GRANITE PROSPECTIVITY OF EASTERN AUSTRALIA

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Granites

- Granites (or granitoids) loosely refer to a wide range of felsic plutonic rocks. They comprise a major proportion of the continental crust.

- Granites redistribute significant amounts of material vertically within the crust.

- Most occur in areas where the continental crust has been thickened by orogeny, including continental arc subduction or collision.

- The majority of granites are derived by crustal anatexis, but the mantle may also be involved. The mantle contribution may comprise heat and/or material.
Granite related mineral deposits

- Granites are related to many ore deposit types:
  - Cu-Au, Cu-Mo, Mo, Sn porphyries
  - Sn-W, W, W-Mo-Bi
  - Polymetallic Pb-Zn-Ag
  - Pegmatite Nb, Ta, F, Li, Be
  - IRGD
  - Iron oxide copper gold
  - Rare and/or strategic metals Re, In, REE
  - Heat

- Deposit types vary - veins, skarns, porphyries, greisens, replacement, disseminations, breccias.
Granite mineral system zonation
On Granite
Goethe - 1784

“I do not fear the reproach that a spirit of contradiction draws me from the contemplation of the human heart - this most mobile, most mutable and fickle part of the creation - to the observation of (granite) the oldest, firmest, deepest, most immovable son of nature. For all natural things are in connection with each other.”
A Classification of Granitoid Rocks Based on Tectonic Setting.

Table 18-4. A classification of granitoid rocks based on tectonic setting

<table>
<thead>
<tr>
<th>OROGENIC</th>
<th>TRANSITIONAL</th>
<th>ANOROGENIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceanic Island Arc</td>
<td>Continental Arc</td>
<td>Post-Orogenic Uplift/Collapse</td>
</tr>
<tr>
<td>Continental Arc</td>
<td>Collision</td>
<td>Continental Rifting, Hot Spot</td>
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- **OROGENIC**
  - Oceanic Island Arc
  - Continental Arc
  - Continental Collision

- **TRANSITIONAL**
  - Post-Orogenic Uplift/Collapse
  - Continental Rifting, Hot Spot

- **ANOROGENIC**
  - Mid-Ocean Ridge, Ocean Islands

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</thead>
<tbody>
<tr>
<td>Calc-alkaline &gt; thol. M-type &amp; I-M hybrid Metaluminous</td>
<td>qtz-diorite in mature arcs</td>
<td>Hbl &gt; Bt</td>
<td>Island-arc basalt to andesite</td>
<td>Tholeitic</td>
<td>Partial melting of mantle-derived mafic underplate</td>
<td>Subduction energy: transfer of fluids and dissolved species from slab to wedge. Melting of wedge, transfer of heat upward</td>
<td></td>
</tr>
<tr>
<td>Calc-alkaline I-type &gt; S-type Mix-Al to sl. Per-Al</td>
<td>tonalite &amp; granodior. &gt; granite or gabbro</td>
<td>Hbl</td>
<td>Andesite and dacite in great volume</td>
<td>Hybrid</td>
<td>Partial melting of recycled crustal material</td>
<td>Tectonic thickening plus radiogenic crustal hea</td>
<td></td>
</tr>
<tr>
<td>Calc-alkaline S-type Peraluminous</td>
<td>migmatites &amp; leucogranite</td>
<td>Bt &amp; Ms, Hbl, Grt, Al, Crd</td>
<td>Often lacking</td>
<td>Continental types</td>
<td>Cst, Cca, Cci</td>
<td>Partial melting of lower crust + mantle and mid-crust contrib</td>
<td>Crustal heat plus mantle heat (rising asthen. + magmas)</td>
</tr>
<tr>
<td>Calc-alkaline I-type S-type (A-type) Metalum. to Peralum</td>
<td>bimodal granodiorite + diorite-gabbro</td>
<td>Hbl &gt; Bt</td>
<td>Often lacking</td>
<td>Hybrid late orogenic</td>
<td>Hlo</td>
<td>Partial melting of mantle and/or lower crust (anhydrous)</td>
<td>Hot spot and/or adiabatic mantle rise</td>
</tr>
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<td>Calc-alkaline A-type Peralkaline</td>
<td>Granite, syenite + diorite-gabbro.</td>
<td>Hbl</td>
<td>Often lacking</td>
<td>Alkaline</td>
<td>A</td>
<td>Partial melting of mantle and fractional crystallization</td>
<td>Ocean plagiogranite</td>
</tr>
<tr>
<td>Alkaline M-type Peralkaline</td>
<td>Plagiogranite</td>
<td>Hbl</td>
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<td>Tocr</td>
<td>Tholeite ocean ridge</td>
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- Increasing SiO$_2$
- Decreasing K/Rb
- More “granitophile” metallogeny
- Redox & other controls
Granite related ore elements are not distributed evenly in the crust
Coastal Range Granites and surrounds....

