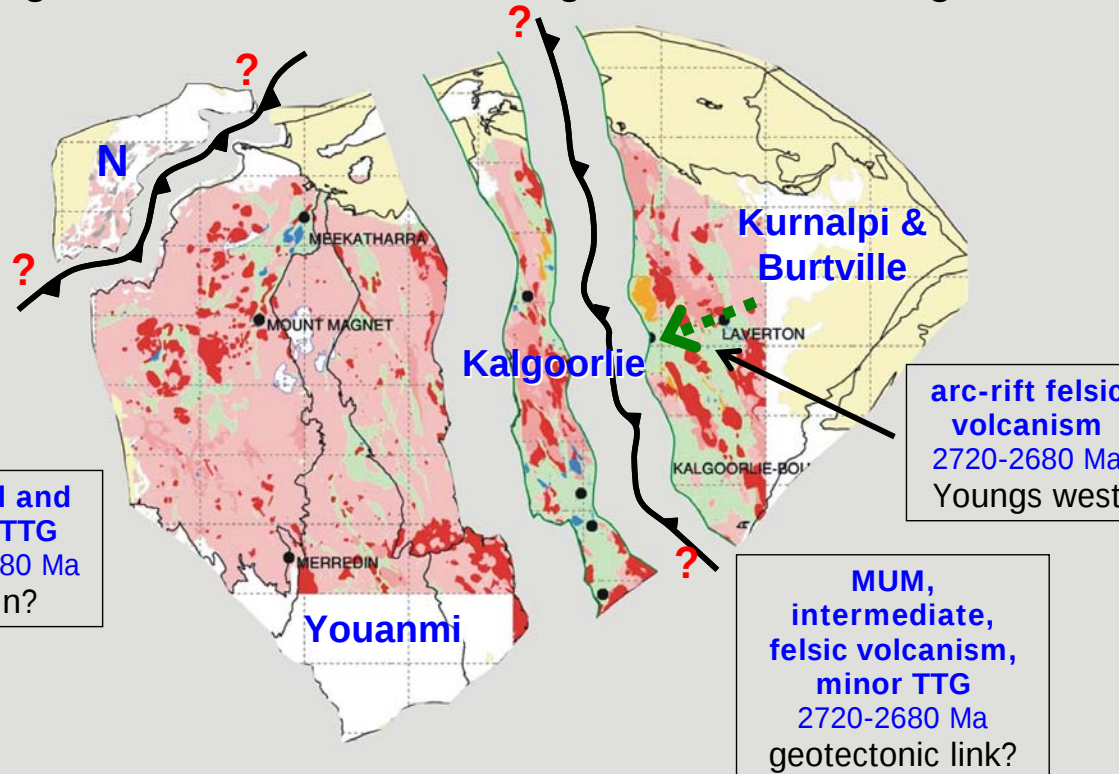
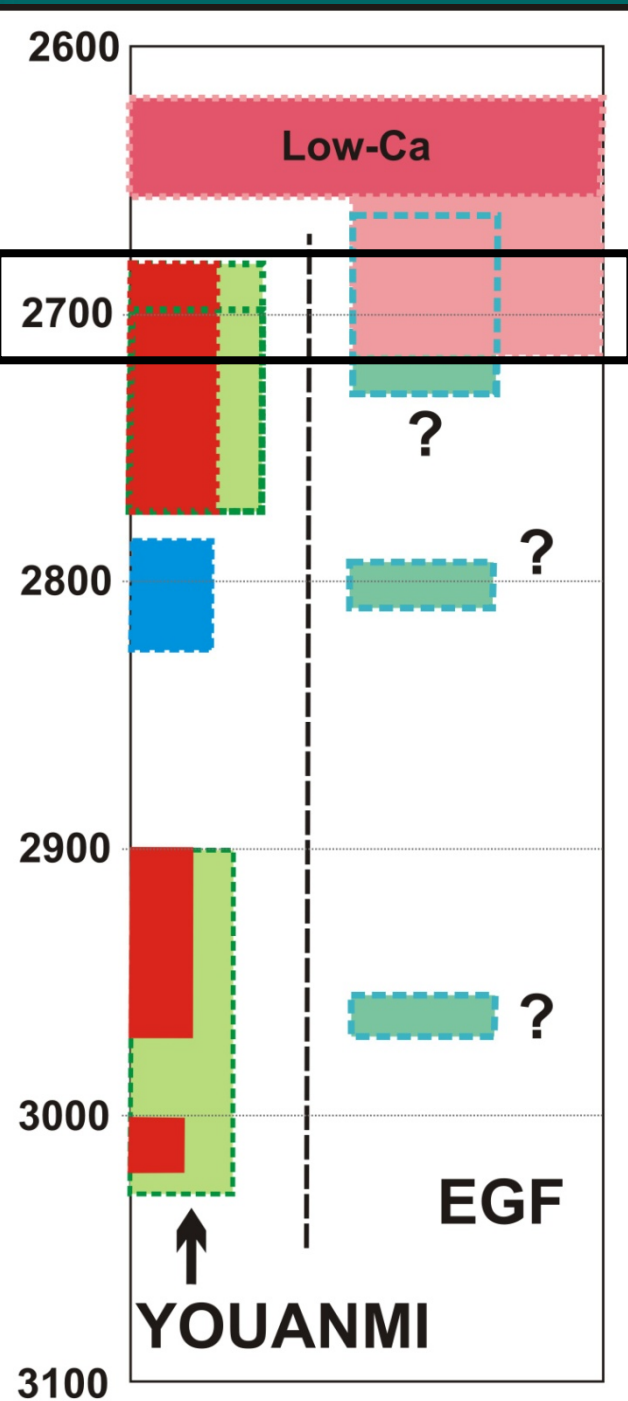


2.72-2.68 Ga

**Sodic granites: mostly high-Al TTGs,
Also high-Mg diorites, high-HFSE
granites, BADR series (east Yilgarn)**

ca 2.72-2.68 Ga

granite-greenstone – Youanmi, Kalgoorlie, eastern Yilgarn

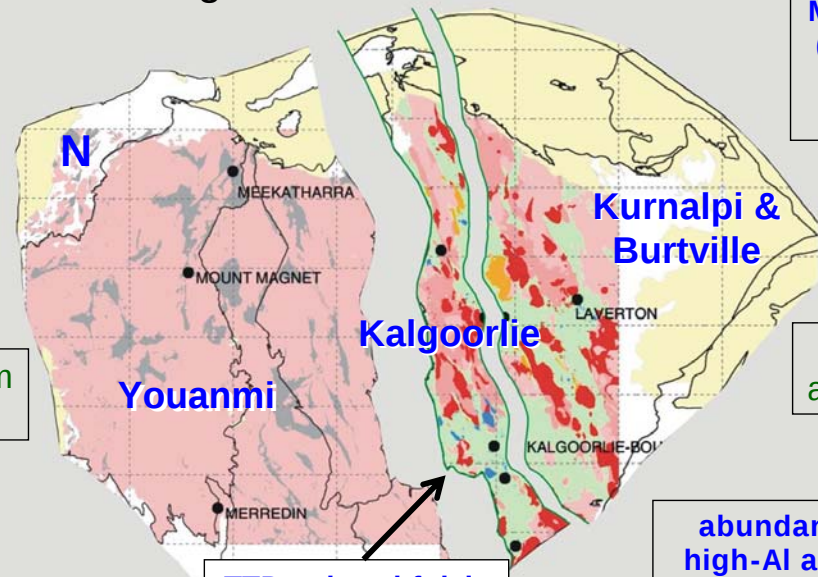
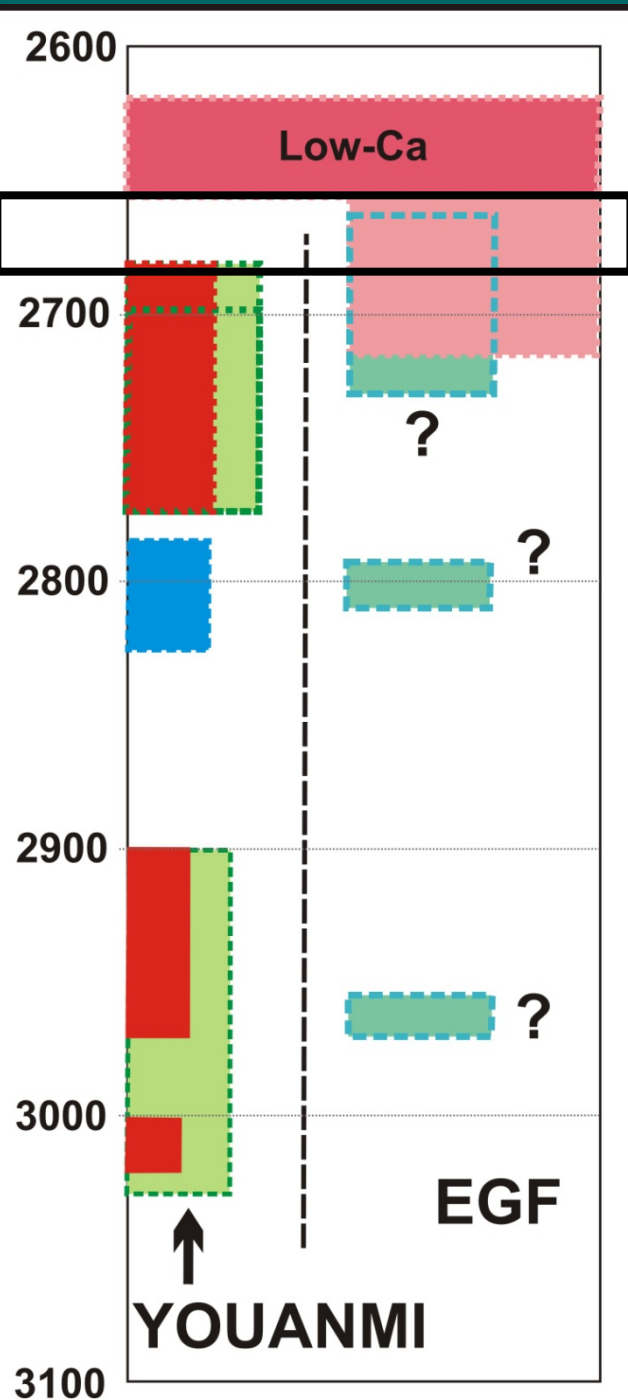


