Tectonic evolution of the south-eastern Mesoarchaean Mwanesi Greenstone Belt: implications for the construction of the Zimbabwe Craton

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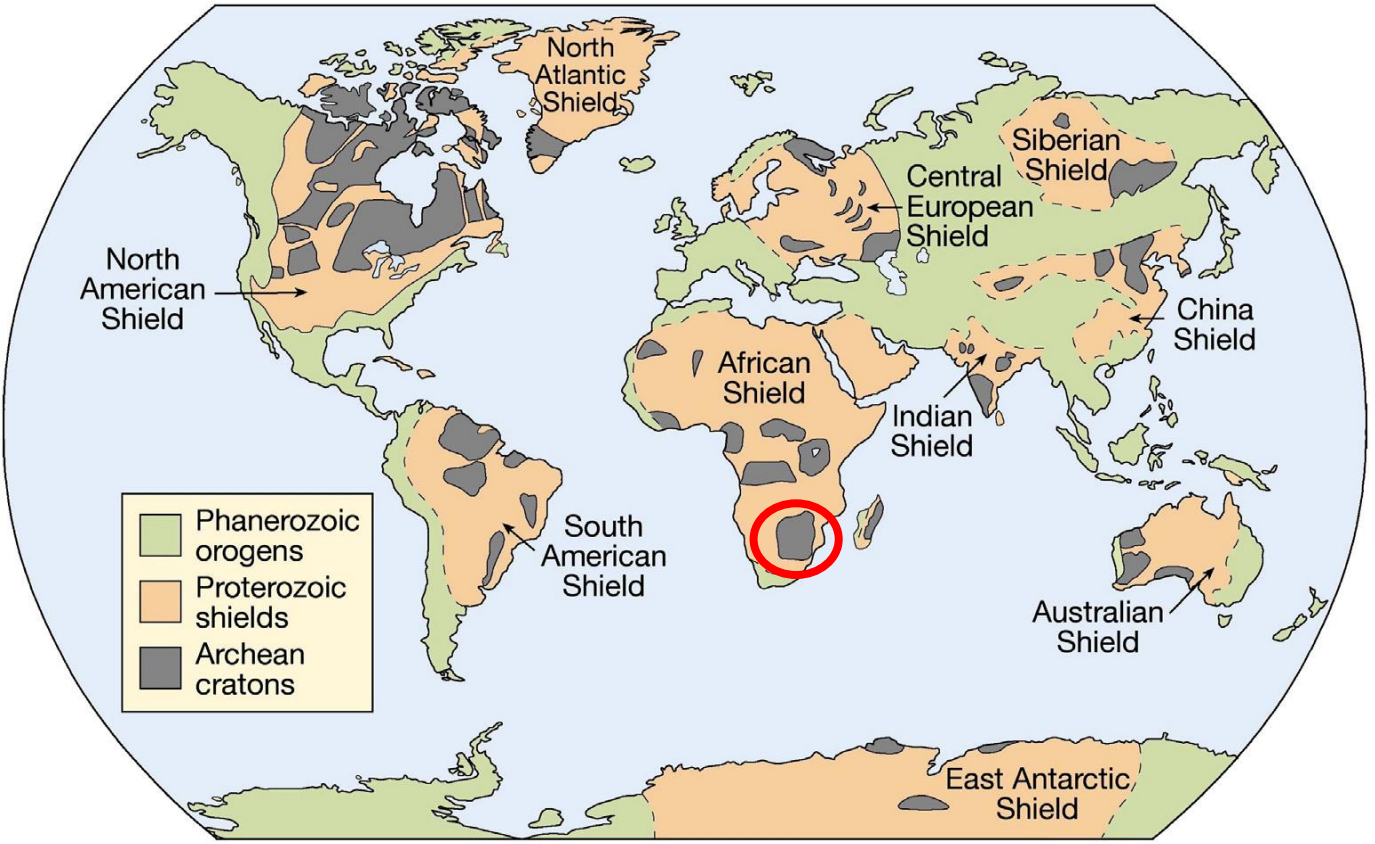
Archaean terrains



Furnes *et al*. (2013)

- Archaean terrains (cratons) comprise greenstone belts and granites
- Age – 3600-2500 Ma
- Tectonic evolution still debatable (Cawood et al. 2018; Gapais, 2018; Brown et al. 2020)

Focus of the study

1. Age of the Mwanesi Greenstone Belt (MGB) and adjacent granite gneisses
2. Deformation record of the MGB and the surrounding granitoids
3. Tectonic model for the evolution of the MGB

Why the MGB?

- Located in the central Zim Craton, offering the best play ground to investigate the Archaean tectonics of the craton

UNIVERSITY OF JOHANNESBURG

Structural and geochronological constraints on the evolution of the south-eastern Mwanesi Greenstone Belt: implications for gold mineralisation

By

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DISSERTATION

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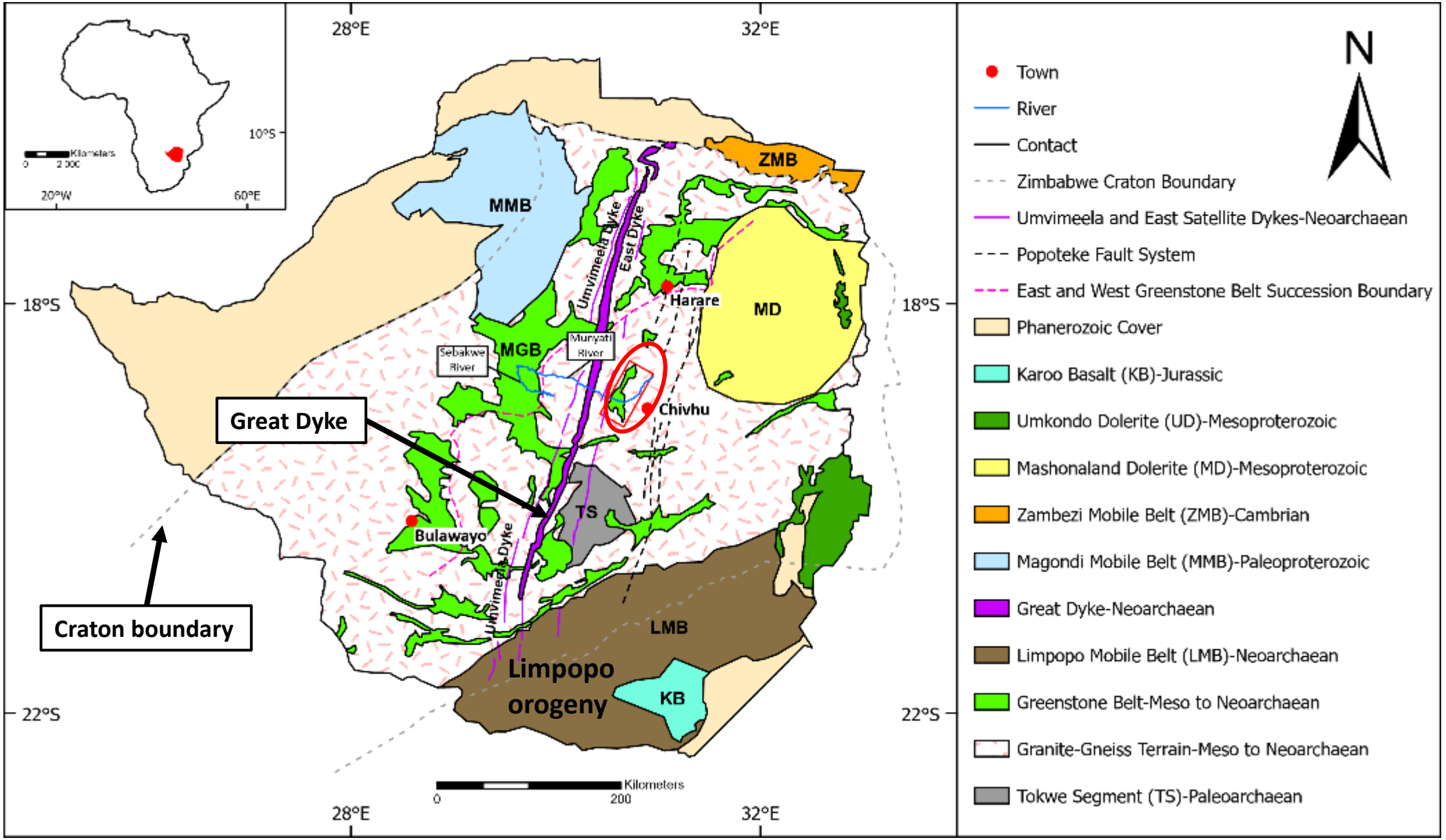
Supervisor: Prof Jeremie Lehmann

Co-supervisor: Prof Fanus Viljoen

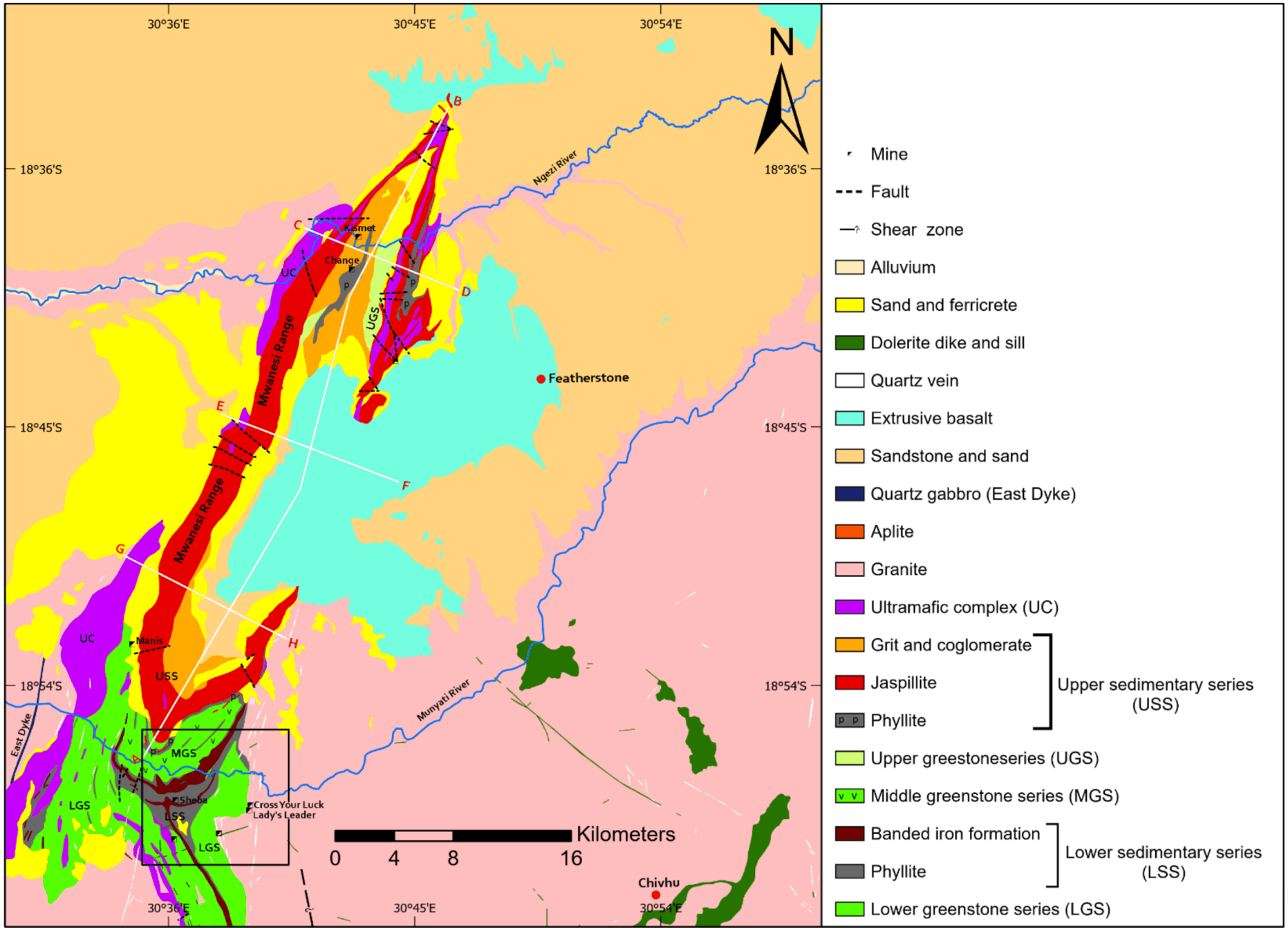
April 2022

Geology of the Zimbabwe Craton



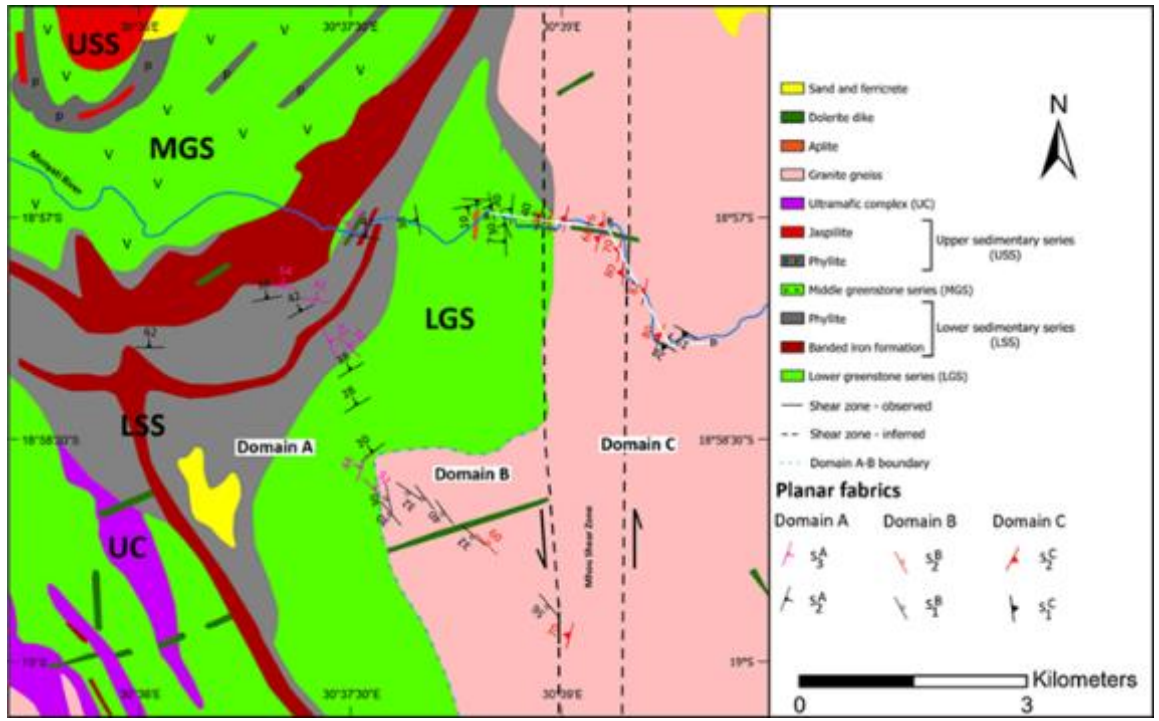
Modified after Markwitz et al. (2010), Western and eastern succession greenstone belts division is after Wilson (1979).

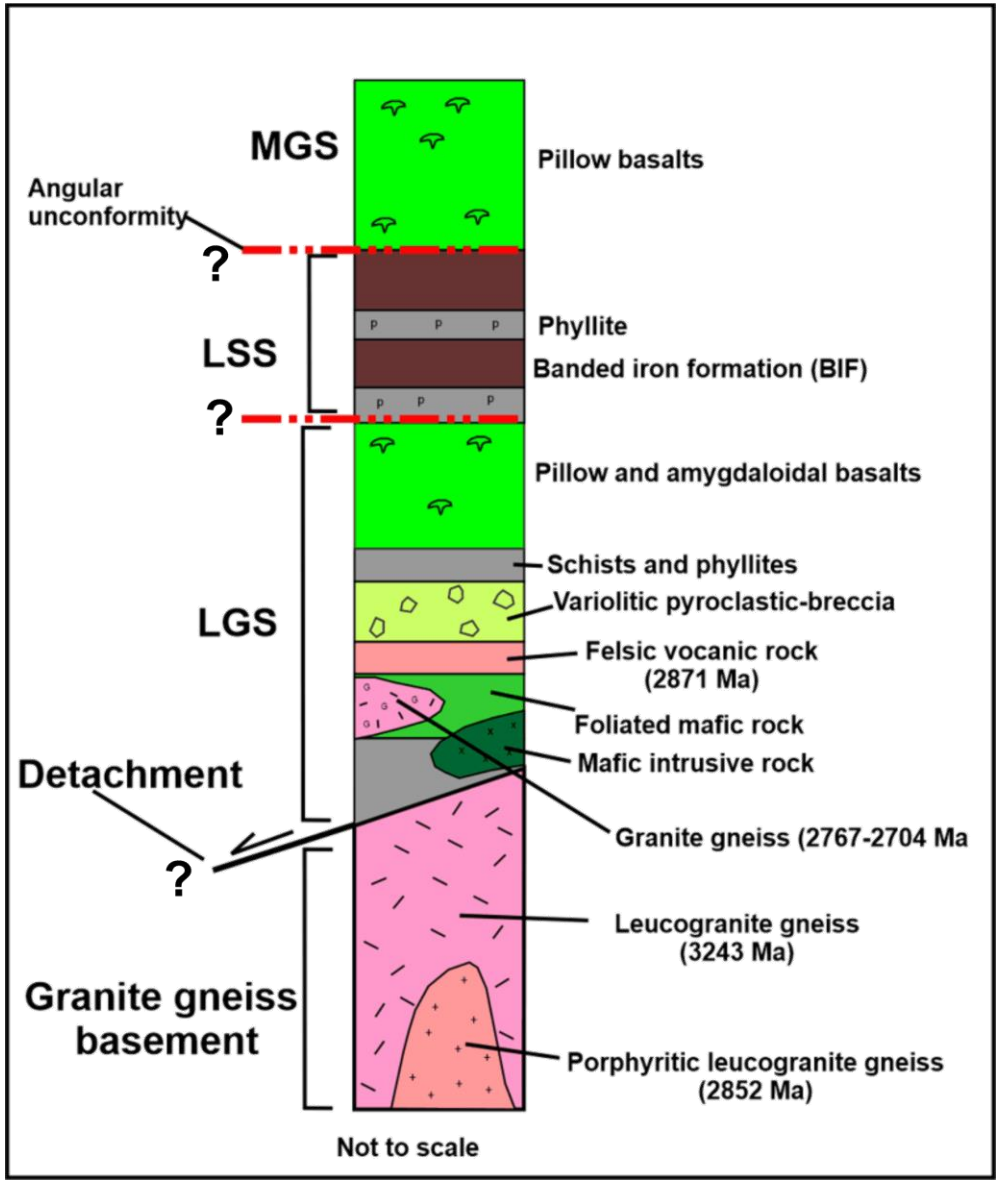
Geology of the Mwanesi Greenstone Belt



Modified after Worst (1962)

