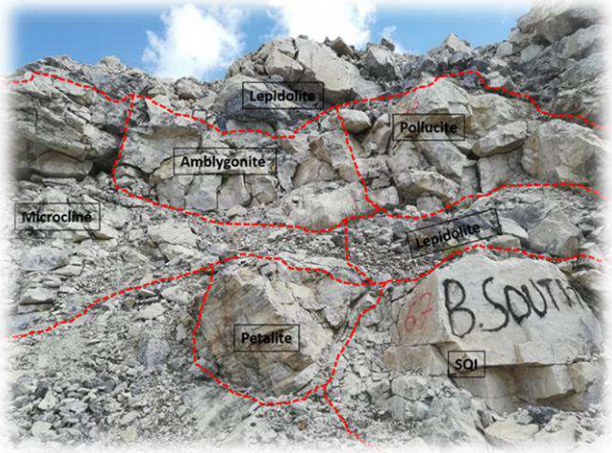
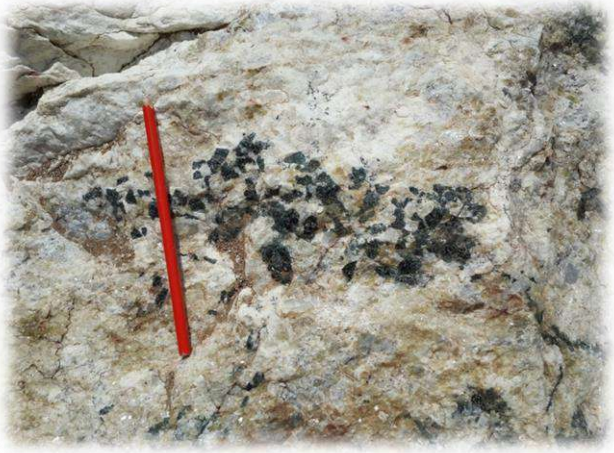






Economic importance of pegmatites in Africa

Judith Kinnaird

Paul Nex

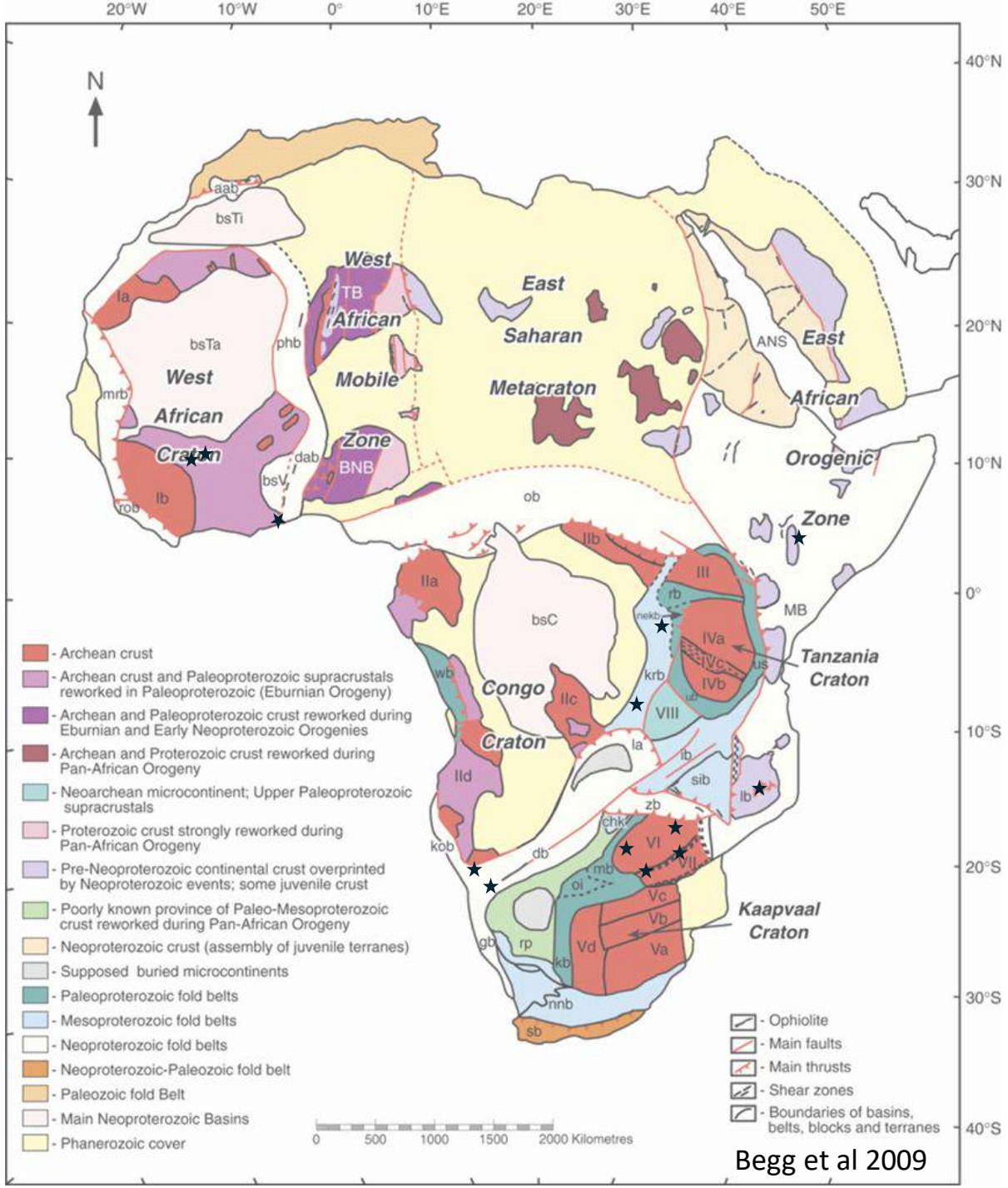
CIMERA: University of the Witwatersrand, South Africa

University of the Witwatersrand

and collaborators

Kathryn Goodenough, Richard Shaw. Anouk Borst, Warrick Fuchsloch, Luisa Ashworth

CIMERA – DST-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis



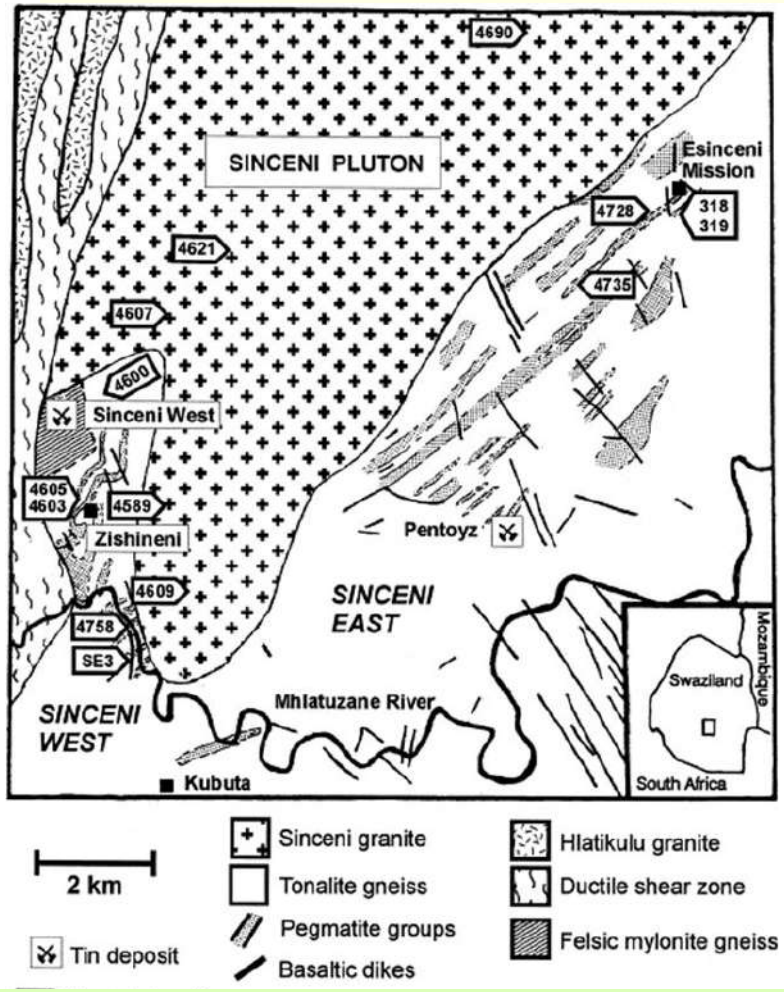
Begg et al 2009

Pegmatites occur across Africa and range in age from Archaean to Neoproterozoic

- Archaean >2500 Ma
- Eburnean (Birimian) ~2000Ma → Columbia
- Kibaran ~1000Ma (Grenvillian) → Rodinia
- Pan African ~500Ma → Gondwana

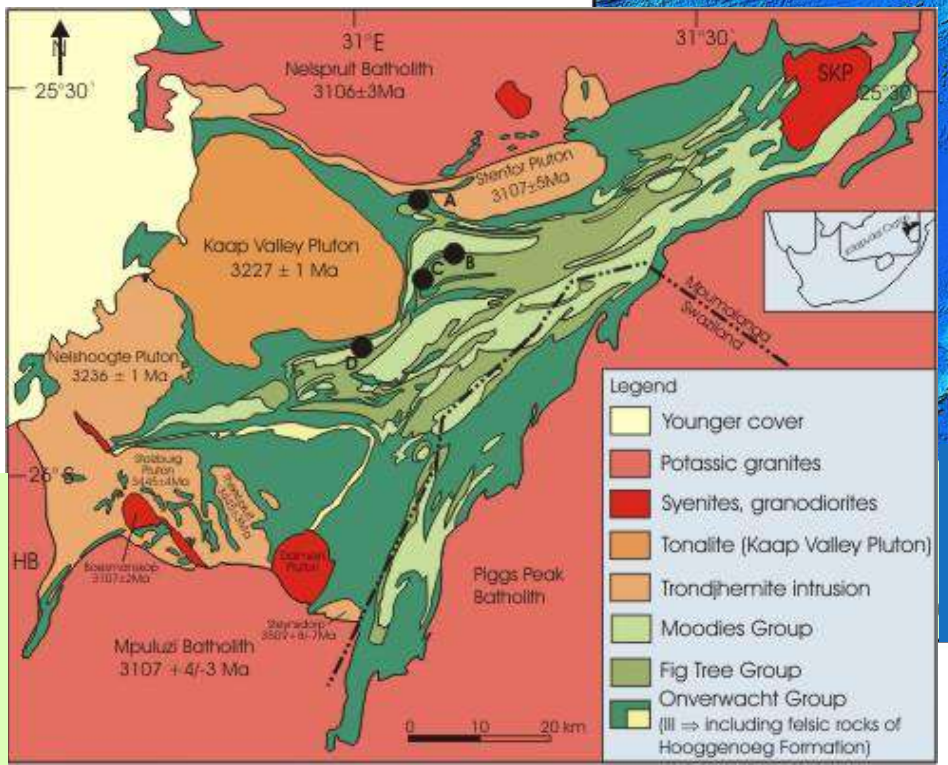
Many pegmatites have been mined for gemstones, tin, or tantalum with some having produced lithium mainly for the ceramics industry, such as Bikita in Zimbabwe.