2.68-2.66 Ga

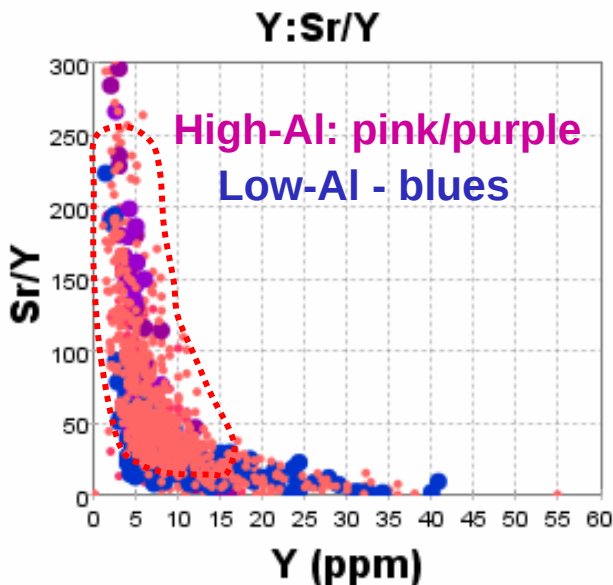
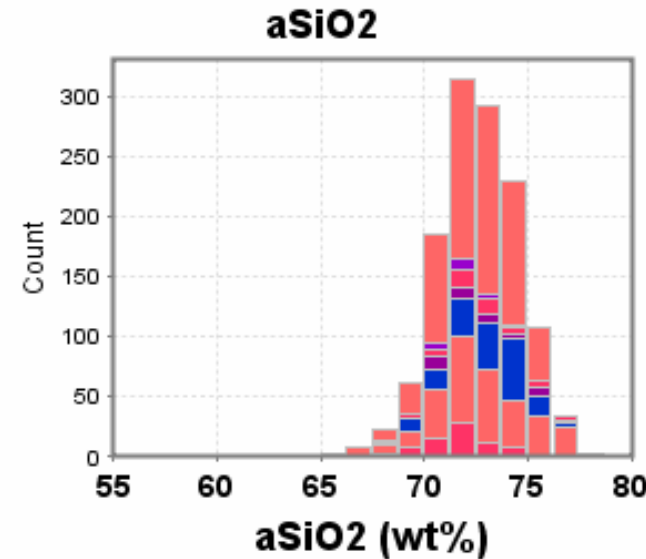
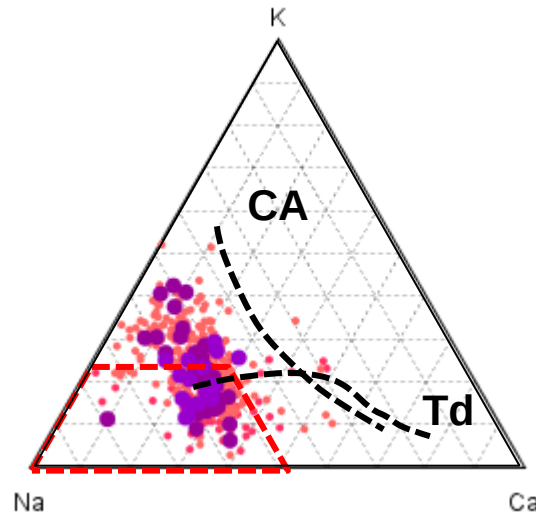
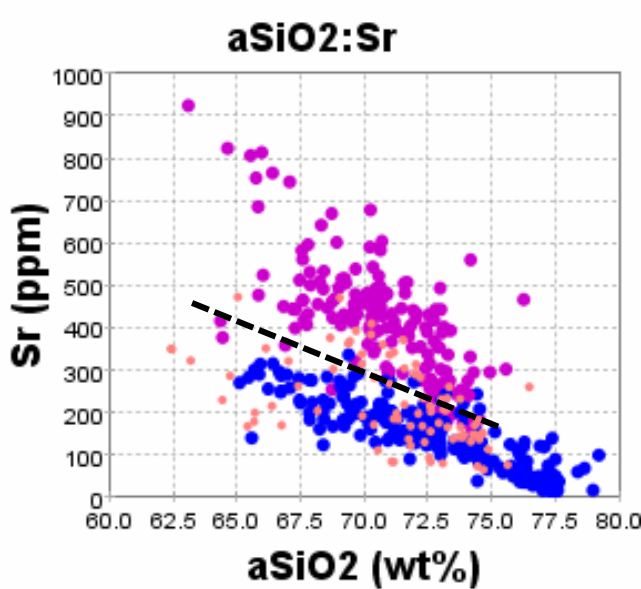
**Sodic granites: mostly high-Al TTGs,
Also high-Mg diorites, high-HFSE
granites, syenites**

