Australian Government

Geoscience Australia

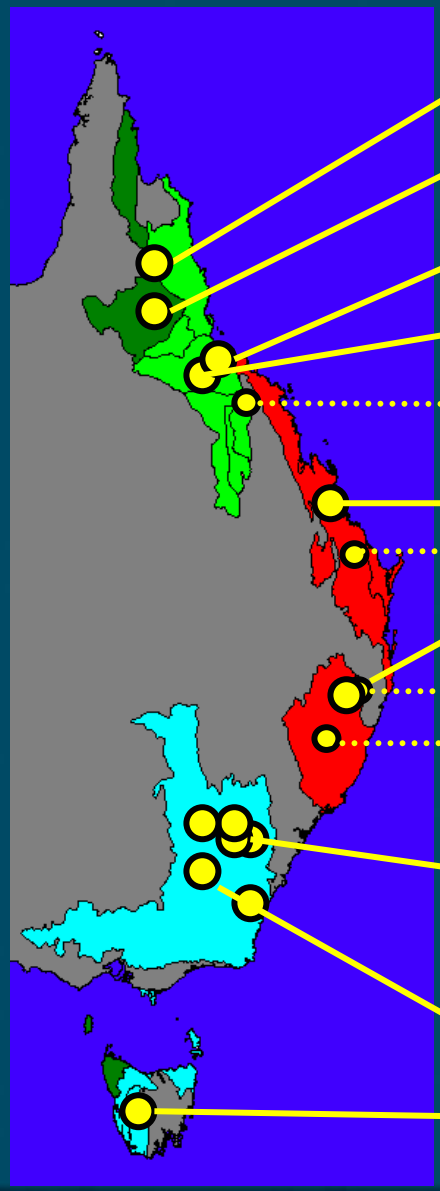
New Insights into Intrusion-related mineralisation in the Tasmanides

Dave Champion (GA)

Digging Deeper

Brisbane, 28th November 2007

Some Au-rich intrusion associated systems of east Australia



Red Dome (1.3 Moz)

Kidston (3.4 Moz)

Ravenswood (3.1 Moz)

Mt Leyshon (2.5 Moz)

Epithermals

Nth Drummond Basin deposits

Mt Morgan (8 Moz)

Kilkivan

Cracow

Timbarra (0.3 Moz)

Mt Rawdon

Drake

Mt Terrible

North Parkes (1.3 Moz)

Cadia/Ridgeway (>19 Moz)

Lake Cowal (3.0 Moz)

Mineral Hill, Mt Adrah, Braidwood

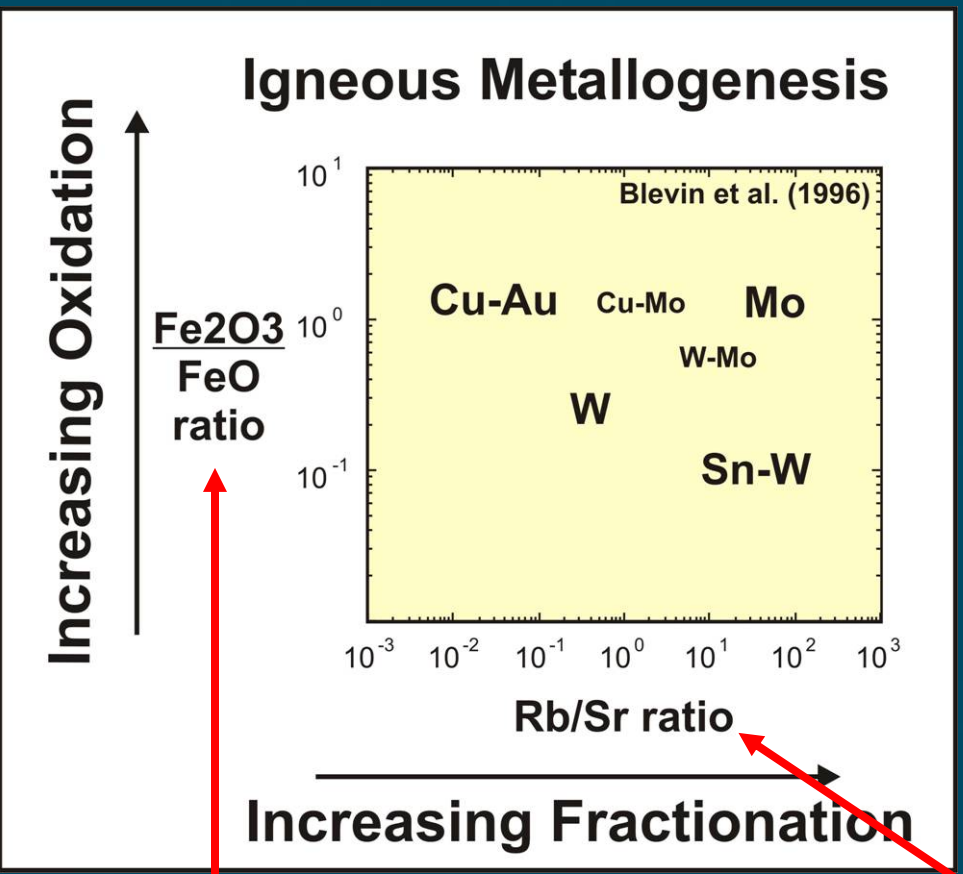
Henty (~1.2 Moz), Mt Lyell (~3 Moz)

Outline

Granite metallogenesis, using regional datasets, esp. regional geochemistry

- Review of igneous metallogeny - commodity type & intrusion parameters
- Intrusion-related mineralisation in E Australia
  - Sn, Cu-Au, Au
- GA datasets & projects

Igneous Metallogenesis



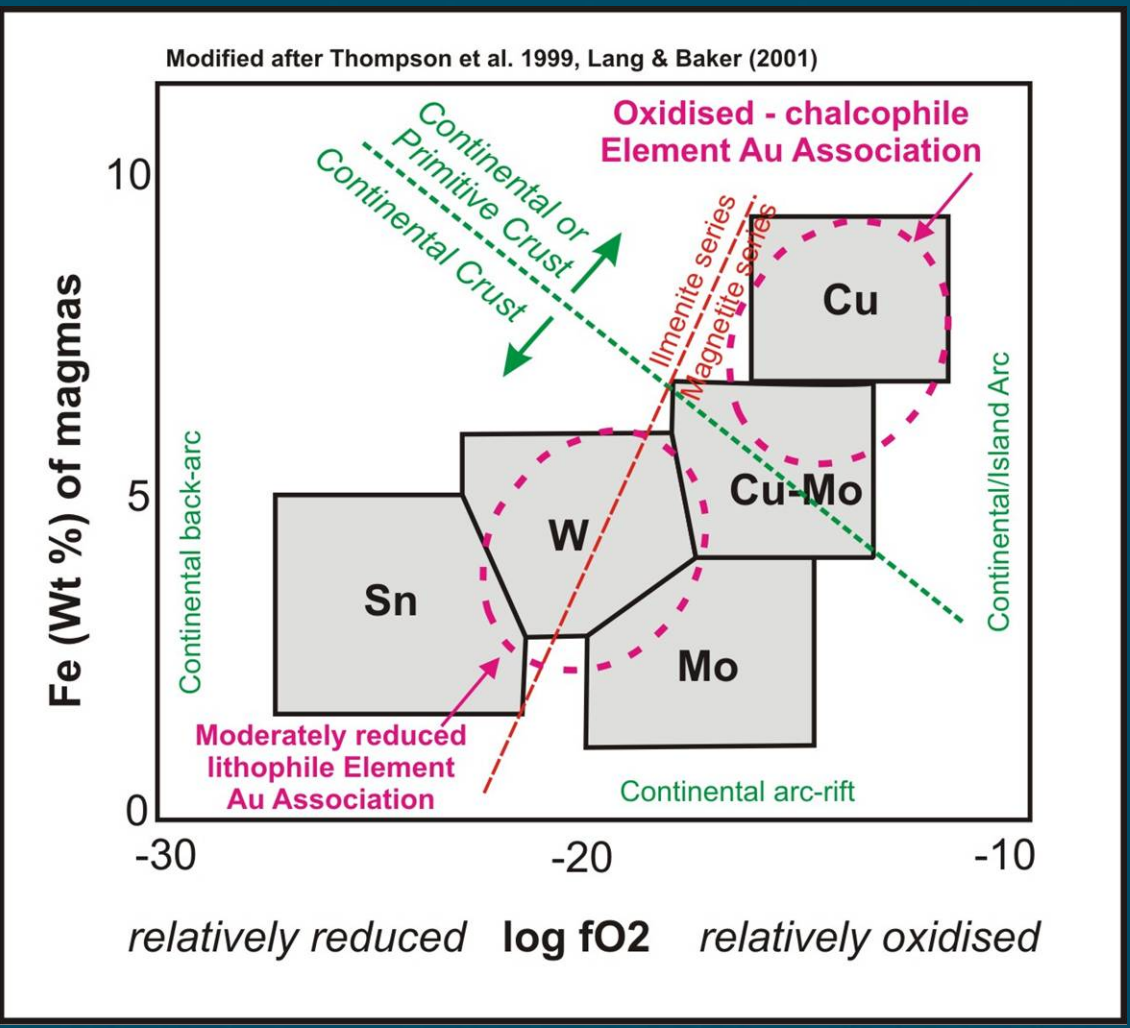
Blevin et al. (1996) showed a strong relationship between commodity types & intrusion parameters:

- oxidation state, and
- compositional evolution

Measure of Oxidation

Measure of compositional evolution

Igneous Metallogenesis

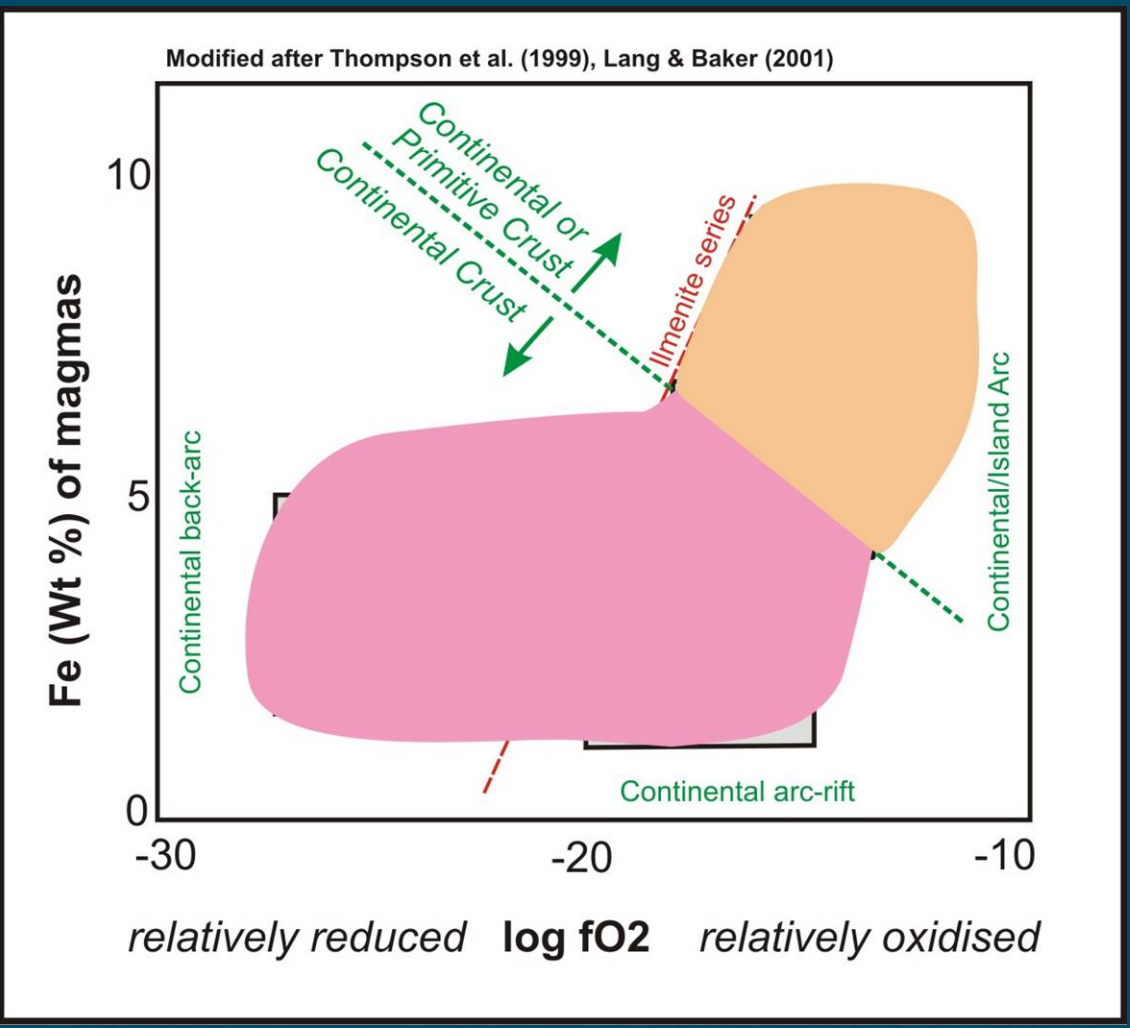


Thompson et al. (1999) showed a similar relationship between commodity types & igneous parameters:

- oxidation state, and
- compositional evolution

Also added a tectonic overlay

Igneous Metallogenesis

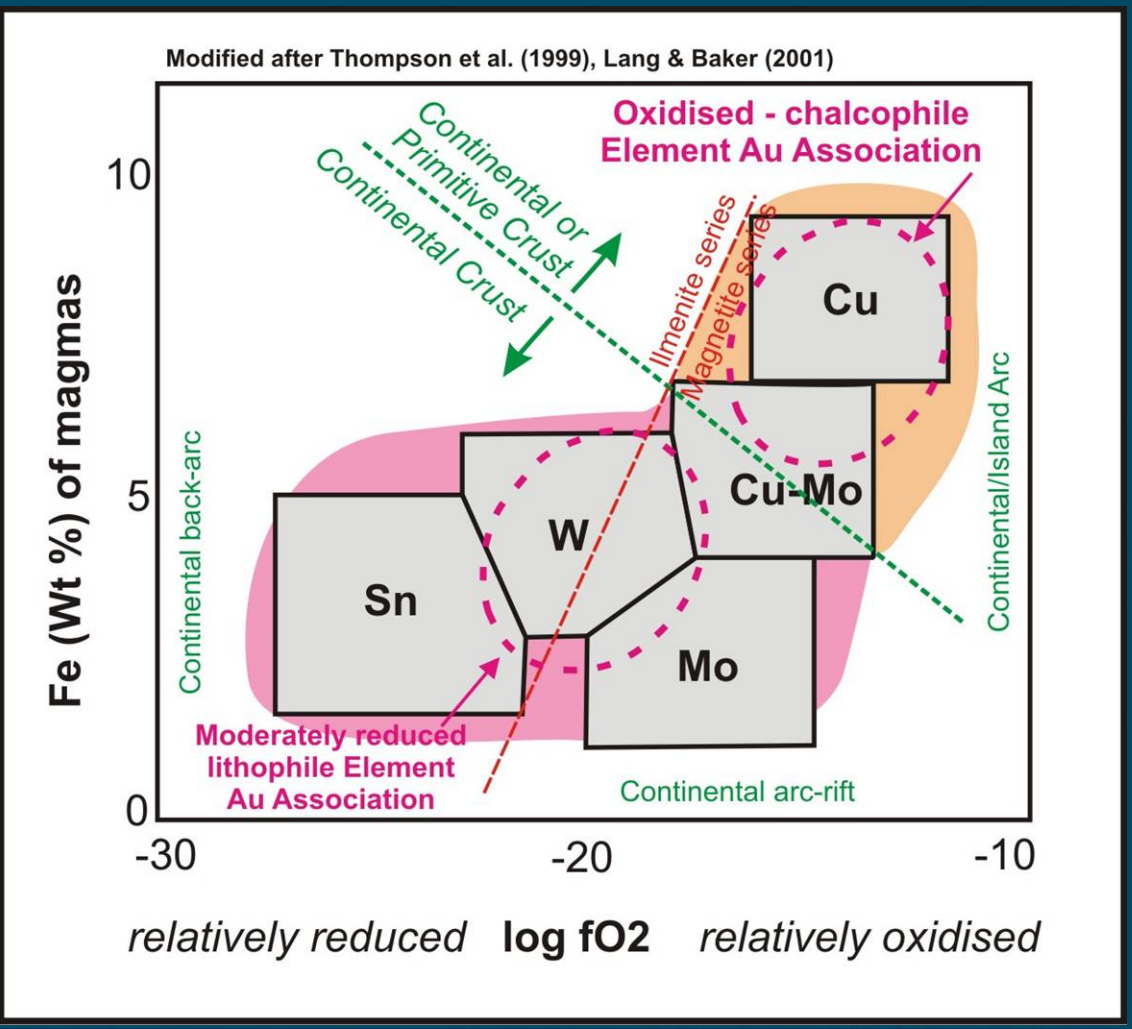


Thompson et al. (1999)

Also added a tectonic overlay

- Primitive (island arc & primitive continental crust)
- Continental Crust

Igneous Metallogenesis



Thompson et al. (1999)

Also added a tectonic overlay

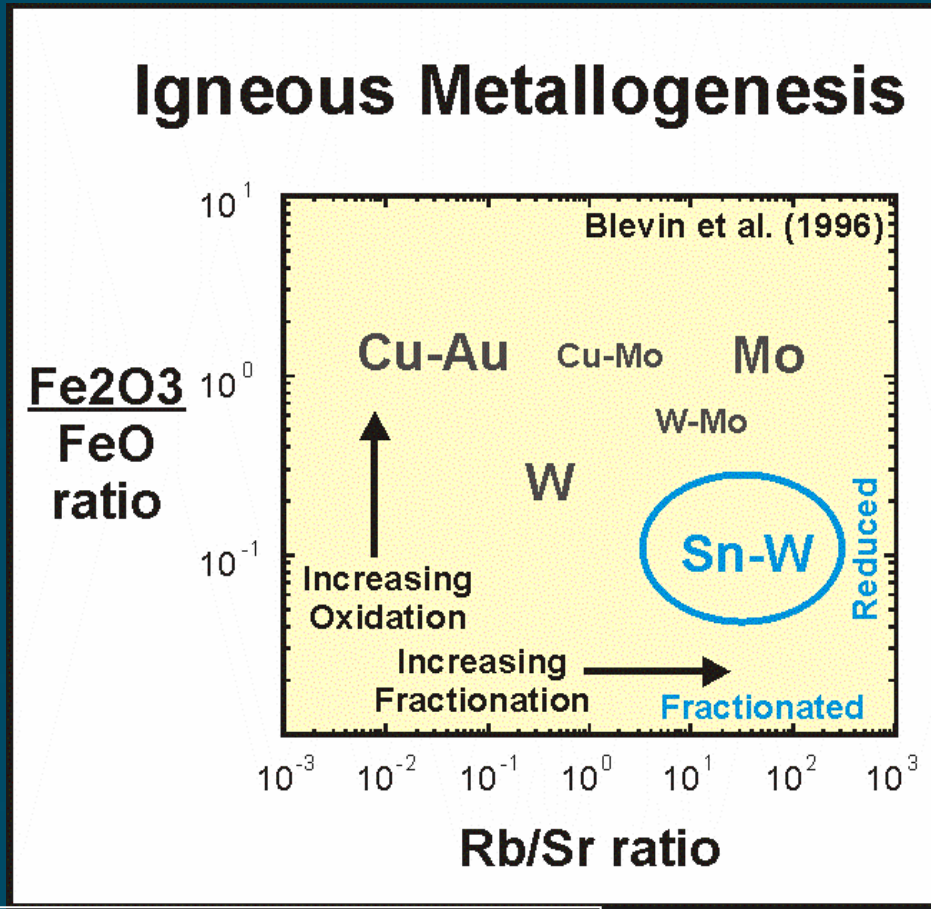
- Primitive (island arc & primitive continental crust)
- Continental Crust

Igneous Metallogenesis

Simple but powerful relationship

Can be used predictively

e.g., Sn related to reduced, strongly fractionated granites

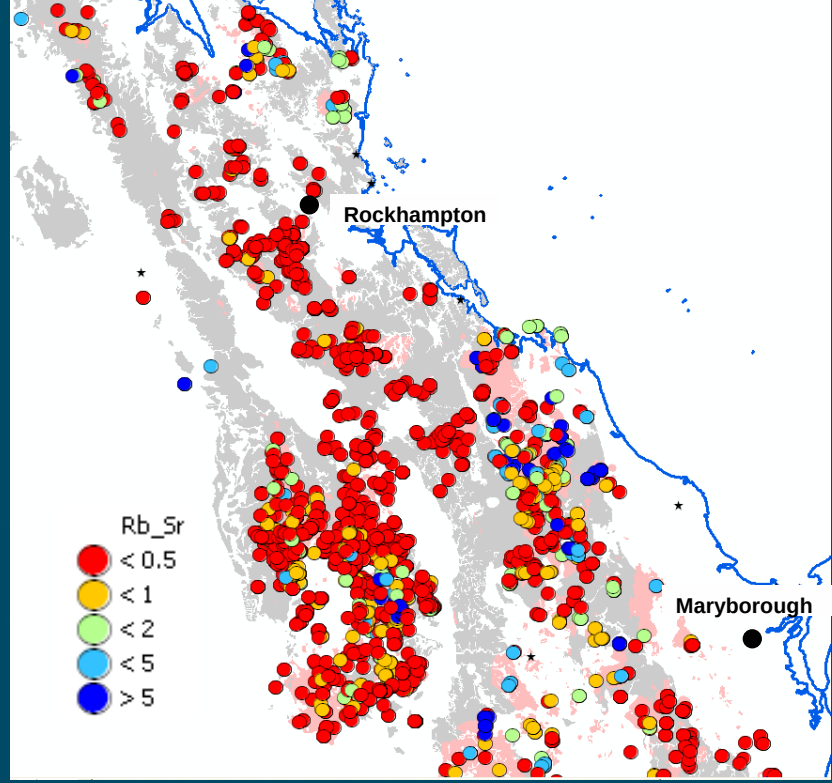


Why? Sn4+ substitutes into ilmenite, biotite, titanite. Sn2+ is incompatible in magmatic minerals, thus:
buildup of Sn occurs in reduced evolved magmas.

