Magmatic Ore Deposits

1. Layered Intrusion (PGE, Cr, Ti, V, Cu, Fe, Ni ..)
2. Pegmatites (Gem, Be, Li, B, Ta, Nb, Sn, U,..)

Magmatic Ore Deposits

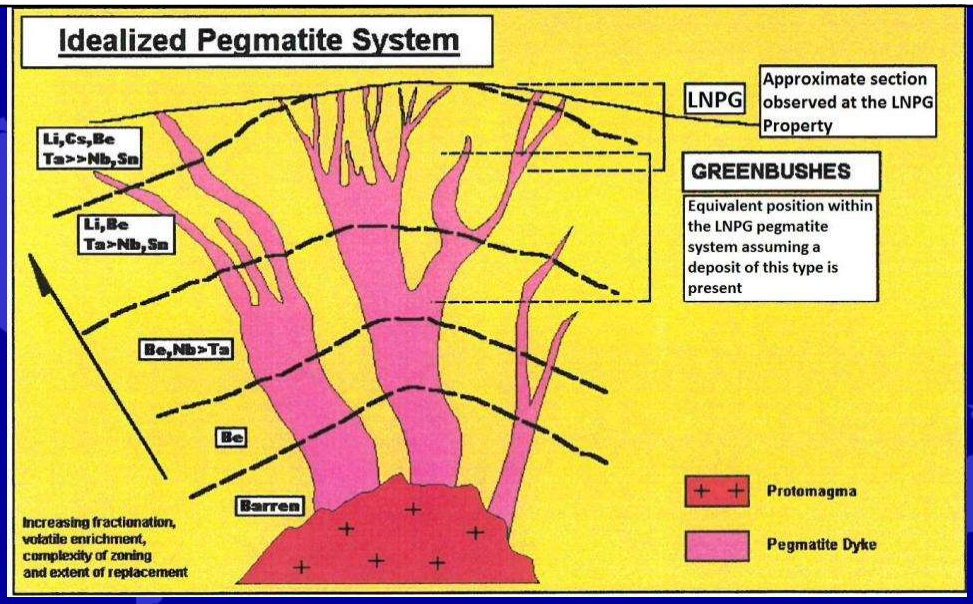
1. Layered Intrusion (Cr, PGE, Ni, V, ..)
2. Pegmatites

Gemstones (Tourmaline, Beryl, Garnet)

Rare elements (Li, Be, Cs, Ta, Nb, Sn, W, U, Th, REE,..)

- White mica, pure quartz, feldspar, kaolinite,
- Beryl ($Be_3Al_2Si_6O_{18}$)
- Tourmaline ($NaFe_3Al_6(BO_3)_3(OH)_4Si_6O_{18}$)
- Monazite $CePO_4$)
- Columbite-Tantalite $(Mn,Fe)(Nb,Ta)_2O_6$) (Coltan, DR Congo)
- Cassiterite (SnO_2)
- Uranitite (UO_2)
- Rutile (TiO_2)
- Zircon ($ZrSiO_4$)
- Garnet (Spessartine: $Mn_3Al_2(SiO_4)_3$)
- Apatite $(Ca_5(PO_4)_3(F,Cl,OH)$

Coltan (Congo)



Idealized Pegmatite System

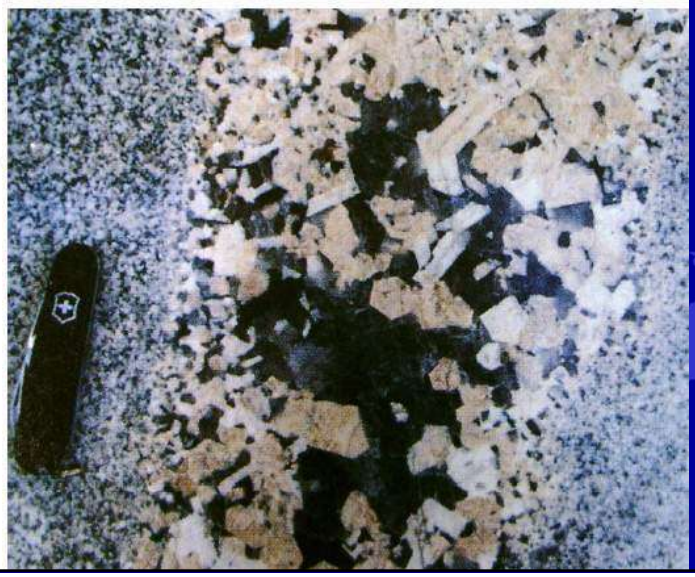
https://mar-petroleumexplorationconsultant.com/9-lithium-batteries-and-pegmatites/

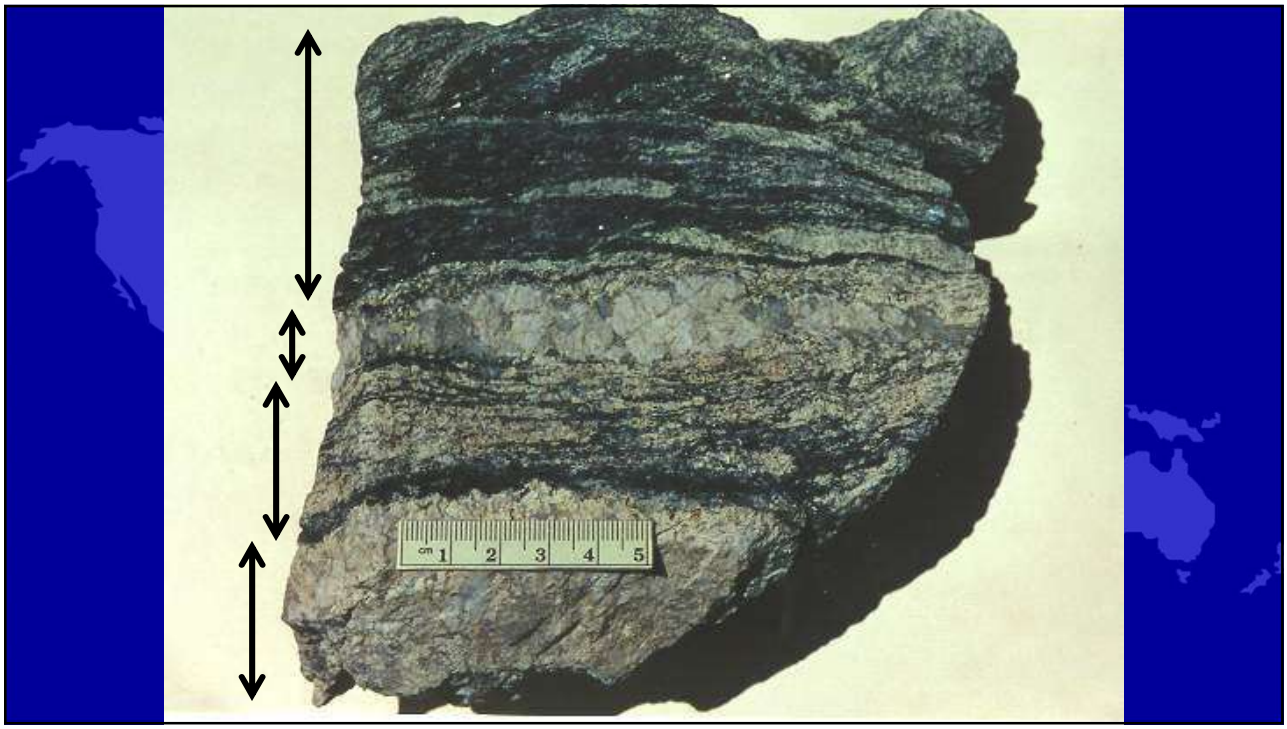
Pegmatite

- very coarse grained dike (not a vein)
- water rich magma
- last bit of melt in a cooling magma
- commonly contains unusual minerals or common minerals with unusual compositions

