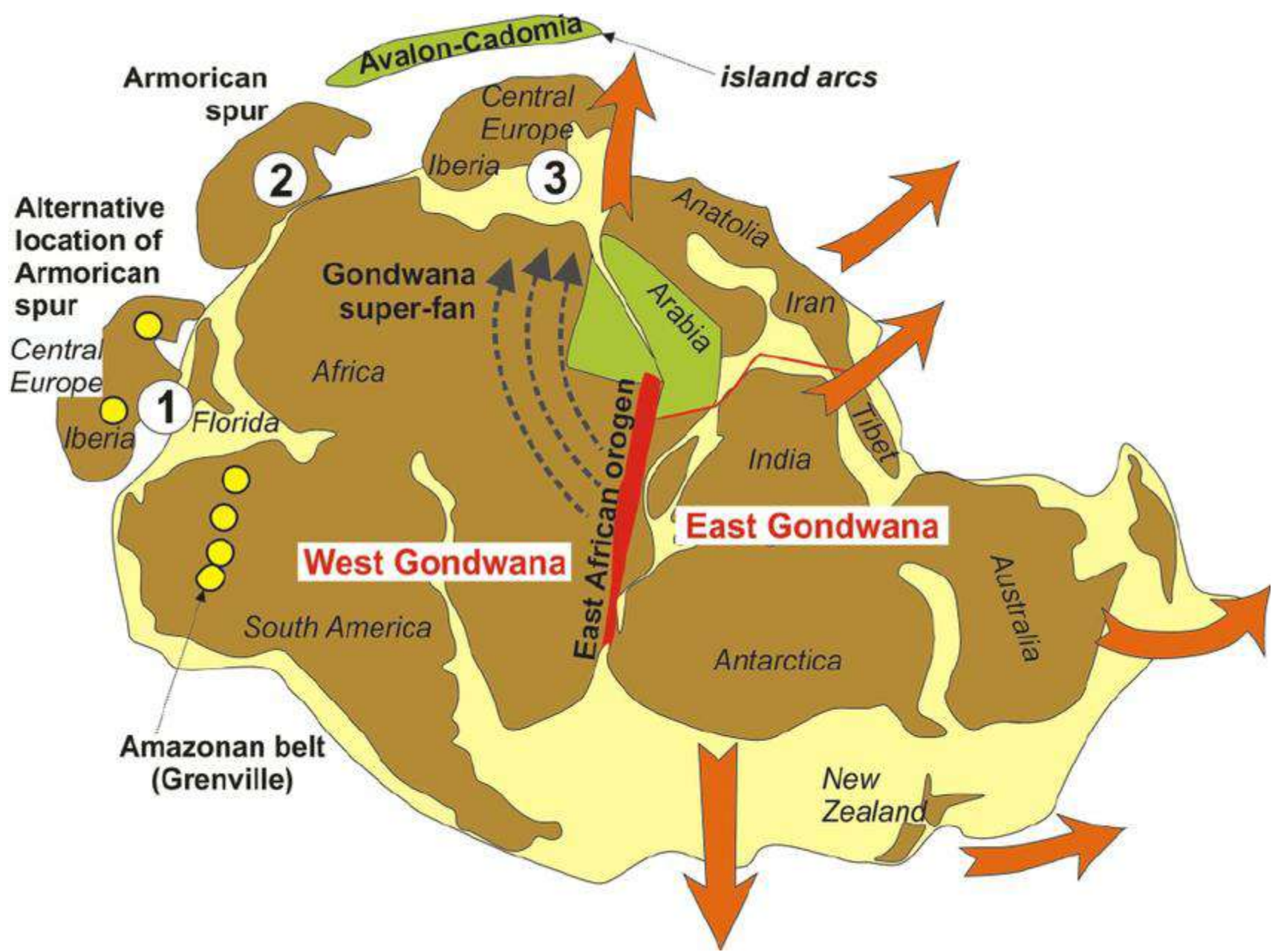
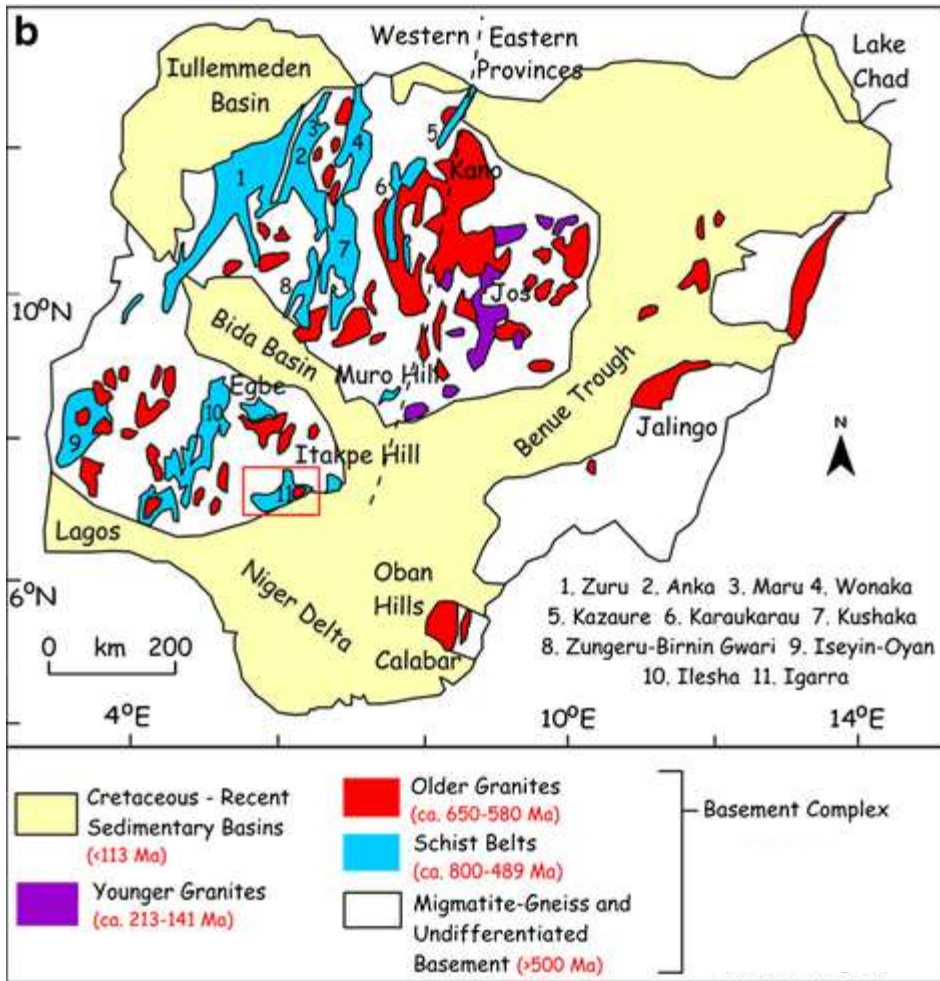


Gondwana
supercontinent

Panafrican
orogeny



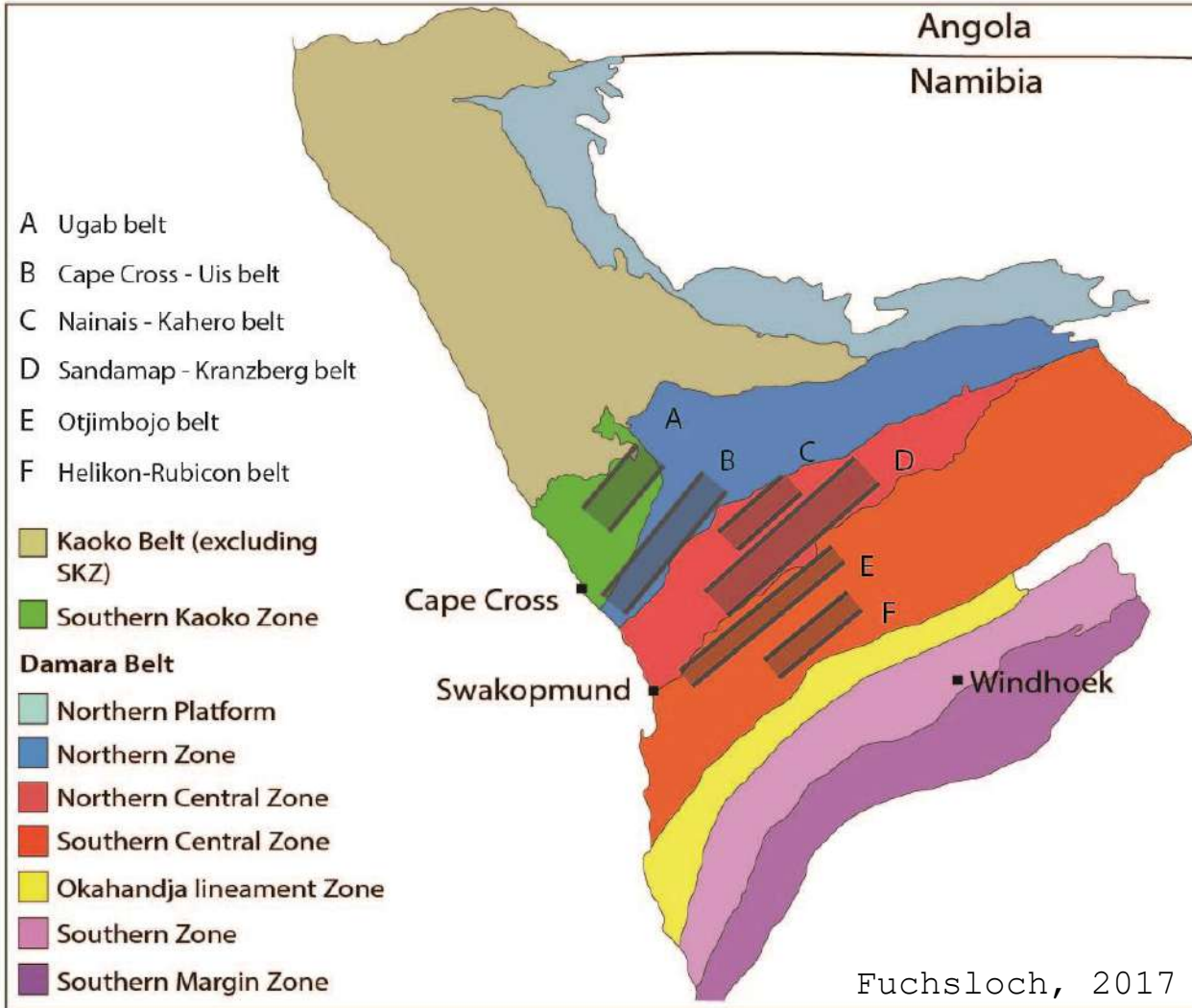
Panafrican pegmatites - Nigeria



Gahnite, Kinnaird, 1987

(modified after Woakes et al. 1987)

Panafrican pegmatites - Namibia



De Rust pegmatite dipping steeply to the north - dip of country rock to the south