Methodology

Can use either

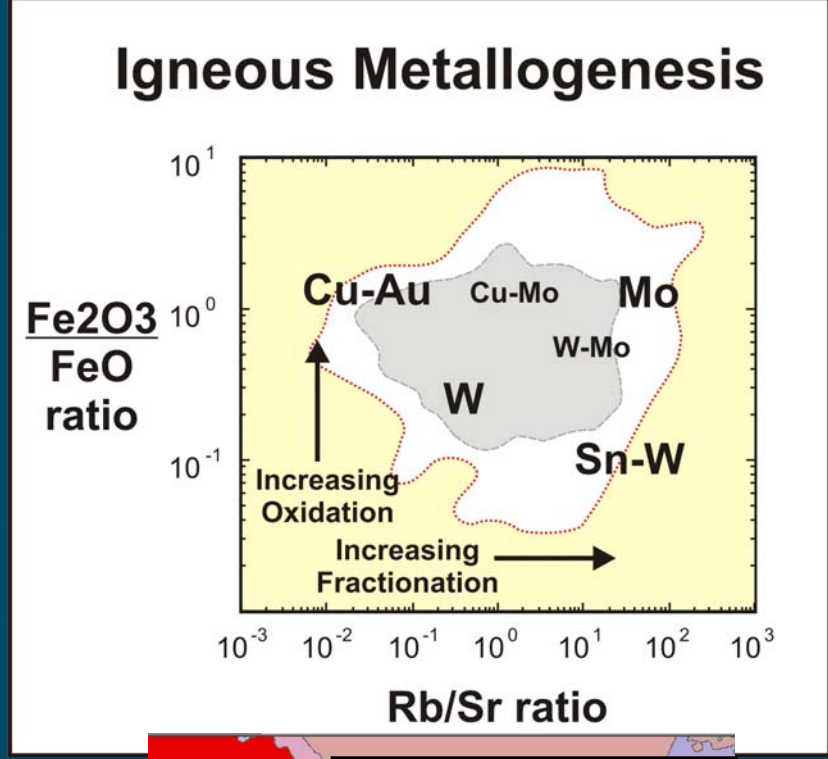
- geochemistry – point datasets, or



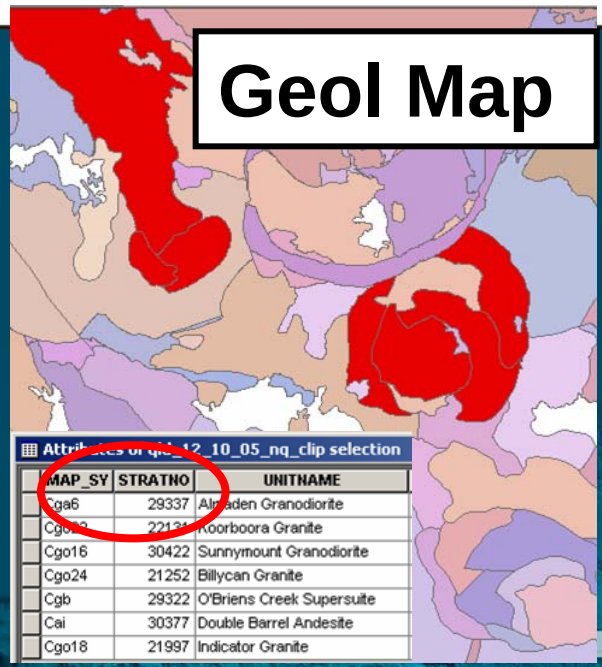
Methodology

Can use either

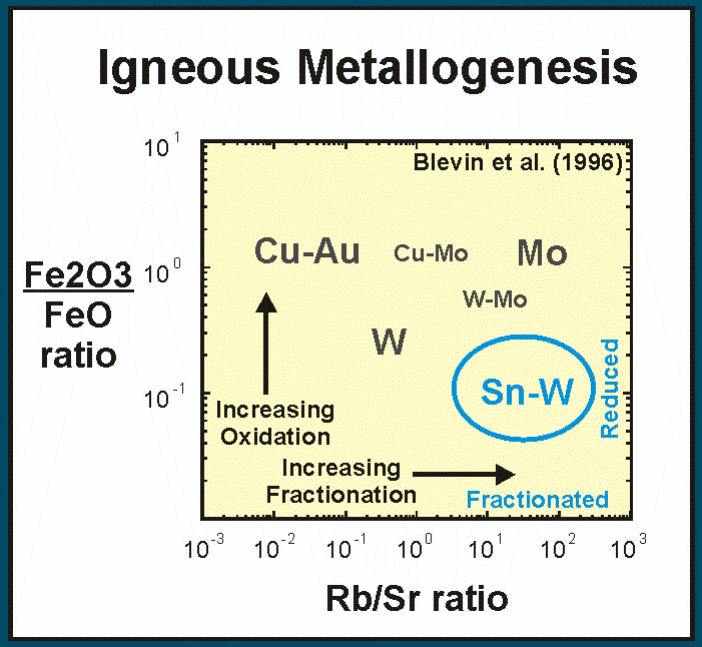
- geochemistry – point datasets, or
- linked to geology

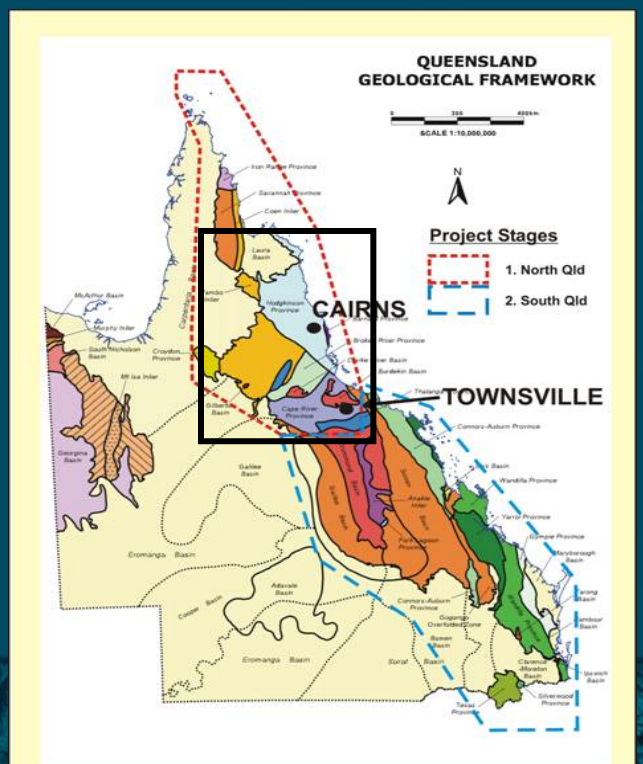


Stratno	Unit_name	No_	Av_SiO2	Max_SiO2	Min(SiO2)	Av_FeO*	Av_Na2O	Av_K2O	Av_Na2O+K2O	Av_P2O5	Av_Ba	Ab_Rb	Av_Sr
23497	Columbia Cree	3	71.75	72.91	70.62	2.65	3.39	1.77	5.16	0.10	477.7	73.8	282.3
27642	Conical Knol	1	72.7	72.7	72.7	1.73	4.7	4.47	9.17	0.05	890	178	95
21535	Convict	3	76.15	76.8	75.14	0.53	3.4	5.46	8.86	0.01	146	345.7	21.3
27041	Cooktown	3	74.19	74.32	74.06	1.42	3.05	5.04	8.1	0.19	138.3	346	43.3
36306	Cope	1	76.86	76.86	76.86	0.44	4.25	4.26	8.51		256	180	14
36284	Copper Bush	2	75.59	76.65	74.52	1.54	4.15	4.19	8.33	0.01	864.5	129	63.5
	Core Shed gra	3	74.15	74.56	73.91	1.59	3.09	4.6	7.69	0.04	404	281.5	92.3
34130	Cornelia granite	1	72.3	72.3	72.3	1.52	4.44	2.85	7.29	0.04	601	99	412
21565	Cottell	1	75.6	75.6	75.6	1.18	3.6	4.55	8.15	0.05	191	294	72
-809	CPmg-Einaslei	1	77.1	77.1	77.1	1.1	3.6	4.79	8.39		16	600	6
	CPv	2	55.52	56.54	54.5	7.25	3.45	1.39	4.84	0.35	420.5	44.5	547.5
21577	Cresent Granoc	1	67.49	67.49	67.49	3.69	3.09	2.48	5.57	0.13	508	93	297
	Crowbar	1	72.97	72.97	72.97	1.72	4.38	4.01	8.39	0.07	713	104	153
24233	Culba Granodic	4	68.73	71.1	66.1	2.86	3.74	3.78	7.51	0.14	610	160	280
-845	Curraghmore	2	73.62	73.82	73.41	1.82	2.72	5.03	7.75	0.06	347.5	186.5	78.5
23529	Dalkum Mgr	2	73.29	73.65	72.92	0.61	4.38	4.09	8.47	0.04	26	428.5	22.3
29262	Dalmore Grano	2	63.17	63.54	62.79	5.12	3.01	2.71	5.72	0.14	454	92.5	268.5
21632	Deadman Gran	2	75.09	77.04	73.14	1.6	2.75	4.74	7.49	0.01	245.5	340	57.5
26262	Deane Granodi	8	66.49	69.95	61.97	3.68	3.47	2.26	5.73	0.10	549.1	80.6	421.4
5344	Delaney Granit	6	72.89	73.97	70.44	1.89	2.71	5.29	8	0.13	523.3	310.7	113.3
23543	Denford Granite	2	75.5	75.93	75.06	1.12	3.57	4.55	8.12	-0.01	5	720.5	5.5
27140	Desailly	3	70.71	73.92	66.7	2.91	2.97	3.99	6.96	0.17	461.7	213.7	119
36594	Desert Creek	4	75.57	76.2	74.9	1.44	3.31	4.69	8	0.04	175.8	355	31.4
36263	Devon	2	75.46	75.89	75.02	1	3.35	4.88	8.23	-0.01	15	580.5	10.5
25715	Dido Tonalite	19	63.86	73.9	45.2	4.17	3.59	1.59	5.18	0.18	509.4	50.1	757.6
5474	Digger Creek G	14	74.84	76.4	72.8	0.71	3.9	4.37	8.27	0.06	264.5	232.4	98.7
	dolerite -Pyh??	1	50.14	50.14	50.14	10.9	2.63	0.25	2.88	0.12	55	9	195
28248	Dregger Granit	2	70.58	70.78	70.38	4.6	2.34	4.81	7.15	0.16	927.5	252	93
23563	Duffs Range Gr	3	73.44	76.82	70.74	1.79	3.66	2.89	6.55	0.05	721.3	89	291.3

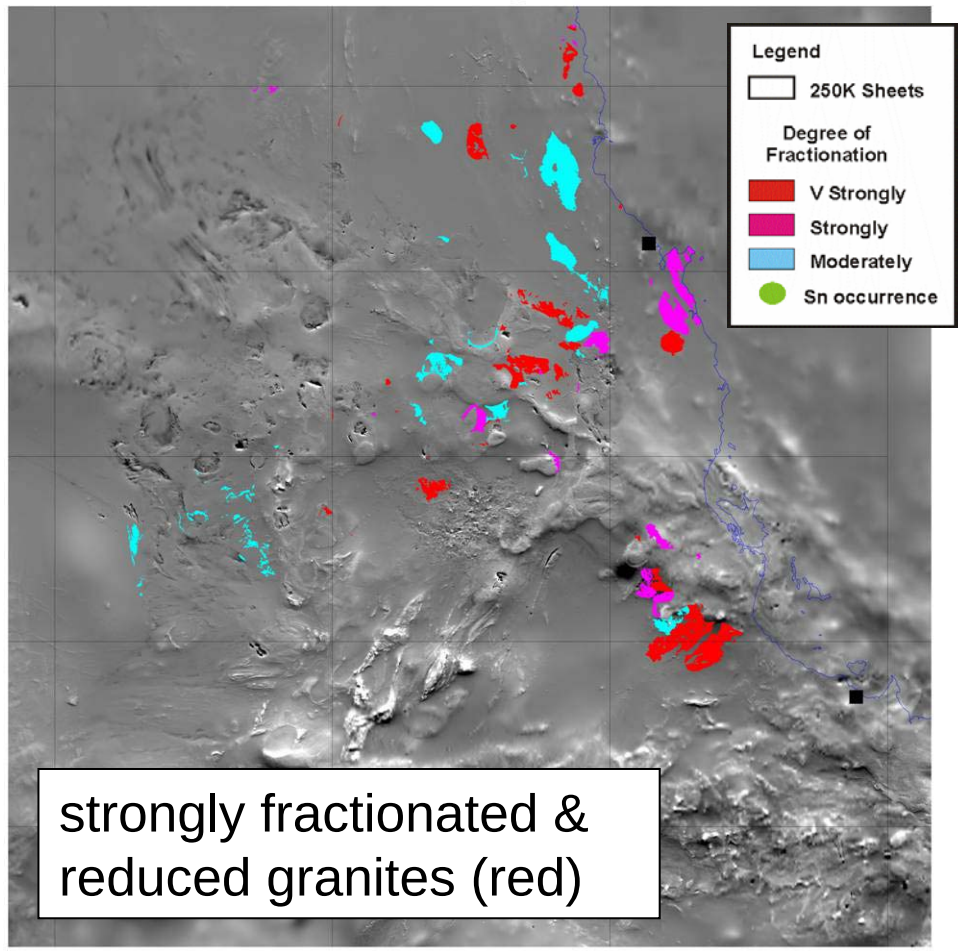


Sn – North Qld



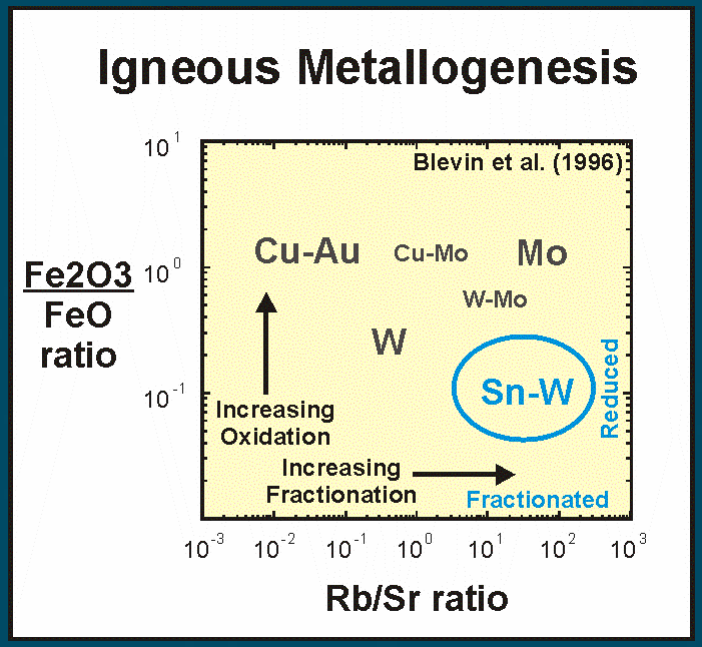


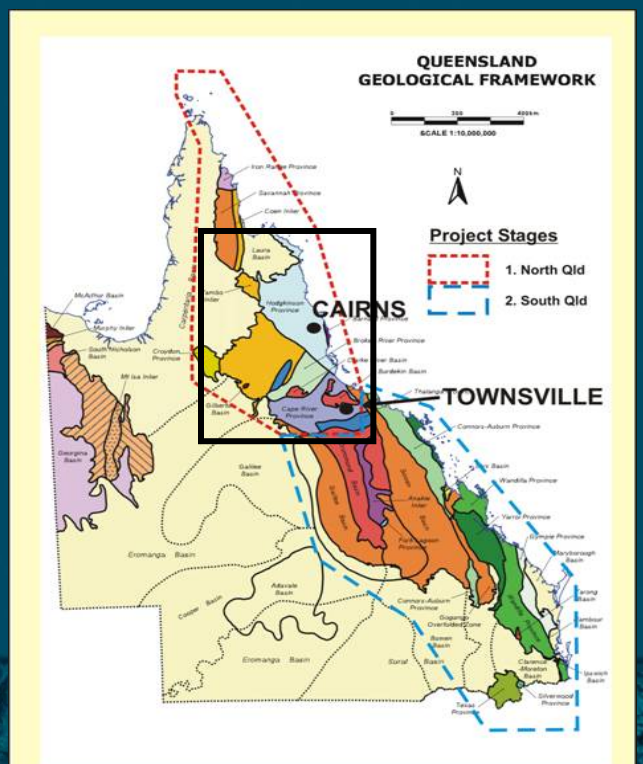
Fract/Reduced granites

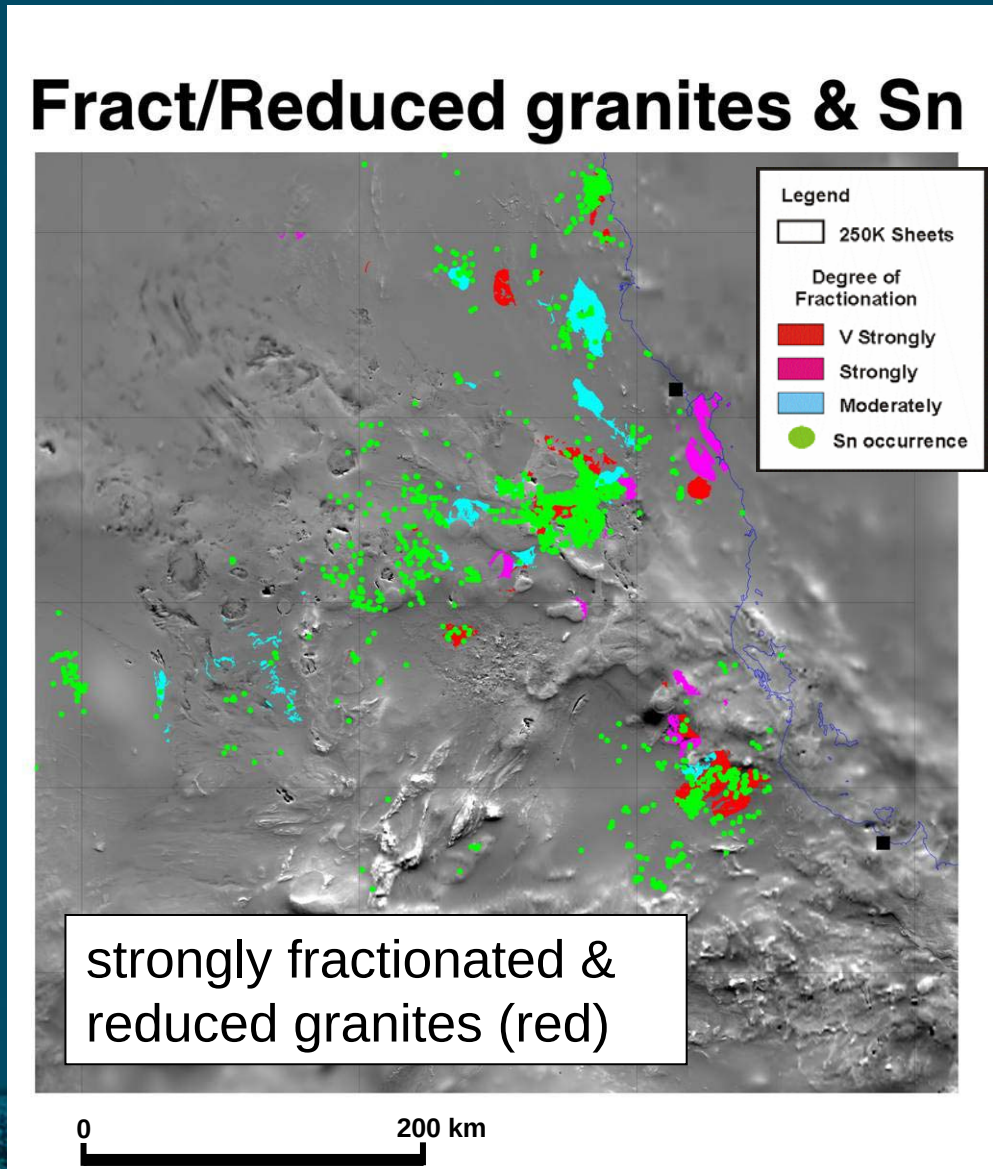


strongly fractionated & reduced granites (red)

Sn – North Qld

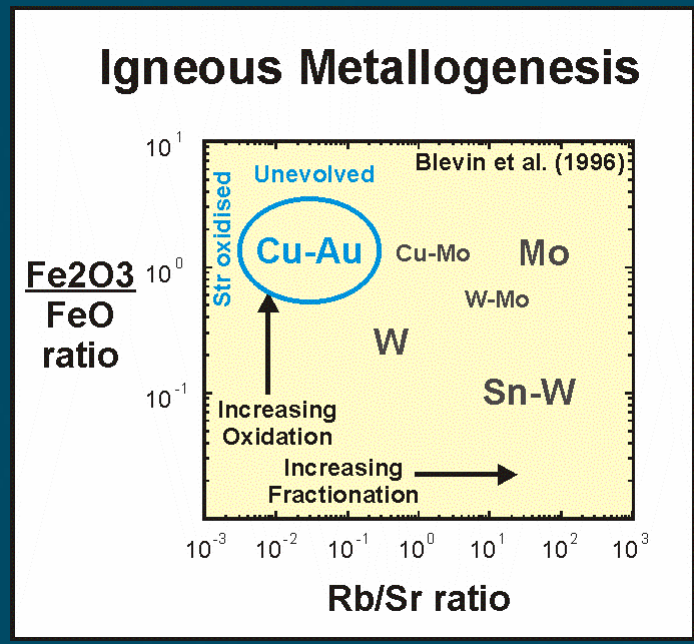

Igneous Metallogenesis
Blevin et al. (1996)
Fe2O3 / FeO ratio
Cu-Au
Cu-Mo
Mo
W-Mo
W
Sn-W
Reduced
Increasing Oxidation
Increasing Fractionation
Fractionated
Rb/Sr ratio


QUEENSLAND
GEOLOGICAL FRAMEWORK
Project Stages
1. North Qld
2. South Qld
CAIRNS
TOWNSVILLE


Fract/Reduced granites & Sn
Legend
250K Sheets
Degree of Fractionation
V Strongly
Strongly
Moderately
Sn occurrence
strongly fractionated & reduced granites (red)
0
200 km

Igneous Metallogenesis – Cu-Au

Strong relationship between Cu-Au mineralisation and intrusions (Blevin, 1996; Thompson et al, 1999)



Au-only systems controversial.

Cu-Au (& Cu): strongly oxidised, unevolved (compositionally) magmas.

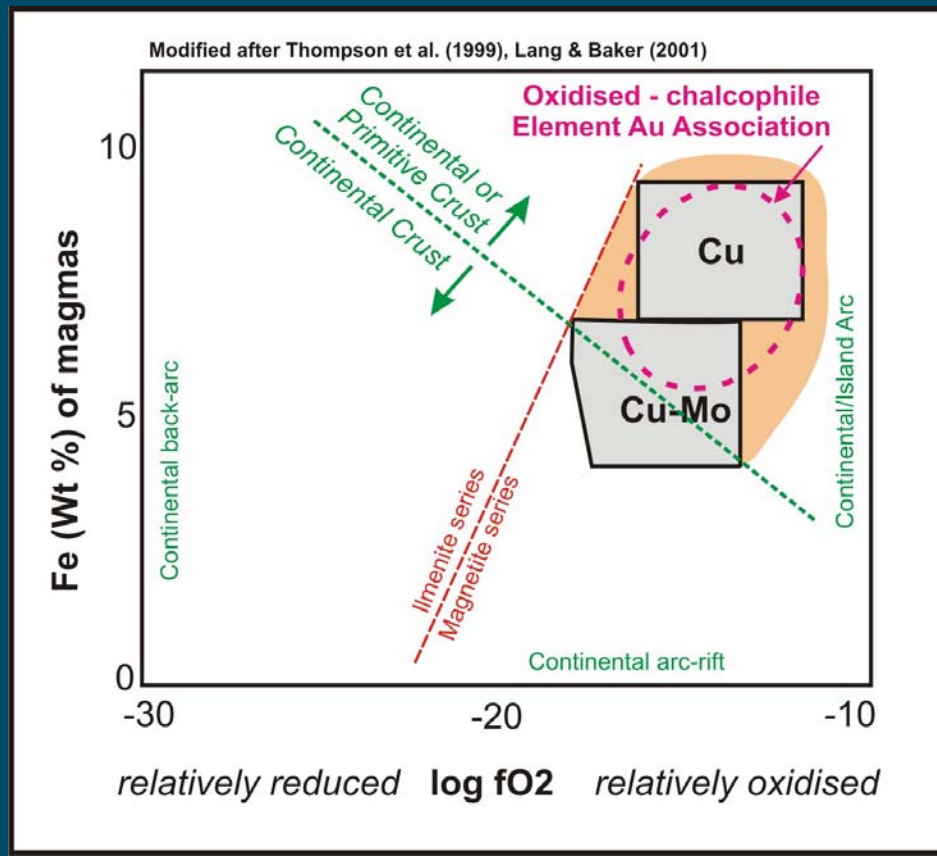
Why? Cu partitions into magmatic sulfides - buildup is preferred in very oxidised magmas where reduced S is absent.

Igneous Metallogenesis – Cu-Au, Cu

Thompson et al. (1999) showed not only:

- strongly oxidised,
- compositionally unevolved magmas, but also

- primitive crust



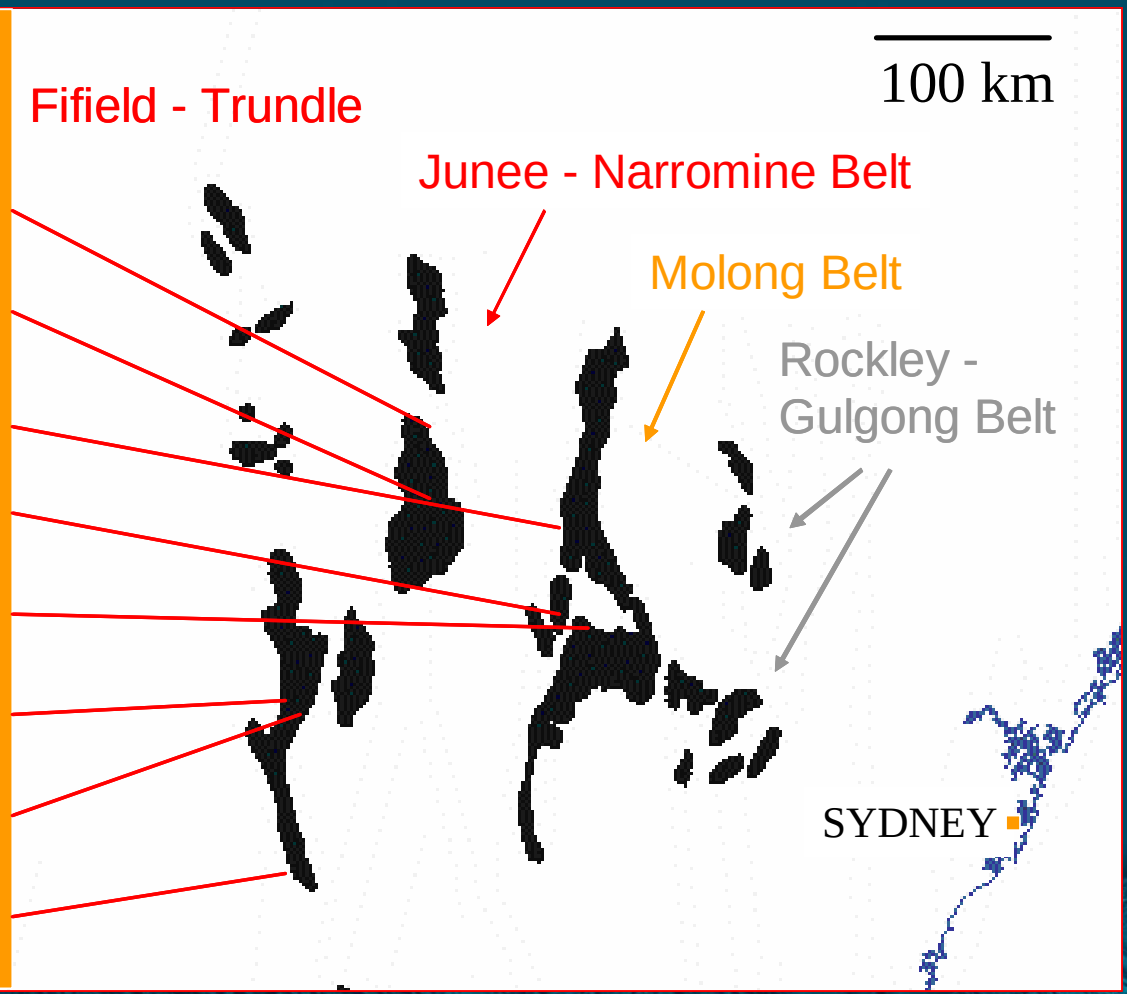
Cu-Au: strongly oxidised, compositionally unevolved magmas, in primitive crustal settings

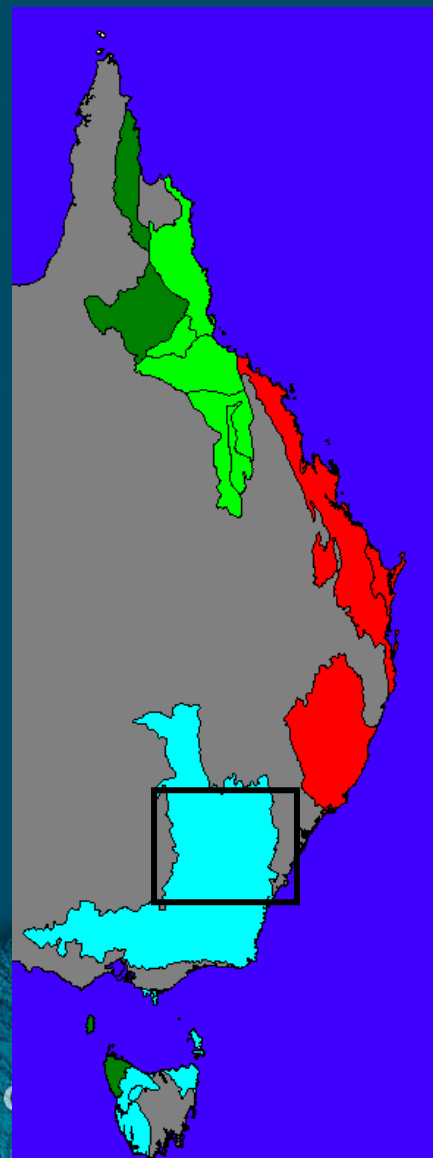
Cu-Au intrusion-related systems - NSW.