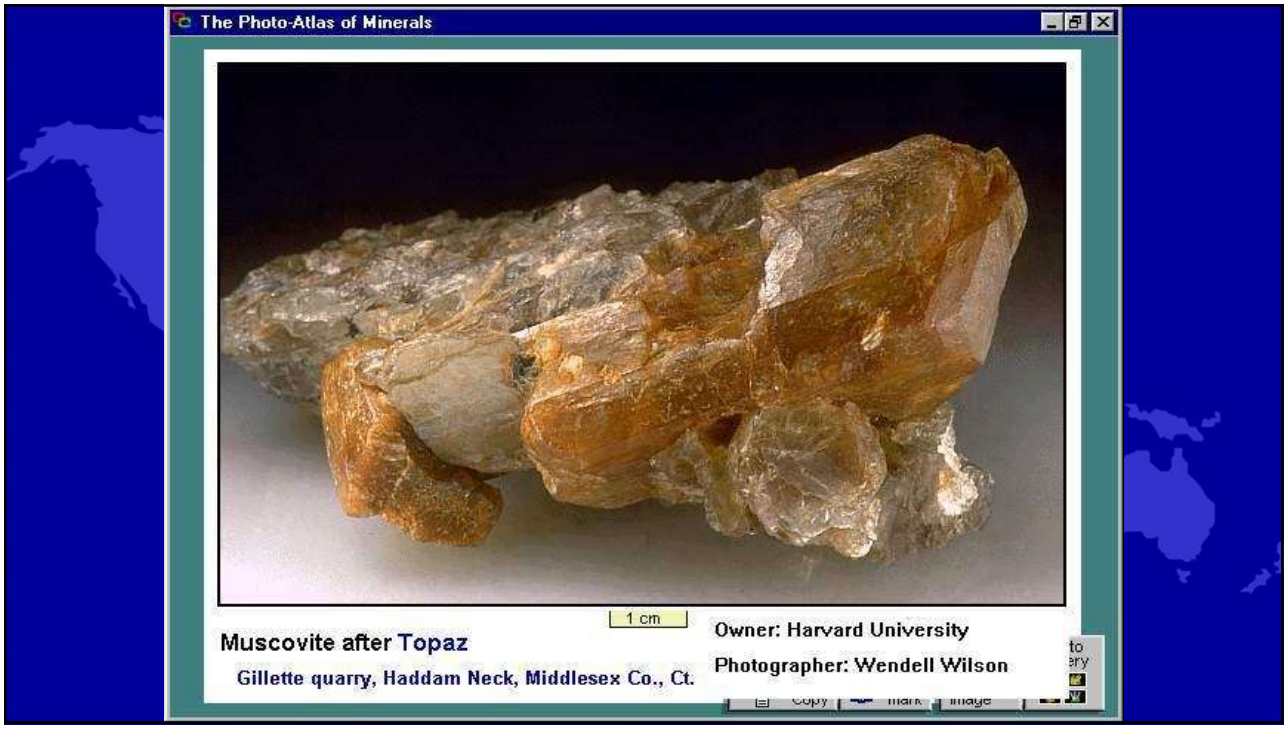
Quartz
Feldspar
Mica

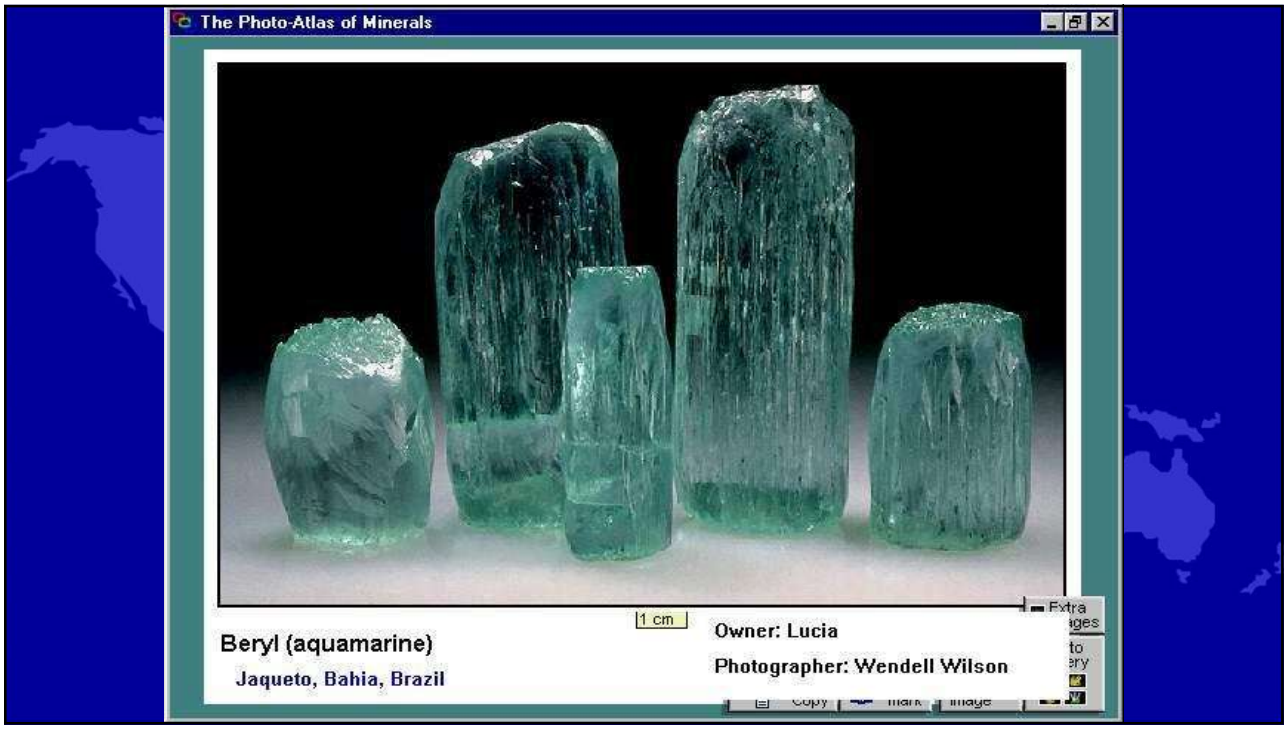
Edges cooled quickly
(chilled margin)
Center cooled more slowly

