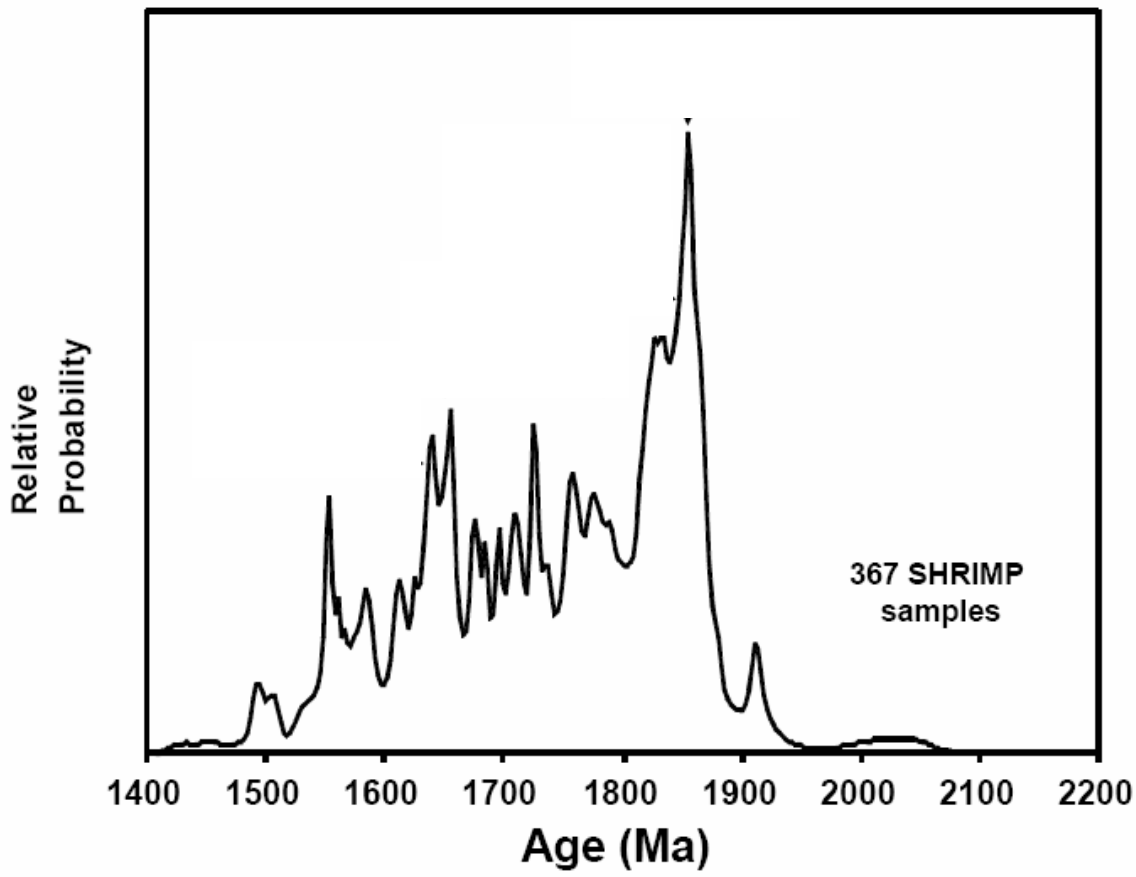
Proterozoic Granites - Australia

- granites widespread (~145,000 km^2)

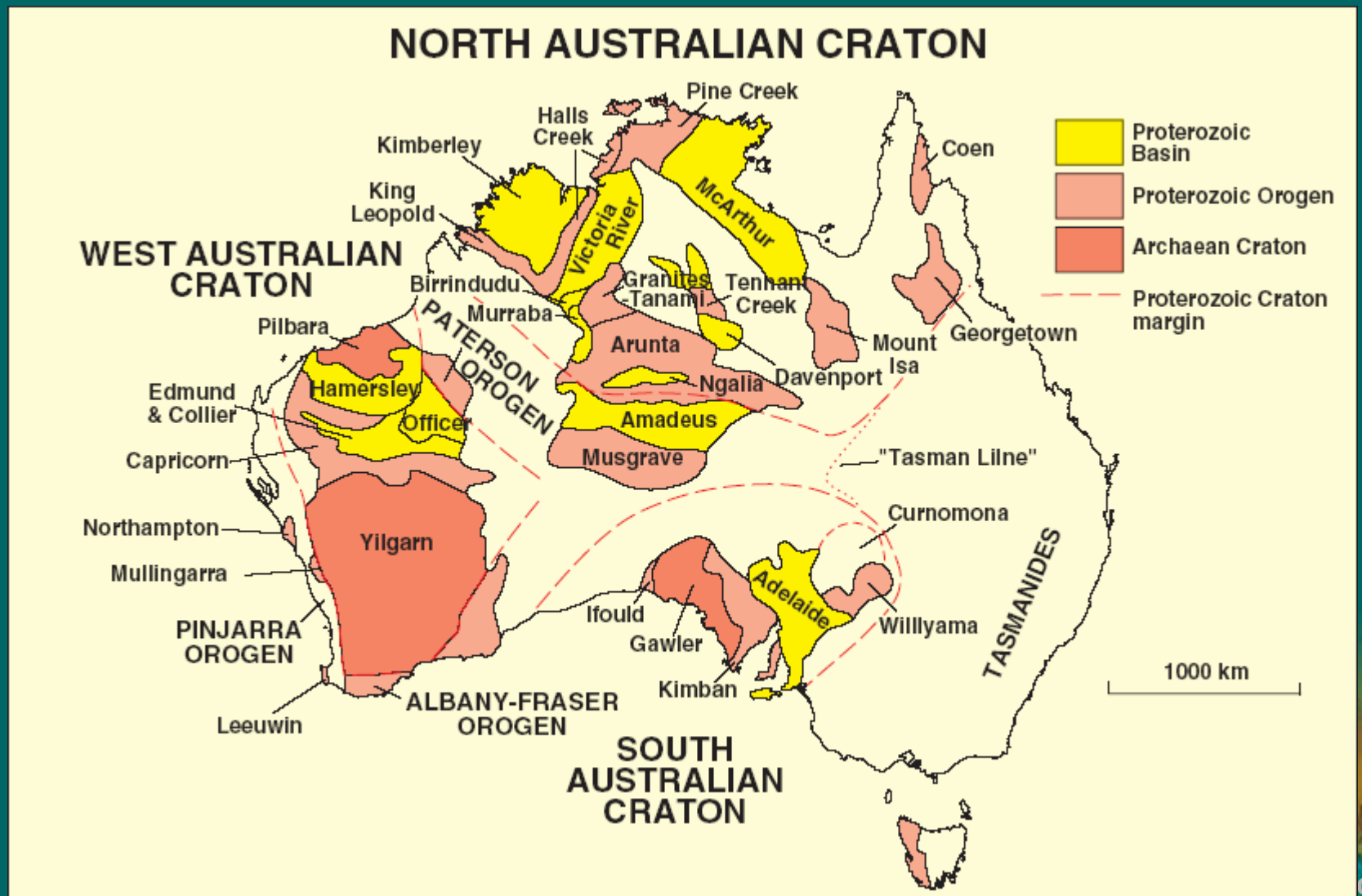
Proterozoic Granites - Australia

- range from (late Neoarchaean-) early Palaeoproterozoic to Neoproterozoic
- most ca. 1950-1500 Ma



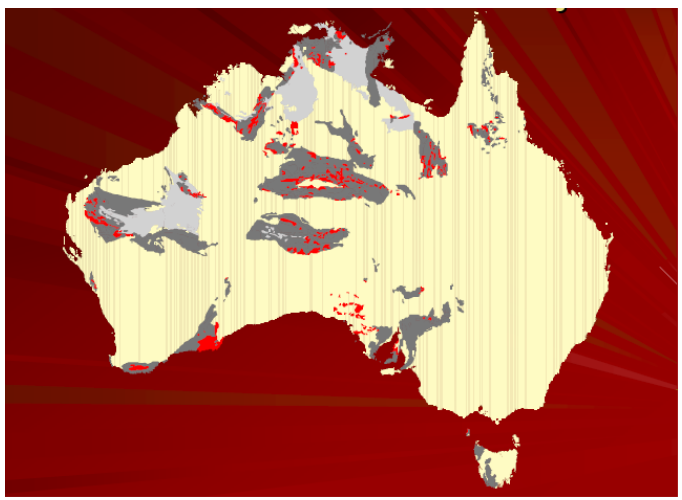
Proterozoic Granites - Australia

- occur in numerous provinces



Proterozoic granites - Australia

Wyborn & co-workers (2001) identified 9 broad Proterozoic granite groups (includes volcanics)



No.	Granite Association	Area (km^2)	% of Area	Granite type (%)	Temp (% of Area)	Pressure (% of Area)
1	Forsayth	3529	2.4	S-Type (2.9%)	Low (2.4%)	Moderate (81.8%)
2	Allia	659	0.5		High (0.5%)	
3	Kalkadoon	25673	17.7	I-Type (88.8%)	Low (31.0%)	
4	Nicholson	19312	13.3			
5	Sybella	8935	6.1		High (54.1%)	Low (6.2%)
6	Cullen	44126	30.4			Moderate (as above)
7	Hiltaba	25480	17.6			
8	Maramungee	1845	1.3		Low (3.7%)	High (3.7%)
9	Sally Downs	3566	2.4			
10	Unclassified	12004	8.3	? (8.3%)	? (8.3%)	? (8.3%)
	Total	145129		100.0	100.0	100.0

Proterozoic granites - Australia

- **Wyborn & co-workers identified 9 broad Proterozoic granite groups (includes volcanics)**
- **most I-type 89%**
- **similar to Archaean**

No.	Granite Association	Area (km^2)	% of Area	Granite type (%)	Temp (% of Area)	Pressure (% of Area)
1	Forsayth	3529	2.4	S-Type (2.9%)	Low (2.4%)	Moderate (81.8%)
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	Total	145129		100.0	100.0	100.0

Proterozoic granites - Australia

- **Wyborn & co-workers identified 9 broad Proterozoic granite groups (includes volcanics)**

- **most I-type 89%**
- **most potassic, 84% of I-types**
- **Unlike the Archaean**

No.	Granite Association	Area (km^2)	% of Area	Granite type (%)	Temp (% of Area)	Pressure (% of Area)
1	Forsayth	3529	2.4	S-Type (2.9%)	Low (2.4%)	Moderate (81.8%)
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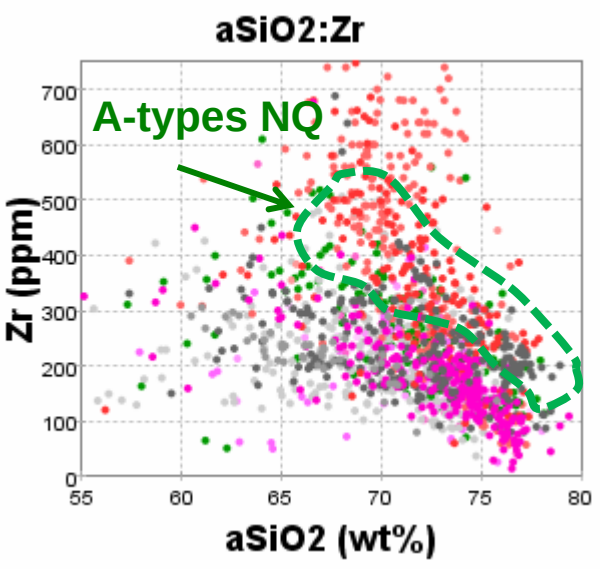
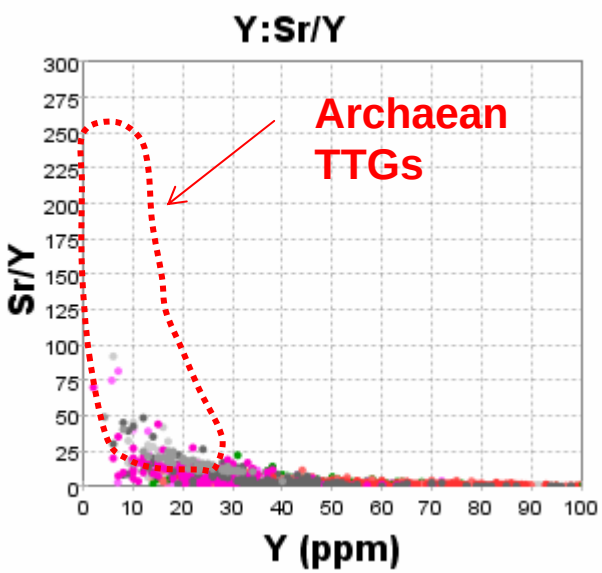
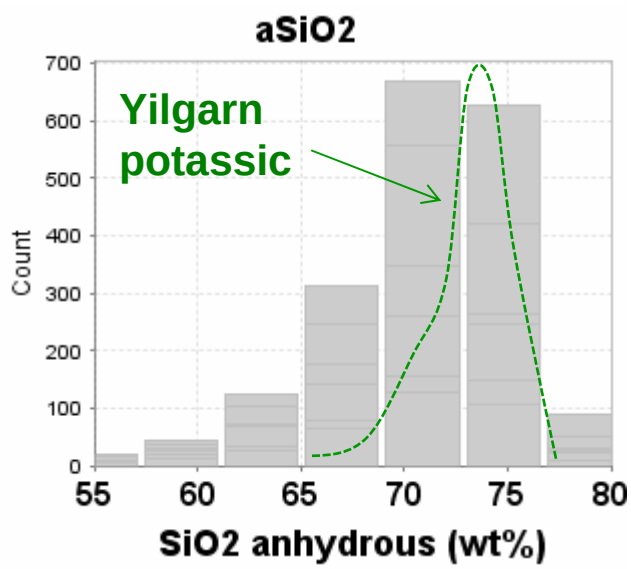
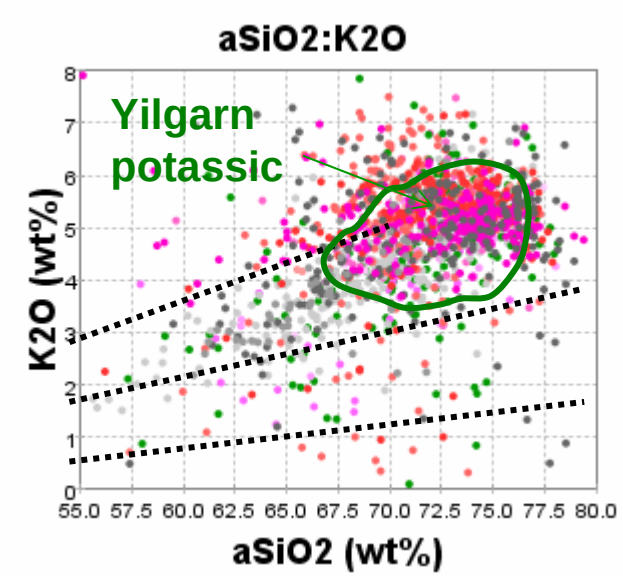
	Total	145129		100.0	100.0	100.0

