Two generations of cassiterite in albite-spodumene pegmatites from SE Ireland: Implications for tin mineralisation in lithium pegmatites

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Tin: a critical metal?

Deemed critical for U.S. economy
(U.S. Interior Department, 2018)
Latest tech gadgets
(2000–1000 BC)
- Displays
- Aircrafts
- Solar panels

Indium tin oxide
Increasingly used in conventional car batteries

Potential use in anodes of Li-ion batteries
- Veins and stockworks $\rightarrow$ Hydrothermal
- Rare-element pegmatites $\rightarrow$ Magmatic? $\rightarrow$ Metasomatic
- Greisens and skarns

Distance to granite ↓
Temperature ↑

Deep

Shallow

Tin deposits
Regional geology

Data source: Geological Survey Ireland

Li(-Sn-Ta) more distal, shallower
Sn-W proximal, deeper

Li Pegmatite
East Carlow Deformation Zone (ECDZ)
Faults
Carboniferous limestone and shale
Devonian to Carboniferous sandstone, conglomerate and mudstone
Silurian meta-greywacke
Ordovician metasedimentary and metavolcanic rocks
Cambrian greywacke and quartzite
Leinster Granite:
1 Northern Unit
2 Upper Liffey Unit
3 Lugnaquilla Unit
4 Tullow Lowlands Unit
5 Blackstairs Unit
- Spodumene pegmatite

Pegmatite lithologies
- Spodumene pegmatite
- Albitites (Ab*)
Pegmatite lithologies

- Spodumene pegmatite
- Albitites (Ab*)
- Quartz-muscovite assemblages (QMA)
- Spodumene pegmatite
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Trace-element zoning in muscovite

The magmatic-hydrothermal transition

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The magmatic-hydrothermal transition

Cassiterite
\( \text{SnO}_2 \)
Cassiterite

CGM = Columbite group mineral

BSE

Ab

Ms

Chl

Qz

Ap

Laser pit
Turbid zoning in 2.1

Alteration? When?

Kaeter et al. (in preparation)
Trace-element zoning in cassiterite

Kester et al. (in preparation)
Zoning and deformation

Pre-2 fracturing and alteration

Syn-2 fracturing?
Melt and fluid evolution

Kaeter et al. (in preparation)
Magmatic cassiterite:
- Less fractionated (low Ta/Nb, Hf/Zr)
- High T, higher impurities

Hydrothermal cassiterite:
- Highly fractionated (high Ta/Nb, Hf/Zr)
- Low T, lower impurities

Supported by melt and fluid inclusion studies as well as petrographic and geochemical observations of cassiterite in other pegmatites.
(e.g. Rao et al., 2009; Dewaele et al., 2011; Borisova et al., 2012; Llorens González et al., 2017)

Magmatic (1) vs Hydrothermal (2)
Cassiterite in the magmatic–hydrothermal transition

Stage I: **Magmatic**
- Fractional crystallization from silicic melt
- Enrichment in incompatible elements incl Sn

Stage II: **Magmatic–metasomatic**
- Unmixing into two melts and fluid
- (1) Magmatic cassiterite from silicic melt
- (1*) Deformation and dissolution–reprecipitation

Stage III: **Metasomatic–hydrothermal**
- Precipitation of albite and hydrothermal muscovite
- Hydraulic fracturing
- (2) Hydrothermal cassiterite
Reading the *mineralogical record* of multistage minerals is a key to decipher complex crystallisation processes.
Cassiterite precipitates after the magmatic first stage of pegmatite formation from both polymerized melt and later aqueous fluid.
So what?
Mining: Tin (and tantalum) is concentrated in metasomatic units and might remain in the ground if the pegmatite is specifically mined for spodumene.

Exploration: Cassiterite as indicator mineral; mineral texture and inclusions can tell us if its source is pegmatite or vein-system.
Thank you for your attention.

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References


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