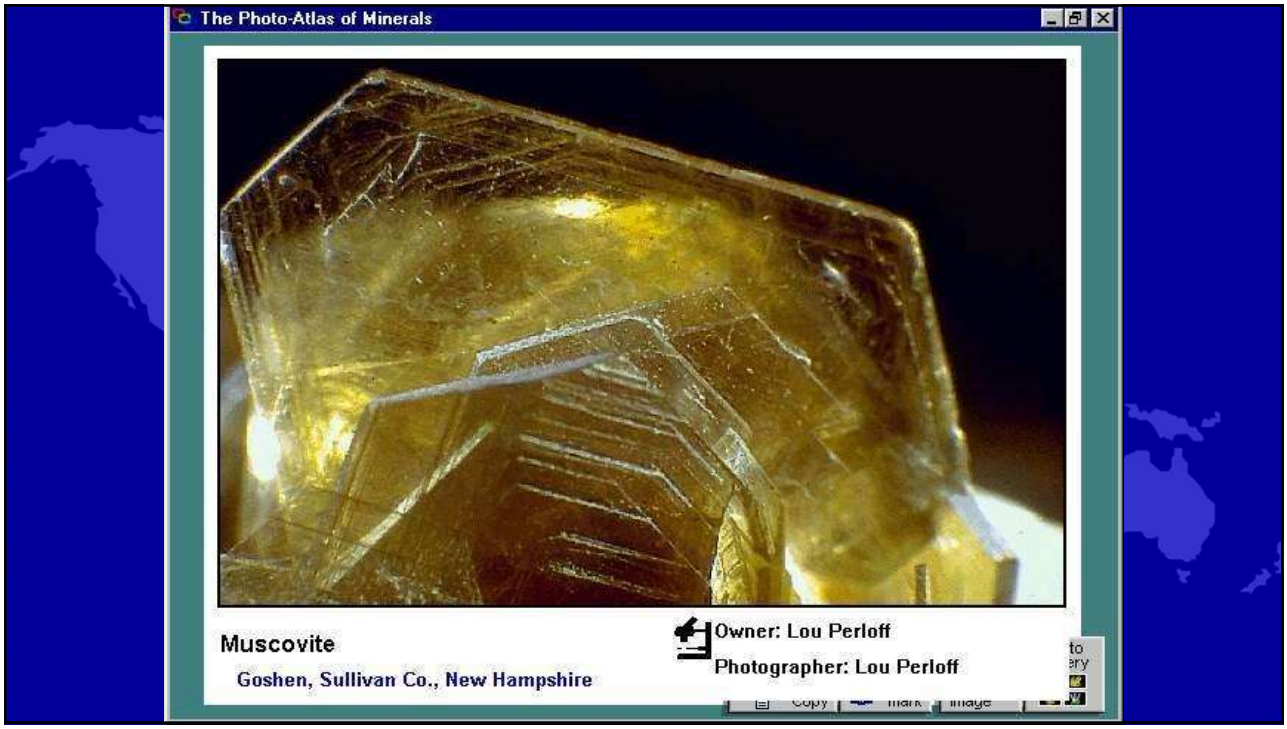




Pegmatitic dikes in gabbro

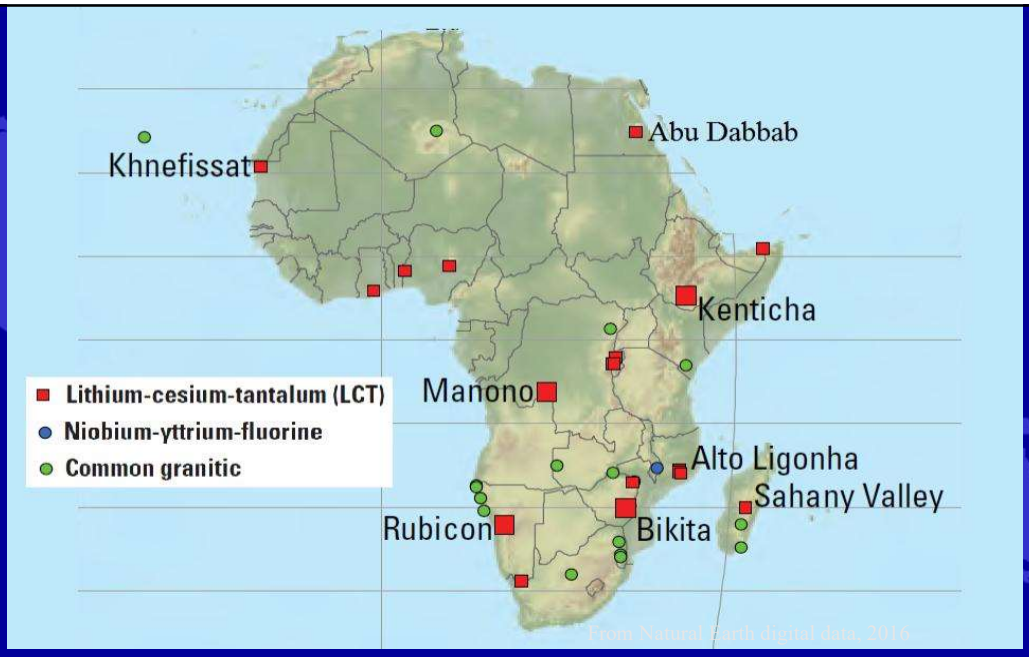

The Photo-Atlas of Minerals
1 cm
Muscovite after Topaz
Gillette quarry, Haddam Neck, Middlesex Co., Ct.
Owner: Harvard University
Photographer: Wendell Wilson


The Photo-Atlas of Minerals
1 cm
Beryl (aquamarine)
Jaqueto, Bahia, Brazil
Owner: Lucia
Photographer: Wendell Wilson


The Photo-Atlas of Minerals
Muscovite
Goshen, Sullivan Co., New Hampshire
Owner: Lou Perloff
Photographer: Lou Perloff

Pegmatites

1. Quartz, Feldspar, Mica
2. Variable host rock
3. Small dikes
4. Archean to Mesozoic
5. Economic: Gem, B, Ta, Nb, U, Sn
6. Residual volatile-rich fluids

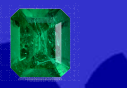


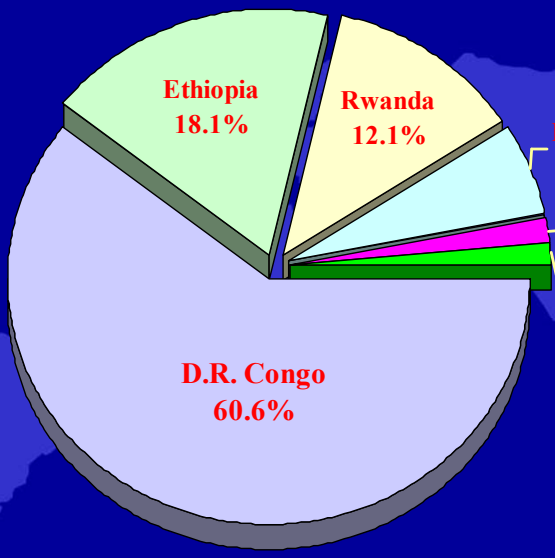
Noteworthy pegmatites in Africa.