Proterozoic – potassic granites









- granodiorite to syenogranite
- SiO2 55-80; mostly >65%
- high-v. high K, mod-low Na2O/K2O
- includes elevated HFSE ('A-types')
- Y-undepleted, Sr-depleted
- range of ages

Proterozoic granites - Australia

- **Wyborn & co-workers identified 9 broad Proterozoic granite groups (includes volcanics)**

- most I-type 89%
- most potassic
- **minor sodic granites (<5%)**
- **Unlike Archaean**

No.	Granite Association	Area (km^2)	% of Area	Granite type (%)	Temp (% of Area)	Pressure (% of Area)
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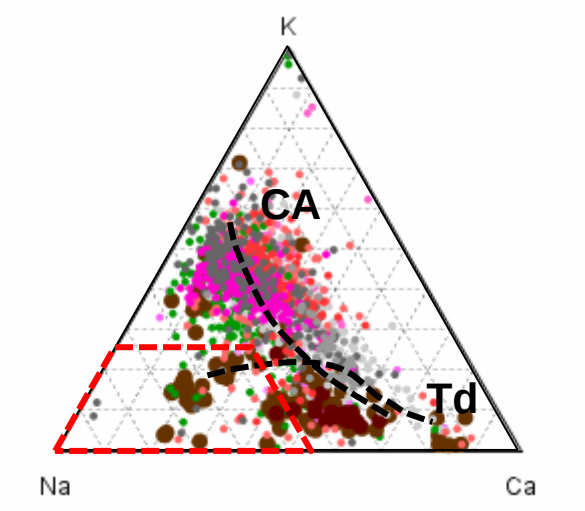
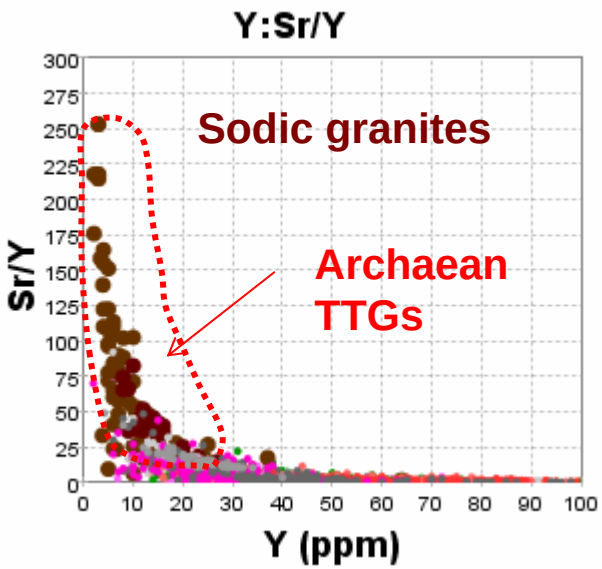
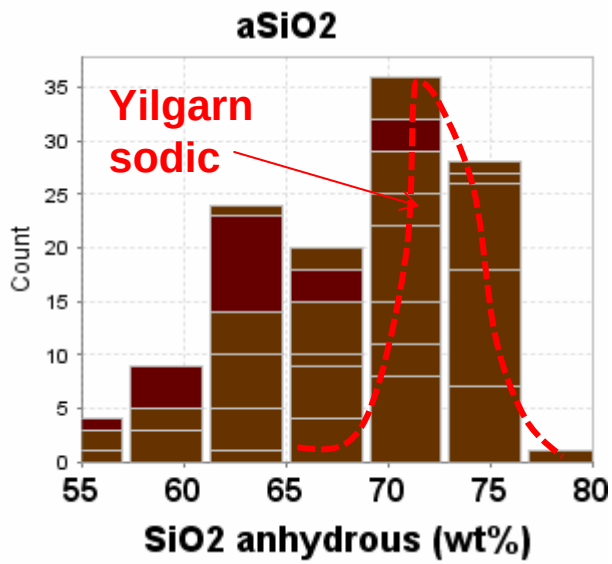
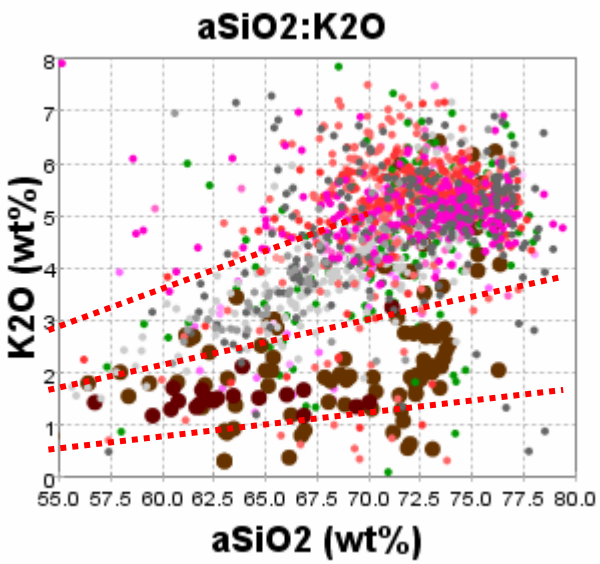
	Total	145129		100.0	100.0	100.0

Proterozoic – sodic granites









- tonalite, granodiorite to granite
- wide SiO2 range (55-75%)
- low-medium K, high Na2O/K2O
- Y-depleted, Sr-undepleted
- range of ages (1880-1550 Ma)
- minor component

Proterozoic granites - Australia

- **Wyborn & co-workers identified 9 broad Proterozoic granite groups (includes volcanics)**

- most I-type 89%
- most potassic
- minor sodic granites (<5%)
- **minor S-type 3%**

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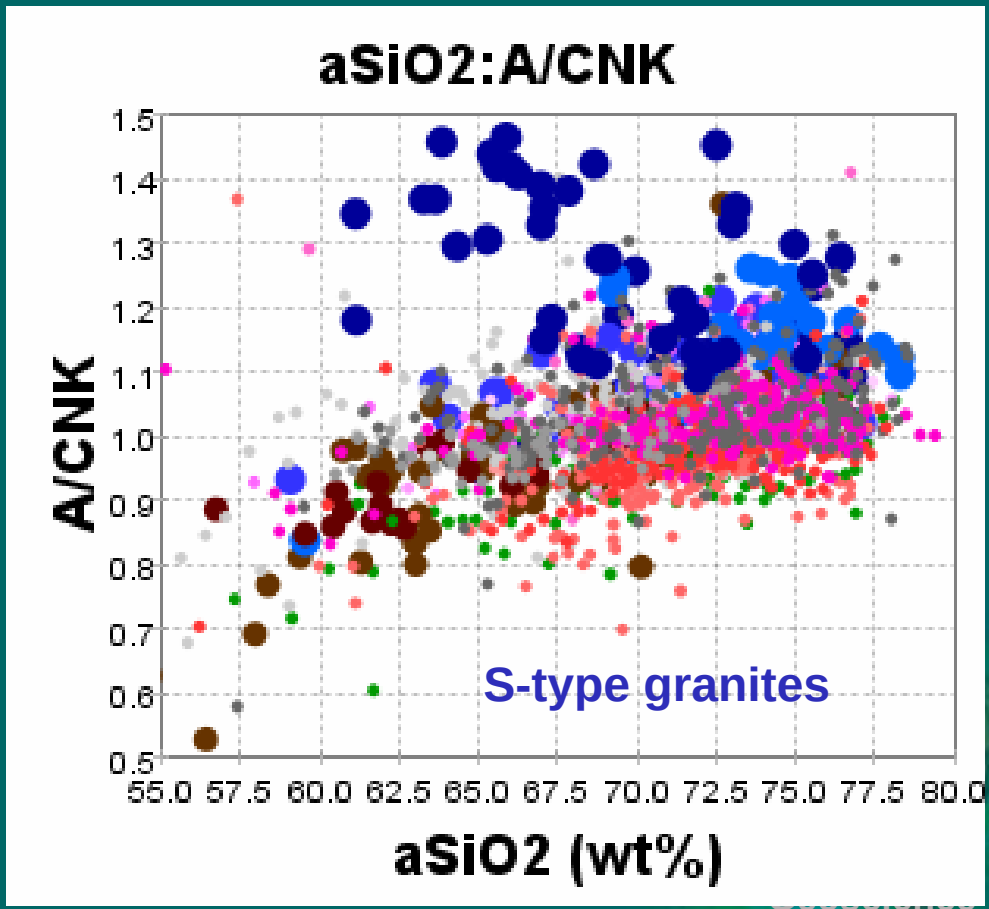
Proterozoic granites - Australia

- **Wyborn & co-workers identified 9 broad Proterozoic granite groups (includes volcanics)**

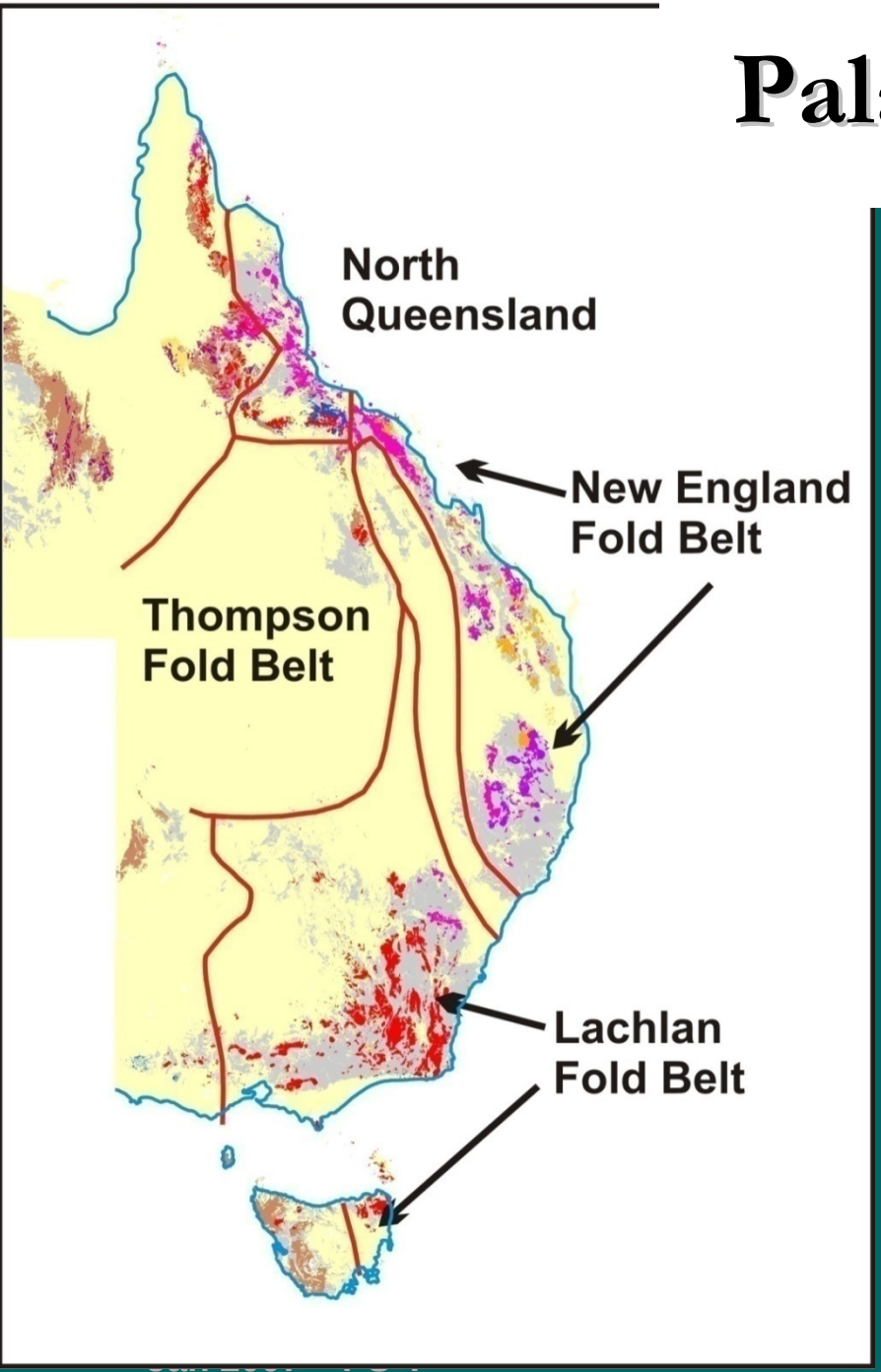
- most I-type 89%
- most potassic
- minor sodic granites (<5%)
- **minor S-type 3% (locally common)**



Proterozoic Granite types

sodic granite (I-type)	minor	<5%
(medium-) high K granite (I)	common	>30%
high-silica high-K granite (I)	common	>30%
high-Mg diorite	minor	?
BADR & intrusives	minor	?
Fe-rich granite (A-type)	some	~10%?
alkaline granite	minor	?
peraluminous (S-type)	minor	<5%