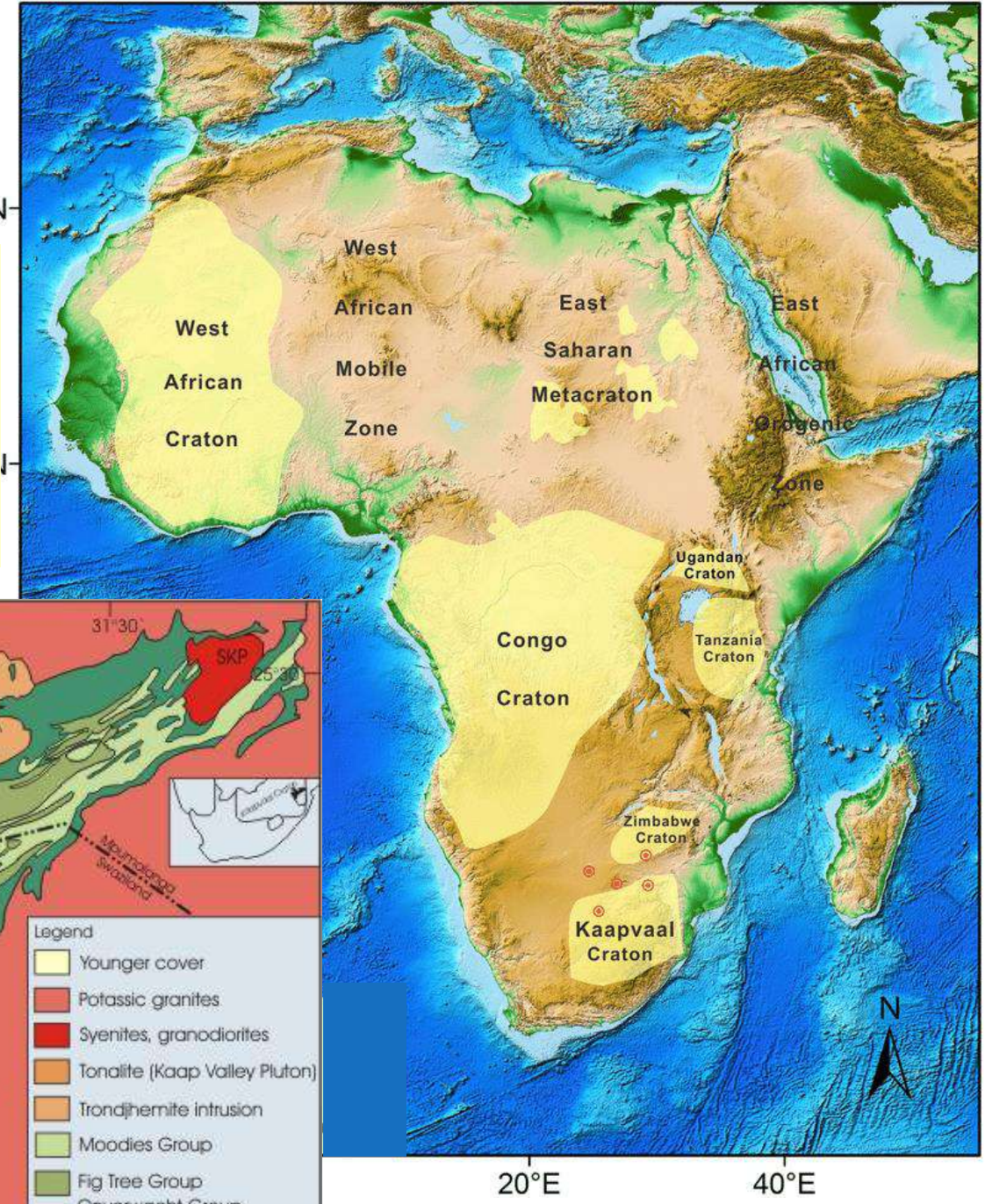
Archaean: Swaziland, Barberton



3 Ga LCT deformed and zoned pegmatites related to Nelspruit batholith

(i) K feld+alb
(ii) alb+spod
(iii) albite

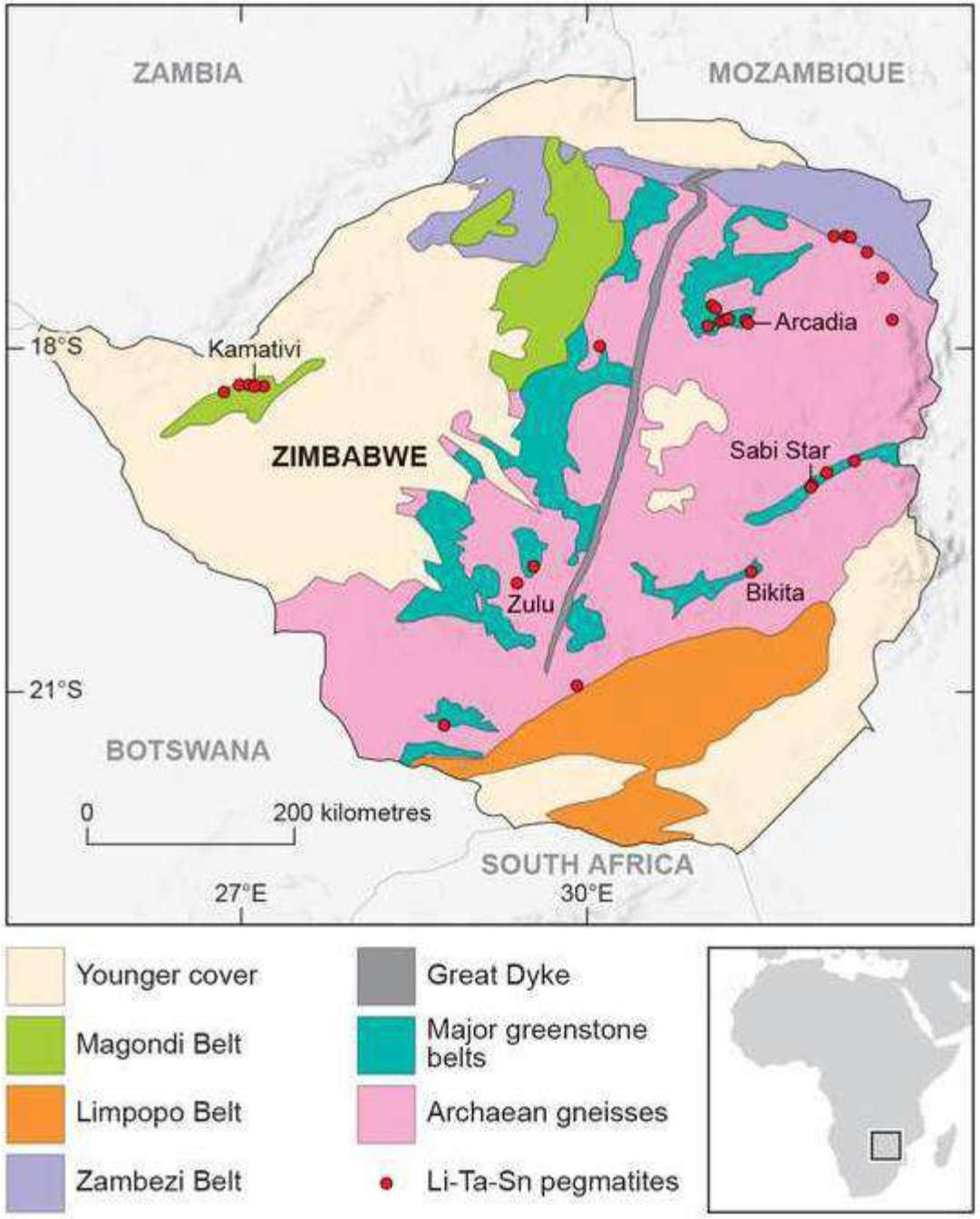




- pegmatite field with cassiterite, beryl and spodumene fractionated from Sinceni granite
- muscovite Rb-Sr ages of 3Ga

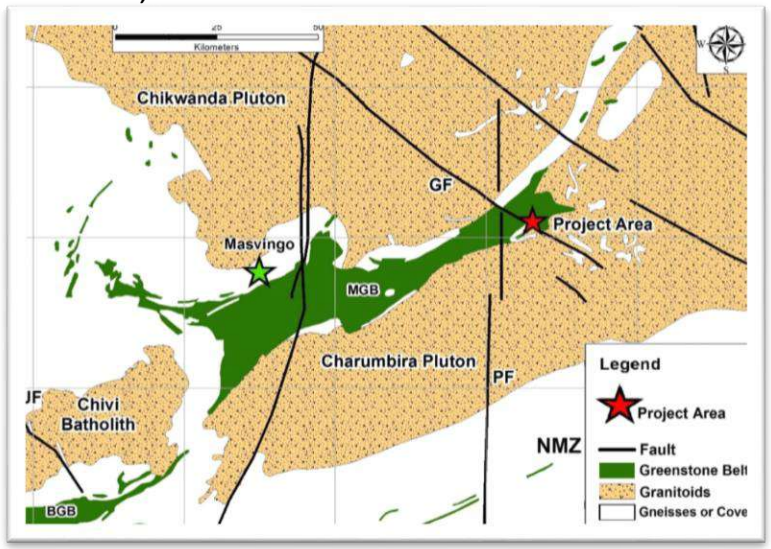
(Trumbull, 1993)

