Lithogeochemistry of Pegmatites at Broken Hill: Vectors to Mineralisation

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OUTLINE

- Geological Framework
- Olarian Metamorphism
- Sampling Rationale
- Pegmatite Styles
- Geochemistry
- What we think
Stratigraphy
GEOCHRONOLOGY

Silts, black shales: deep marine, turbiditic: cap rocks, deep burial

RAPID SUBSIDENCE

quartzofeldspathic: shallow marine-shelf (maybe lacustrine)

Albitic, quartzofeldspathic: fluvial to estuarine

Stevens (2006)
**GEOLOGY**

- Rift sedimentation and volcanism (1850 to 1670Ma).
- Narrow Rift.
- Mineralisation 1685-1670Ma

- At least four deformations, two thermal events

**Key units**

2. Broken Hill Group: Ore host especially in upper parts.
5. Paragon Group: Carbonaceous shales, deeper marine,
Where did it start?

- Lithium
- Documented occurrences of Li minerals (amblygonite)
- GIS data indicates almost 10% of tenure area occupied by outcropping pegmatite
- 50% tenure under cover.
- Suggests pegmatite rock volume in district might be as much as 20%
PEGMATITES

- Provide a sample medium ubiquitous to the district
- Often the only outcropping rock in areas of sub-crop or cover
- Many more occurrences of pegmatite than mapped
- Are they products of anatexis and largely *in situ*?
- Are they allochthonous and intrusive?
Zone of Lithium-rich pegmatites
Broken Hill

Metamorphic Zone

Greenschist

Amphibolite

Decreasing temperature and pressure

Granulite

Mineral-rich sediments

Fault

Pegmatite

Granite

(Melting of Sediment)

Broken Hill Pegmatites
Schematic Model

Adapted by Silver City from Fitzherbert 2015, Cerny 1991 and Breaks et al 2003
METAMORPHISM

Olarian Orogeny: 1600 - 1580 Ma

Pegmatites: 1600-1590 Ma
Mundi Granite: 1590-1580 Ma

“In a regional sense some pegmatites appear to be large sill-like bodies which are stratabound”
Pegmatites stratabound?
“Due to the stratabound nature of the metamorphic field gradient there is also an association with metamorphic facies zones and isograds”….. (Fitzherbert 2015)
Metamorphic isograds generally conform with the stratigraphy.
Mineralogy documented to occur within pegmatites includes:
- amazonite (green lead-rich feldspar)
- zinc–rich micas
- sulphides.
**SAMPLING**

- Sample weight 2.5-3kg
- 2 objectives
  - Minerals
  - Representative
- Area sampled dependent on meeting objectives
- Range 5x5m to 50x50m
ANALYSIS

Lab
- ALS Orange
- 4 acid digest
- 48 element ICP-MS
- Representative sample

Scanner
- Minerals only
- XRF + 10mm window
- LIBZ < 5mm window
- Need flat surfaces
- No comparison with Lab
- Similar trends
- We had a go but data was largely inconclusive & not suitable
Pegmatite Type 1

- “Leucogranites"
- Fs-qtz in f.g. fs groundmass
- Fs + Qtz <2mm - <10mm
- Coarser sized accumulations
- Perthitic
- Musc +/- biotite, tourmaline, garnet
- Outcrop >50m
- Variable contacts
- Granite-like + coarse pegmatite segregations
- + Pb and Zn, - Cu
- +/- immobile + average or slightly depleted LCT.
Pegmatite Type 2

- Fs-Qtz-Musc
- Fs+ Qtz < 20cm – 30cm
- Musc <2cm – 5cm
- +/- Tour (≤10cm)
  Garnet ≤ 5cm
- Garnet to sediment contacts.
- Concordant and discordant
- <1-5m wide to 5-10+m long
- All units and facies
- + Pb, Zn, U and in many LCT elements
Pegmatite Type 3

- Qtz-Musc only
- Mapped Qtz veins
- Musc often green (Rb and Li-rich?)
- Waukeroo tin field
- < 2m wide +10m long
- Concordant, often sheared
- Tour locally abundant margins of pegmatites
- Host rocks intensely replaced by tourmaline, preserving fine sedimentary detail
- Freyers Metasediments, Hores Gneiss (Broken Hill Group), Sundown Group and Paragon Group
- + LCT elements + Cu & Zn, - Pb.
Pegmatite Type 4

- Zoned across + along strike
- Across - white, translucent Qtz core with Qtz + Fs + Musc on margins
- Along – Qtz vein to Qtz+FS+Musc pegmatite
- Qtz & Fs phenocrysts to 15cm
- <2m x 5m - 10m x 15m
- All units, concordant and cross-cutting
- Visually Type 2 but zoned and coarser
- - Pb, Ag, Zn, +/-Sn and Cs
Pegmatite Type 5

- White Fs dominant
- Fs crystals to 1.5m
- Qtz < 15%
- Musc + Gnt uncommon, Tour rare
- Recorded as beryl-bearing
- Discordant
- Locally offset suggesting earlier phase
- -- most elements except Ag, Co, Cr, Pb, Th, V and W.
Tin Deposits
Riddock

- + Ag, Pb, Mn, Zn
- Anomalous rock
- Little surface exploration
- Limited drilling
- Poor outcrop
- Complex geology

Silver distribution
+ Ag, Pb, Mn, Zn
Anomalous rock
Little surface exploration
Limited drilling
Poor outcrop
Complex geology

Lead distribution
Limestone

- + Ag, Pb, Mn
- Limited surface exploration
- No drilling
- Poor outcrop
- Some historical soil contamination - XRF
- Good correlation with geology

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Lead distribution
FRACTIONATION TRENDS

- Defined by K/Rb and K/Cs ratios
- Square = avg upper crust and North American Shale Composite
- Green - granulite, red – amphibolite, blue – greenschist
- Initial loss of Cs at granulite grade
- Single fractionation series
Elemental Fractionation

K/Rb : Cs ppm

K/Rb : Ga ppm

K/Rb : Li ppm

K/Rb : Nb ppm
Elemental Fractionation

K/Rb : P ppm

K/Rb : Ta ppm

K/Rb : Tl ppm

K/Rb : Sn ppm
Elemental Fractionation

K/Rb : Ag ppm

K/Rb : Cu ppm

K/Rb : Zn ppm

K/Rb : Pb ppm
Zone of Lithium-rich pegmatites
Broken Hill

Intrusive and allochthonous

Partial Melting

Broken Hill Pegmatites
Schematic Model
REFERENCES