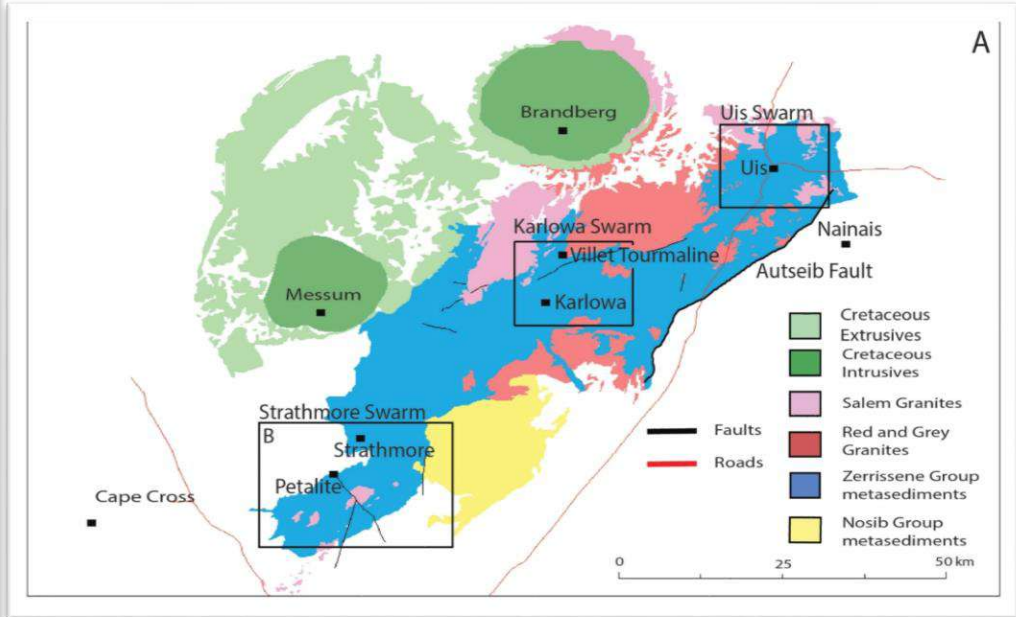
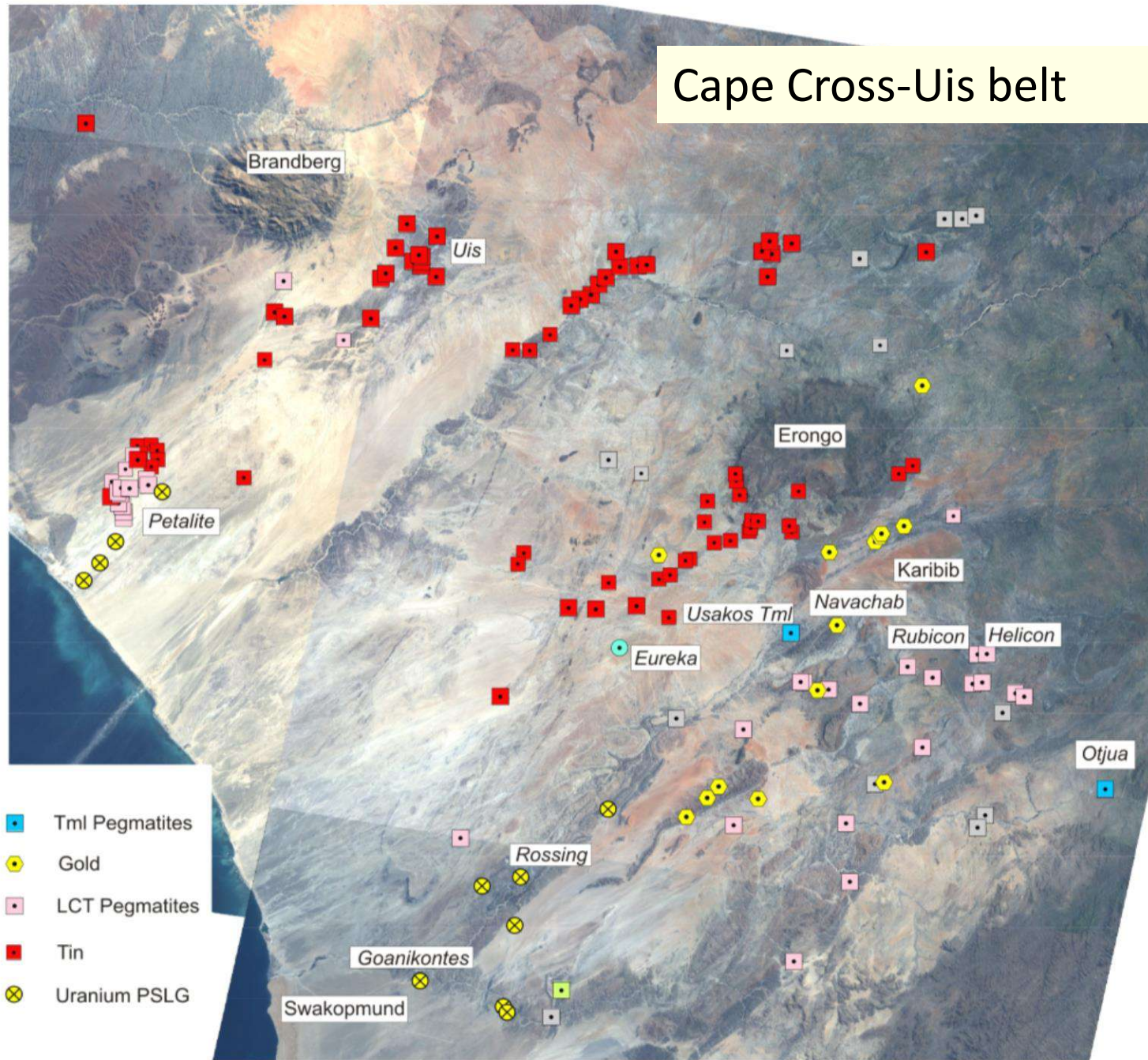


The inner intermediate zone with a 1 m long spodumene

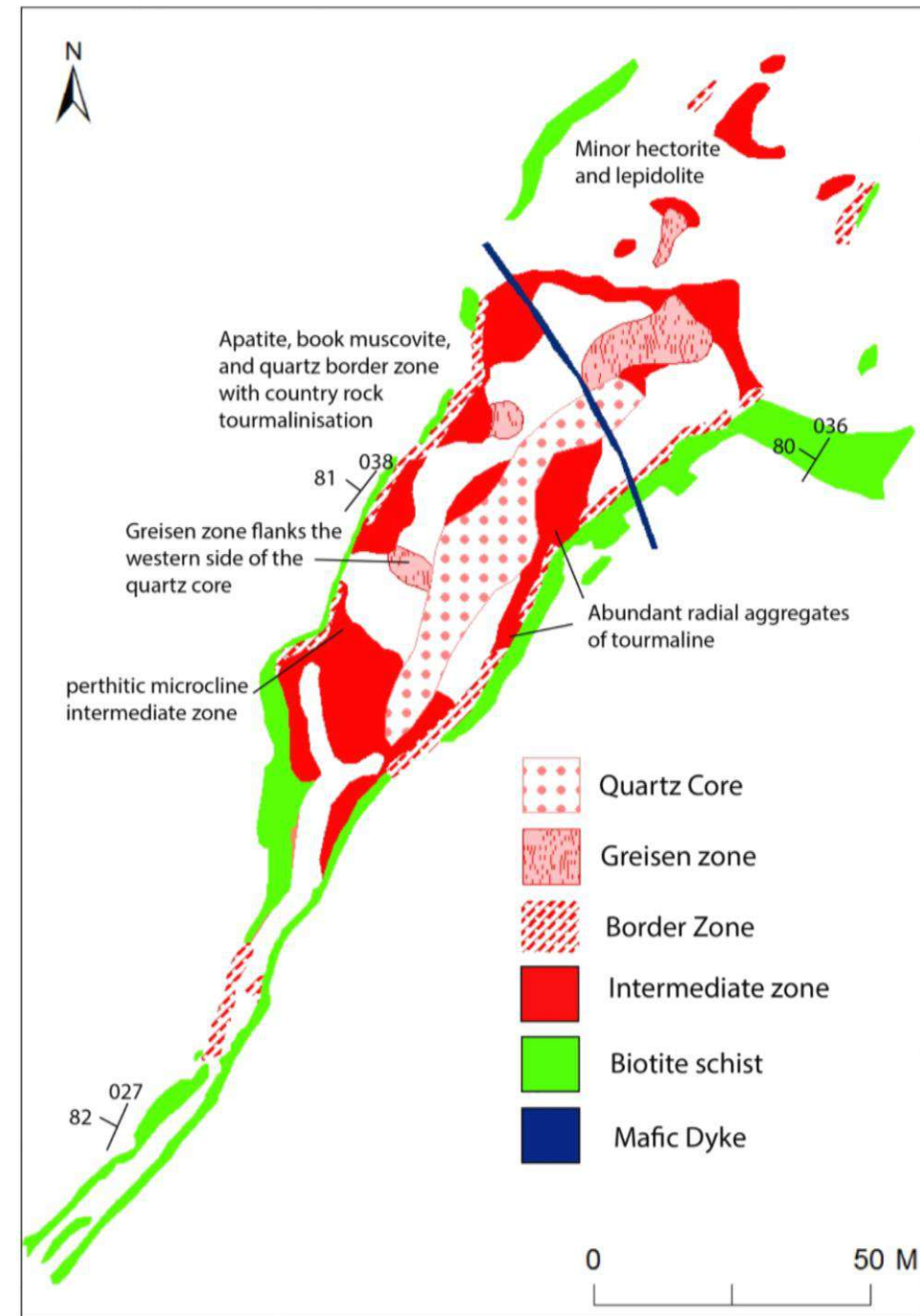
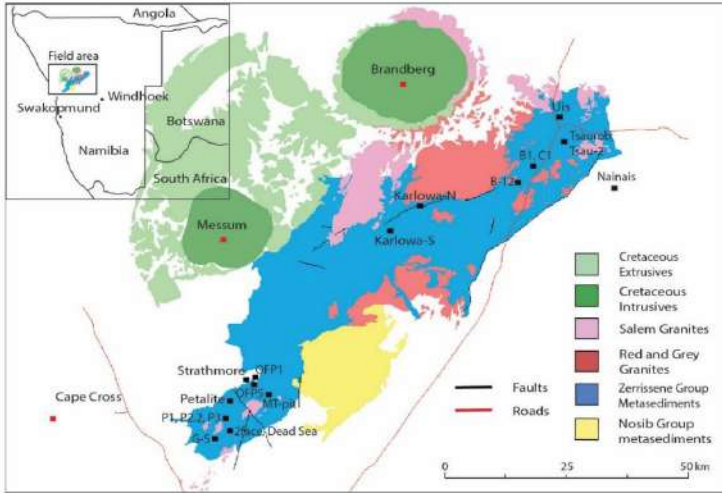


(Photos: Nex 2021).