Van Kranendonk

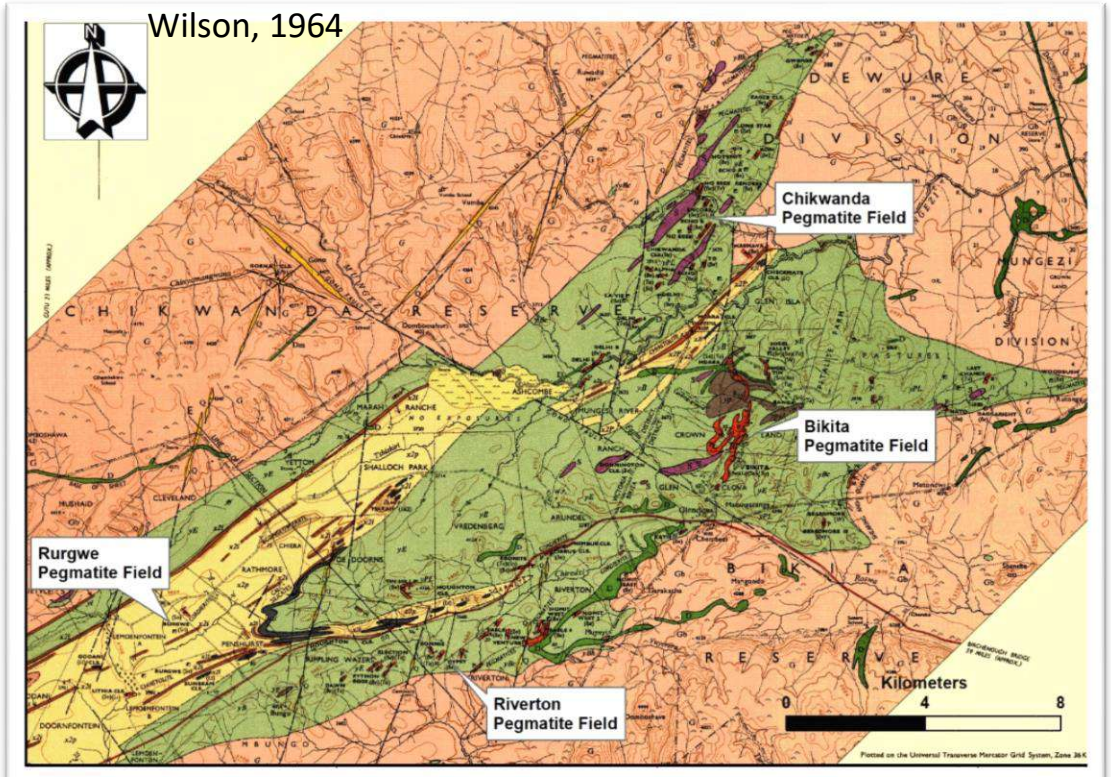


Map after Shaw et al. (2022) in Goodenough et al in press

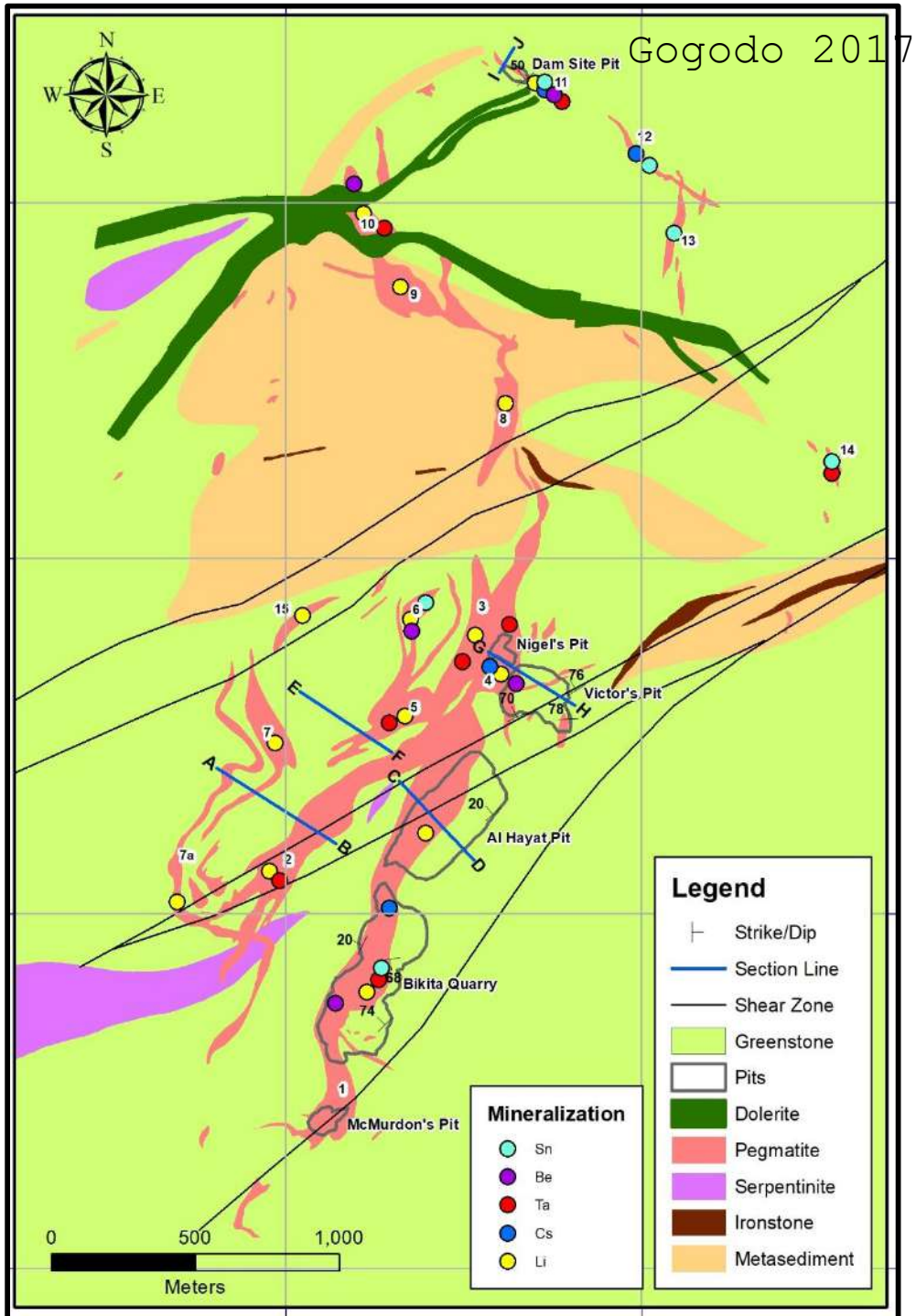
Wilson, 1990

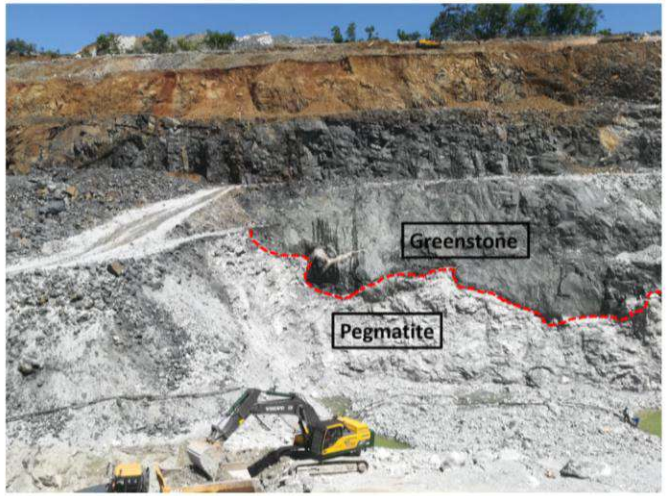


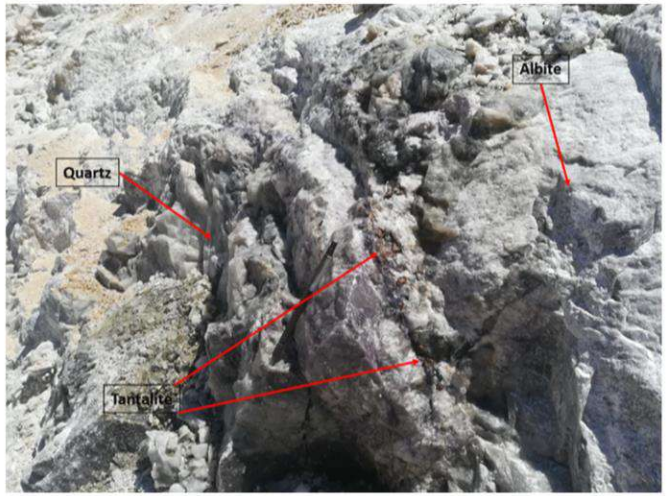
Wilson, 1964

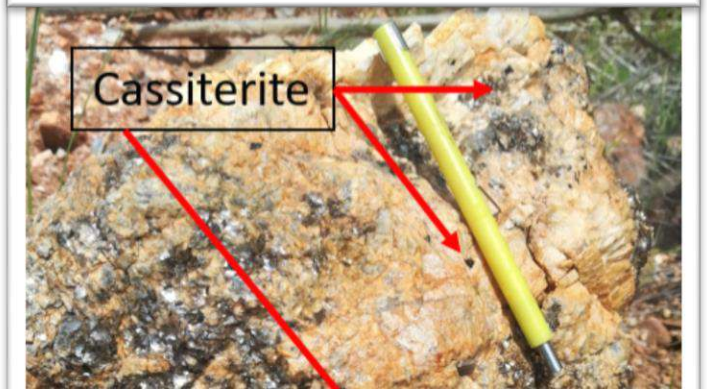


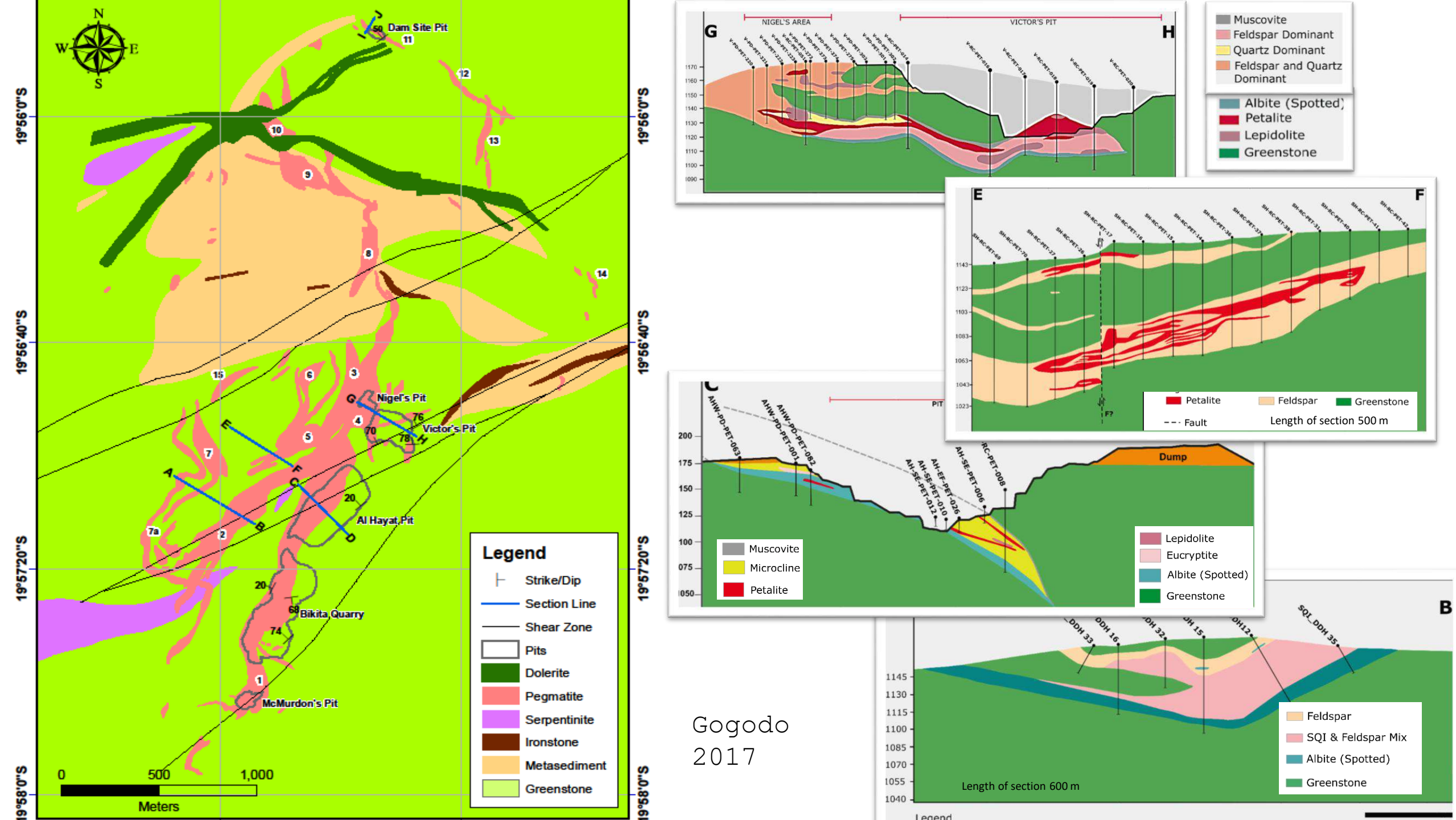
Gogodo 2017


N
W
E
S
50 Dam Site Pit
11
12
13
10
9
8
14
15
6
3
G
Nigel's Pit
4
76
70
78
Victor's Pit
H
5
F
7
A
C
20
Al Hayat Pit
7a
2
B
D
20
68
Bikita Quarry
74
1
McMurdon's Pit
0
500
1,000
Meters
Mineralization
Sn
Be
Ta
Cs
Li
Legend
Strike/Dip
Section Line
Shear Zone
Greenstone
Pits
Dolerite
Pegmatite
Serpentinite
Ironstone
Metasediment


Greenstone
Pegmatite


Albite
Quartz
Tantalite


Cassiterite


N
W
E
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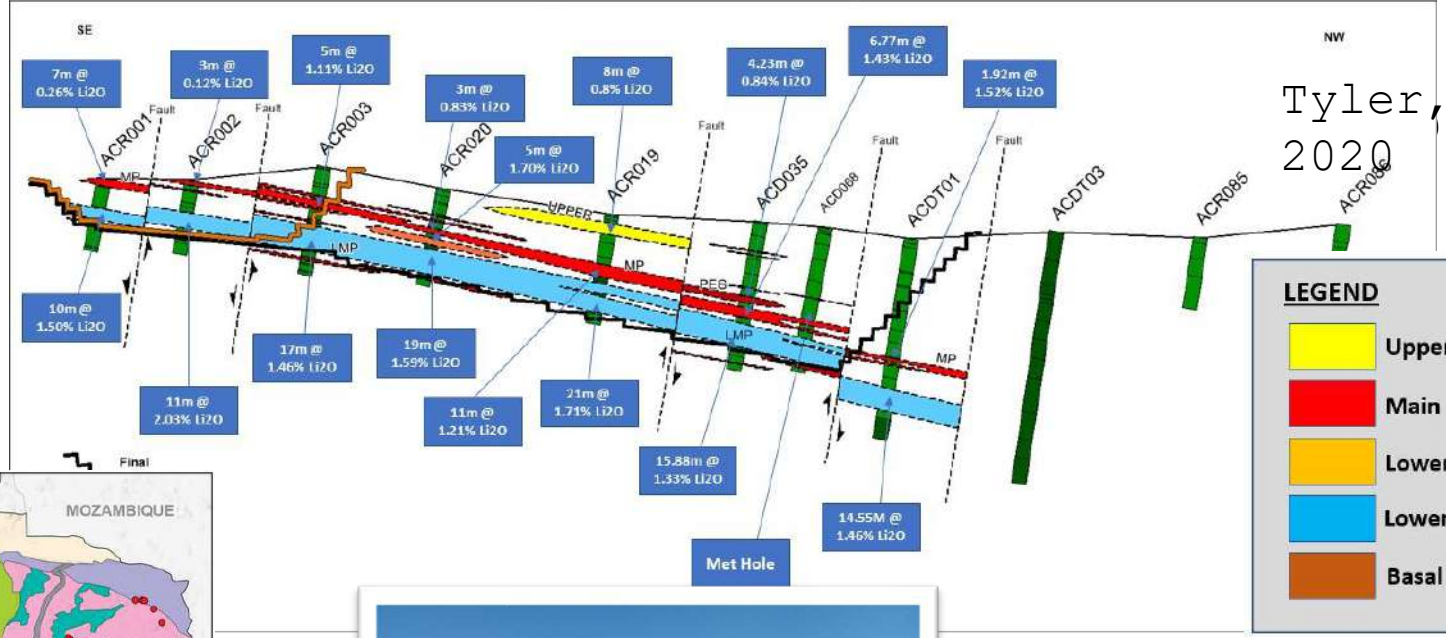
Dam Site Pit
Nigel's Pit
Victor's Pit
Al Hayat Pit
Bikita Quarry
McMurdon's Pit
19°56'0"S
19°56'40"S
19°57'20"S
19°58'0"S
0
500
1,000
Meters
Legend
Strike/Dip
Section Line
Shear Zone
Pits
Dolerite
Pegmatite
Serpentinite
Ironstone
Metasediment
Greenstone
NIGEL'S AREA
VICTOR'S PIT
Muscovite
Feldspar Dominant
Quartz Dominant
Feldspar and Quartz Dominant
Albite (Spotted)
Petalite
Lepidolite
Greenstone
Petalite
Feldspar
Greenstone
Fault
Length of section 500 m
Dump
Muscovite
Microcline
Petalite
Lepidolite
Eucryptite
Albite (Spotted)
Greenstone
Feldspar
SQI & Feldspar Mix
Albite (Spotted)
Greenstone
Length of section 600 m

