Metasomatism in the Mesoproterozoic – evidence for a regional fluid event in the central Aileron Province

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AUSTRALIA'S NORTHERN TERRITORY

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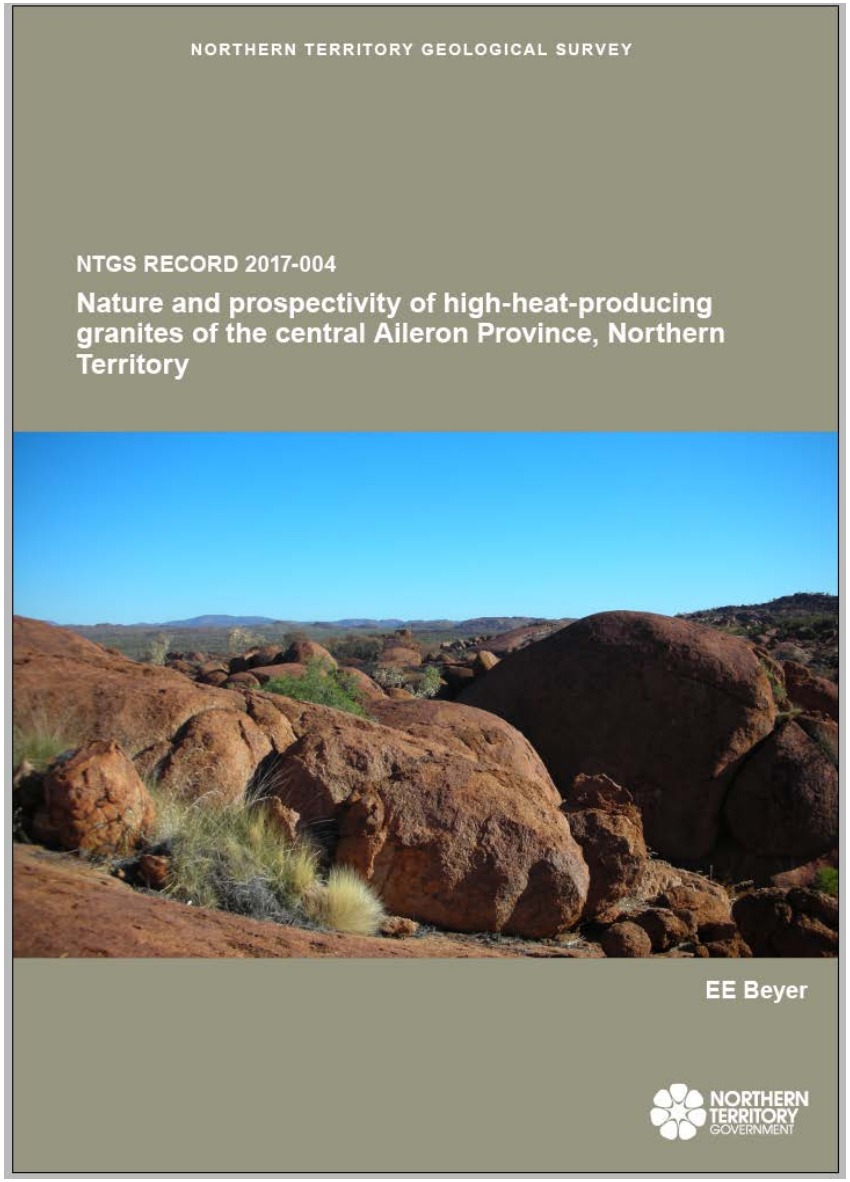
Background

- *Hussey (2003) report on REE deposits in the Arunta Region identified high-heat producing (HHP) granites as potential hosts or sources*
- *Two granites were of particular interest – Wangala and Ennugan Mountains granites*
- *Host zones of biotite schists enriched in U, Th and REE*
- *Led to NTGS project investigating the nature and prospectivity of the two granites and the relationship, if any, between them and the biotite schists*