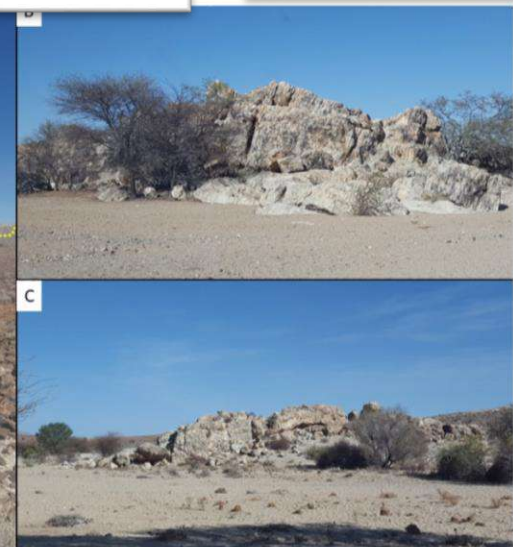
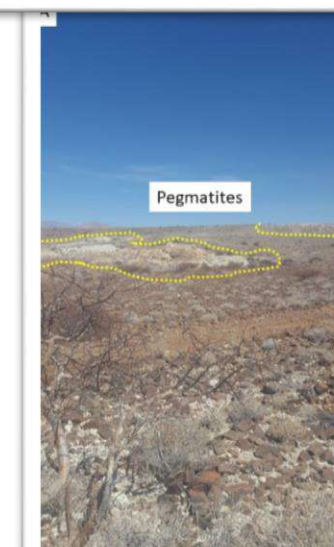
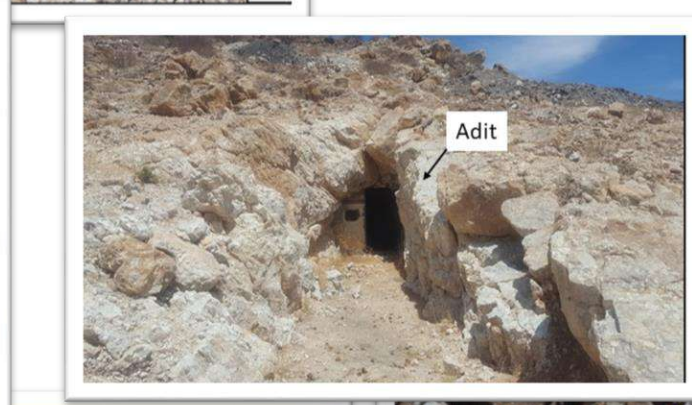
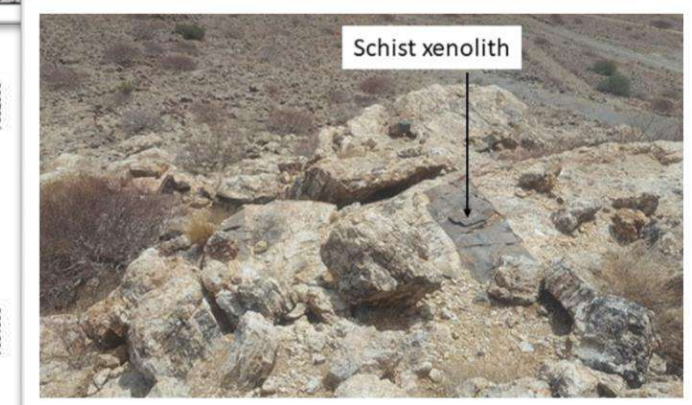
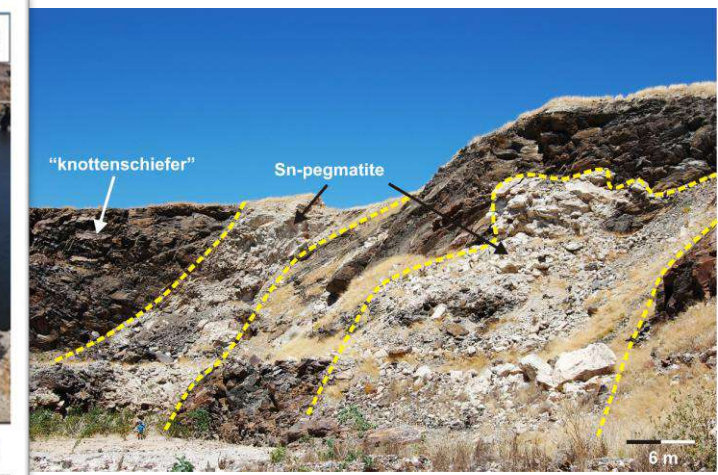
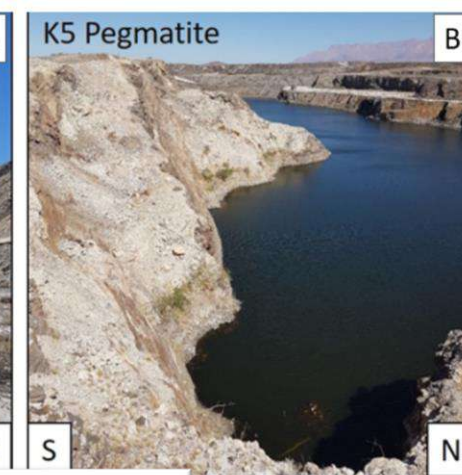
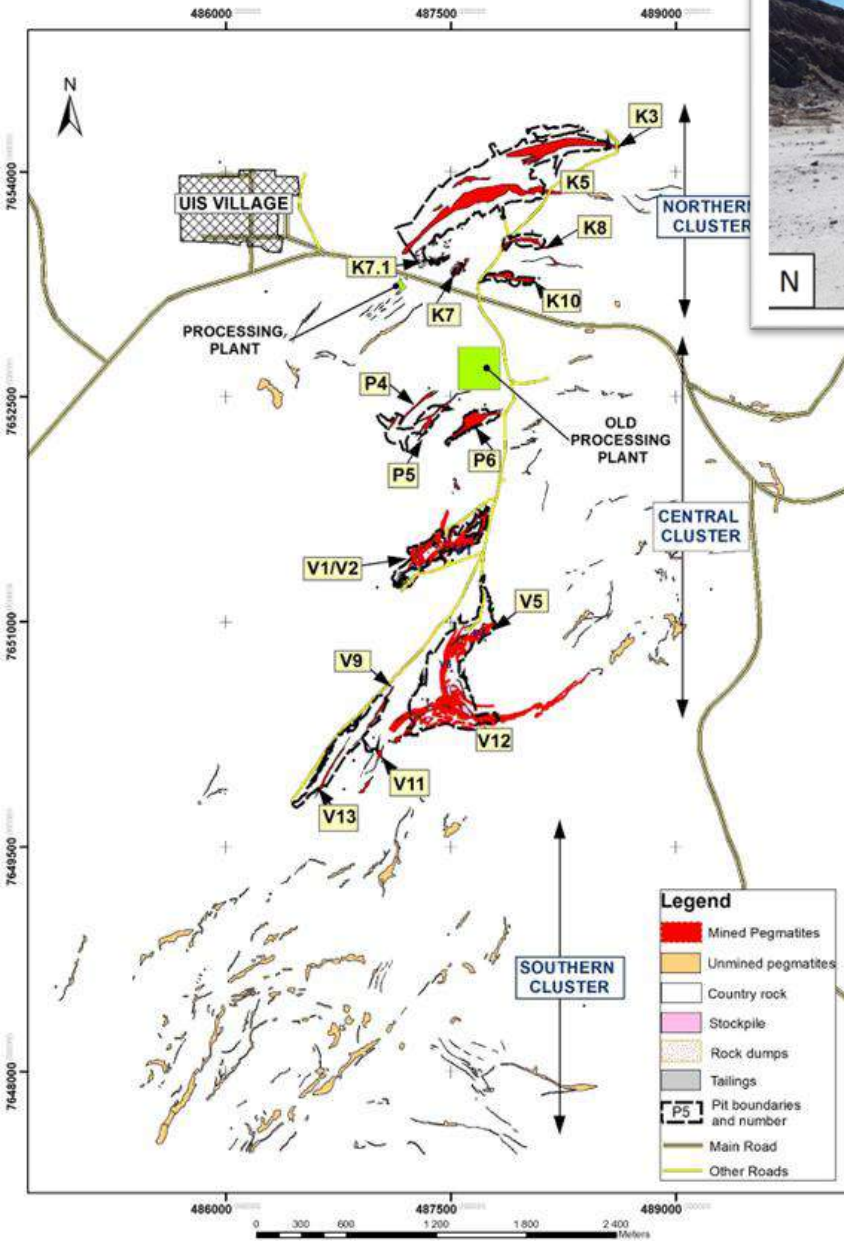
Cape Cross-Uis belt



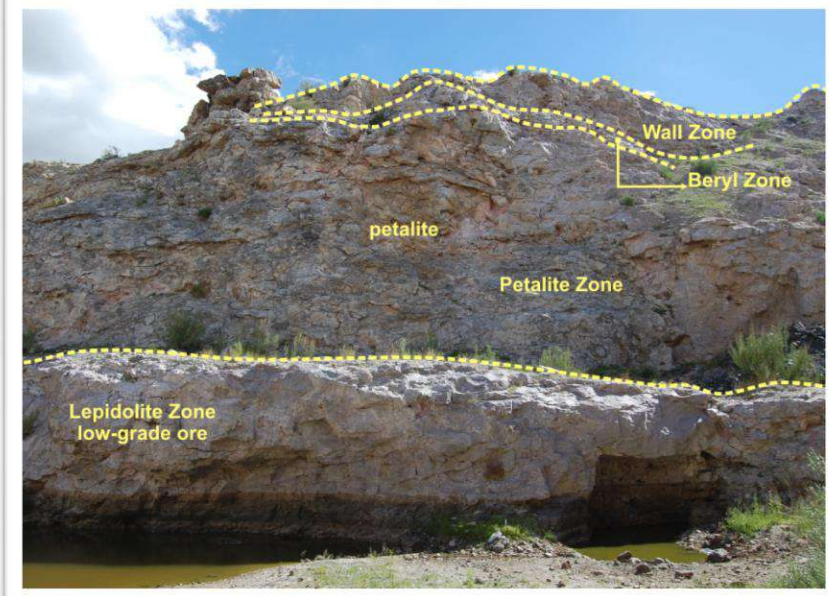
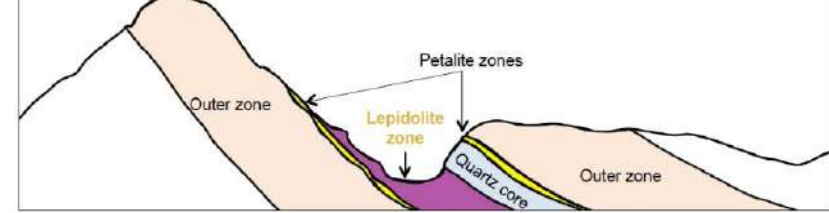
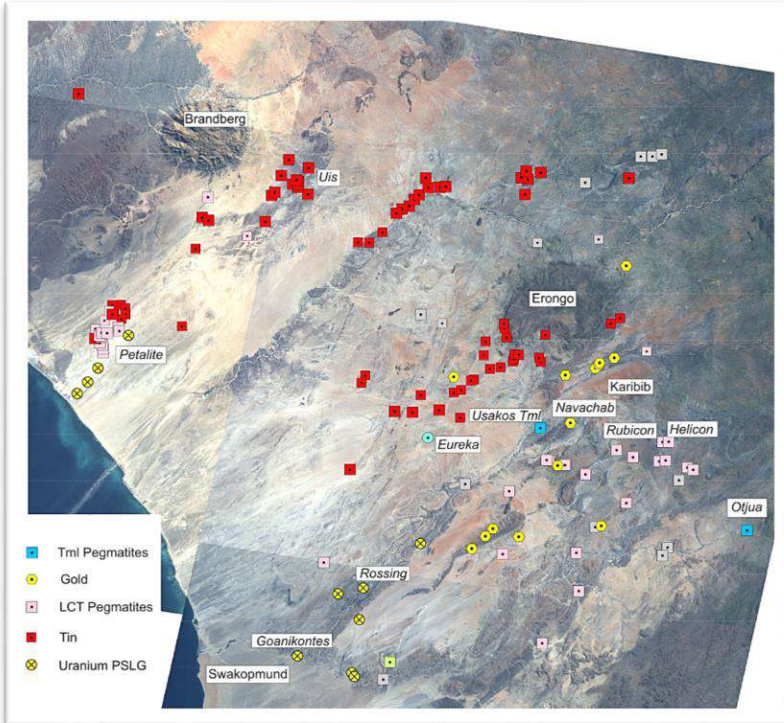
Petalite pegmatite