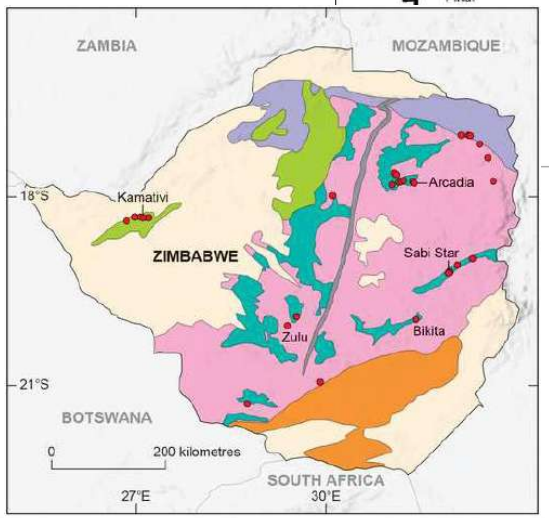
Gogodo
2017

Arcadia, Zimbabwe

Photos: Paul Nex



Tyler, 2020

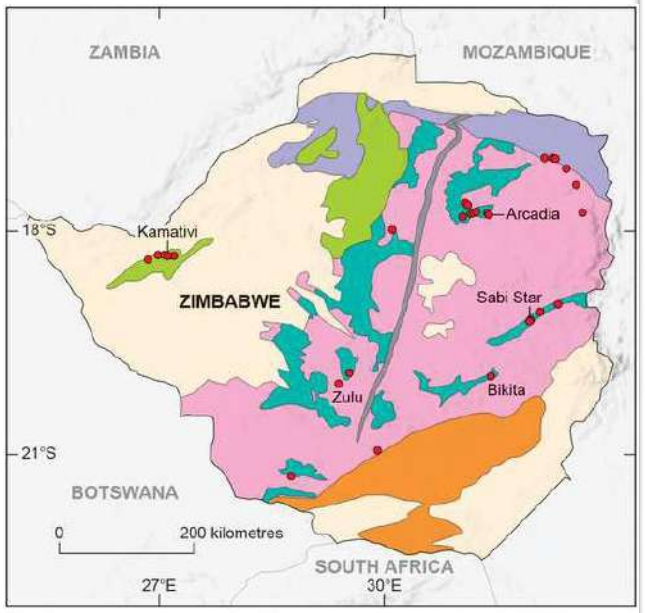


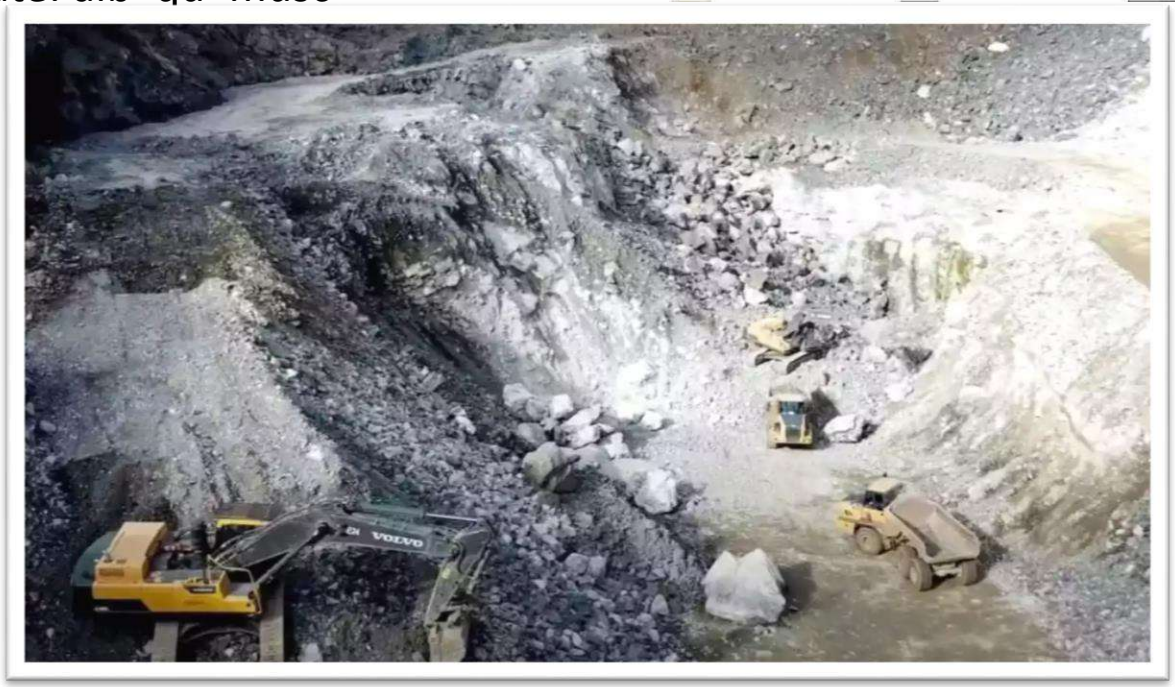
- 38 km east of Harare
- historical open pit (1966-1972)
- pegmatites emplaced into meta- basalts
- <14 stacked sheets
- petalite and spodumene
- poorly zoned,
- tantalite credits

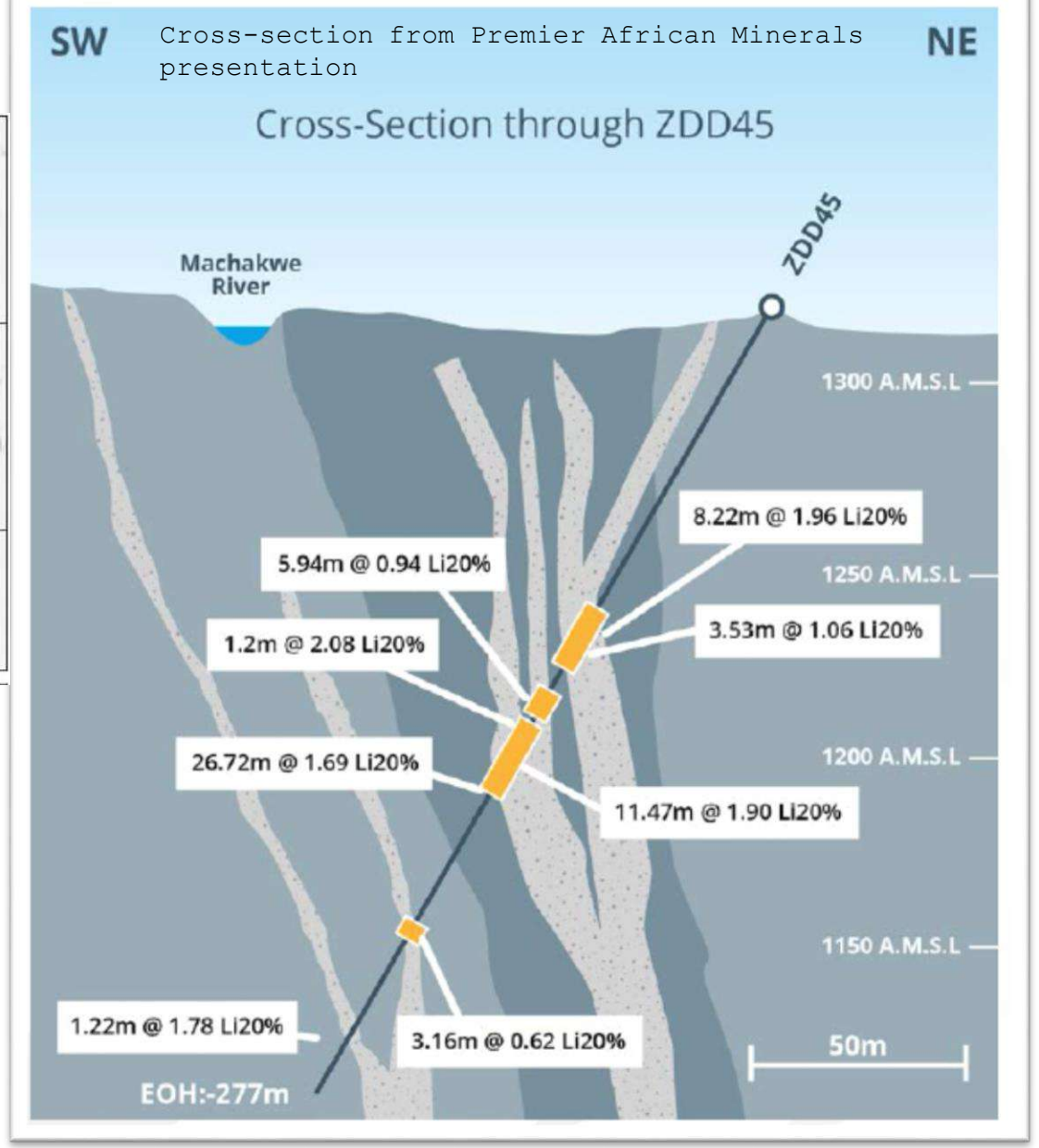
www.mining technology

Zulu Project:
Premier African Minerals

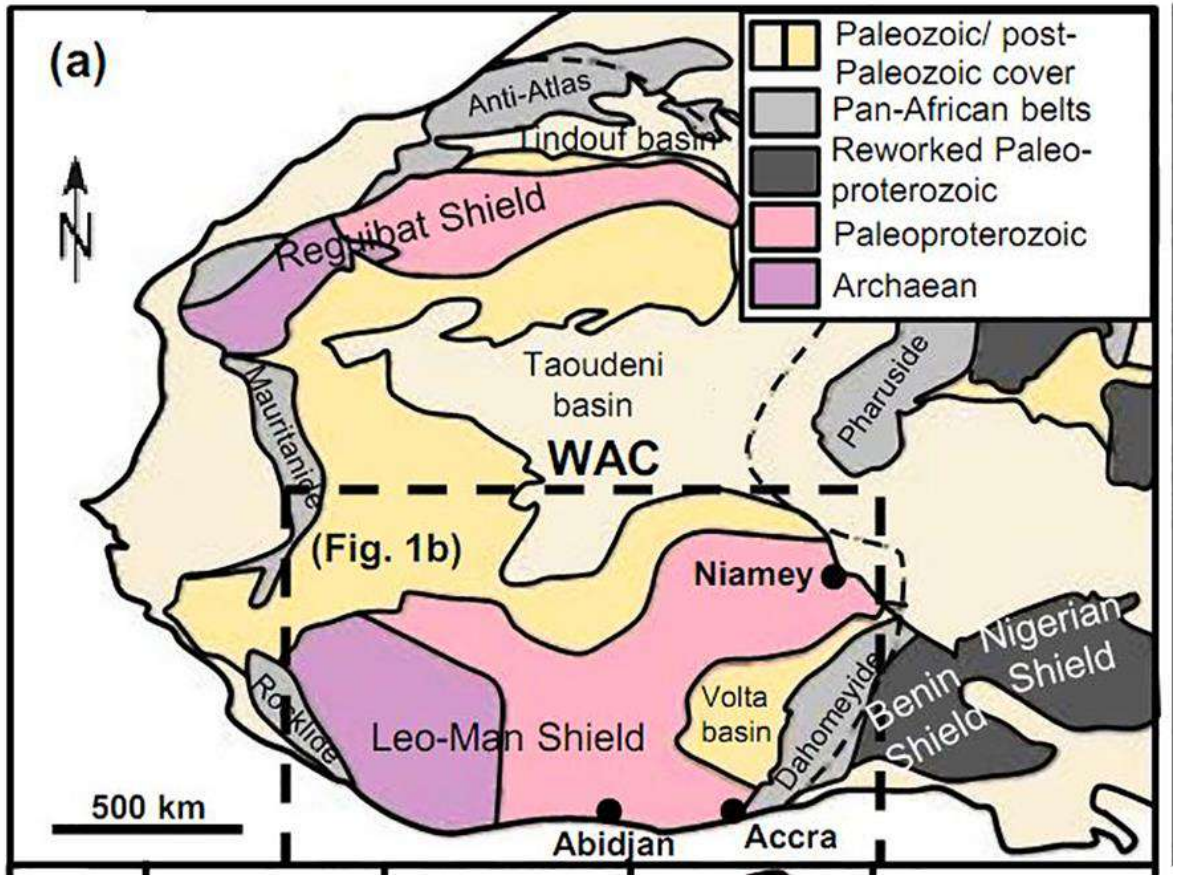
- The Main Pegmatites exploits the contact between a serpentinised ultramafic sill and underlying meta-volcanic succession.
- <50m wide and <1km long
- Border: alb+qu+musc
- Intermed: SQI (after pet)+micr+qu
- Core: indistinct
- Late: alb+qu+musc





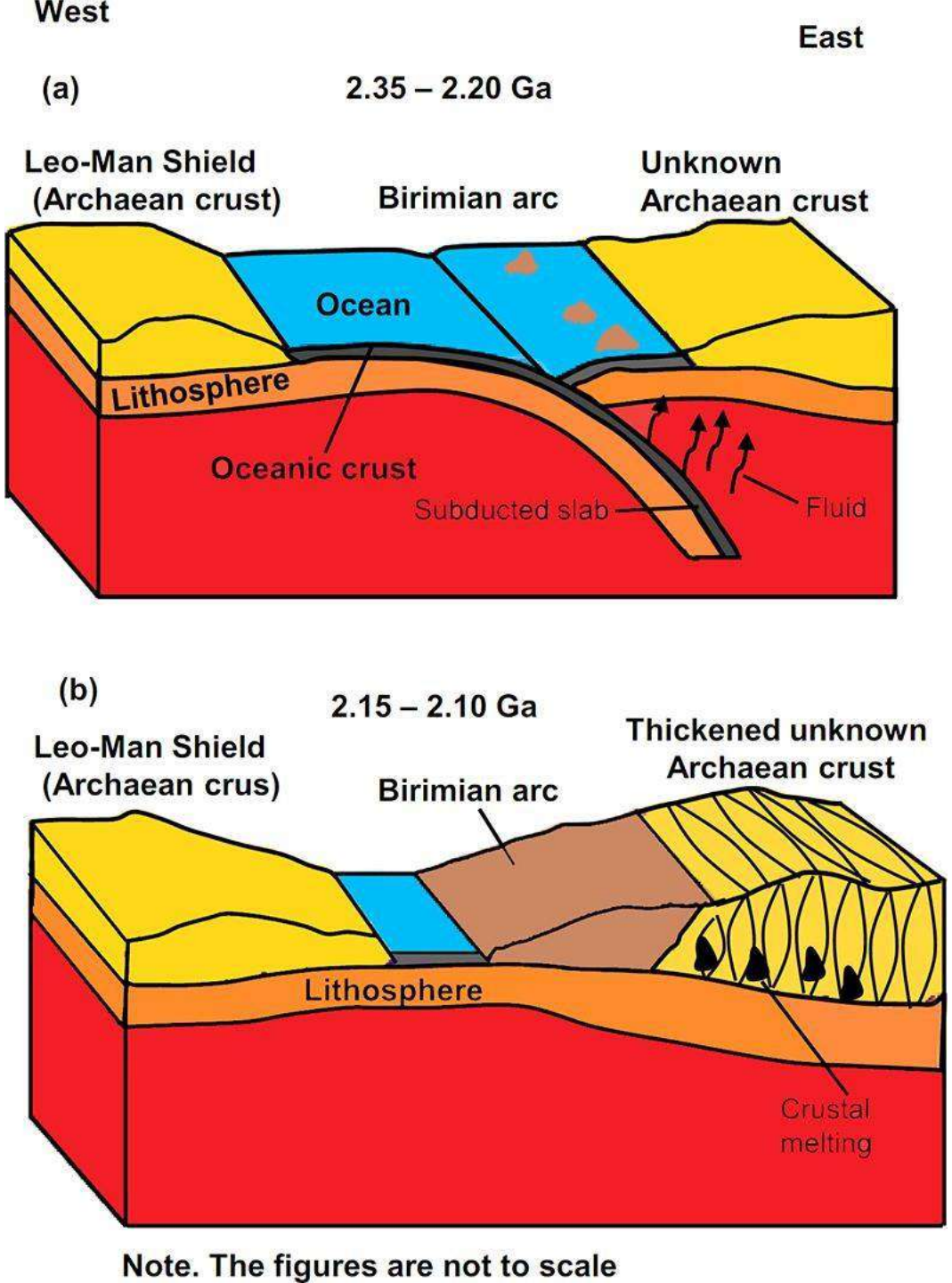


Multiple, anastomosing sub-vertical pegmatites
Spodumene and petalite present
Drilling 2016-1017 followed by a maiden SAMREC compliant resource:
20.1 Mt @ 1.06% Li_2O_5, 51 ppm Ta_2O_5
November 2017 Scoping Study completed