Lithostratigraphy



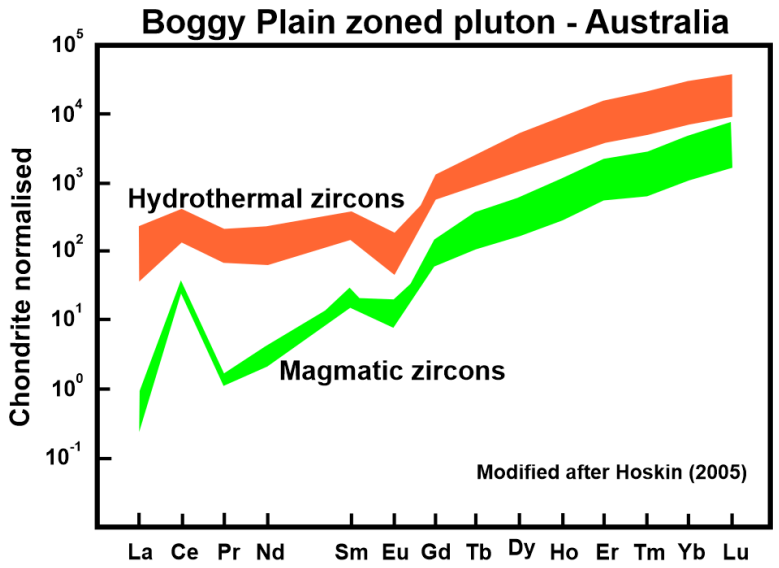


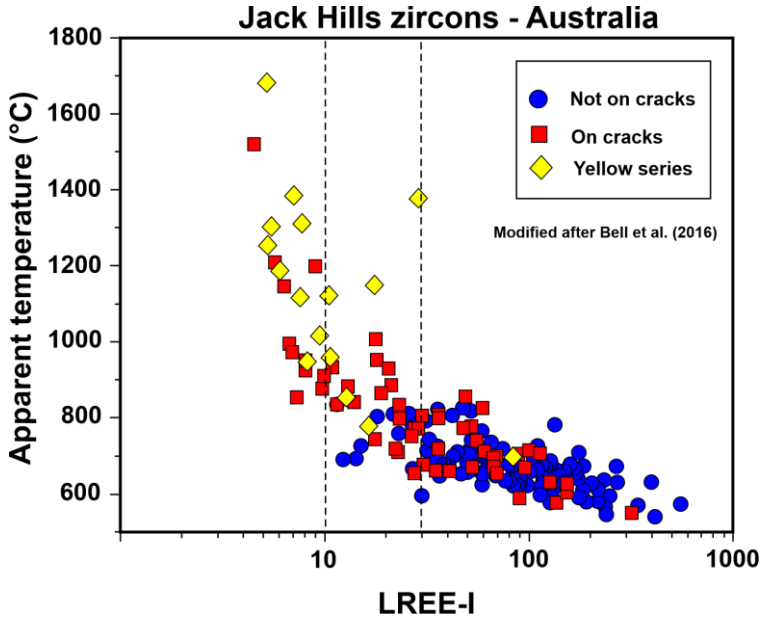
Modified after Worst (1962); Ages from this study

Zircon U-Pb dating

- Four granite gneisses and an intra-formational felsic volcanic rock of the LGS were dated
- Most of the zircons yielded discordant ages
- Zircons have been affected by hydrothermal alteration
- Trace elements were used to identify analyses from magmatic zircons

Zircon alteration





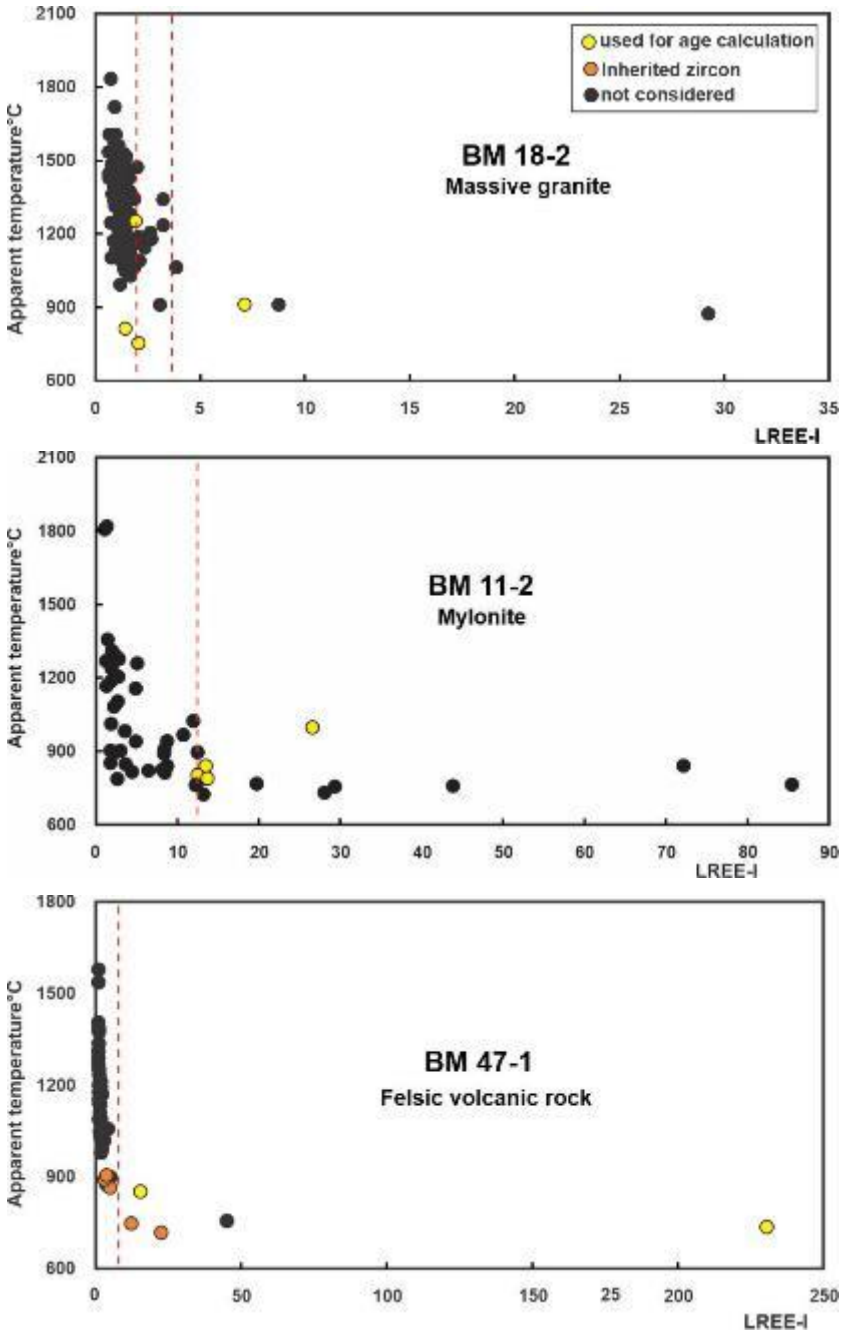
$$LREE\text{-}I = (Dy/Nd) + (Dy/Sm)$$

Bell et al. (2016)

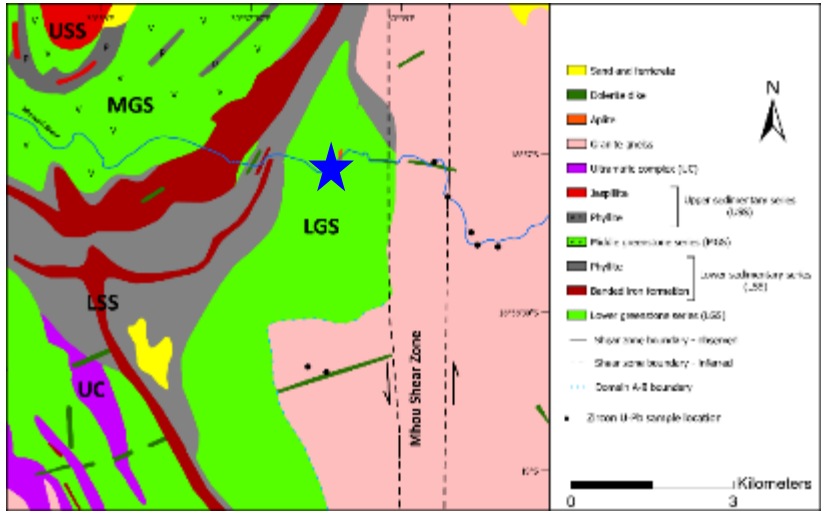
$$T(^{\circ}C)zircon = \frac{5080 \pm 30}{(6.01 \pm 0.03) - \log(Ti)} - 273$$

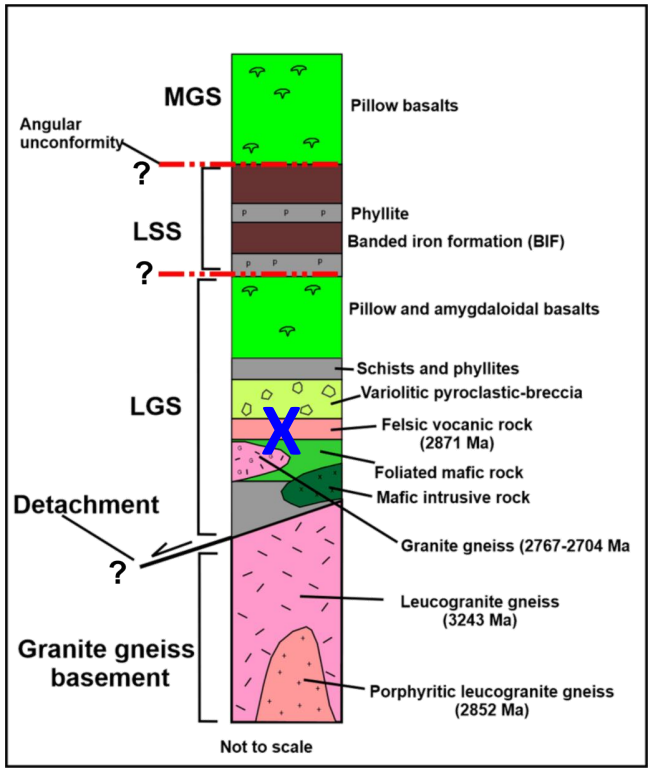
Watson et al. (2006)