ca 2.68-2.66 Ga

granite-greenstone – Kalgoorlie (?amalgamation)
granite – eastern Yilgarn

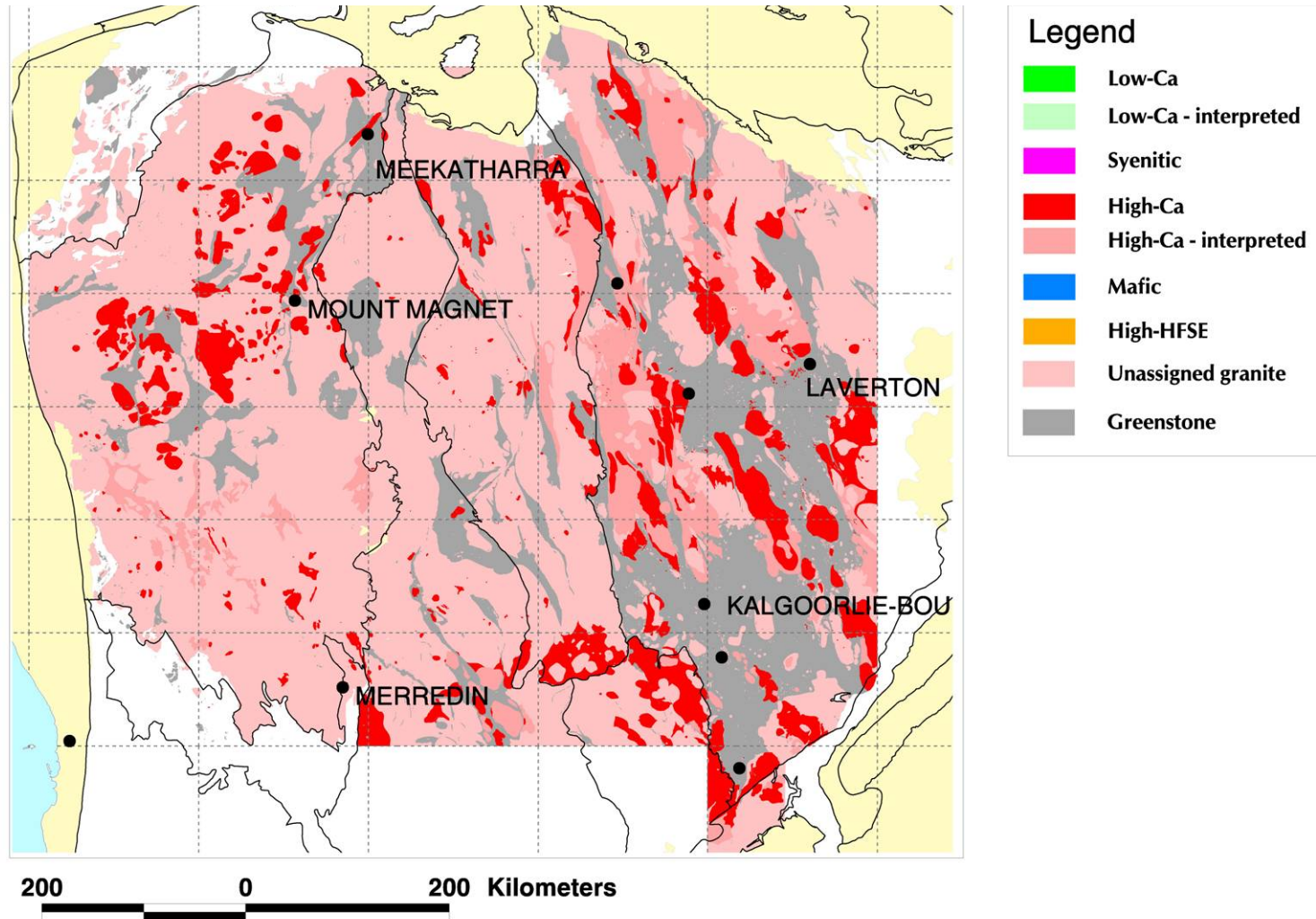


Yilgarn – sodic granites



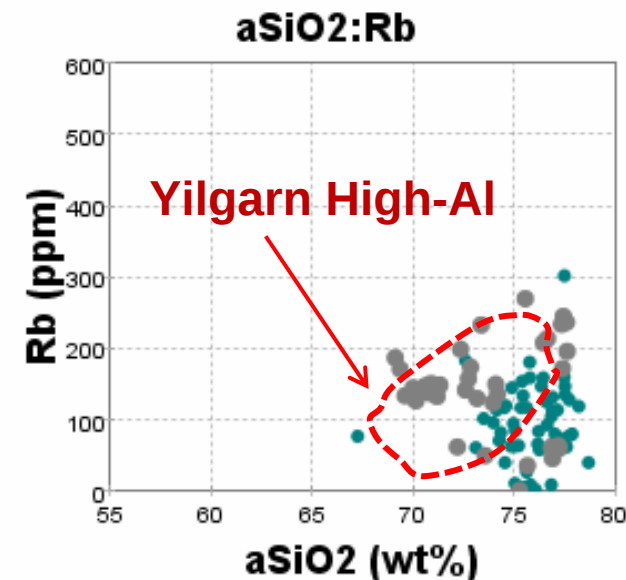
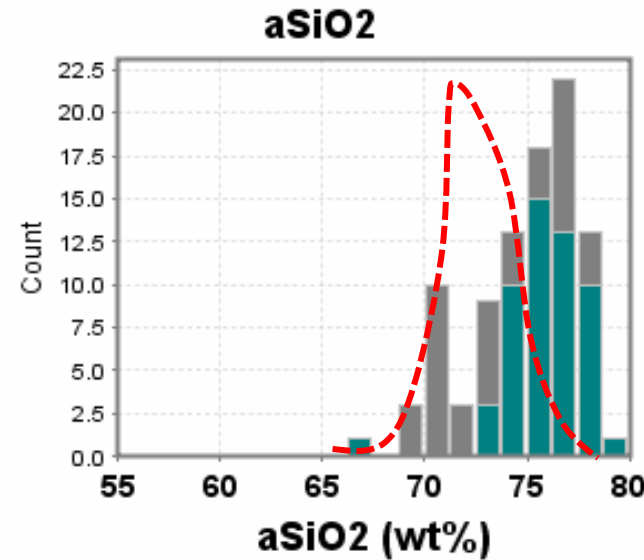
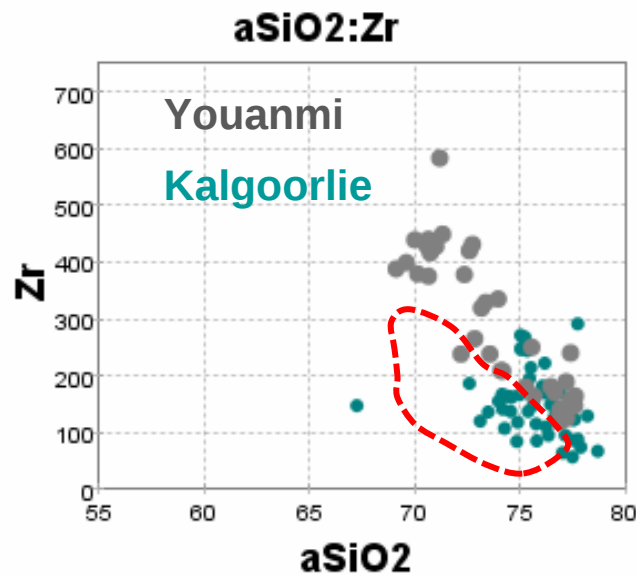
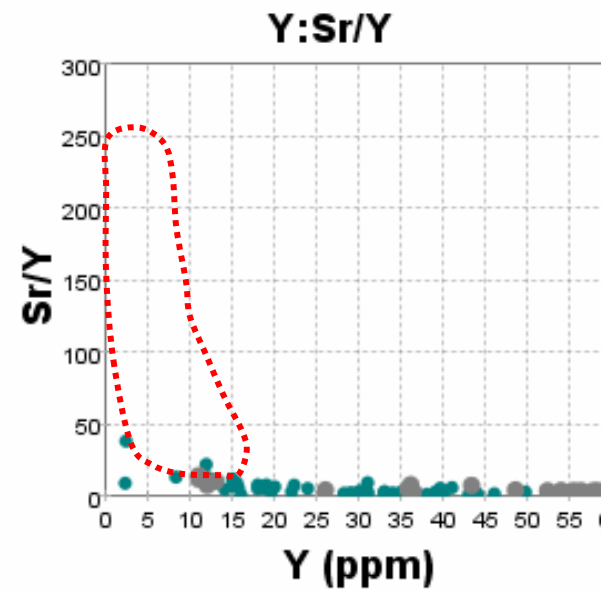
- mostly granodiorite, trondhjemite & granite – tonalite rare
- sodic, high Na₂O/K₂O,
- SiO₂ > 66%
- high-Al & low-Al subgroups (high Sr, low Y; and low Sr, high Y)
- dominant magmatism in Yilgarn

Sodic Granites



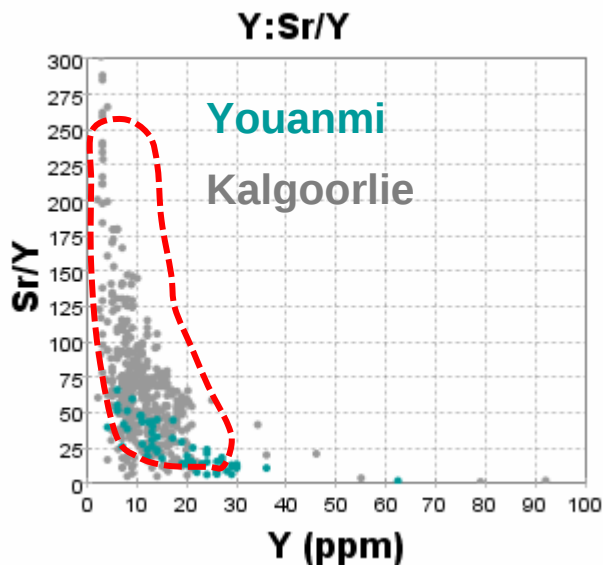
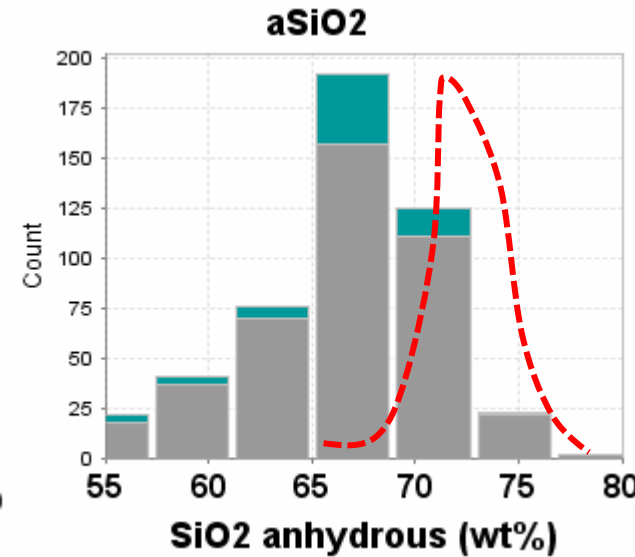
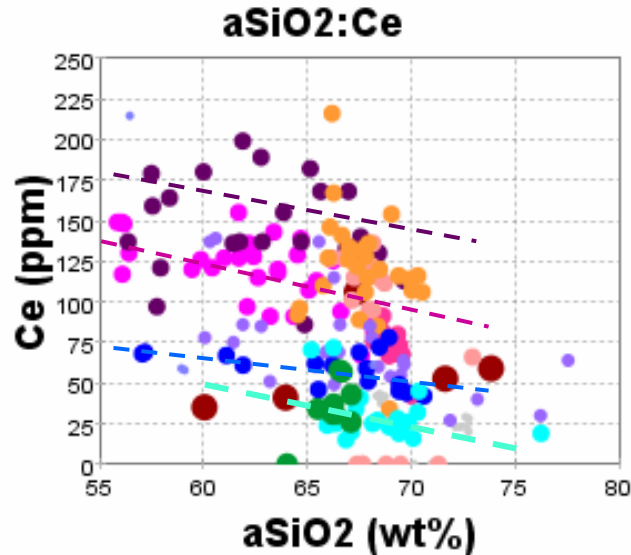
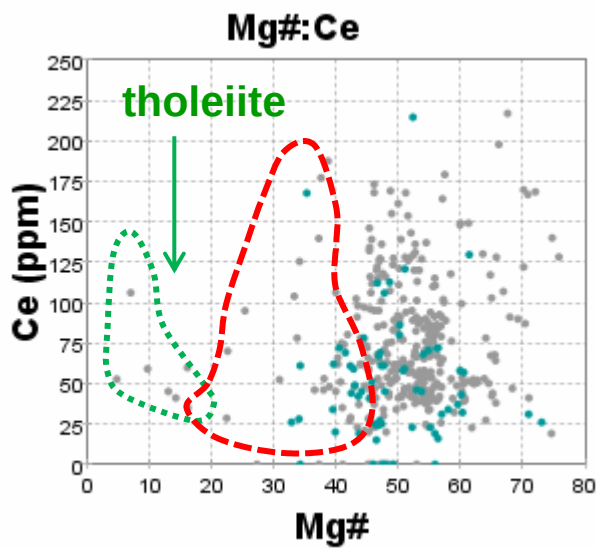
- Dominant (>60%) – Archaean 'TTG'
- In greenstones & external