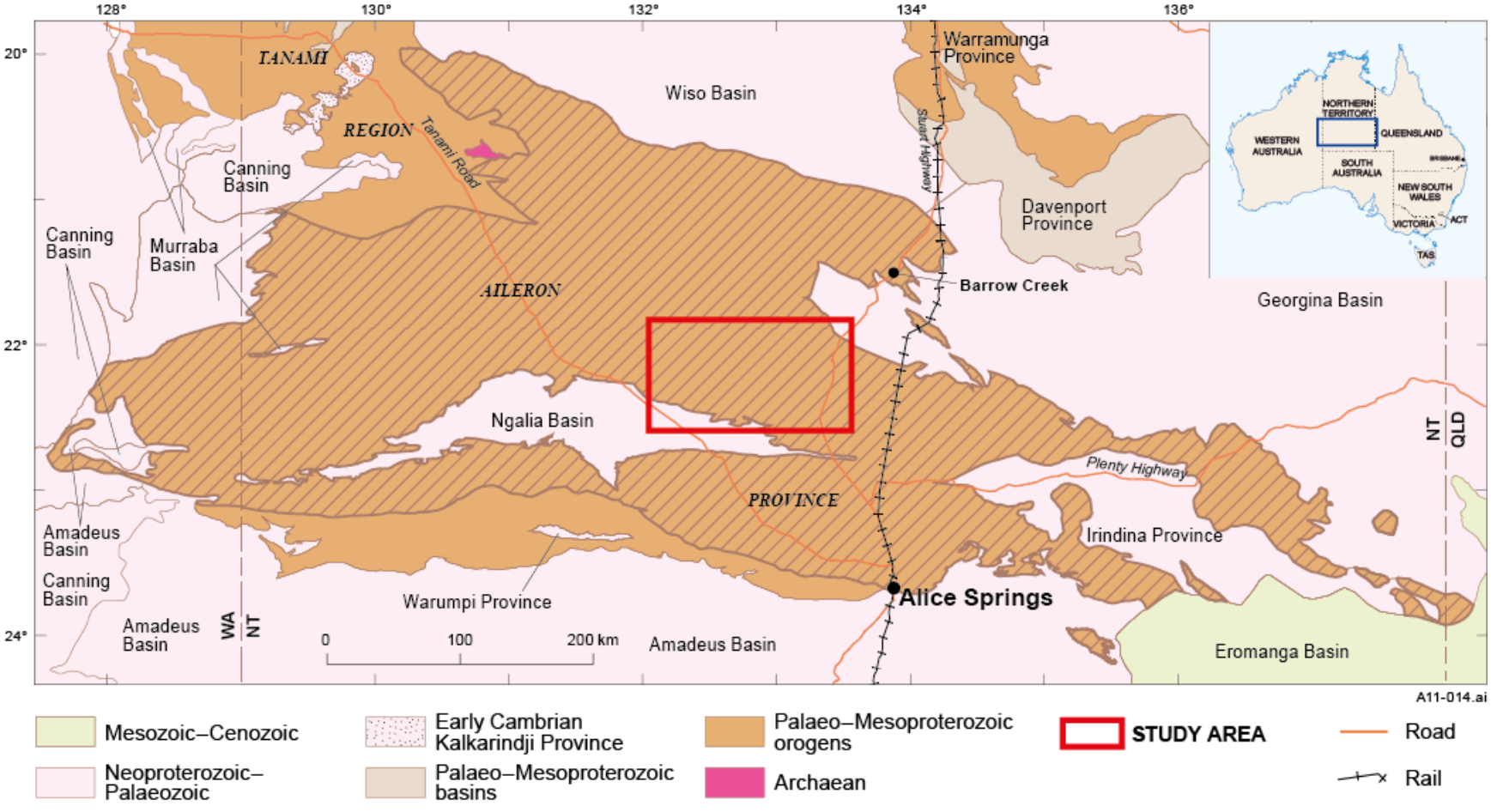
NTGS Record 2017-004

Beyer EE, 2017. Nature and prospectivity of high-heat-producing granites of the central Aileron Province, Northern Territory. *Northern Territory Geological Survey, Record* 2017-004.

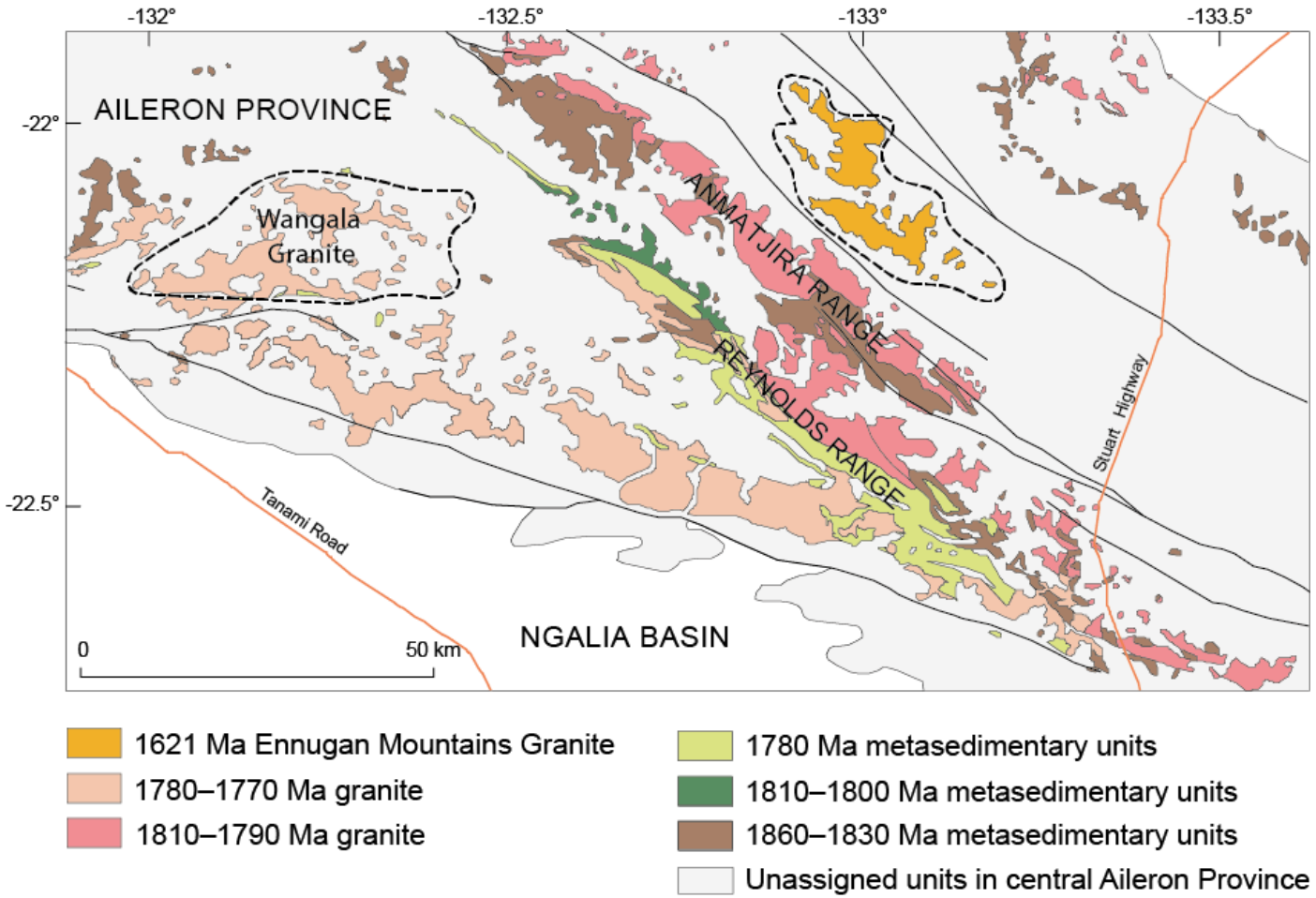
Available for download from the NTGS digital library GEMIS http://geoscience.nt.gov.au/gemis/ntgsjspui/community-list