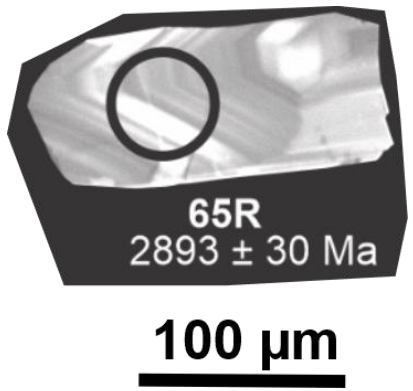
This study



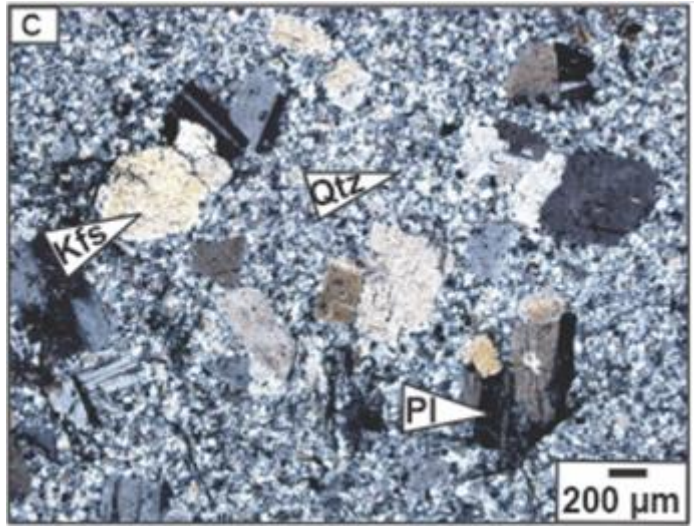
Zircon crystallisation ages

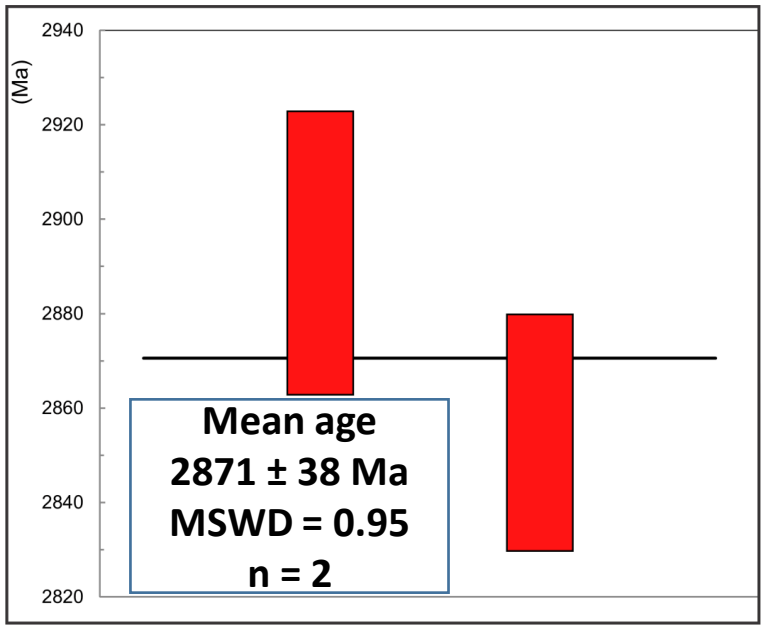






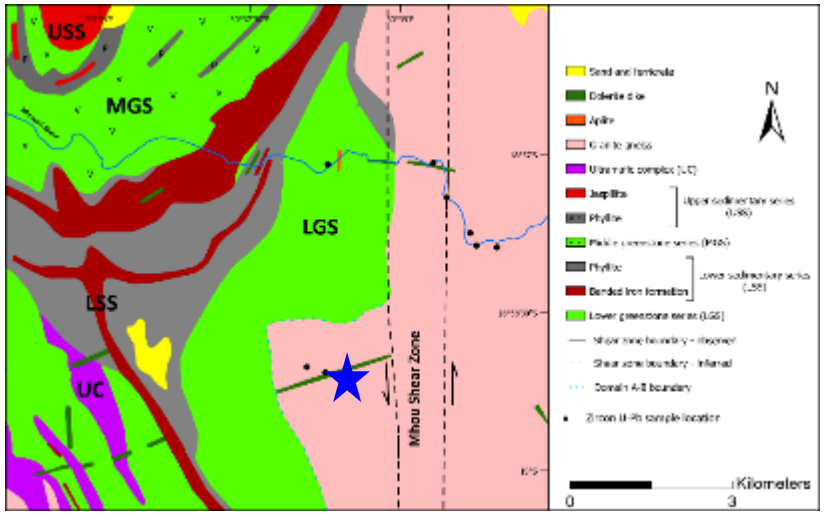
Felsic volcanic rock

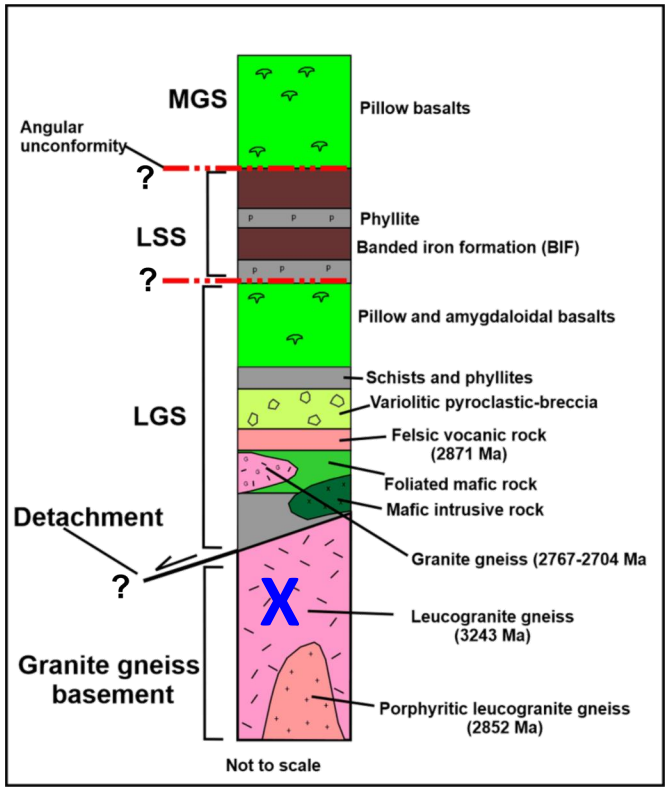




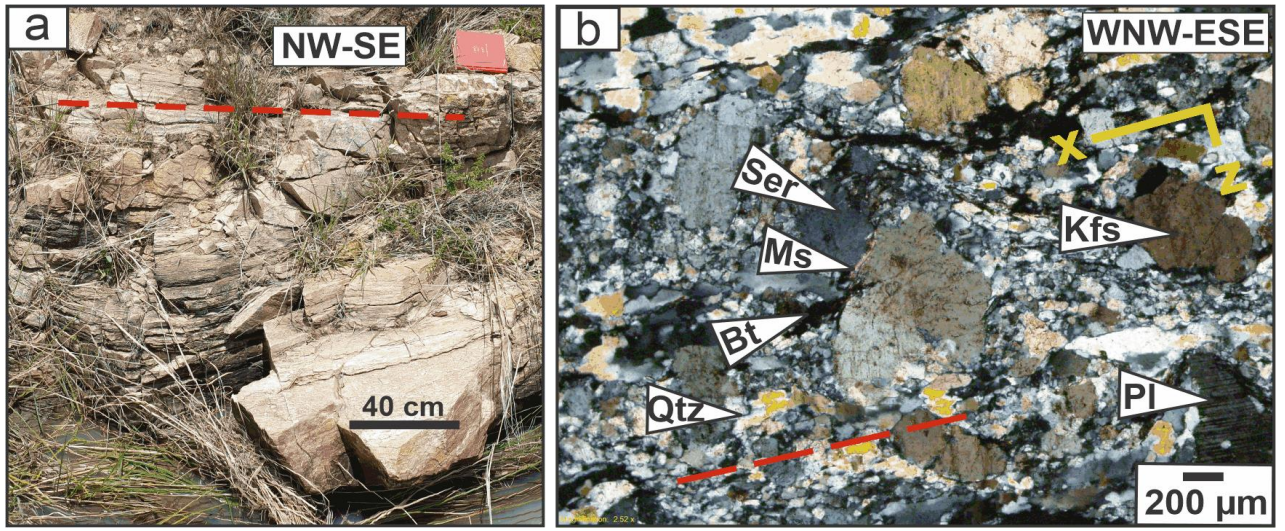
Inherited zircons at 3329-2982 Ma

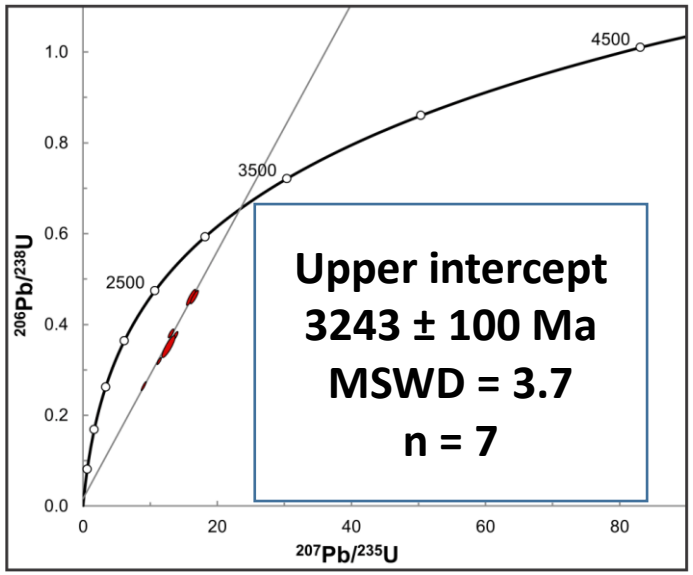
Zircon crystallisation ages





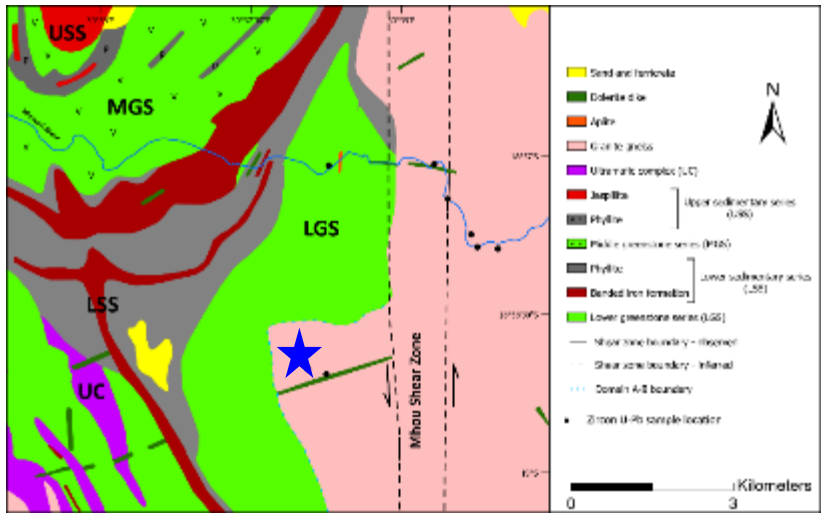
Leucogranite gneiss

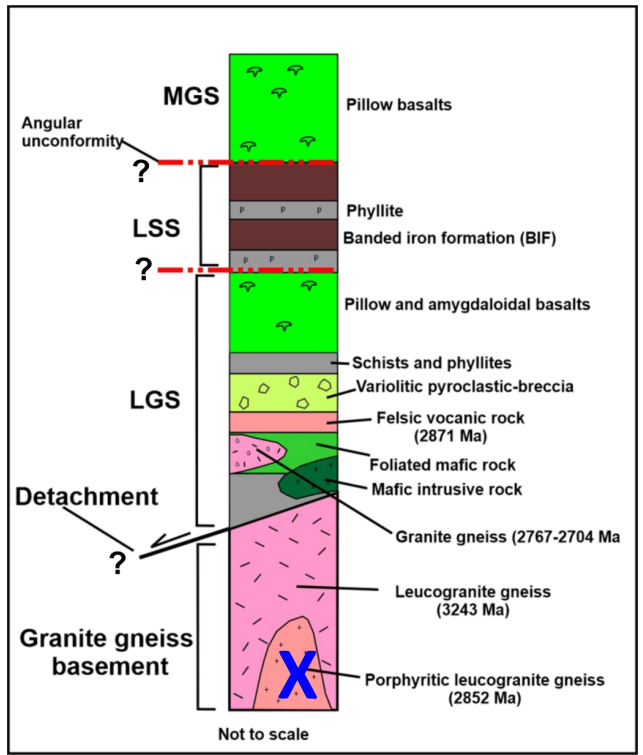




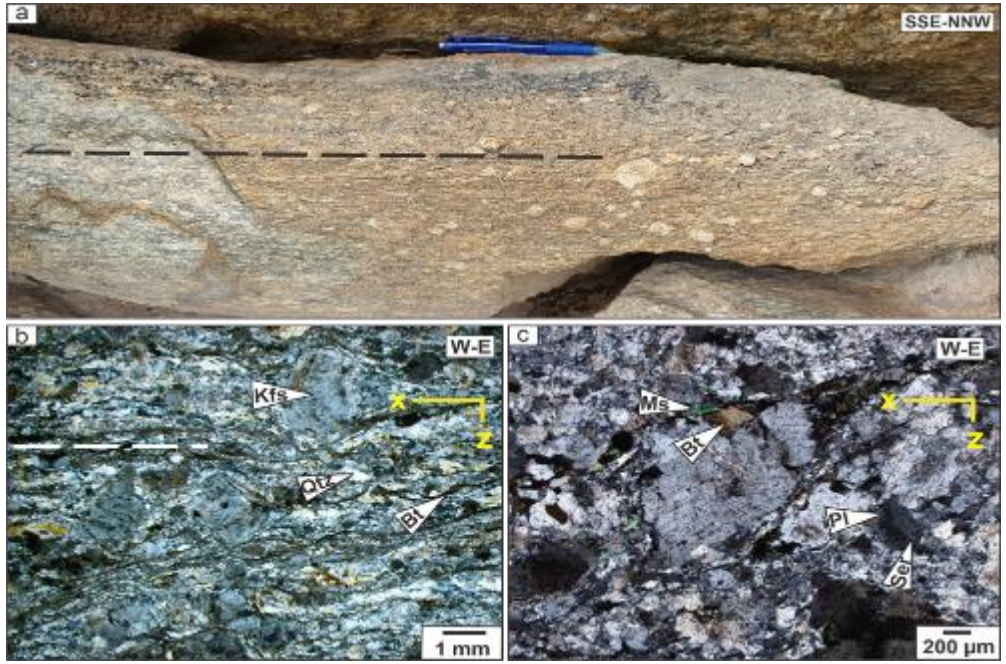
Inherited zircon at 3555 Ma

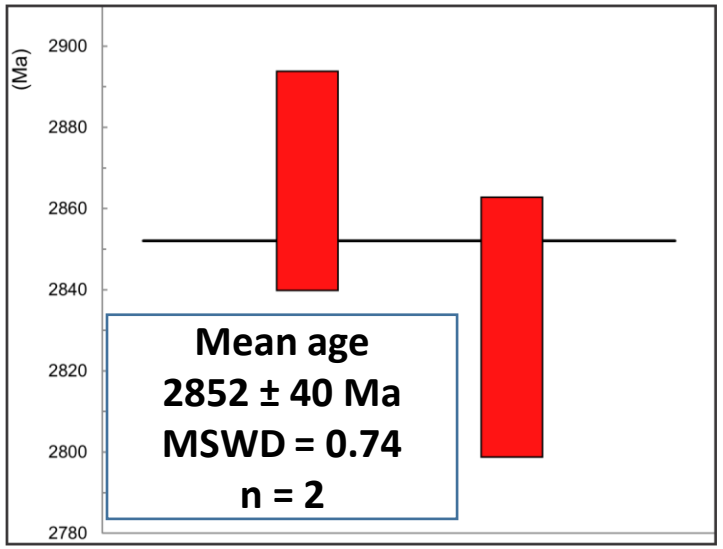
Zircon crystallisation ages





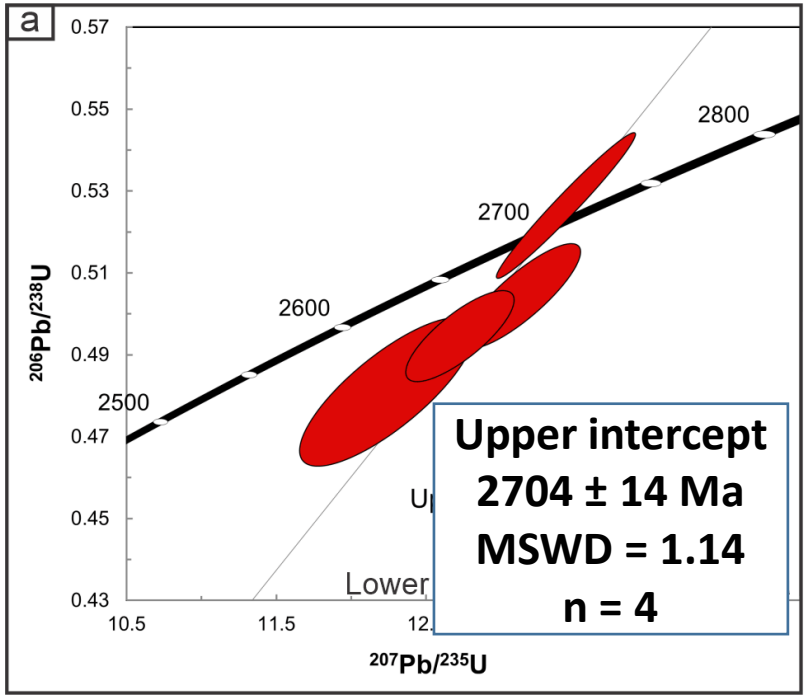