Palaeozoic – E Australia

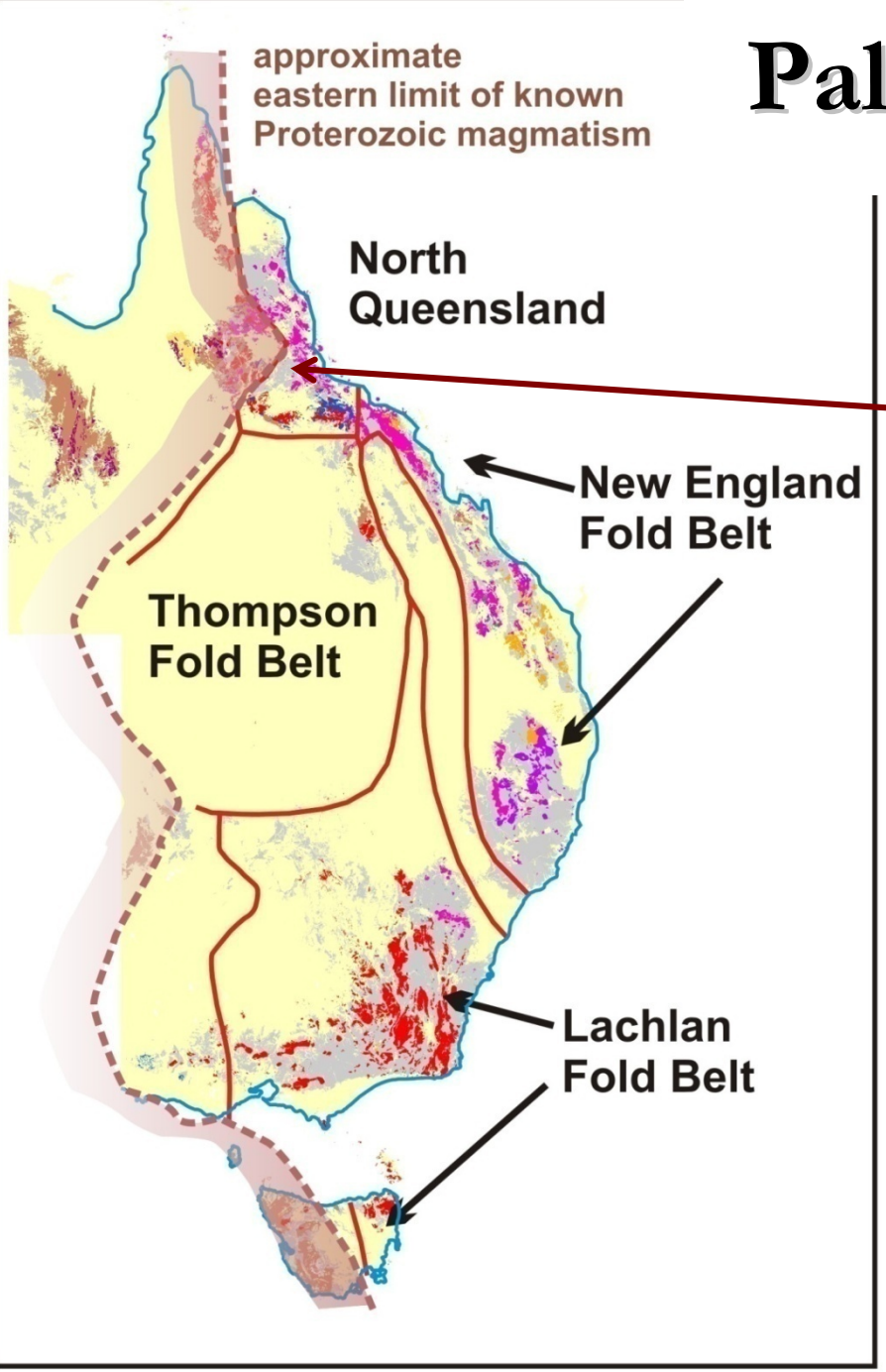


4 main regions

- **Lachlan**
- **Thompson**
- **North Qld, &**
- **New England Fold**

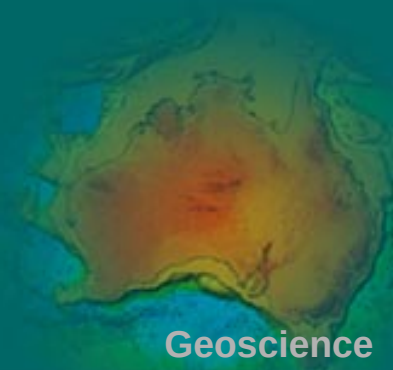
Convergent margin for much of the Palaeozoic

Palaeozoic – E Australia

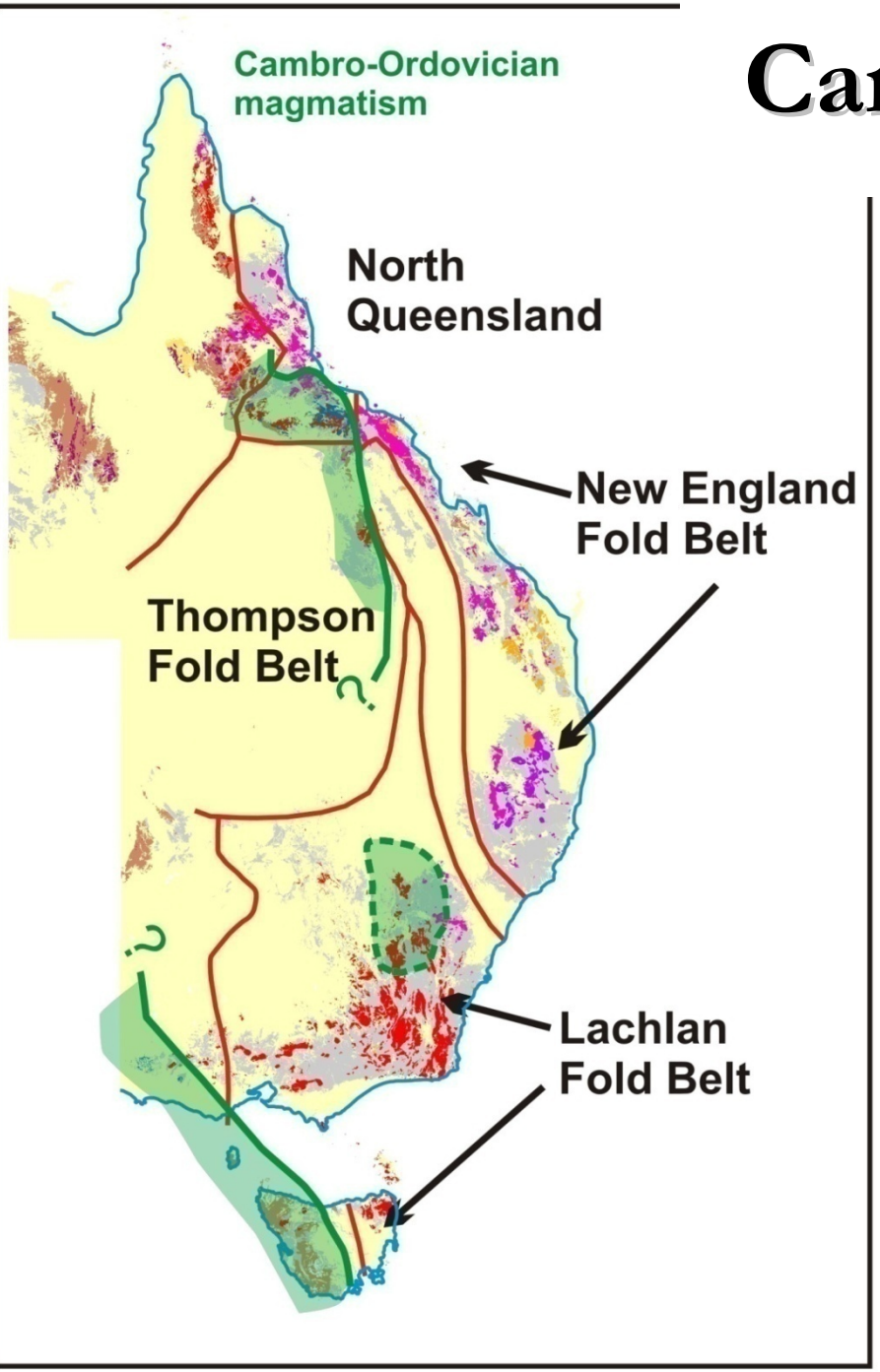


Boundary of Proterozoic magmatism (mostly approximate)

Note some late Neoproterozoic rocks east of this line



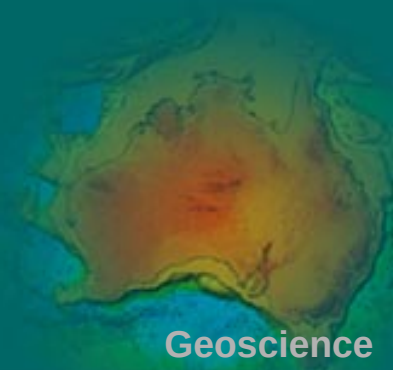
Cambrian to Ordovician



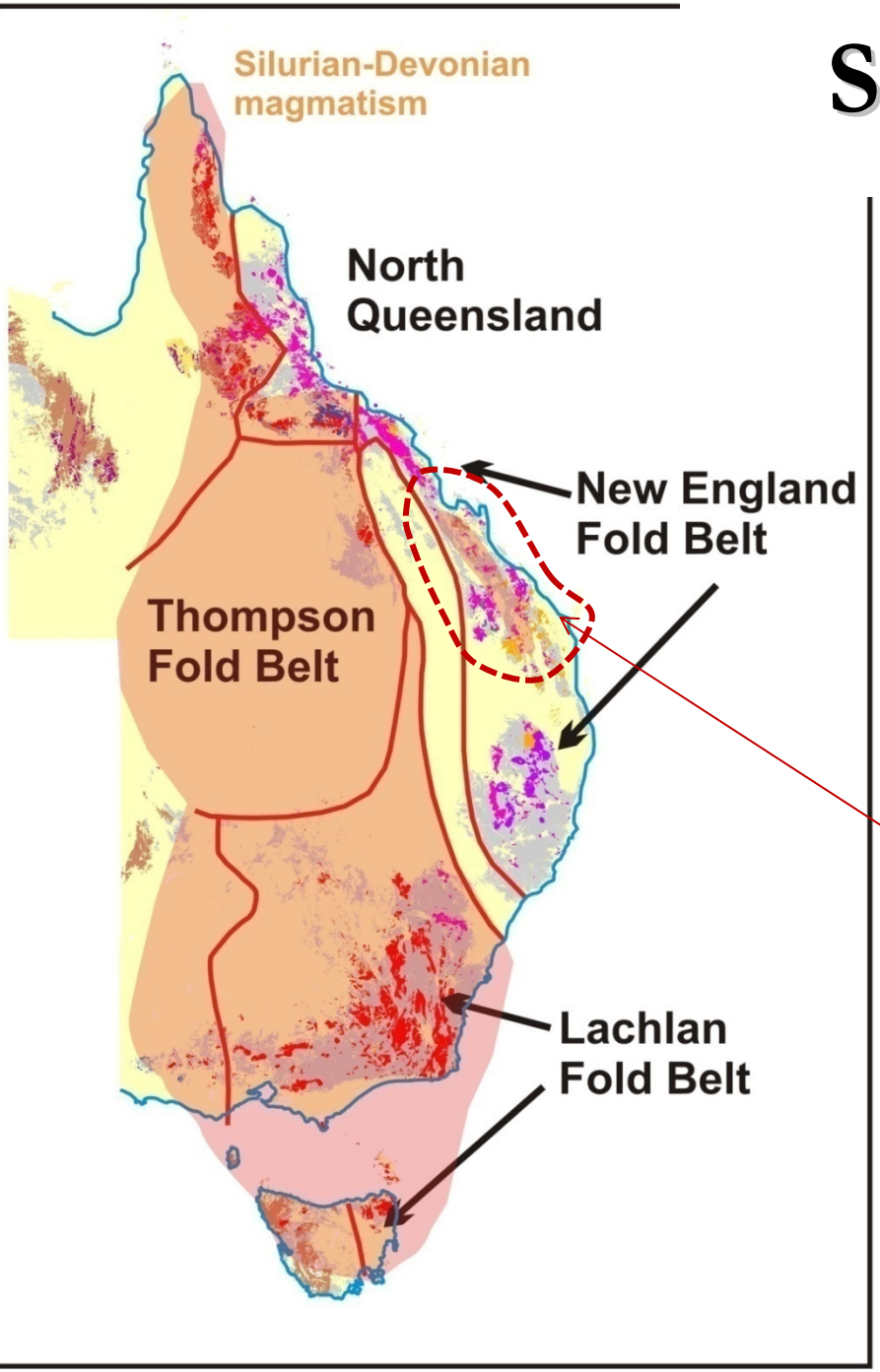
Occurs along E. Australia

Once continuous??