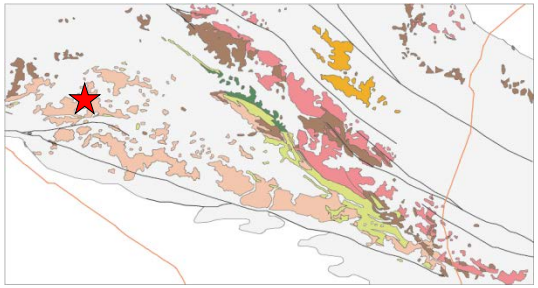
Regional geology



Geological setting



Wangala Granite

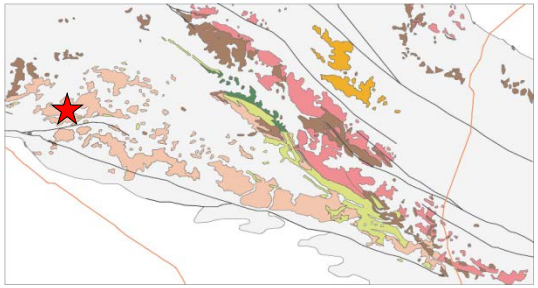


- *Magmatic age of ca 1777 Ma*
- *Composite batholith of five discrete, mappable phases*
- *Porphyritic to equigranular textures*
- *Muscovite ± biotite ± garnet-bearing*
- *Moderately to strongly peraluminous*
- *S-type ie sedimentary source*

Ennugan Mountains Granite

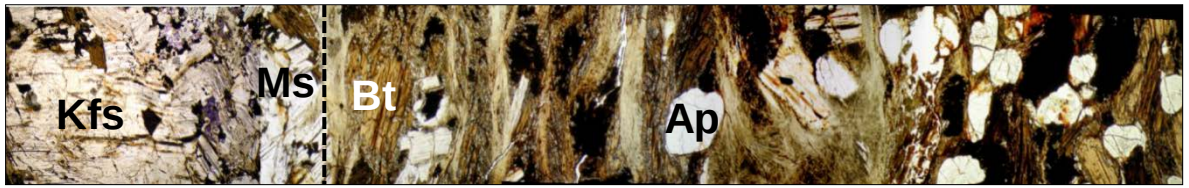
- *Magmatic age of ca 1621 Ma*
- *Multi-phase intrusion*
- *Porphyritic to equigranular textures*
- *Biotite ± hornblende-bearing, rare allanite*
- *Moderately metaluminous*
- *I-type ie igneous source*

Biotite-apatite schist in the Wangala Granite



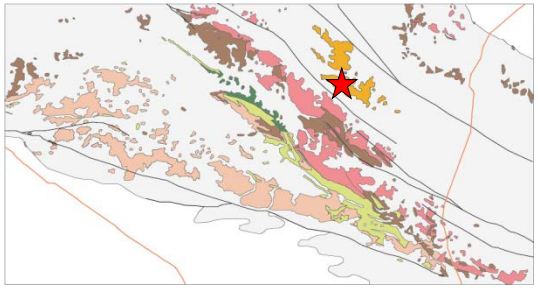
- *East-northeast trending belt over an area of ~2 km^2 in southern Wangala Granite*
- *Host the Quartz Hill apatite-U-REE prospect*
- *Discrete linear bodies ≤2m wide and ≤10m long and carapaces on weathered surfaces*
- *Bt ≤75%, Ap ≤25%, minor Ms-Qtz±Fl±Toz±Sil*
- *Contact with granite is transitional and marked by sericitisation of feldspars, mica alteration and the presence of fluorite and rare topaz => fluid interaction across granite-schist interface*

Granite **Schist**

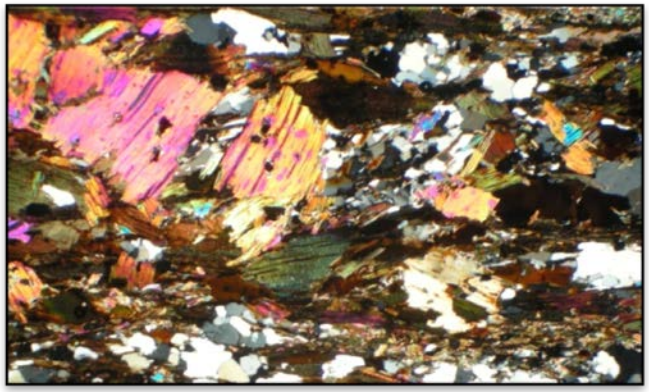


Field of view approximately 2 cm across

Biotite schist in the Ennugan Mountains Granite



- *Several zones of biotite schist ≤2 m wide in southern outcrops*
- *Associated with large quartz fault zones*
- *Quartz fault zones and schists are sheared and aligned with the main NW-trending foliation fabric in the granite*
- *Composed of abundant foliated biotite, large strained muscovite “fish” and fine-grained quartz*



Field of view approximately 4.5 cm across

Previous work

WANGALA GRANITE

- *Rafts of metasomatised metasedimentary country rock (Davies 1979)*
- *“Metasomatic concentrations” of minerals from the granite (Stewart et al 1980)*
- *Zones of hydrothermally altered pegmatite and/or host granite (Hussey 2003)*

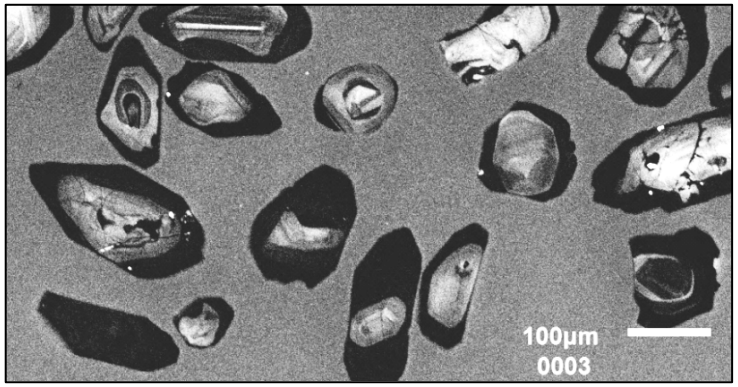
ENNUGAN MOUNTAINS GRANITE

- *Shear zones (Kojan 1980)*

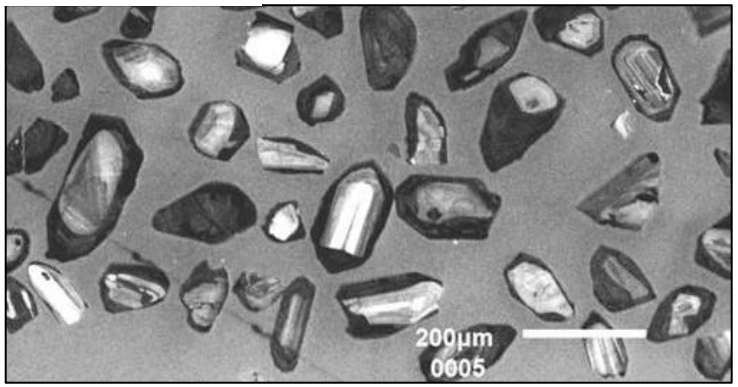
Test using geochronology and geochemistry