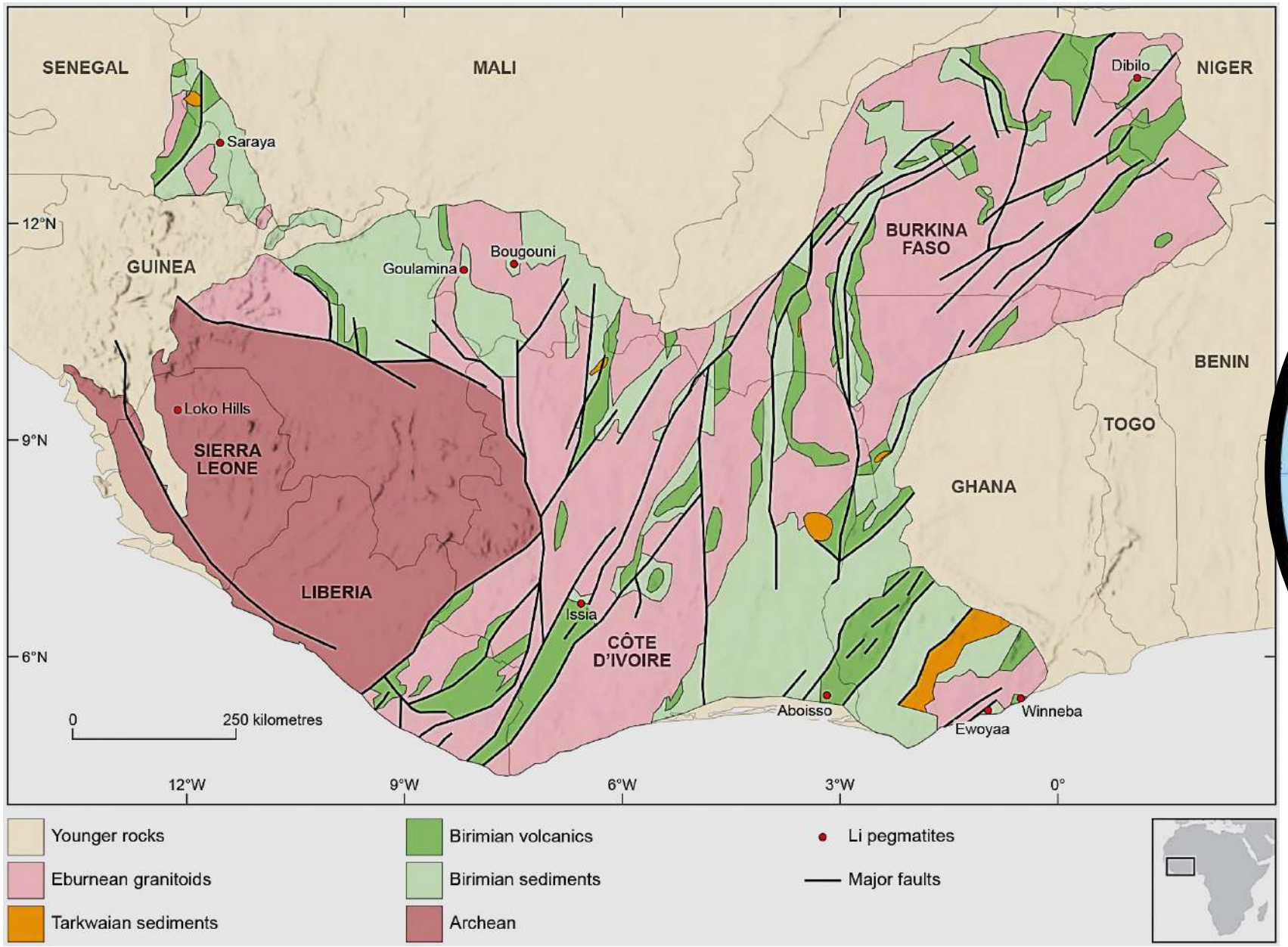


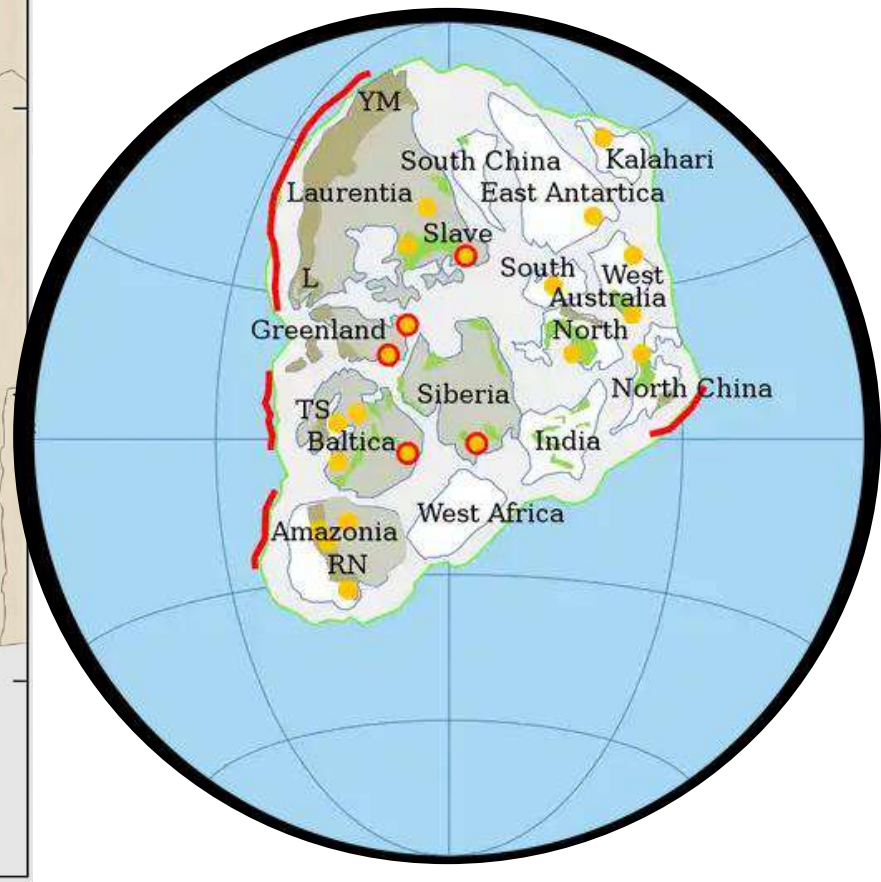
Eburnean-Birimian ~2000 Ma

formation of Columbia Supercontinent



Formation of Columbia



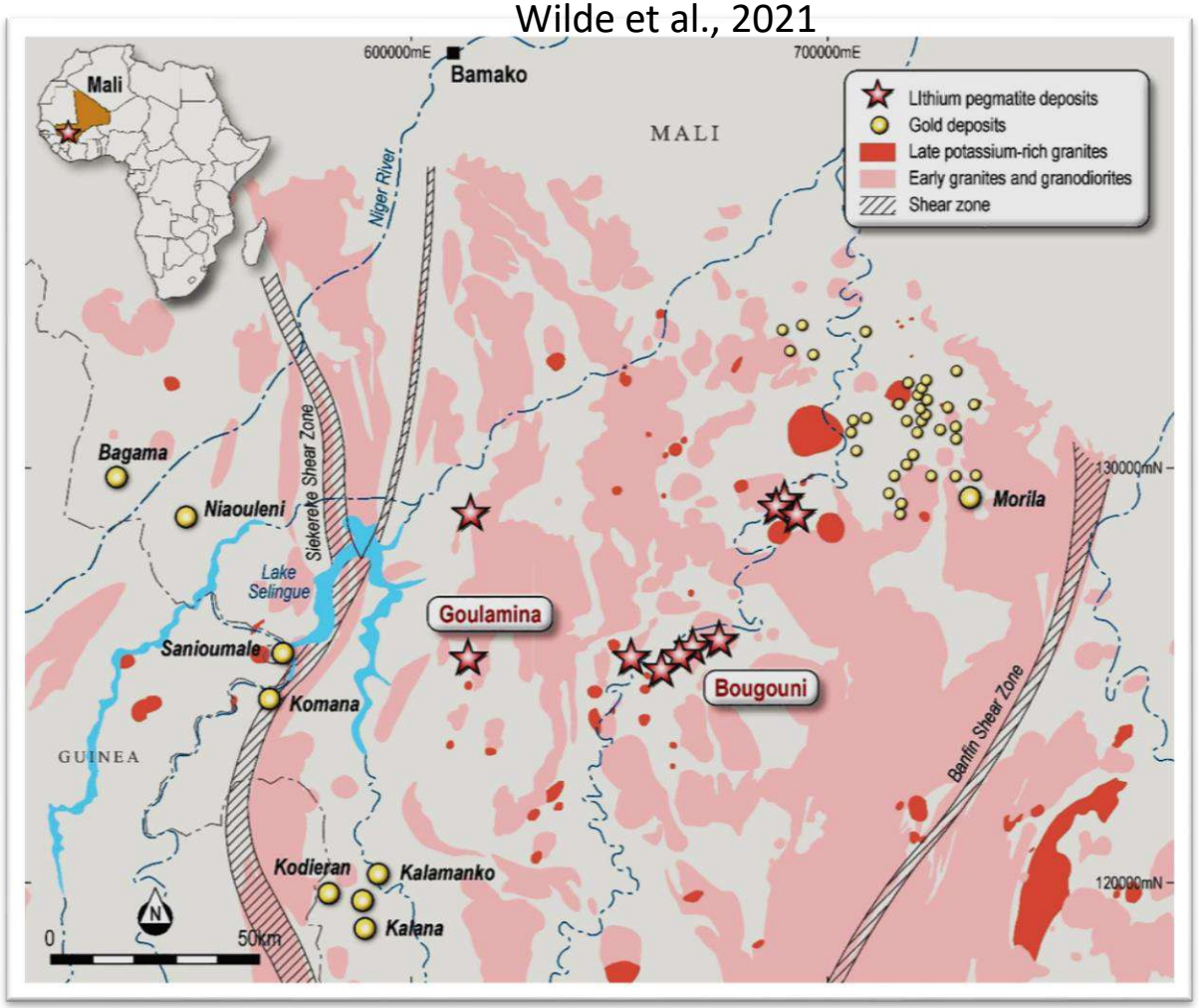


Simplified geological map of West Africa after Gunn et al. (2018)

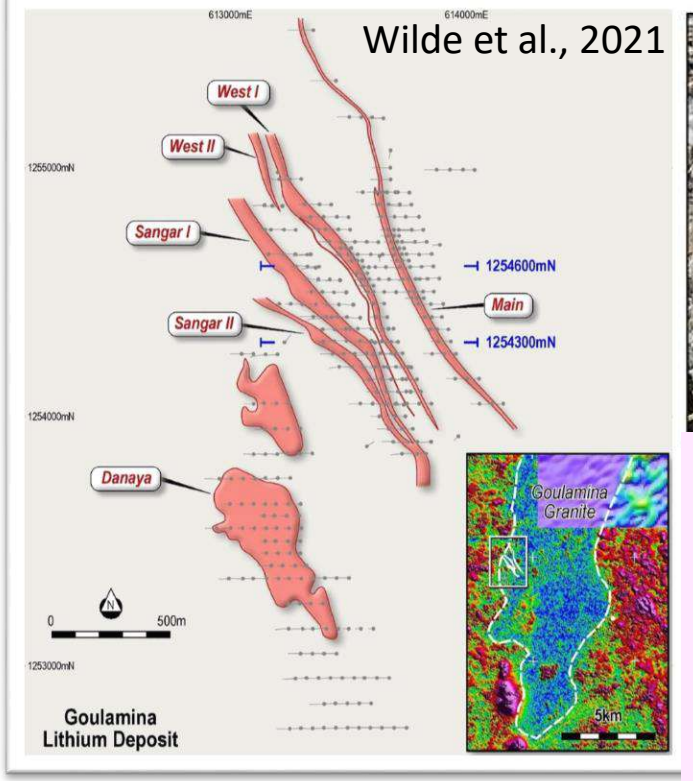
From Goodenough et al: in press

Goulamina and Bougoni Eburnean-Birimian ~2000 Ma

Wilde et al., 2021



Wilde et al., 2021



- 5 spodumene pegmatites (Main, West, West I, Sangar I & II) 70% of the resource
- intrude the peraluminous Goulamina Granite.
- Steep dip trend NW-SE, 10 to 80 m thick, >1 km

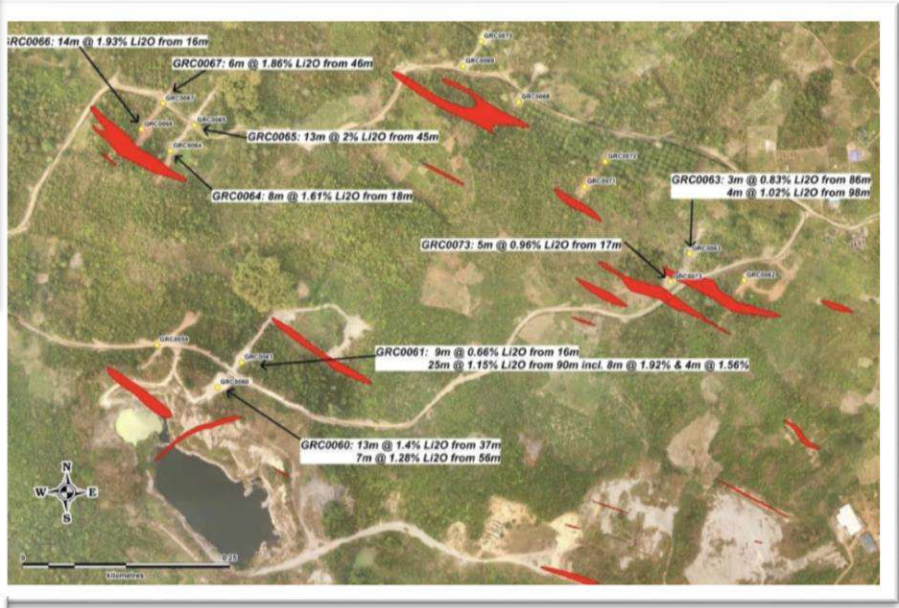
.