Ordovician island arc (remnants) in central Lachlan FB



Silurian to Devonian

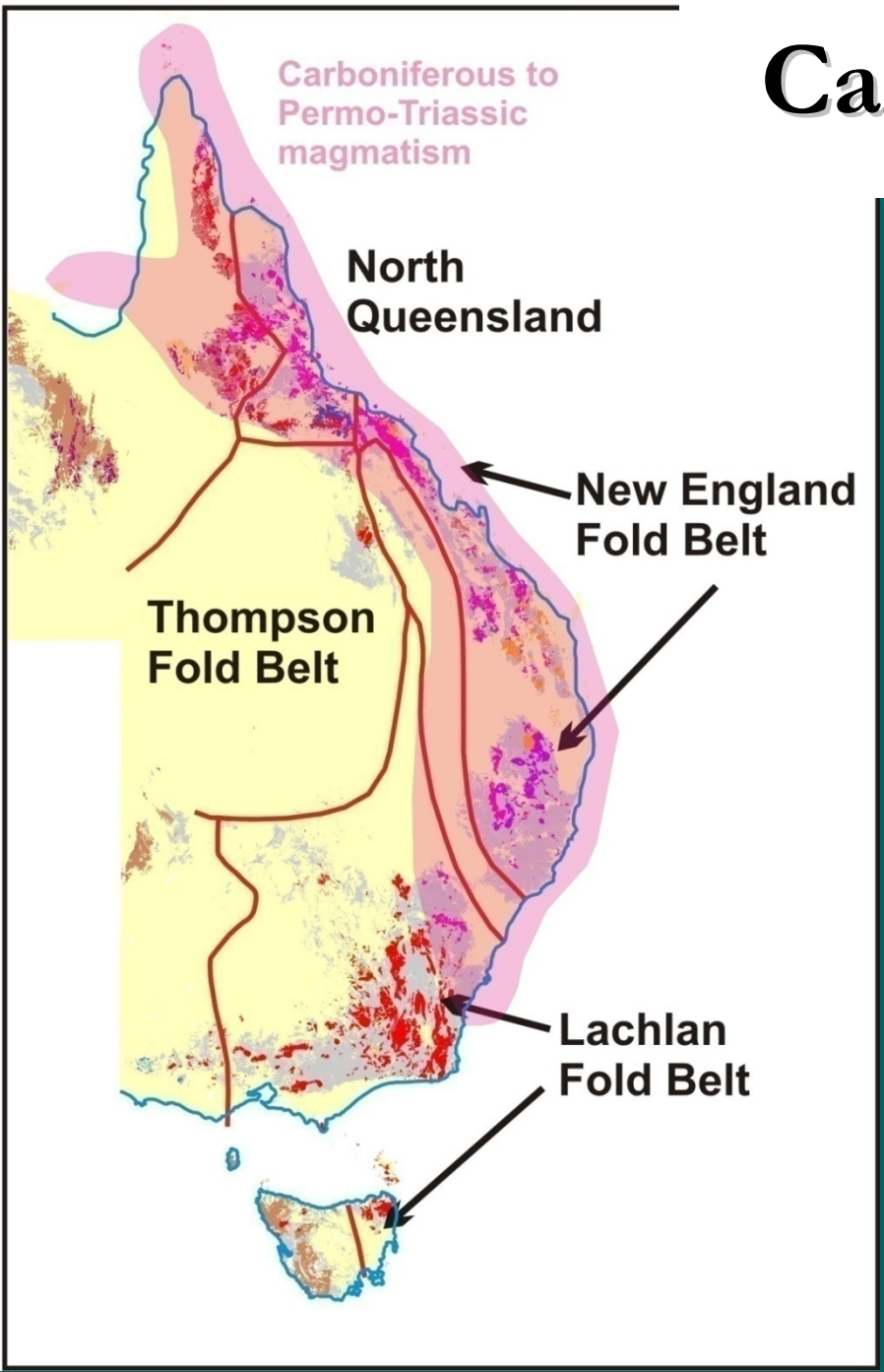


Magmatism widespread along E. Australia from Lachlan FB to North Qld

- **remnant Devonian Island Arc in New England FB**

- **North Qld differs from Lachlan**

Carboniferous-Permian



Voluminous magmatism

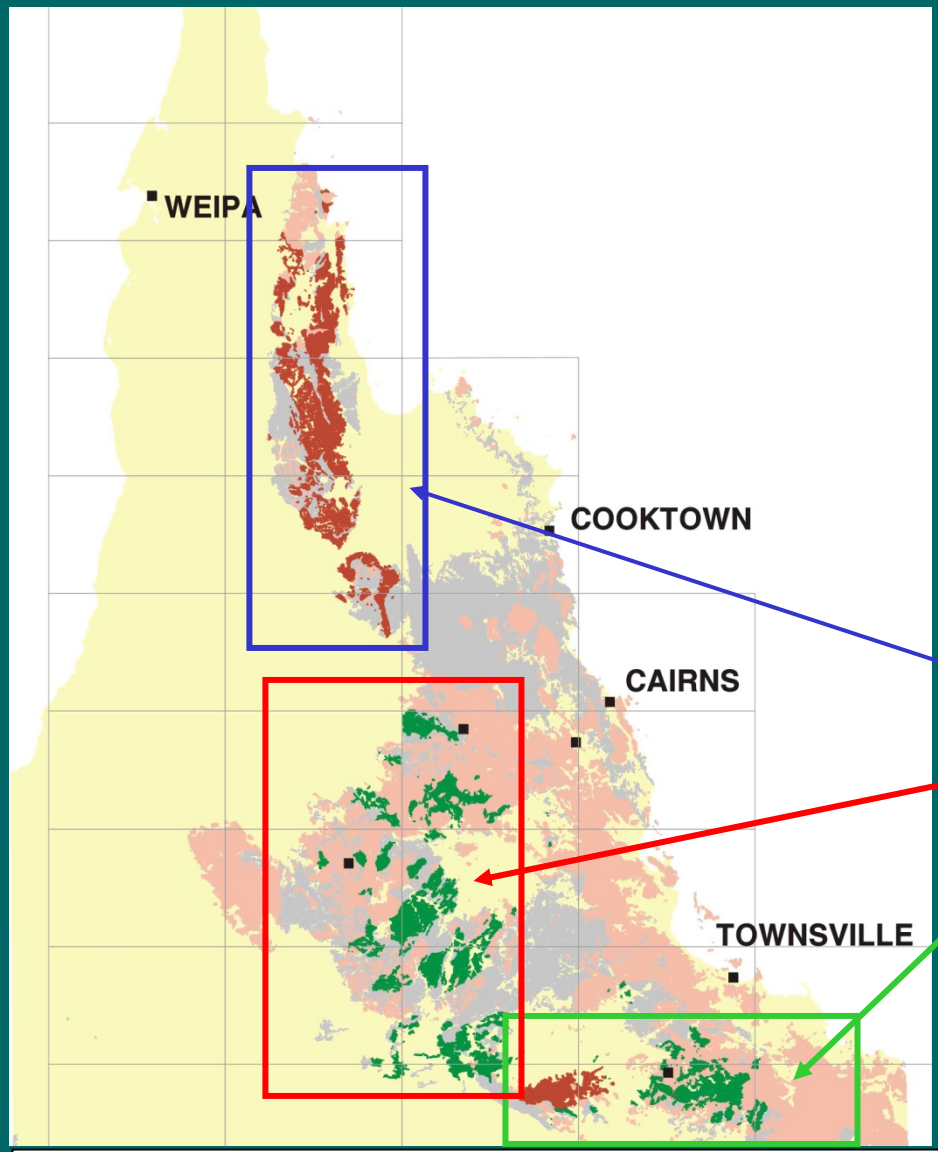
Concentrated in:

- **north Queensland &**
- **New England FB**

New England FB – classic continental arc

North Qld – behind-arc continental response

Silurian-Devonian in North Queensland



•Modified from Bain & Haipola (1997) digital data

2 age subgroups

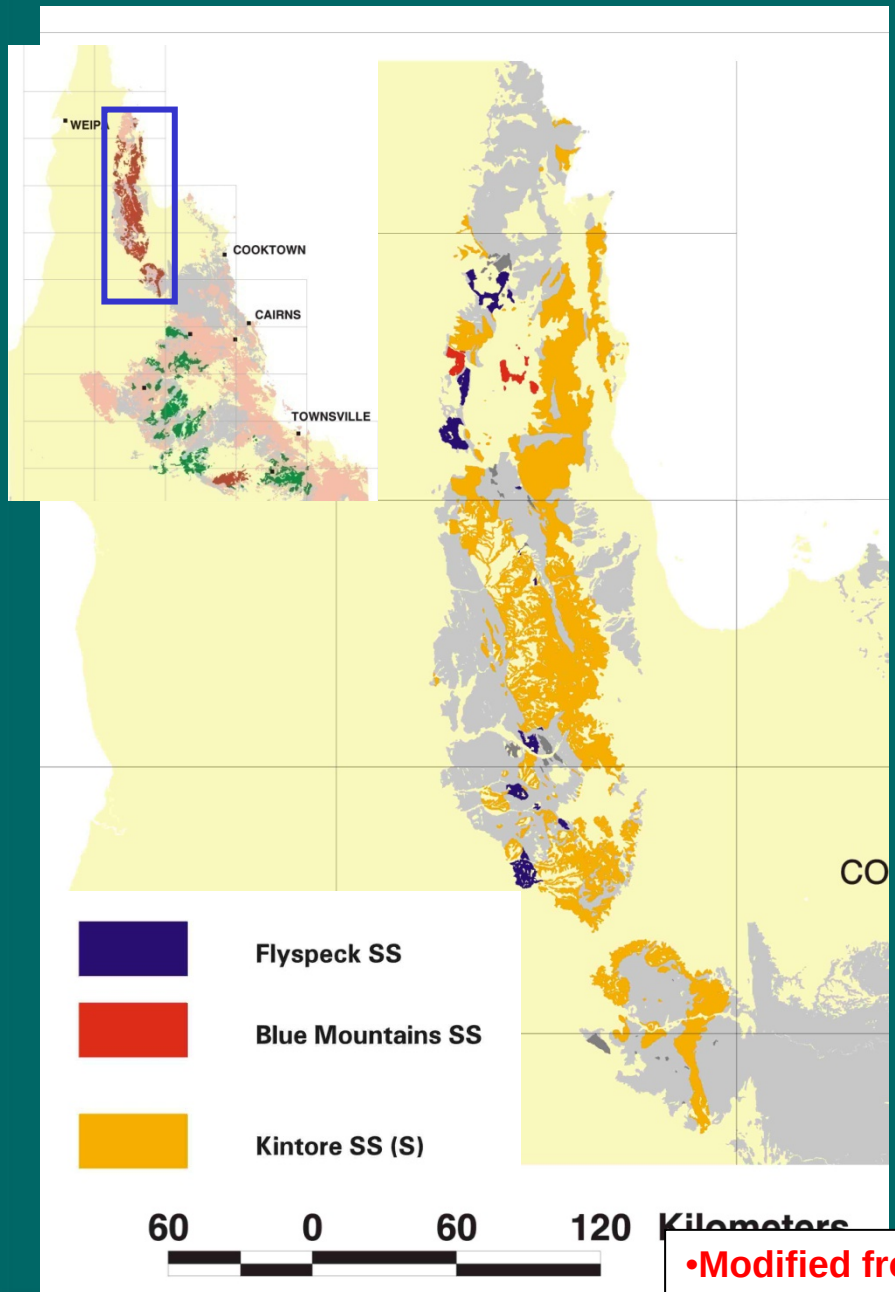
- Silurian to Early Devonian (green)
- Devonian (red)

Pronounced regionality

- Cape York (like LFB)
- Georgetown (distinct)
- Charters Towers

Same age as Lachlan Fold Belt

Silurian-Devonian: Coen region



Combination of:

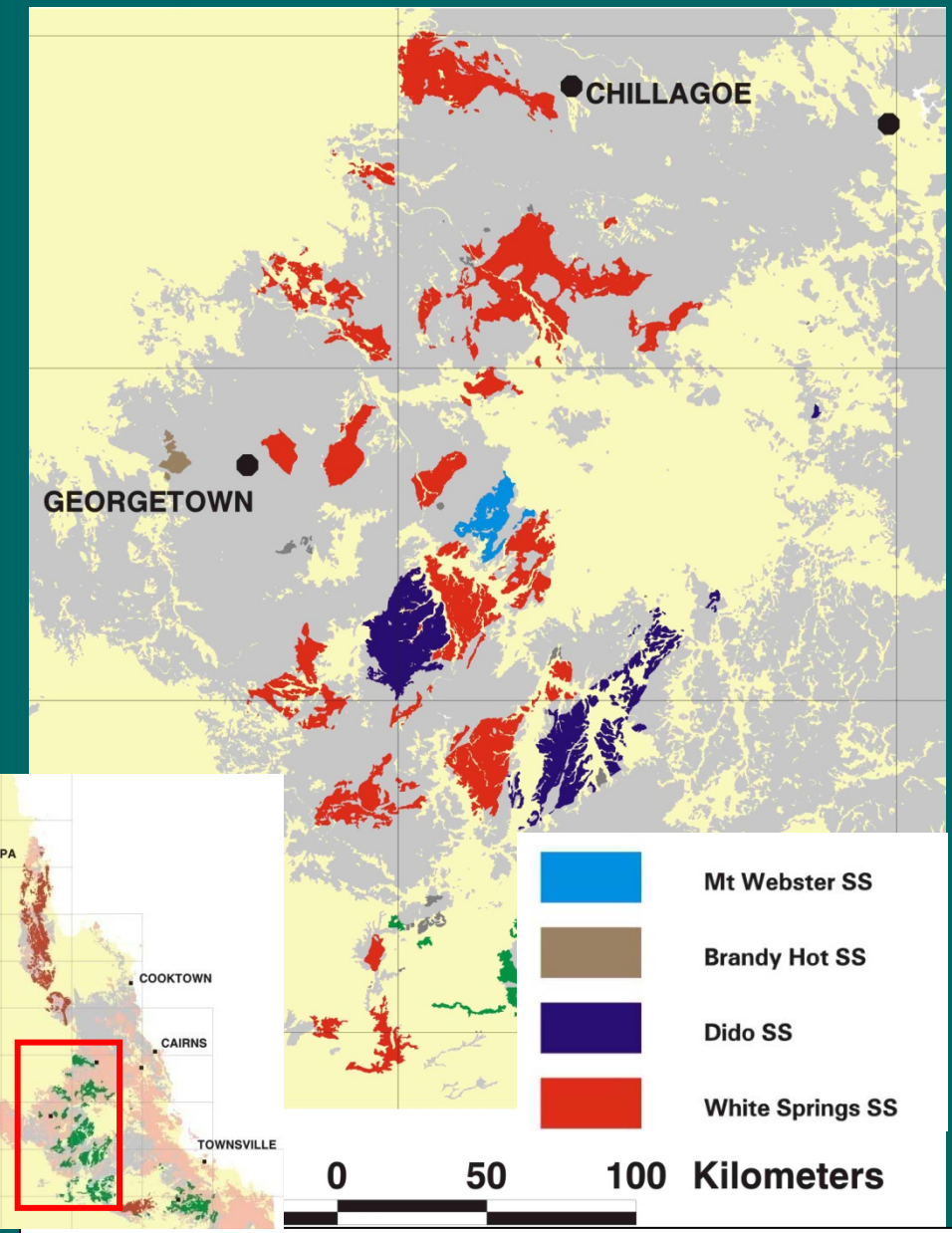
- **LFB-like S-types (Kintore SS) - ~85%**
- **minor I-types (<15%)**
- **most Sr-depleted, Y-undepleted**
- **ca 410-390 Ma**

Similarities to Lachlan FB;

Contrasts with Georgetown region

•Modified from Bain & Haipola (1997) digital data

Silurian-Devonian - Georgetown region



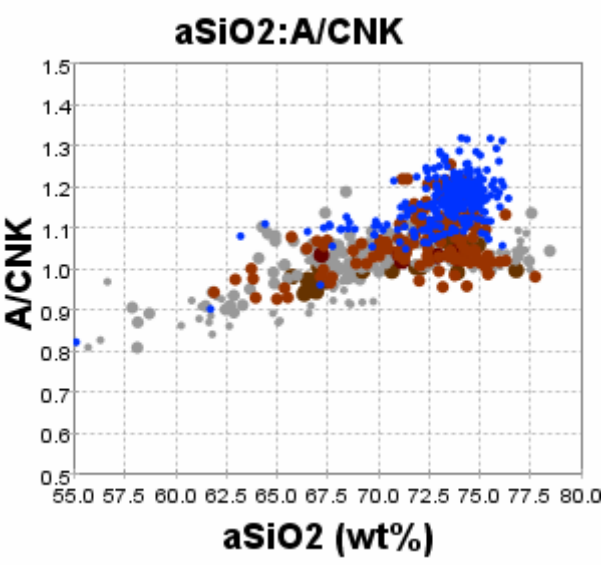
•Modified from Bain & Haipola (1997) digital data