U–Pb dating of Wangala Granite and schist

Wangala Granite



Bt-Ap schist



Complex zircon cores

- *1777 ± 11 Ma in granite (LA-ICPMS)*
- *1762 ± 16 Ma in schist (LA-ICPMS)*
- *Older cores ca 2500–1820 Ma in granite and schist, inheritance*

Thick high-U zircon rims

- *1571 ± 28 Ma in granite (LA-ICPMS)*
- *1569 ± 25 Ma in schist (LA-ICPMS)*

Monazite in schist

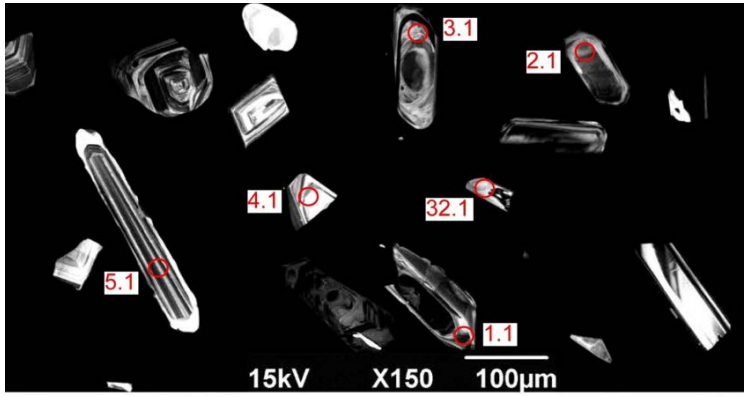
- *1573.6 ± 1.5 Ma (SHRIMP)*

New accessory mineral growth at ca 1574 Ma, synchronous with the 1590–1560 Ma Chewings Orogeny

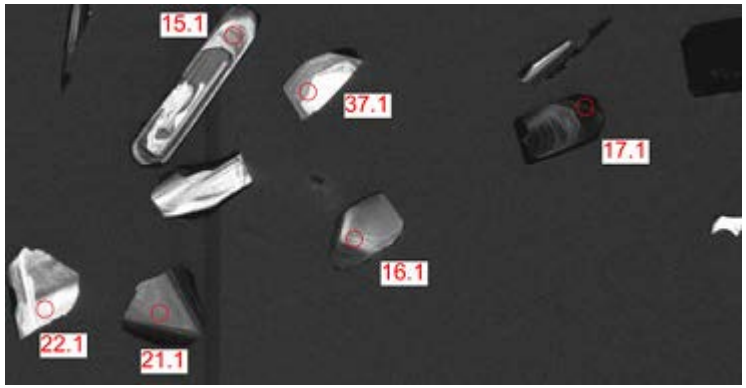
Chewings Orogeny is a significant high-T, low-P tectonothermal event in the central Aileron Province

U–Pb dating of Ennugan Mountains Granite and schist

Ennugan Mountains Granite



Bt schist



Oscillatory zoned zircons

- *1621 ± 5 Ma in granite (SHRIMP)*
- *1615 ± 3 Ma in schist (SHRIMP)*
- *No older, inherited zircons*

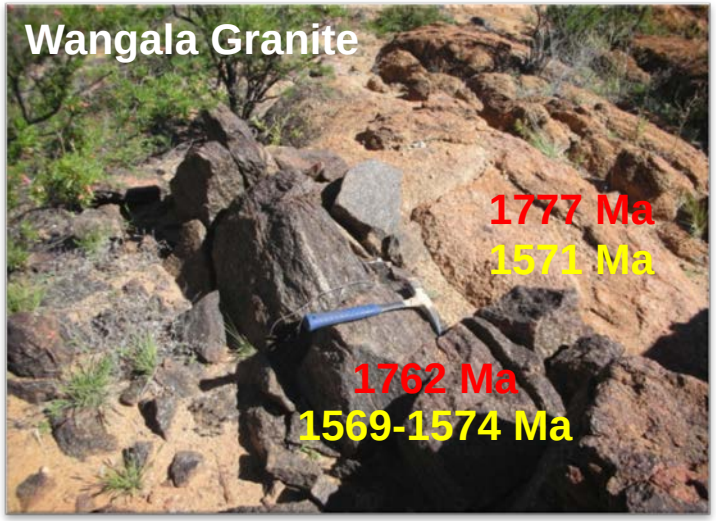
Monazite in schist

- *1606 ± 2 Ma (SHRIMP)*
- *1574 ± 7 Ma (SHRIMP)*

New accessory mineral growth at ca 1574 Ma, synchronous with the 1590–1560 Ma Chewings Orogeny

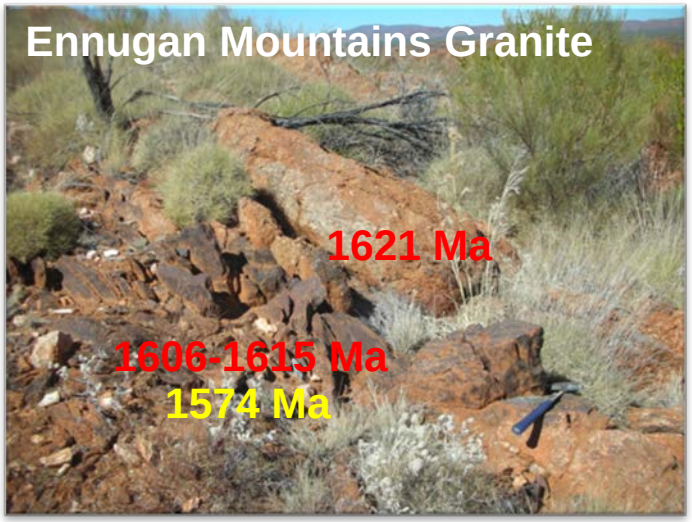
Very good agreement with 1569–1574 Ma ages in Wangala Granite and Bt-Ap schist

What is the geochronology telling us…?