Porphyritic leucogranite gneiss

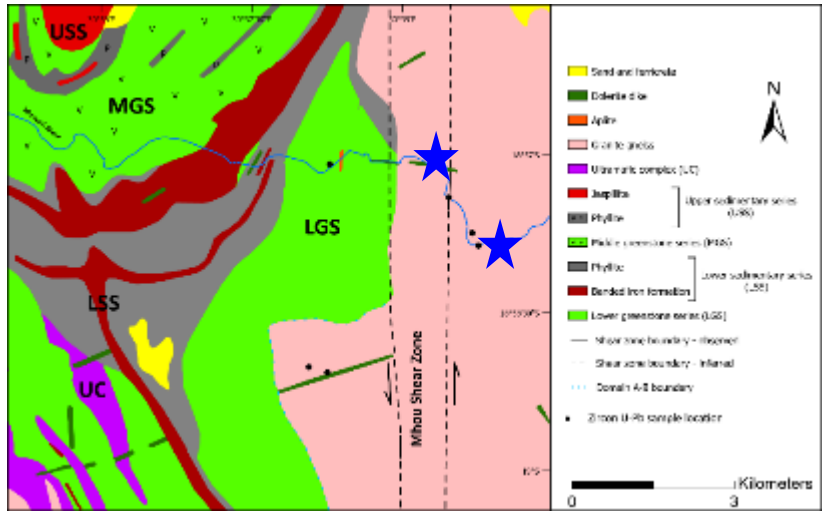




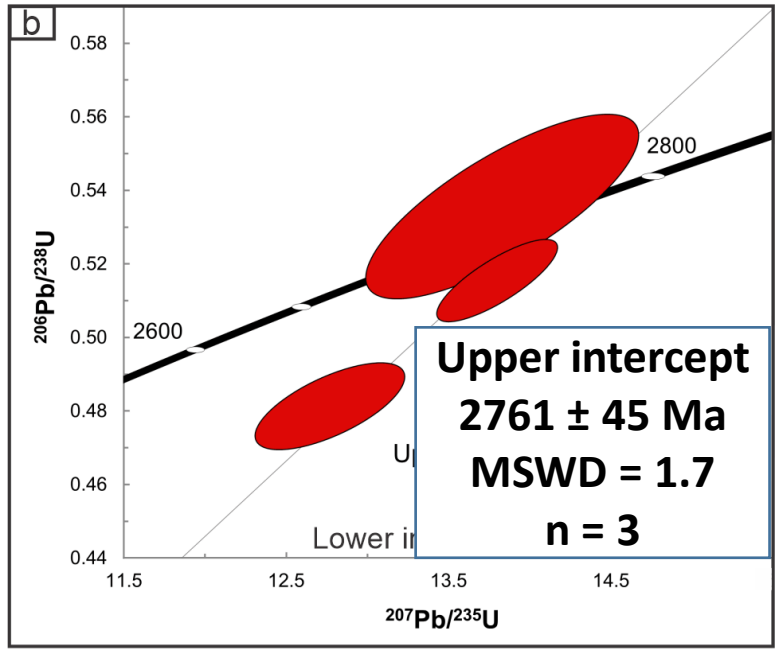
Zircon crystallisation ages

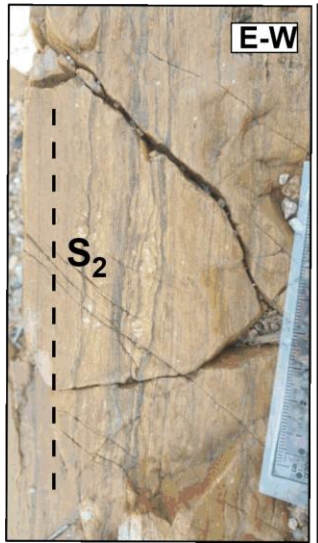
Granite gneiss mylonite

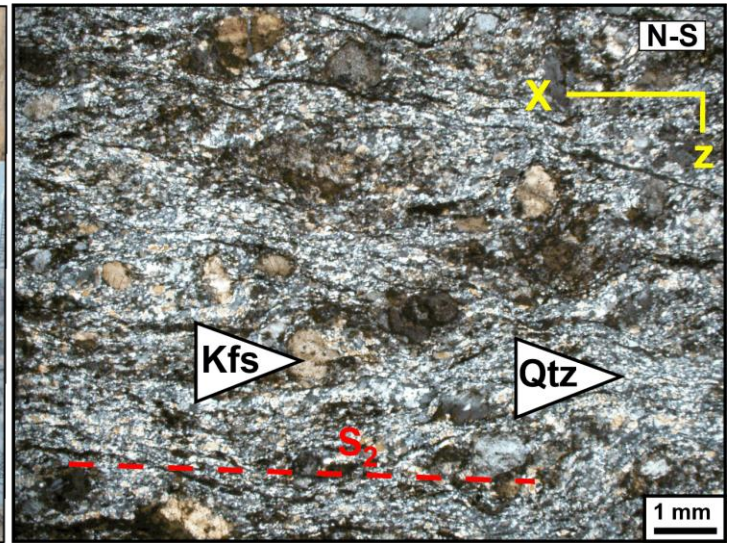


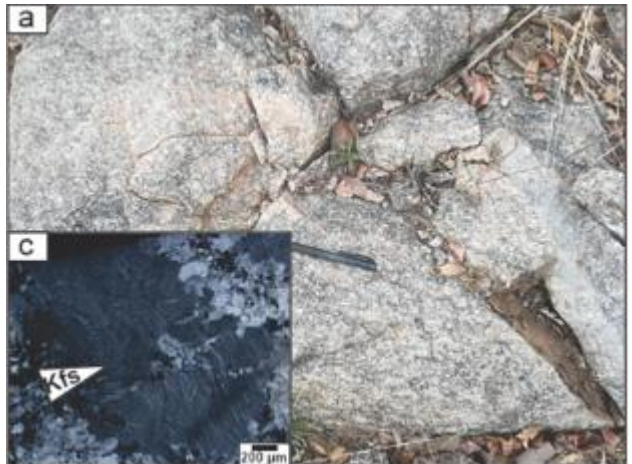


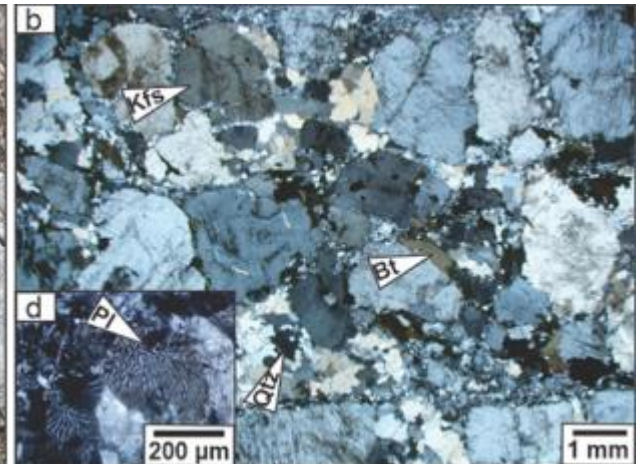
Massive granite



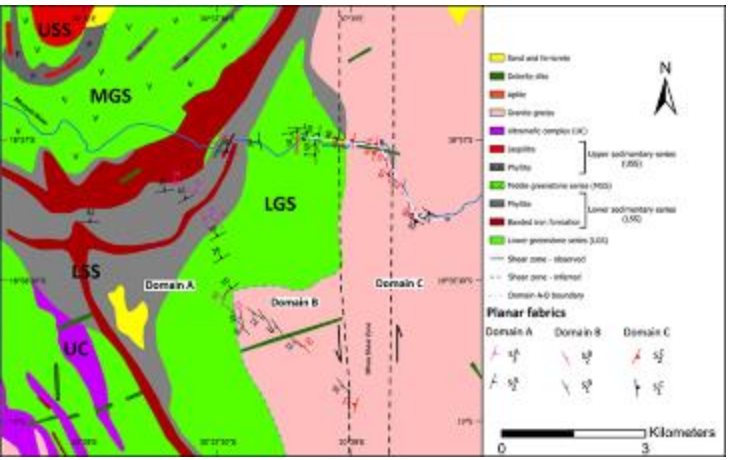


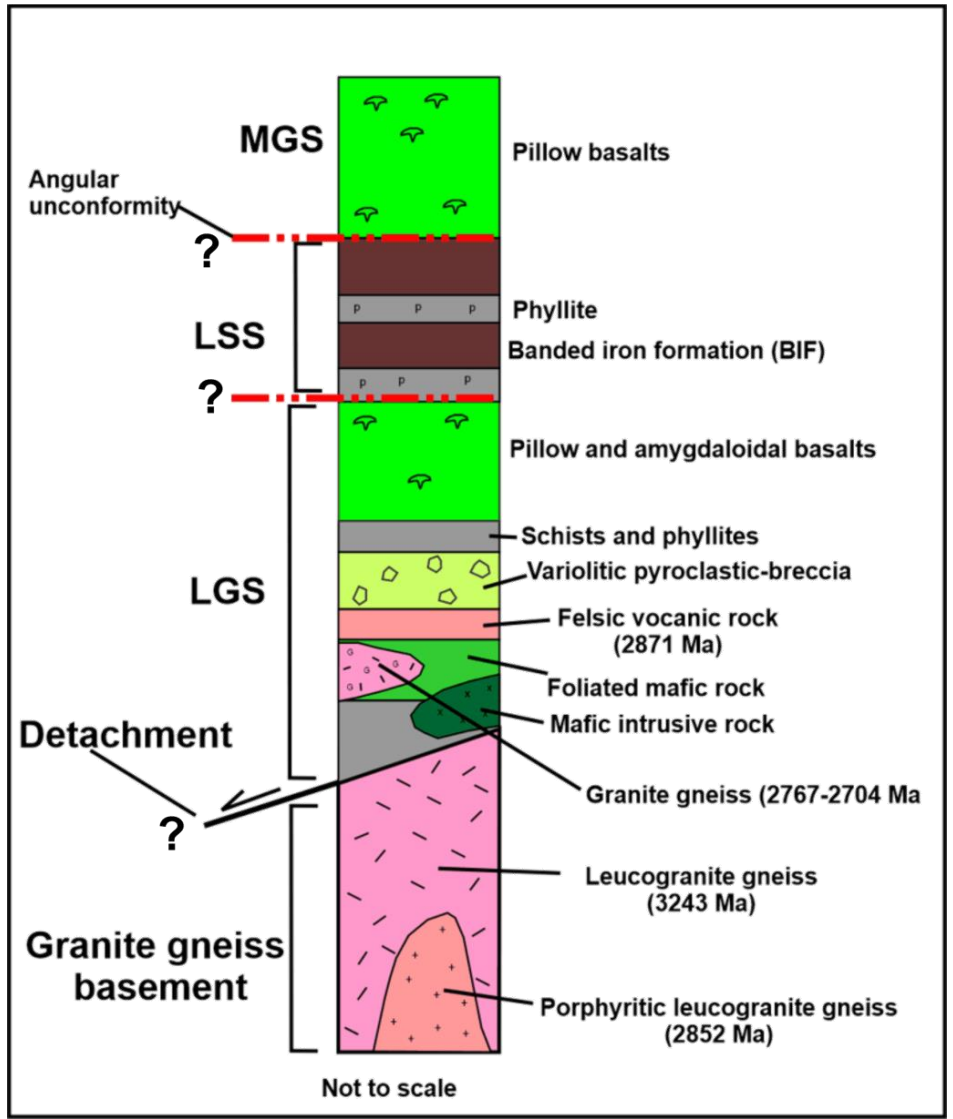


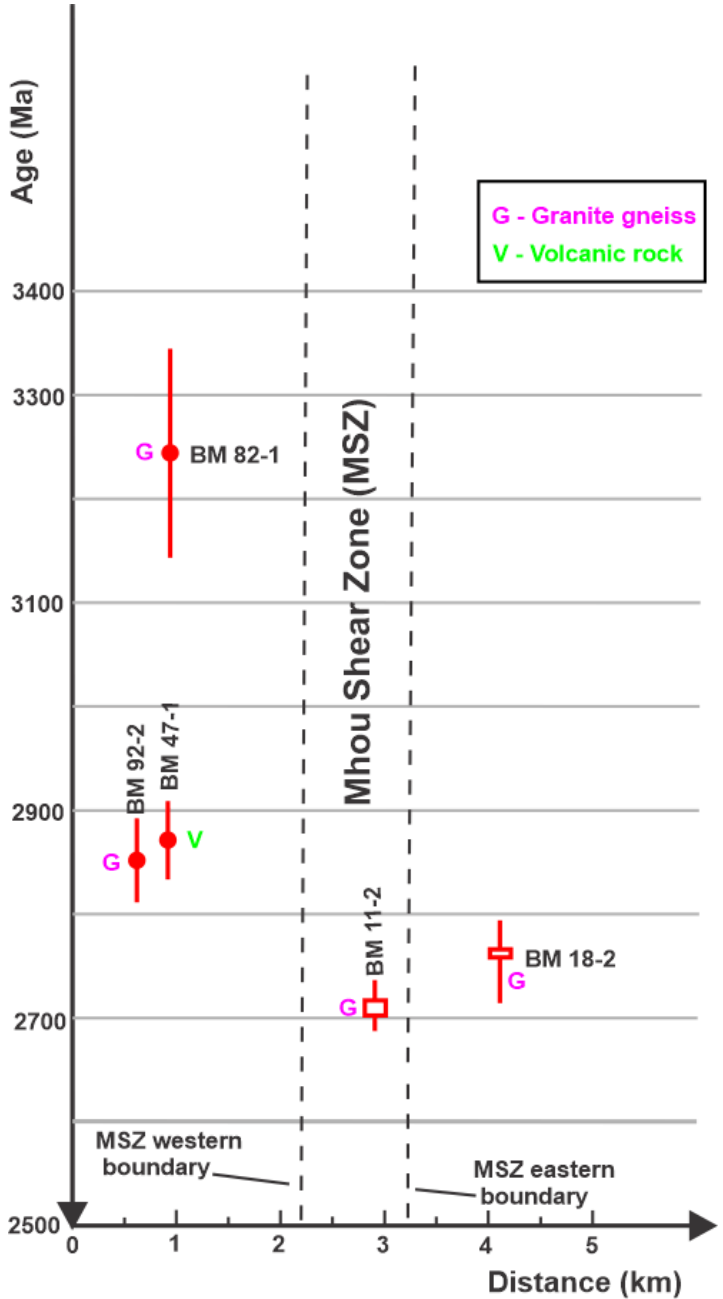




Summary of lithostratigraphy and zircon U-Pb dating

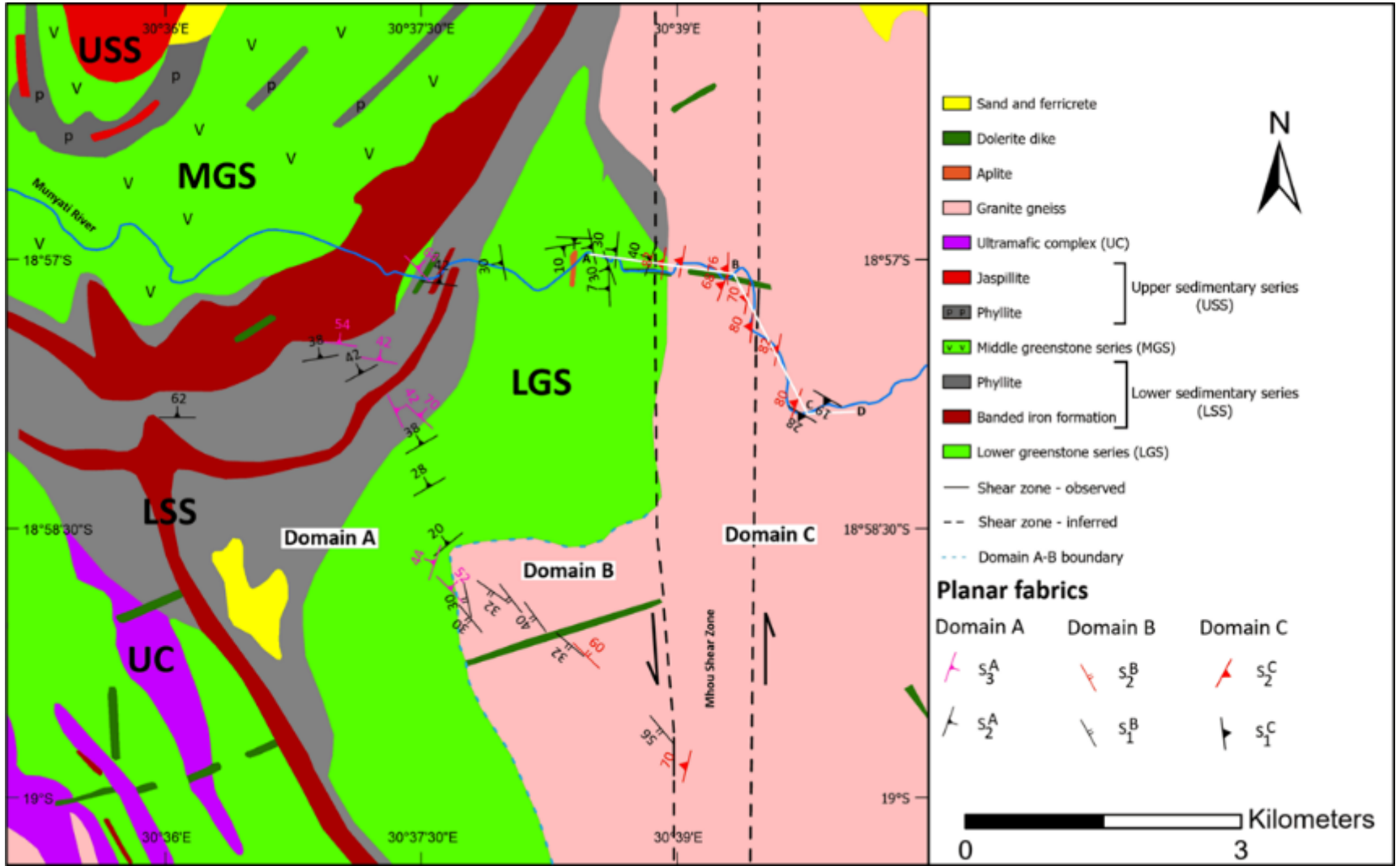






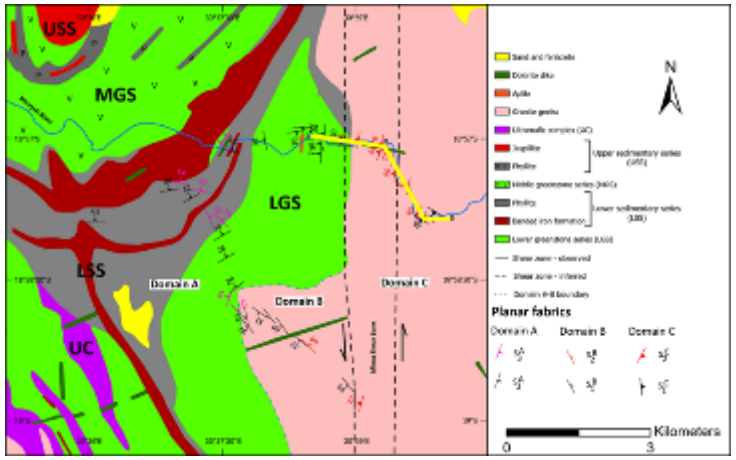
Deformation

- 3 deformation events recorded



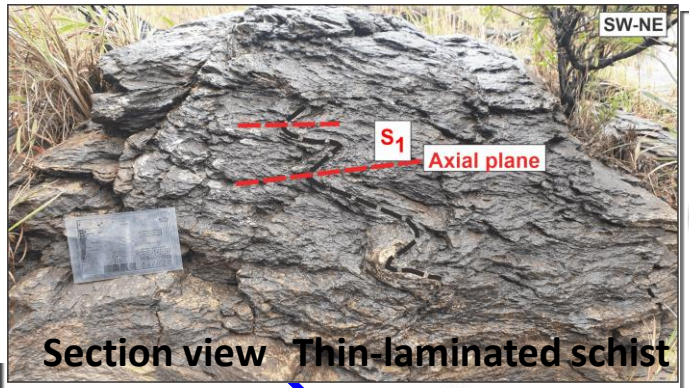
Modified after Worst (1962)