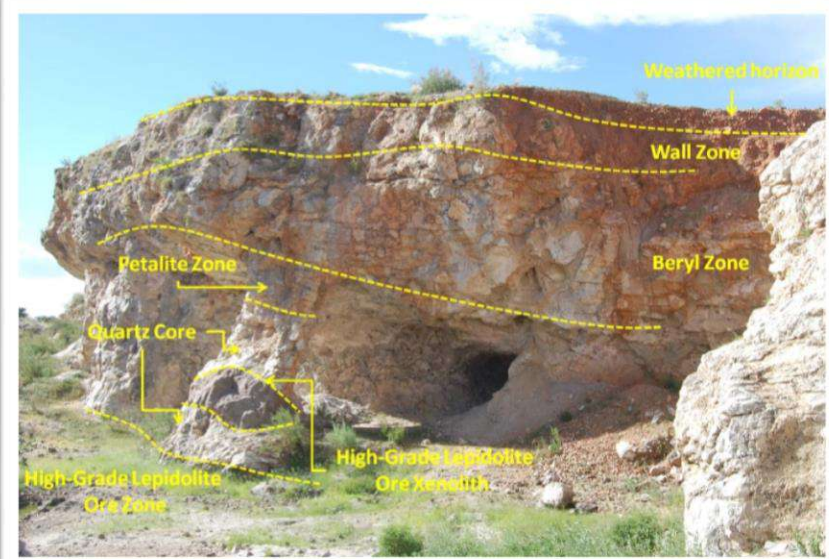
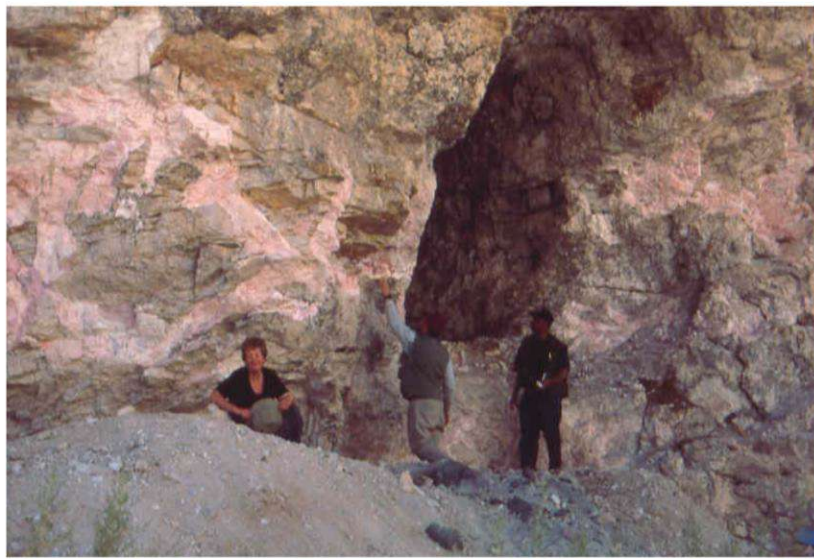
Uis



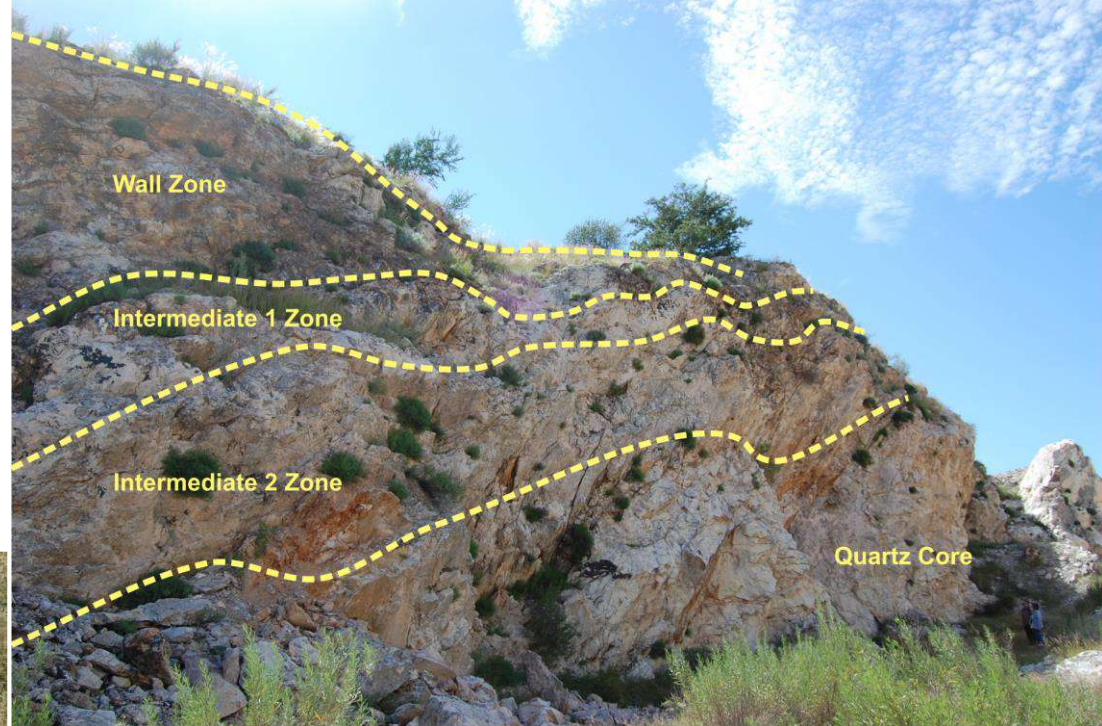
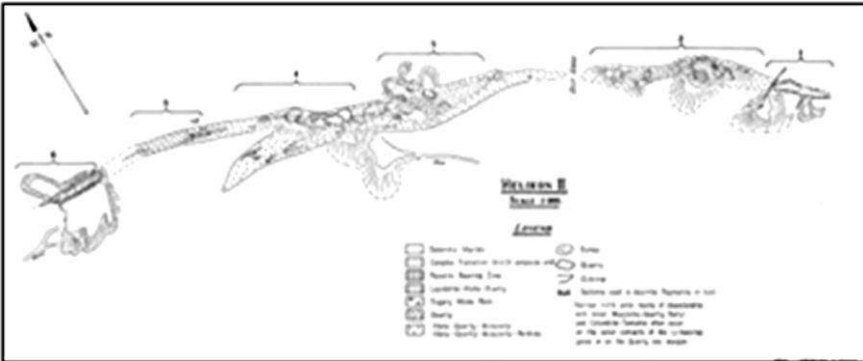
Rubikon pegmatite



Luisa Ashworth PhD 2018

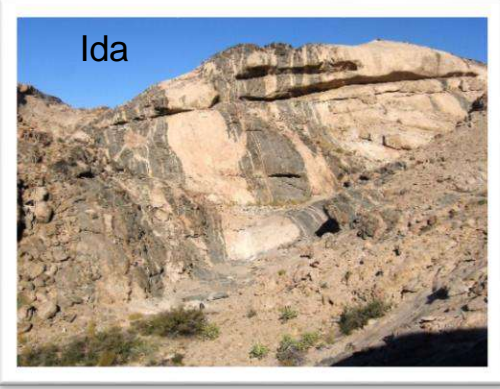


Helicon



Luisa Ashworth PhD 2018

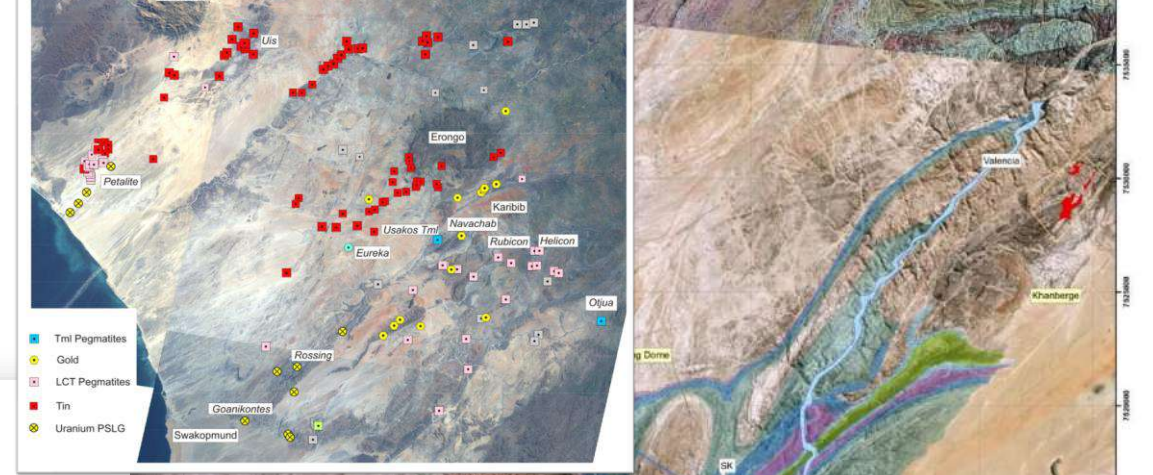




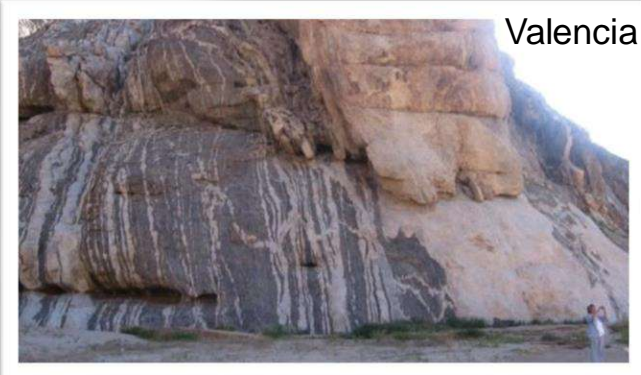
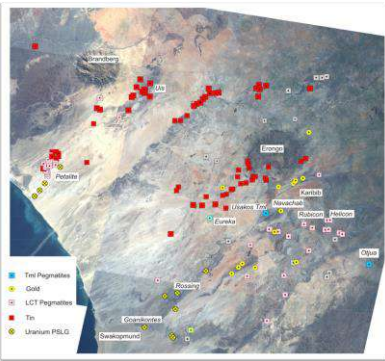
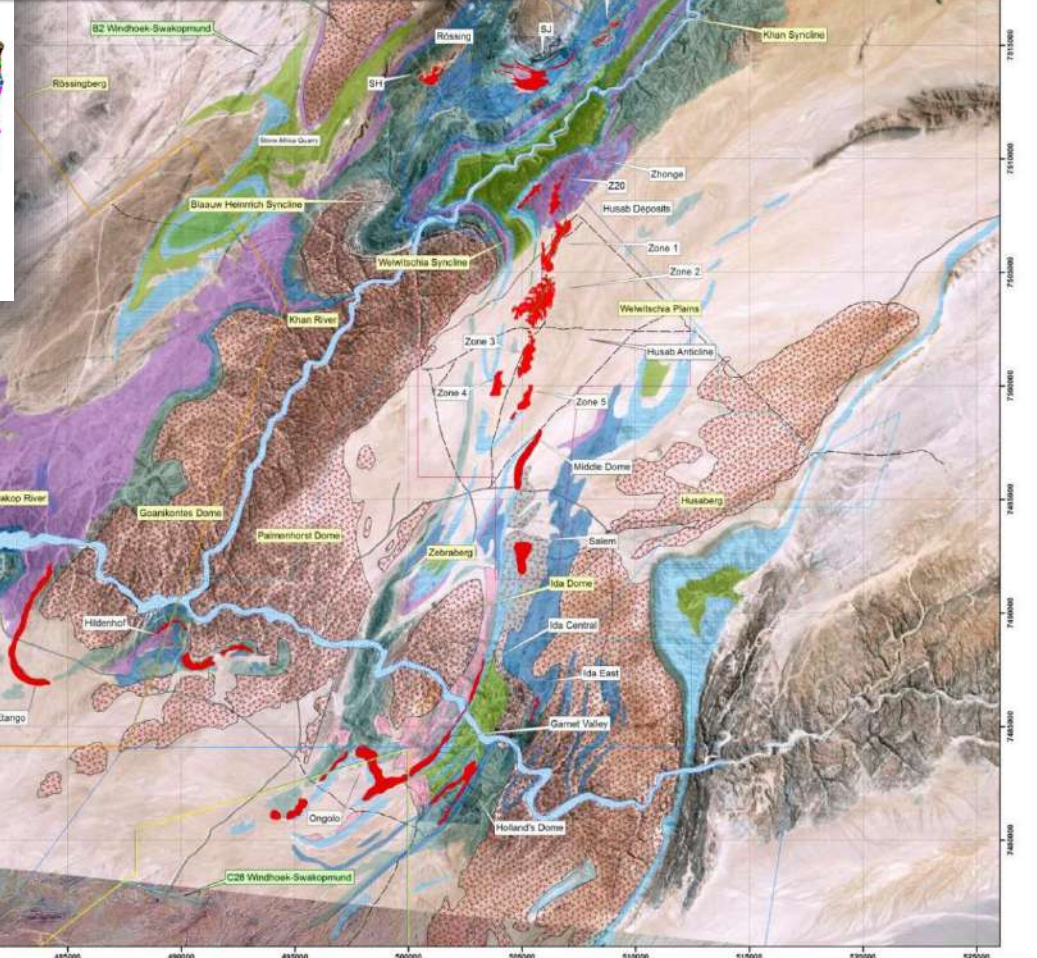
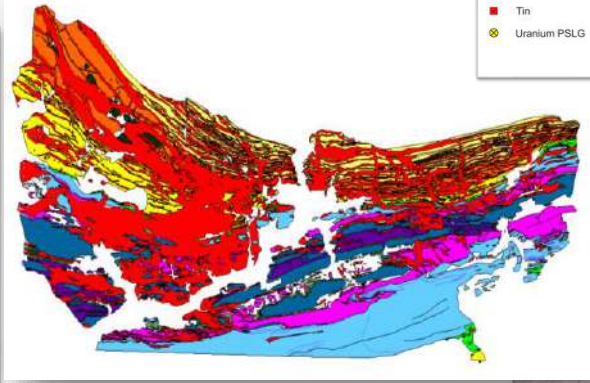
Ida