WANGALA GRANITE

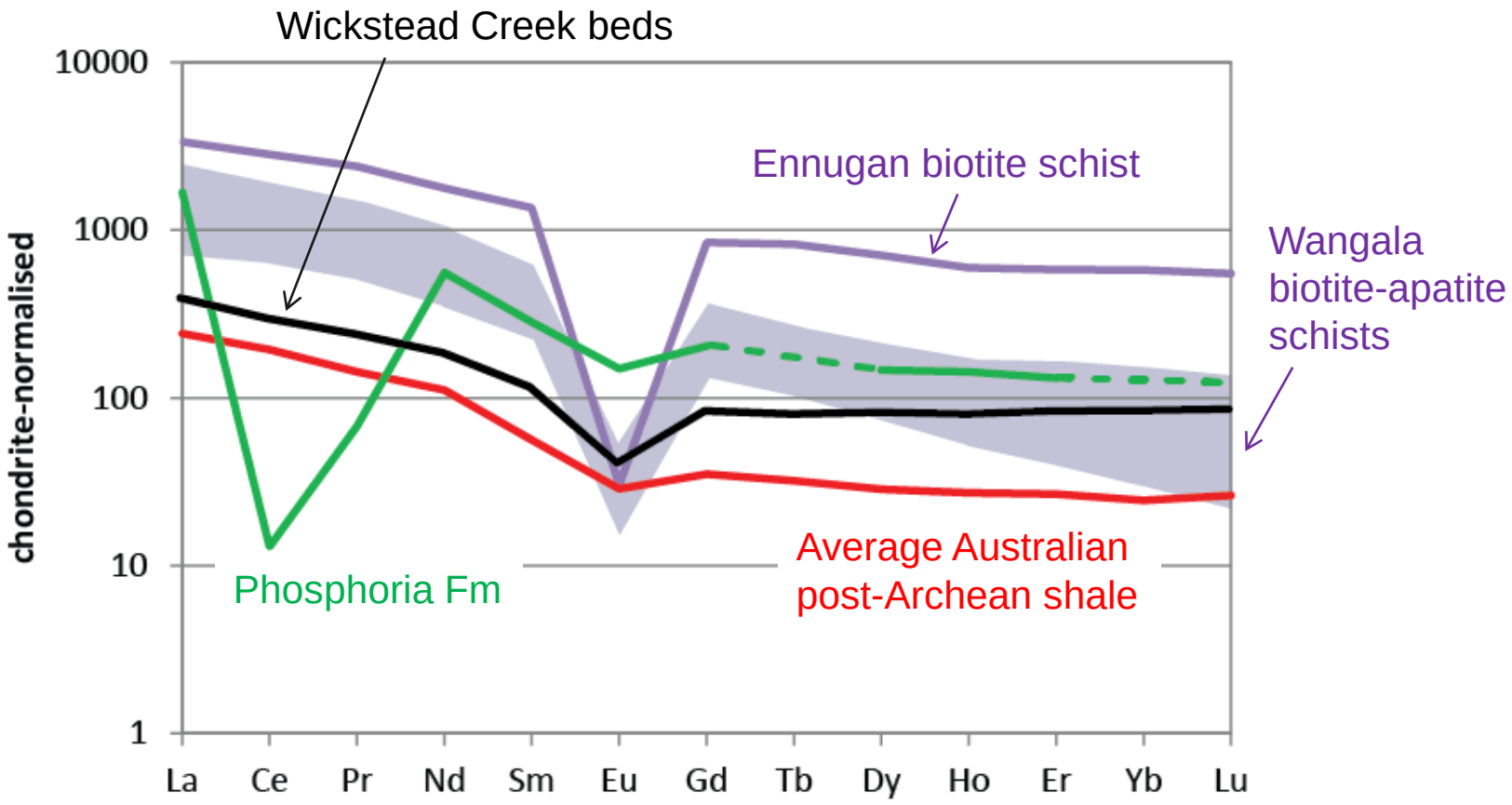
- *Good agreement between U–Pb ages in granite and schist – implies a genetic relationship between the two*
- *However, granite is hosted in ca 1775 Ma Wickstead Creek beds – ca 1762 Ma age for biotite-apatite schists implies they could be rafts of metasomatised country rock*



ENNUGAN MOUNTAINS GRANITE

- *Good agreement between U–Pb ages in granite and schist – implies a genetic relationship between the two*
- *Hosted by 1860–1840 Ma Lander Rock Formation but no zircons of this age in schist – not rafts of country rock*