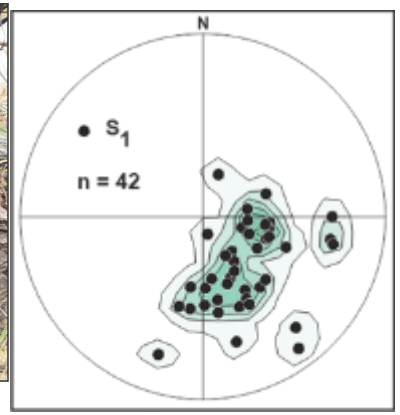
D_1 event

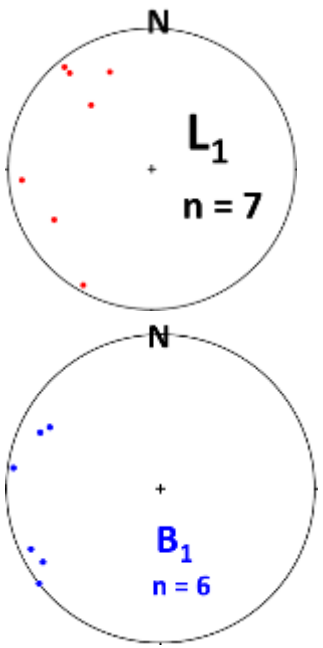


Supracrustal rocks

S_1 is axial planar cleavage to F_1 recumbent folds

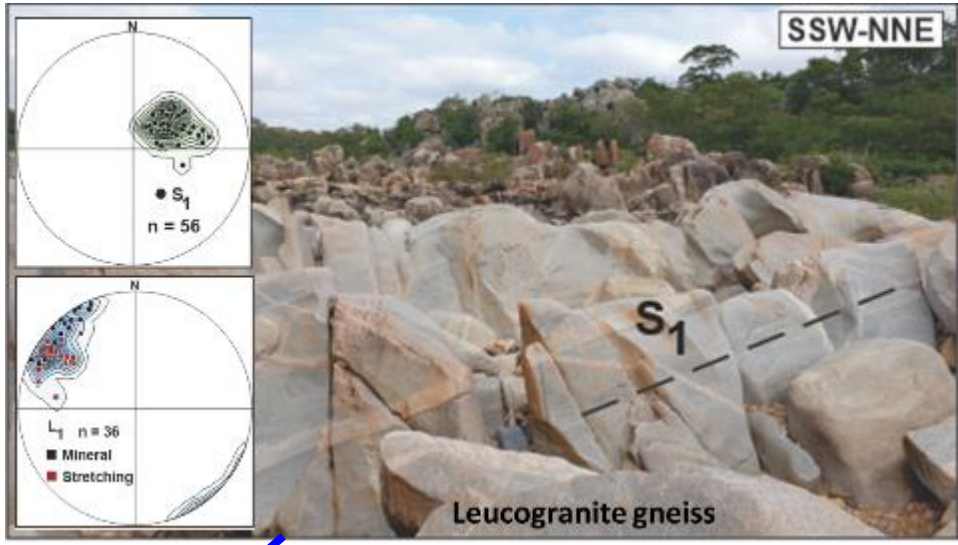


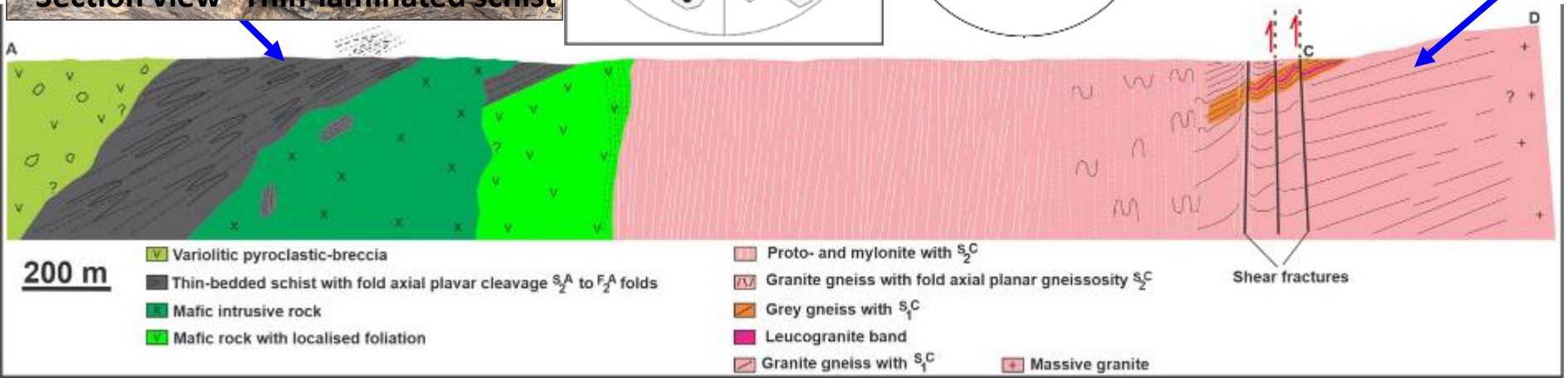




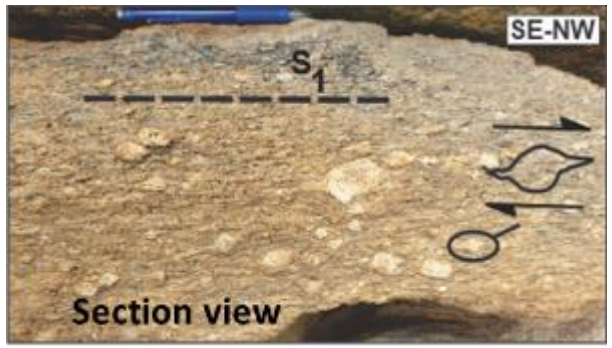
Granite gneisses

S_1 is gneissic foliation

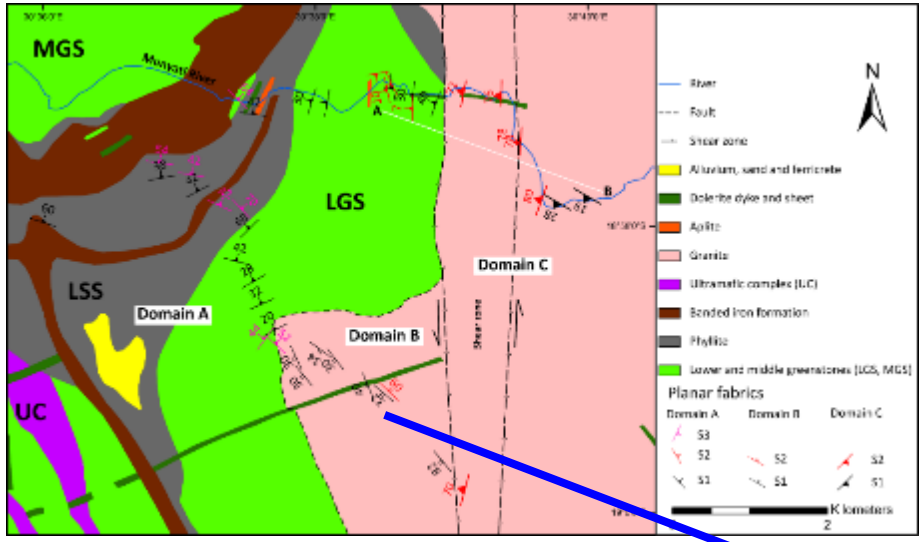


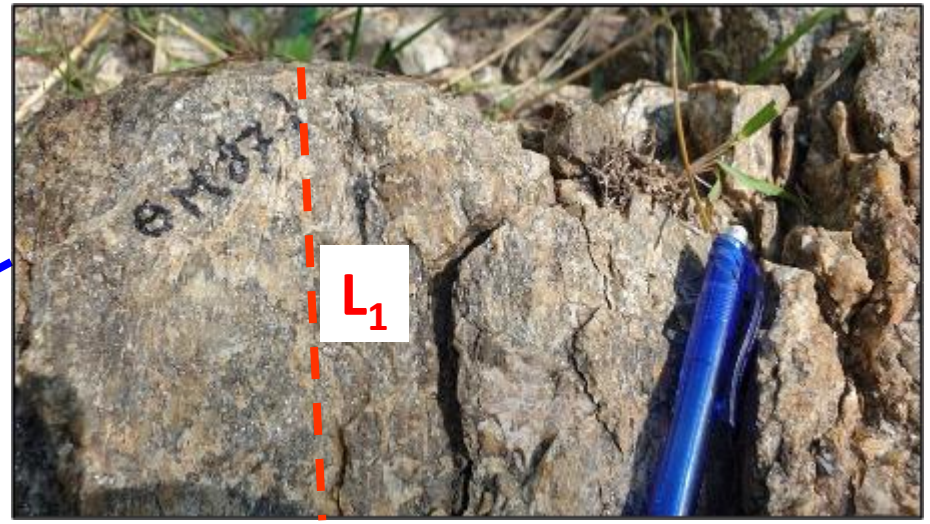


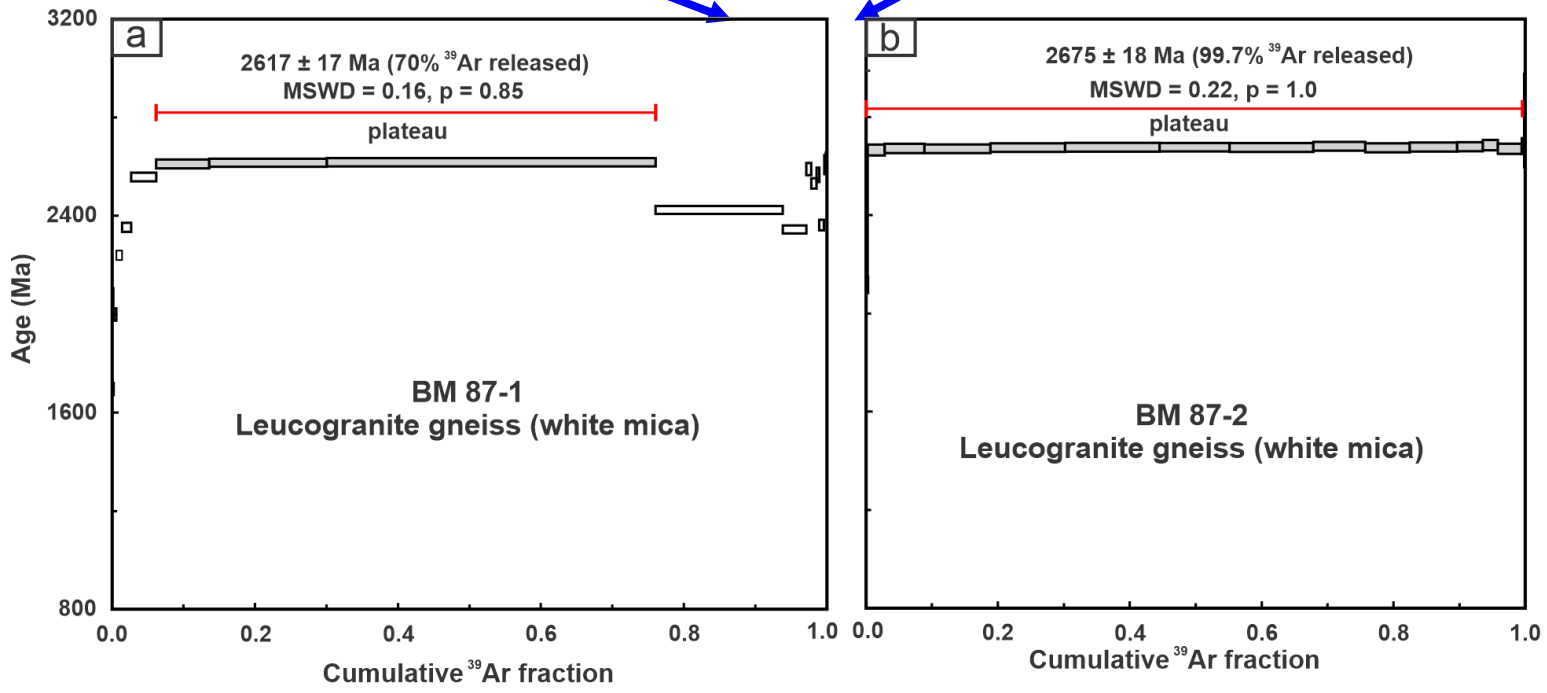
Porphyritic leucogranite gneiss



D_1 deformation age - $^{40}Ar/^{39}Ar$ geochronology

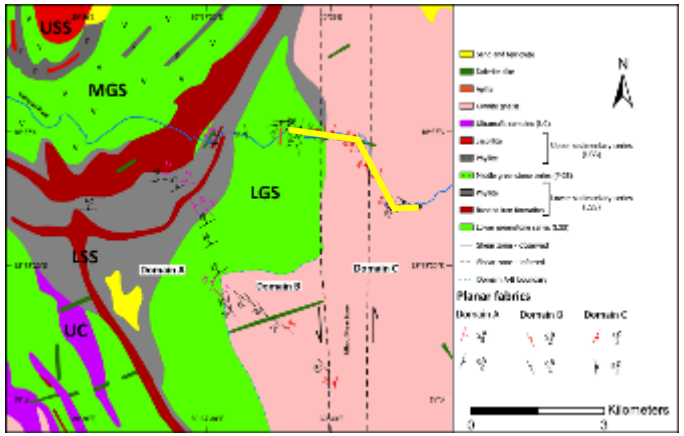


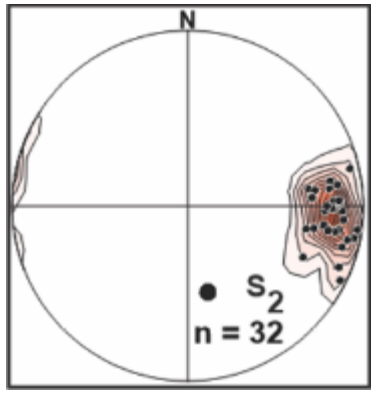


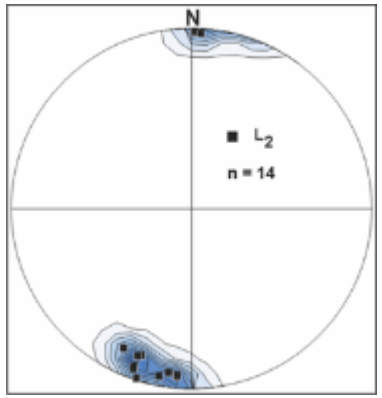


D_1 - 2688-2617 Ma

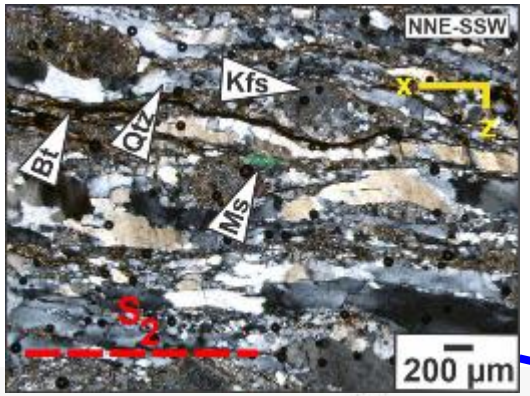
D_2 event

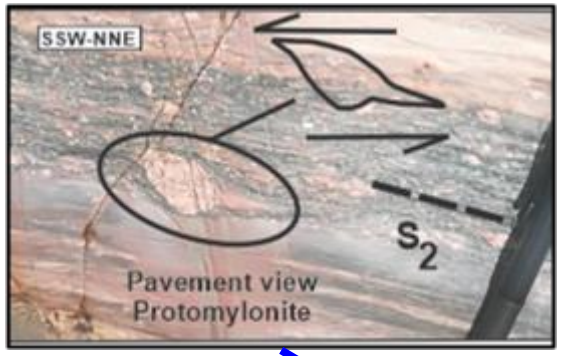


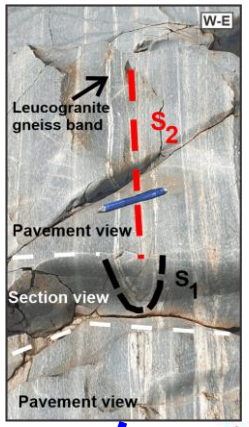




Mylonitic foliation S_2 folds in the MSZ

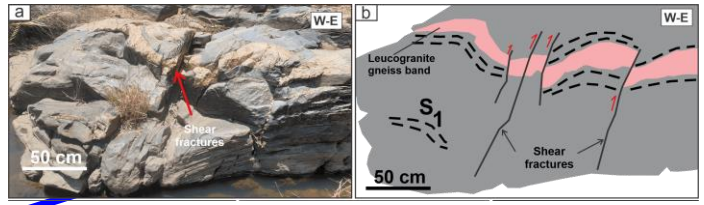


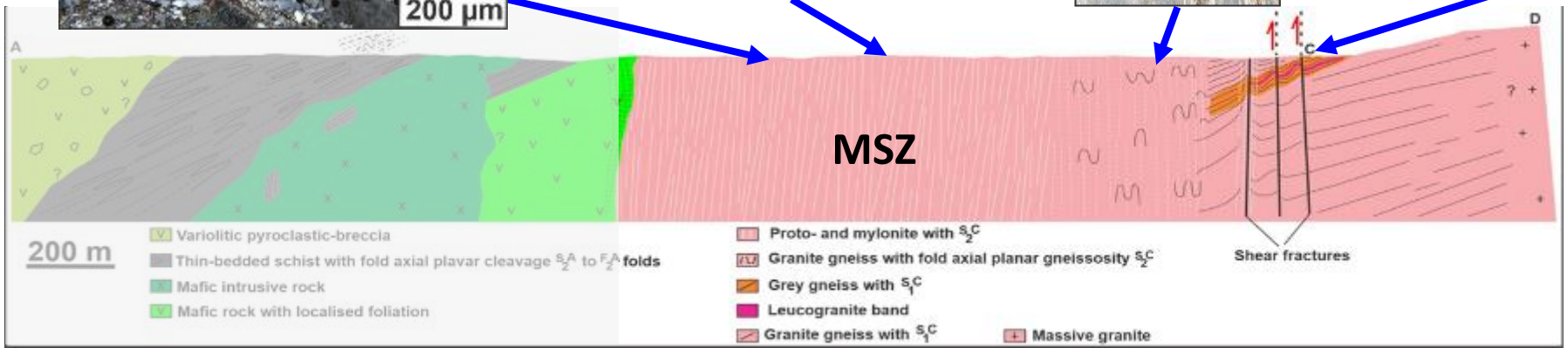




Fold axial planar cleavage S_2 to F_2 folds

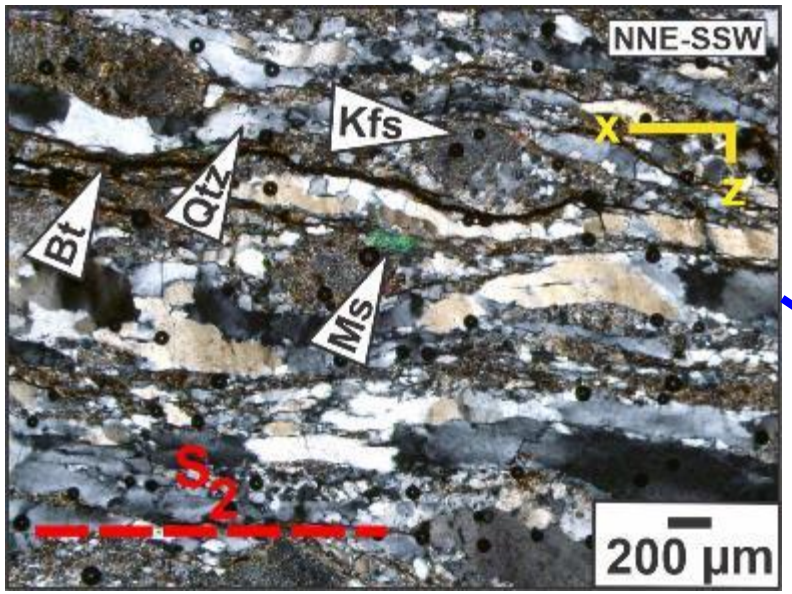
Upright F_2 folds in the grey gneiss

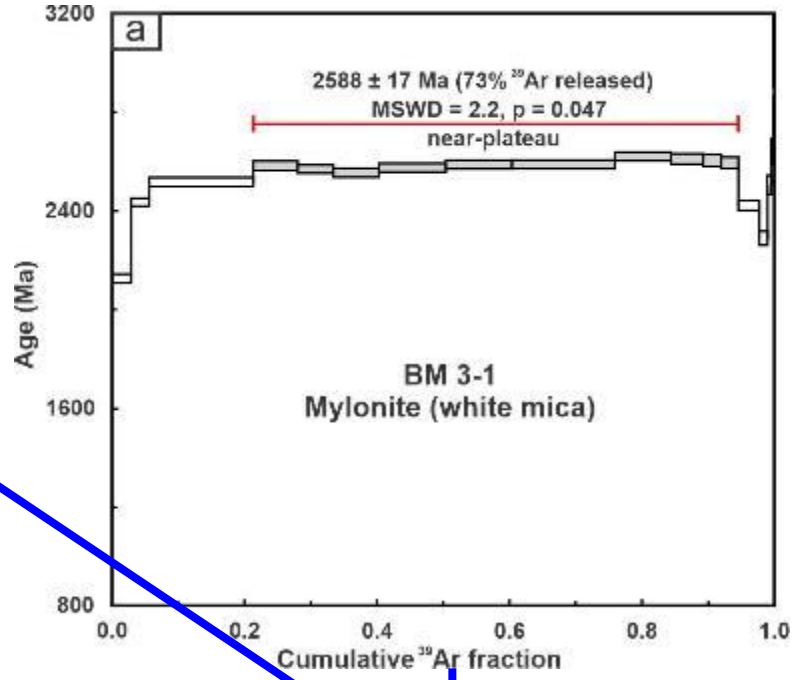


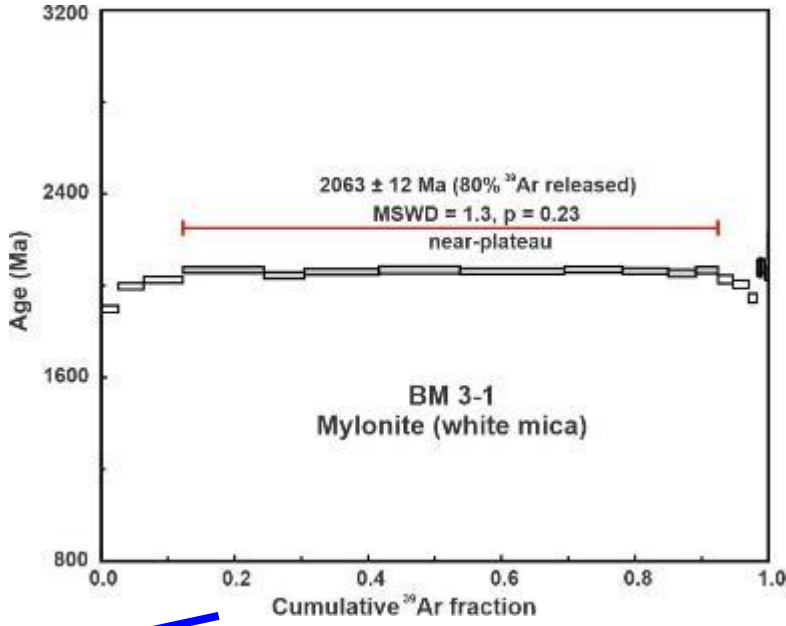


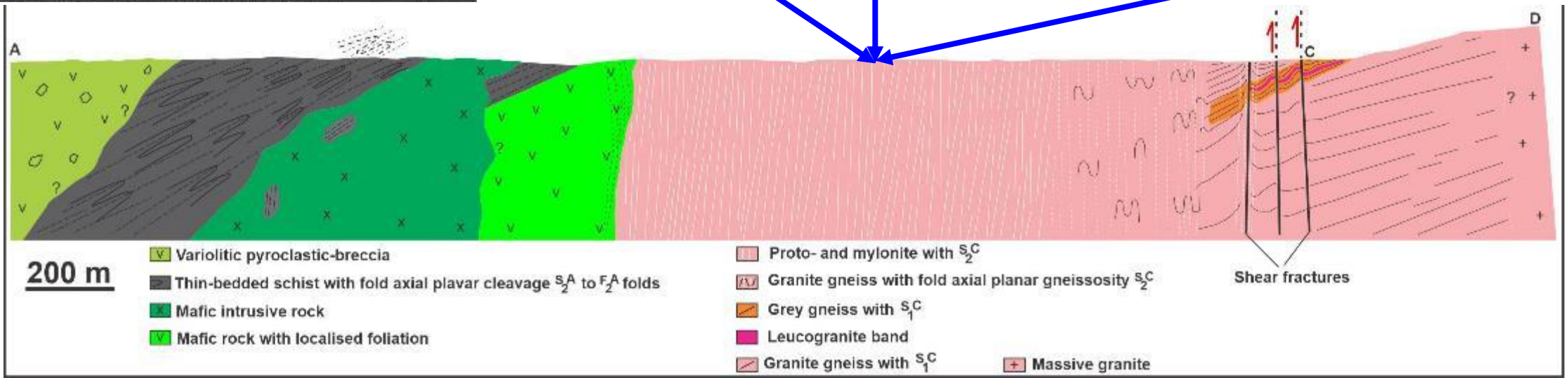
D_2 deformation age - $^{40}Ar/^{39}Ar$ geochronology