Yilgarn – high-HFSE granites



- monzogranite; minor granodiorite
- mostly high SiO₂ >70%
- elevated Ti, Fe, Zr, Y, HREE; and low LILE
- often associated with volcanics
- typically early but range of ages
- minor component

Yilgarn – ‘Mafic’



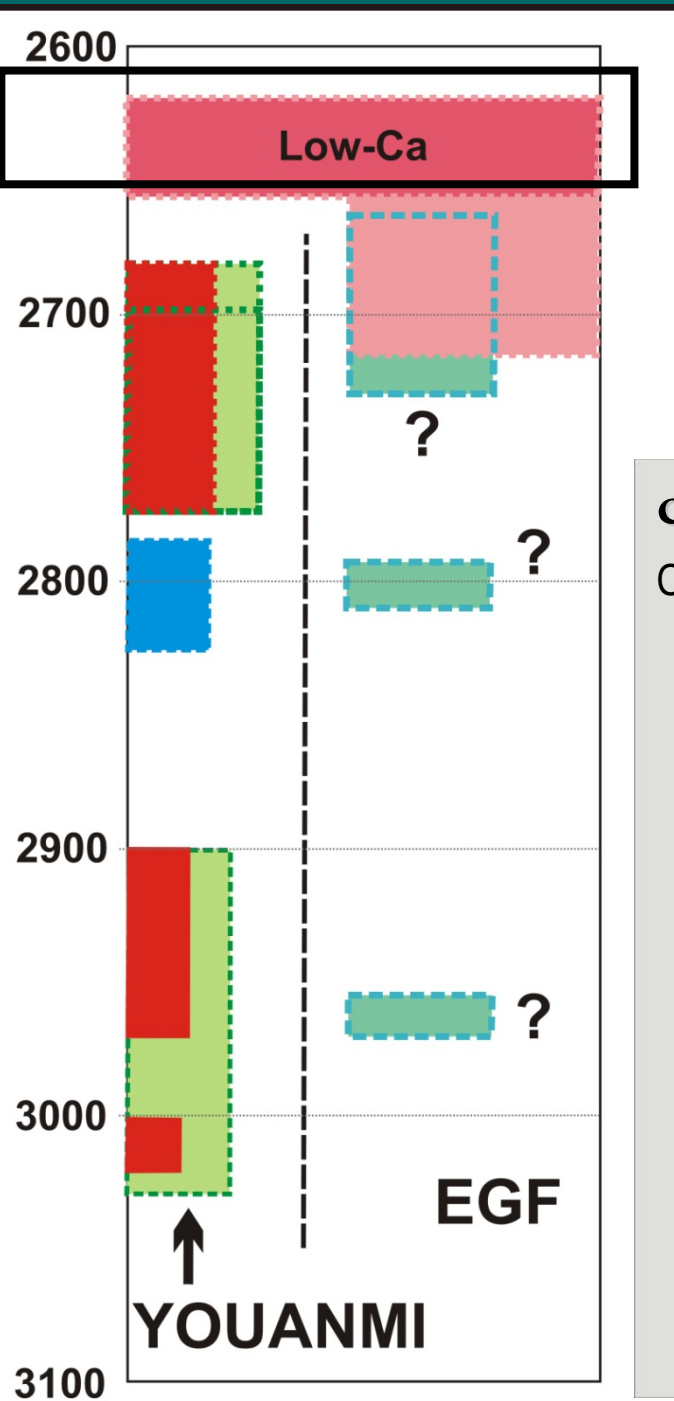
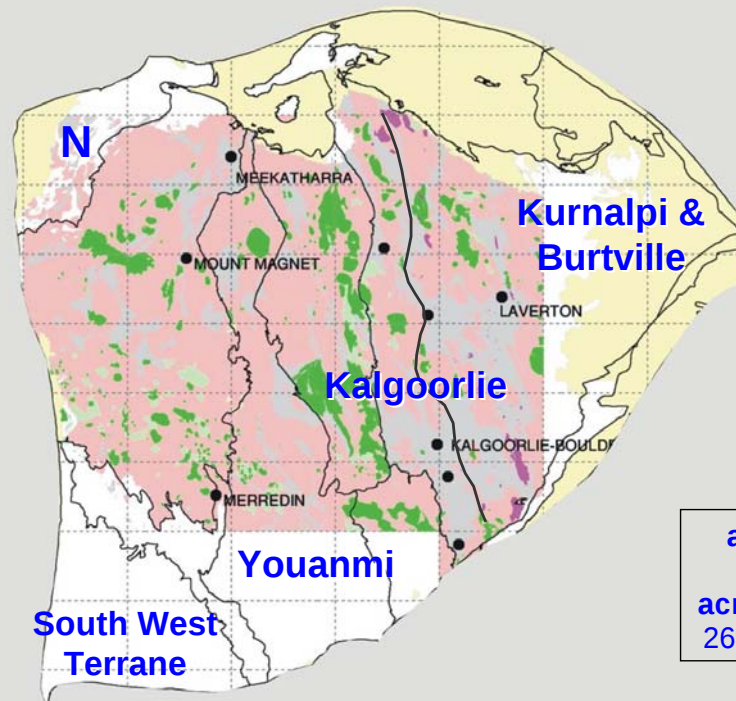
- qtz diorite to granodiorite
- SiO₂ 55 to 75%
- mostly high MgO, Mg#, Ni, Cr
- variably enriched LILE, LREE
- minor component; mostly late; more ‘enriched’ rocks younger

2.65-2.63 Ga

Potassic granite – craton wide
Syenite - only eastern half

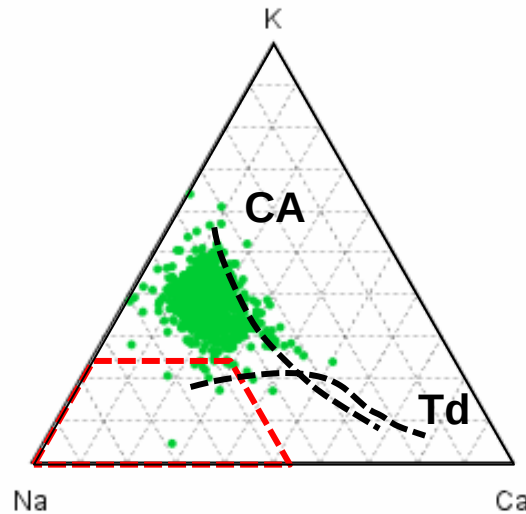
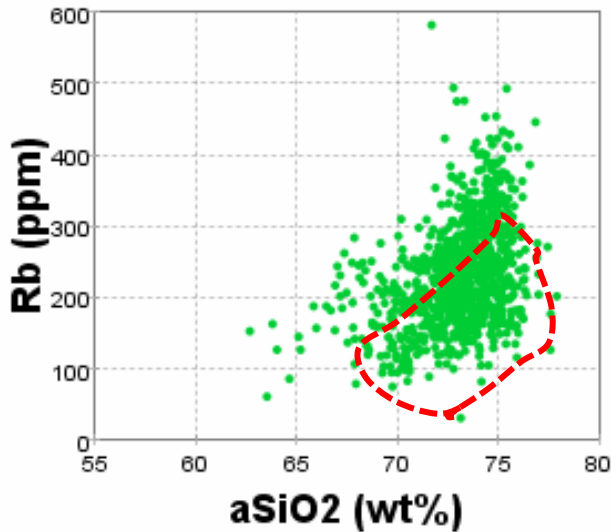
ca 2.65-2.63 Ga