Macquarie arc: Ordovician intraoceanic island arc

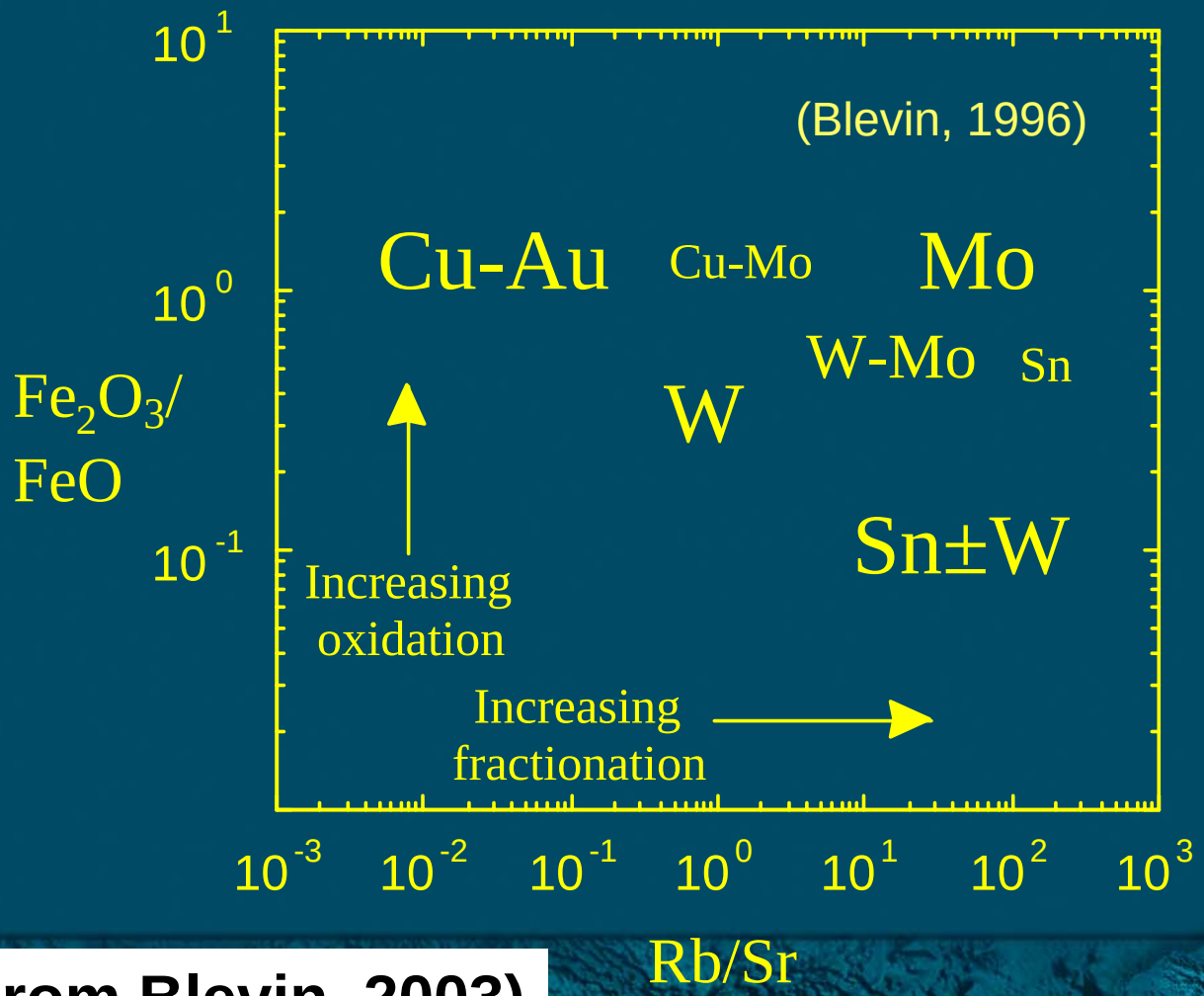
(e.g., Glen, 2005)

Peak Hill
Goonumbla
Cu Hill
Cargo
Cadia
Cowal
Marsden
Gidginbung





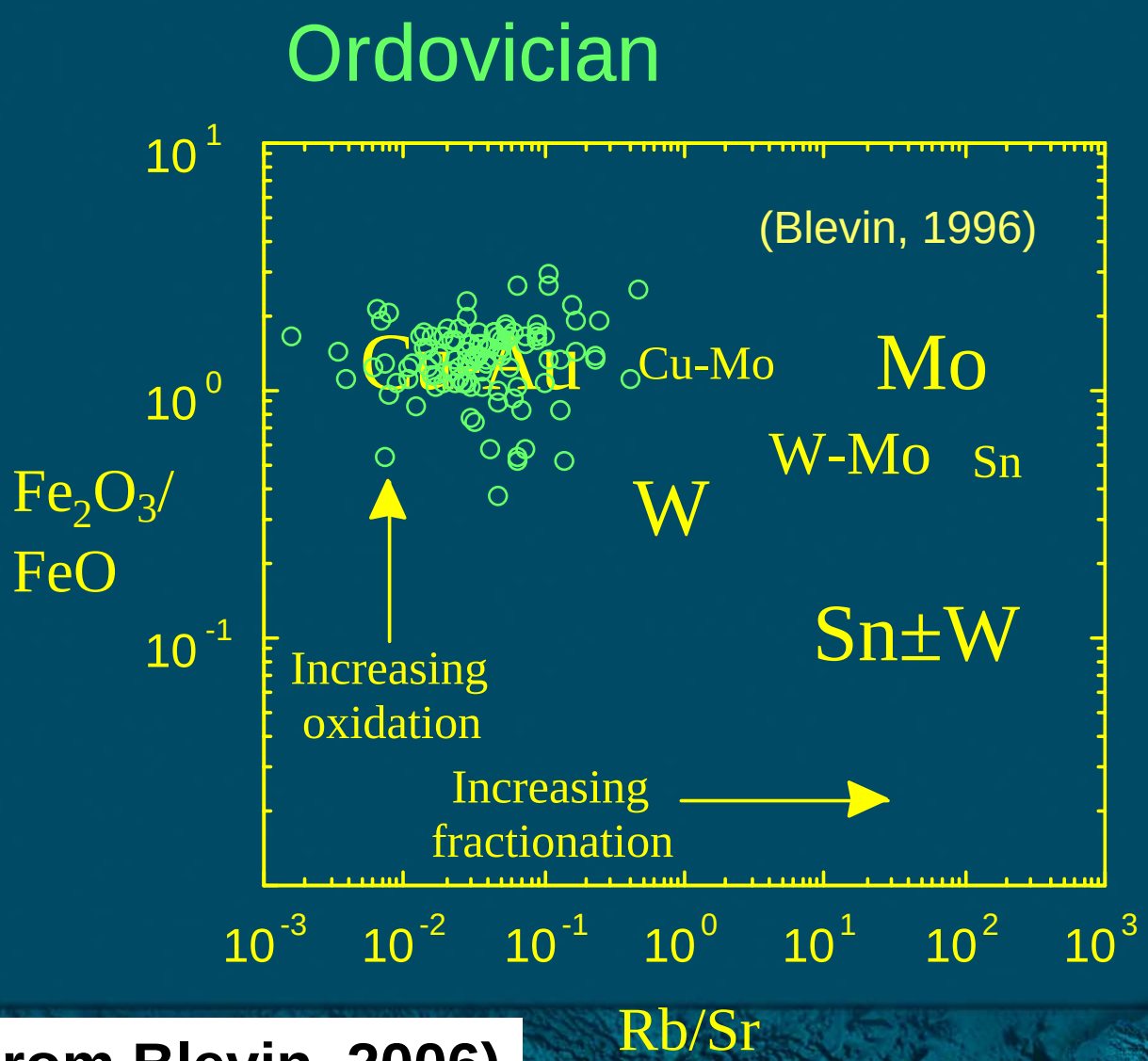
Lachlan Fold Belt Magmatism



Ordovician of LFB most prospective for porphyry Cu-Au

(From Blevin, 2003)

Lachlan Fold Belt Magmatism



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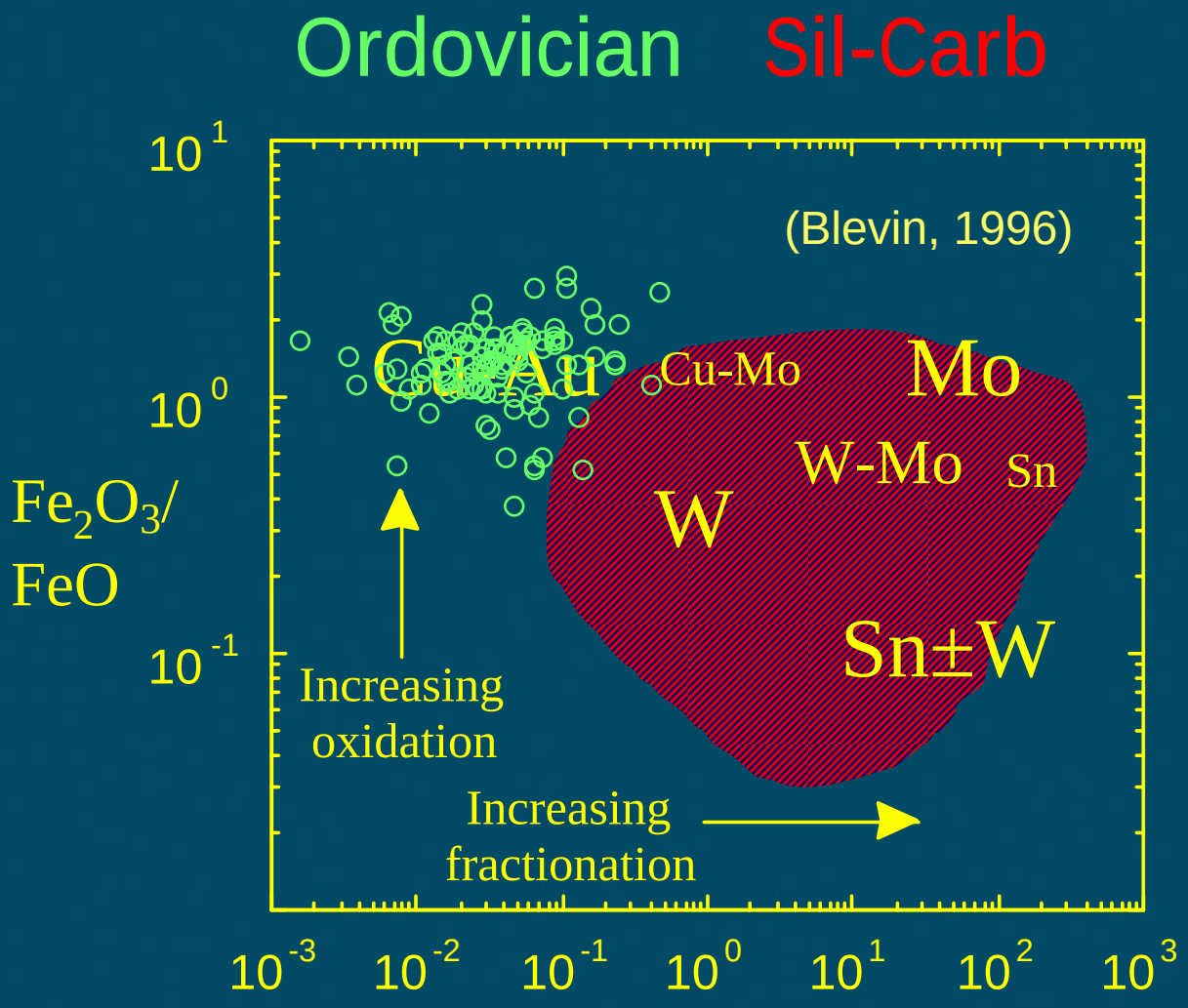
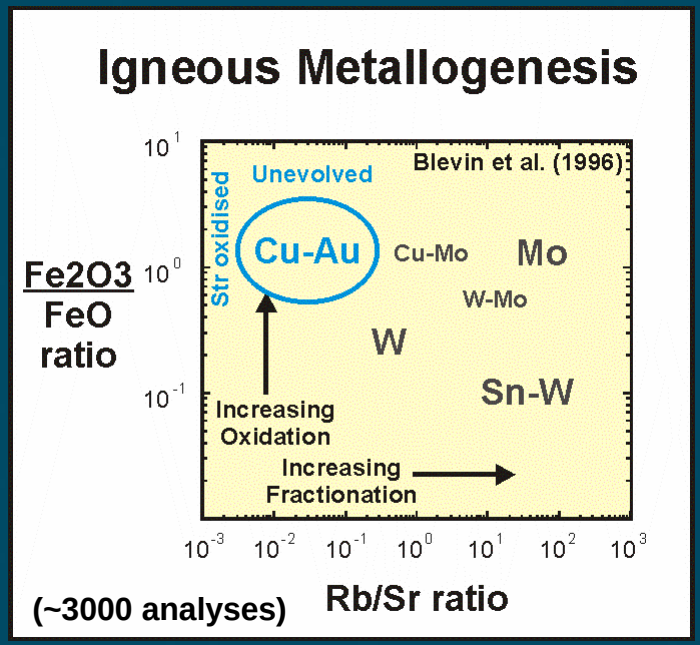
Lachlan Fold Belt Magmatism

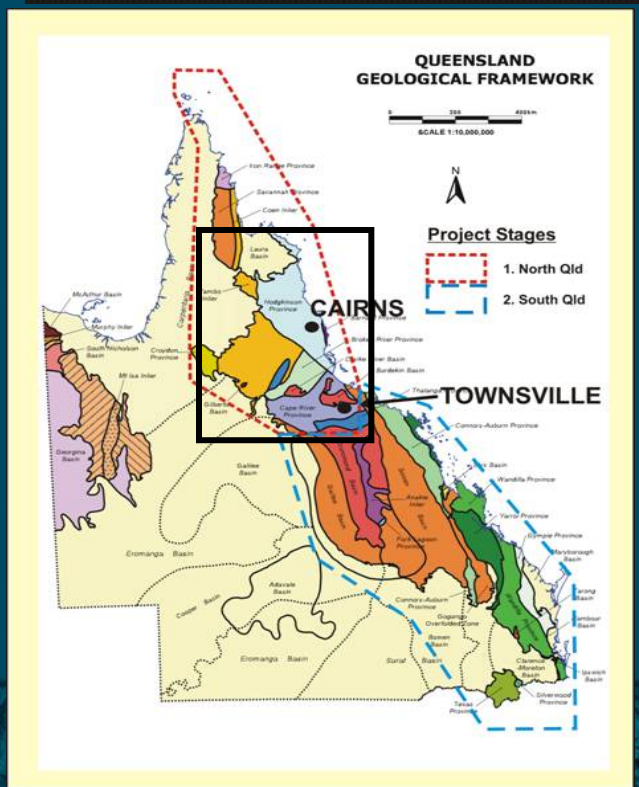


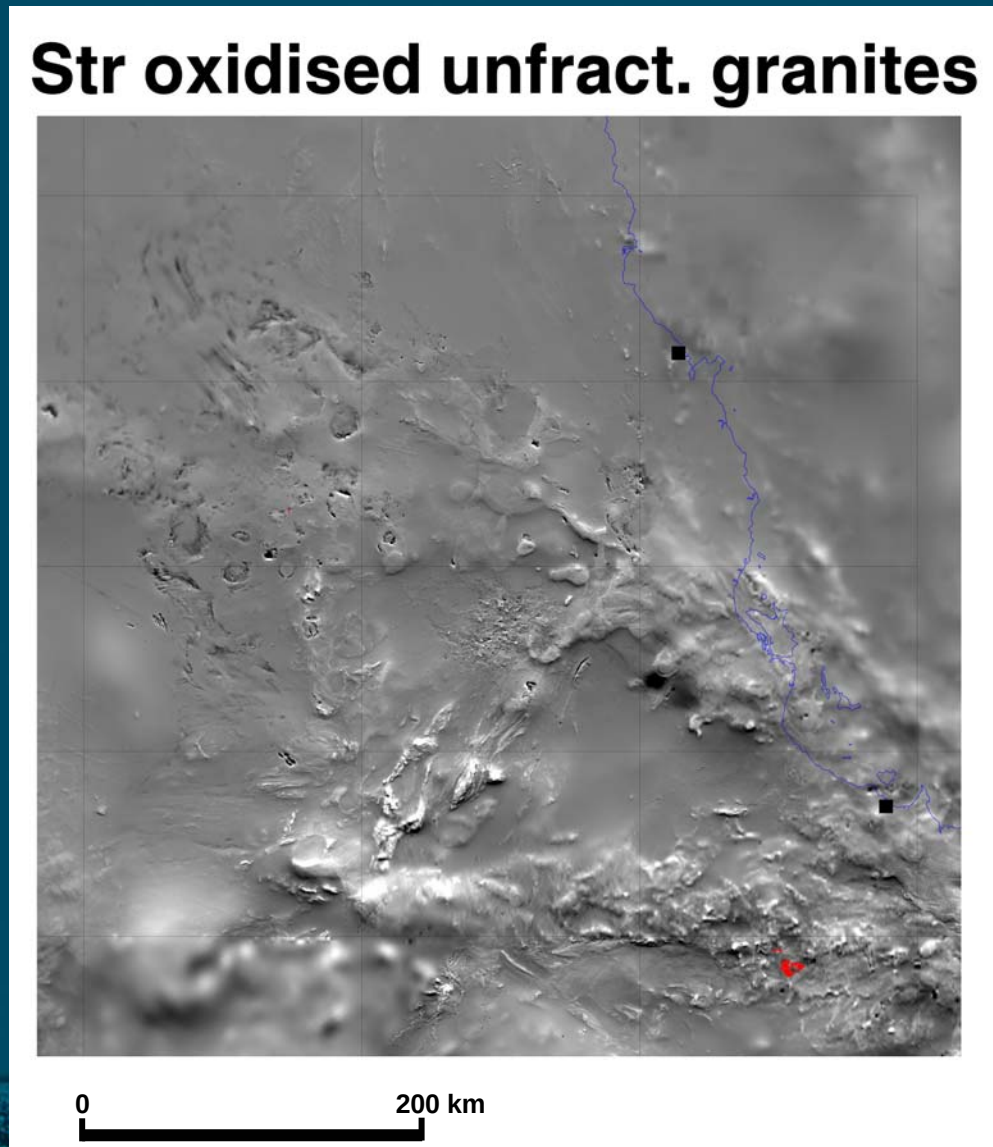
Ordovician of LFB most prospective for porphyry Cu-Au

(From Blevin, 2006)