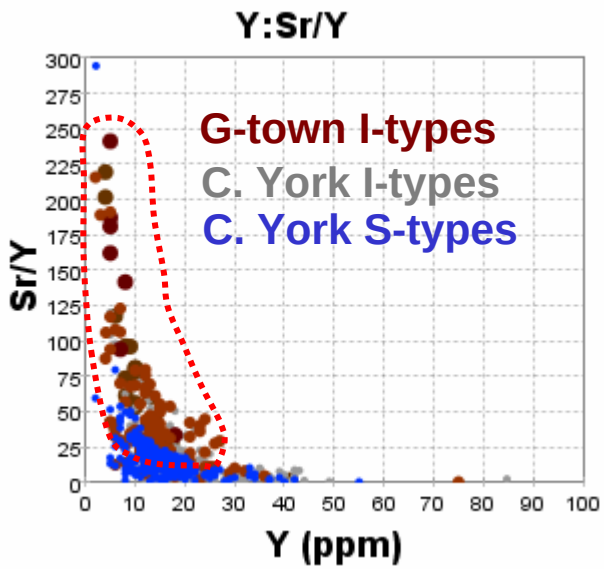
Combination of

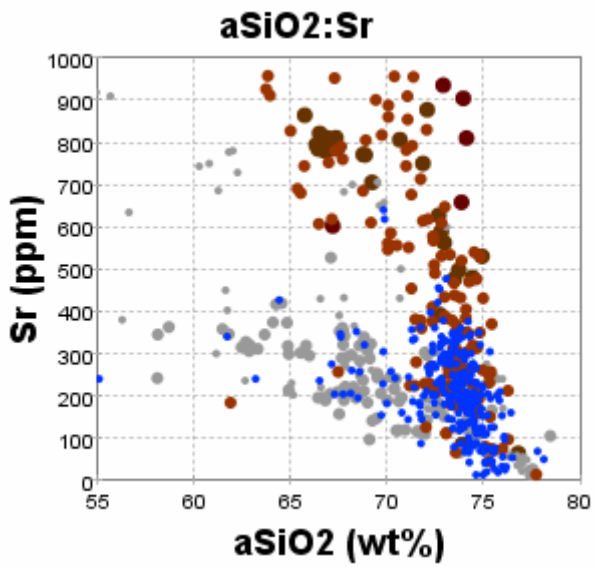
- sodic I-types: tonalite, trondhjemite
- medium-K granodiorite to granite (red)
- most Sr-undepleted, Y-depleted
- ca 430 Ma
- no S- or A-types

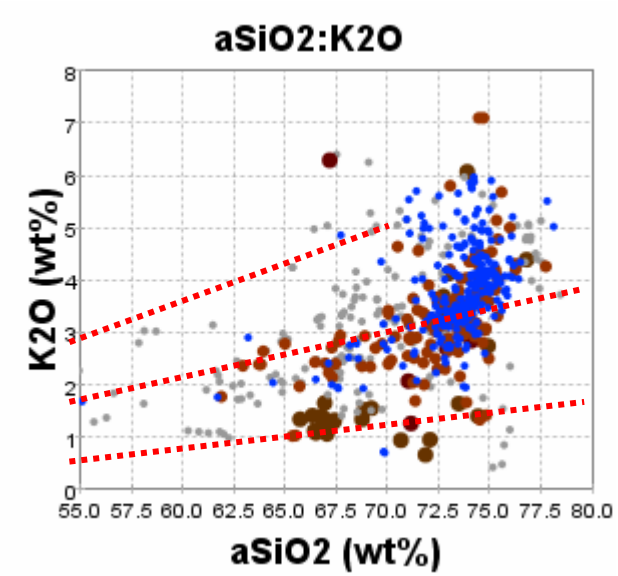
Contrasts with Coen region, and LFB

Silurian-Devonian- North Qld



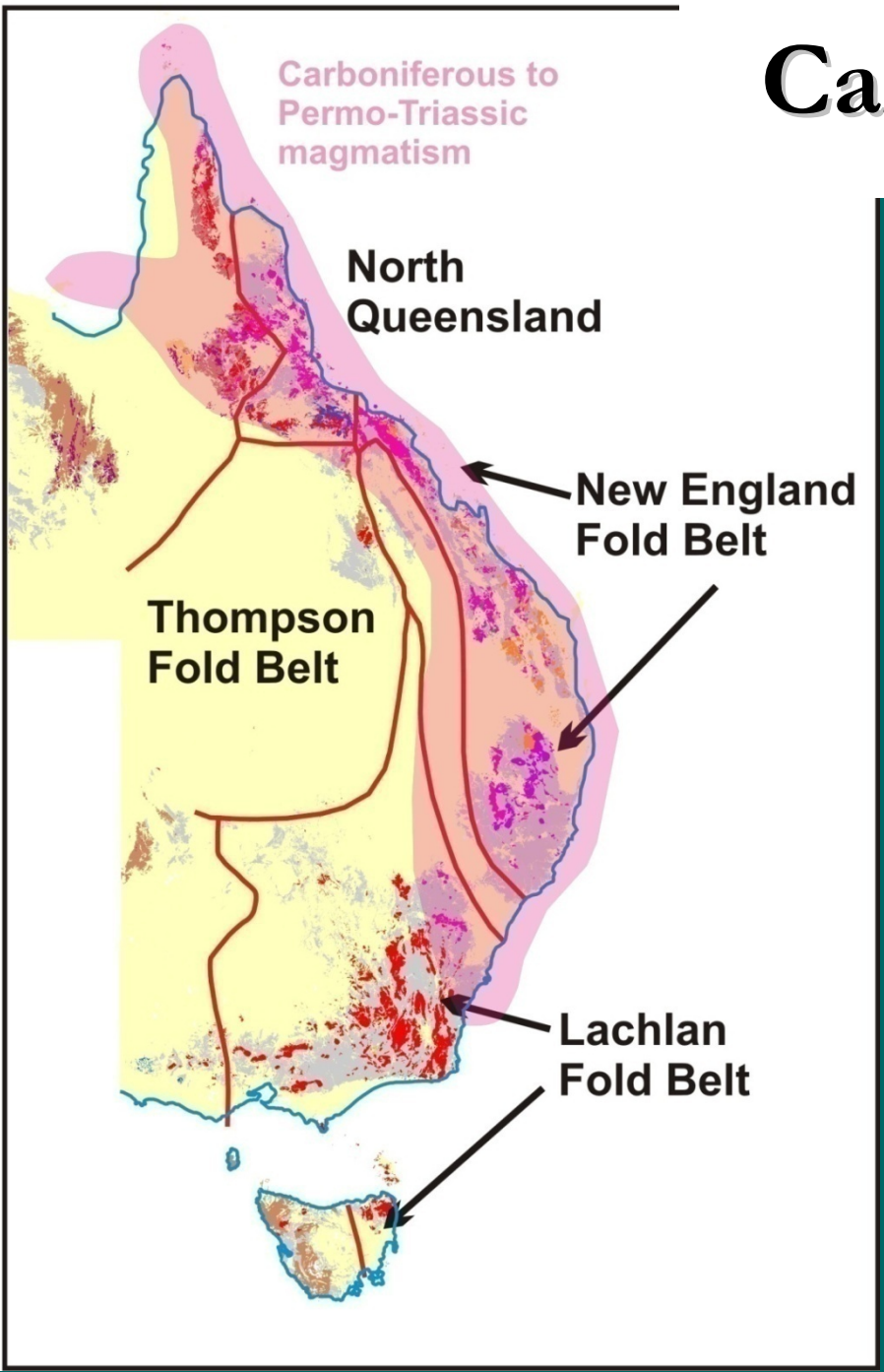






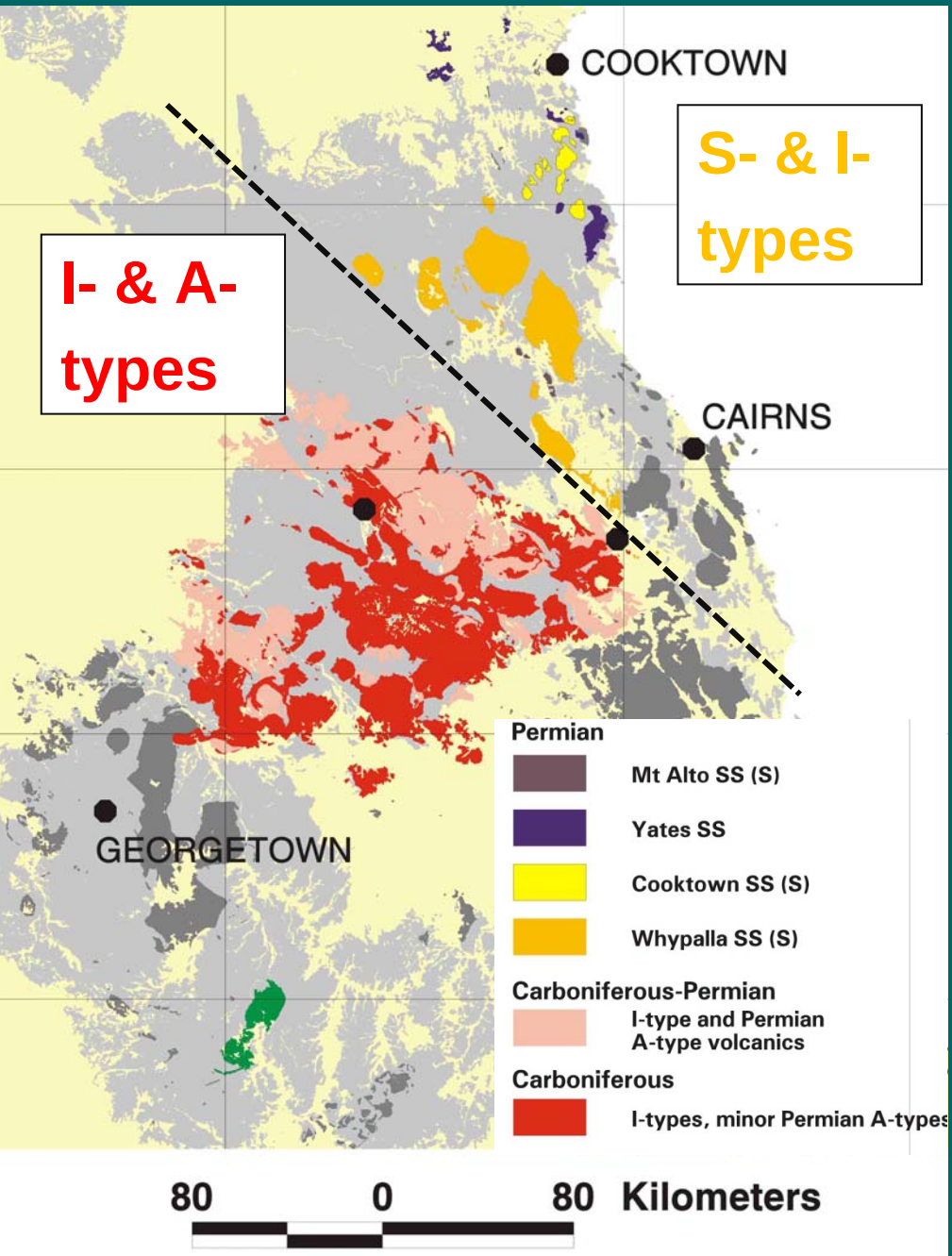
- I-types wide SiO2 range (60-77%)
- Cape York: medium- to high-K, Y-undepleted, Sr-depleted
- Georgetown: sodic to medium K; Y-depleted, Sr-undepleted

Carboniferous-Permian

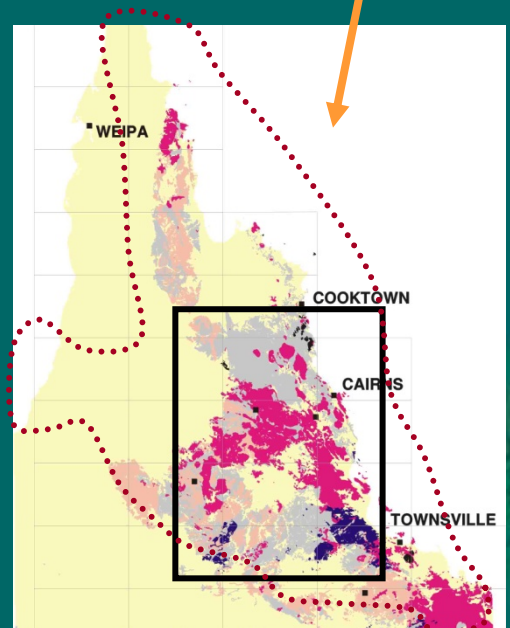


- look at North Queensland (behind-arc), &
- New England FB – classic continental arc
- overlapping ages

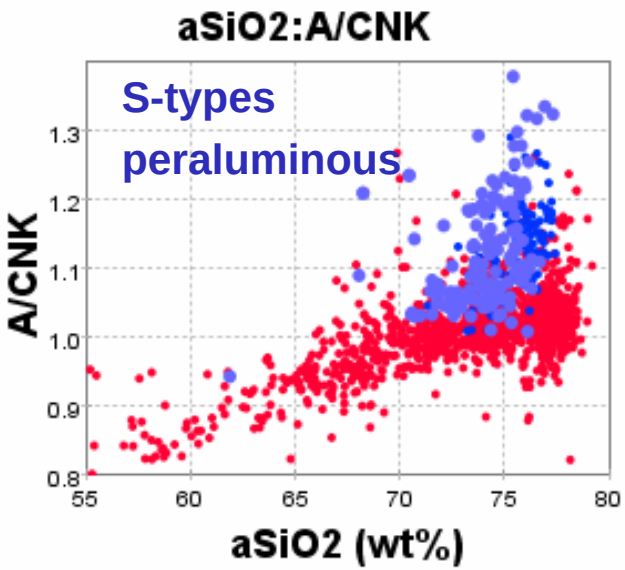
North Queensland - Carboniferous-Permian