D_2 - 2588-2541 Ma

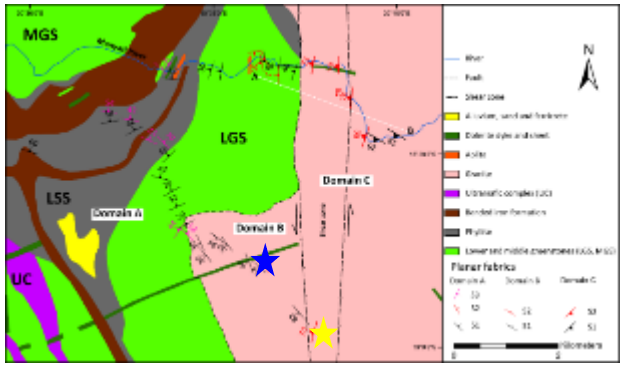


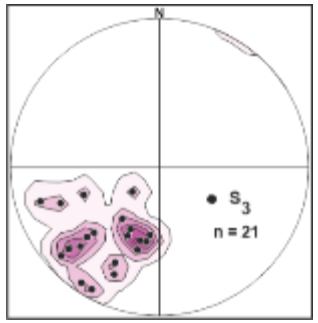


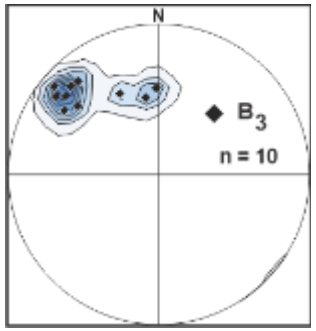


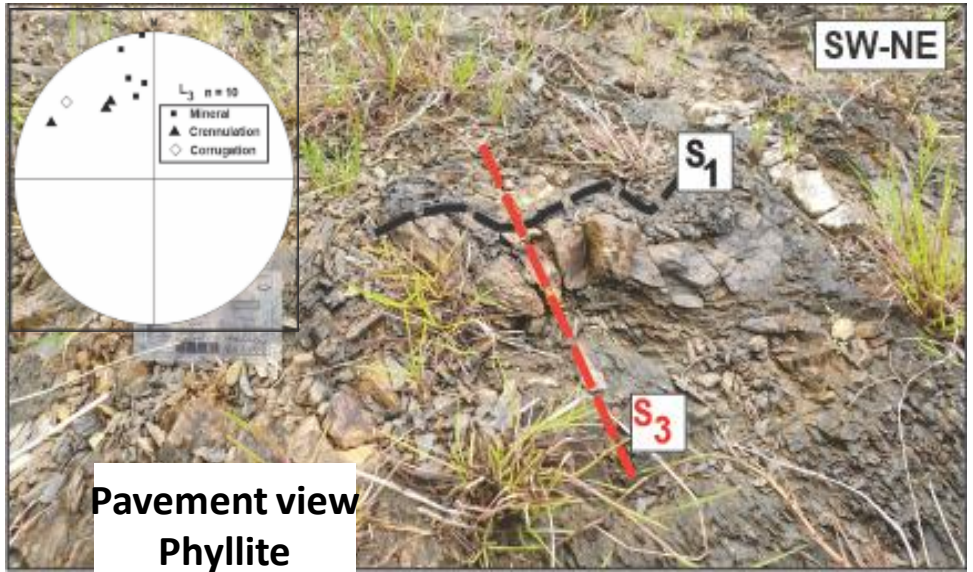


D_3 event

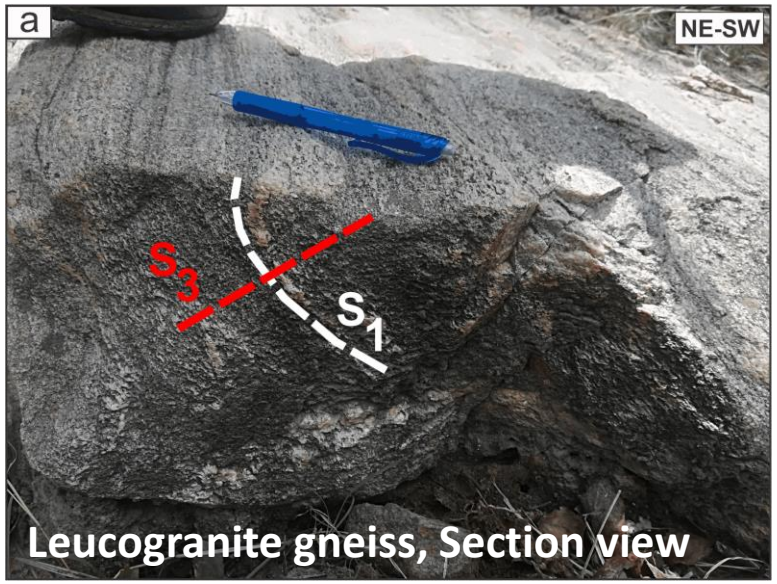




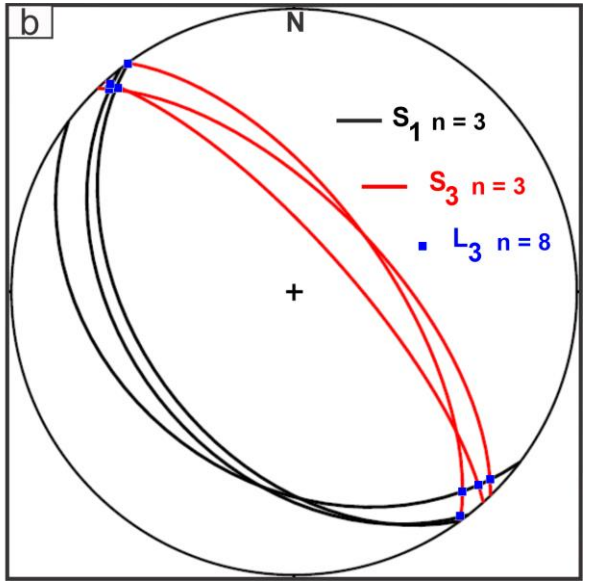


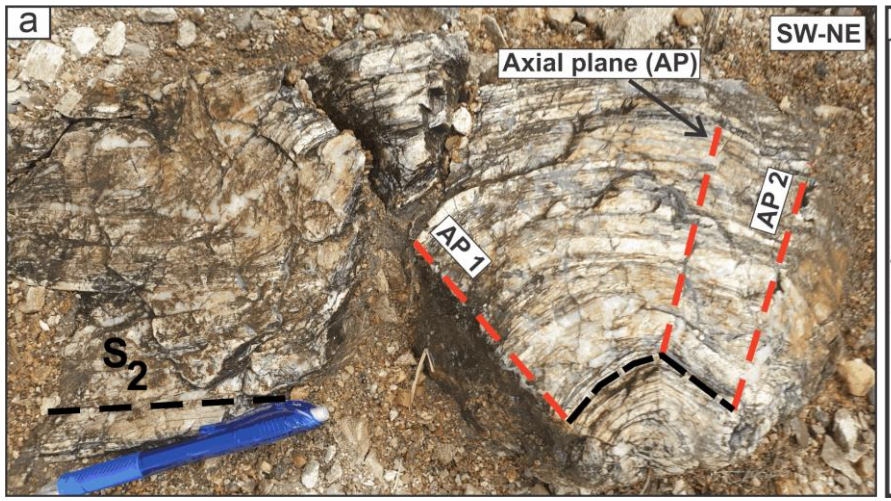


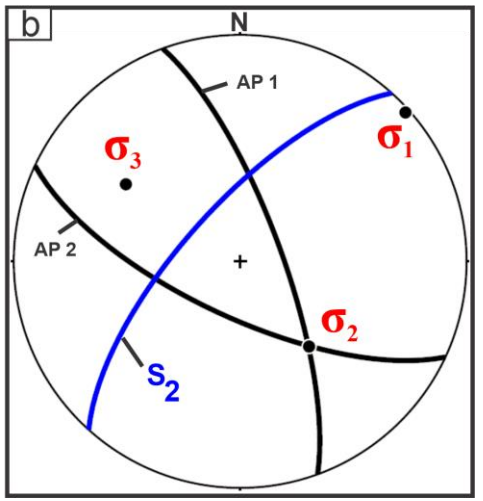
Pavement view
Phyllite



Leucogranite gneiss, Section view



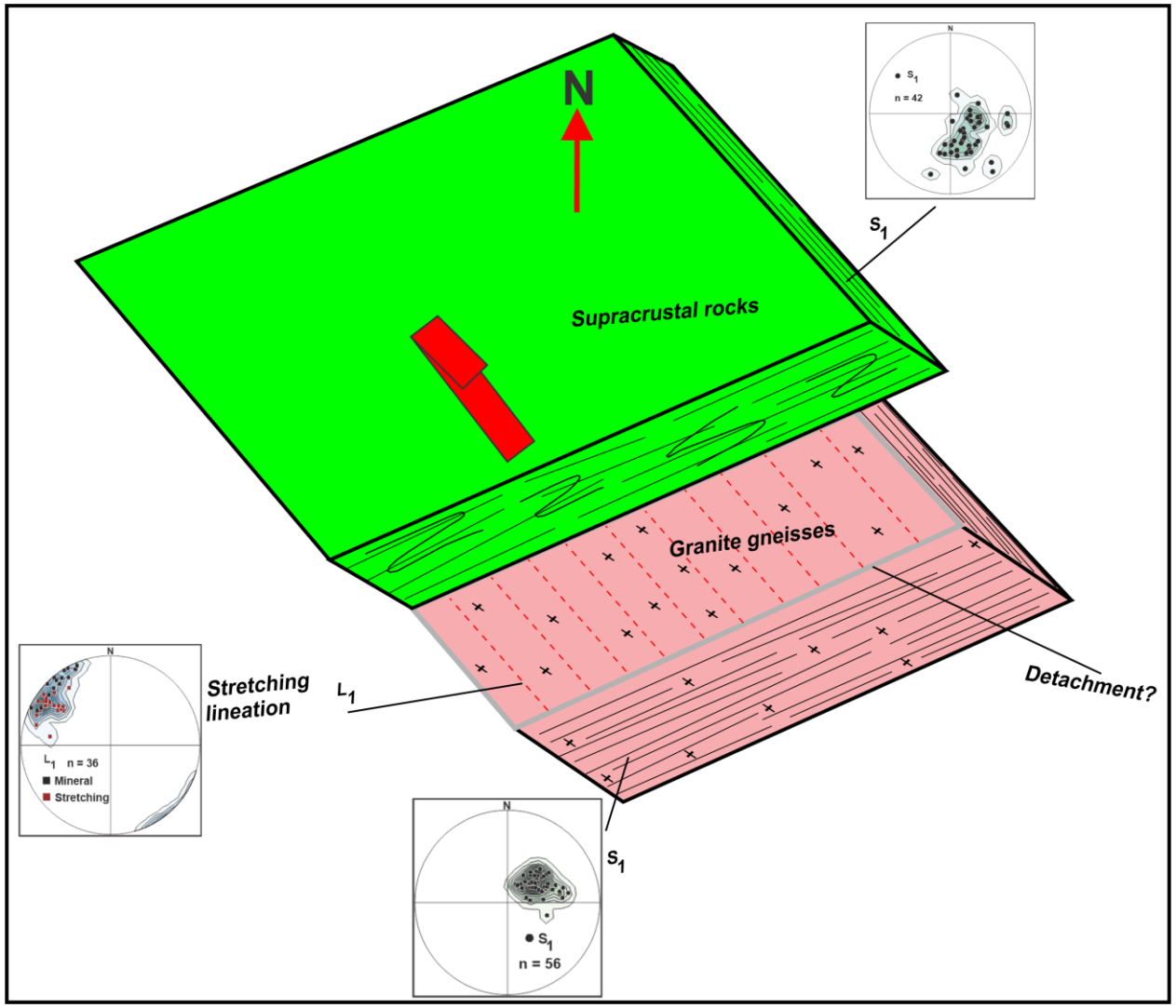




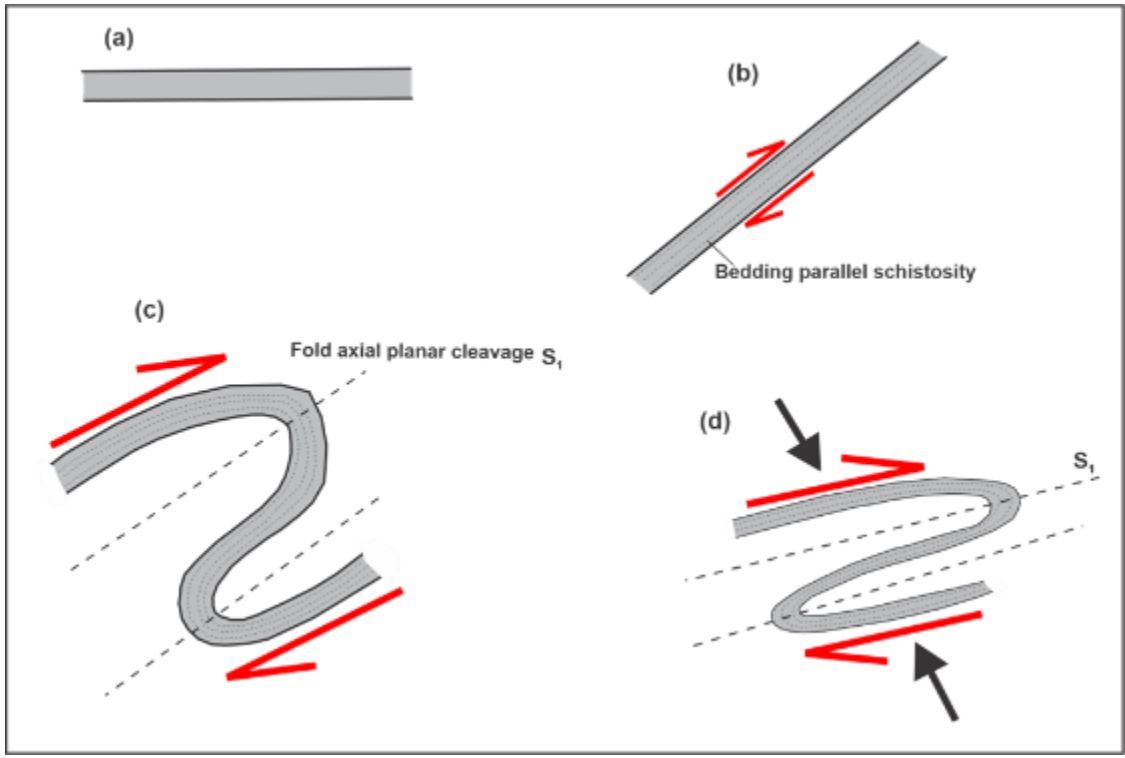
Mylonite, Pavement view

Interpretation of deformation events

D_1 – Dextral strike-slip shearing event (~ 2688-2617 Ma)