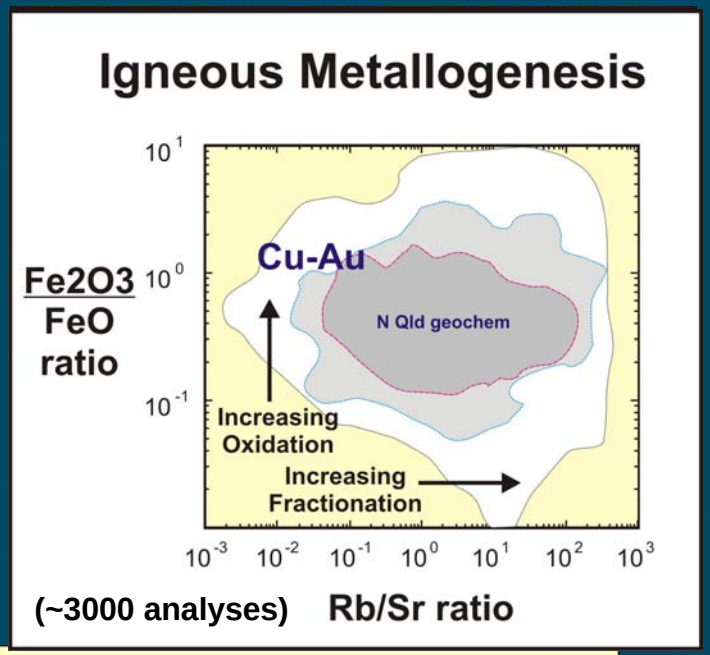
Cu-Au – North Qld

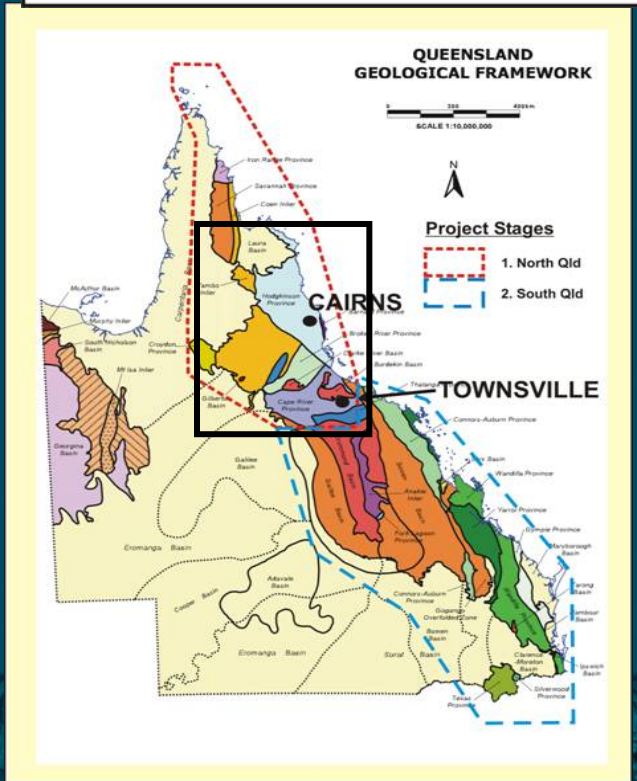


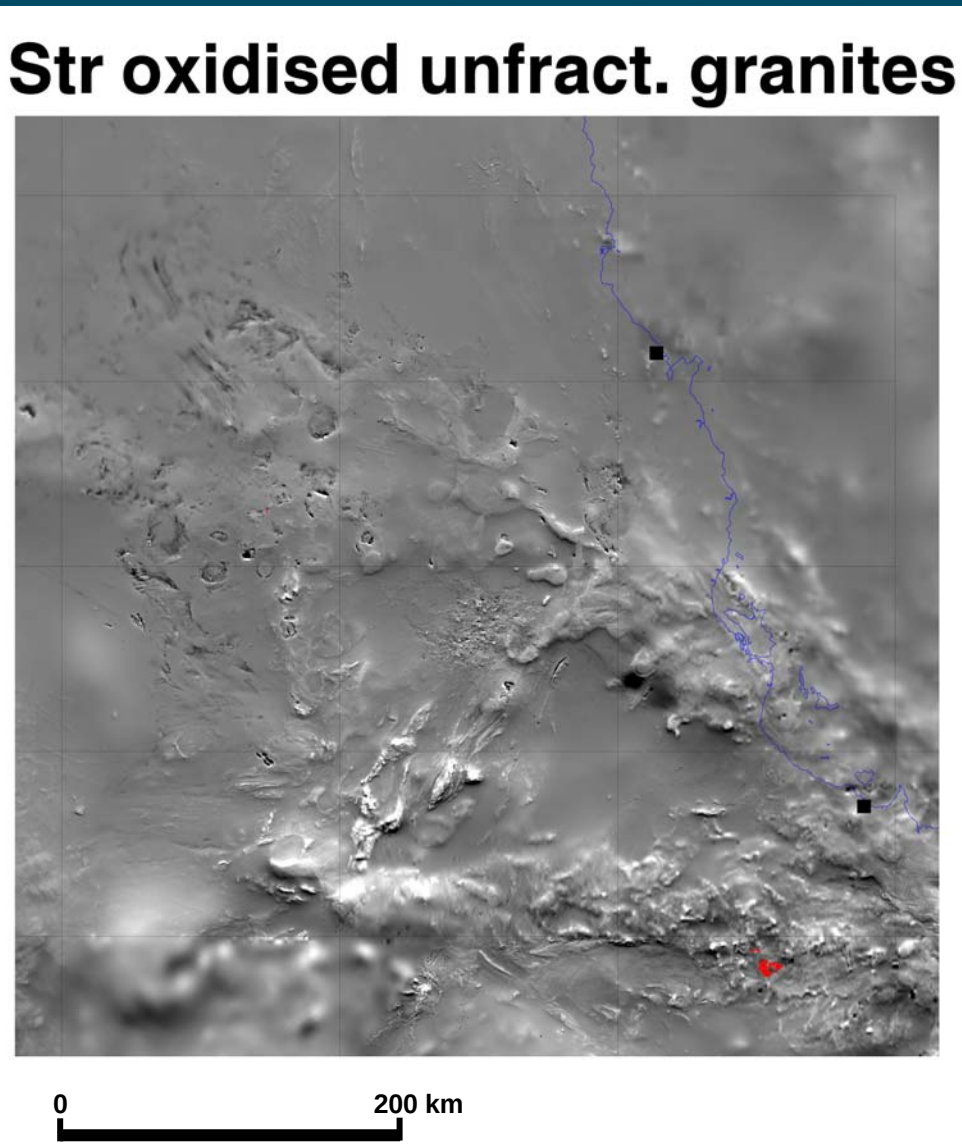


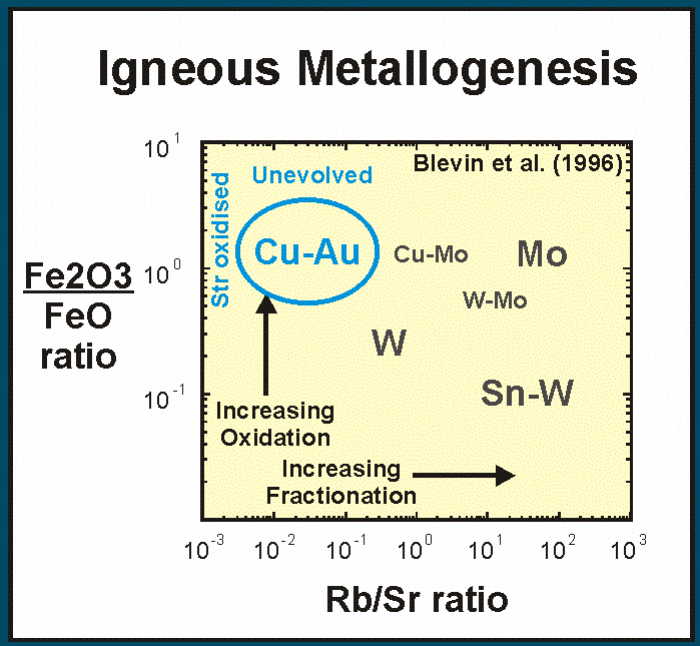


Cu-Au – North Qld



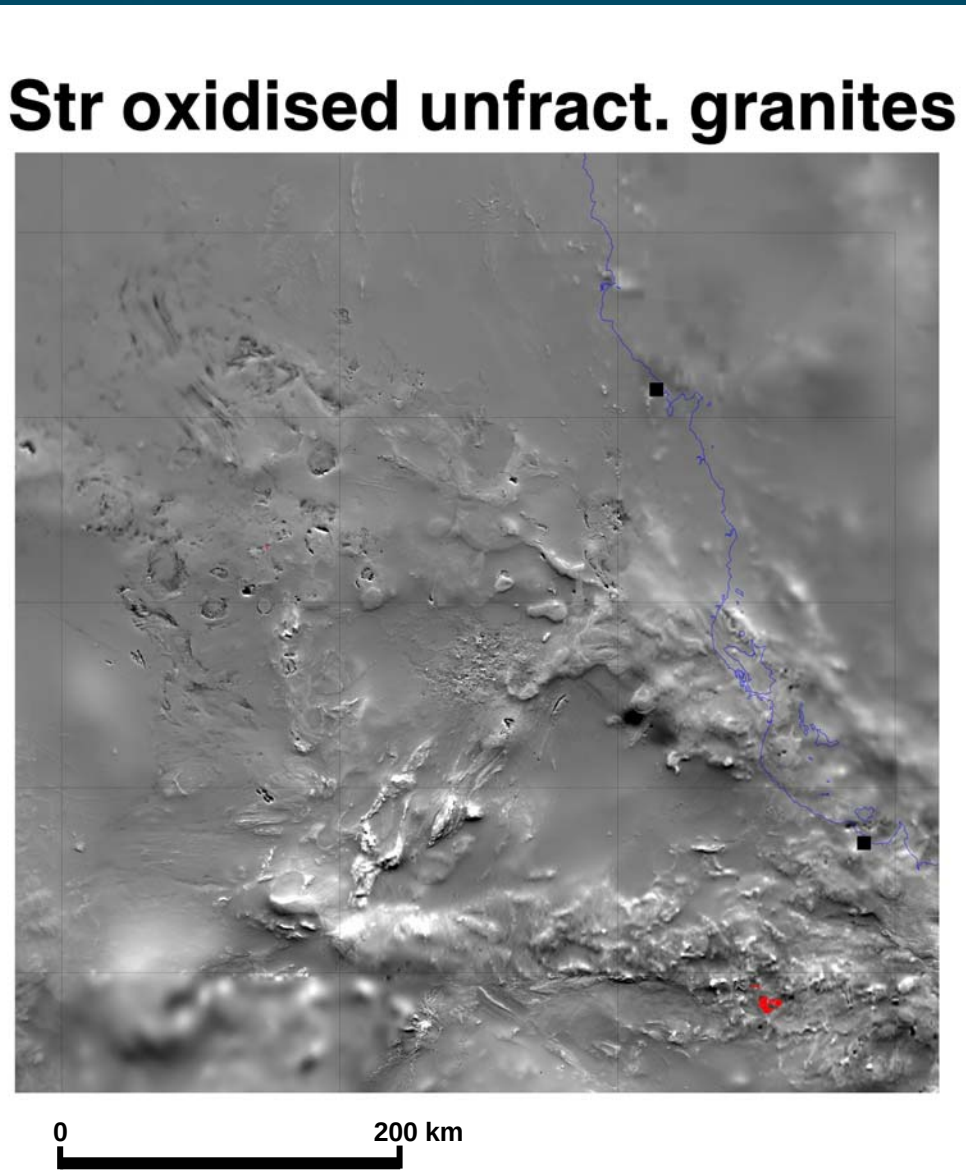




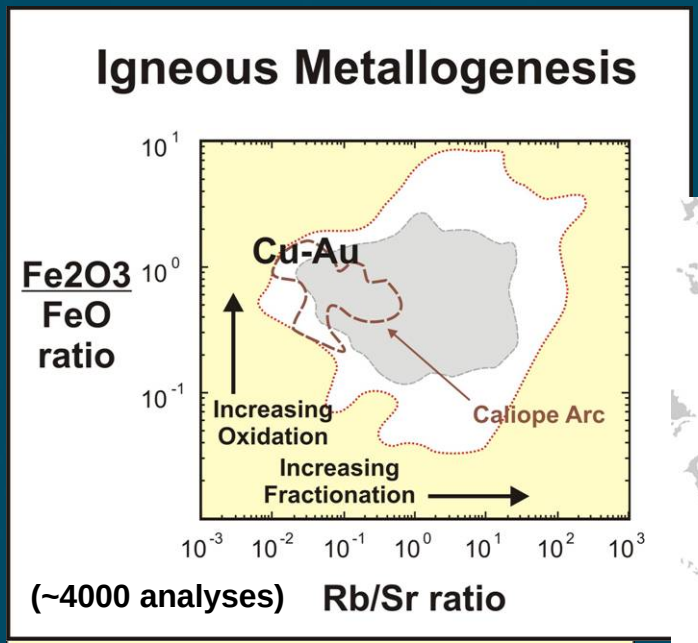


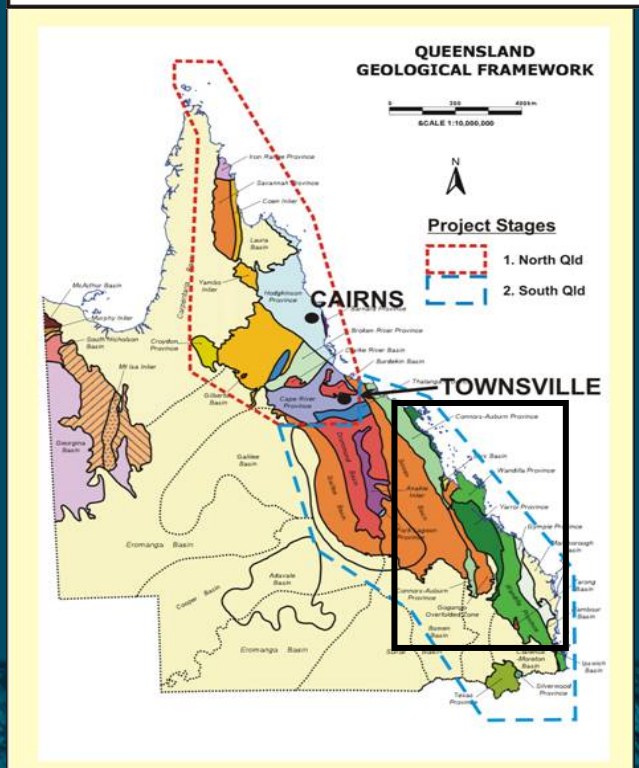
Cu-Au – North Qld

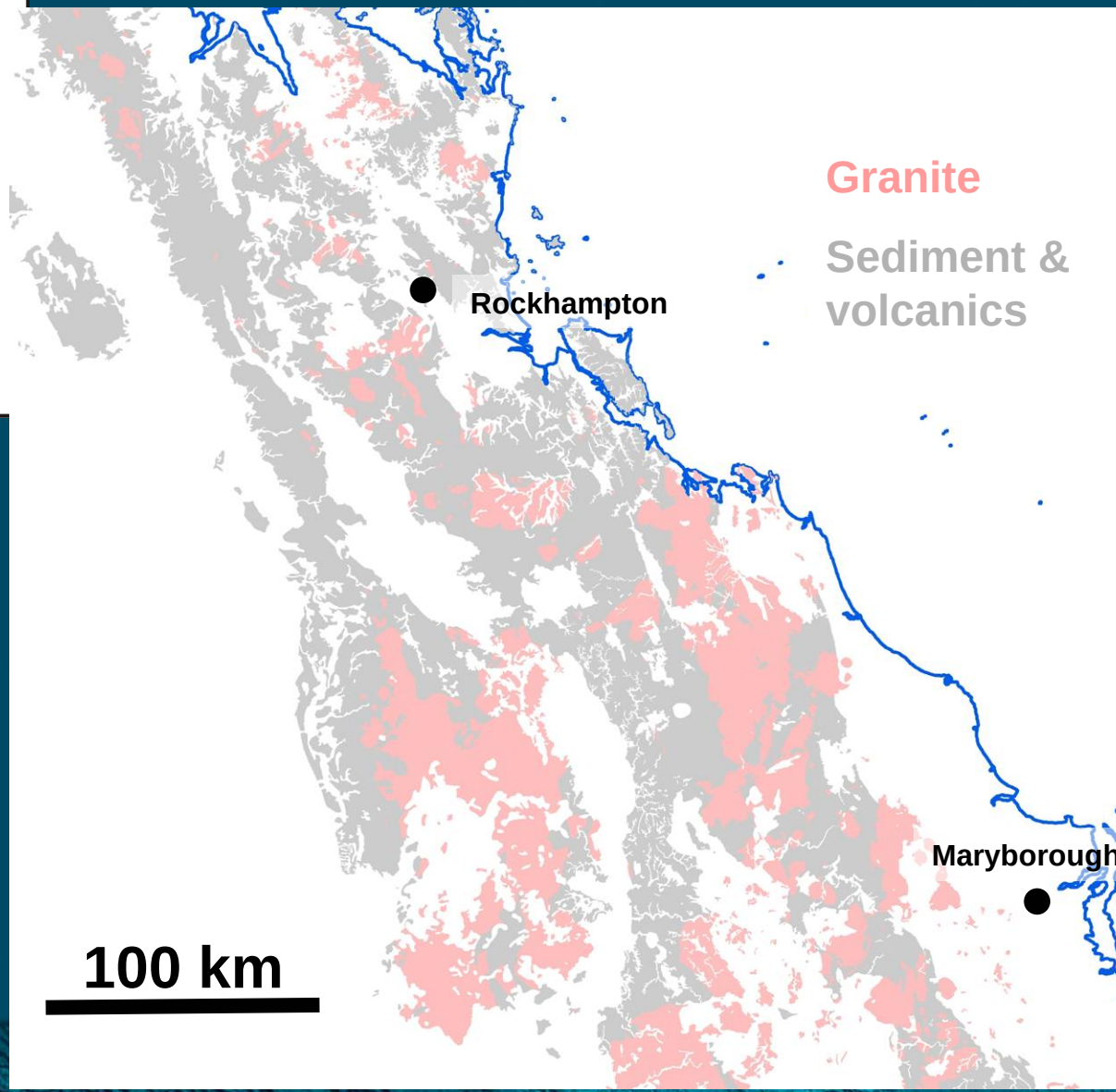
- unevolved, strongly oxidised granites largely absent from north Qld
- as are significant Cu-Au deposits