…further evidence from geochemistry

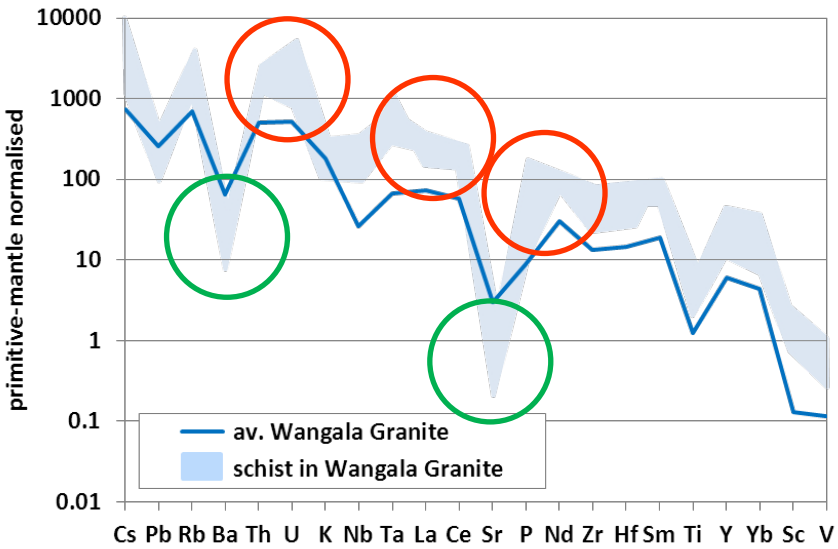


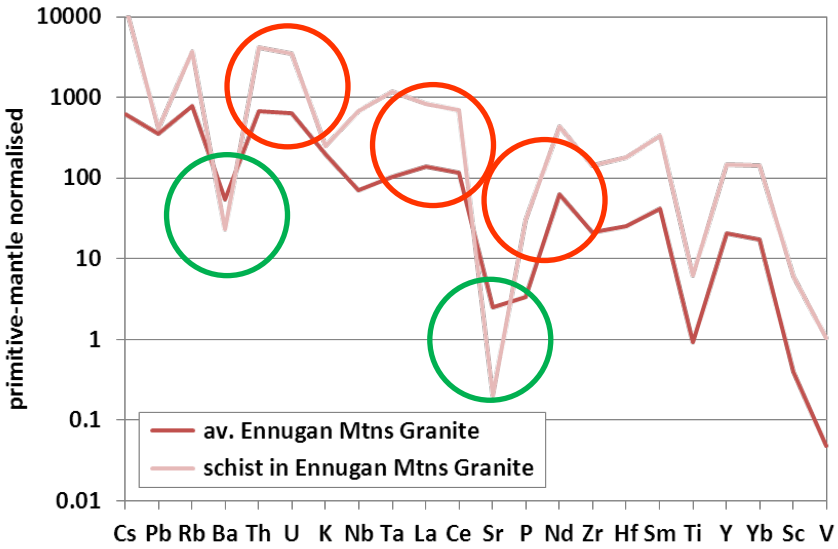
The schists are <u>not</u> altered country rock

Geochemistry of granites vs schists

- *Trace element patterns for granites and biotite schists have a similar shape*
- *Schists enriched in numerous elements compared to host granites including F, **P**, HFSE, **REE**, Ce, Rb, **U, Th** and some metals incl. Zn, Li and W*
- *Schists depleted in some elements compared to host granite e.g. Na, Si, **Ba** and **Sr** ⇒ related to lack of Pl in the schists*

Which phases in the schists host the enrichment?





Trace element budget in schists

WANGALA schist

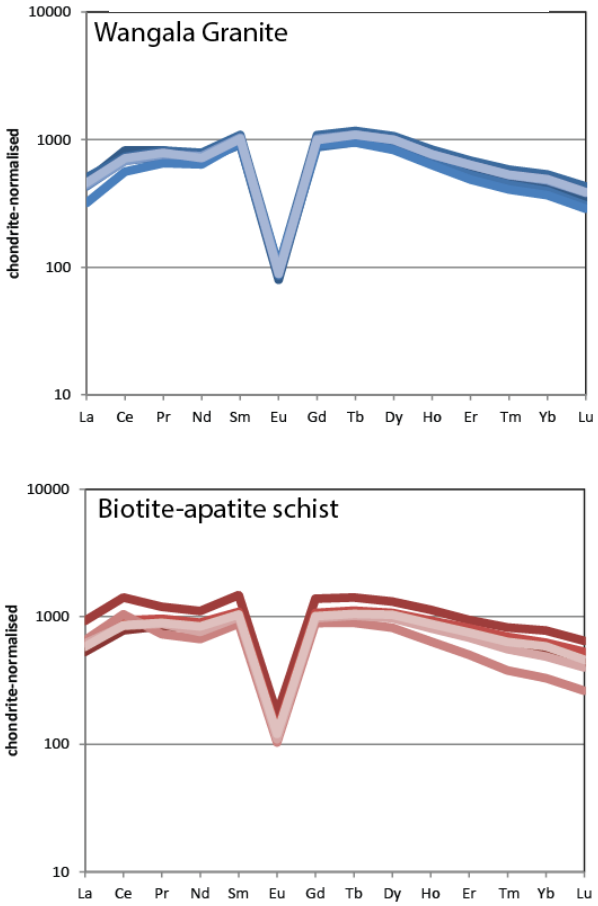
- *Apatite and biotite are enriched in F, U, Th and REE compared to the host granite*

ENNUGAN schist

- *Lacks apatite*
- *Biotite hosts bulk of, muscovite to a lesser degree*

ENNUGAN MOUNTAINS GRANITE		
Element	Biotite (granite)	Biotite (schist)
F (wt%)	0.39	1.43
U (ppm)	0.27	9.5
Th (ppm)	0.08	1.5
Ce (ppm)	0.05	0.98

REE patterns for apatite in Wangala schist

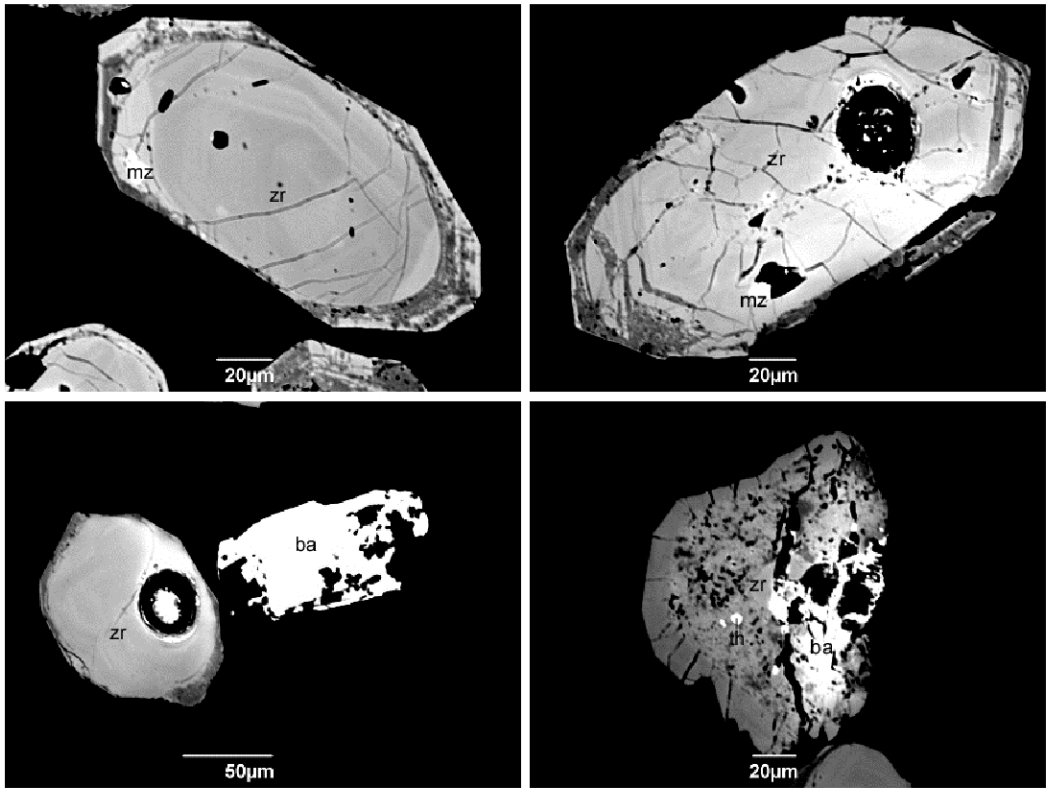


These minerals precipitated from a fluid enriched in F, U, Th and REE

Micro-inclusions in zircon

*LA-ICPMS analysis of Wangala schist revealed some unusual enrichments in **ca 1574 Ma** zircon rims compared to cores*