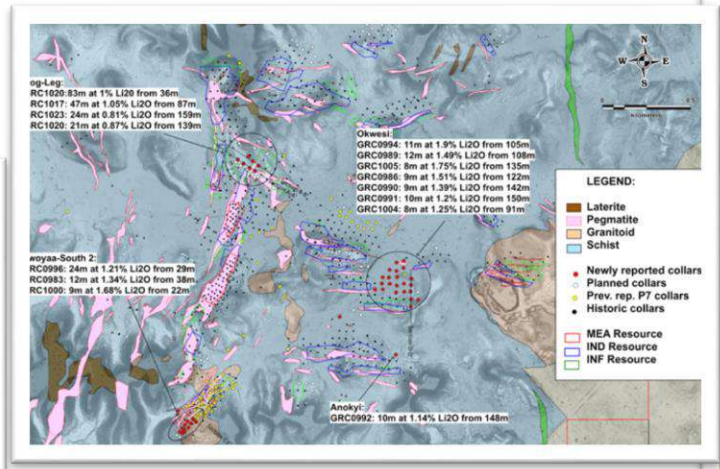
- Danaya pegmatite swarm ~30% of the resource.
- ~400 m wide and >1.5 km long but thinner.
- lack both regional and internal zonation.
- Spodumene <15cm long, often the only Li phase.
- Magmatic assemblage is albitised resulting in patchy fine-grained albite. Late-stage weathering lowers lithium contents.

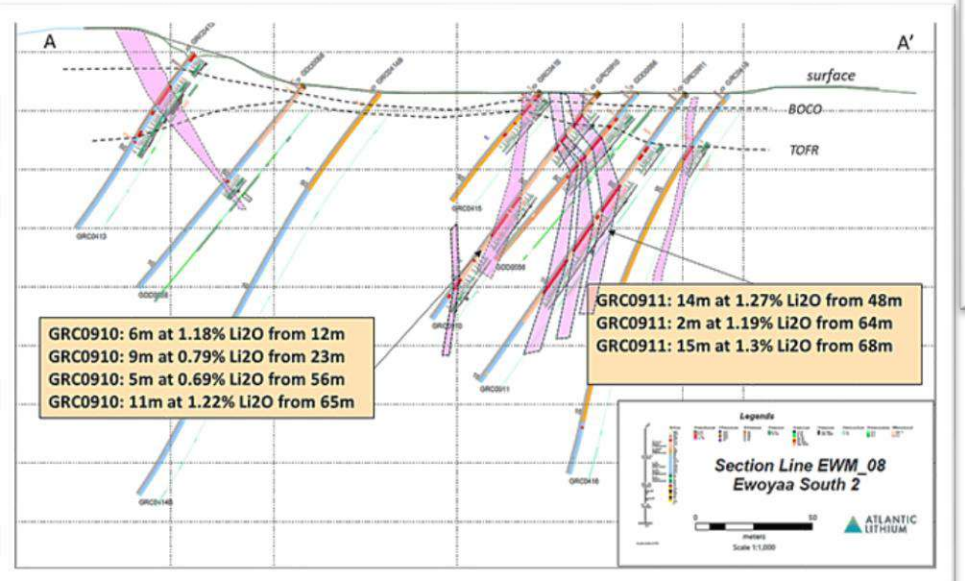
- The Goulamina spodumene pegmatite field, is one of the largest hard-rock Li deposits in the world, >20 km
- A resource of 103 Mt at 1.32% Li_2O • 1.4 Mt of contained Li_2O. Annual lithium use 1.4 Mt

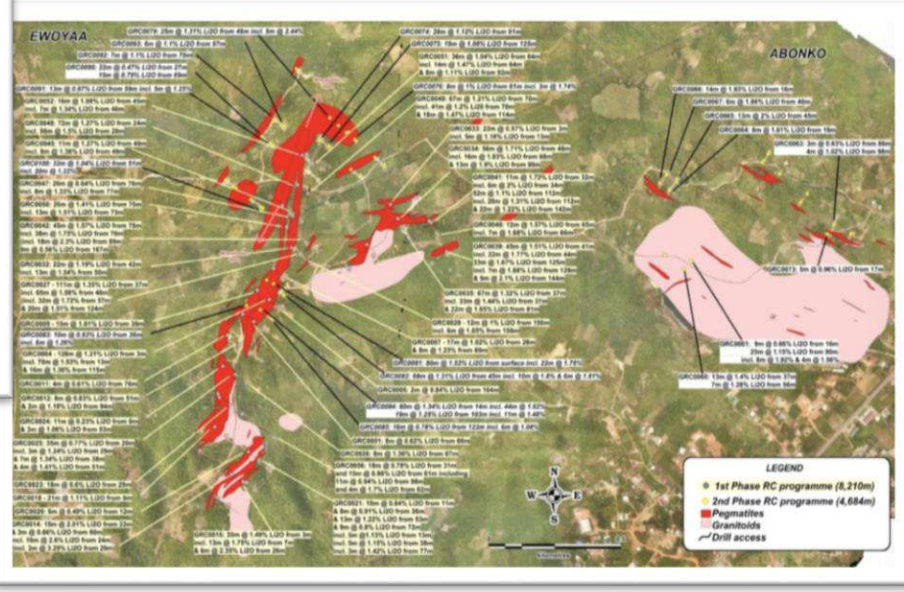
Ewoyaa pegmatites

- hosted by Birimian mica schists and granitoids.
- 2 - 60 m in width and <800 m along SE strike.
- Steeply-dipping and the dominant strike is SE.
- Spodumene-bearing throughout unzoned bodies.
  Crystals <10cm with UST (qu + feld + apatite + musc)
- Magmatic albite: later albitisation reduces Li grade
- JORC compliant resource 35.3Mt @ 1.25 Li_2O
- Ore Reserves 25.6Mt @ 1.22% Li_2O
- 3.5Mt at 1.37% Li_2O Measured
- 24.5Mt at 1.25% Li_2O Indicated







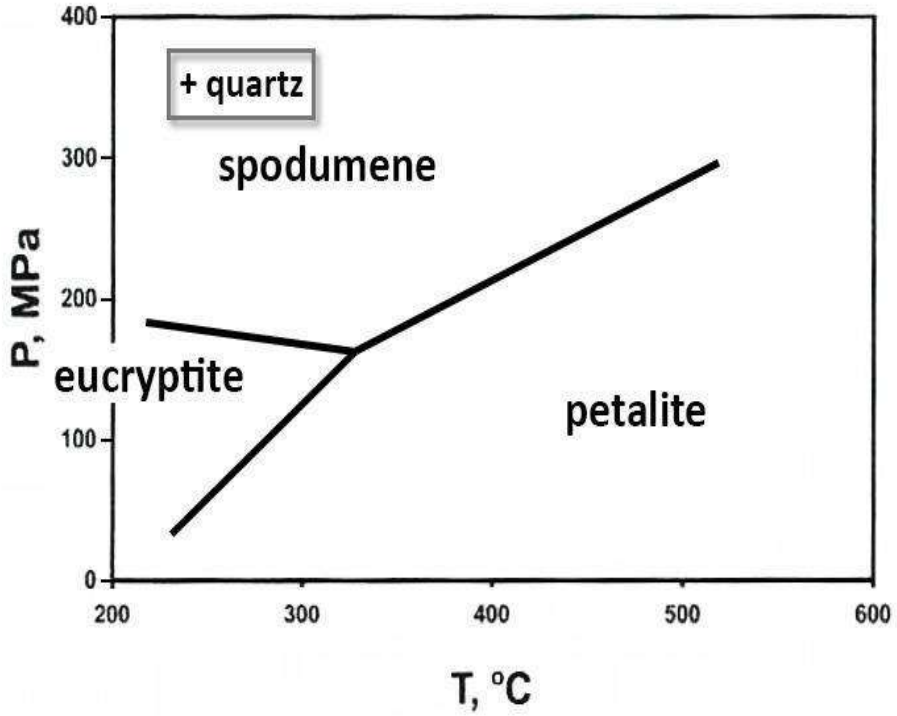


Petalite or spodumene?