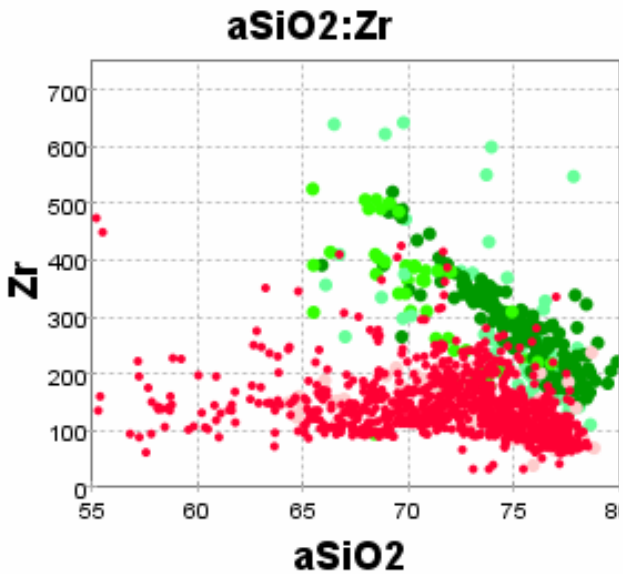


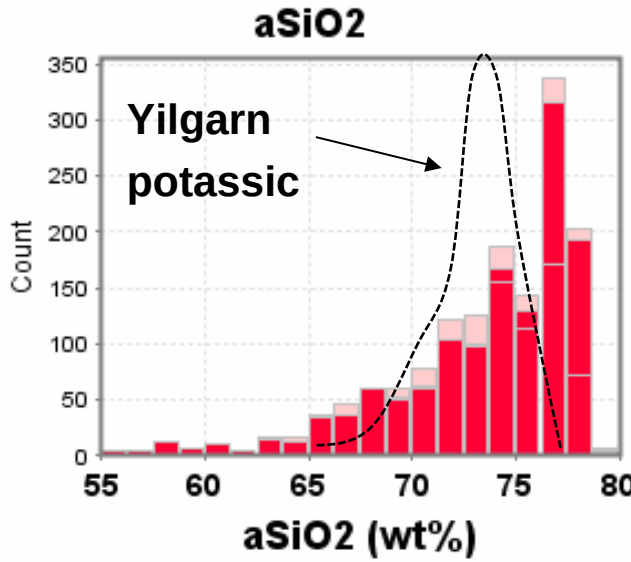
- voluminous high silica I-types – part of extensive coastal belt
- significant S-types
- lesser A-types
- regional variability

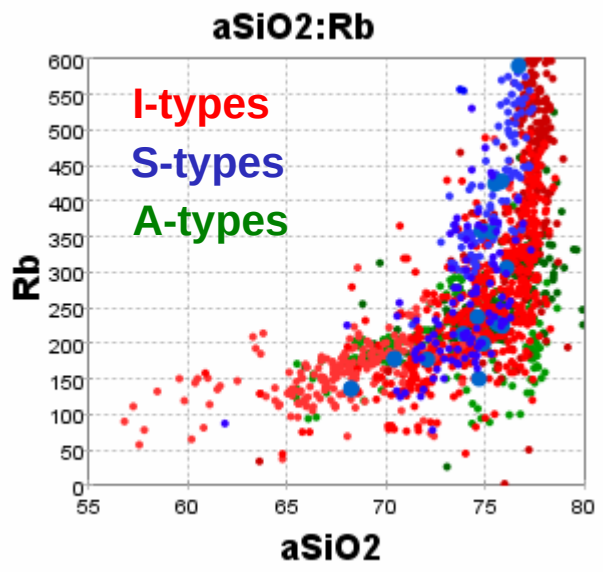


Carboniferous-Permian - North Qld



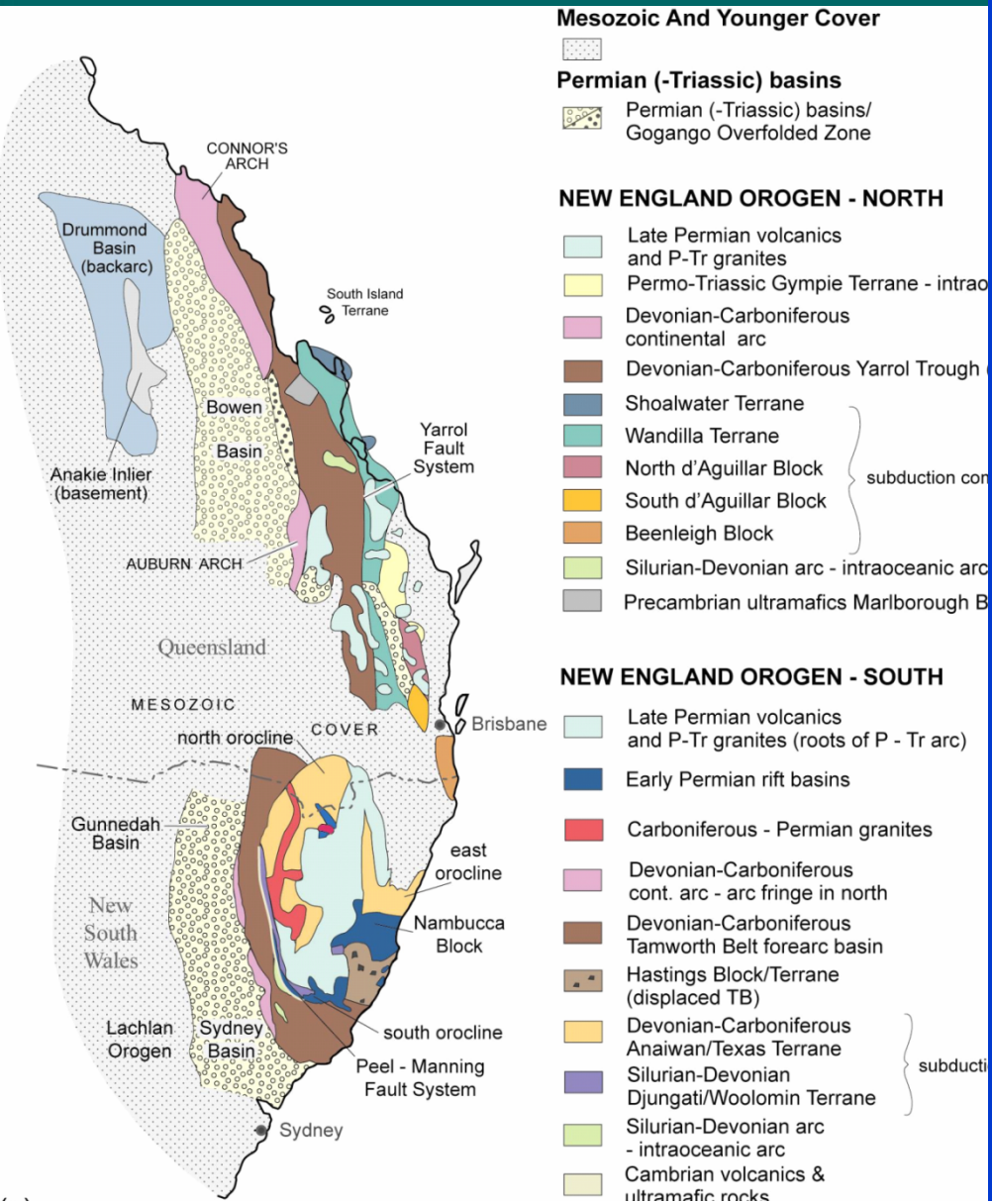






- SiO2 mostly 65-77%, I-types wider range
- all types strongly fractionated
- all largely high-K (>85%)
- Y-undepleted, Sr-depleted (>95%)
- evolved isotopic signatures (S-types least evolved)

New England – island & continental arc



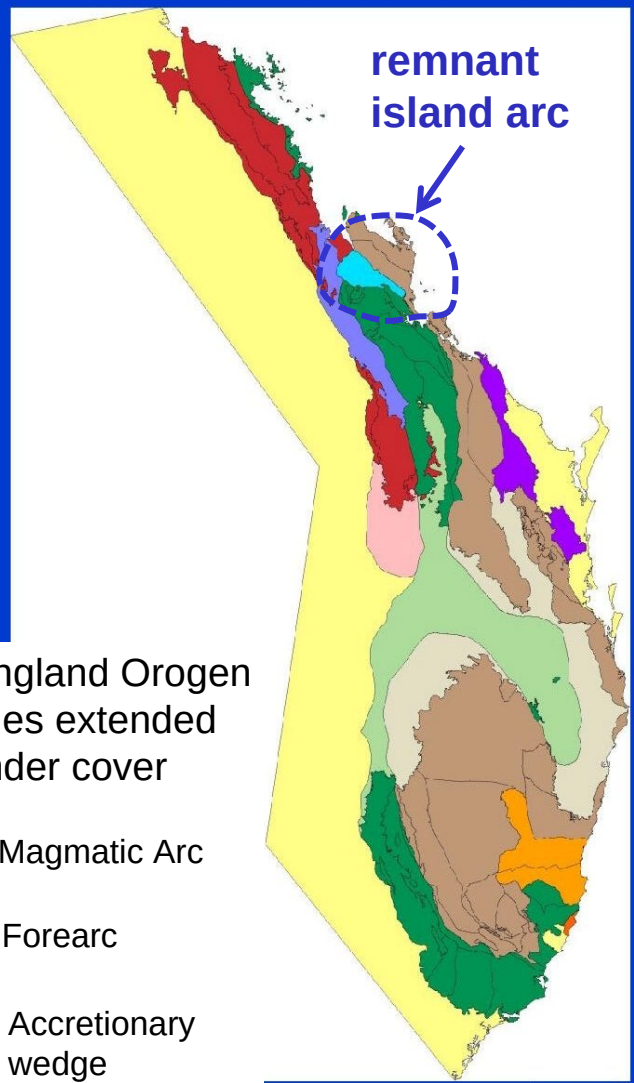
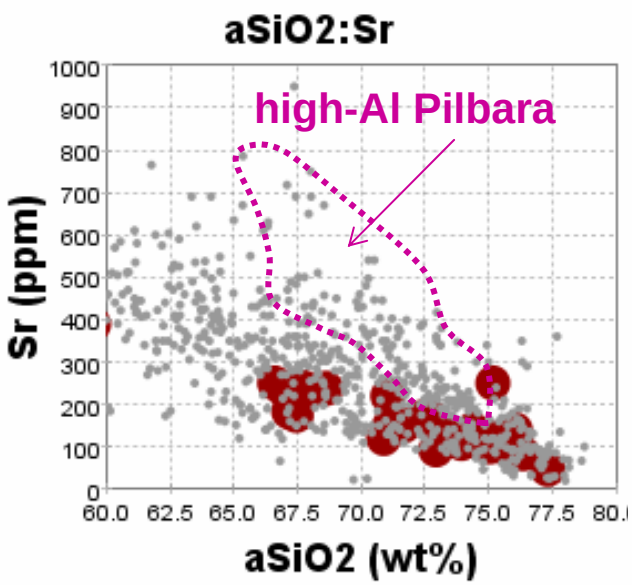
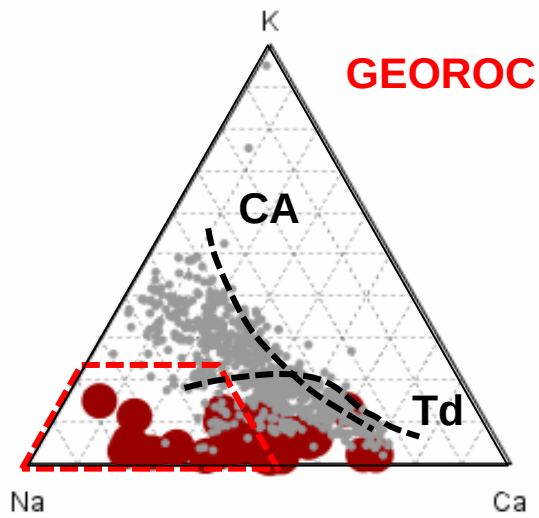
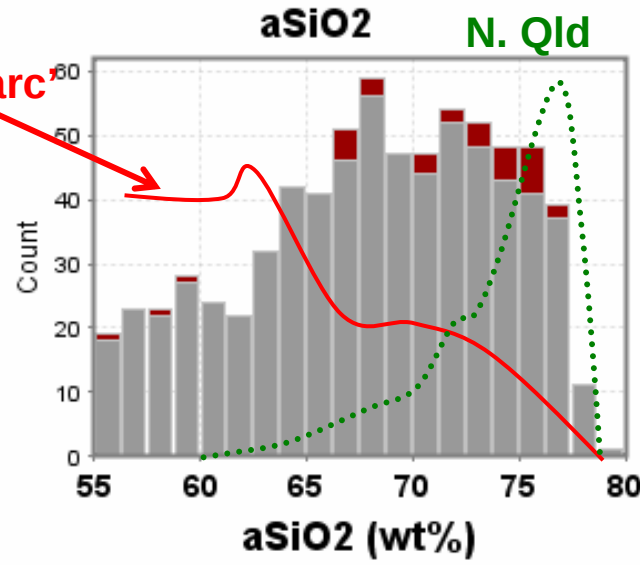


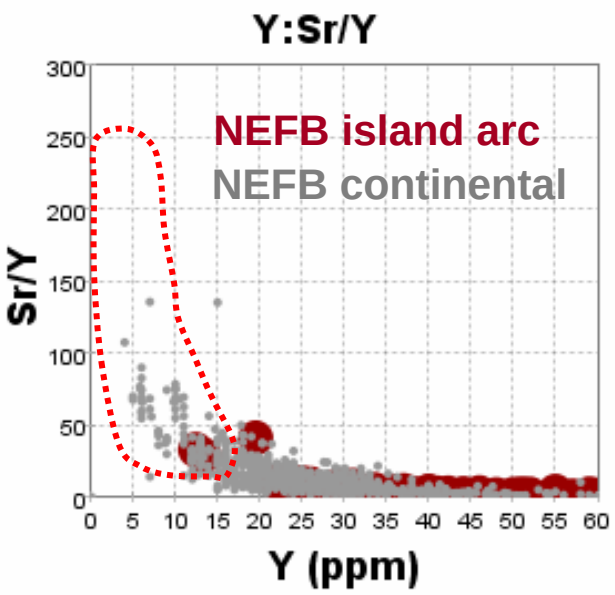
Figure from Dick Glen (2006). http://www.smedg.org.au/M&WProg.htm