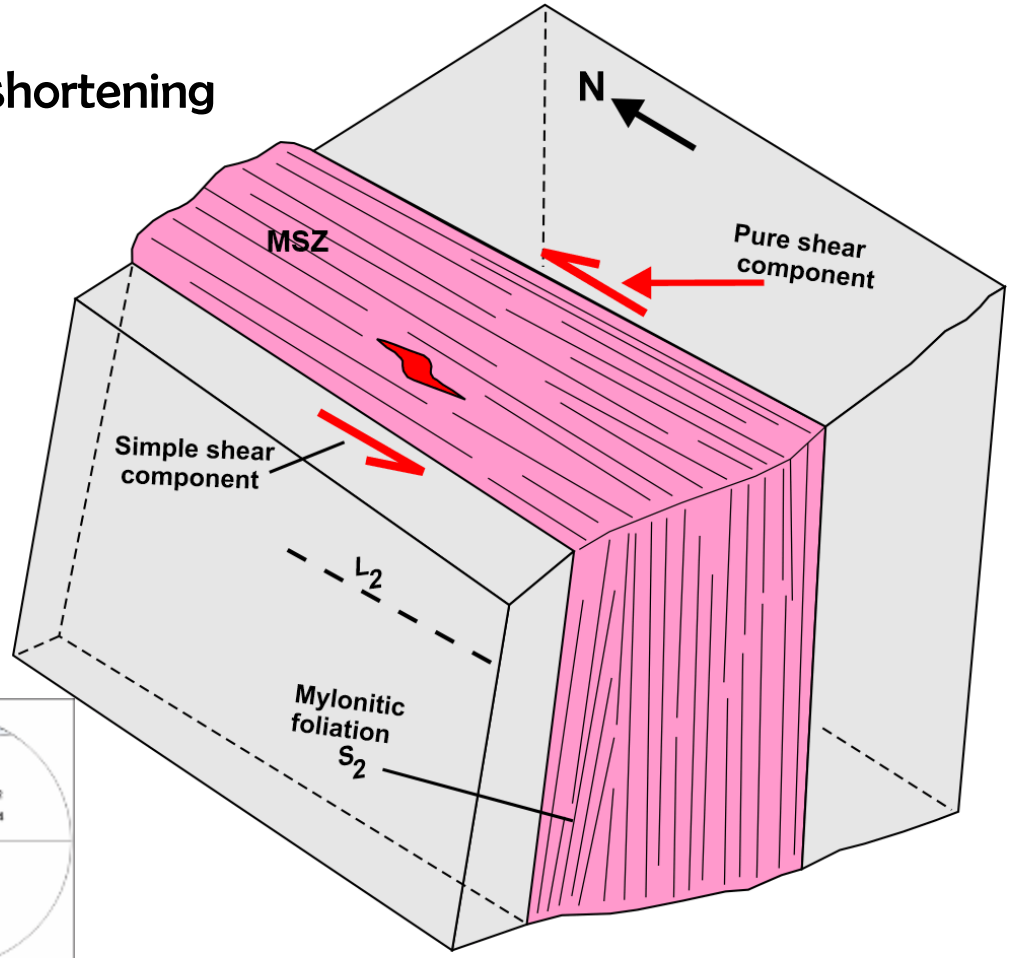
F_1 recumbent folds

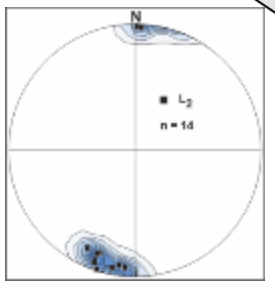


Interpretation of deformation events

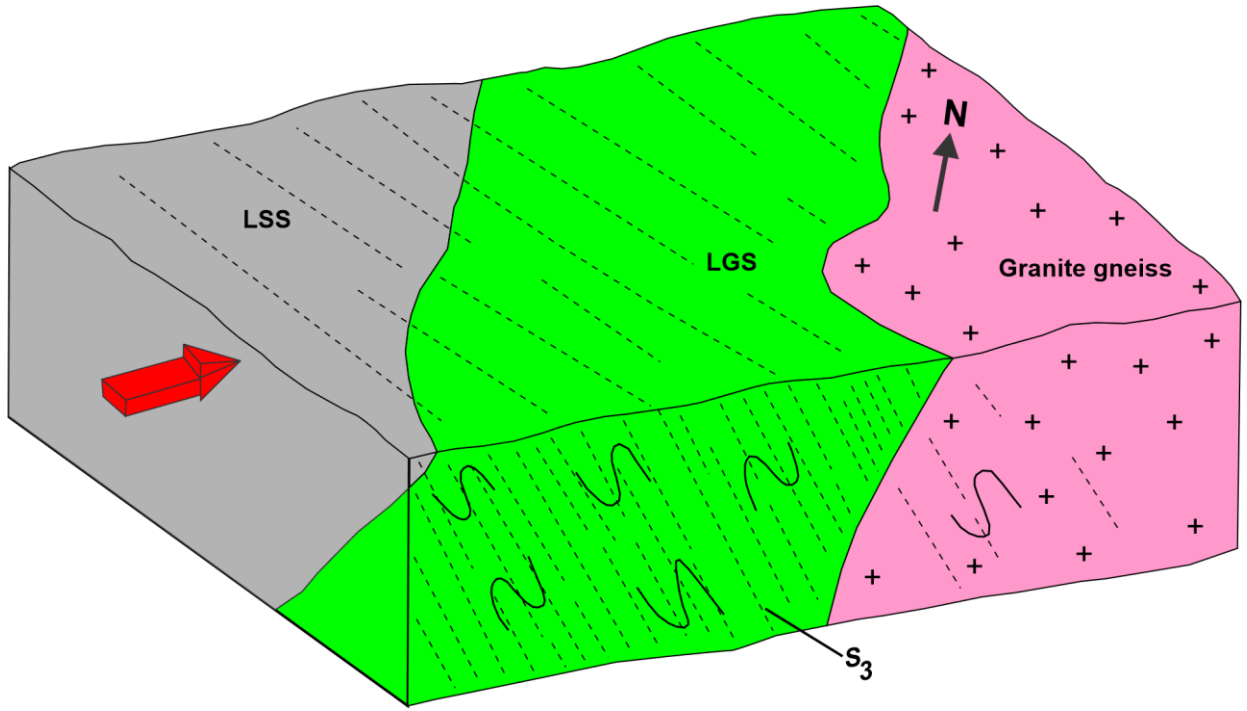
D_2 - Wrench-dominated transpression (~ 2588-2541 Ma)

NW-SE shortening

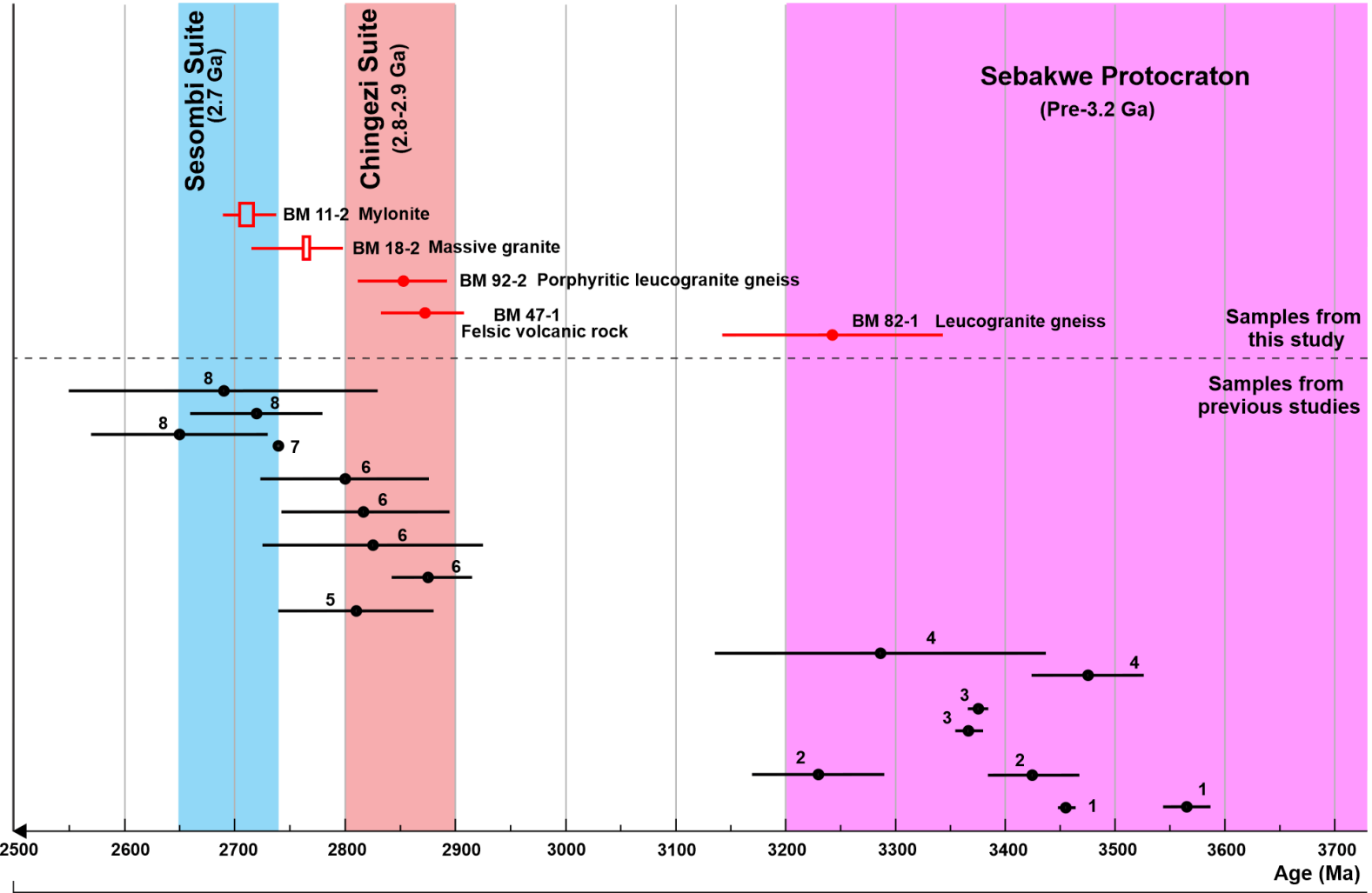




D_3 - NE-SW shortening



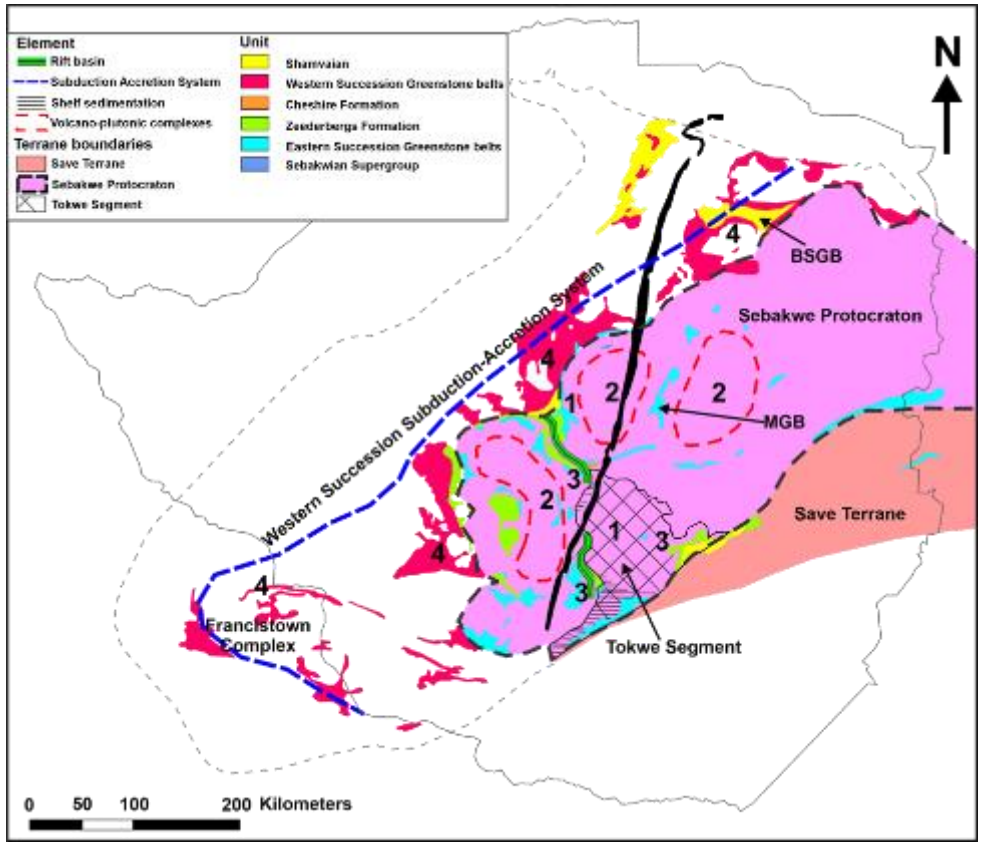
Regional significance of zircon U-Pb ages



Sources

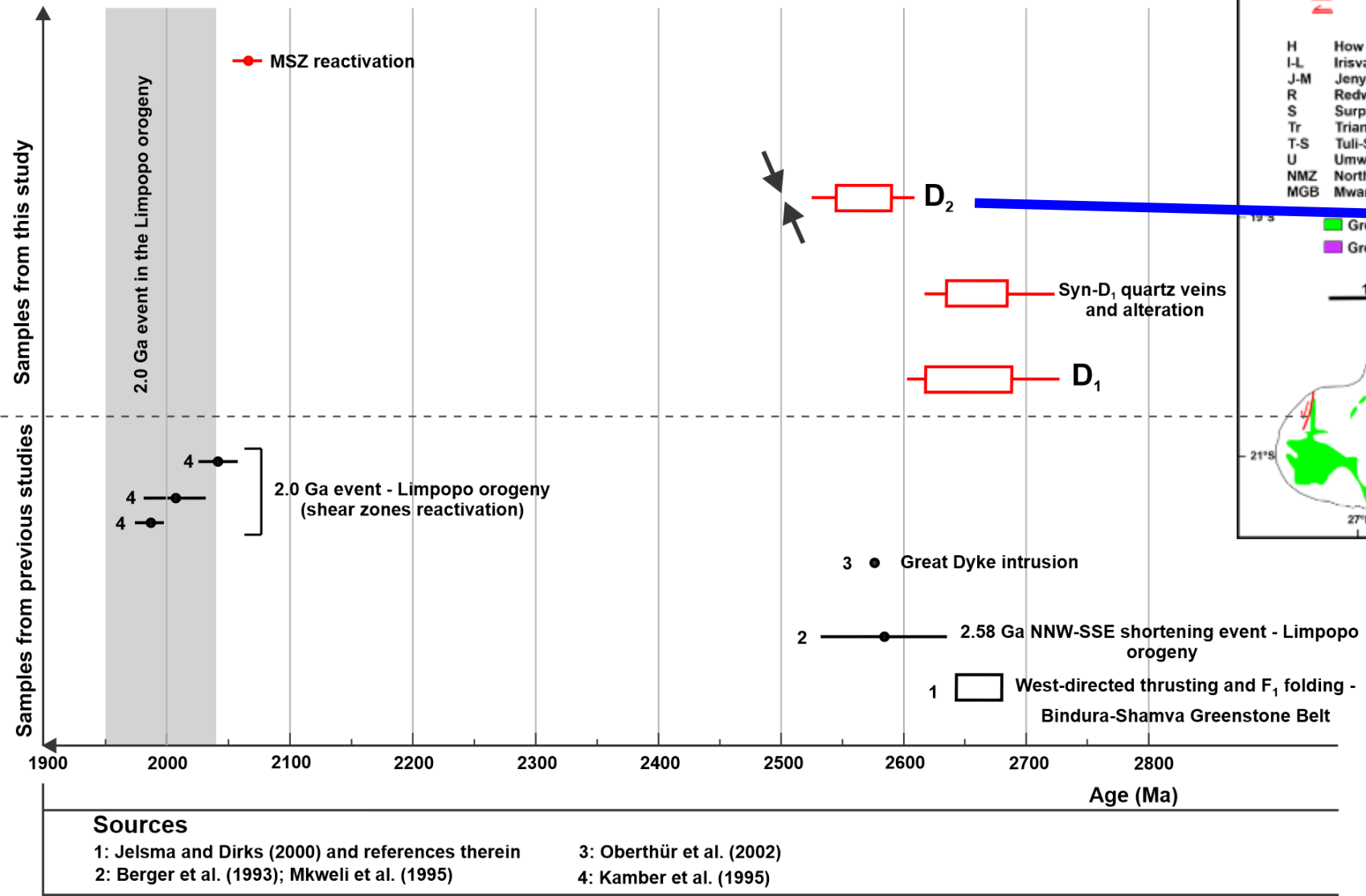
1: Hawkesworth and Bickle (1977)
2: Horstwood et al. (1999)
3: Dodson et al. (2001)
4: Hawkesworth et al. (1975)
5: Hawkesworth et al. (1979)
6: Taylor et al. (1991)
7: Taylor et al. (1991)
8: Hawkesworth et al. (1975)

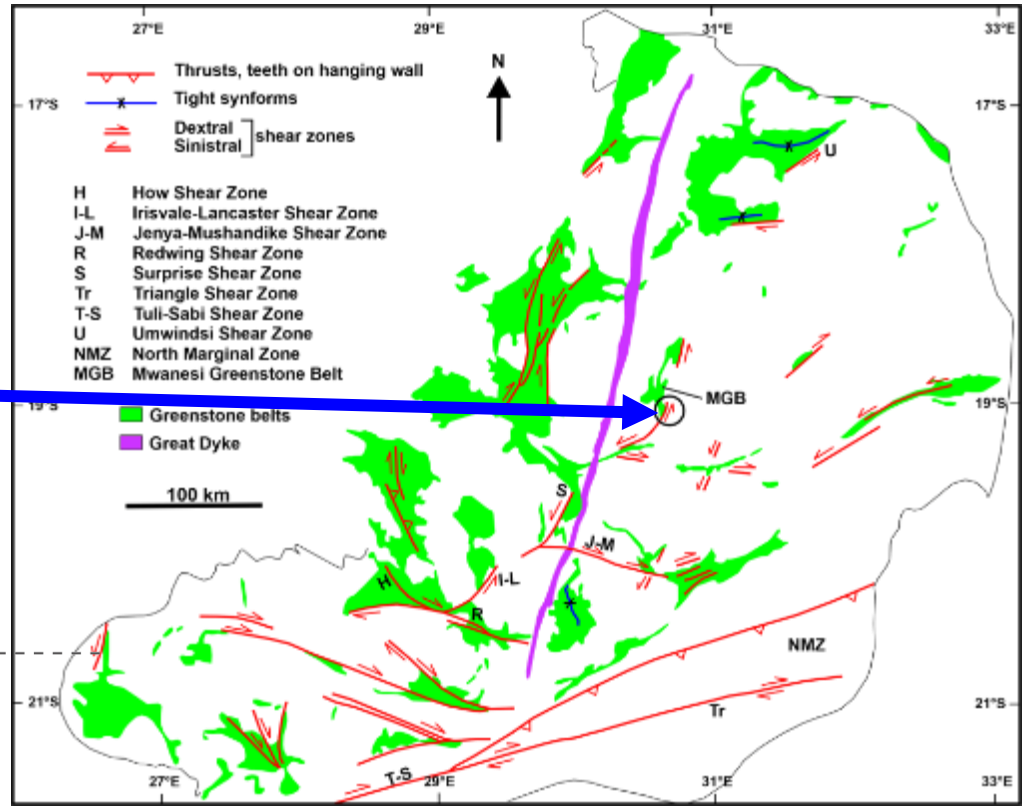
- Remnants of the Sebakwe Protocraton
- Granites coeval with the Chingezi and Sesombi suites



Modified after Jelsma et al. (2021)

Regional significance of $^{40}Ar/^{39}Ar$ ages





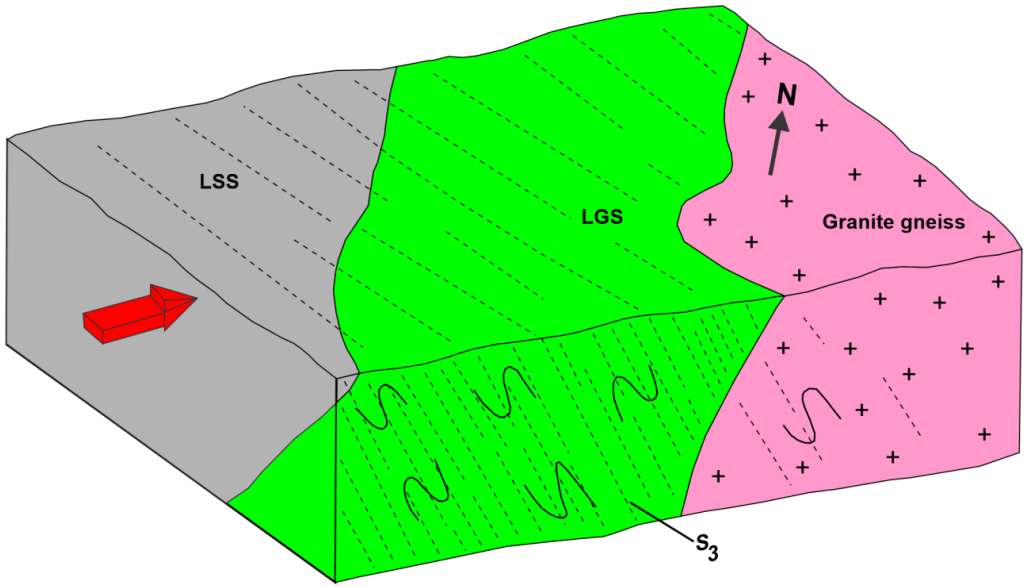
Modified after Treloar and Blenkinsop (1995)