Bikita pegmatite, Zimbabwe

- **Mica (Muscovite – Biotite)**
- **Beryl / Emerald – Beryllium ($Be_3Al_2Si_6O_{18}$)**
- **Spodumene - Lithium ($LiAlSi_2O_6$)**
- **Tantalite - Tantalum ($(Fe,Mn)Ta_2O_6$)**
- **Columbite – Niobium ($(Fe,Mn)Nb_2O_6$)**
- **Tourmaline – Boron ($XY_3Z_6(T_6O_{18})(BO_3)_3V_3W$)**

(X = Ca, Na, K Y = Li, Mg, Fe^{+2}, Fe^{+3}, Mn^{+2}, Al, Cr^{+3}, V^{+3}
Z = Mg, Al, Fe^{+3}, V+3, Cr^{+3} T = Si, Al, B **V = OH, O W = OH, F, O**





Tantalum

Cassiterite (SnO_2)

- Cassiterite is a tin oxide mineral, stannous dioxide (SnO_2)
- It is the most important source of tin, and most of the world's It occurs in igneous and metamorphic rocks throughout the world.
- It is also a residual mineral found in soils and sediments.
- Cassiterite is more resistant to weathering than many other minerals, and that causes it to be concentrated in stream and shoreline sediments.
- Sn (low melting 230°C) - brazing - alloys

Properties and Characteristics of Lithium (Li)

High Energy Density:
Lithium has a high energy density, which means it can store a significant amount of energy in a small and lightweight package.

Low Density:
Lithium is a lightweight metal with a low density, which makes it attractive for various applications where weight reduction is critical, such as aerospace, automotive industries and mobile phones.

Low Melting and Boiling Points:
Lithium has a low melting point of 180.54°C and a low boiling point of 1,342°C.
This property makes lithium relatively easy to process and extract from its ores using conventional metallurgical methods.

Abundance in Earth's Crust:
Lithium is found in small amounts in the Earth's crust. It is associated with granite, pegmatites, and other geological formations.

Lithium (Li) Ore Minerals

Mineral name	Chemical formula	Lithium content (Li %)	Appearance (colour and lustre)
Spodumene pyroxene	$LiAlSi_2O_6$	3.7	White, colourless, grey, pink, lilac, yellow or green; vitreous
Lepidolite (lithium mica)	$K_2(Li,Al)_{5-6}\{Si_{6-7}Al_{2-1}O_{20}\}(OH,F)_4$	1.39–3.6	Colourless, grey/white, lilac, yellow or white; vitreous to pearly
Petalite	$LiAlSi_4O_{10}$	1.6–2.27	Colourless, grey, yellow or white; vitreous to pearly
Eucryptite	$LiAlSiO_4$	2.1–5.53	Brown, colourless or white; vitreous
Amblygonite	$LiAl[PO_4][F,OH]$	3.4–4.7	White, yellow or grey; vitreous to pearly
Hectorite	$Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$	0.54	White, opaque; earthy
Jadarite	$LiNaSiB_3O_7(OH)$	7.3	White; porcellanous

Occurrence of Lithium (Li) Ore

1. **Pegmatite Deposits:**
   Pegmatites are coarse-grained igneous rocks that are enriched in rare elements, including lithium. Pegmatite deposits are one of the primary sources of lithium ore, particularly spodumene.

2. **Salt Brine Deposits:**
   Lithium can also be found in underground brine deposits, which are formed by the evaporation of salty water in arid regions. These deposits are rich in lithium salts, such as lithium chloride, lithium carbonate, and lithium hydroxide.

3. **Sedimentary Deposits:**
   Lepidolite is a common lithium-bearing mineral found in some sedimentary deposits.

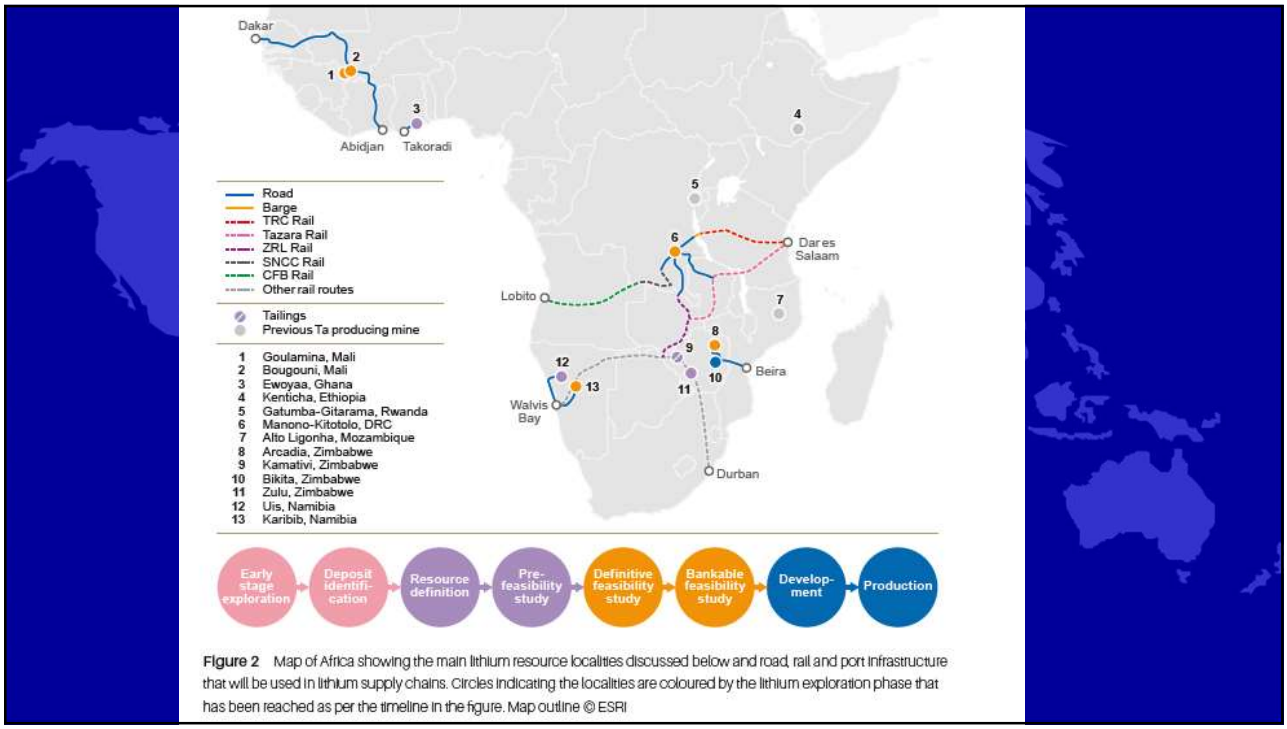
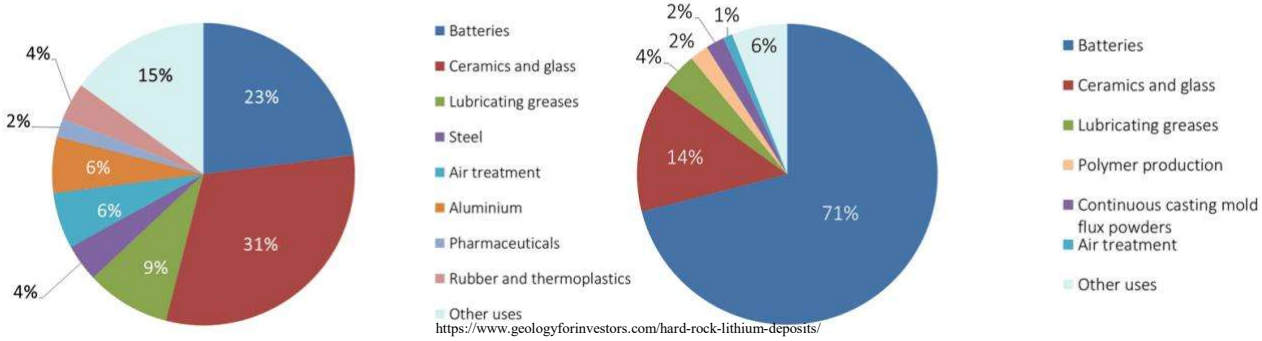