NEFB – Mt Morgan & CP

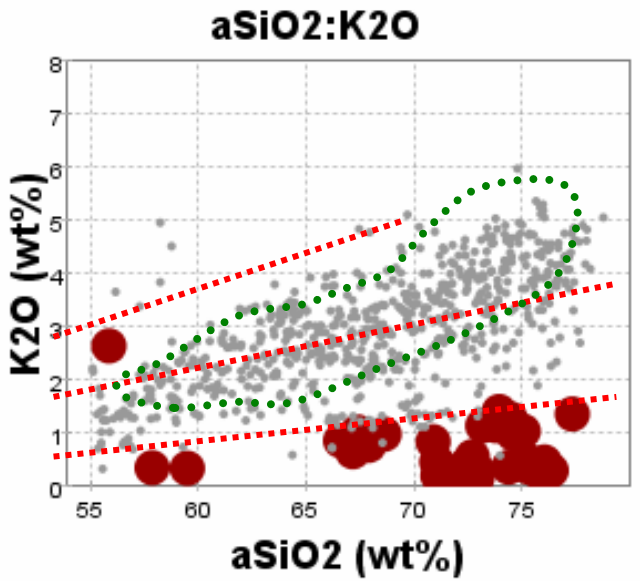








- diorite to granite
- medium- to high K
- sodic in island arc
- mostly low Sr, and high Y
- wide relatively even SiO2 range



Palaeozoic Granite types – domain specific

	North Qld		NEFB
	SD	CP	
sodic granite (I-type)	minor to common	minor	minor
medium-high K granite (I)	common	common	common
high-Si high-K granite (I)	minor	common	some
high-Mg diorite	minor	?	minor
BADR and intrusives	minor	minor	common
Fe-rich granite (A-type)	?	moderate	?
alkaline granite	minor	minor	?
peraluminous (S-type)	minor to common	moderate	minor

Granite types through time

	Archaean	Prot	Palaeozoic
sodic granite (I-type)	**dominant**	minor	minor
medium-high K granite (I)	common	common	common
high-Si high-K granite (I)	common	common	common
high-Mg diorite	minor	minor	minor
BADR and intrusives	minor	minor	**common**
Fe-rich granite (A-type)	minor	moderate	minor
alkaline granite	minor	minor	minor
peraluminous (S-type)	v. rare	minor	**common**

(underlined = variable)

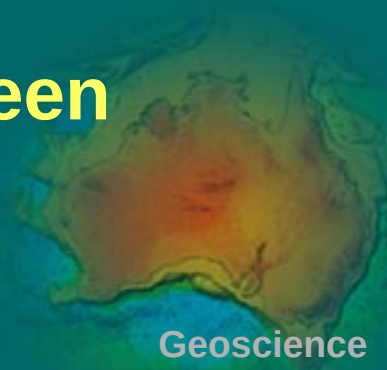
Secular trends – initial summary

- granite types occur through time; relative abundances change
- sodic (mostly high-Al) granites abundant in Archaean; mostly minor since
- medium- to high-K granites from mid-late Archaean, dominant in Proterozoic & abundant in Palaeozoic
- S-types rare in Archaean, minor in Proterozoic, rel. common in Palaeozoic
- ‘classic’ island/continental arc rocks largely missing in Archaean & Proterozoic
- variability appears to increase, especially in Palaeozoic

Secular trends – Archaean vs rest

Archaean clearly most distinctive

- **shows a pronounced secularity; not obvious after this**
- **dominated by early sodic (mostly high-Al) granites (TTGS)**
- **these give way to medium- to high-K granites from mid-late Archaean**
- **other granite types minor; most not seen before 3.2 Ga**



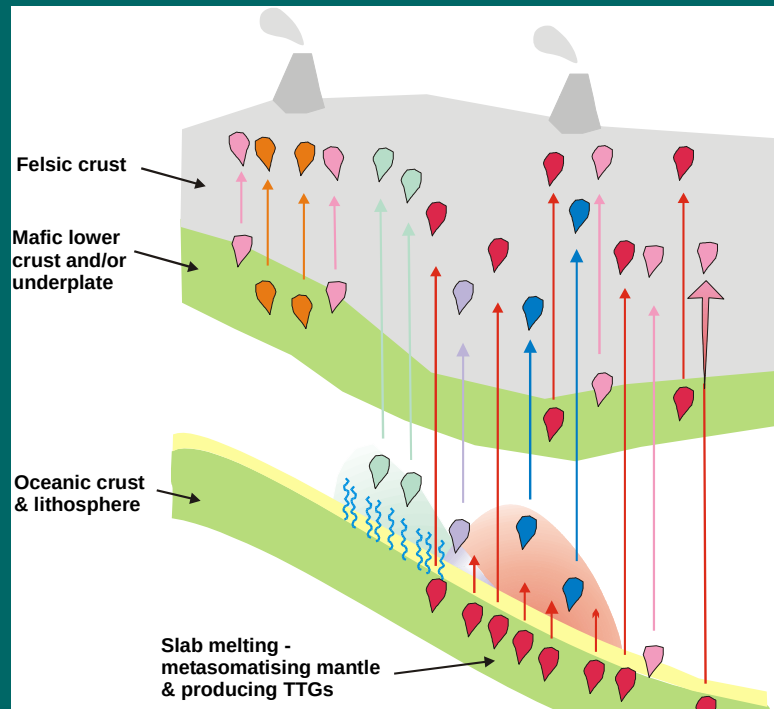
Secular trends – Archaean vs rest

Why is the Archaean distinctive?

Common interpretations 1.

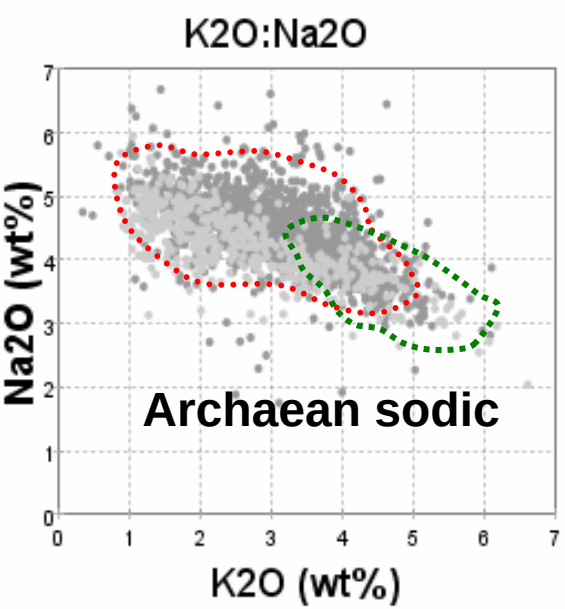
- **sodic (mostly high-Al) granites derived by partial melting of basaltic protolith at high P**
- **either thickened crust or**
- **subducting slab or both**

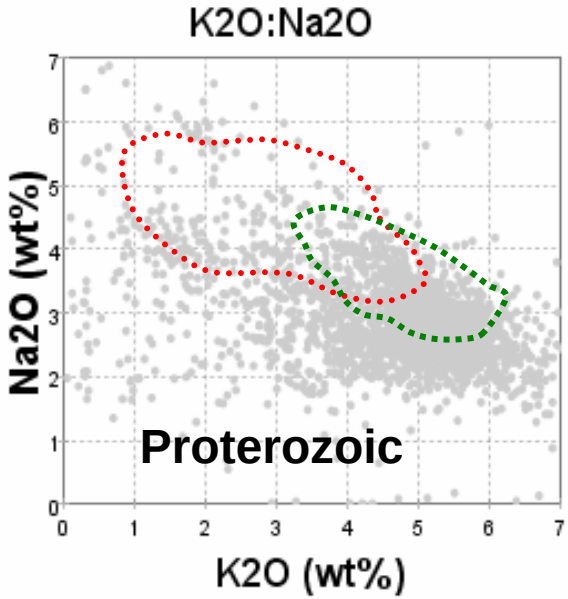
Process unique at the scale seen in the Archaean

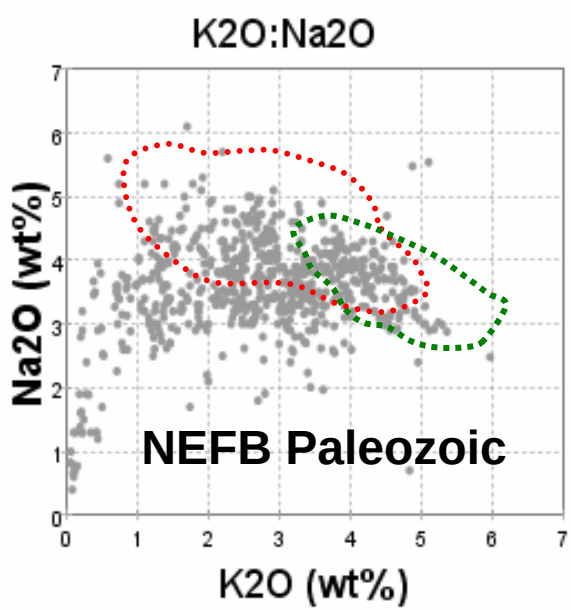


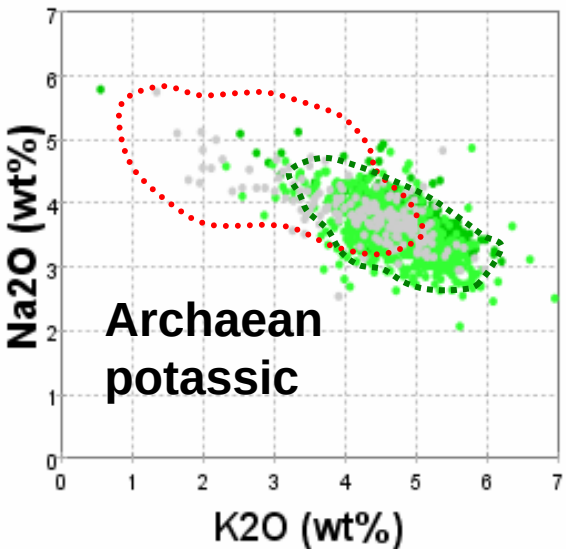
Na/K through time

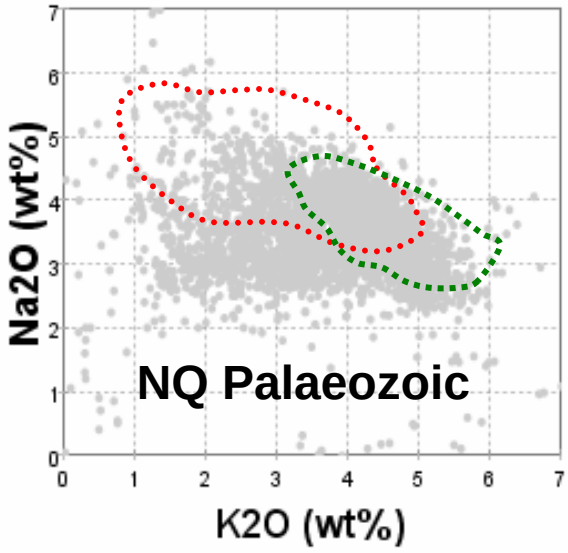
High Na/K ratios & high Na2O only in Archaean