Craton-wide Low-Ca granite 'bloom'; Syenitic in eastern Yilgarn

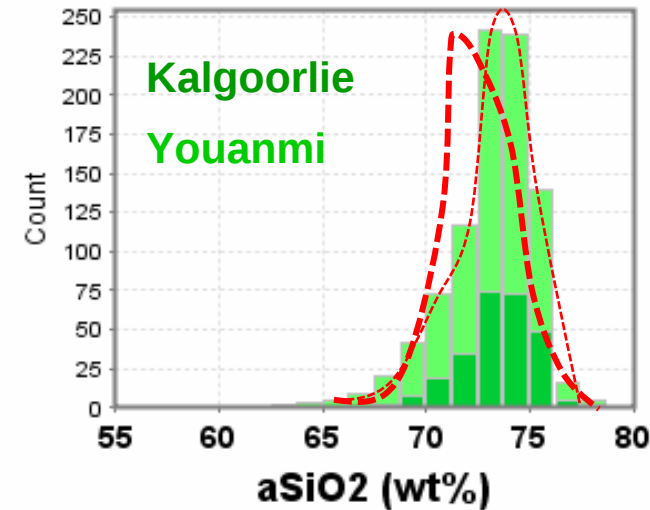


Yilgarn – potassic granites

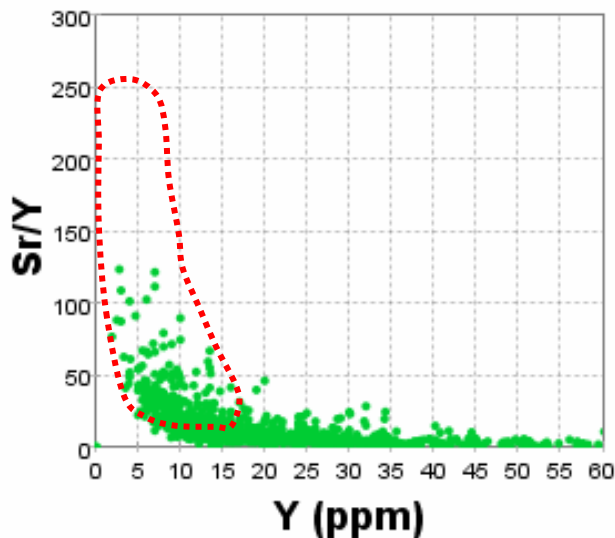
aSiO₂:Rb



aSiO₂

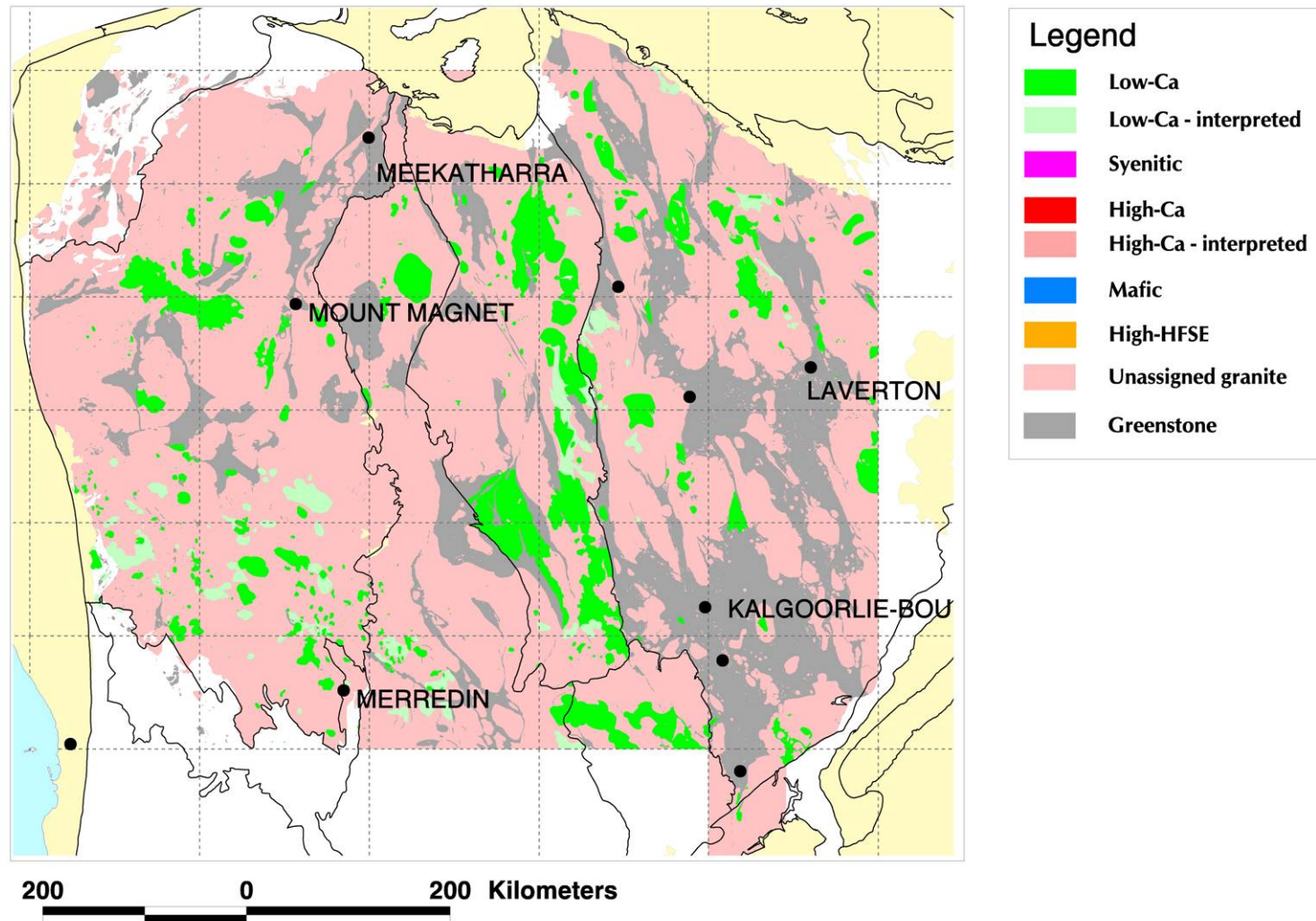


Y: Sr/Y



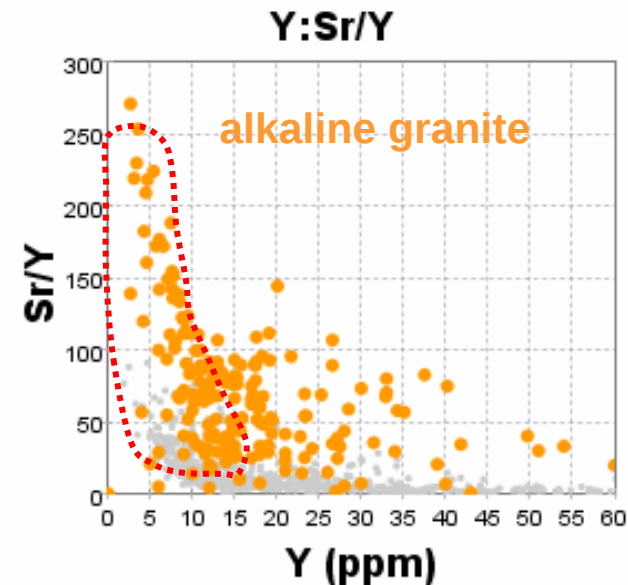
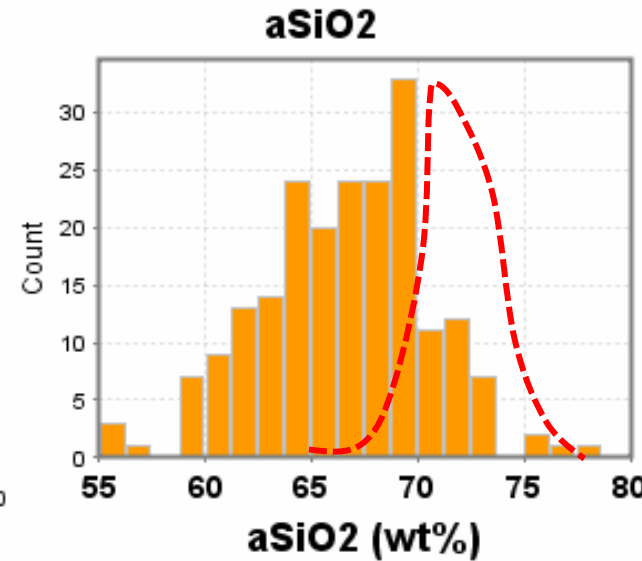
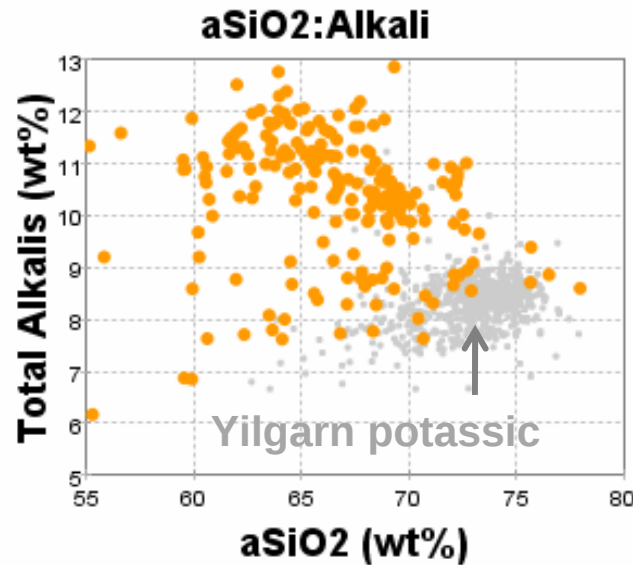
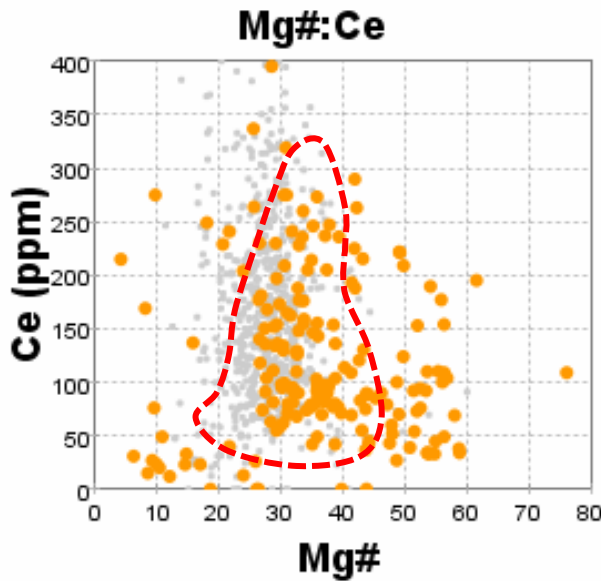
- mostly monzogranite-syenogranite
- SiO₂ > 68%
- potassic, moderate-low Na₂O/K₂O
- elevated HFSE, LILE
- mod-strongly fractionated
- Yilgarn-wide magmatic event