Element (ppm)	Core	Rim
U	7087	15341
P	1735	53857
Y	3816	83830
La	65	13402
Ce	478	20443
Dy	123	13090

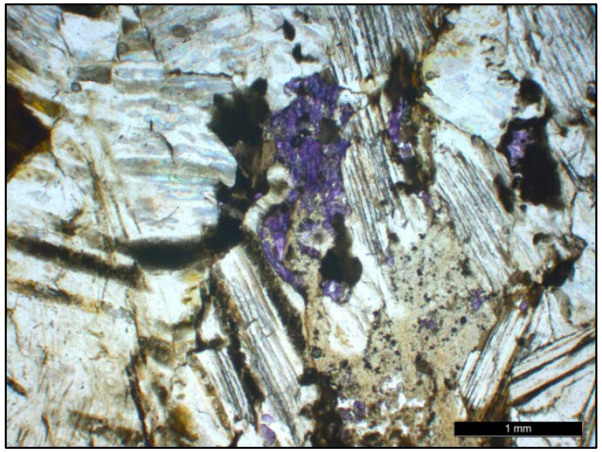


BSE images courtesy of D. Huston, Geoscience Australia

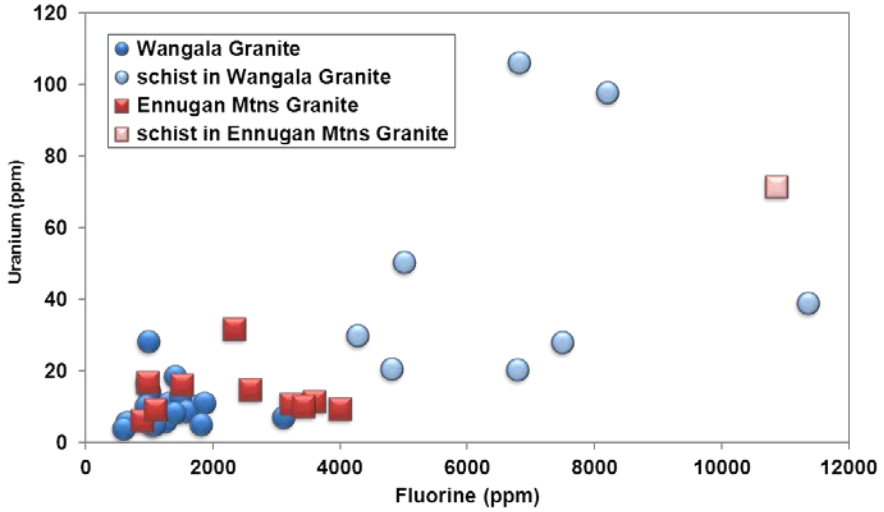
BSE images reveal micro-inclusions of monazite, thorite and barite in zircon rims – precipitated during ca 1574 Ma fluid event

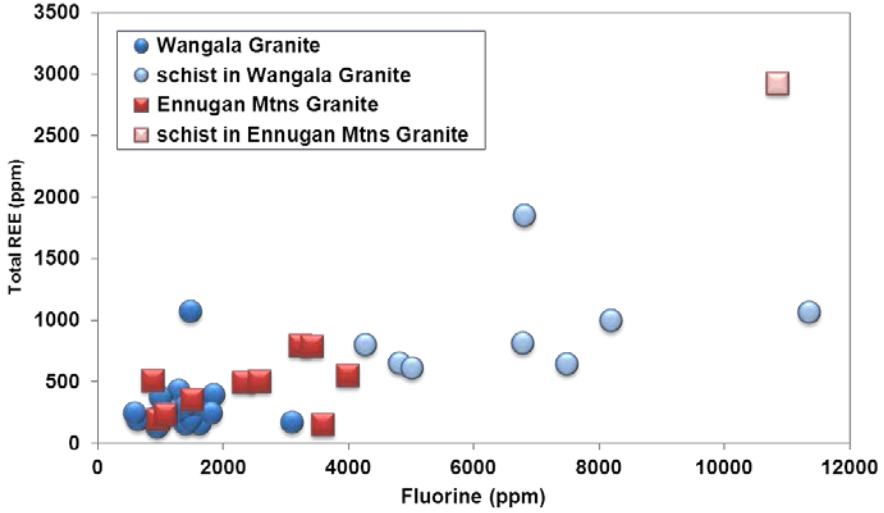
Nature of alteration fluid

- *Schists are strongly enriched in fluorine compared to host granites*
- *Fluorine is a powerful ligand for metal transport*
- *Good correlation between F and U, Th, REE, P and metals incl. Sn, W, Zn*