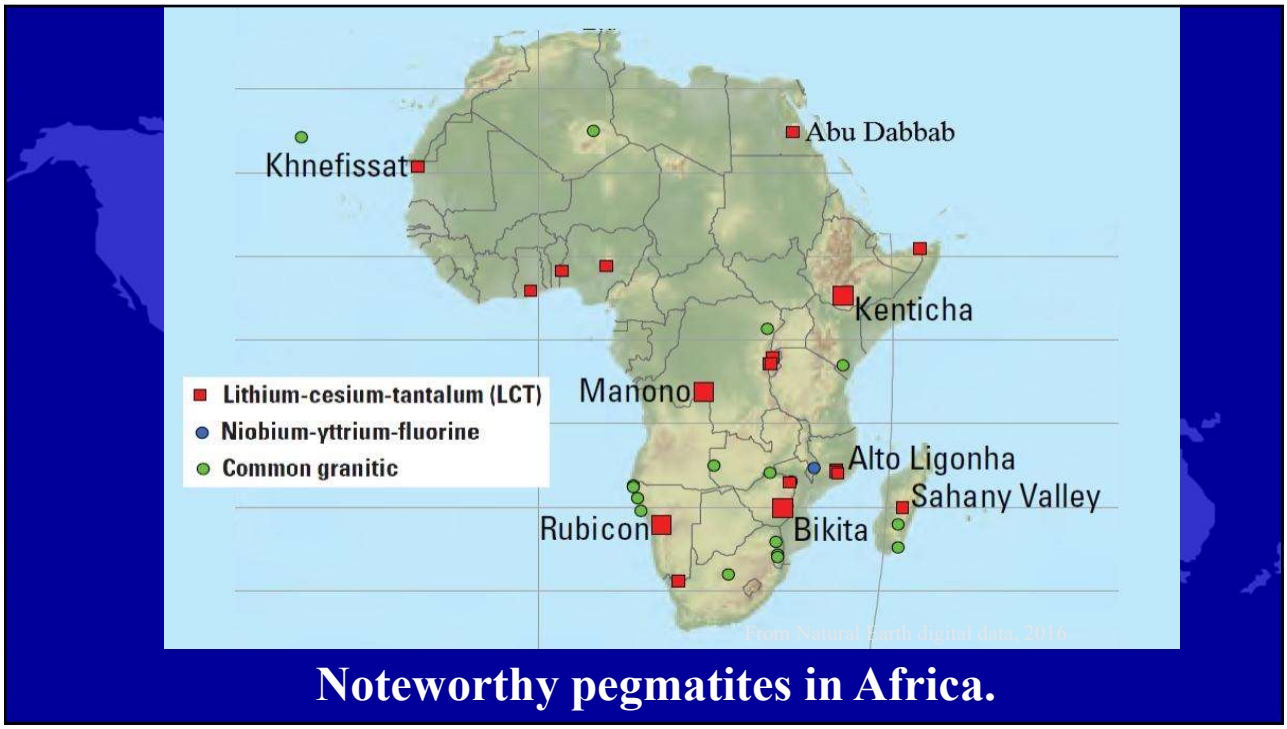
Figure 2 Map of Africa showing the main lithium resource localities discussed below and road, rail and port infrastructure that will be used in lithium supply chains. Circles indicating the localities are coloured by the lithium exploration phase that has been reached as per the timeline in the figure. Map outline © ESRI