Potassic Granites



- Abundant (>20%), across Yilgarn
- Mostly absent from greenstones

Yilgarn - Syenite



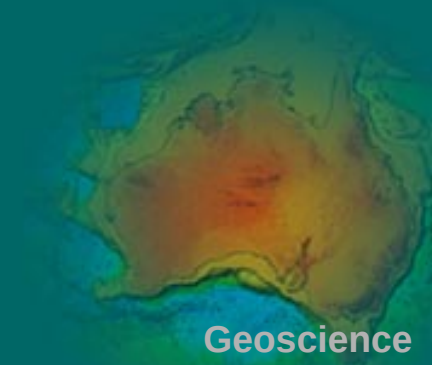
- syenite-monzonite to syenogranite
- SiO₂ 55 to 77%
- high alkalis, wide range of HFSE, LREE, low FeO, MgO
- only in Kalgoorlie Superterrane
- minor; mostly late

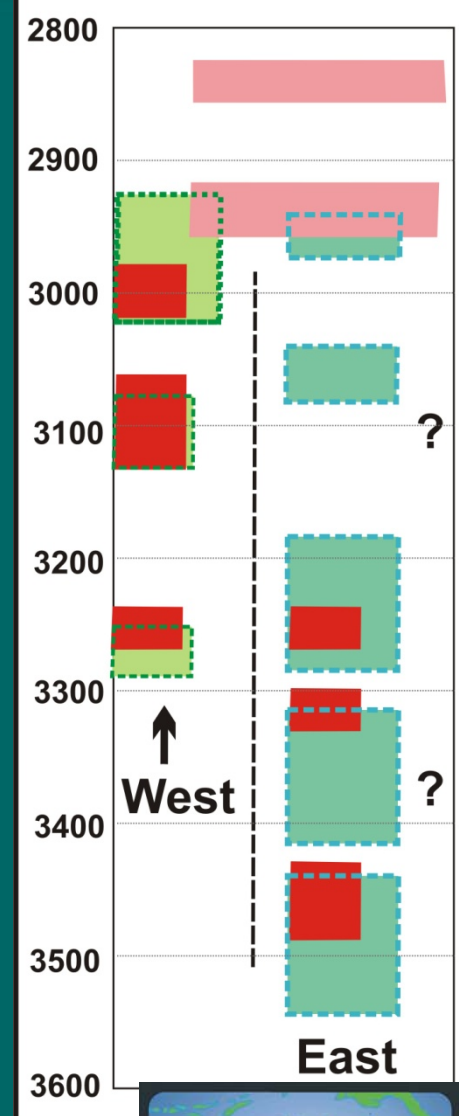
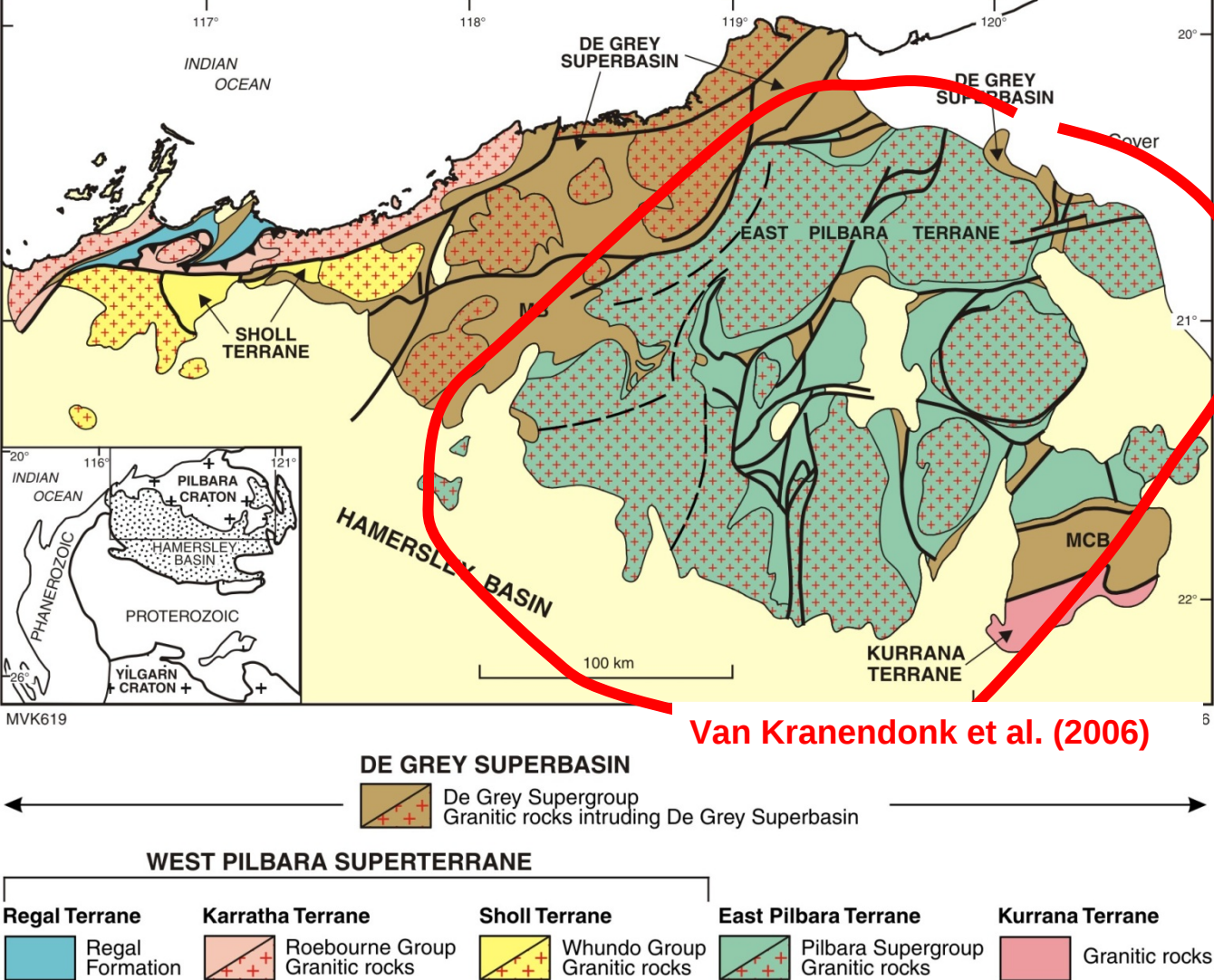
Secular trends – Archaean vs rest

Archaean Yilgarn granite history

- shows a pronounced secularity in both provinces
- dominated by early sodic (mostly high-Al) granites (TTGS)
- these give way to medium- to high-K granites in late Archaean
- other granite types minor