Goanikontes



Rössing



Valencia

- ▶ sheets in a corridor ~70 km long and 30 km wide, belt of HT-LP metamorphic rocks (Kinnaird and Nex, 2007).
- ▶ leucogranite sheets - small lenses to >100 m wide sheets
- ▶ Grade ~350ppm

petrology of the leucogranites



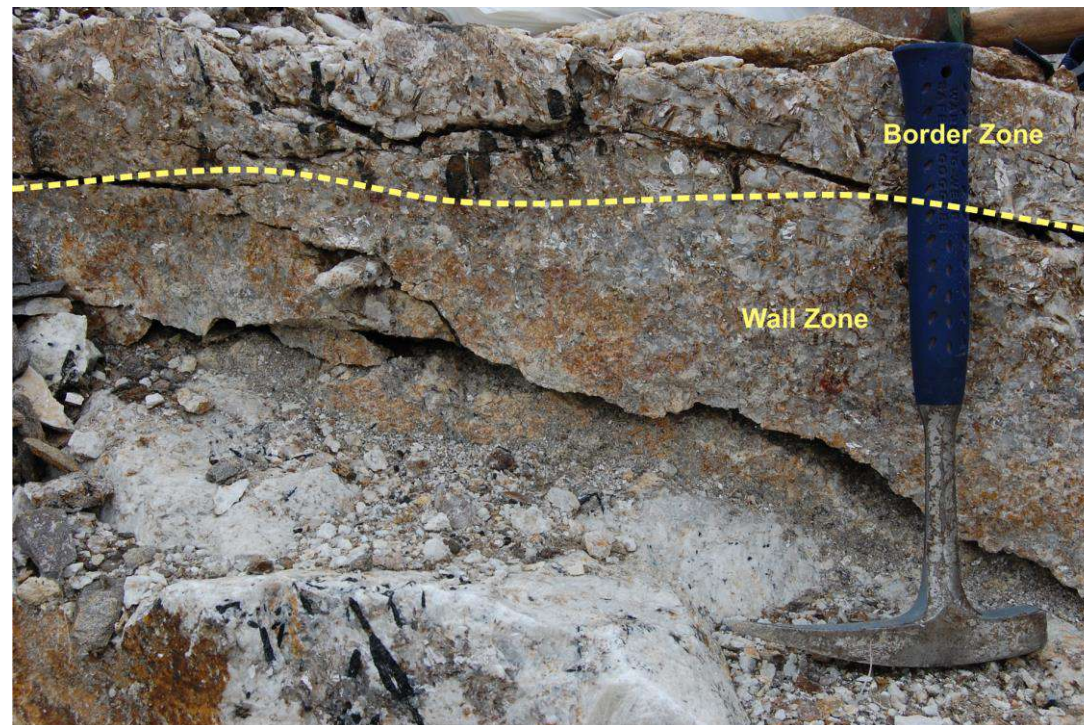
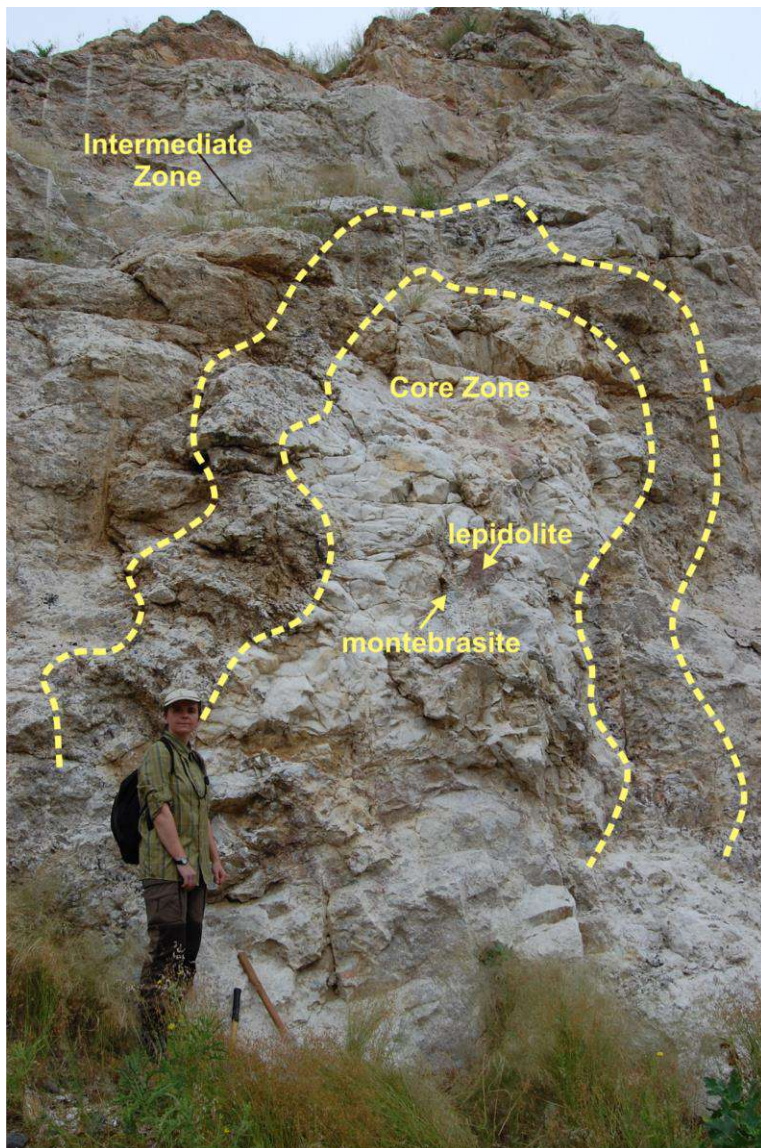
- textures are very variable leucogranites
- low % mafics
- 6 sheeted leucogranite 3 were emplaced pre-D₃; 3 postdate D₃
- only type D (4th in sequence) and E (5th) have U enrichment



- 55% primary uraninite: 5% primary betafite $\{(Ca, Na, U, REE)_{16-x} (Nb, Ti)_{16} O_{48} (O, OH, F)_{8-y} zH_2O,$
- 40% secondary U-silicates e.g. uranophane, coffinite replace uraninite on grain boundaries on joints and fracture. Accessory minerals are very wide-ranging but rarely abundant: biotite, calcite, and fluorite

Usakos pegmatite

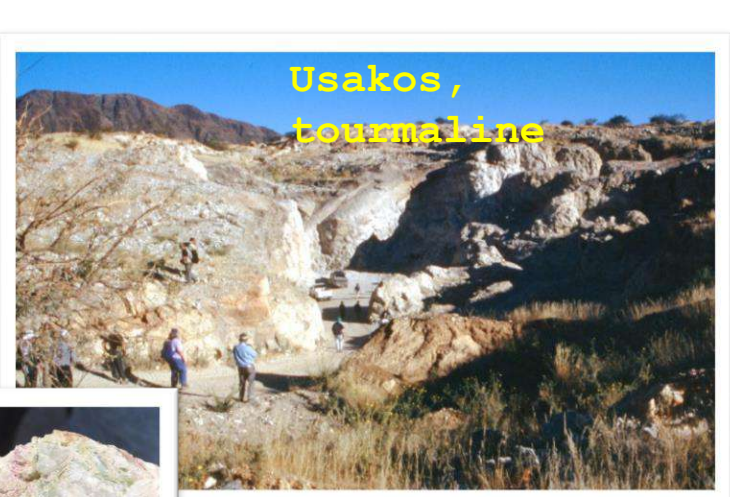
Intruded into Kuiseb schist.
Strikes NE. Dips 50 - 60° NW.



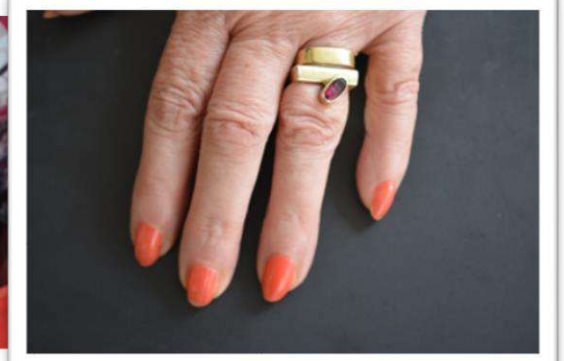
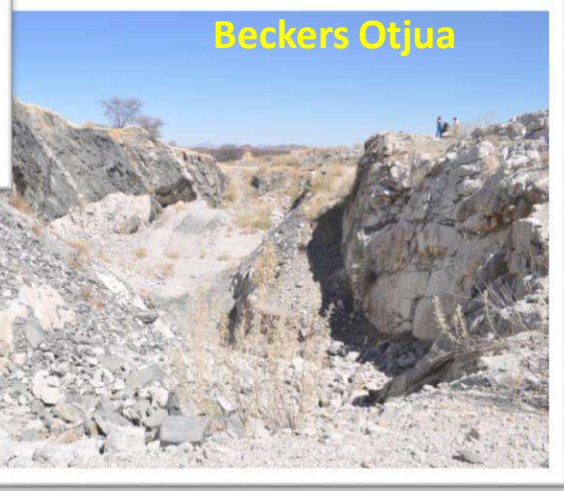
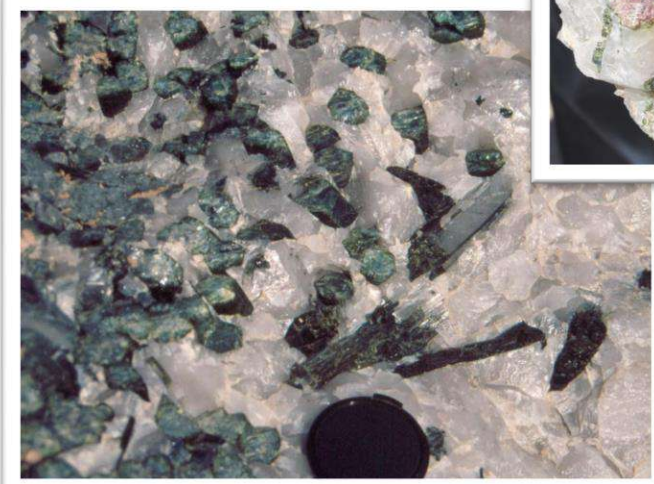
Border Zone: Bladed muscovite, black tourmaline and UST quartz.

Wall Zone: equigranular quartz, albite, muscovite and black tourmaline

- **Intermediate Zone:** albite + quartz + fine-grained black tourmaline.
- **Massive quartz core:**
Tourmaline mineralisation in clay-filled pockets.