EVOLUTION OF THE SHARE OF DIFFERENT SECTORS IN LITHIUM CONSUMPTION BETWEEN 2010 AND 2020



https://www.geologyforinvestors.com/hard-rock-lithium-deposits/

2010 2020

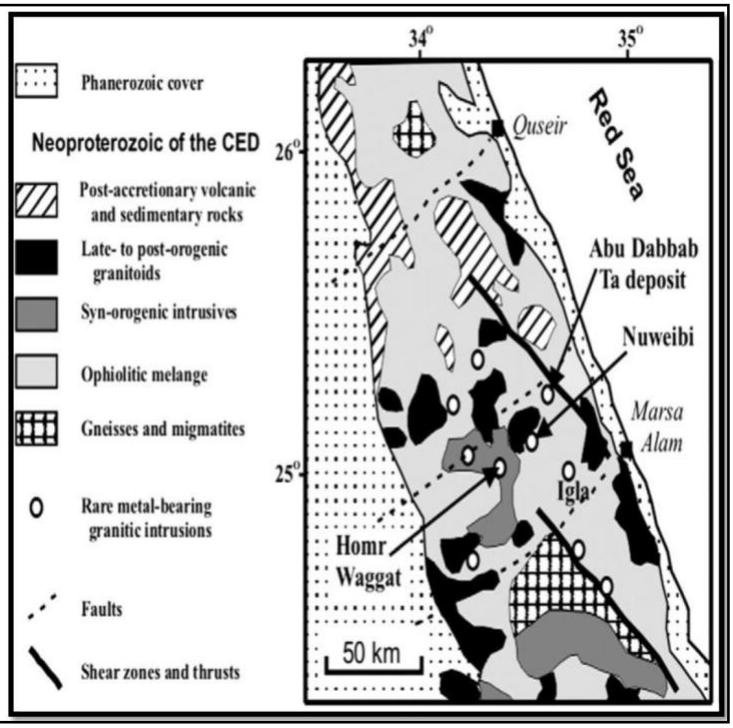


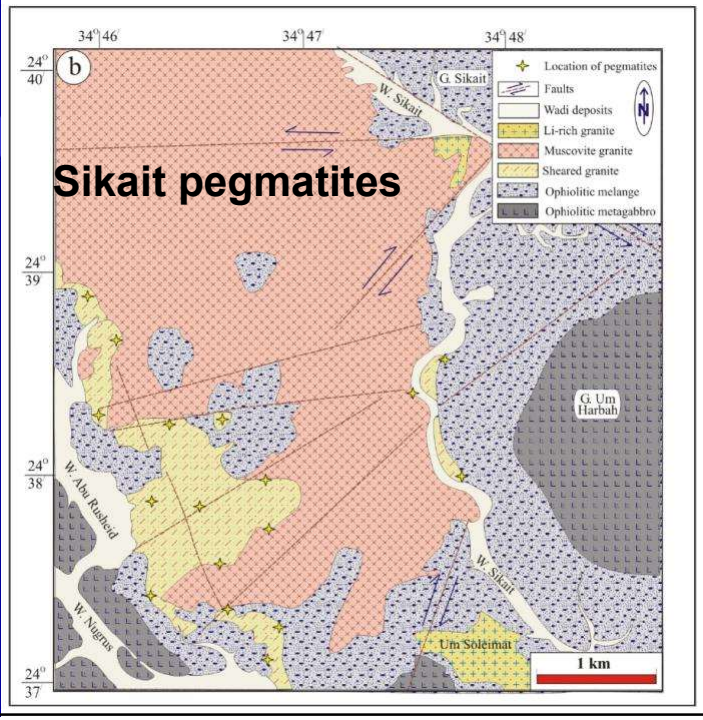
Noteworthy pegmatites in Africa.

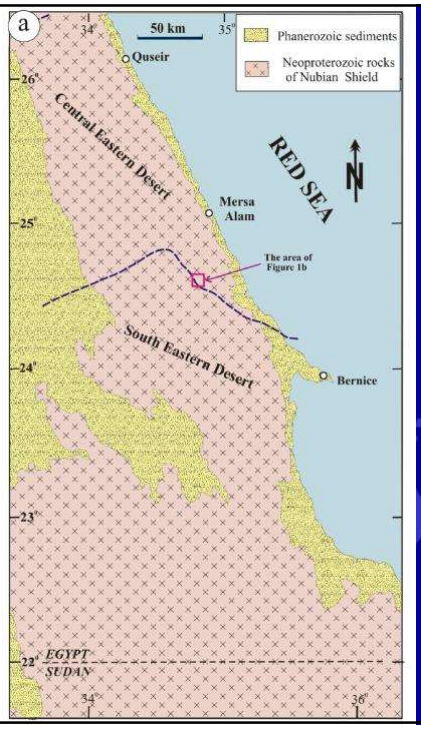
Abu Dabbab

Ta–Nb minerals (colombite–tantalite)

The veins are made up mainly of quartz, Li–mica, topaz, cassiterite, beryl, and fluorite ± wolframite ± chalcopyrite.