Petalite

$LiAlSi_4O_{10}$ 3.0 - 4.7% as Li_2O = 2.27% Li

- Very low thermal expansion



Spodumene

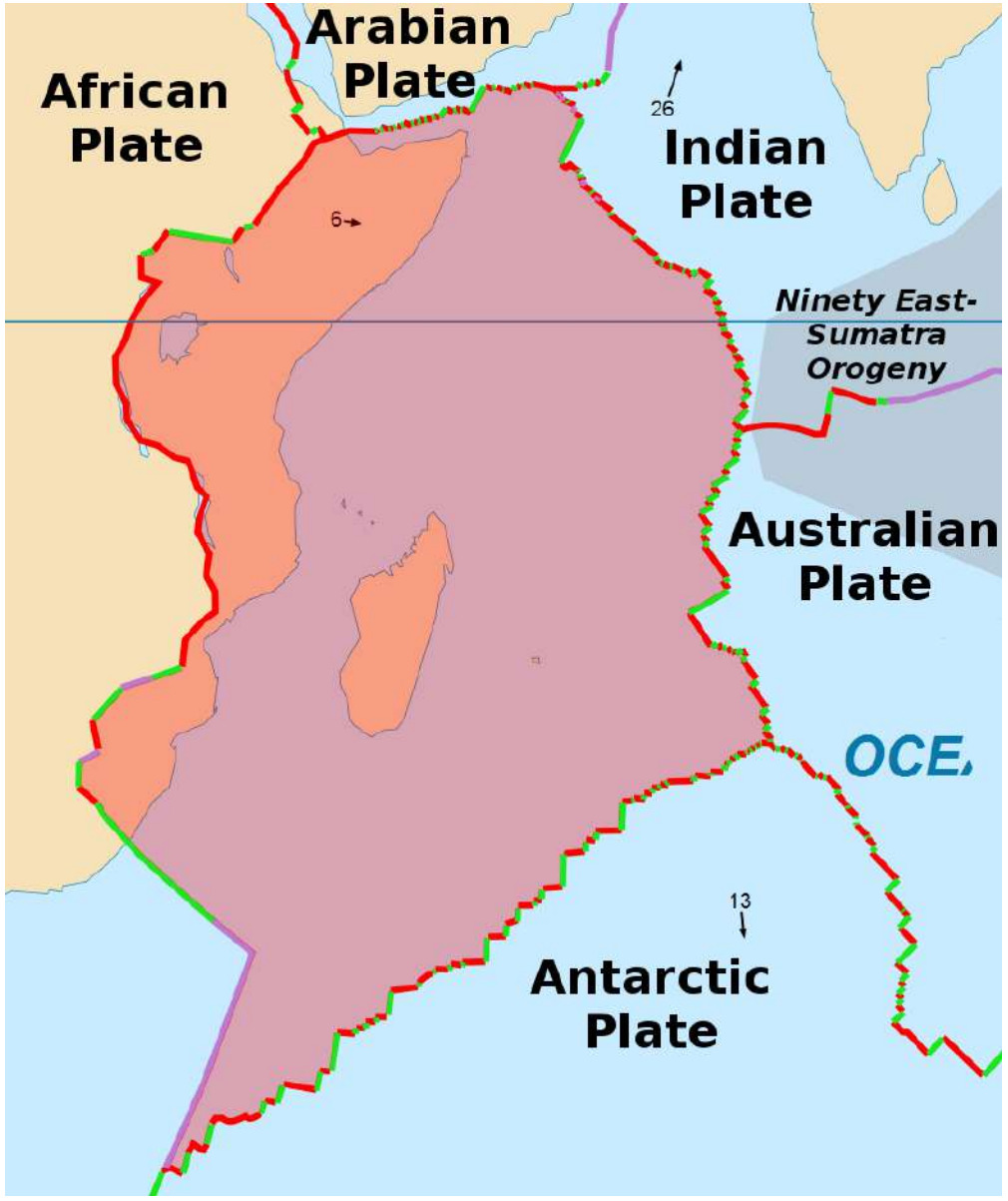
$LiAlSi_2O_6$. Li_2O 8.3% = 3.73% Li

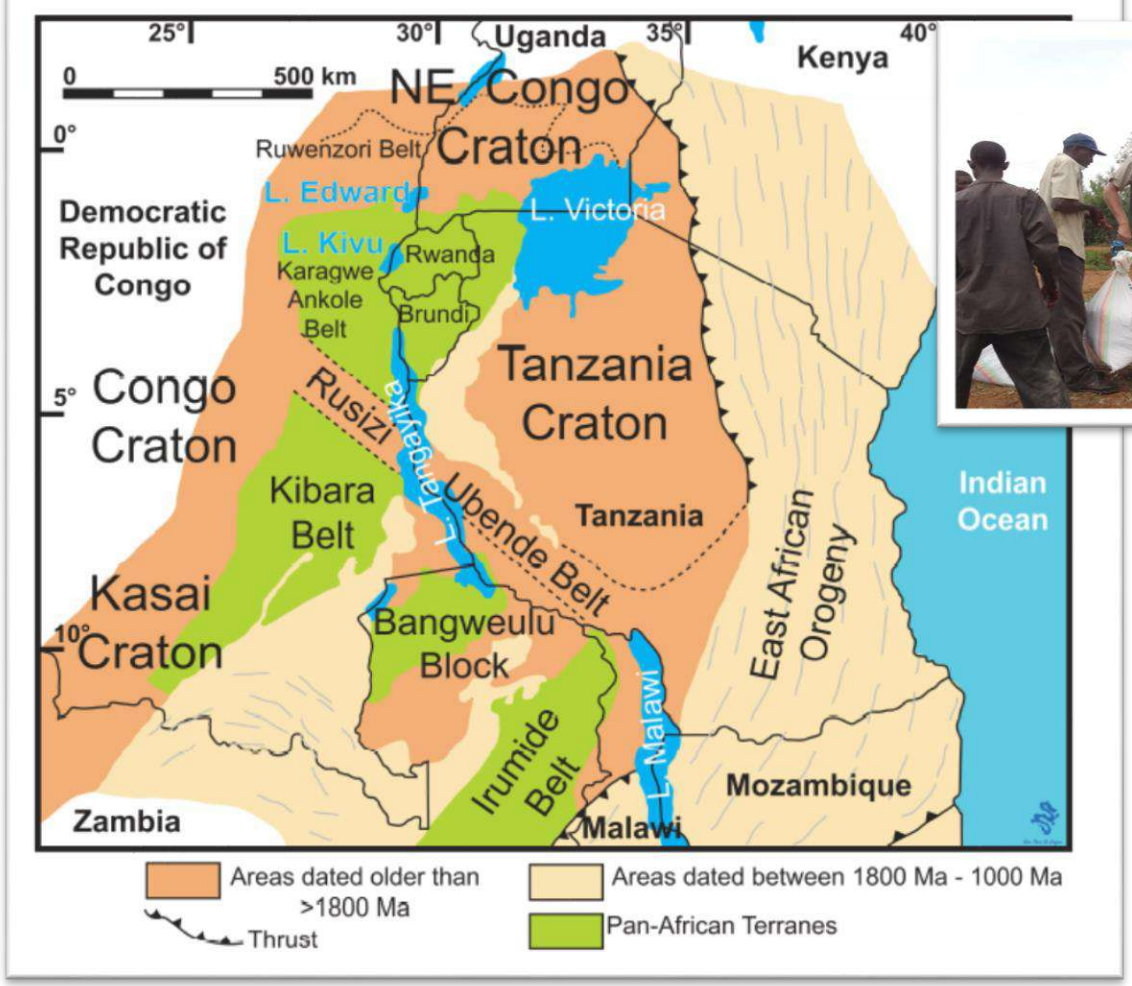
- Better for batteries
- Highly prized gemstone

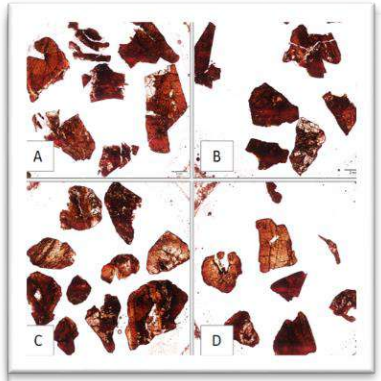
hiddenite

kunzite

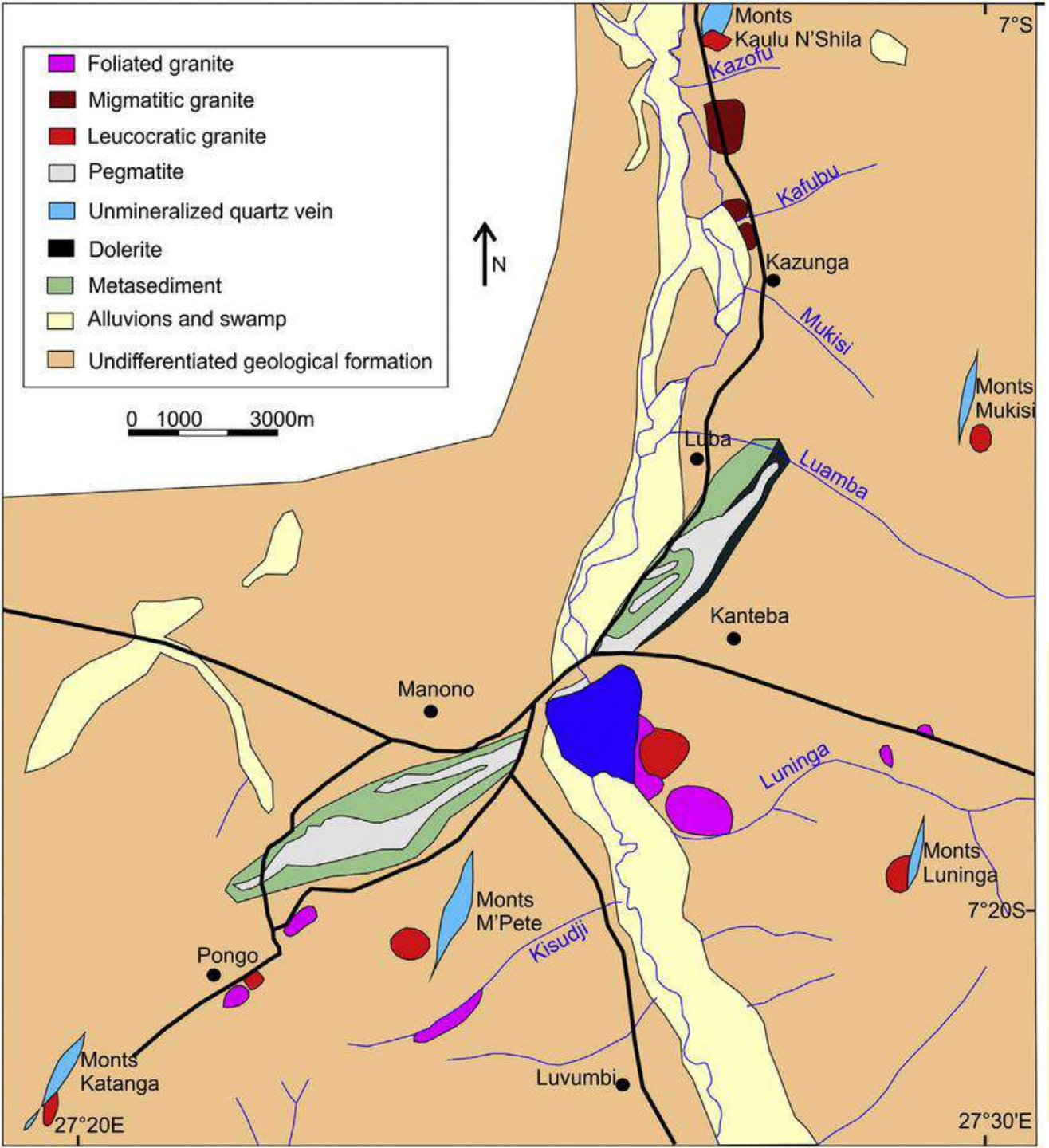
Kibaran ~1000Ma (Grenvillian) Rodinia

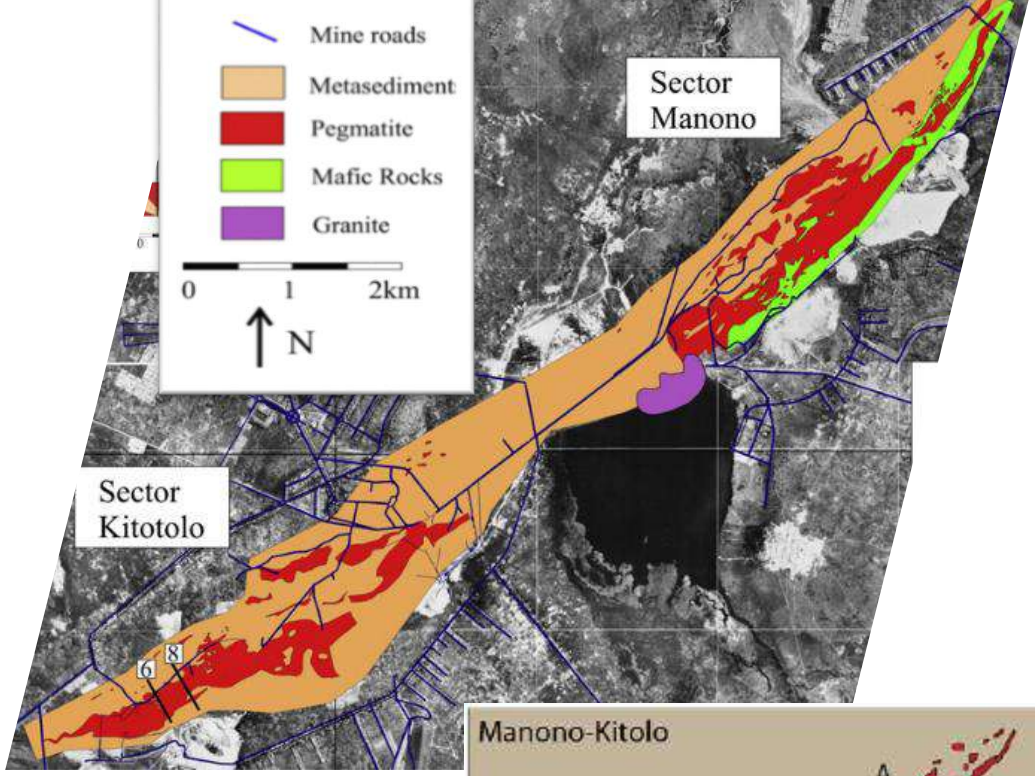




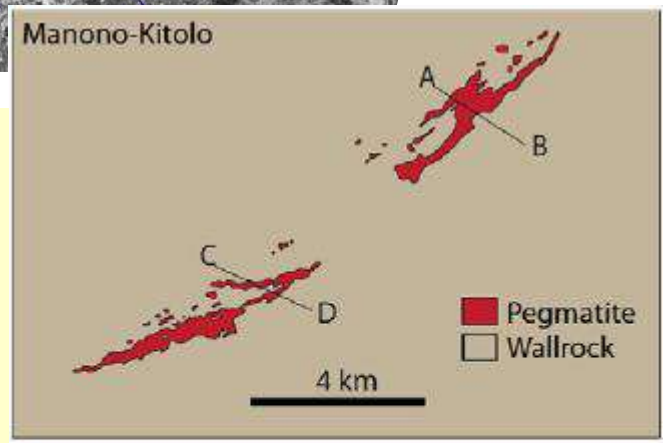


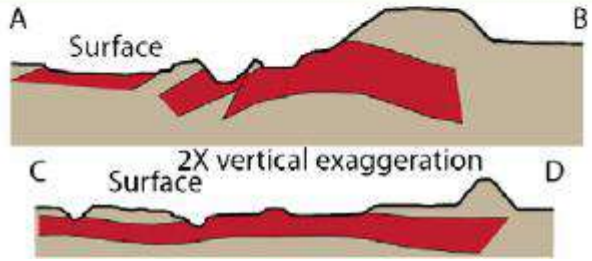
- Post-compressional G4 Kibaran “tin granites” intruded at 986 ± 10 Ma (U-Pb SHRIMP zircon; Tack et al., 2010; Dewaele *et al.,* 2010; Melcher et al., 2015).
- Tin granites are sub-alkaline, strongly peraluminous equigranular biotite-muscovite granites (Pohl and Gunther 1990).
- The Karagwe-Ankole belt hosts zoned clusters of barren and rare-metal pegmatites and Sn–W mineralised quartz veins