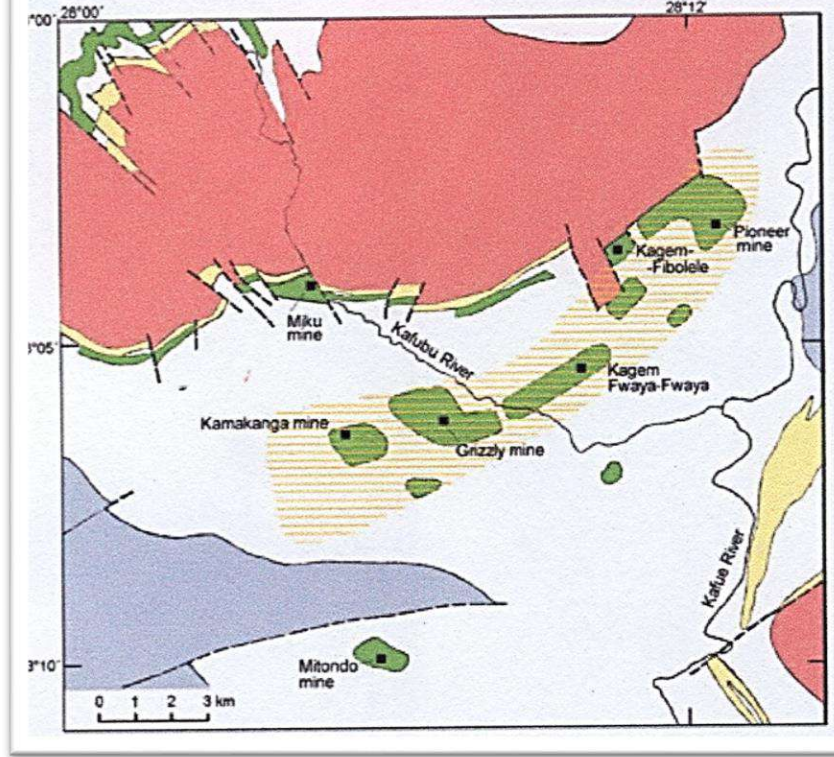


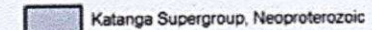


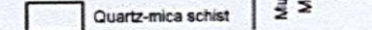
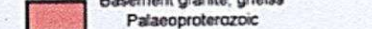
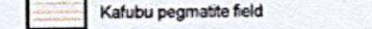
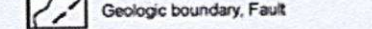


Jeremejevite (Erongo)



Zambia

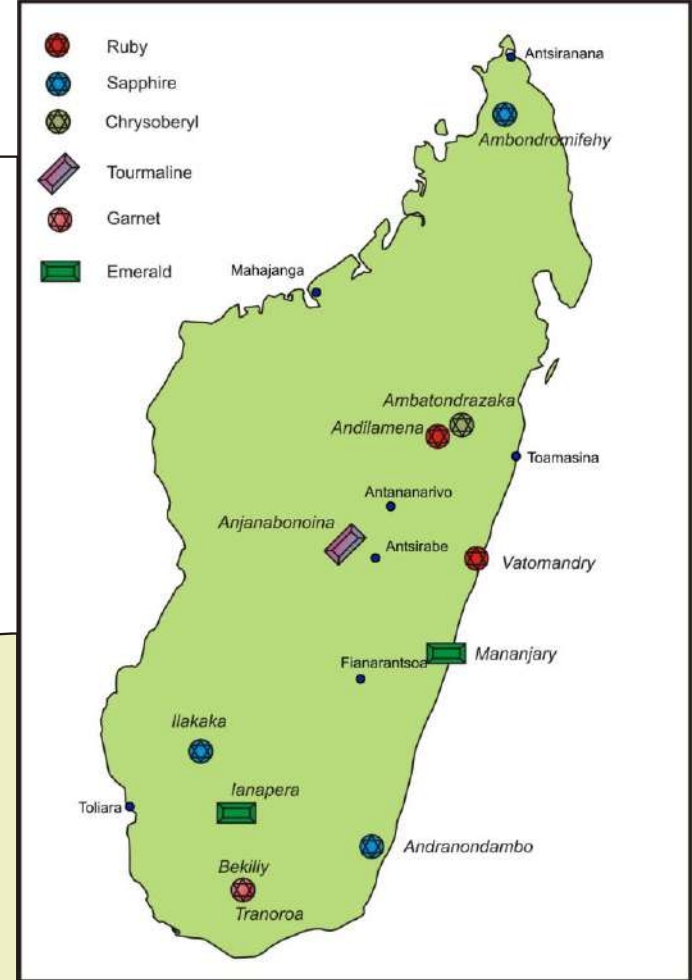
-  Amethyst
-  Garnet
-  Emerald
-  Aquamarine
-  Tourmaline



-  Katanga Supergroup, Neoproterozoic
 -  Metabasite
 -  Quartzite
 -  Quartz-mica schist
 -  Basement granite, gneiss Palaeoproterozoic
 -  Kafubu pegmatite field
 -  Geologic boundary, Fault
-  Miwa Supergroup
 Mesoproterozoic



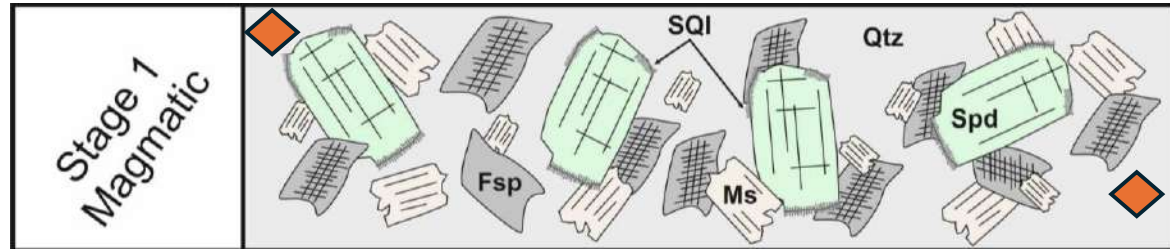
Kagem emerald mine, Kafubu



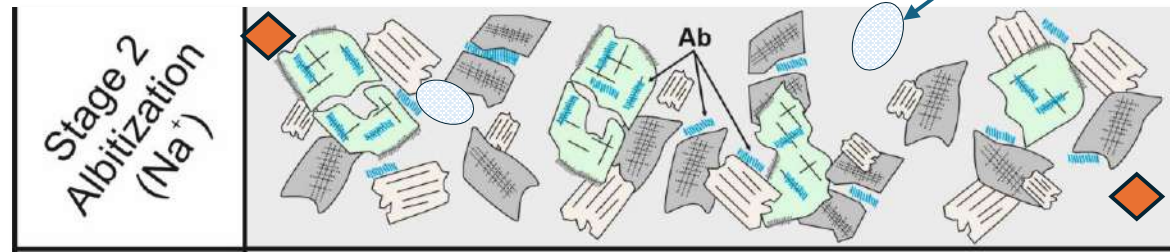
**Liddicoatite
tourmaline**

Is the mineralisation magmatic or hydrothermal?

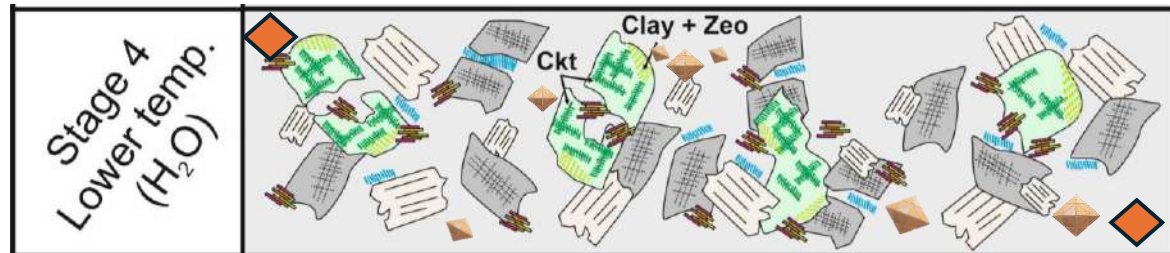
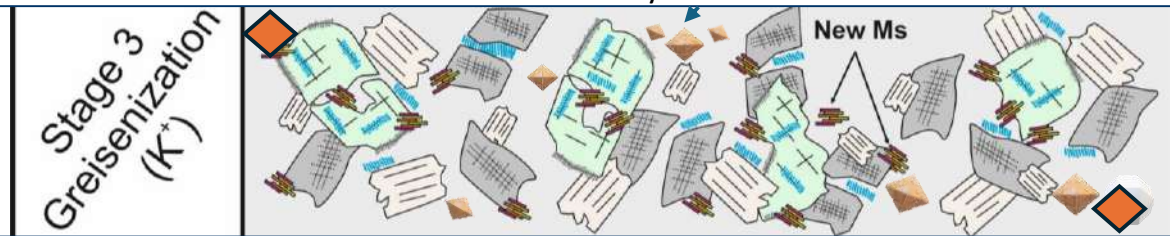
Marais, 2019



primary cassiterite



hydrothermal cassiterite



Modified from Goodenough et al in press



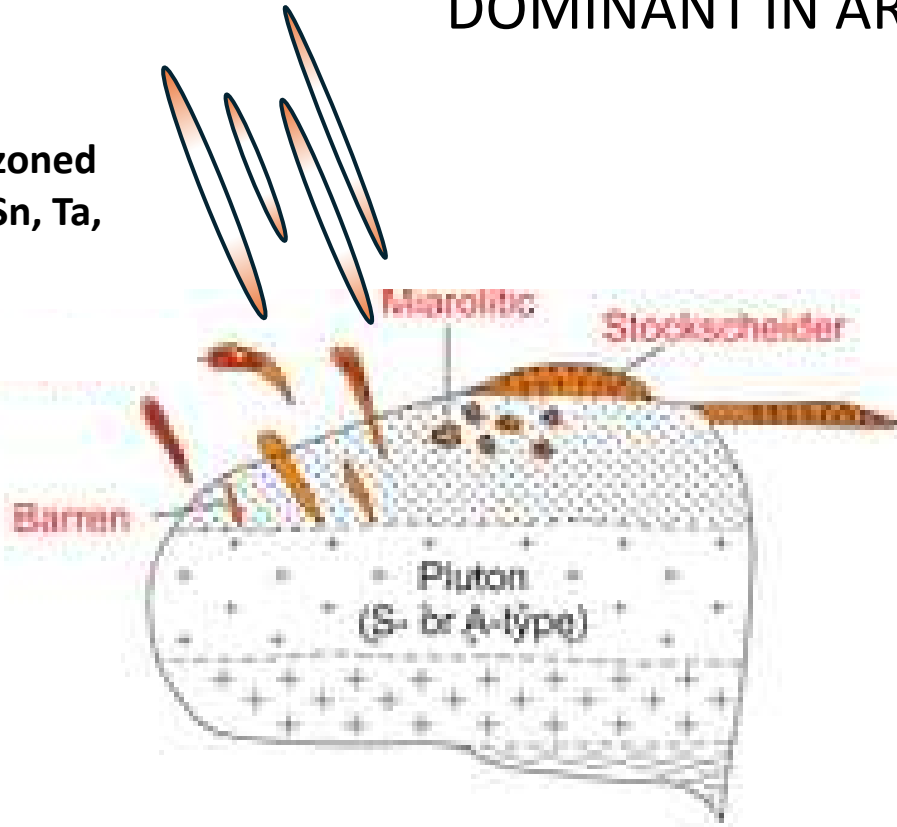
Marais, 2019



DOMINANT IN ARCHAEOAN?

DOMINANT IN PROTEROZOIC?