Chillagoe

Cairns

Triassic-Mesozoic
Permian
Carboniferous
Siluro-Devonian
Ordovician
Cambro-Prot

Townsville
Current success for Zn, Au, W, Mo, Bi, Sn, Ag

FNQ – Sn, W, Mo, Au, Bi, Ag, Zn, Pb, F, Cu.
Red Dome Porphyry

Endoskarn vein

Feld. Pheno

Quartz Pheno

2 cm
Kidston Porphyry with high T. mineralisation

Qtz-MoS$_2$ vein
Igneous Metallogenic Relationships - NQ

Younger mesothermal Au deposits lie in “quiet” zone between granite supersuites, not along major faults - denotes location of major change in lower crust.

Major faults & lineaments: granites change composition across Clarke R. lineament, ignore major Palmerville Fault

Oxidation state increases inboard - continental effect.
Cape York (CYG) and Coastal Ranges (CRG) Granites are compositionally evolved - CYG much like the LFB Sil-Dev while CRG are more fractionated.
Coastal Ranges comprise the only substantive amounts of fractionated (and evolved) granites.
Porphyry-like Cu & Mo (±Au) systems - NNEO (after Horton, 1982)

Current activity for Au, Cu and Mo
Compositional character of granites are typical of continental margins.
Unroofing?

Au in molybdenites

Timbarra

Marked contrast to the northern NEO

Exploration activity/success for Sn, Mo-Bi, Au, Ag-BM-In
Known Potential
Fertile Igneous Rocks
Analogies with major Sn, Au systems
Has not been subject to modern exploration
Has lots of hiding places
Granite Character by Province - LFB

Victorian Au

Maldon

Candelo S’suite

I/S - Type
U/F - Frac.
O/R - Ox

I/U-O
I/U-O/R
I/S-U/F-R
S-F-R
S-U-R
I-U-O

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Tasmanian TASGO 3D VRML model
Granites become less “S-type” to the east
Radiogenic isotopes are identifying broad zones that reflect source regions, materials and crustal architecture.

Master LFB Nd/Sm-Rb/Sr-O Database

- No Data
- < -8.8
- -8.8 - -7.2
- -7.2 - -6.0
- -6.0 - -4.6
- -4.6 - -2.0
- -2.0 - 0.0
- 0.0 - 1.9
- 1.9 - 4.3

Nd mapping project

Initial Sr  
eNd

0.7 0.71 0.72 0.73 0.74

Sri - S
Sri - I
Sri - Sed

-8.8 - -7.2
-7.2 - -6.0
-6.0 - -4.6
-4.6 - -2.0
-2.0 - 0.0
0.0 - 1.9
1.9 - 4.3
The diagram illustrates the relationship between Nd isotopic ratios (εNd) and age (Ma) for various geological periods and regions, represented by different symbols and colors: NEO, Sth, Nth, MMTC, LFB, Ord, RAV Perm, LFB Perm, Nth Hodg Perm, Sth I-types, LFB S-types, Nth Qld Carb. The diagram categorizes Au deposits into three ranges: <10t Au, 10-100t Au, and >100t Au.
Recent detailed studies using combined Hf and O isotopes in zircons have confirmed that granites have complex source histories.

Such studies (with Nd etc) will help in understanding the relationship between metal sources and other inputs that also affect composition and intensive parameters.
- Do felsic Au systems require a special Au source?
- Why the coincidence of similar granite types with IRGD?
- Do they require the conjunction of a specialised Au source and an appropriate magma (i.e. is everyone correct?)
Moving forward.....

- Mapping
- Geophysics
- Chemistry
- Alteration
- Isotopes

Redundant or Fundamental?

- Improved classification (chem, pet, geophys).
- Easier application.
- Mapping of provinces (isotopes, supersuites, crustal architecture).
- Comparative studies eg. IRGD, provinces

\[ f_X \]

\[ X_N \]