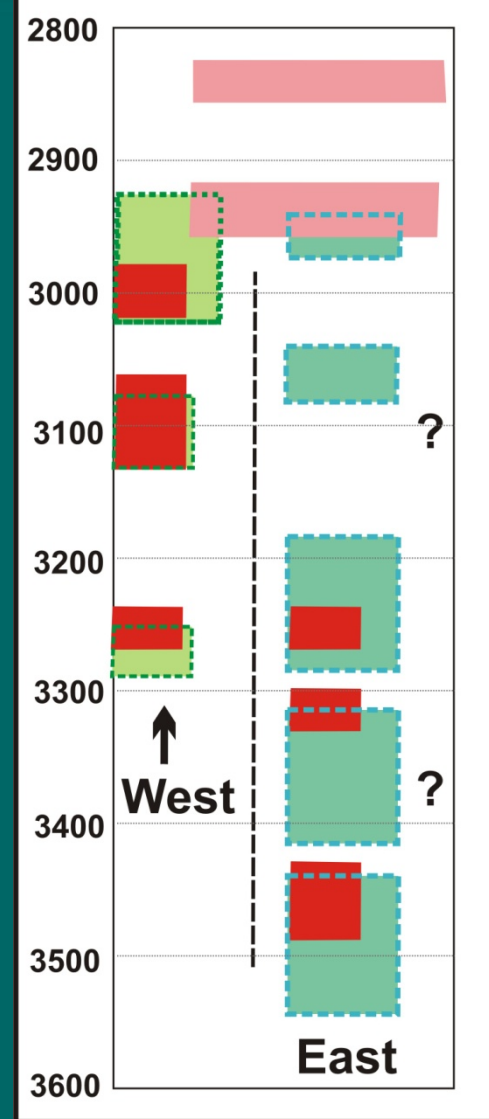
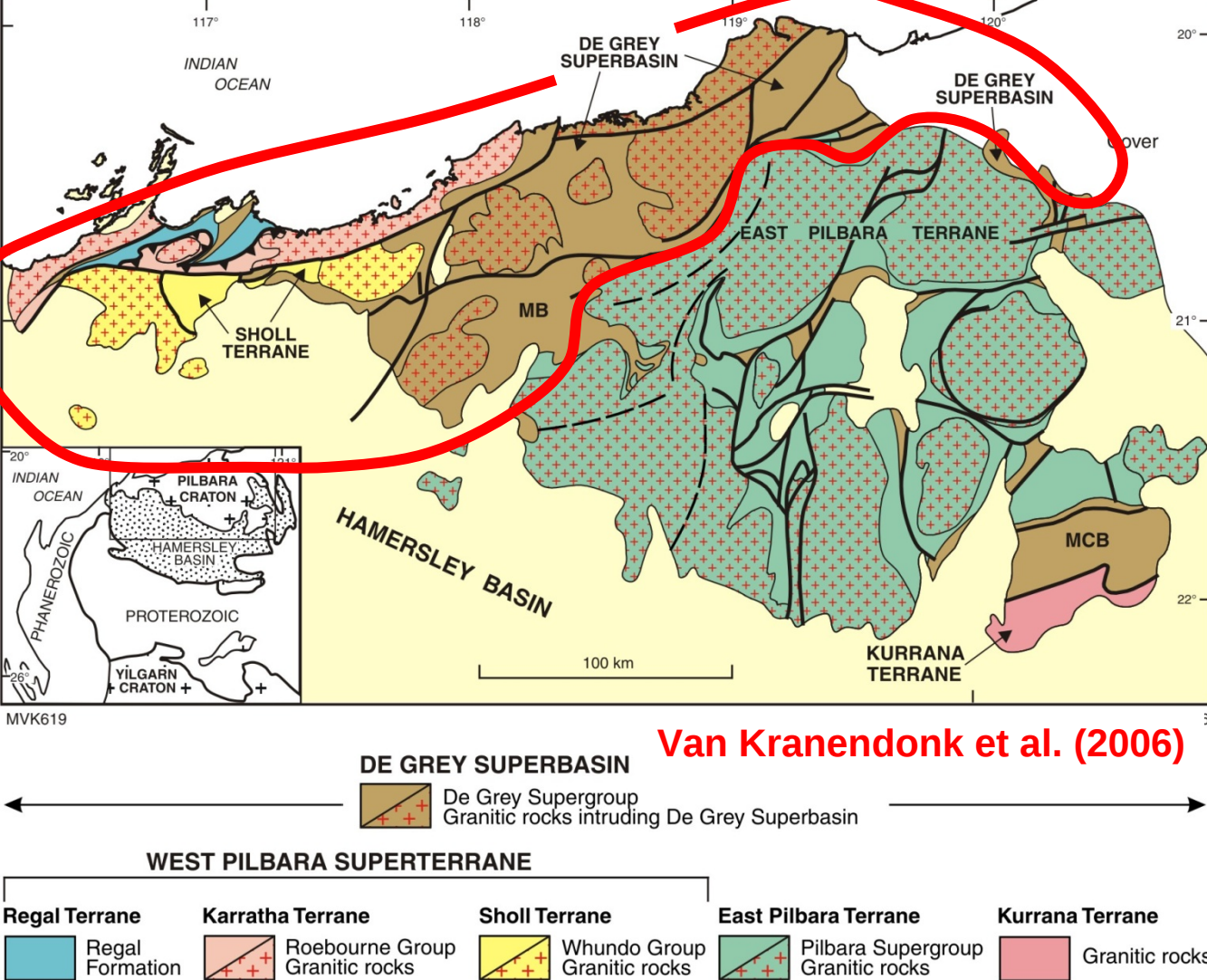
Pilbara Craton is the same





East Pilbara Terrane

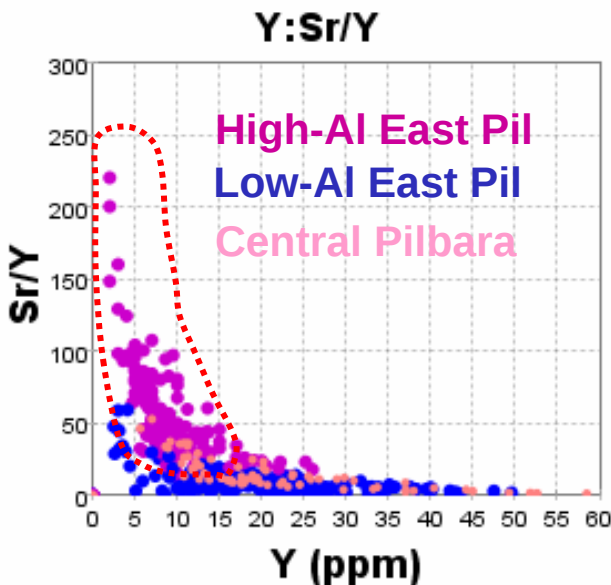
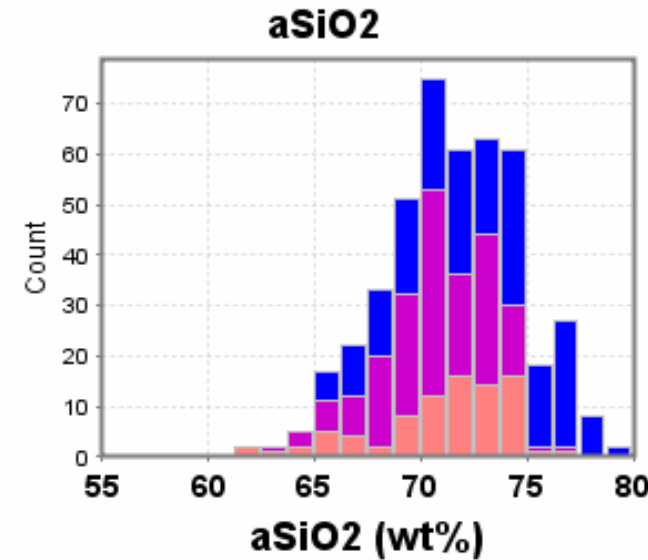
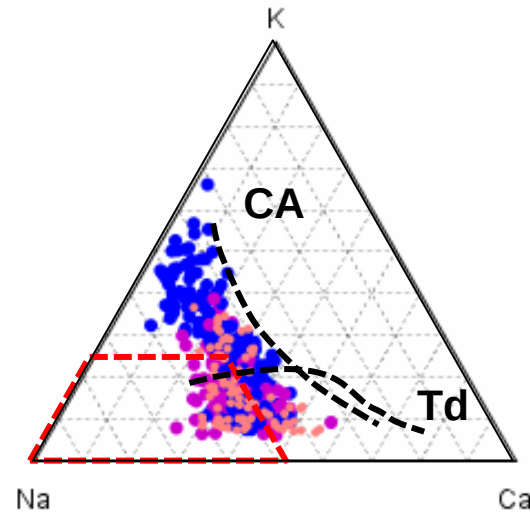
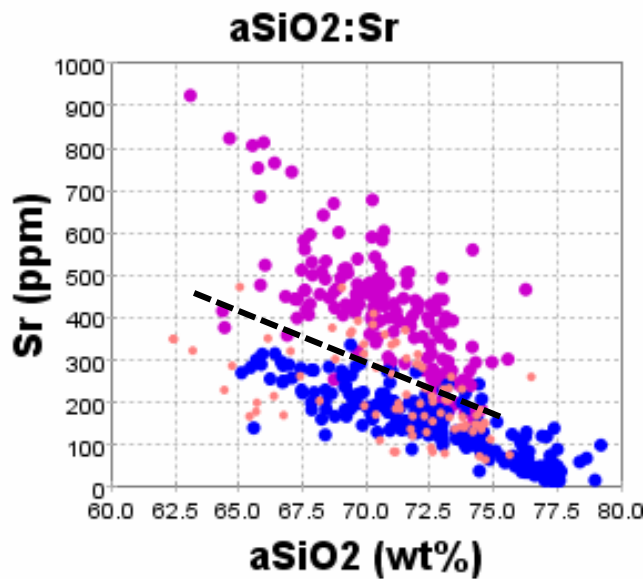
- long history (>800 Ma)
- granite: >3.5, 3.45, 3.3, 3.24, 2.95, 2.85, 2.76 Ga