Mineralised: zoned and unzoned Sn, Ta, Li pegmatites

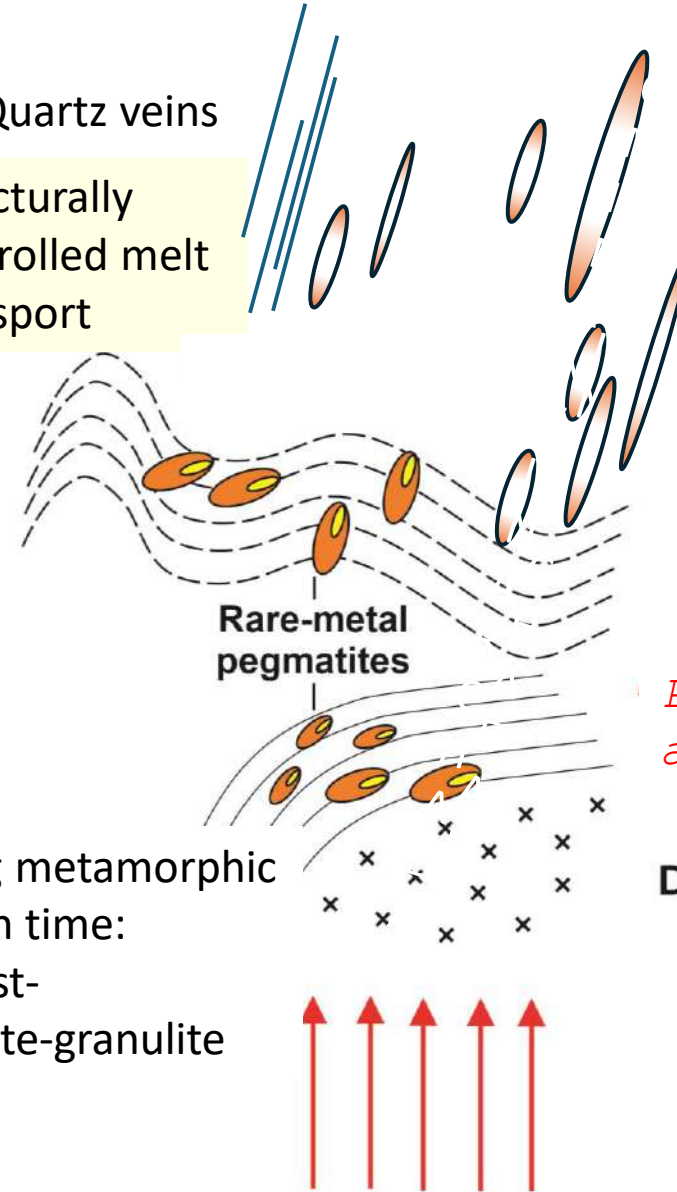


Fractionating from large plutons that are the last intrusions in a sequence

e.g. Swaziland, Barberton, Bikita, Goulamina,

Modified from Goodenough et al, in press

Quartz veins
Structurally controlled melt transport



Increasing metamorphic grade with time:
greenschist-
amphibolite-granulite

HEAT SOURCE

Mineralised: zoned and unzoned Sn, Ta, Li pegmatites

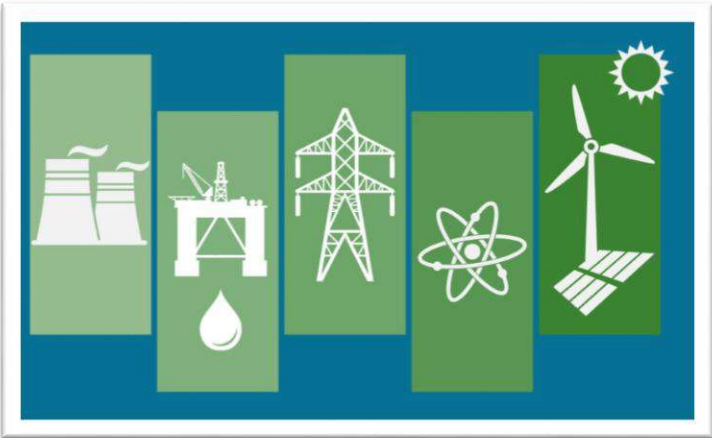
Barren pegmatites

H₂O present melting

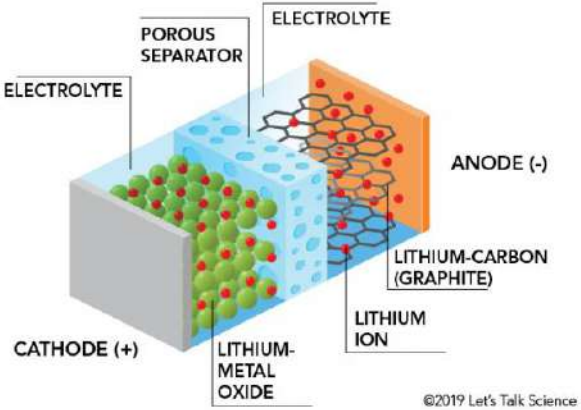
Progressive anatexis

Dehydration melting

of muscovite, and later biotite



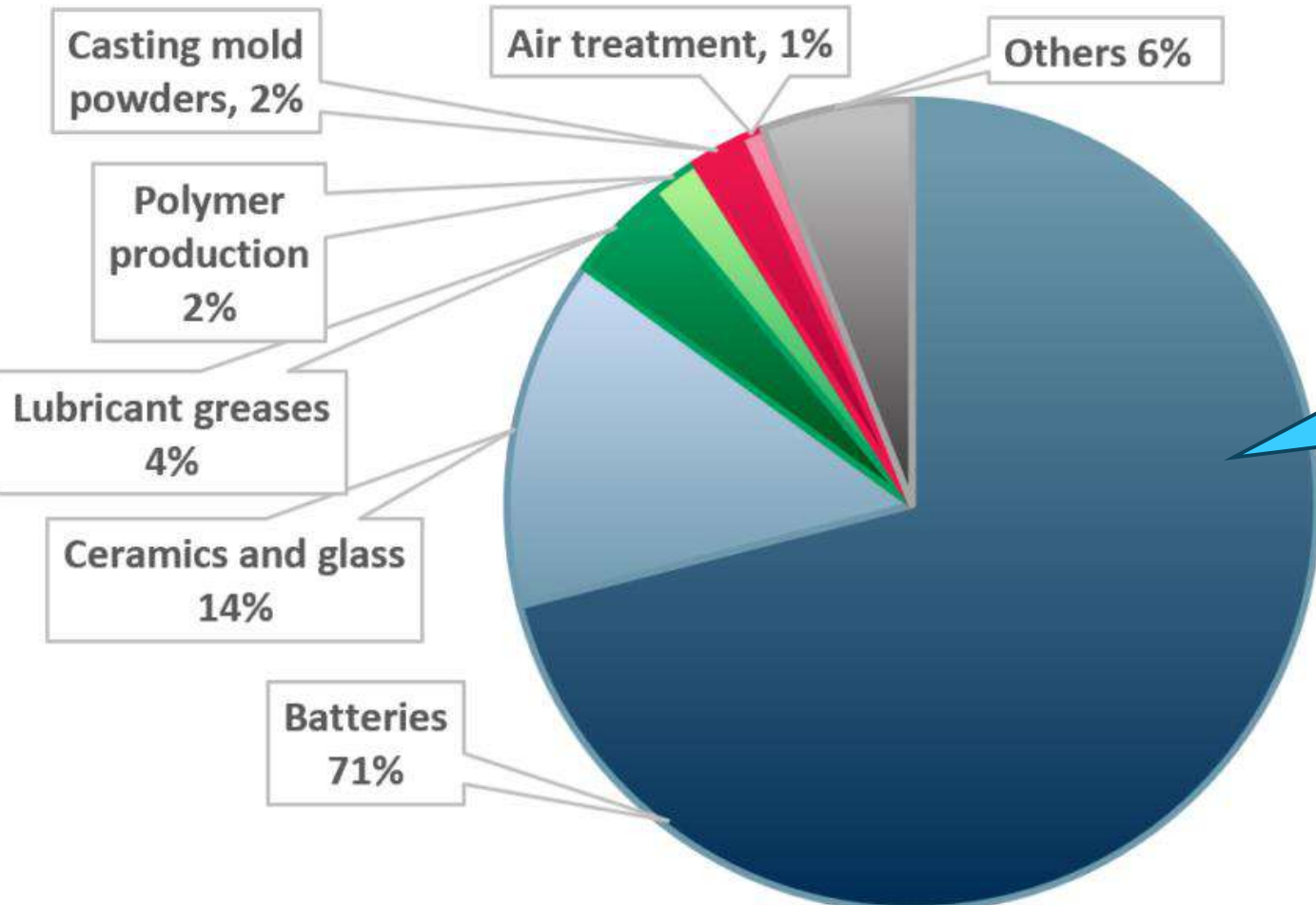
PARTS OF A LITHIUM-ION BATTERY



International agreements to limit climate change to less than a 2°C temperature increase, requires a global transition to clean renewable energy sources including an electrification of the transport sector.



THIS REQUIRES LITHIUM

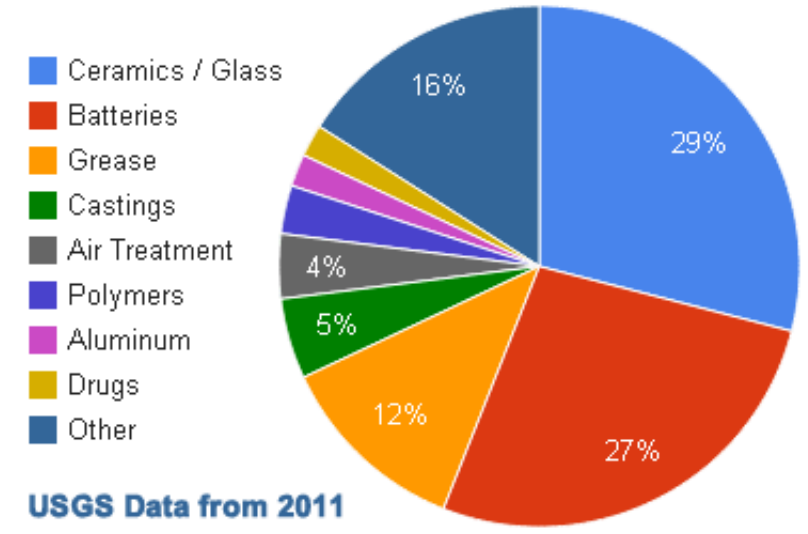


USGS, 2020

In 10 years the requirement for lithium for batteries has increased from 27% to 71% of the total Li production

According to the World Bank (2020) society will need a 488% increase in lithium by 2050 to meet its needs for the transition to green energy

