

Interconnected miarolitic texture

PHIL BLEVIN, SMEDG – APRIL 2009

Granites and mineral deposits in NSW

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Granites and "granites"

- Refer loosely 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 of sialic masses.
- The majority of granites are derived by crustal anatexis, but the mantle is also likely involved. The mantle contribution may comprise heat and/or material.

Here we take the broadest view and include intermediate and felsic intrusives.





Granites and "granites"

NSW has a diverse range of granite related mineral deposits - Sn, W, Mo, Au, Cu, Ag, Pb, Zn, F.....

Diverse range of compositions and types, from primitive arc to S-types.

Substantial volume of failed granites.

Granites represent a data rich environment for research and exploration.



Igneous related mineral systems in NSW - new work



- Mapping of mineral systems.
- Dating of mineral systems.
- Fingerprinting mineral system geochemistry.
- Better understanding of the fundamental controls on magmatic fertility.
- Use these to better understand the distribution of mineralisation in time and space throughout the state.
- Develop new concepts.
- Opportunities for existing and new commodities.



A magmatic view of ore systems

- Compositional type (I, S..)
- Differentiation processes.
- Degree of compositional evolution.
- Oxidation state.
- Physical parameters (level of emplacement, volatile content, T etc)

This scheme assigns metallogenic associations to granites.



Source: Harris et al., 2003, after Shinohara and Hedenquist, 1997



The redox-fractionation story







There is a complete metal gradation that compliments the continuous variation of igneous rocks in redox/frac space.





Gold in felsic magmatic systems

EXTERNAL SOURCES

- Wall rocks...
- Mafic magmas...

INTERNAL SOURCES

- Au-rich to begin with...
- Efficient concentration...

Caveat emptor....

- The fractionated felsic shallow chambers are the tops to more extensive plumbing (not representative of whole the magmatic system).
- Magmatic compositions and intensives allow passage of Au through the magma to the hydrothermal stage.
- Magnetite?????





The primacy of magma compositions

- Huge effort over last decade and half on fluid/vapour transport and partitioning of metals.
- Driven by early observations of Cu partitioning into the vapour phase of the famous Cu mineralised Mole Granite.
- Infamous statement that porphyry Sn systems will be found under porphyry Cu deposits.
- Auditat 2009 concluded that metallogenic fertility is a function of magma composition
 déjà vu? Haven't



Seo et al, in press, 2009



...apologies to the movie "Top Secret"



we....?



Magnetic susceptibility is a function of oxidation state AND the total Fe content of the rock.







A robust and practical scheme for classifying igneous rocks





Fig. 20.

OTLM Studies (Optical transmission light microscopy)

What is the relationship between the present oxidation state of igneous rocks versus the oxidation history of those magmas and their sources? Guess what mineral will help solve this?

"Early crystallization of magnetite can play a mitigating role in the ability of a calc-alkaline magmatic system to yield a Aurich ore fluid."

Zircon!











To better understand the magmatic development of the Macquarie arc <u>from the</u> <u>perspective of the intrusive complexes</u>

- What are the *magma sources*, and how have these changed or interacted over time?
- Is there a link between *magma generation* process and *metallogenic fertility*?
- What are the *tectonic implications*?



Zircons are robust mineral archives

- U-Pb isotopes (SIMS)
- O isotopes (SIMS)
- Lu-Hf isotopes (LA-ICPMS)
- Trace elements (LA-ICPMS)
- Thermometry (Ti content)

Will be used to understand age, origin and oxidation controls on magmas.











Ce⁴⁺ & Eu³⁺ Vs Ce³⁺ & Eu²⁺

Goonumbla regional samples





Applications to other systems across the state

Inverell

Mole





Combined isotope systems within zircons

 $\frac{Continental \ crust}{low \ \varepsilon_{\rm Hf}}, \ high \ \delta^{18}{\rm O}$

<u>Sediment</u> (¹⁸O-enriched) terrigenous: low ε_{Hf} pelagic: high ε_{Hf}

Nd & Hf uncoupling useful too!

<u>Mantle wedge</u> high ε_{Hf} , low δ^{18} O

Courtesy of Tony Kemp, JCUNQ

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<u>Basaltic slab</u> (upper) high ε_{Hf} , ¹⁸O-enriched (lower) high ε_{Hf} , ¹⁸O-depleted



Cassiterite: the new "zircon"

- A new project with PRISE/RSES (Marc Norman).
- Develop SHRIMP based U-Pb dating for cassiterite.
- Trace element geochemistry by LAICPMS for Nb-Ta, Ti, Zr-Hf, Sc, W, Fe, In, U, Th.....
- Potential for Hf isotopes actually trace the source of the ore fluids themselves.
- Will allow rapid dating and characterisation of cassiterite for regional assessment and metallogenic reconnaissance.



- Initial pilot project funded by ANU.
- Samples from NSW will be used.
- Possible ARC project depending on outcomes.

Initial results extremely encouraging:

- High U, low Pb
- Dates for Kikoira, Elsmore, Emmaville



Cassiterite compositions compared

Nb & Ta



I-type - Emmaville

W 10⁹ 0 Y89 10⁸ Zr90 and the second Nb93 \diamond × Sn114 10^{7} W182 Ta181 Hf178 10⁶ Ti49 Sc45 ۰ 10⁵ 10⁴ 1000 0 09 0 യാറ ഔ താനാററ 100 ·o@@@@~@~@ **— –** 10 20 30 10 40 50 60 Time [Sec] **HREE** S-type - Kikoira









Molybdenum and cassiterite dating.