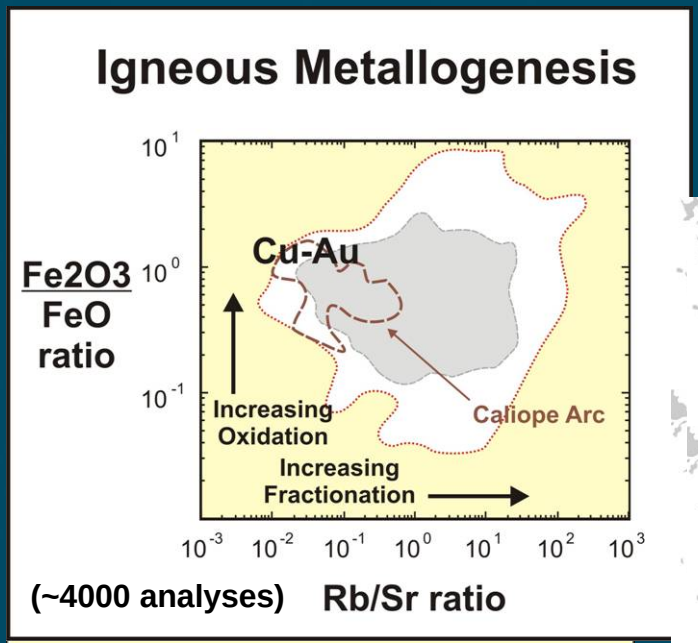
Cu-Au - New England

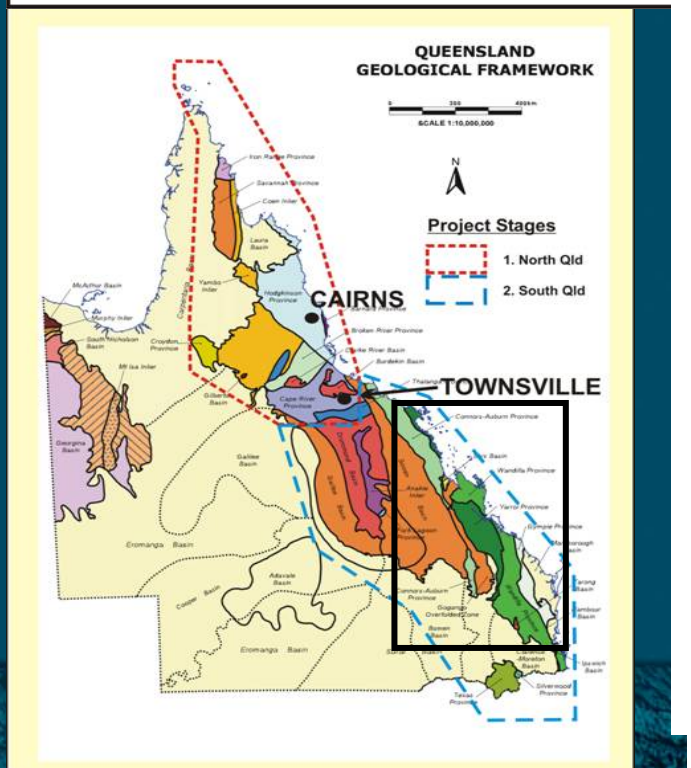






Cu-Au - New England





Oxidised & primitive grt

Granite

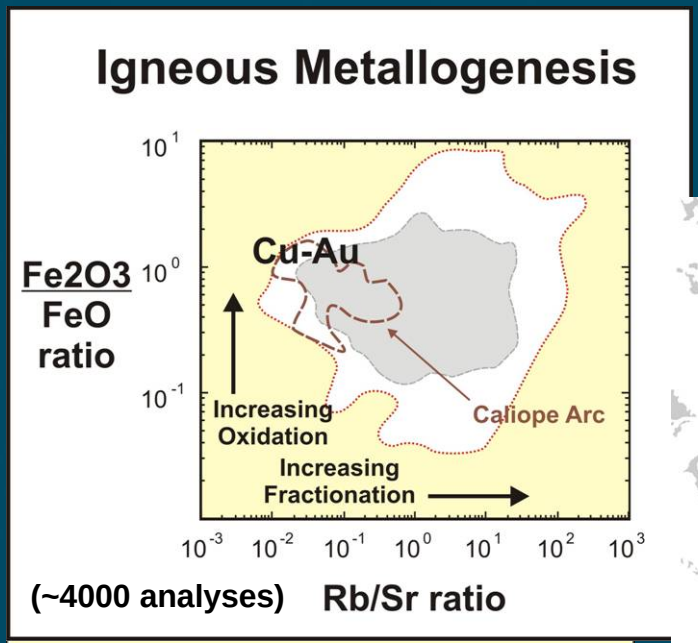
Sediment & volcanics

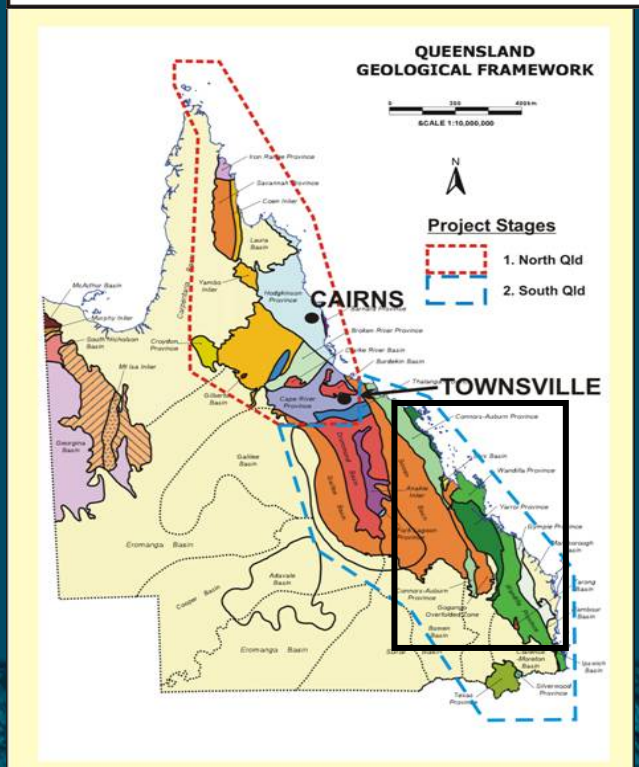
Rockhampton

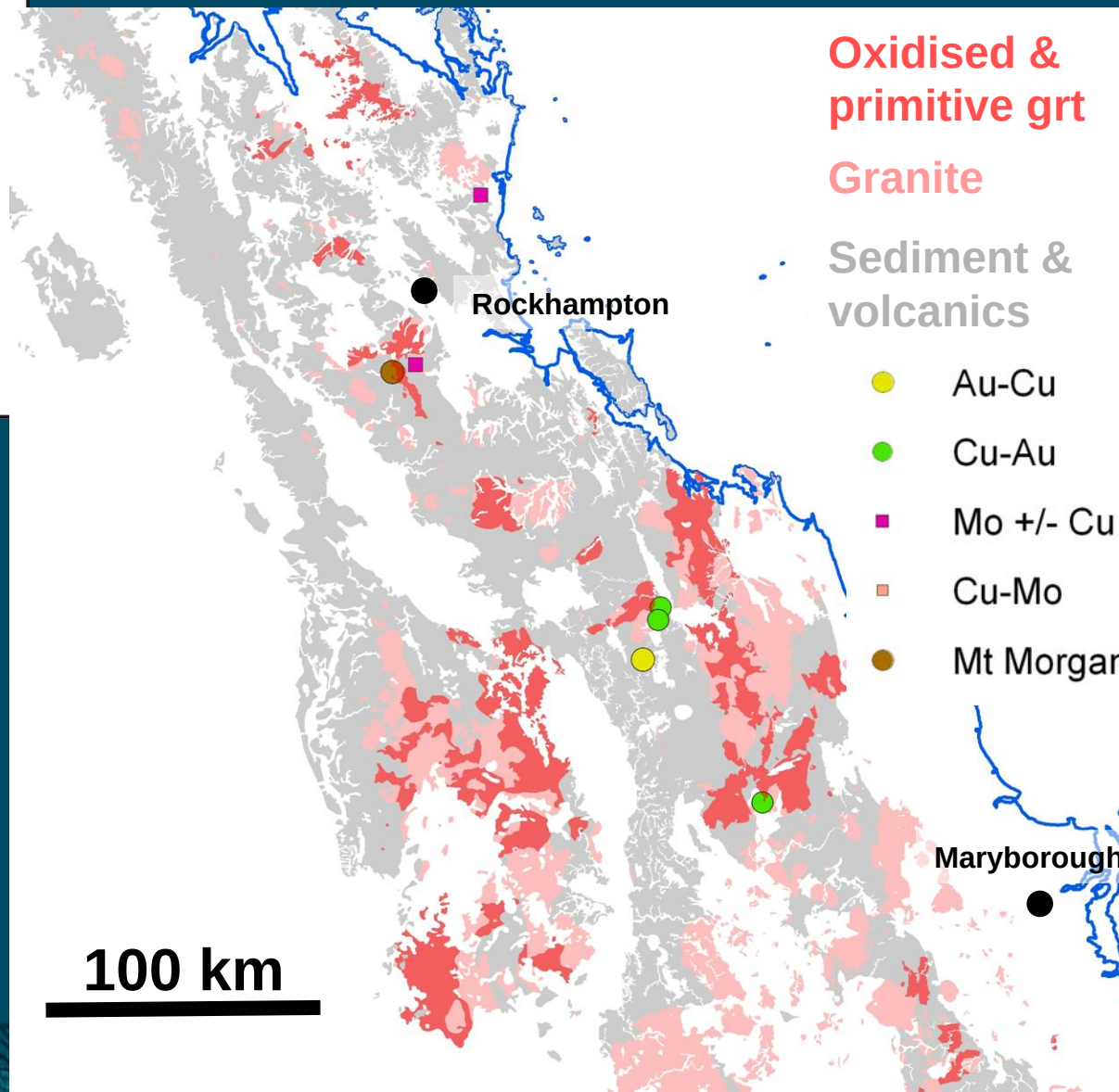
Maryborough

100 km

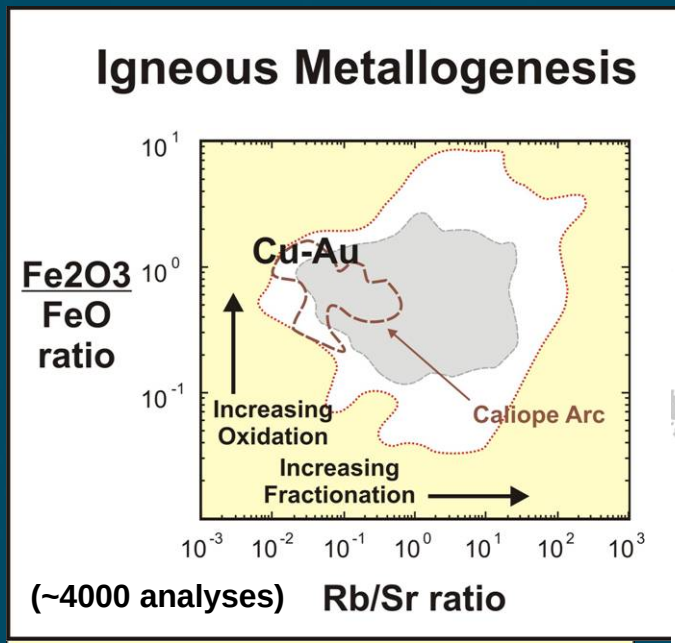
Cu-Au - New England

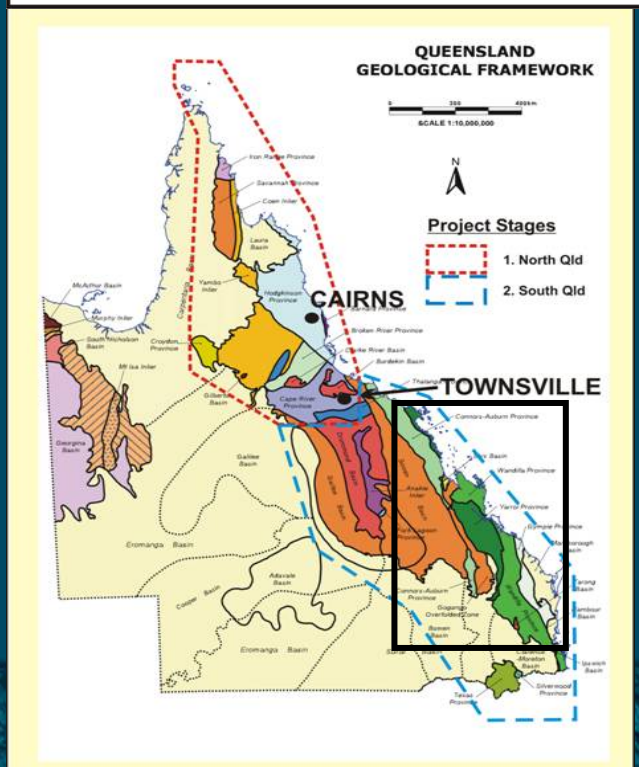


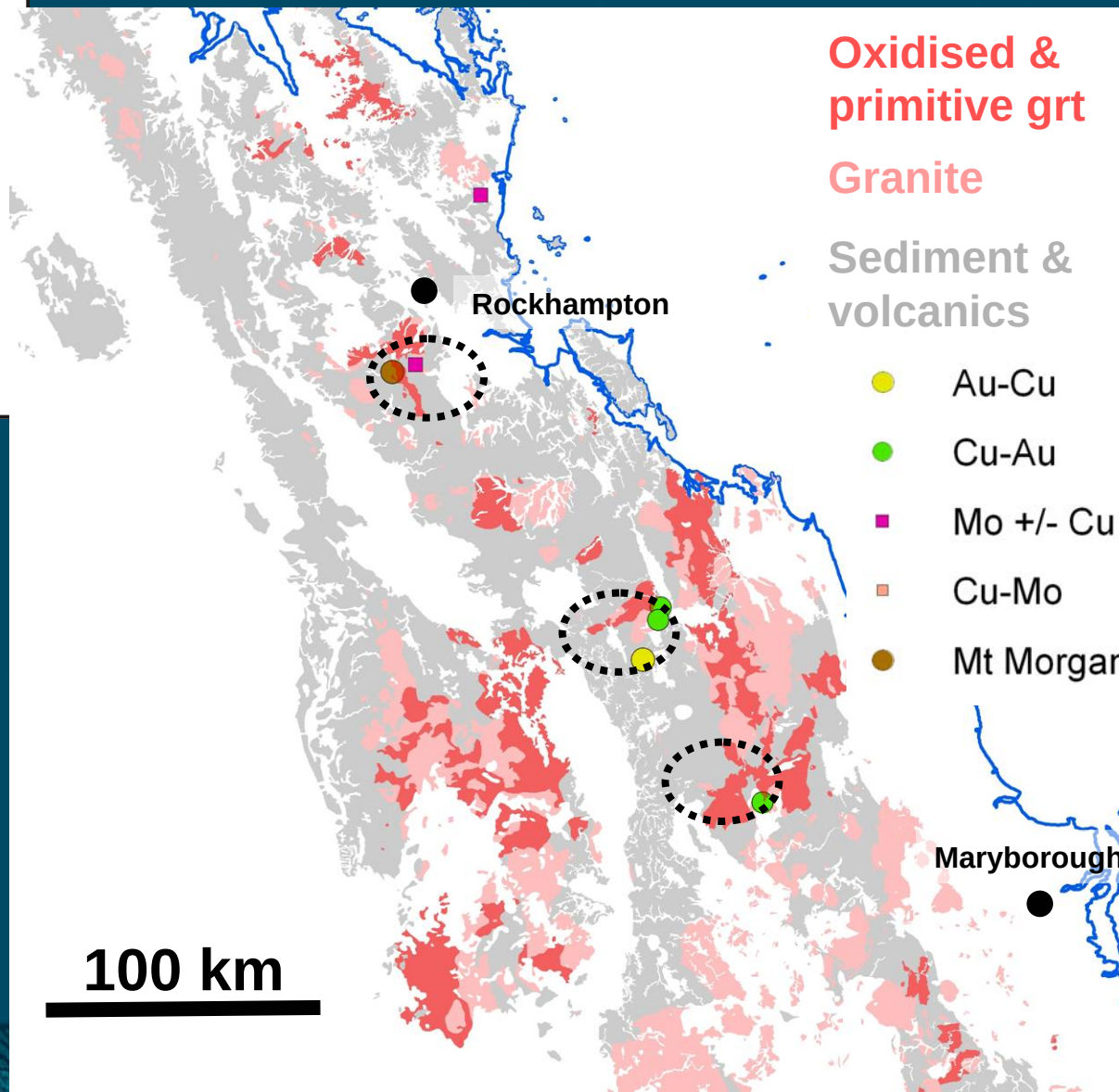




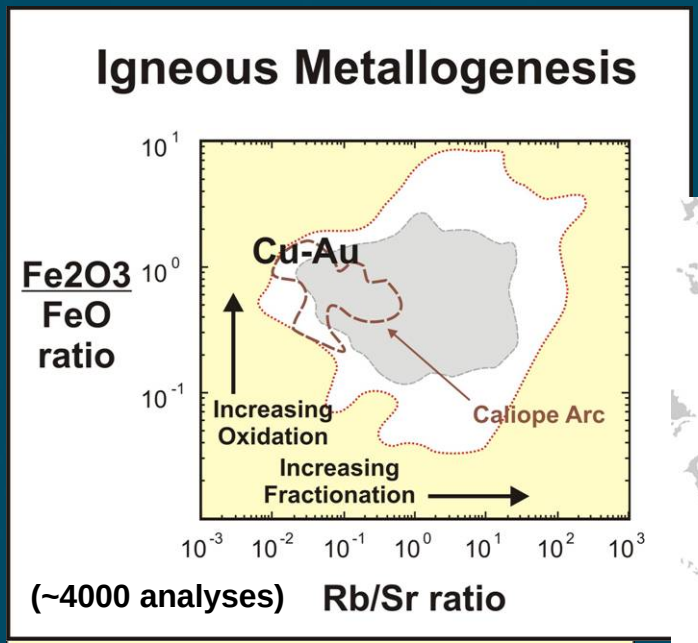
Cu-Au - New England

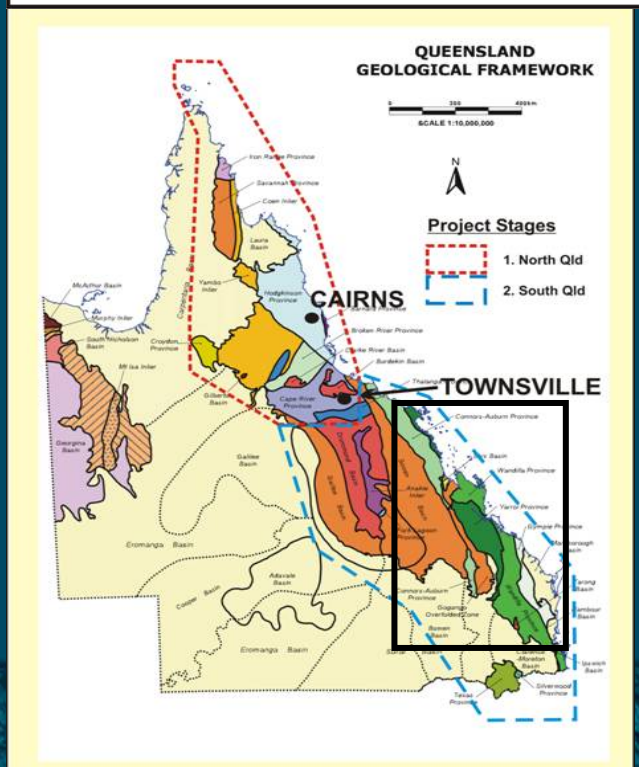


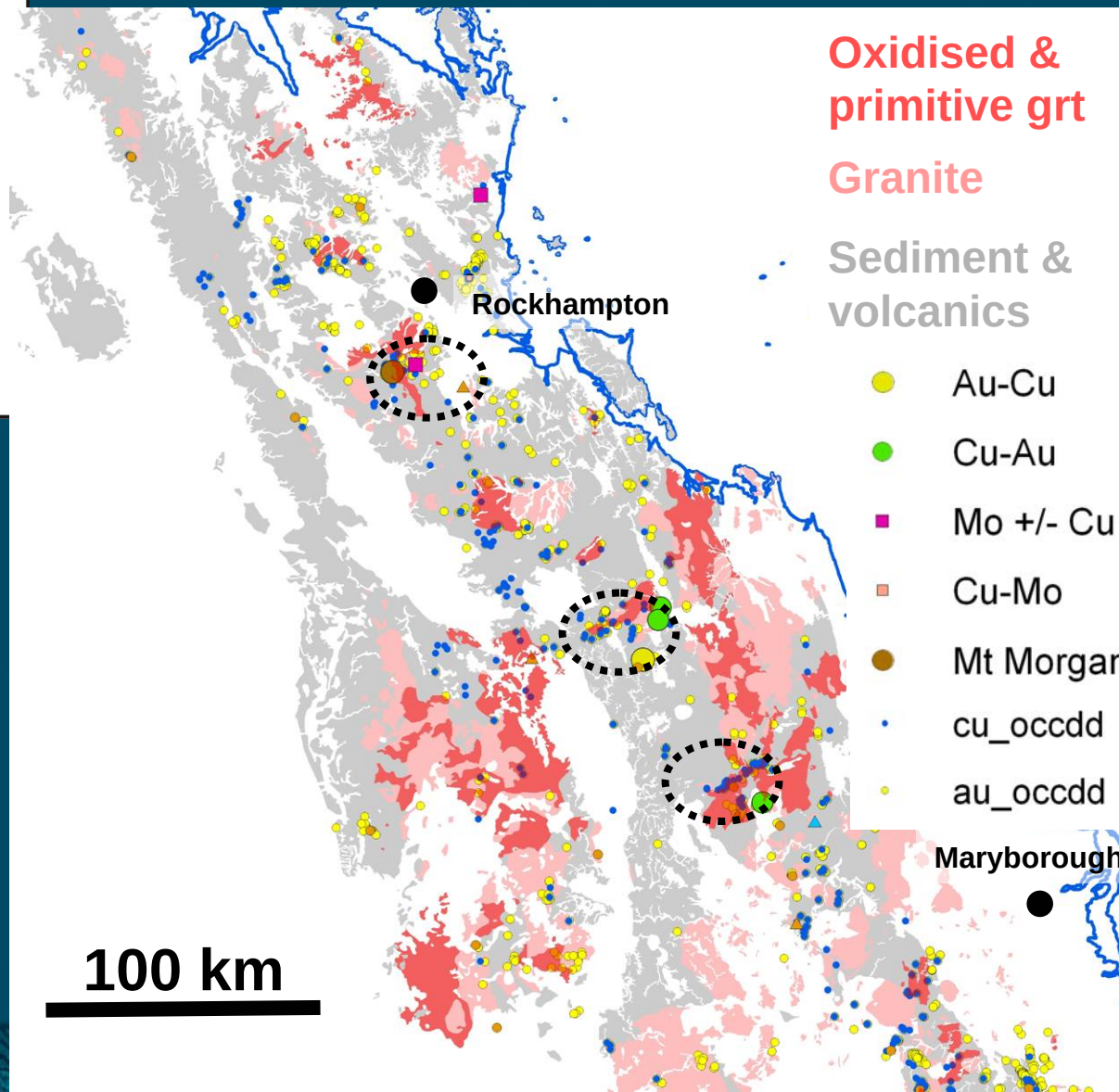




Cu-Au - New England







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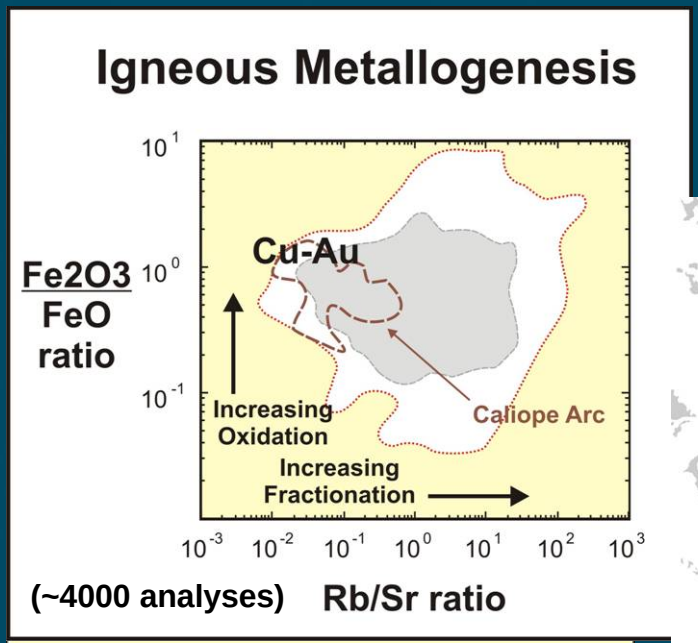
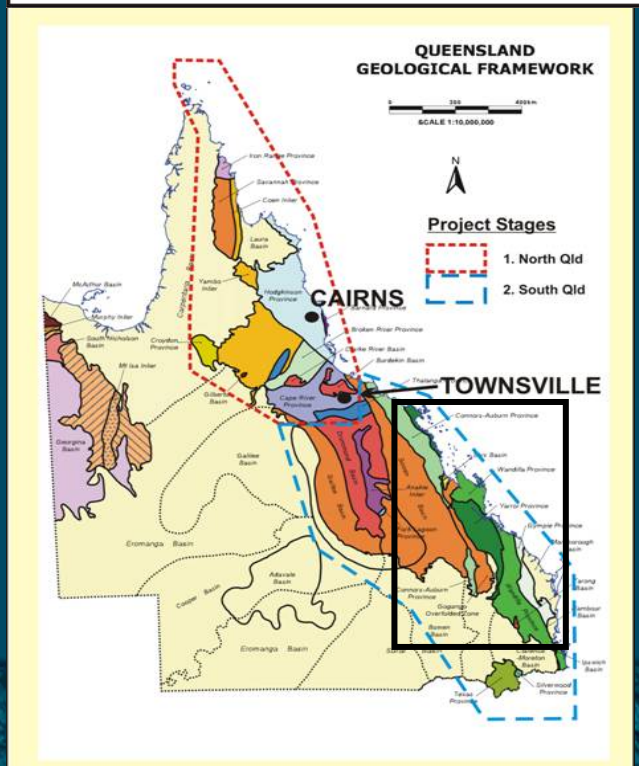
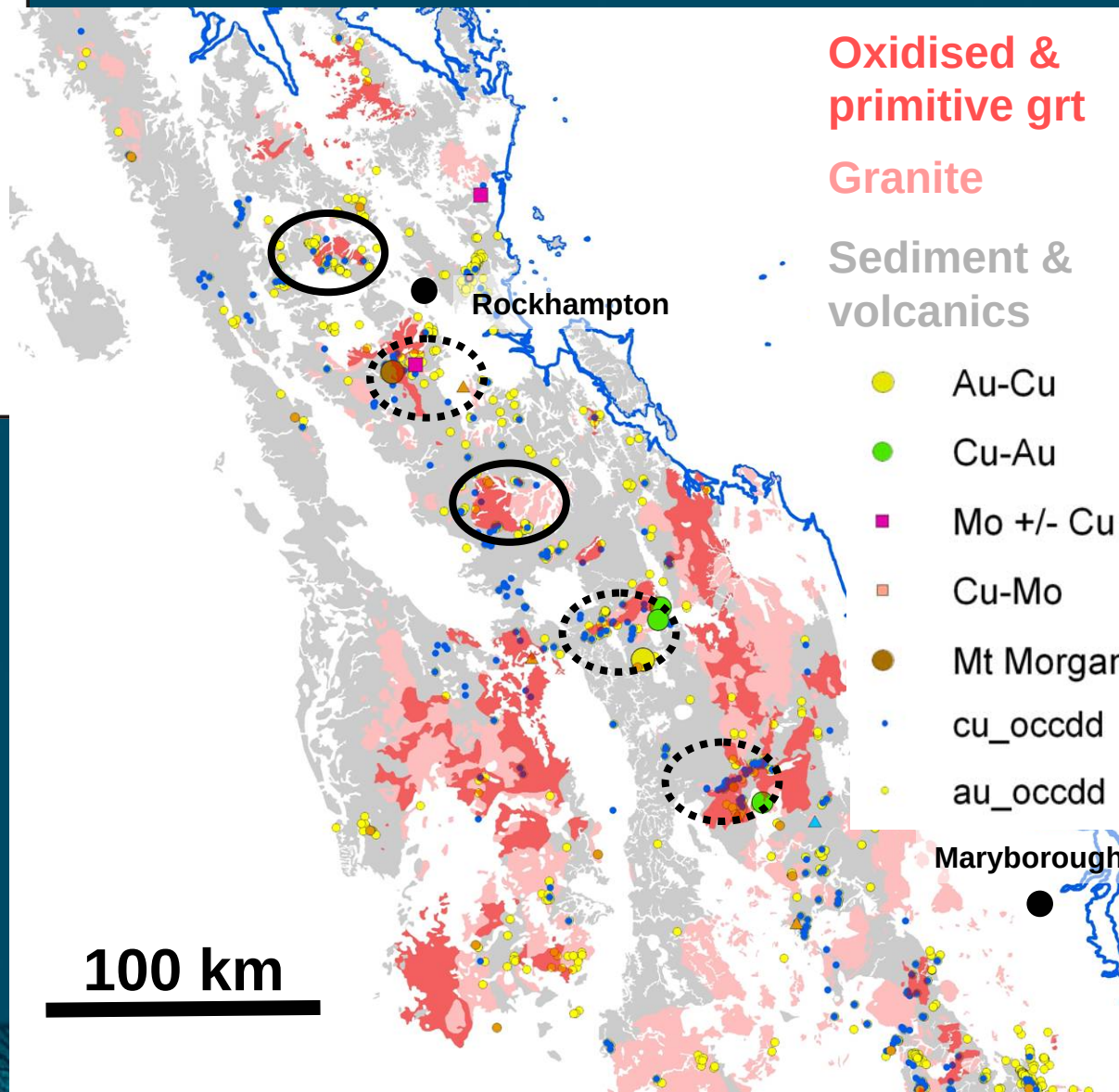
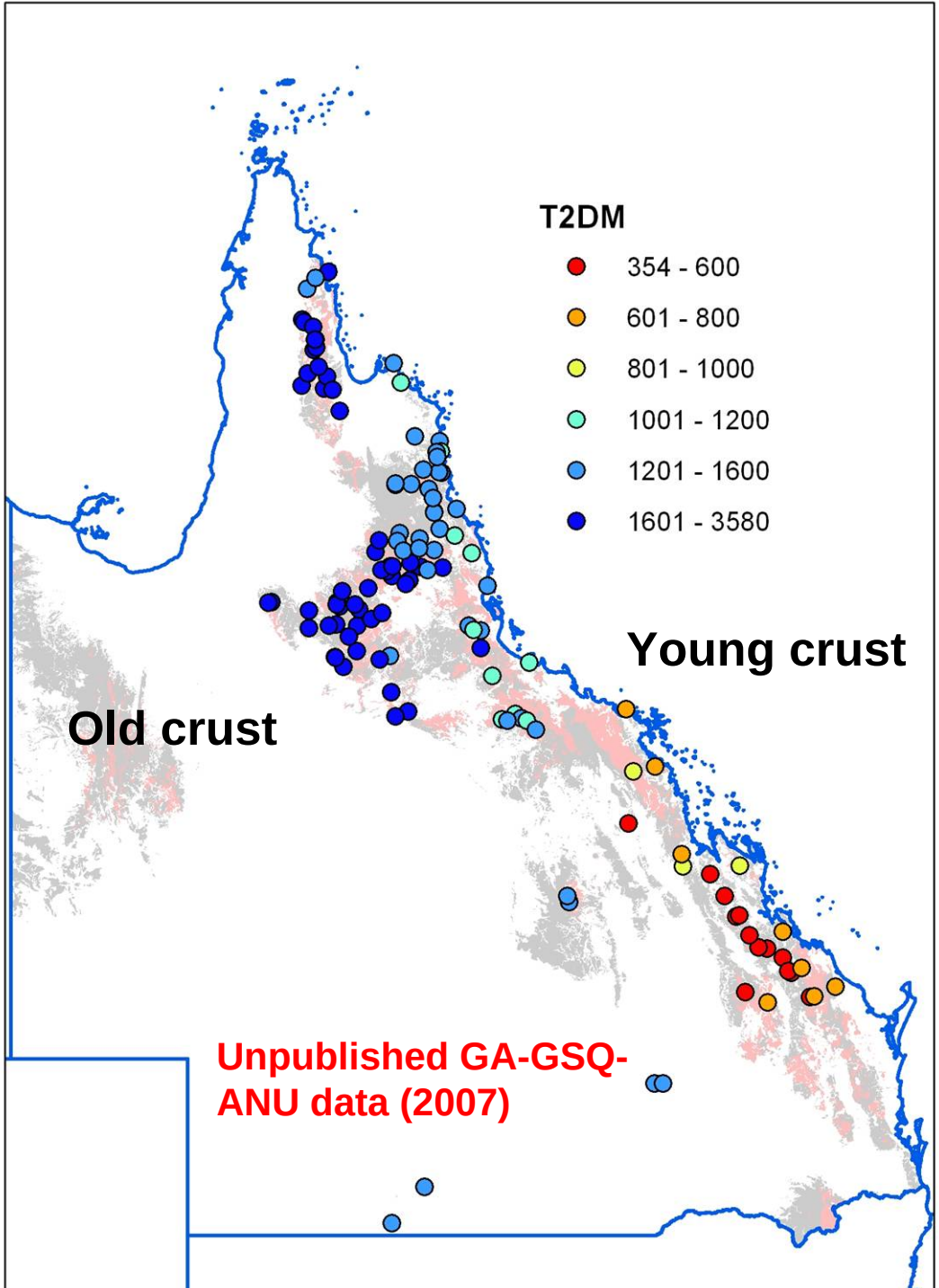






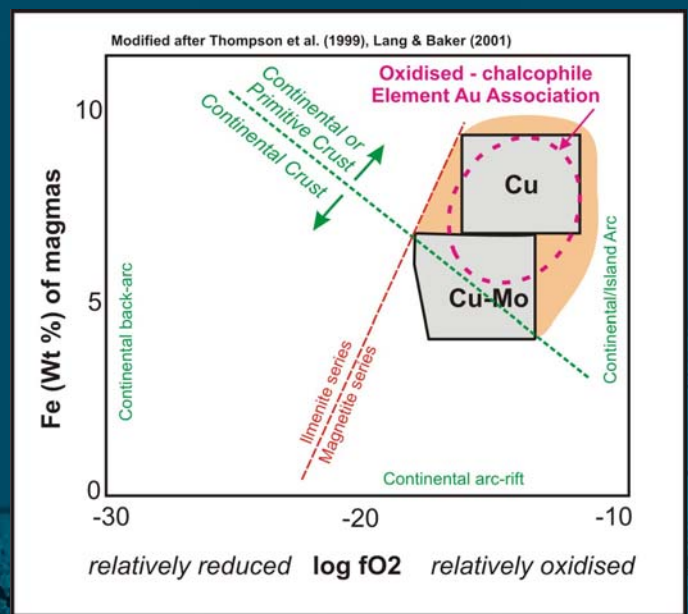


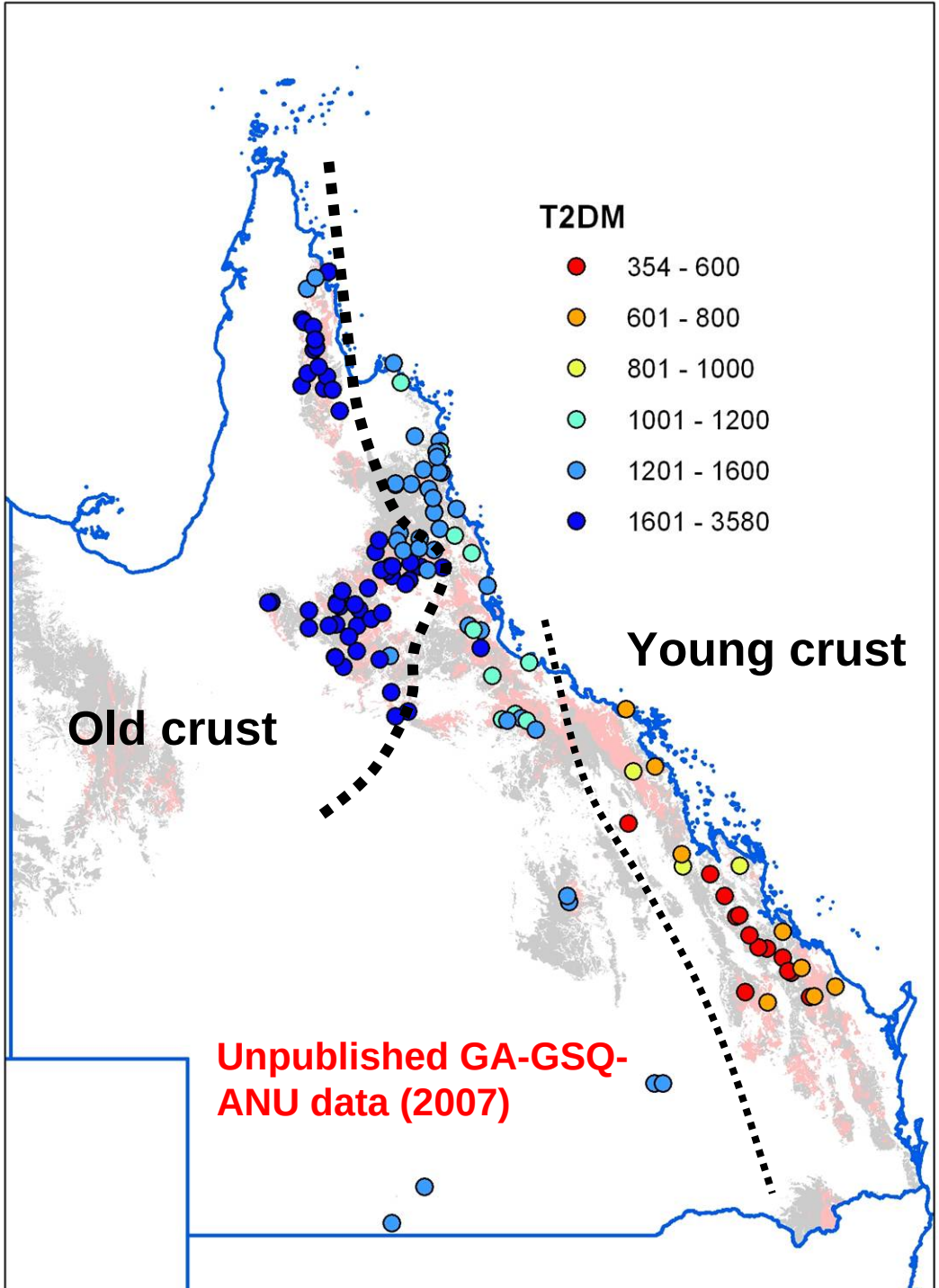
Nd isotopes

Use Sm-Nd model ages to map crustal ages

These show:

New England is more primitive (younger) than rest of Qld.