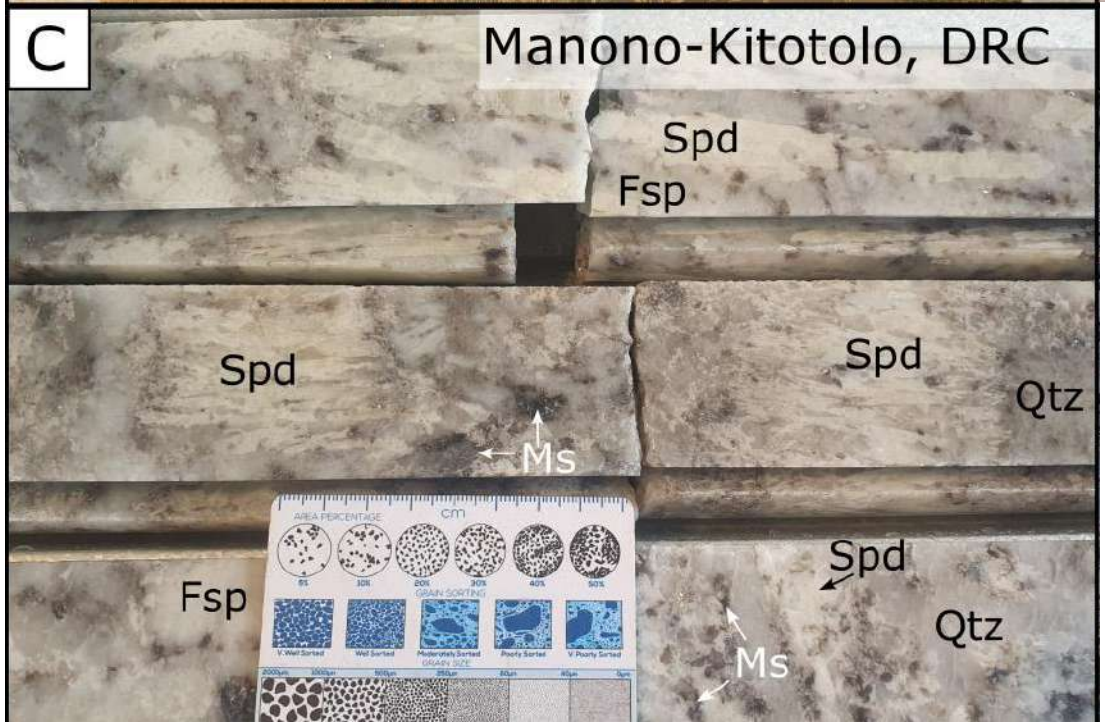


- Multiple Sn, Nb-Ta, Li pegmatites, 945-930Ma
- 15 km in length, 800 m wide
- 6th March ASX press release, AVZ Minerals intersected 282.95 m of spodumene-bearing pegmatite.
- Exploration is ongoing





Photos: Anouk Borst in Goodenough et al in press

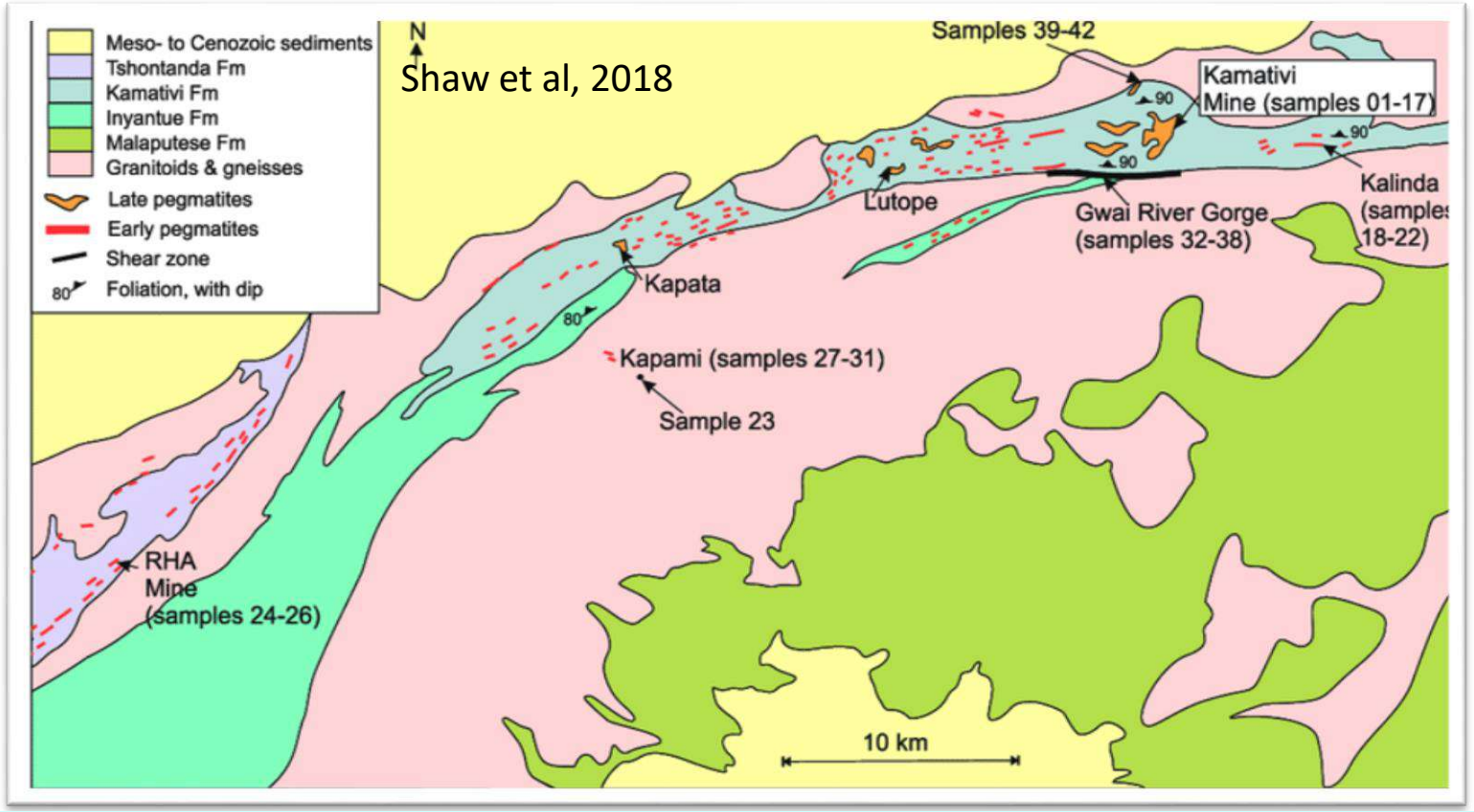


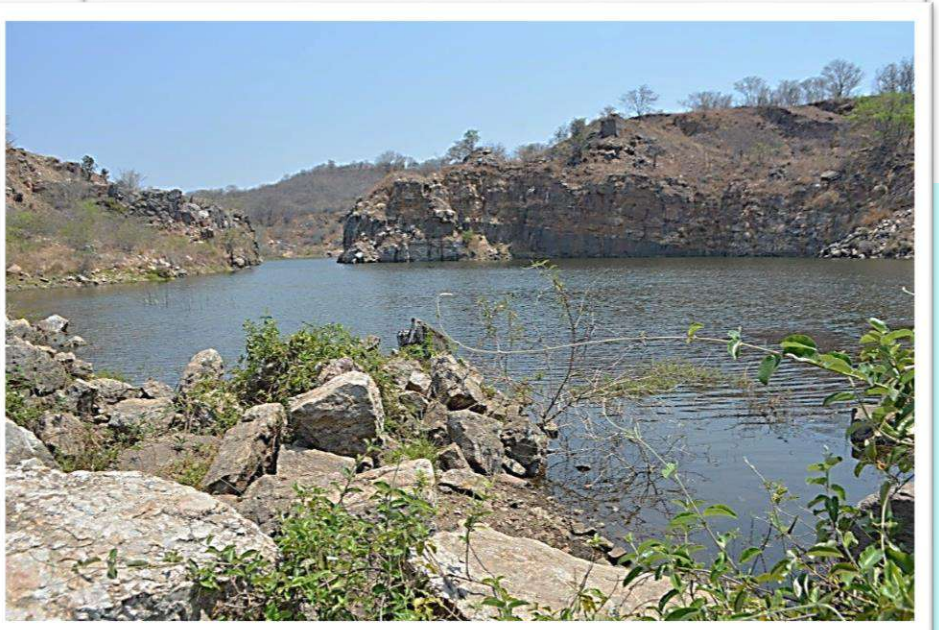
- Tin mined 1915 - 1980s.
- spodumene abundant, typically as tabular crystals with a UST perpendicular to pegmatite contacts
- individual crystals <40 cm in size.
- Tailings dumps now mined by artisanals;
- lithium exploration.
- Southern quarry in Kitotolo drained for diamond drilling and resource estimation.
- pegmatite outcrops in the quarry walls show metre-scale layering, dipping towards the southeast.

Kamativi

- pegmatites dated at c. 1030 Ma

Melcher et al., 2015; Glynn et al., 2017

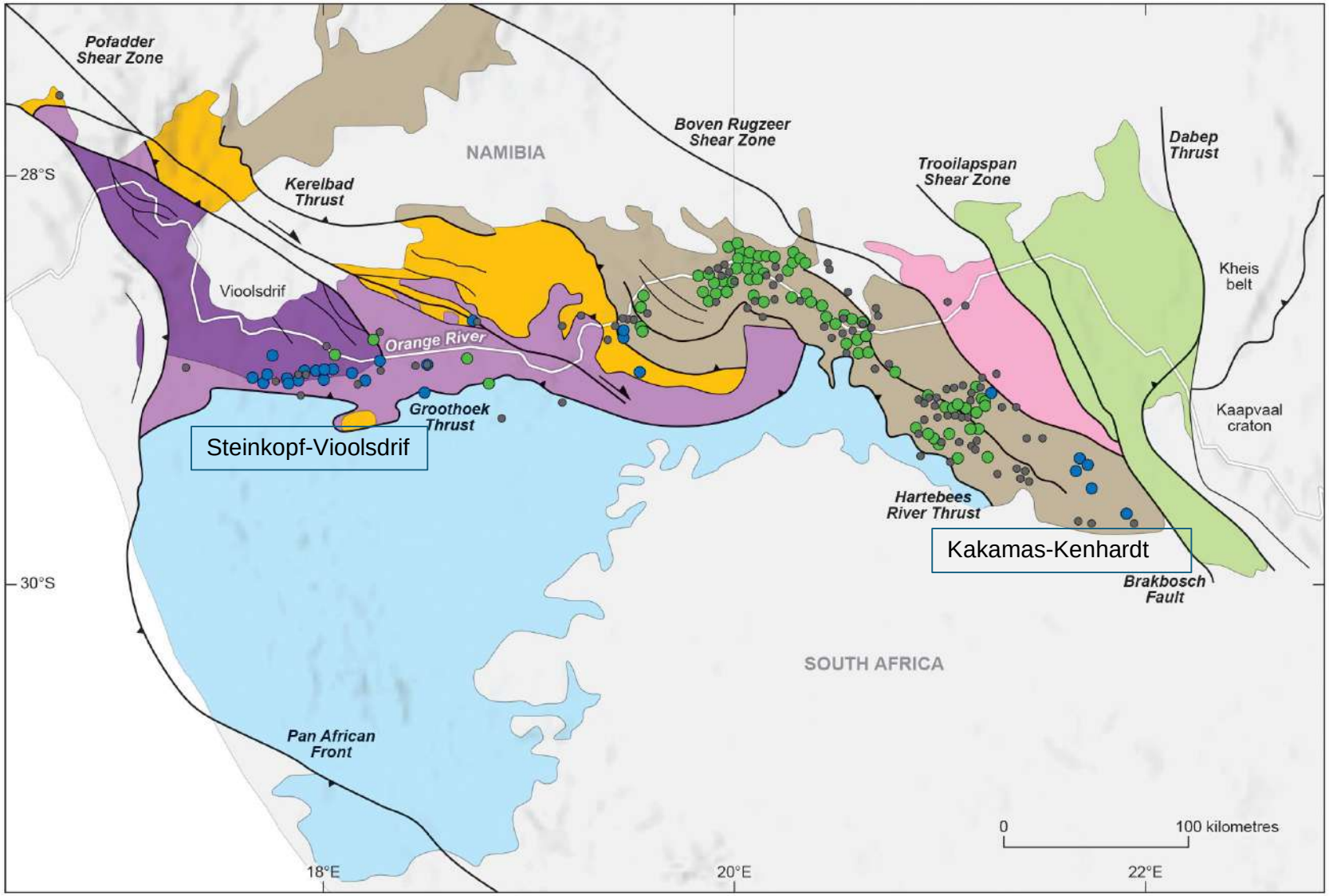




- Mined for cassiterite 1936 -1994 producing about 37,000 t tin and 3,000 t of tantalite (Cronwright & Derbyshire, 2018), Li never extracted
- reappraisal of old Sn/Ta mines has shown potential for Li prospects
- indicated resource of lithium in tailings of 26 Mt grading 0.58% Li_2O
- 2 groups: (1) barren tourmaline (2) thick flat-lying cassiterite-bearing
- Suggested reserves of 120 Mt of spodumene-bearing ore, makes it one of the largest lithium reserves globally

Photos: Paul Nex

- The Kamativi pegmatite is c. 40 m sheeted intrusion.
- Lacks a classic internal zonation, although has c. 50 cm thick barren border zone lacking lithium minerals.
- Dominated by microcline and quartz with spodumene and minor montebrasite ($(Li, Na)AlPO_4(OH, F)$)



Nex 2005 Ballouard et al, 2020

Noumas 11, (photo Cape Minerals)

Noumas 1 Relic texture of spodumene,

Hugo, 1970

(photos Francois Burger)

(photos) Duncan Miller

Straussheim (photos Duncan Miller)

Quartz, mica, microcline and albite