Variability in granite compositions

Compilation of granite data is being used to:

- Map large scale variability in the Tasmanides
- Understand source controls
- Follows the observed metallogeny
- Will provide info on heat generation and potential

K/Rb

- 21 140
- 140 250
- 250 300
- 300 400
- **>**400

- K and Rb substitute into same minerals.
- Rb slightly excluded relative to K.
- Rb thus increases with crustal reworking relative to K.
- K/Rb DECREASES with crustal evolution.





K/Rb ratio follows geophysical and "basement" terrane boundaries

AWG_ZONE_East

W

Sn



Mo







"New metals": Indium

- Indium occurs in several types ore systems. In vein and porphyry style Sn systems, indium mainly reports in the sulfide stage (Sn -> Cu-Bi-Pb-Ag-As).
- Principal ore forming minerals (sph, ccp, cst, stn) contain 75% of the bulk In.
- Other minerals include roquesite, kesterite....
- 28% of known world reserved in one deposit (Mount Pleasant).
- Metallurgy (and thus reserves) in other deposit types are difficult to establish.



In NSW:

- In reported from Conrad Howells
- Apocryphal(?) stories from the 1970s that Sn smelters recovered In from New England cst.
- Comparative studies suggest New England Itypes high potential for In.



Analogy for New England – the Canadian Maritimes











Indium: geology, mineralogy, and economics. Schwarz-Schampera & Herzig, Springer, 2002; and New Brunswick Dept Natural Resources website: <u>www.gnb.ca</u>





Ground up Granite

- Granite being mined directly for manufactured sand
 - The biggest quarrying operations in Asia (Karimun 6-8 Mtpa).
 - Angularity and fines have been an issue being addressed by blending, new crushing (eg. cone) and screening technologies and processes.
 - Manufactured granite used for three gorges dam.
- New Boral Quarry
 - Marulan Granodiorite, production up 3.5 Mtpa
 - High quality aggregates for use in the Sydney metropolitan concrete and asphalt markets.
 - Replace exhausted river sand deposits
 - Close to Sydney, adjacent a railway
 - Construction late 2009 (~200 jobs), with operations commencing approximately two years from that time (~30 jobs).
 (From Boral website)







Potential for recovery of accessories?

- Granites have accessory zircon, apatite, ilmenite and rutile.
- Potential for recovery of these if "quarrying" is paying for the mining bill?
- Potential benefit of local buyer (zirconia plant, Murray basin sand miners?).

Unit	K ₂ O %	SiO₂ %	P ₂ 0 ₅ %	Zr	Се	Y	Th
Walcha Road	4.0	67	0.24	195	71	19	34
Gulgong	high	73	0.08	110	52	17	28
Tarana	4.6	73	0.07	135	68	19	29
Young	3.5	69	0.14	181	68	31	18
Marulan	3.8	72	0.05	131	69	26	18





Granite Miners Seek Help from Trade Ministry: The Jakarta Post, 23 March 2007, page 14

Approximately 20 barges carrying up to 3,000 tons of granite from the Riau islands to Singapore have been detained following the banning of sand exports. The Navy detained the barges due to suspicions of sand smuggling and violations of maritime regulations.





Granite Heat Potential

The heat production (*A*) of a rock is given by: $A = 0.01 * \rho * (3.48 * K\% + 2.56 * Thppm + 9.52 * Uppm)$ where ρ is density in tonnes/m³ (or SG) and *A* is μ W/m³



HPE are concentrated in granites but with variable abundances. Typically the most felsic (light-coloured) granites have heat productions (*A*) of about 3μ W/m3 – less felsic granites have lower values.

Some granites have higher heat production, those greater than 5 μ W/m³ the High Heat Producing (HHP) granites. 12.7% of the more than 8000 granites that B. W. Chappell analysed from eastern Australia are HHP.

Courtesy of Bruce Chappell and Doone Wyborn







Some examples of heat production

	K%	Thppm	Uppm	Α
average crust	1.25	4.5	1.2	0.8
SE Aust seds	2.9	17.4	3.3	2.5
SE Aust granite	3.1	19	4.8	2.9
Cornish granite	4.3	15.4	12.8	4.8
Innamincka	3.7	33	18	7.3
Stinking Cornishman	3.7	65	43	15.9



Carboniferous Granite Study

Heejin Jeon and Ian Williams RSES, ANU

- SHRIMP dating
- Hf and O isotopes
- Chemistry



Dated: Chapmans Ck, Oberon, Tarana, Lett, Duronal, Wuuluuman & Gulgong

341 – 328 Ma

- Dating of granites in south, Sydney Basin windows, mineralised & HHP granites.
- Metallogenic and tectonic implications.
- Geothermal implications.





HHP potential, Sydney basin





Granites are more than just fancy kitchen surfaces......

The Geological Survey of NSW (MinSys) are undertaking new studies on all aspects of granite and related rocks from an applied metallogenic aspect to better understand the known metallogeny and what controls it and to map potential for a range of new commodities.

We also invite industry participation in these projects.