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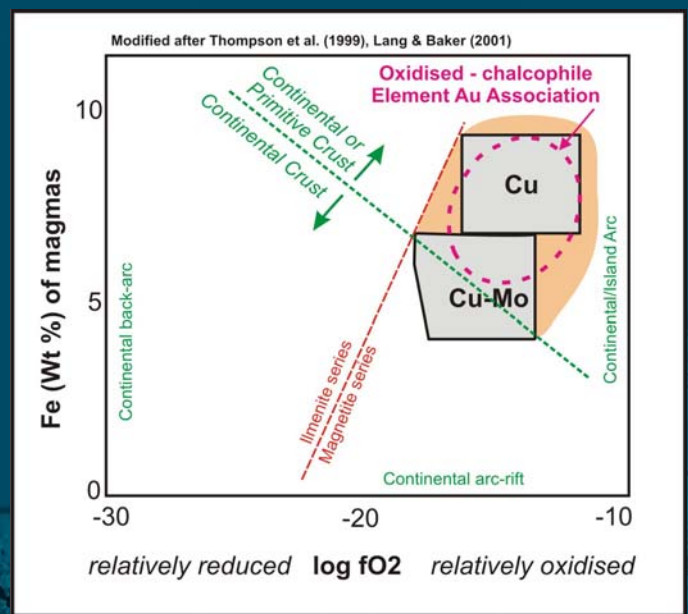

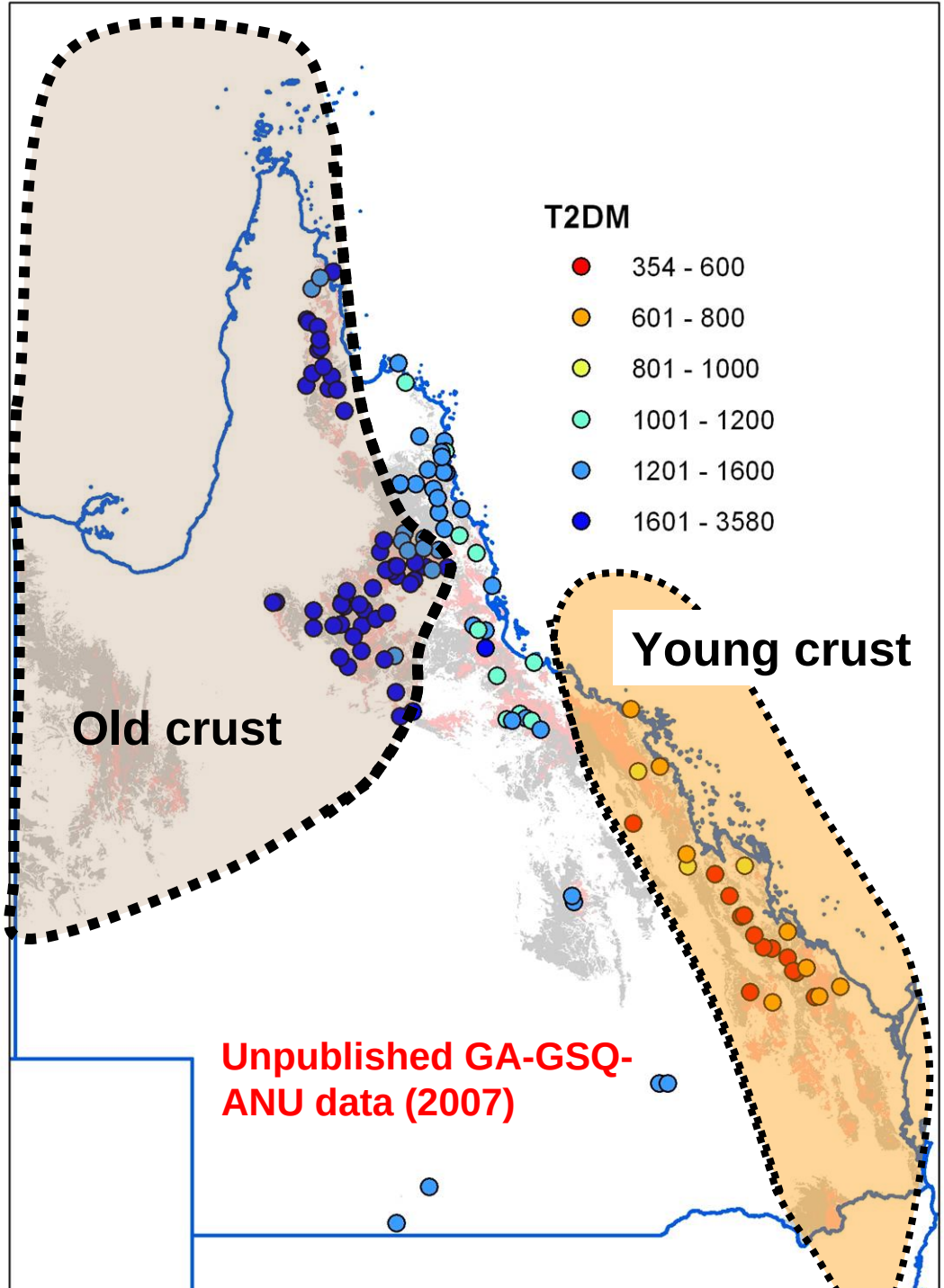

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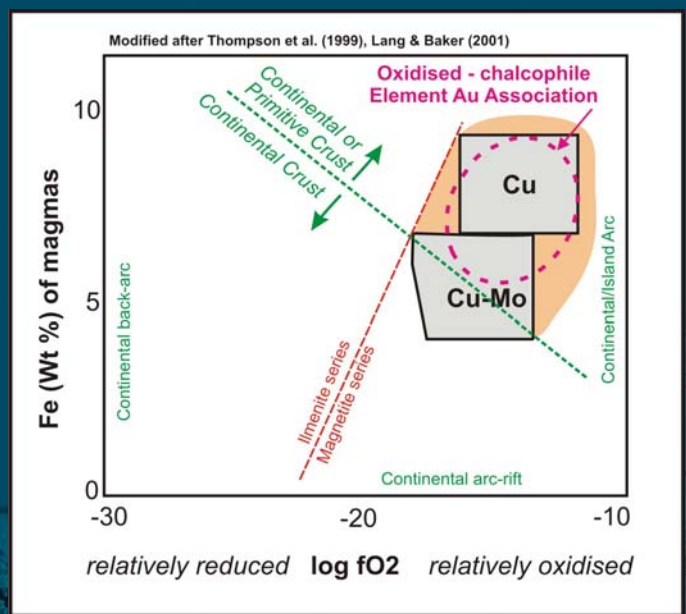

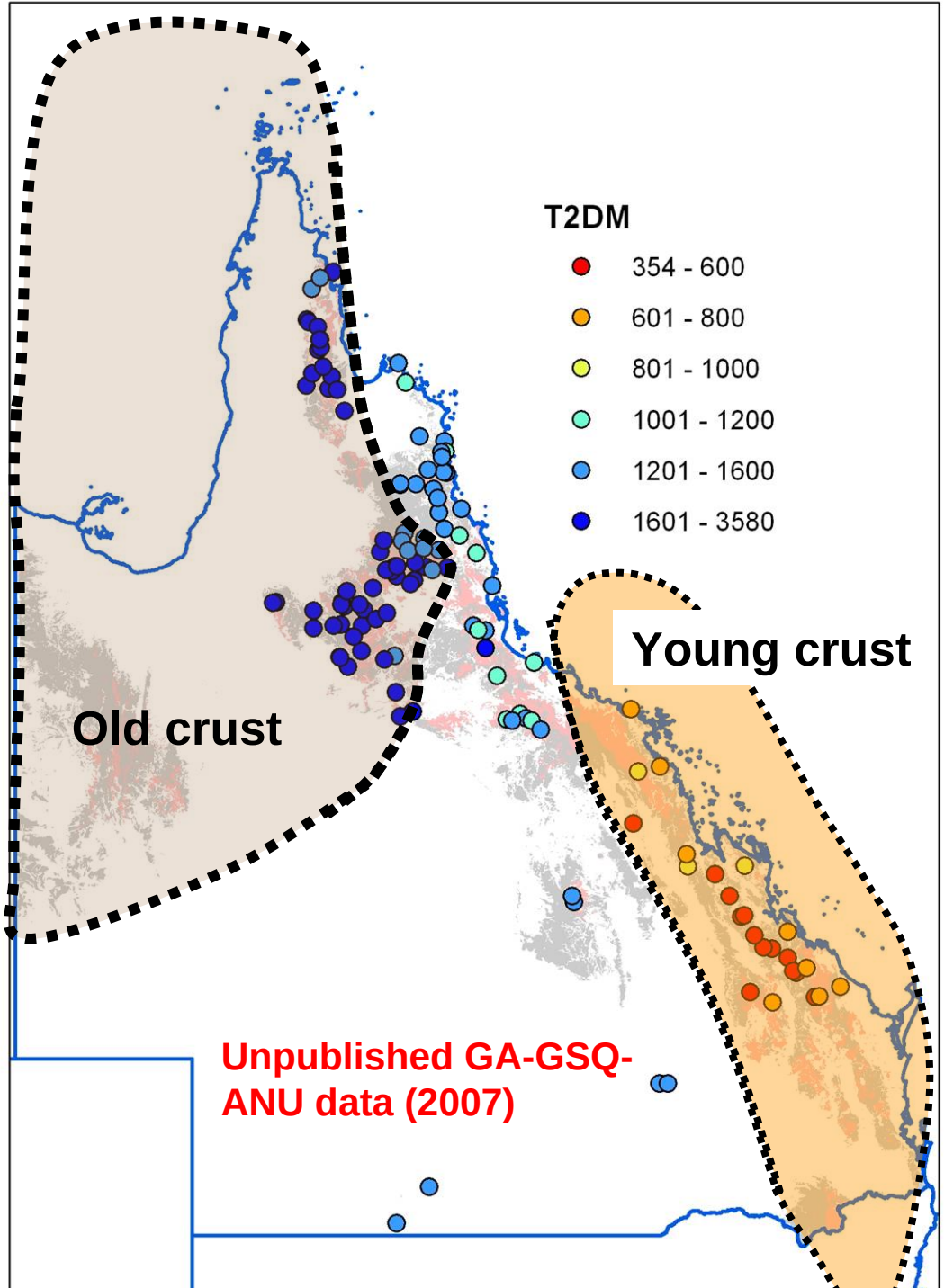

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These show:

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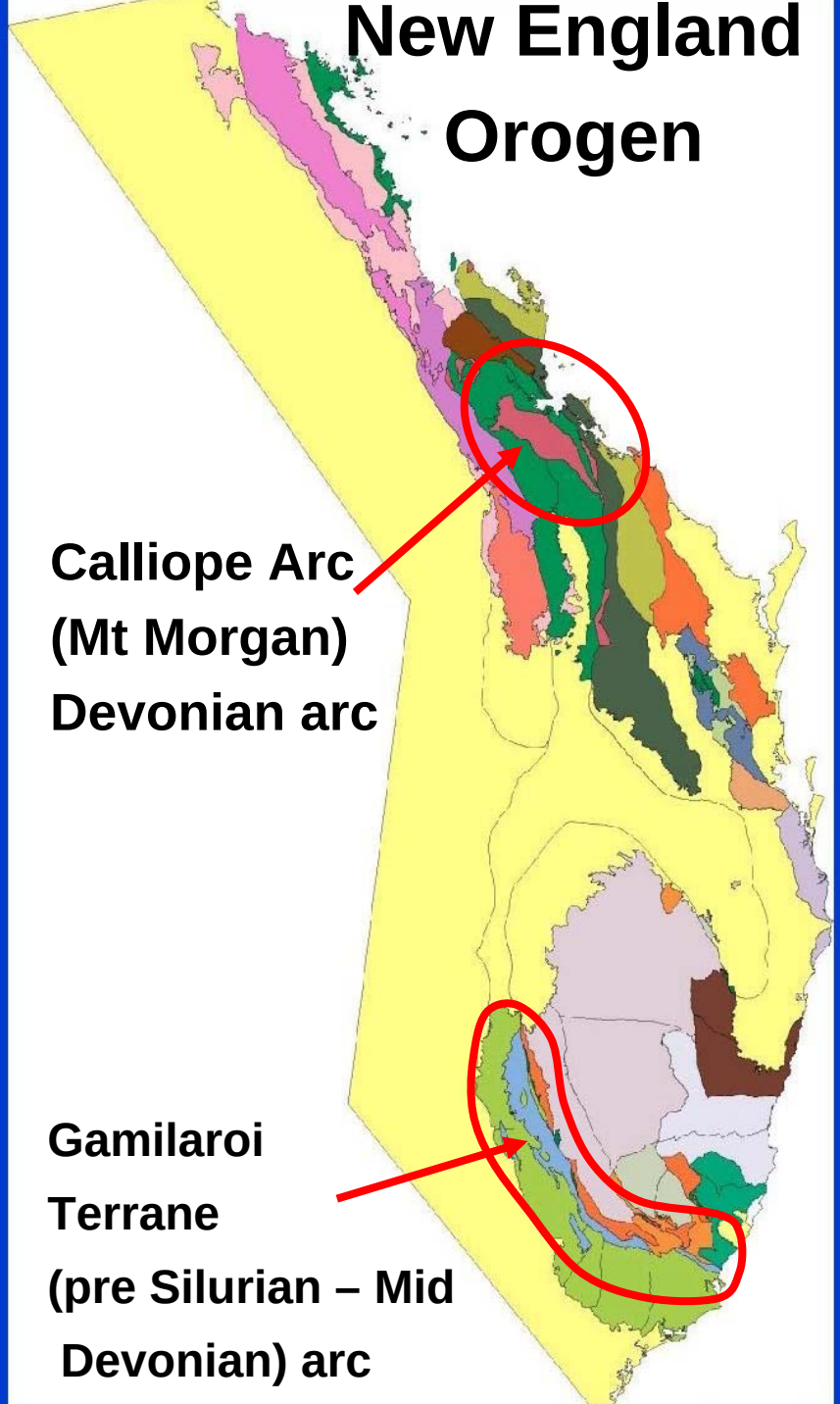
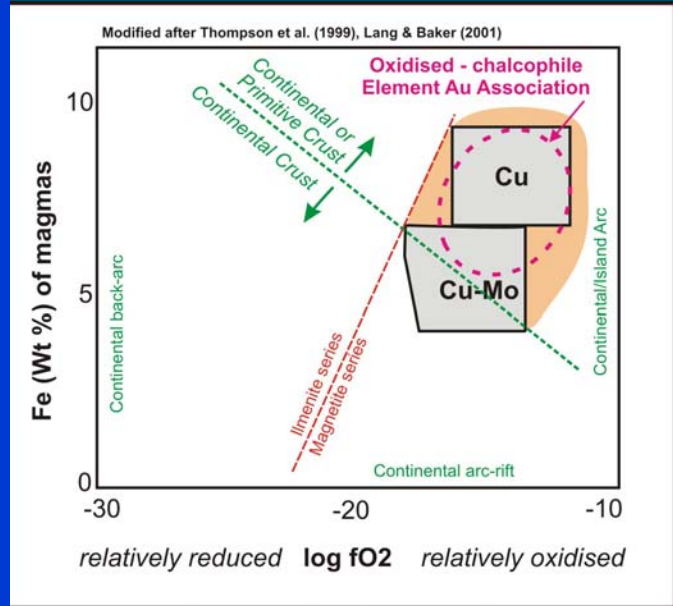
Best for Cu-Au, Cu.



Island arcs

Accreted oceanic arc terranes occur within the New England Orogen.

Calliope contains Mt Morgan.



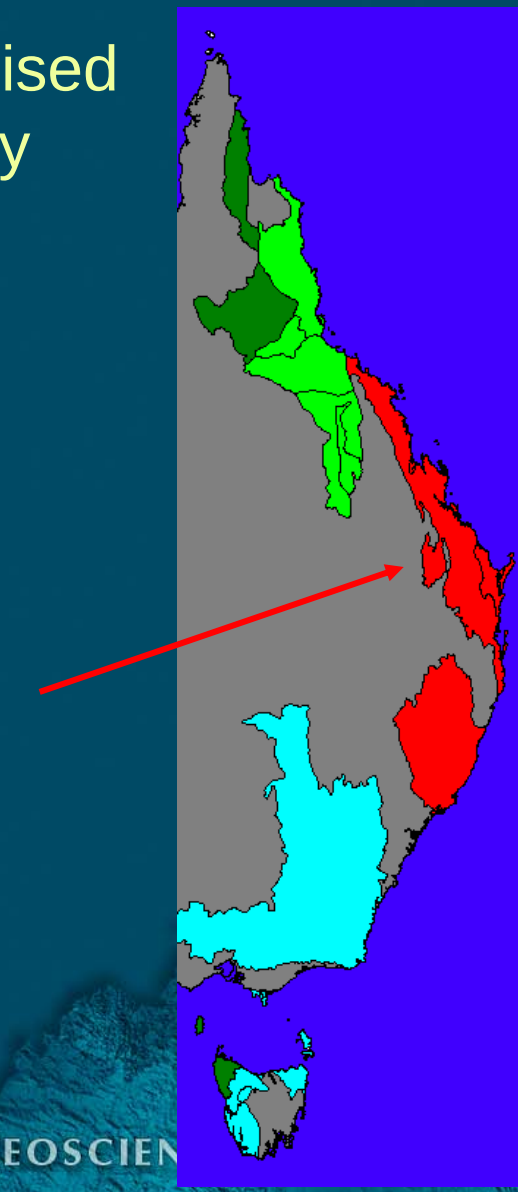
Eastern Australian exploration

Many E. Australia granites apparently not oxidised or not primitive enough to fall in the porphyry Cu-Au window

Exceptions include:

- the Ordovician of NSW; &
- parts of the New England Fold Belt.

What about other intrusion-related gold mineralisation?



‘Intrusion-related gold’ (IRG) Model

Au ± Bi, W, Mo associated with intermediate to felsic intrusions (e.g., Lang & Baker, 2001)

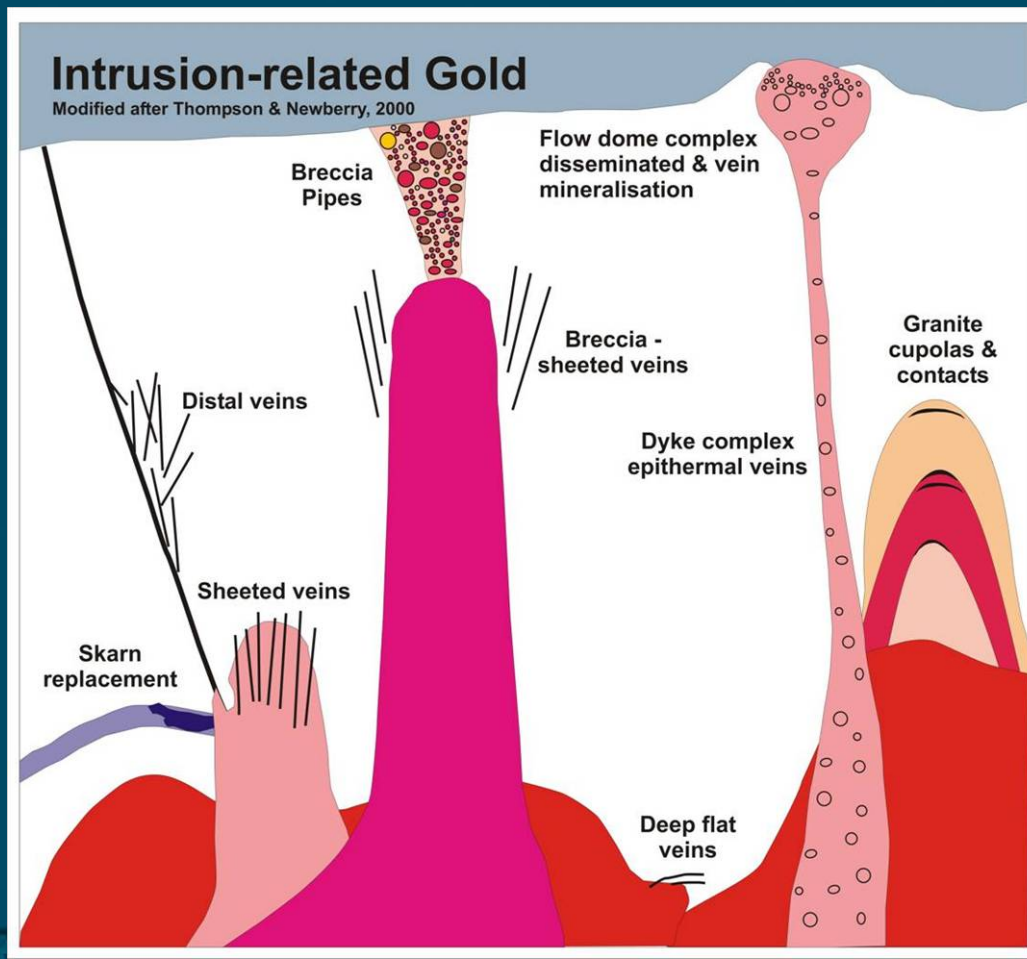
Examples:

- Fort Knox, US (>200 t Au),
- Kidston, Aust (~140 t),
- Timbarra, Aust,
- ?Pogo, US (~160 t)

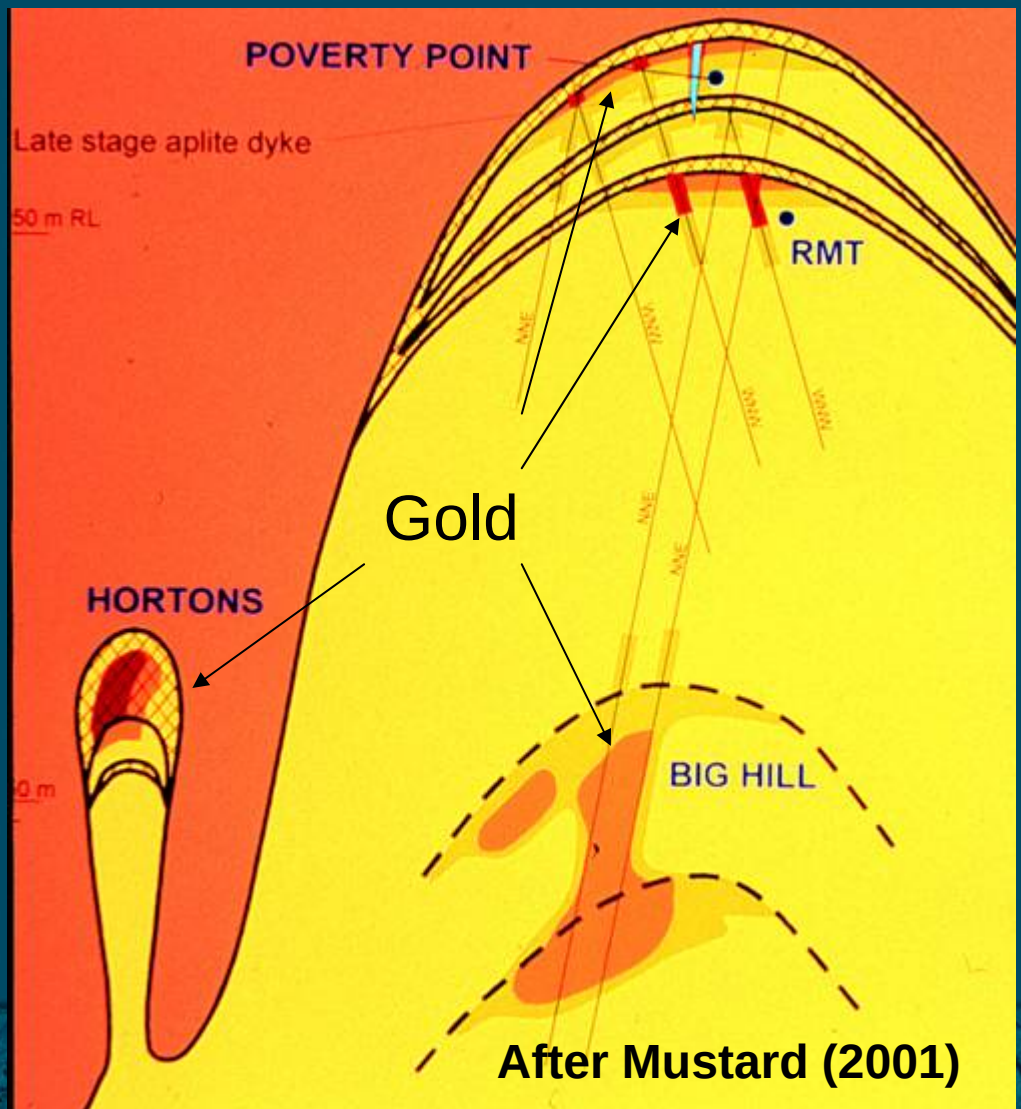
Variety of styles

(sheeted veins, stockwork veins, breccias, disseminated & greisens, skarns, distal veins?)