West Pilbara Superterrane

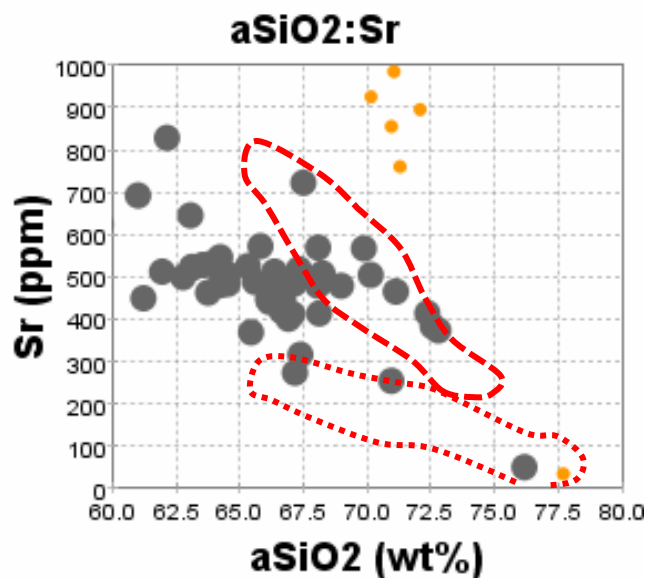
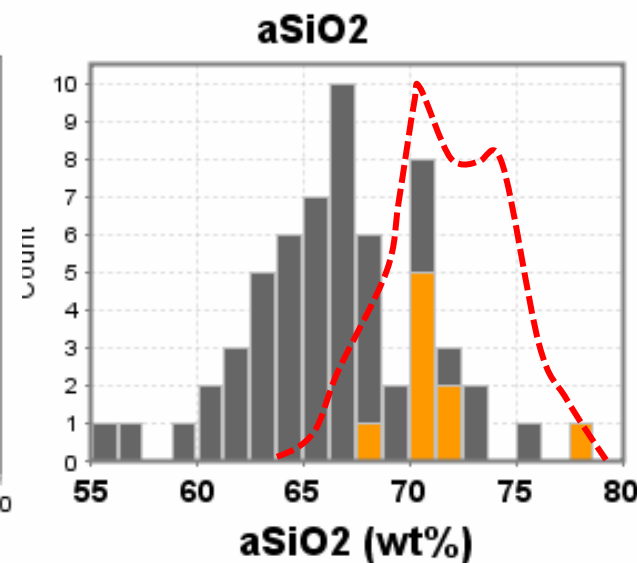
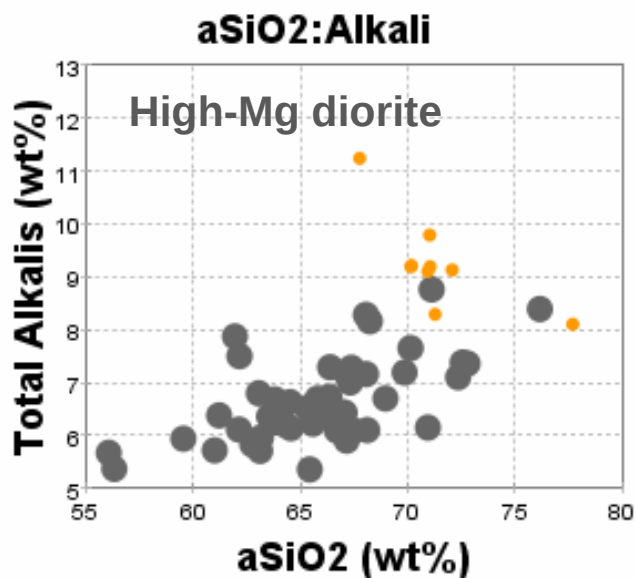
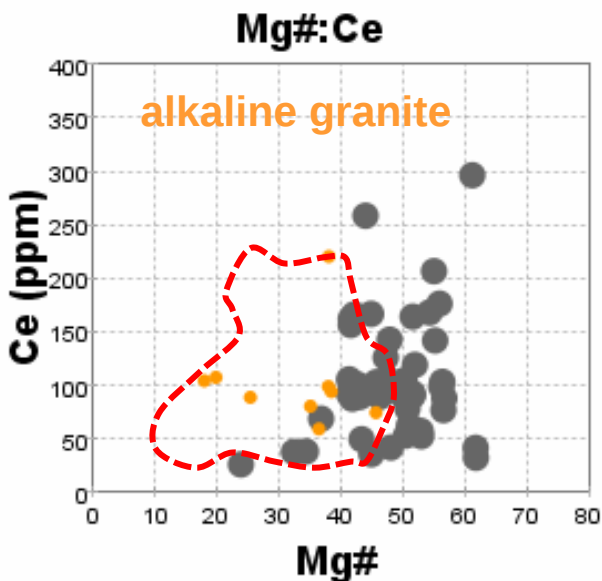
- Comprises: **Sholl**, Regal & Karratha Terranes
- De Grey Superbasin (2.97-2.92 Ga) overlies contact

Pilbara – early sodic granites



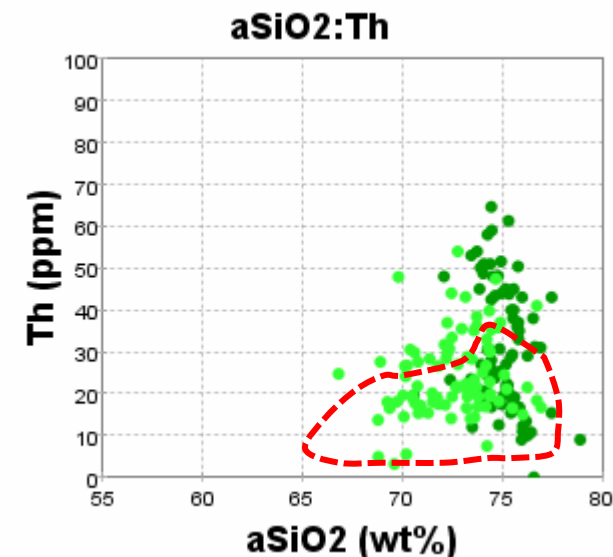
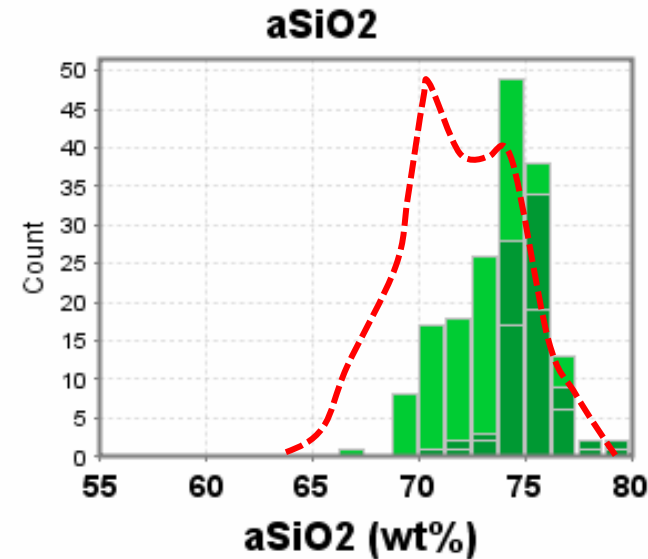
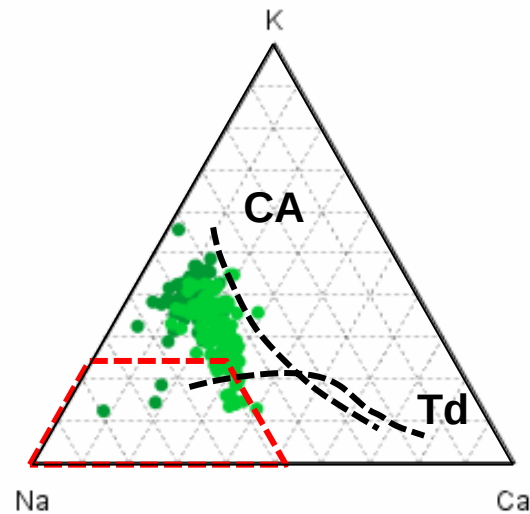
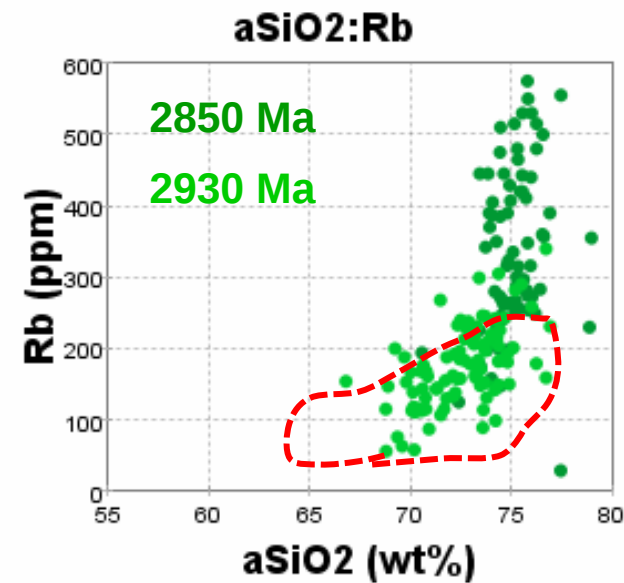
- earliest granite in each region
- mostly granodiorite, trondhjemite & granite
- SiO₂ > 65%
- sodic, high Na₂O/K₂O,
- high-Al & low-Al subgroups (high Sr, low Y; and low Sr, high Y)

West Pilbara – ‘Mafic’ & Syenite



- high-Mg diorite to granodiorite
- SiO₂ 55 to 75%
- high MgO, Mg#, Ni, Cr & elevated LILE, LREE
- alkaline granite: high alkalis
- not found in the East Pilbara

Pilbara – late potassic granites



- monzogranite & syenogranite
- SiO₂ > 68%
- potassic, moderate-low Na₂O/K₂O
- elevated HFSE
- 2850 Ma granites fractionated
- last major felsic magmatism

Archaean Granite types

sodic granite (I-type)	<u>dominant</u>	ca. 3.47 Ga
medium-high K granite (I)	<u>common</u>	3.3 Ga
high-silica high-K granite (I)	<u>common</u>	2.95 Ga
high-Mg diorite	minor	2.95 Ga
BADR & intrusives	minor	<3.1 Ga
Fe-rich granite (A-type)	minor	ca. 3.47 Ga
alkaline granite	minor	2.945 Ga
peraluminous (S-type)	very rare	ca. 2.7 Ga