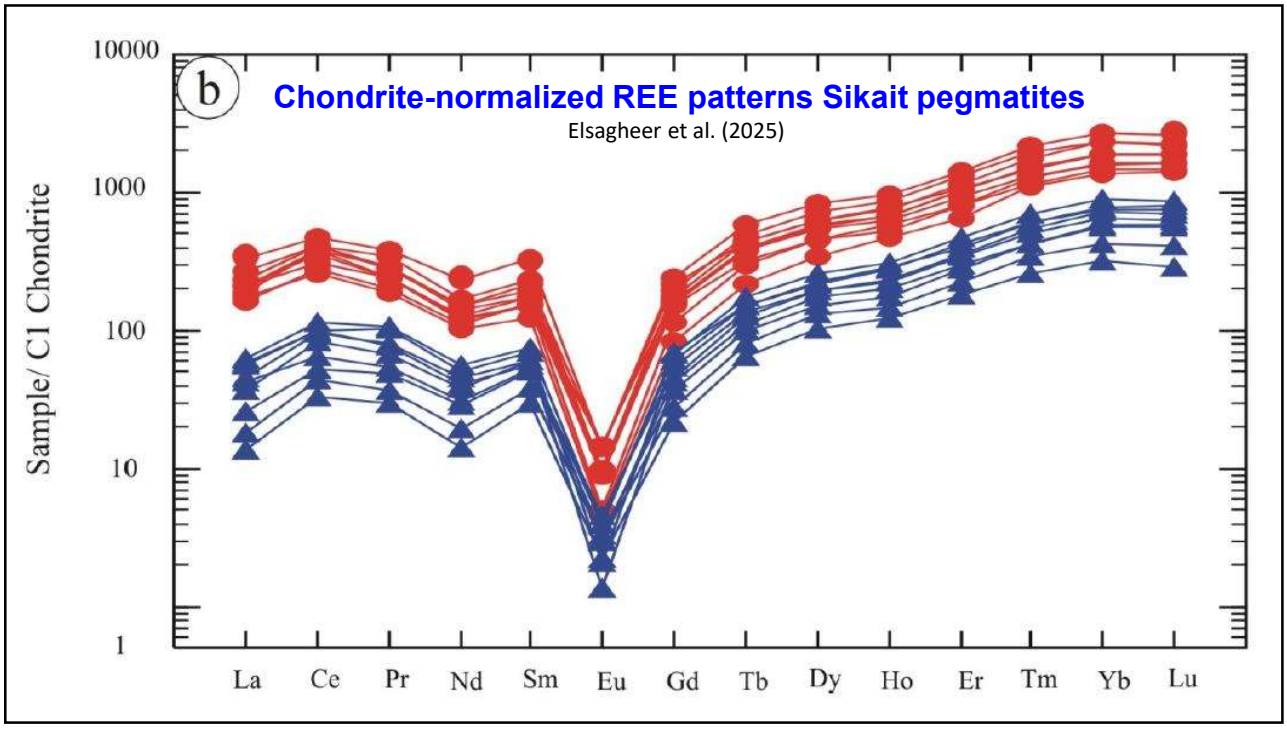


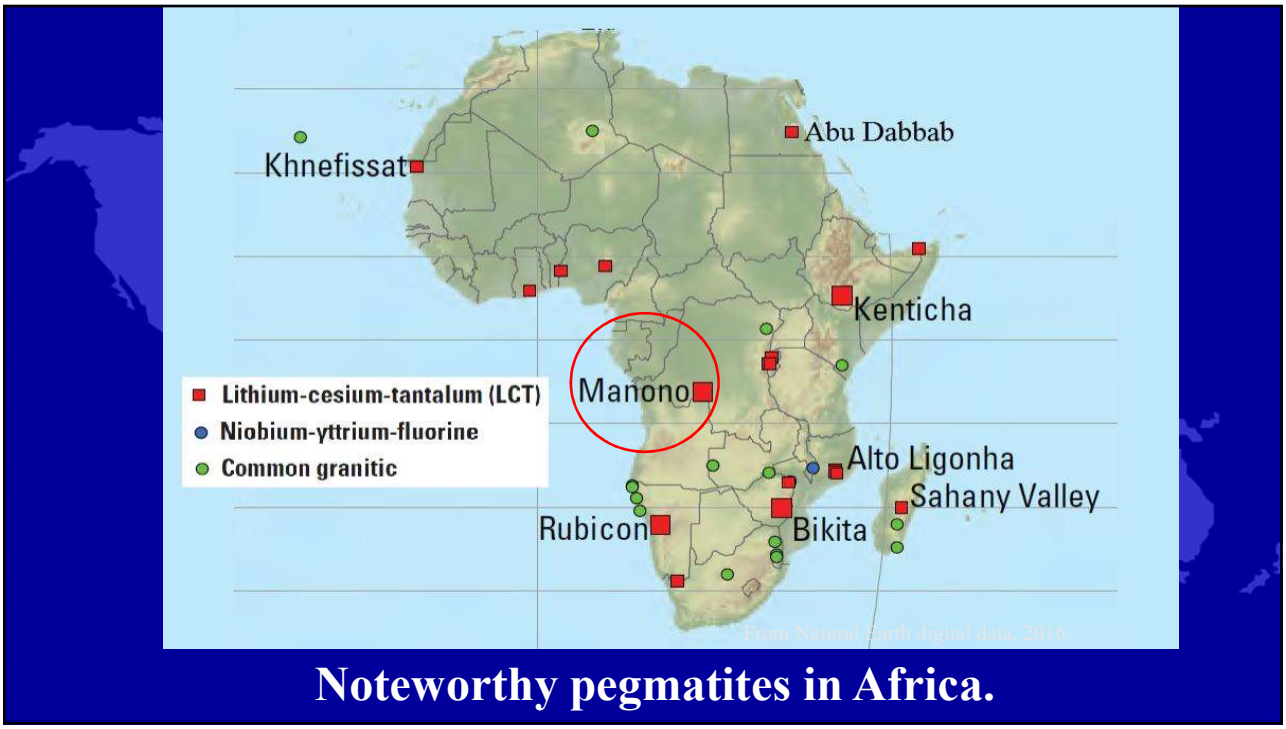
Sikait pegmatites

Sikait pegmatites

- Minerals: Quartz, K-feldspars, albite, and micas
- Economic elements: Nb, Ta, Y, Th, Hf, REE, U
- Accessory minerals: garnet, columbite, fergusonite-(Y), cassiterite, allanite, monazite, bastnaesite (Y, Ce, Nd), thorite, zircon, beryl, topaz, apatite, and Fe-Ti oxides.

- **Greisen**
  Greisen is a fine-to-medium-grained rock, consisting mainly of K-feldspars, quartz, and muscovite.
- Accessory minerals: cassiterite, fluorite, tourmaline, and topaz.

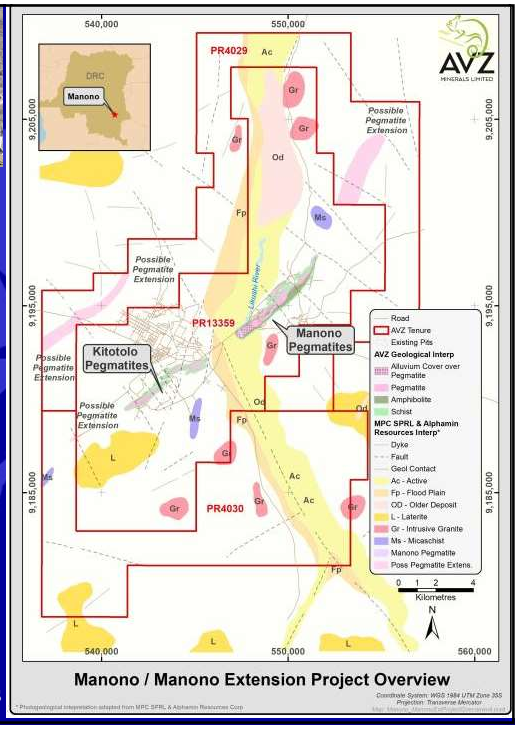




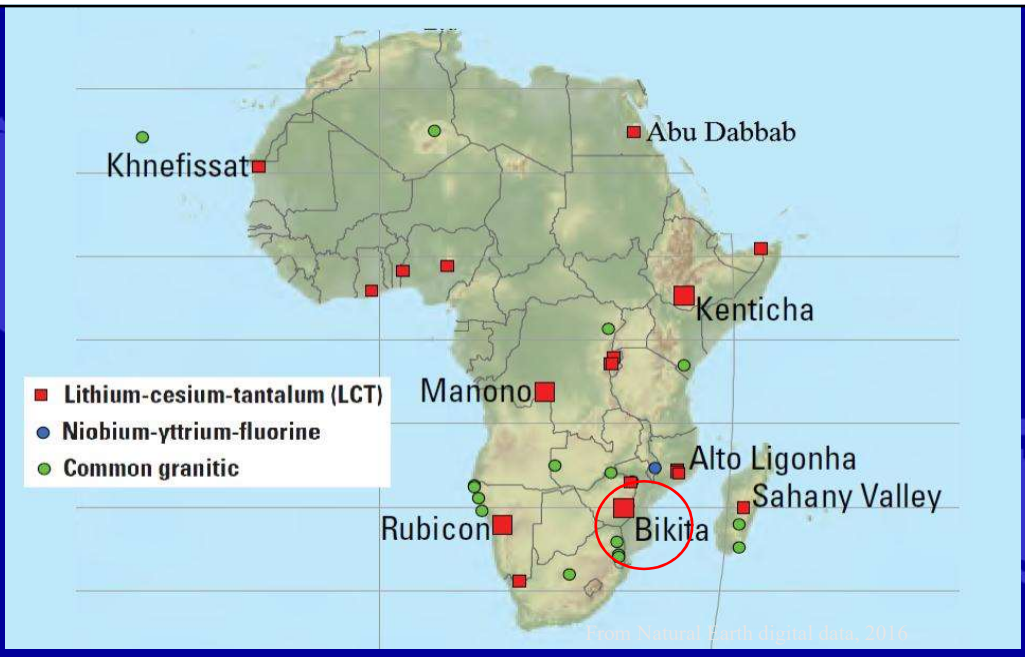
Noteworthy pegmatites in Africa.