Controversial



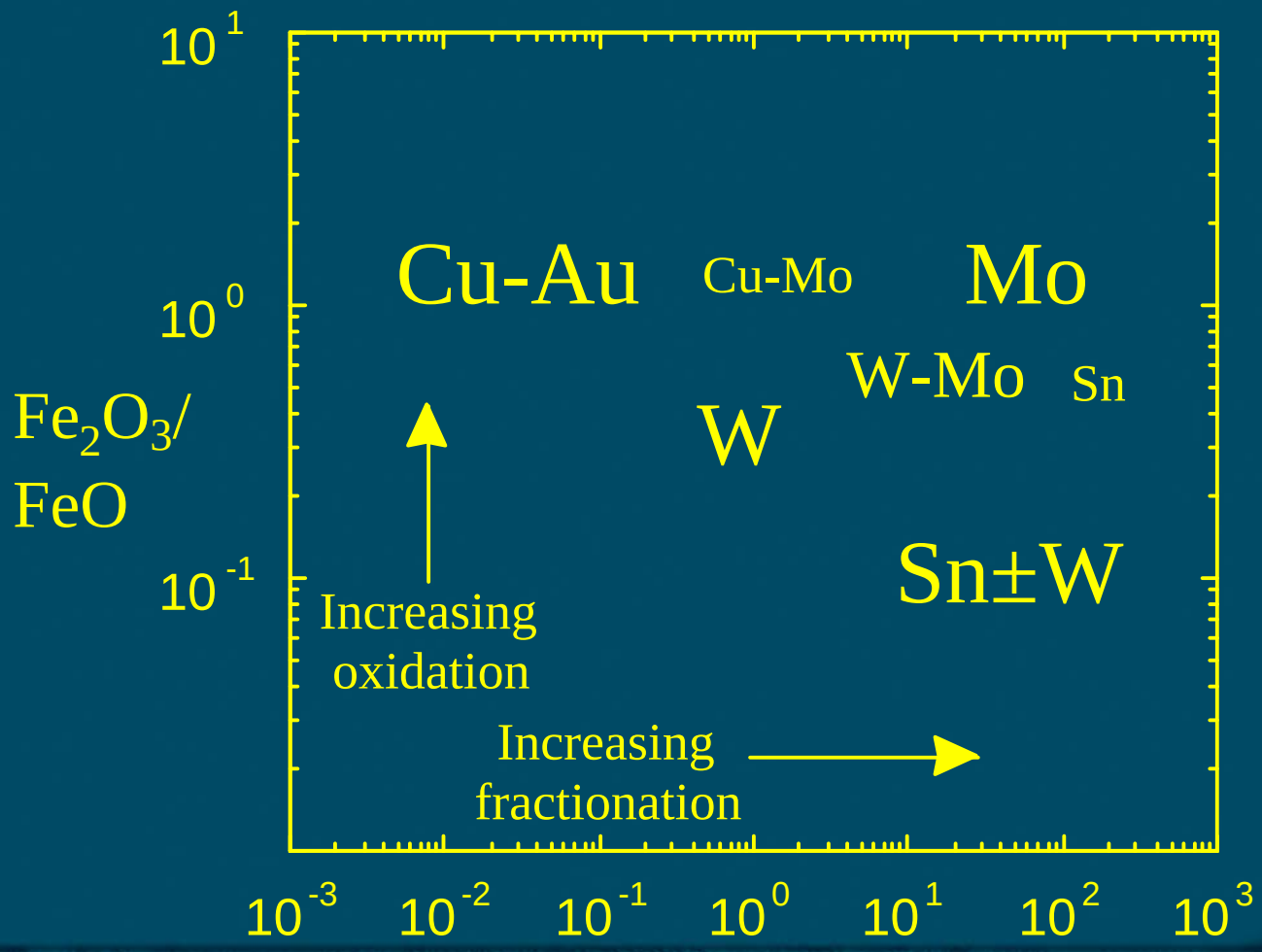
Intrusion-related Gold



Timbarra Type

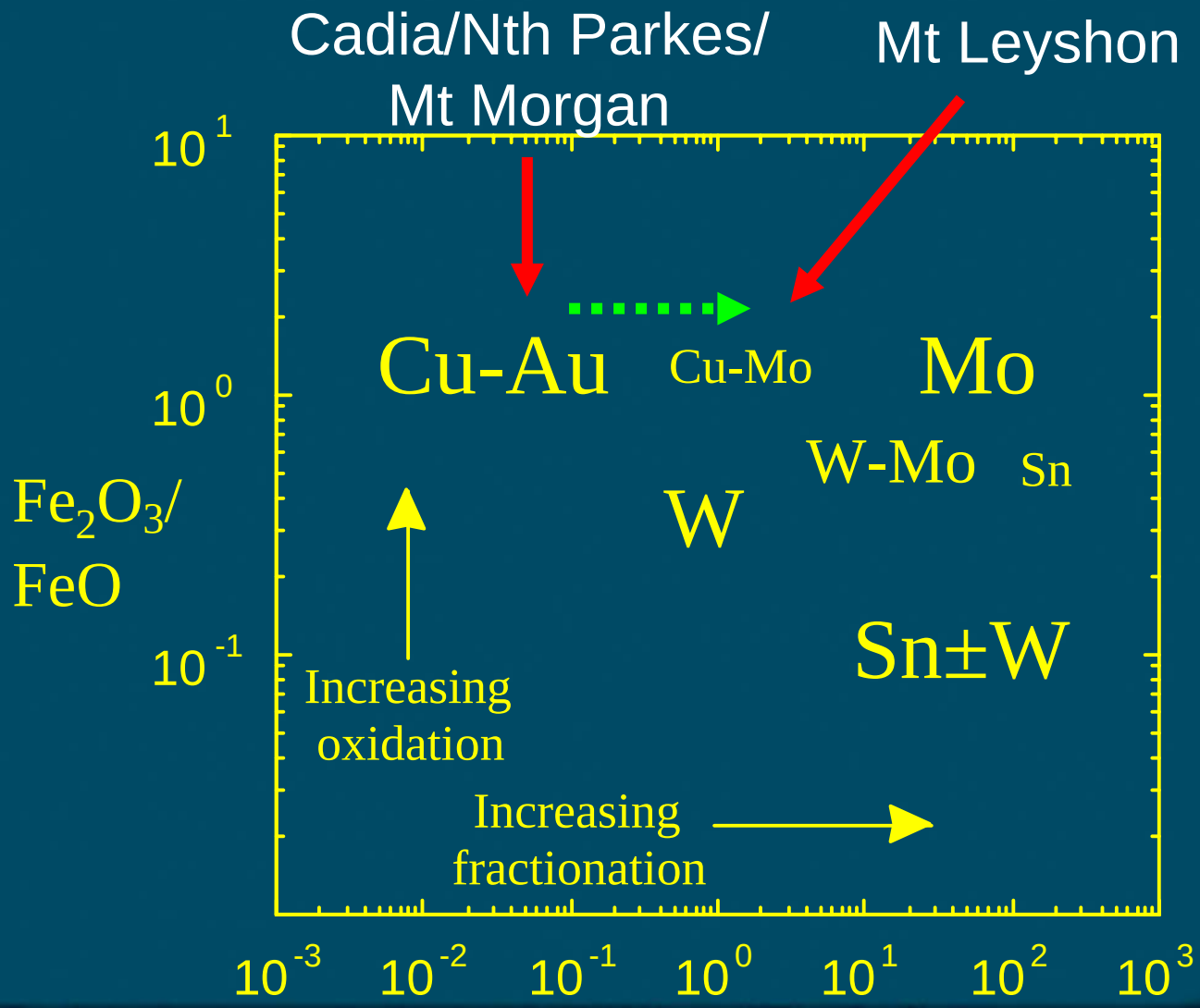
- Au disseminated in granite
- looks like a Sn system
- looks like intrusion-related deposit
- <1/2 million ounces Au (sealed though)

Australian IRGs vs por Cu-Au



(From Blevin, 2003)

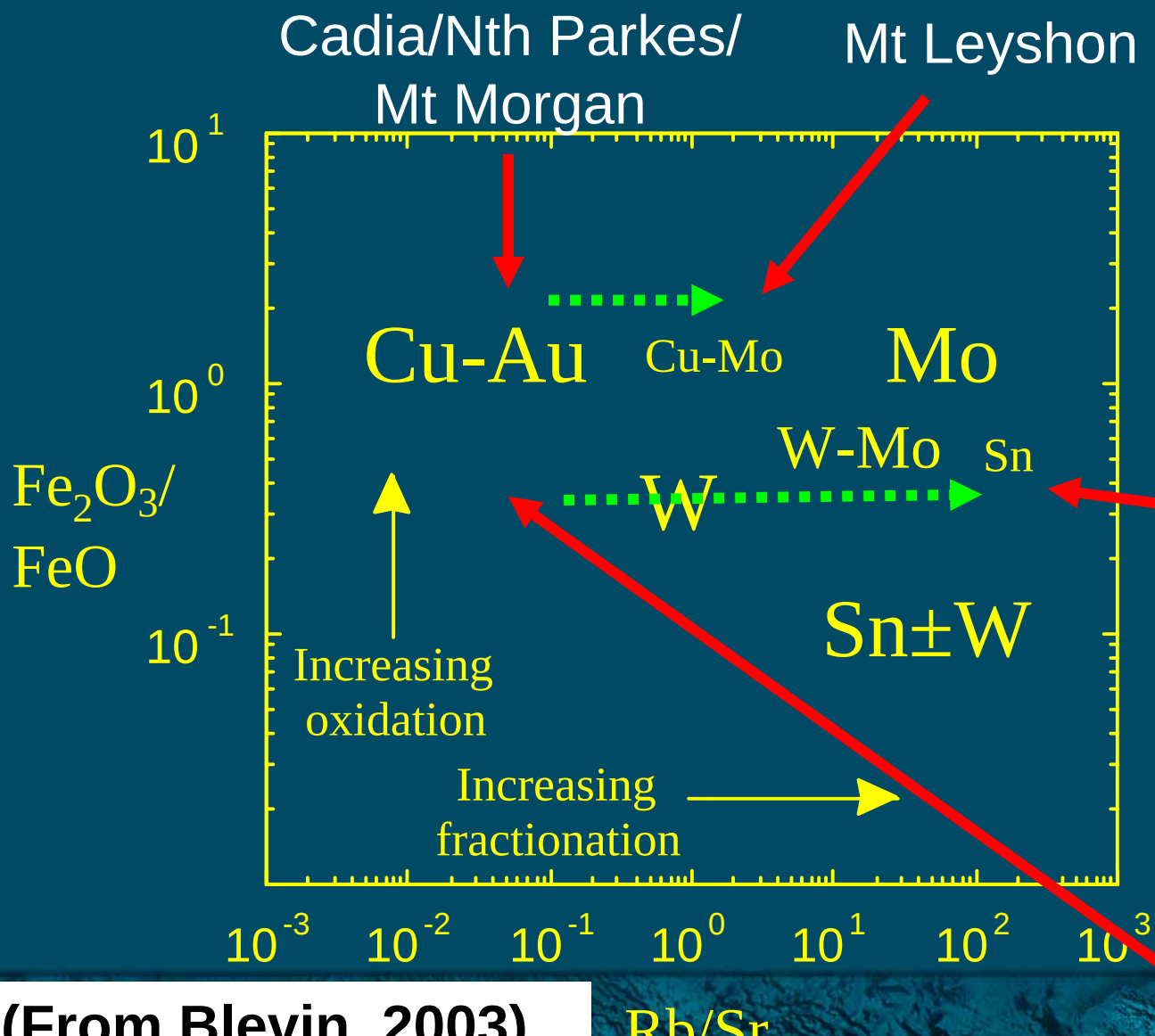
Australian IRGs vs por Cu-Au



Strongly oxidised Cu-Au

(From Blevin, 2003)

Australian IRGs vs por Cu-Au

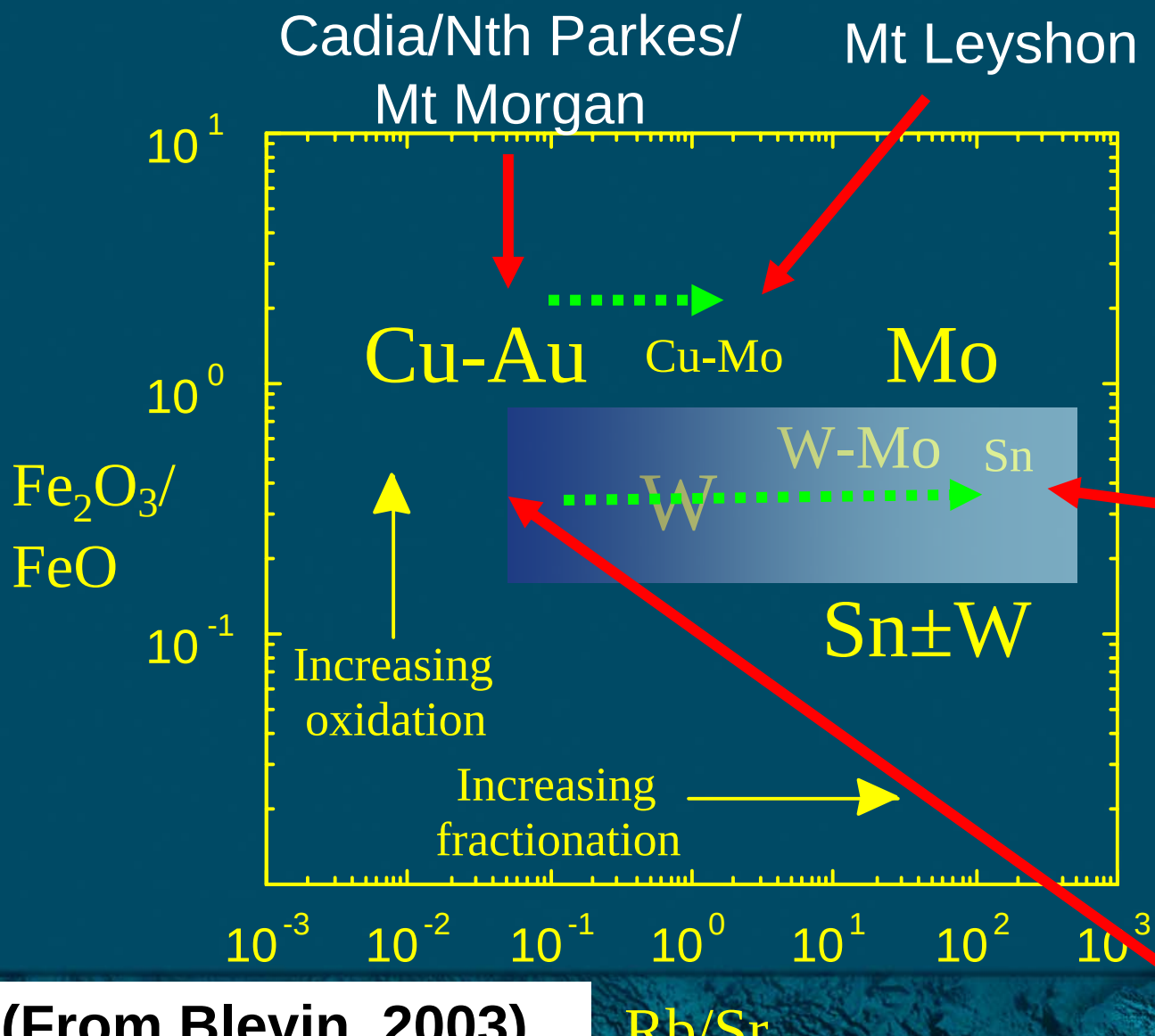


Strongly oxidised Cu-Au vs weakly oxidised Au systems

- Timbarra
- Kidston
- Red Dome
- Burraga
- Mineral Hill
- Mt Adrah

(From Blevin, 2003)

Australian IRGs vs por Cu-Au



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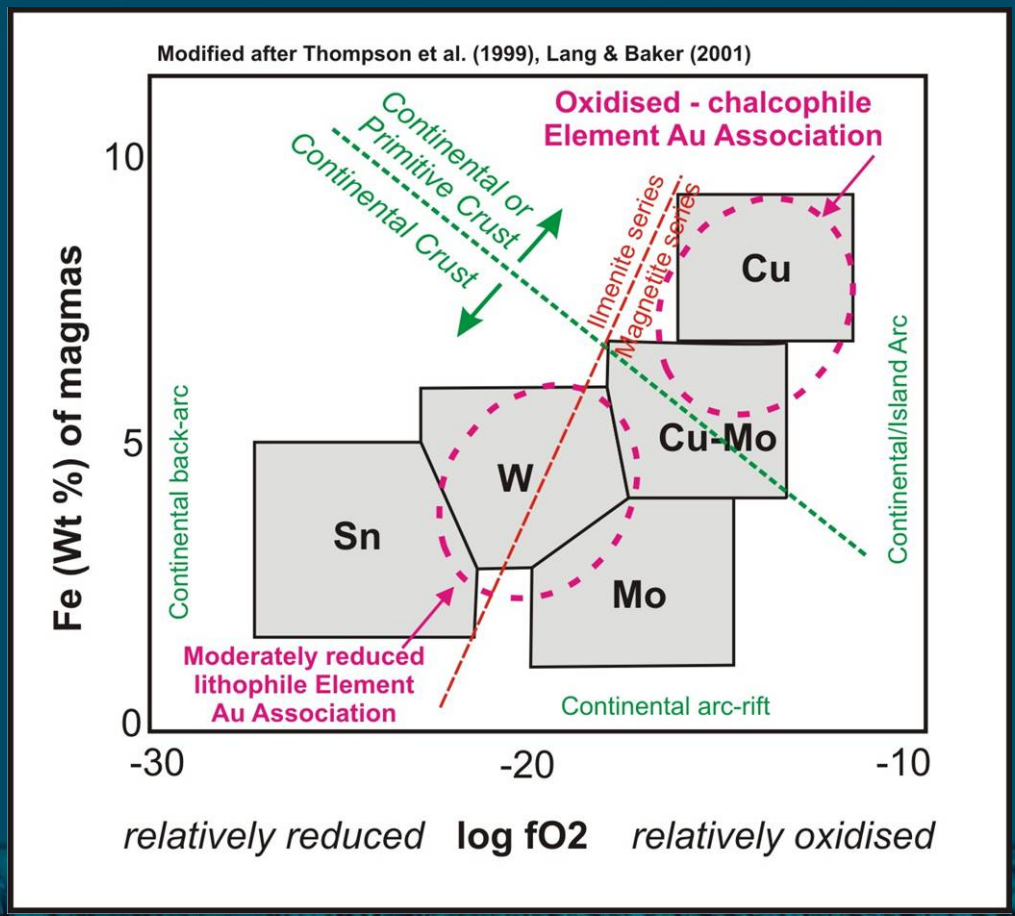
Intrusion-related Au vs porphyry Cu-Au

Thompson et al. (1999) identified similar end-members, with a lithophile element-association



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vs
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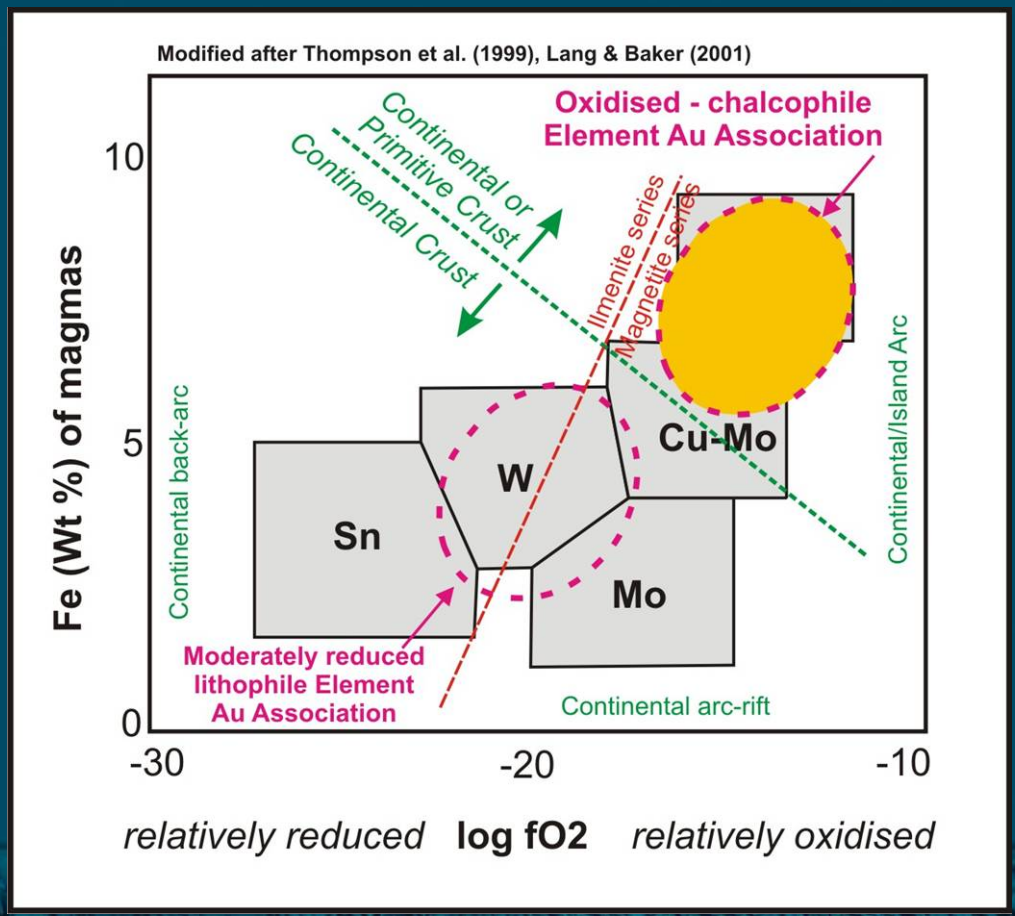