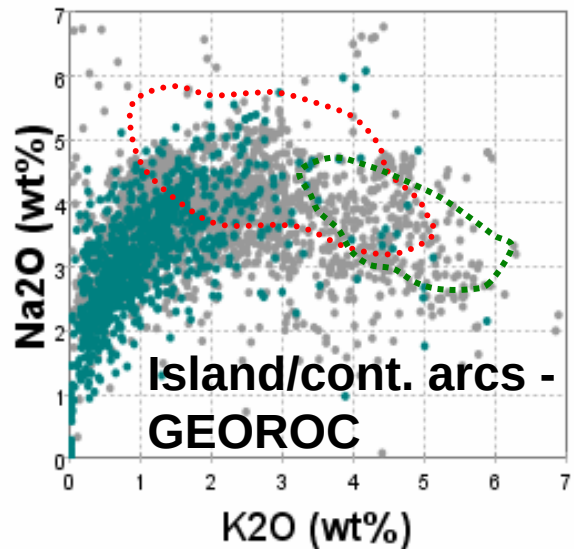






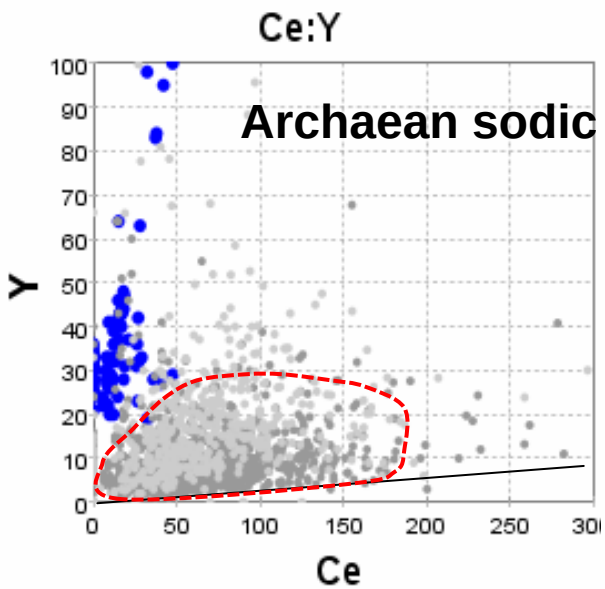


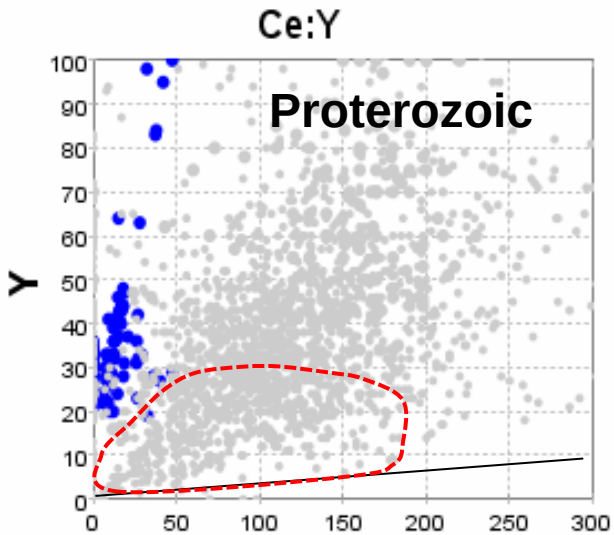


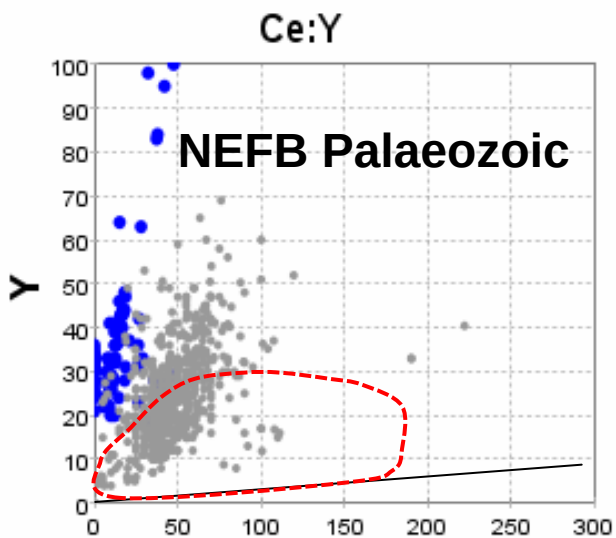


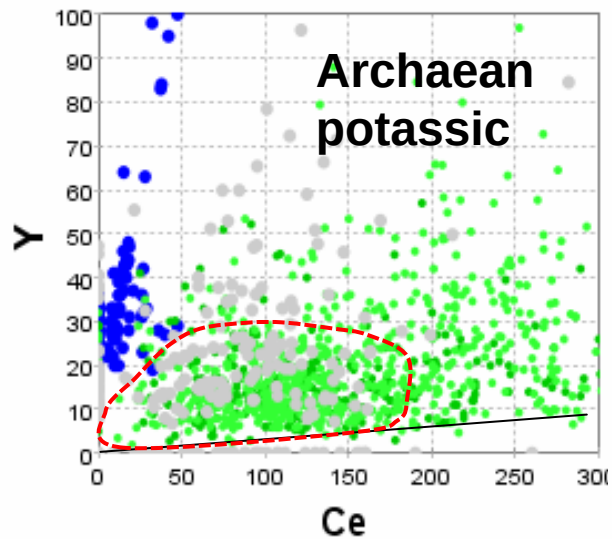
Ce/Y through time

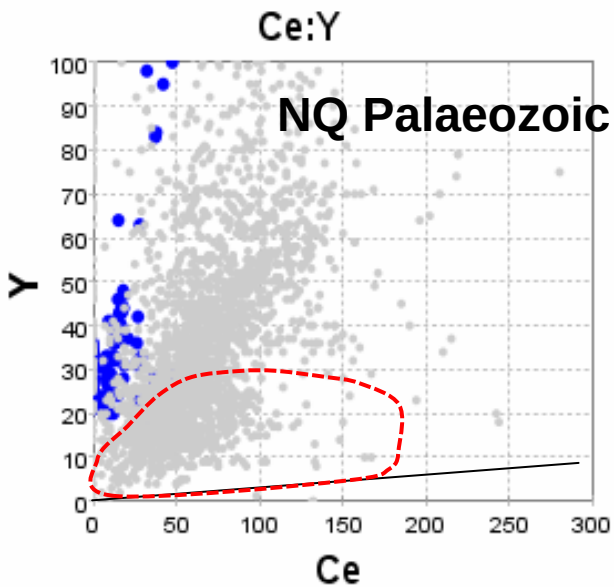
Steeper REE patterns (high Ce/Y) in Archaean

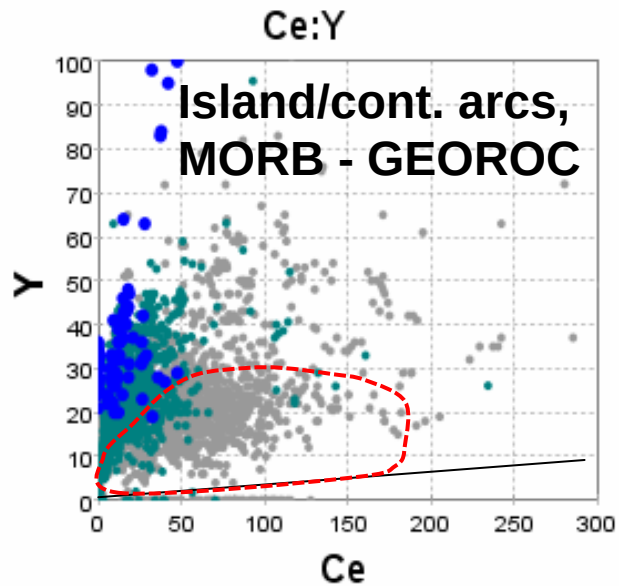












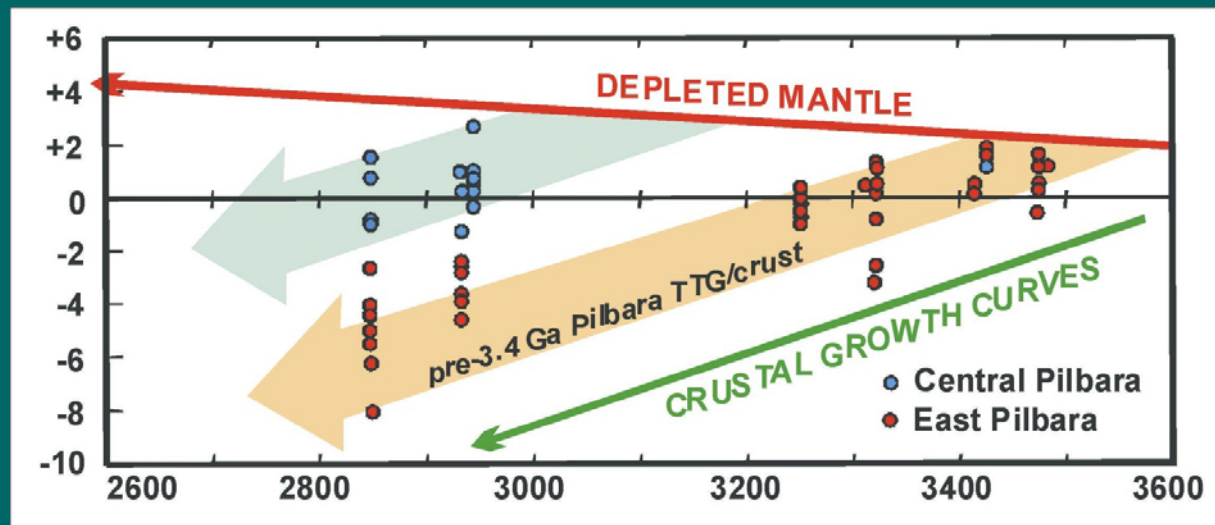
Secular trends – Archaean vs rest

Why is the Archaean distinctive?

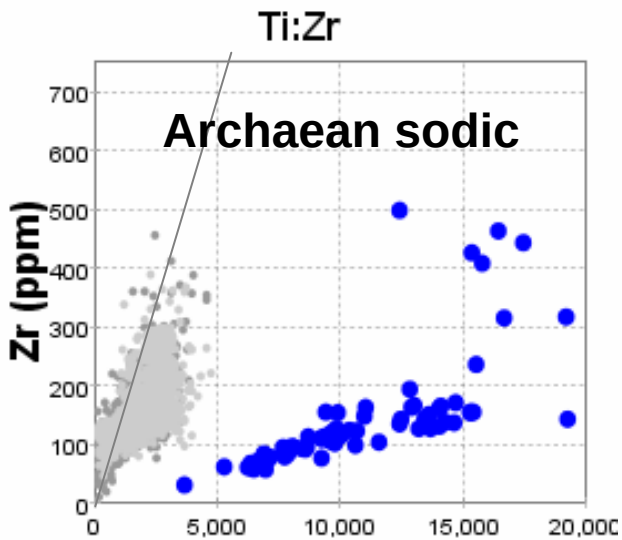
Common interpretations 2.

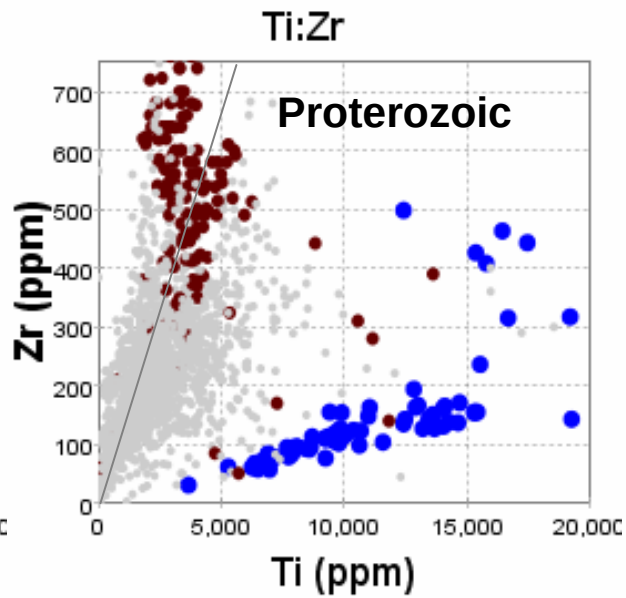
- **potassic granites simply reflect onset of crustal melting, in particular of what must have been a largely compositionally homogeneous crust, i.e., melting older TTGs**

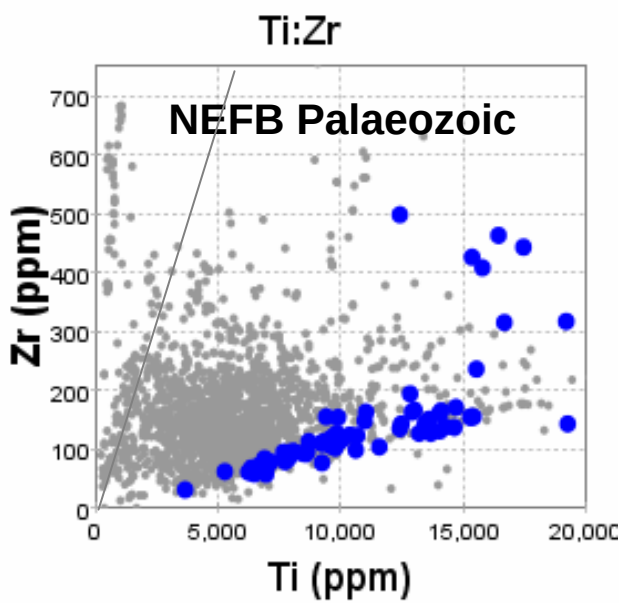
Evidence?

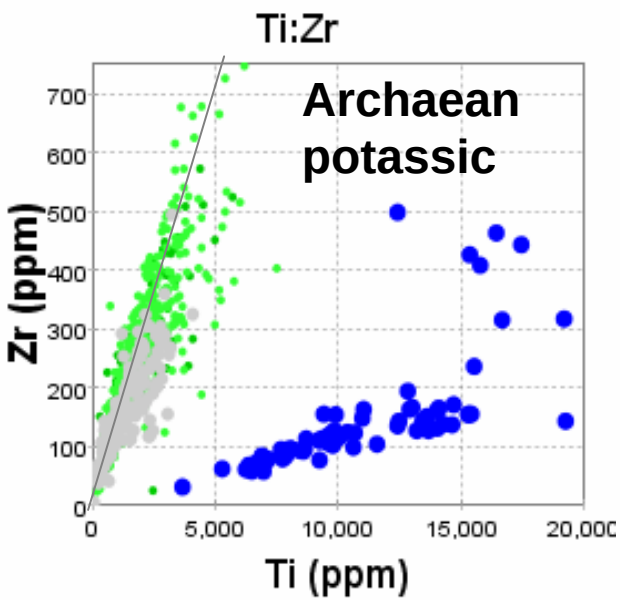


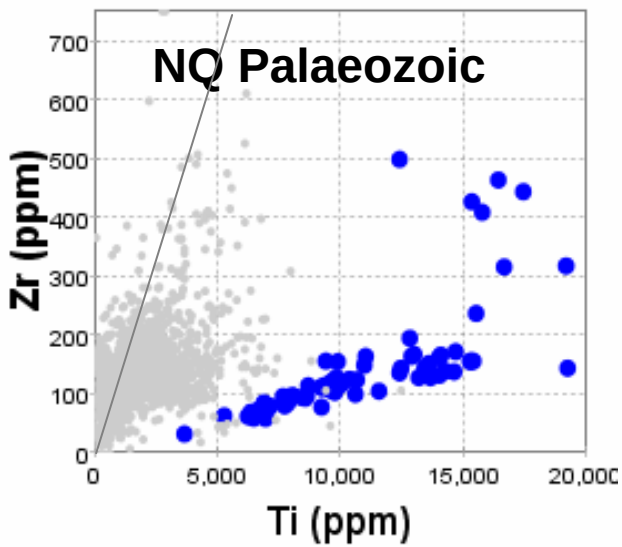
Ti/Zr through time

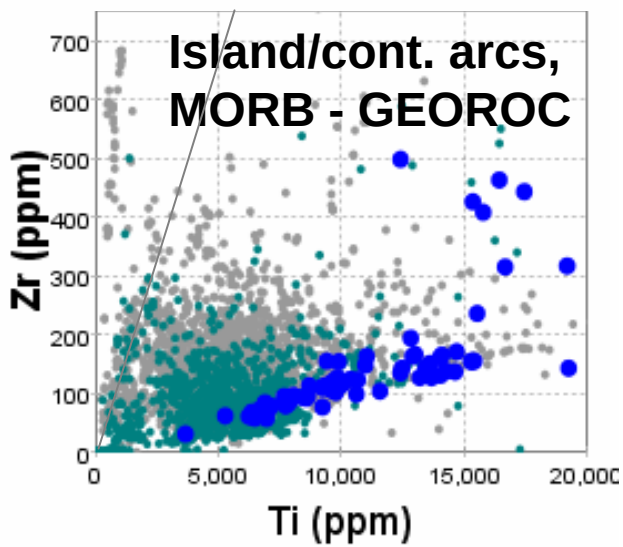












Ce/Y through time

High Ce/Y in Archaean K-rich granite = TTG protolith