Manono-Kitotolo Lithium and Tin (Democratic Republic of Congo)

- The third largest lithium mine in the world
- Sn, Nb–Ta and Li mineralized pegmatites
- lithium-rich LCT pegmatite (**Lithium, Cesium, and Tantalum**)
- Granite-related mineralization, rich in cassiterite (stannic oxide, SnO_2), columbite–tantalite, wolframite $(Fe,Mn)WO_4$/ferberite ($FeWO_4$), spodumene and beryl.
- Tin (Sn), tungsten (W), niobium (Nb), beryllium (Be).
- Age: 900 to 950 MA
- Owner: AVZ Mineral and Tianhua Times
  AVZ Minerals is an Australian company, while Tianhua Times is a Chinese company.
- KoBold Metals, a U.S.-based mining exploration company, has announced a deal to buy AVZ Minerals Ltd.'s



Manono / Manono Extension Project Overview

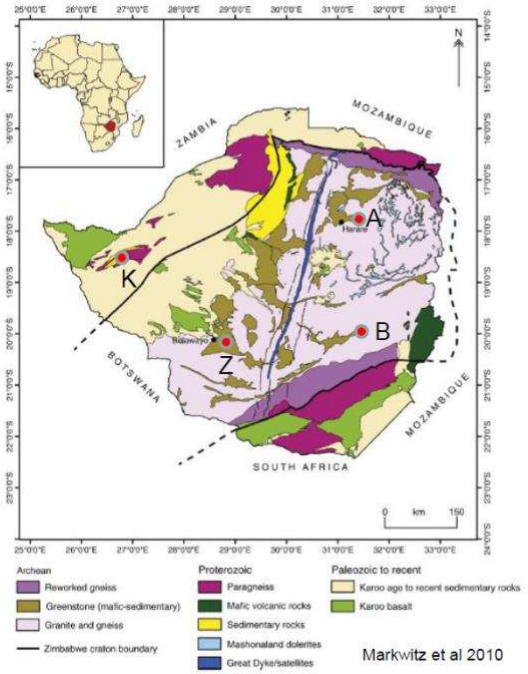


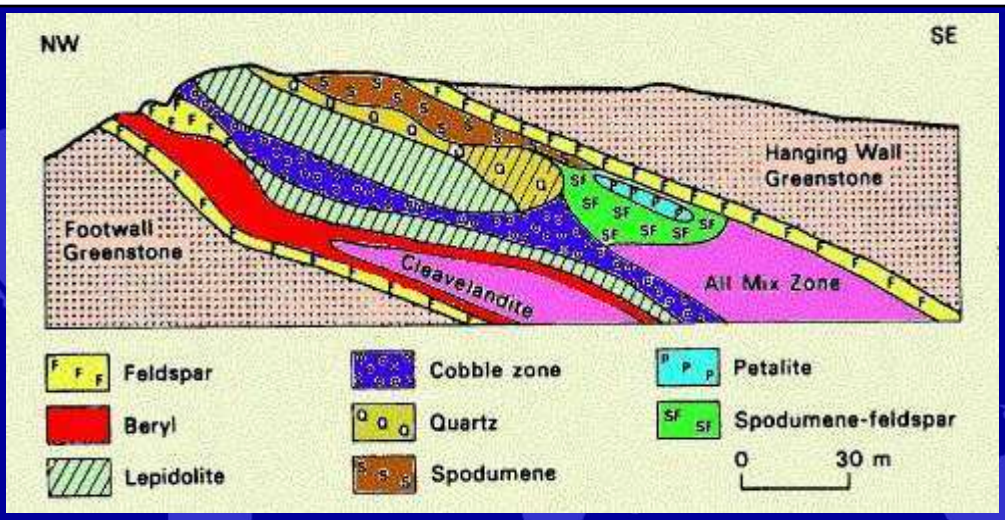
Noteworthy pegmatites in Africa.

Zimbabwe

Bikita & El Hayat pegmatite:
Largest Li produer in Africa
Third after Greenbushes and Tanco
Mined for 70 years
Li, Ta, Be, Cs

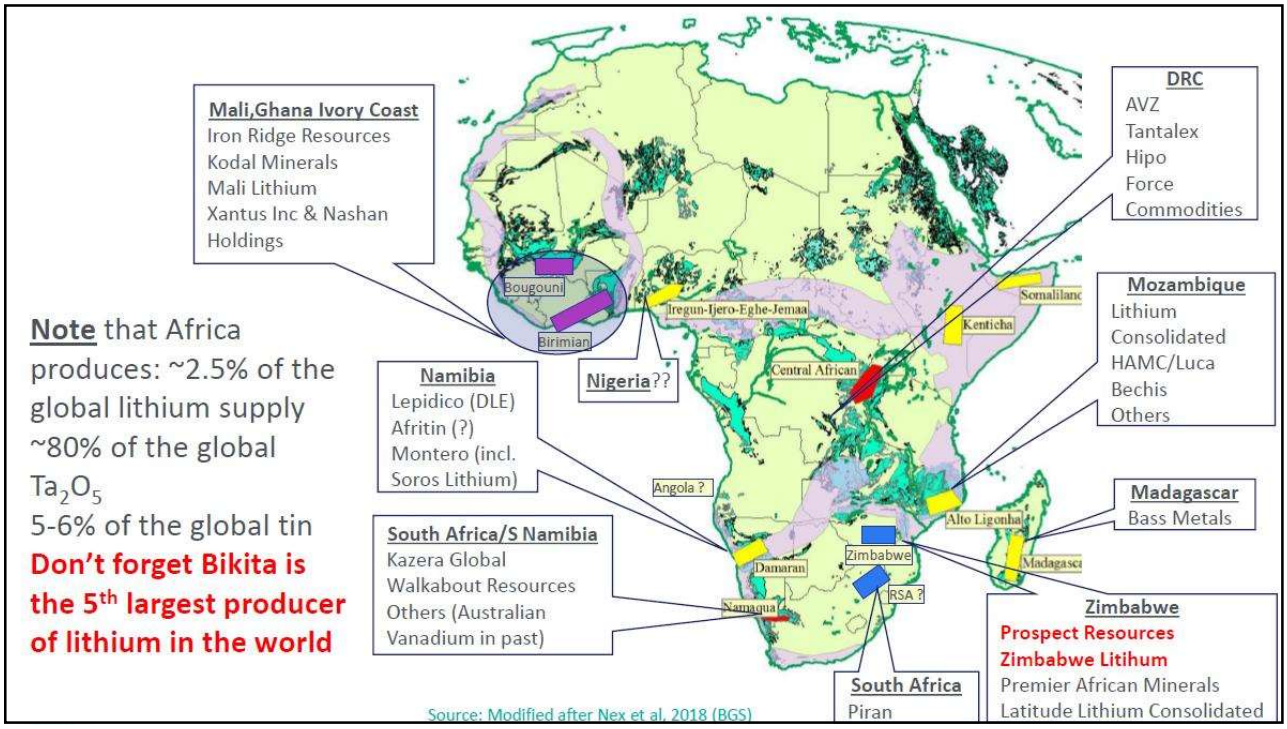
A – Arcadia Project
B – Bikita Minerals (Active Mine)
K – Kamativi Project
Z – Zulu Project





Zoning within Bikita Pegmatite, Zimbabwe

Spodumene ($LiAlSi_2O_6$) in the pyroxene family.
Ore of lithium and a source of ceramic materials.
When brilliant and glassy, clear spodumene is valued as a semiprecious gem



Note that Africa produces: ~2.5% of the global lithium supply
~80% of the global Ta_2O_5
5-6% of the global tin
Don't forget Bikita is the 5th largest producer of lithium in the world