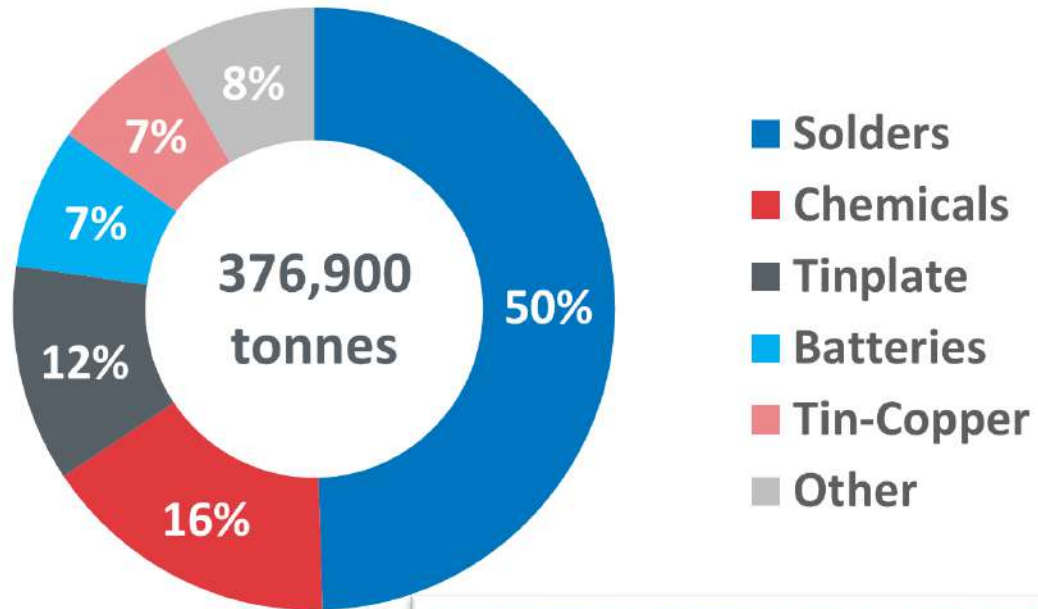
Uses of Lithium



USGS Data from 2011

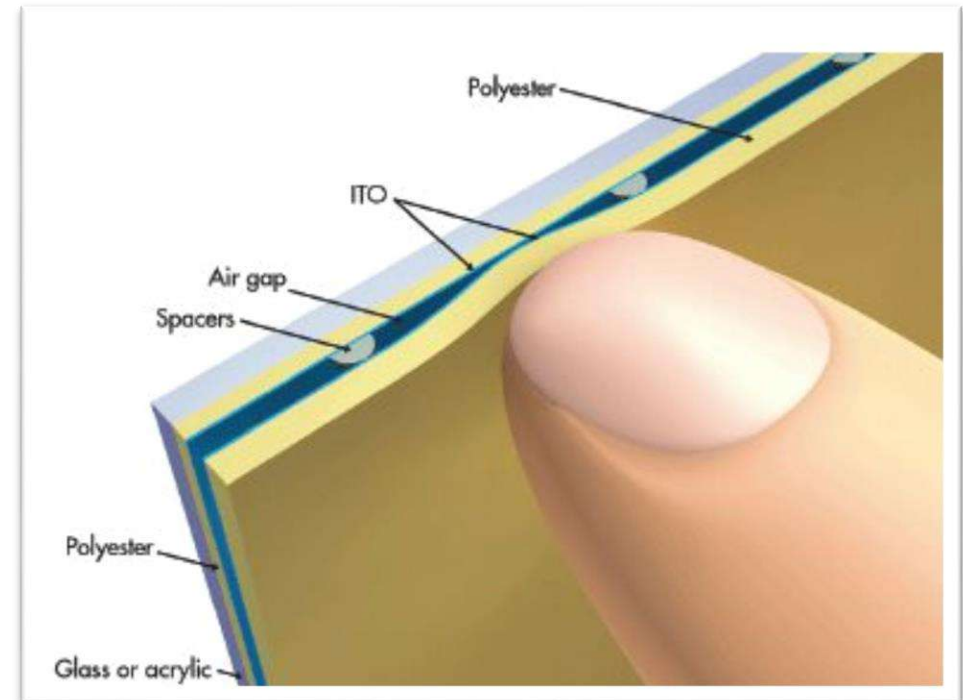
Global tin use by application, 2022

ITA estimates global refined tin use share, tonnes

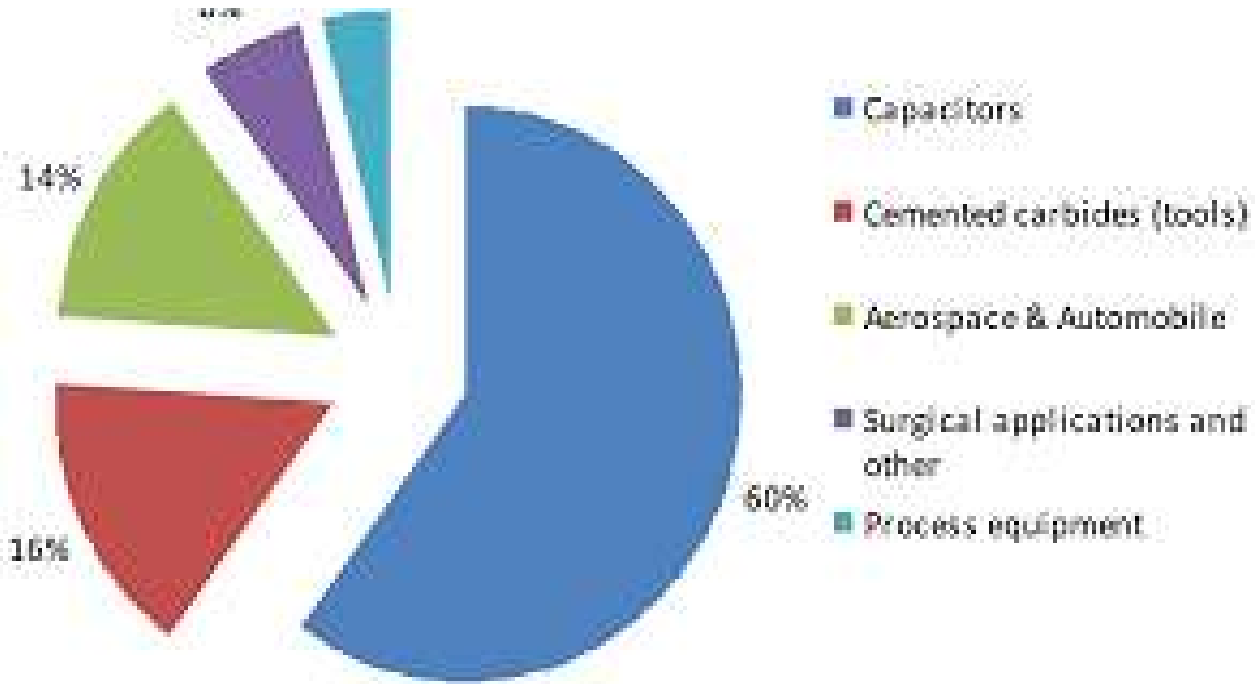


Indium-tin oxide is used in touch screens – 74% In, 18% O₂, and 8% Sn by weight.

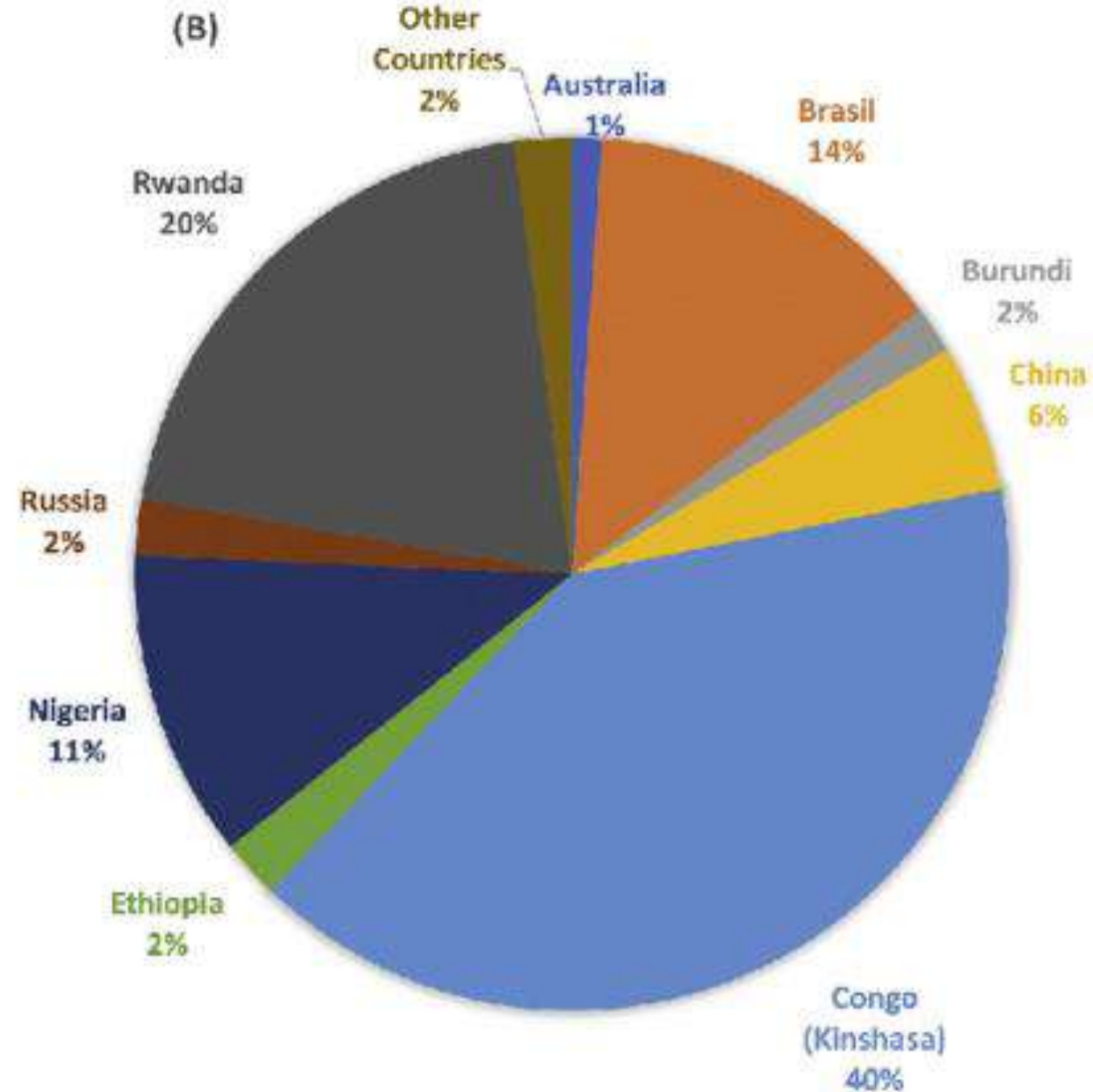
- demand for tin is set to increase with electronics being the main downstream market
- Sn application in Li-ion batteries will also stimulate demand growth as this industry is actively developing



Tantalum

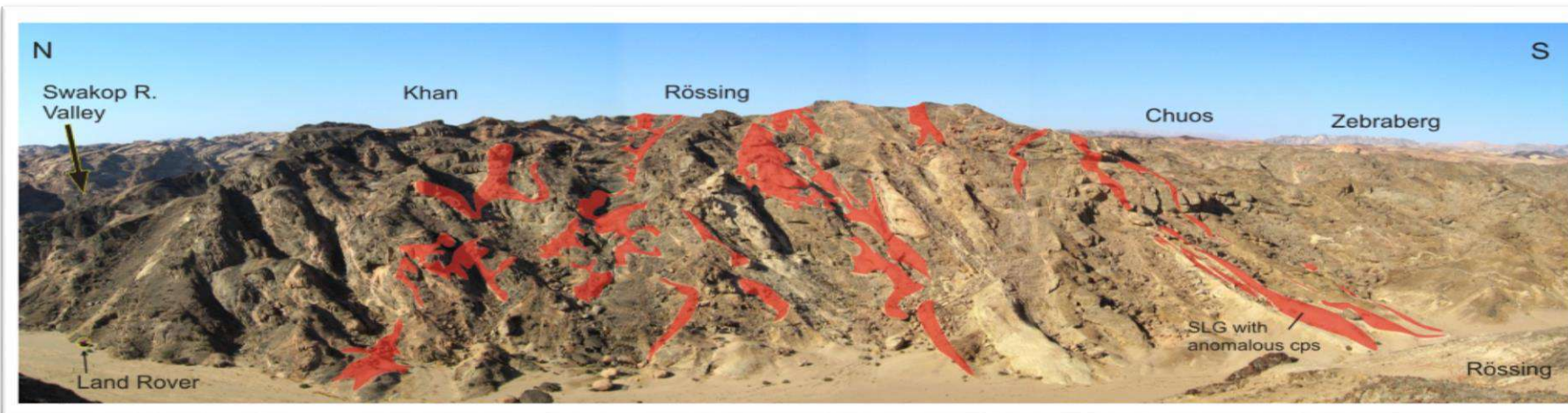


Source: Annex V to the Report of the Ad-hoc Working Group on defining critical raw materials, p. 190



Conclusions

- Archaean, Eburnean, Kibaran and PanAfrican
- Pegmatites are products of supercontinent assembly
- Different types can occur across a range of terranes at the same time.
- Archaean lithium-enriched pegmatites appear to be granite fractionates
- Later pegmatites are predominantly from anatexis



Thank you