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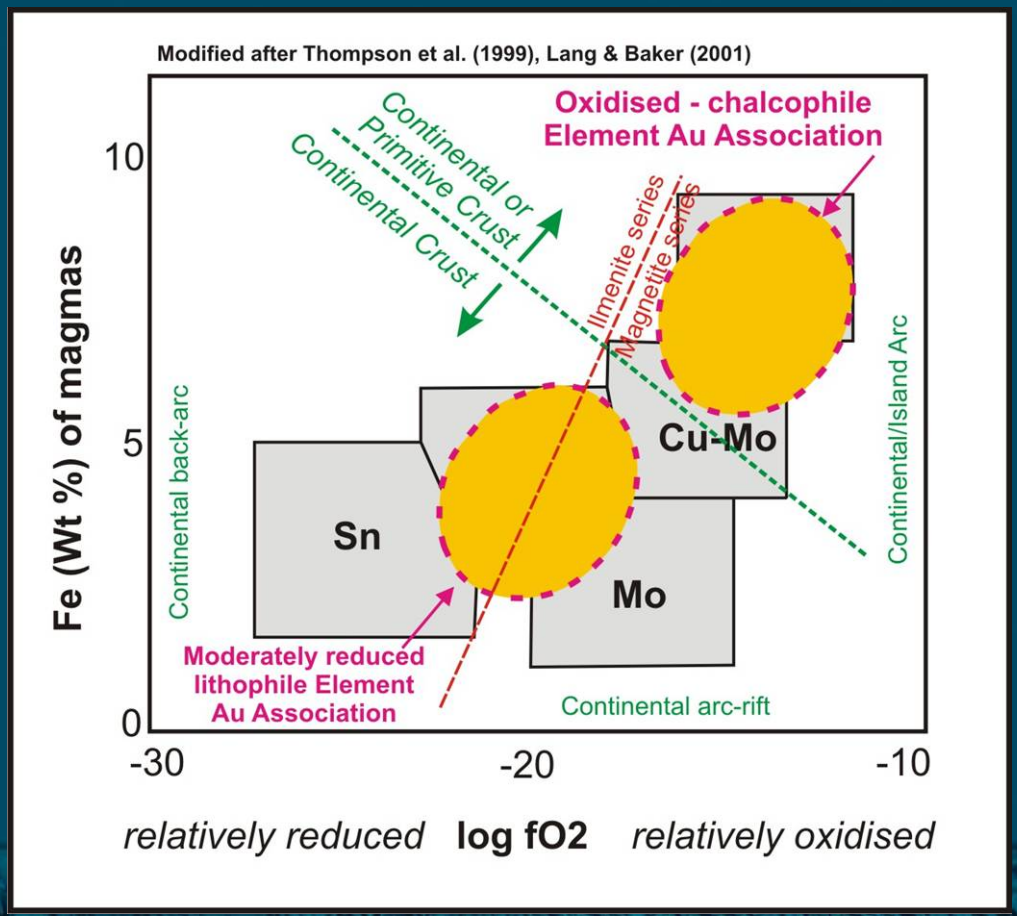
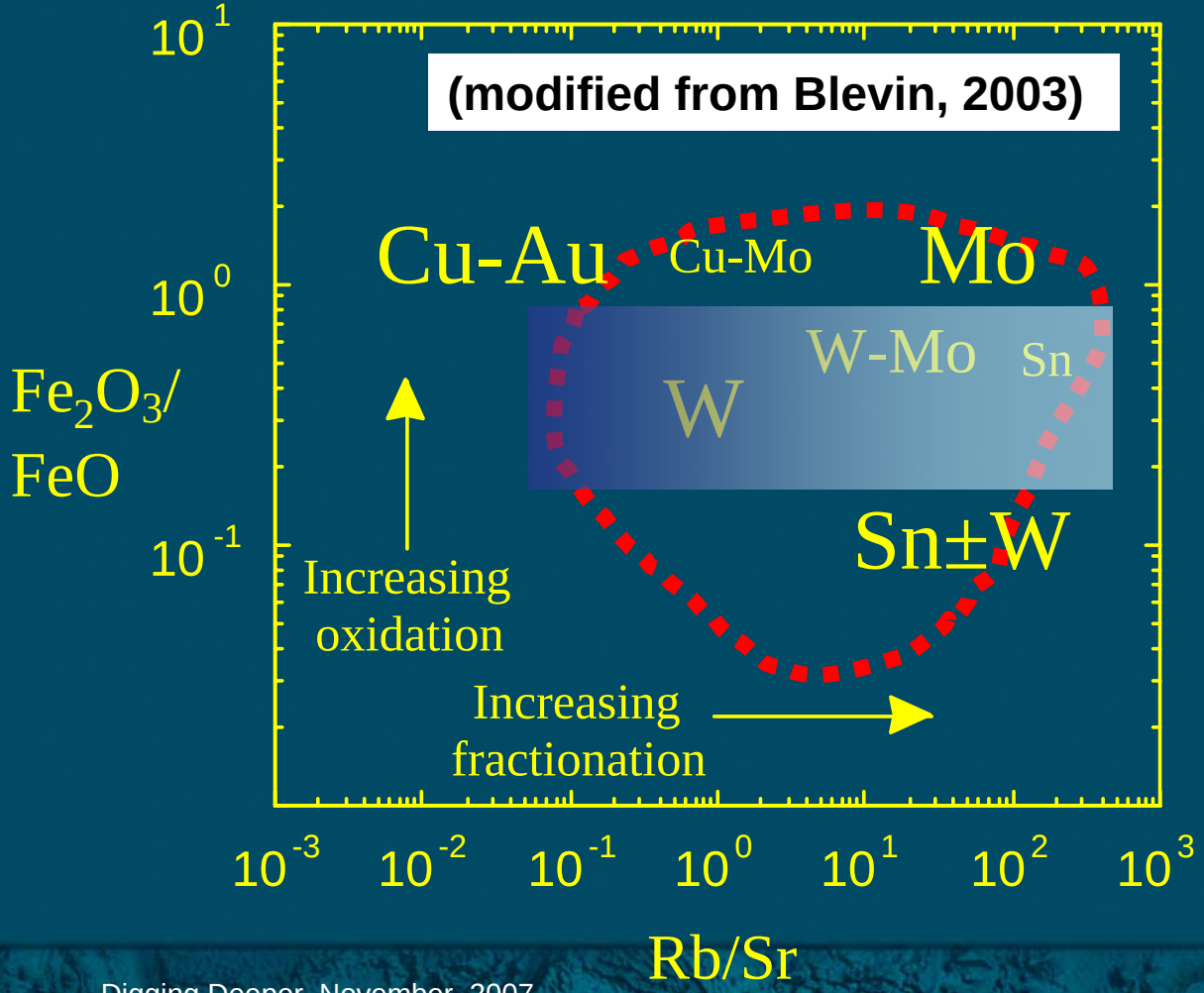


Strongly oxidised Cu-Au
vs
weakly oxidised Au systems

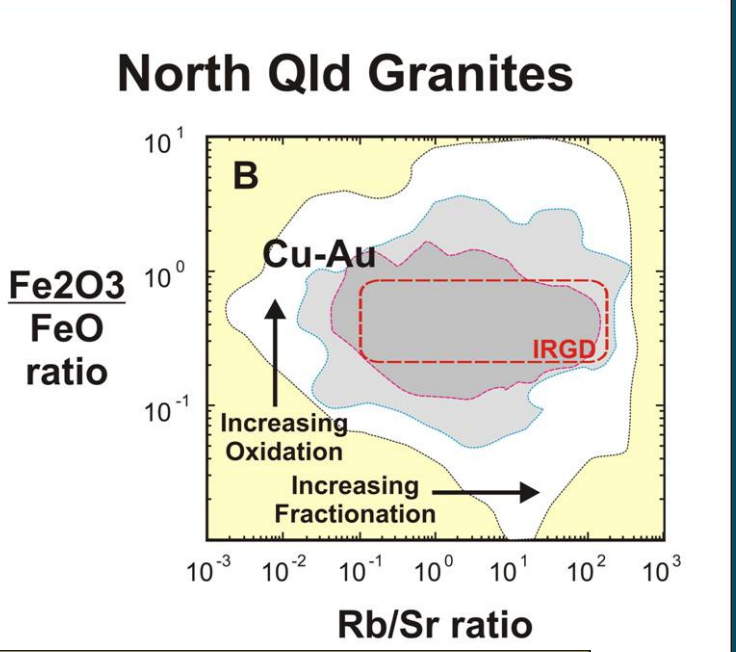
Lachlan Fold Belt Magmatism

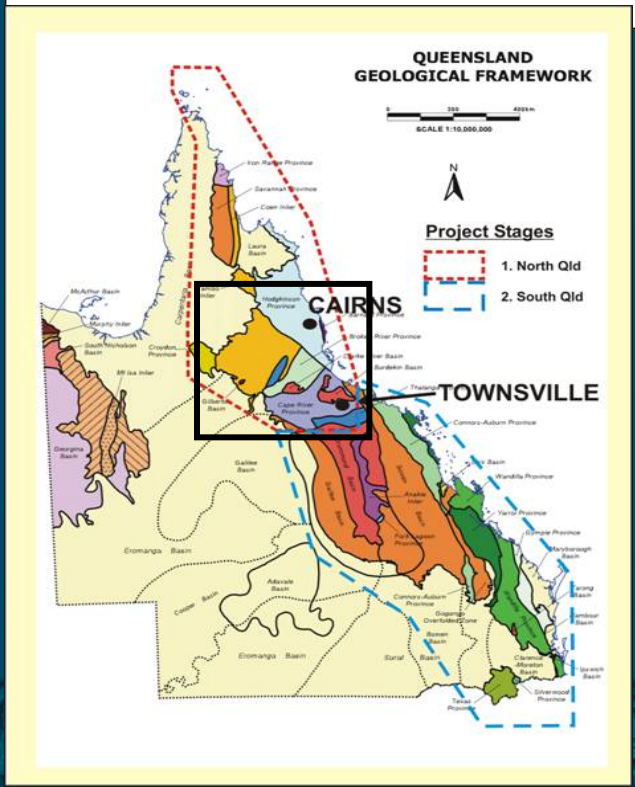
Silurian-Devonian Granites

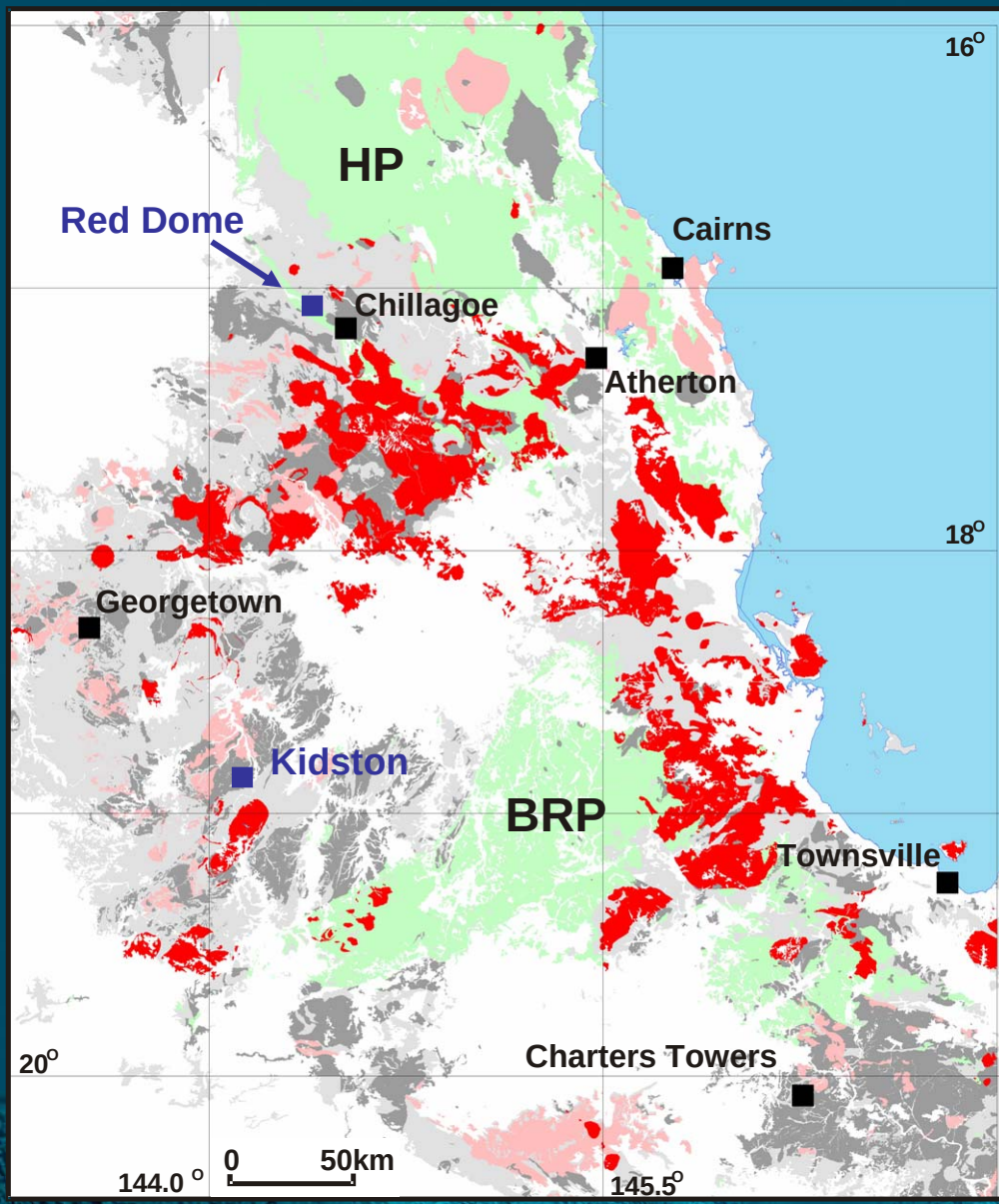


Siluro-Devonian granites of the Lachlan F.B. prospective for granite-related Au-only systems

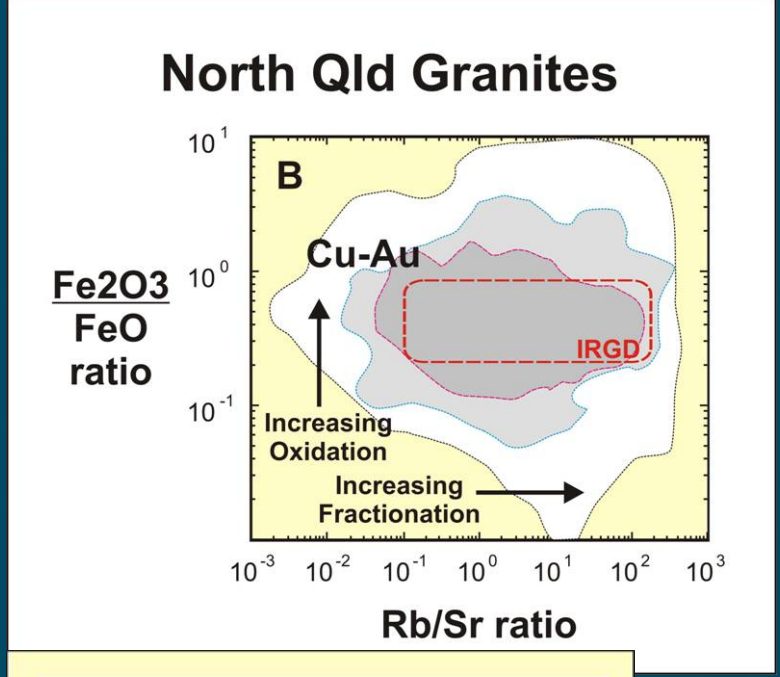
IRG – N. Qld

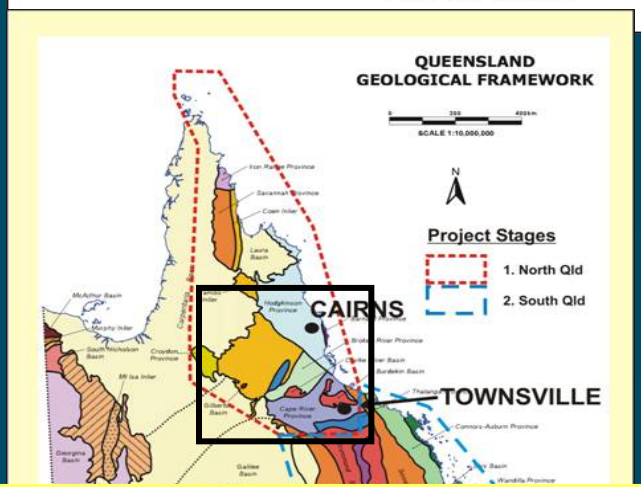

North Qld Granites
B
Cu-Au
IRGD
Increasing Oxidation
Increasing Fractionation
Fe2O3 / FeO ratio
Rb/Sr ratio
10^1
10^0
10^-1
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3

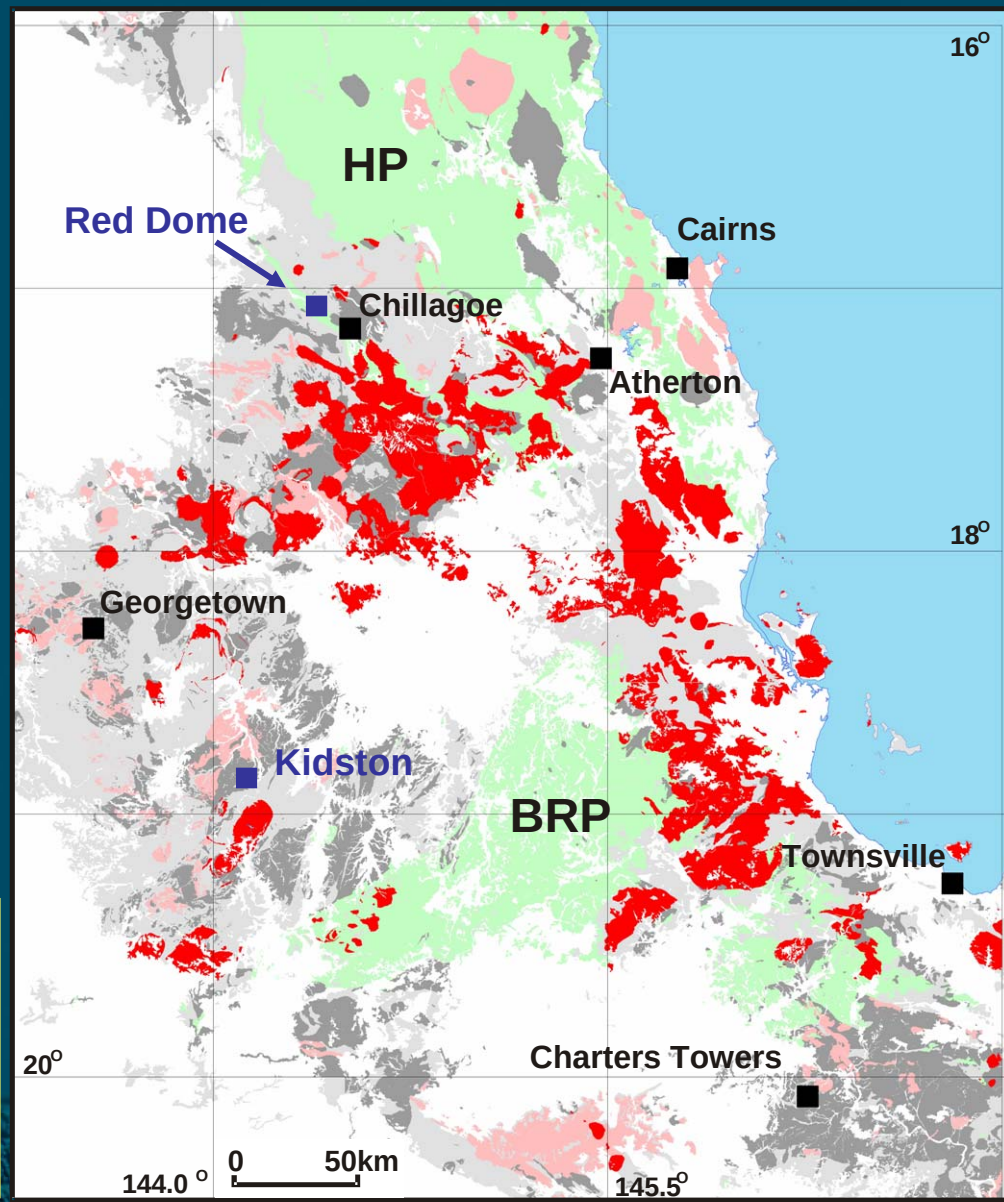

QUEENSLAND
GEOLOGICAL FRAMEWORK
Project Stages
1. North Qld
2. South Qld
CAIRNS
TOWNSVILLE


HP
Red Dome
Chillagoe
Cairns
Atherton
Georgetown
Kidston
BRP
Townsville
Charters Towers
16°
18°
20°
144.0°
145.5°
0
50km

IRG – N. Qld

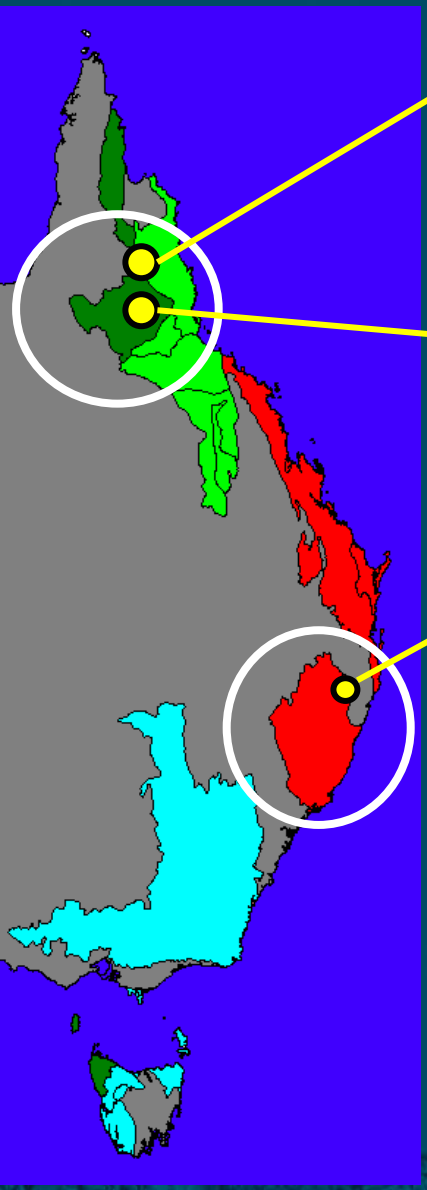






N Qld prospective for IRGD. (also southern New England F.B.)

Au-rich intrusion associated systems

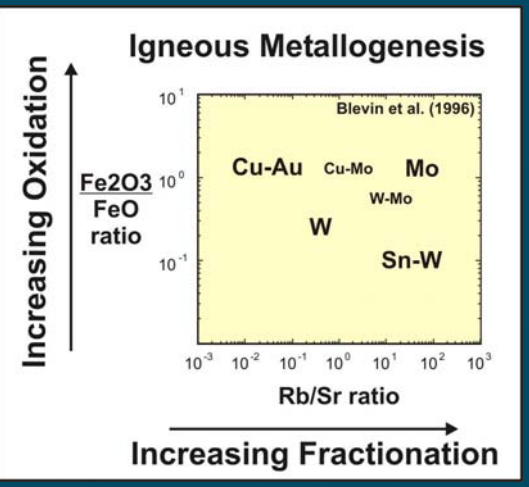


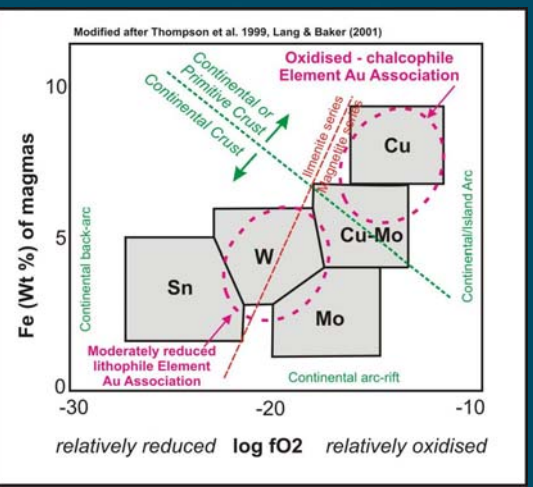
- Strong similarity between granites of southern New England and Georgetown-Chillagoe area of N Qld.
- Why no deposits such as Kidston, Red Dome in New England; and vice versa?

Current & Future products

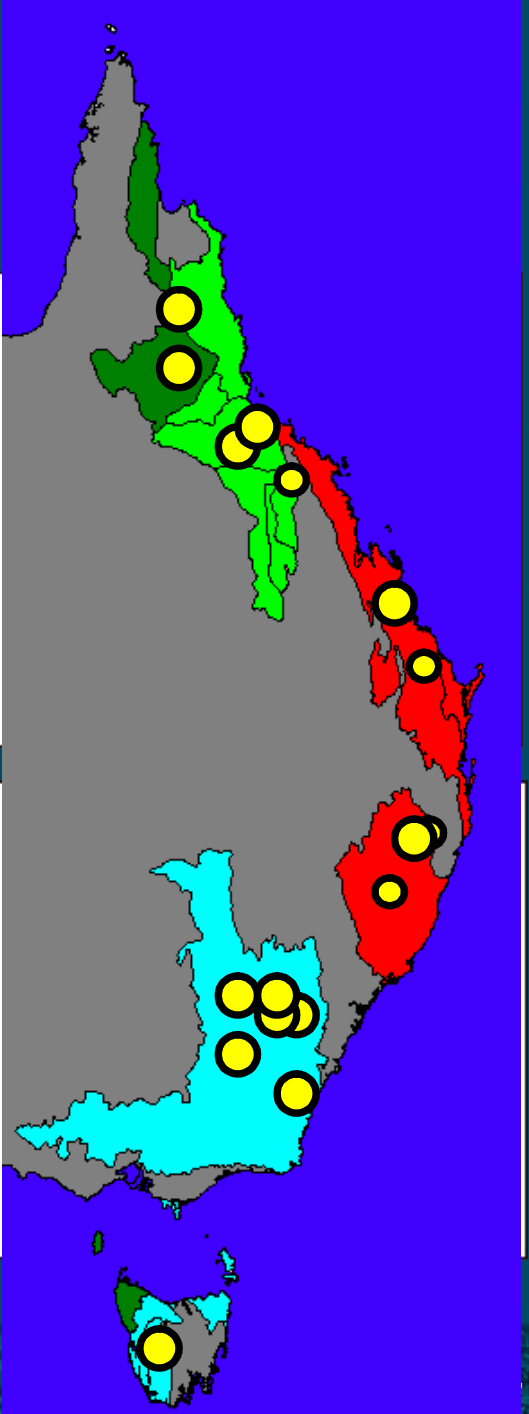
- Phanerozoic Synthesis Project (07/08):
  - tectonic and metallogenic synthesis of eastern Australia. Reports, time-space plots & thematic maps on geodynamic synthesis & metallogeny.
  - granite-related metallogenesis of Eastern Australia Report & metallogenic granite & host rock datasets.
- Geochemical analyses - Australian rocks
  - available as downloadable data sets (www.ga.gov.au/gda/)
  - upgrading to link to digital 'Million scale surface geology of Australia' (www.ga.gov.au/minerals/research/national/nat_maps/nat_geol_maps.jsp)

Conclusions





- Intrusive characteristics exert strong predictable control on commodities
- Intrusion-related Au mineralisation covers a range of styles – Cu-Au and Au-only
- Eastern Australia still prospective for intrusion-related mineralisation
- digital datasets from GA/state surveys will facilitate the search for these systems



Conclusions

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References

Blevin P. L., Chappell, B. W., Allen C. M. 1996. Intrusive metallogenic provinces in eastern Australia based on granite source and composition. Transactions of the Royal Society of Edinburgh: Earth Sciences, 87, 281-290

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Thompson J. F. H., Sillitoe R. H., Baker T., Lang J. R., Mortensen J. K., 1999. Intrusion-related gold deposits associated with tungsten-tin provinces. Mineralium Deposita 34, 323-334