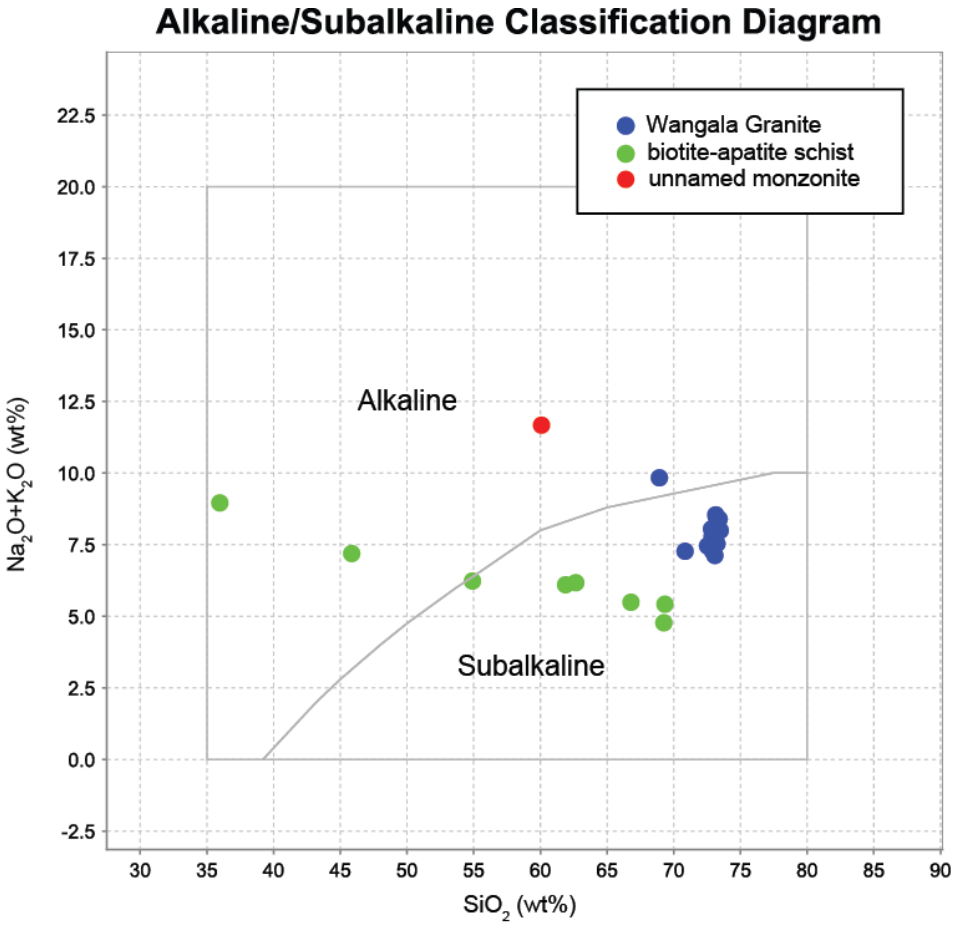
Fluorite at interface between Wangala Granite and bt-ap schist





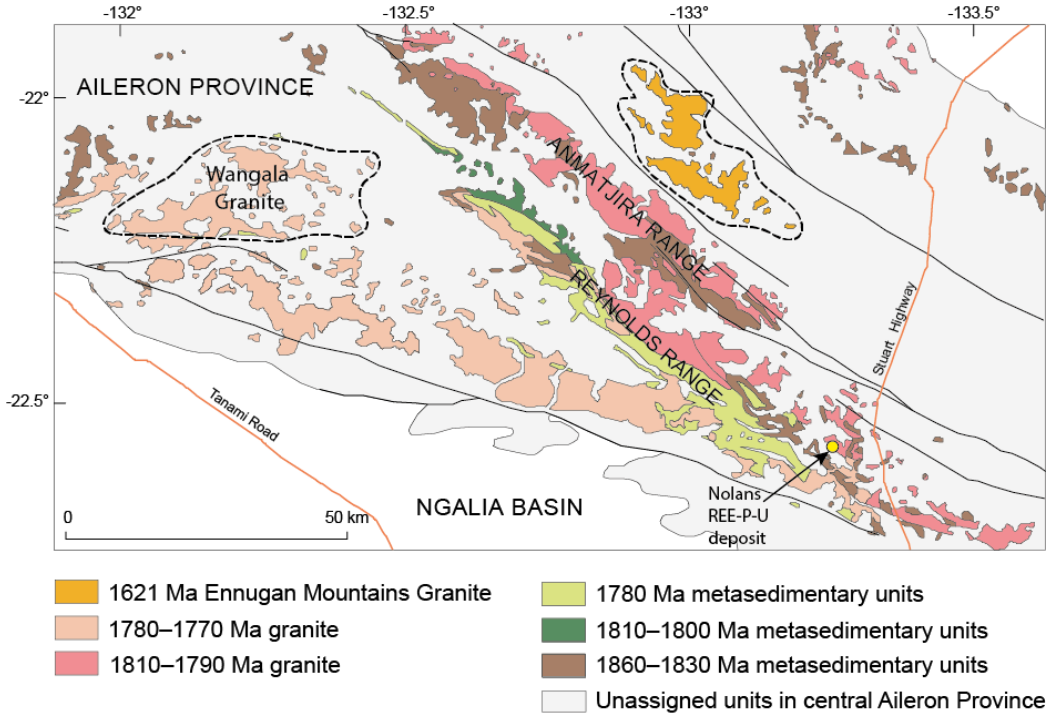
Source of fluid?

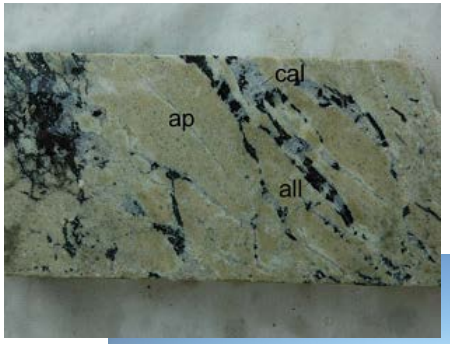
- *1570–1530 Ma magmatism in the western Aileron Province*
- *Wangala bt-ap schists range to alkaline compositions*
  *=> **is their source also alkaline?***
- *Alkaline rocks rare in the Aileron Province and none known from the Mesoproterozoic*
- *Isolated occurrence of monzonite intruding the southern outcrops of Wangala Granite*
- *Has an alkaline composition and is similarly enriched in F and incompatible elements as the schists*
- *Age dating of monzonite would help confirm it as a potential source*



Speculative at best, however…

Link to Nolans REE-P-U fluorapatite vein deposit





Huston *et al* (2016)

- *Mineralisation is hosted in ca 1806 Ma Boothby Orthogneiss, which is NOT a HHP granite*
- *New isotopic evidence suggests that massive fluorapatite was deposited during a ca 1550–1525 Ma fluid event (Huston et al 2016)*
- *Fluids derived from alkaline low-degree melts*

Summary

- *Biotite-rich schists in two unrelated HHP granites*
- *Geochronological and geochemical data reveal that the schists are discrete zones of metasomatised granite*
- *Zircon and monazite U–Pb data indicate that metasomatism took place at ca 1574 Ma, synchronous with the 1590–1560 Ma Chewings Orogeny*
- *Metasomatic fluid was fluorine-rich and enriched in P, U,Th, REE and metals*
- *Source of the fluid is unknown but was potentially alkaline in composition*
- *Ca 1550–1525 Ma alkaline fluid event recognised at the Nolans deposit shows that this was a regionally significant event that affected more than just HHP granites*