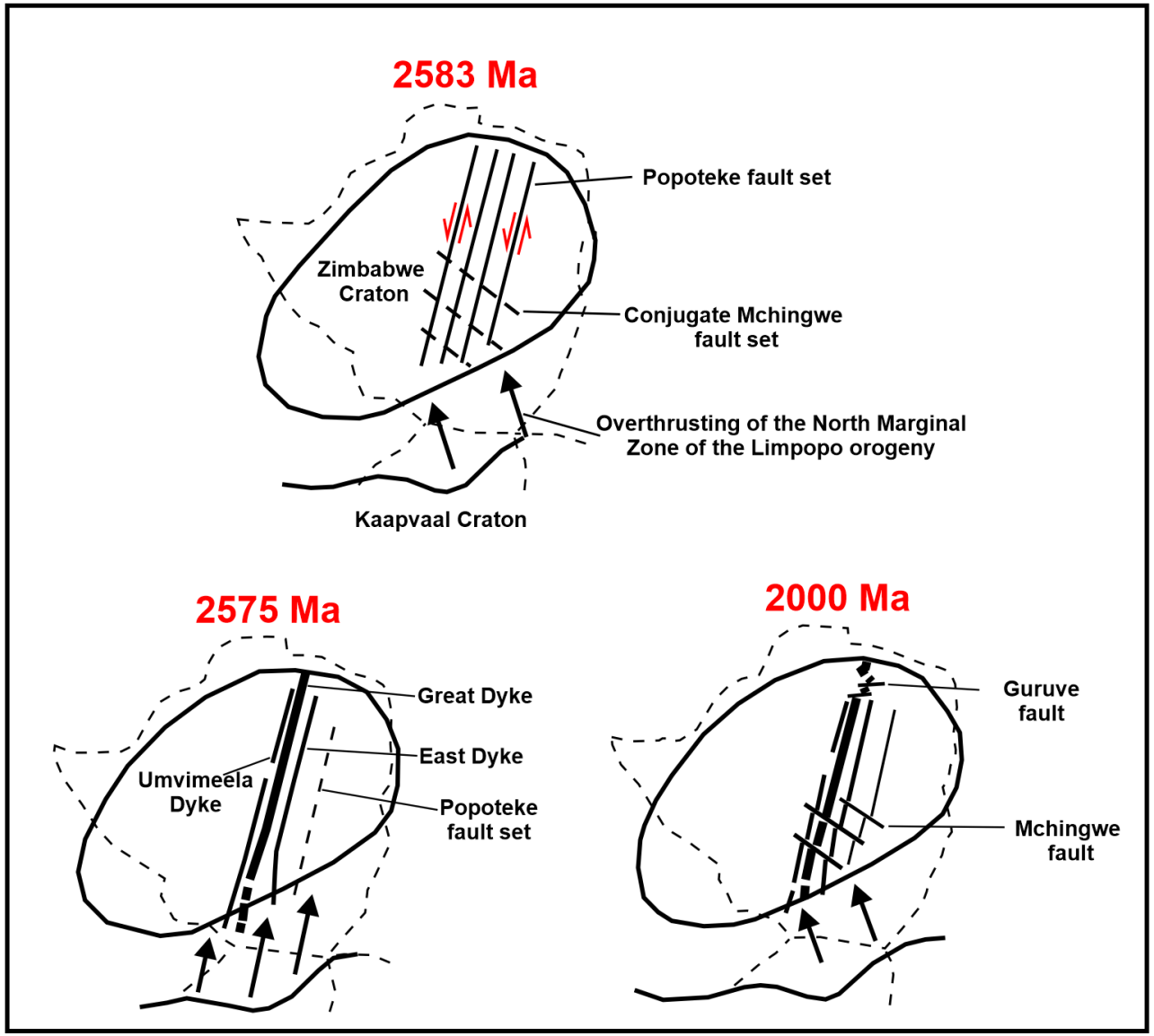
Sources

1: Jelsma and Dirks (2000) and references therein
2: Berger et al. (1993); Mkweli et al. (1995)
3: Oberthür et al. (2002)
4: Kamber et al. (1995)

Regional significance of D_3

D_3 related to the emplacement of the Great Dyke?

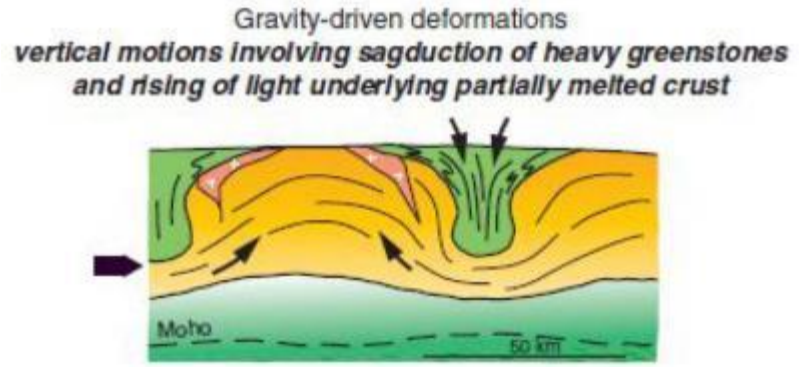




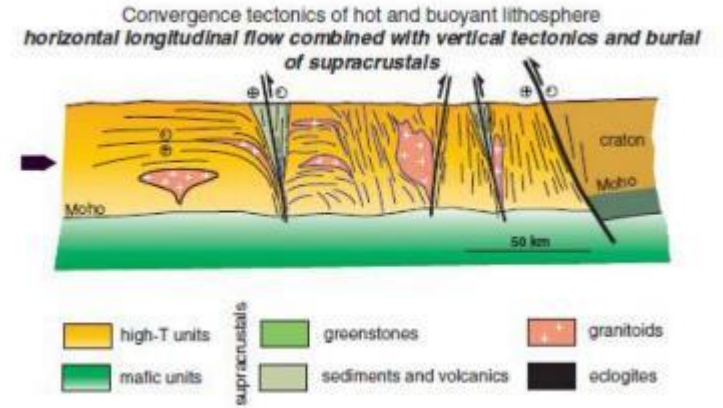
Sketches modified after Wilson (1996)
Ages: Berger et al. (1993); Mkweli et al. (1995); Oberthür et al. (2002)

Tectonic evolution of the MGB

Gravity-driven tectonics

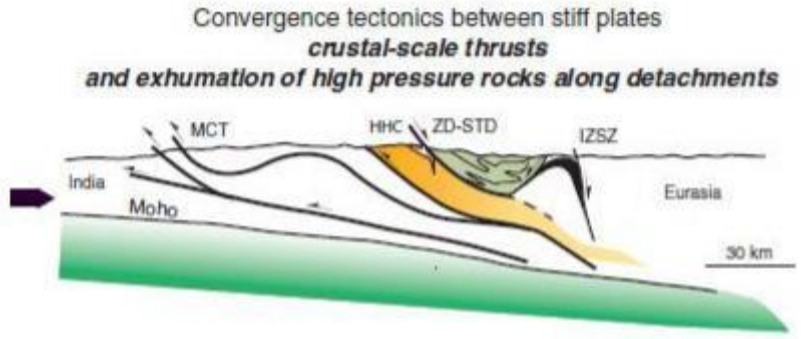


Pop-down tectonics



Schematic diagrams from Gapais (2018)

Modern-type tectonics



Evidence of horizontal crustal shortening and extension

- Shallow dipping fabrics (S_1 & L_1) with dextral strike-slip kinematics
- Subhorizontal stretching lineation L_2 and sinistral kinematics in the MSZ
- Upright to inclined F_3 folds, steeply dipping axial planar cleavage S_3 and paleostress analysis on MSZ box fold F_3 (NE-SW contraction)

Concluding remarks

- The indicative age of the MGB is constrained at ~ 2871 Ma (Lower Bulawayan)
- Three magmatic events in the granite gneisses: ~ 3243 Ma (Sebakwe Protocraton), 2852 Ma (Chingezi Suite), and 2767-2704 Ma (Sesombi Suite)
- Polyphase deformation is recognised in the MGB
    1. **D_1** – Dextral strike-slip shearing (~ 2688-2617 Ma) coeval with **F_1** folding in Bindura Greenstone Belt
    2. **D_2** - Wrench-dominated transpression (~ 2588-2541 Ma) related to the 2.58 Ga event in the Limpopo orogeny
    3. **D_3** - NE-SW shortening related to the second stage of the Great Dyke development
- Deformation record of the MGB gives valuable insights on the construction of the Zimbabwe Craton

Acknowledgements

- Prof K.S. (Fanus) Viljoen (SARChI Geometallurgy) is thanked for funding the project. Prof K.S. (Fanus) Viljoen acknowledges funding from the South African Department of Science and Innovation through their Research Chairs initiative, as administered by the National Research Foundation (NRF)

National Research Foundation

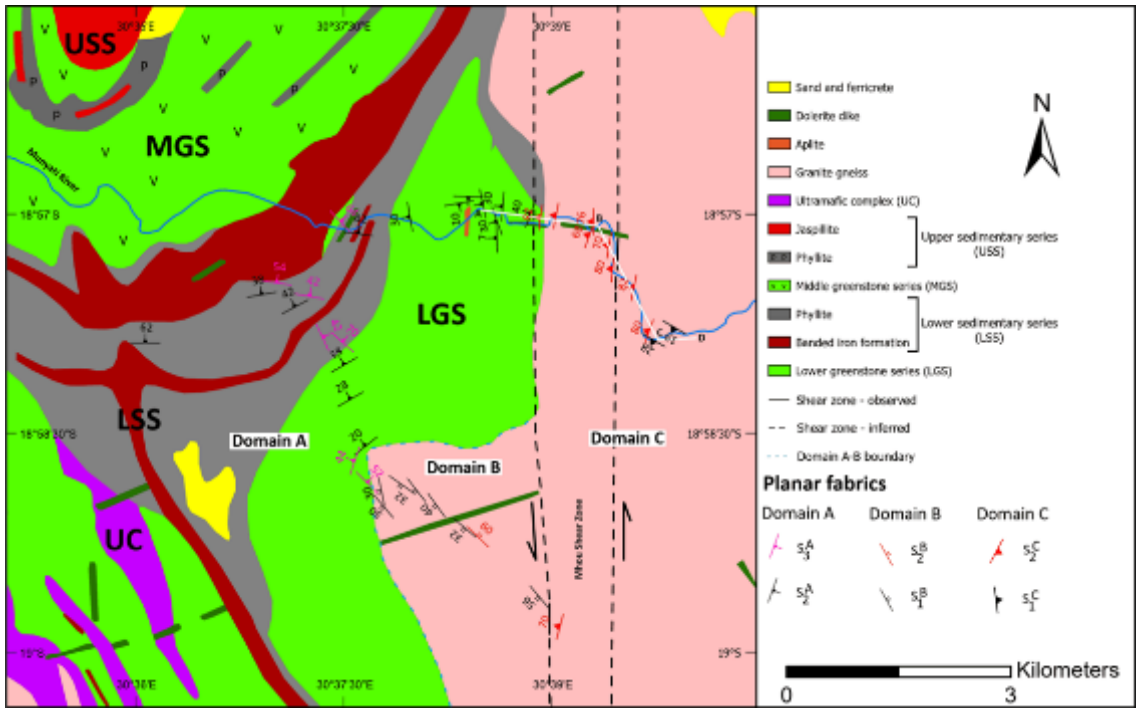
IRP BuCoMO

Building Continents - From Mantle to Ore

Thank you

brianmapingire7@gmail.com

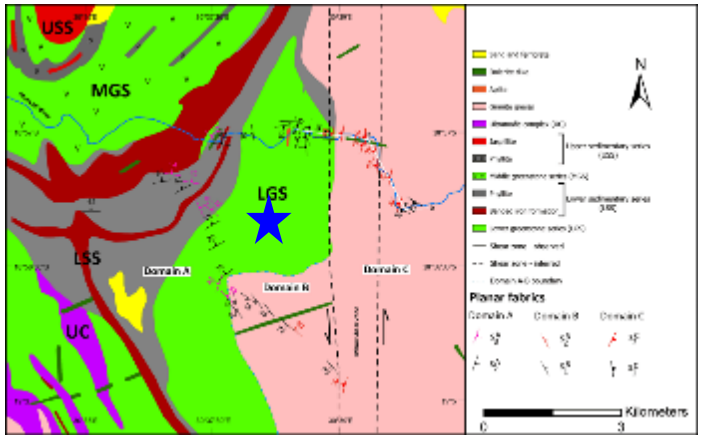
Lithostratigraphy – Adjacent granite gneisses



- Granite gneisses and minor isotropic granite
- Medium to coarse-grained, porphyritic, largely leucocratic
- Grey gneiss intruded by leucogranite gneiss
- Granite gneiss bands, and crosscutting dikes
- Granite gneisses transected by mylonites of the MSZ

Lithostratigraphy – Lower Greenstone Series

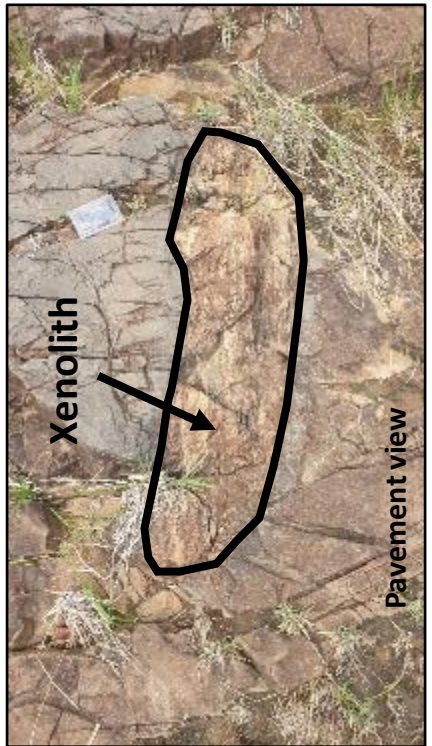
- **Metasedimentary rocks** – pelitic schists
- **Volcanic rocks** - pillow and amygdaloidal basalts, pyroclastic-breccia, felsic volcanic rocks
- **Intrusive rocks** – mafic rocks, and dikes



Metasedimentary rocks

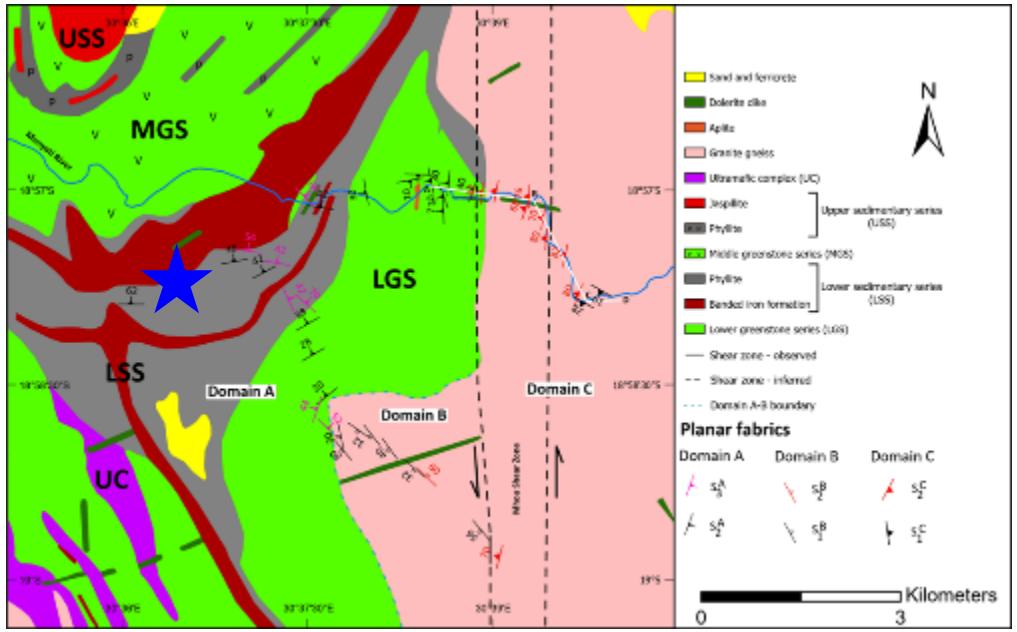
Volcanic rocks

Intrusive rocks



Mafic intrusive rock

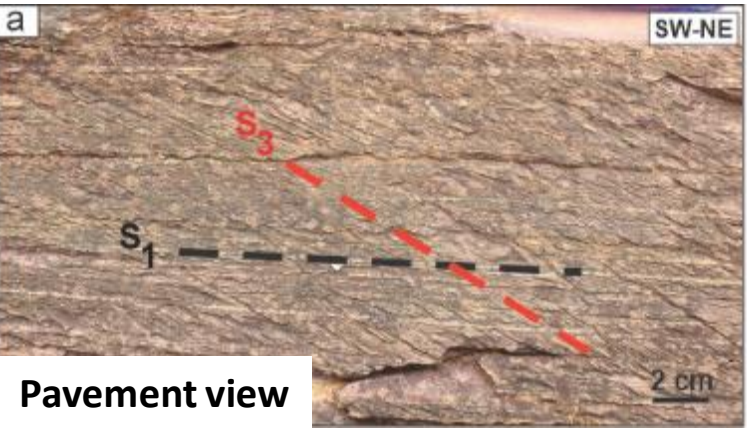
Lithostratigraphy - Lower Sedimentary Series



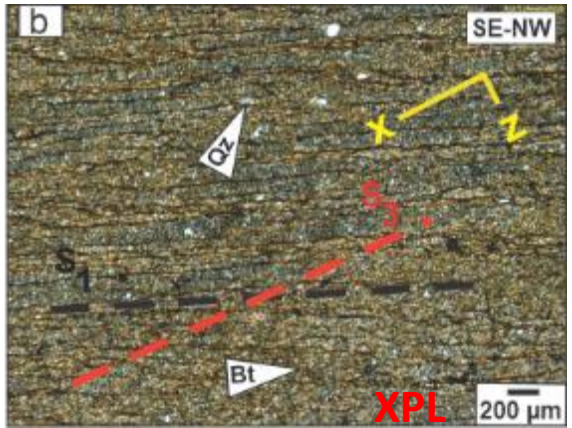
- Phyllite and BIF
- BIF intruded by subvolcanic basalts

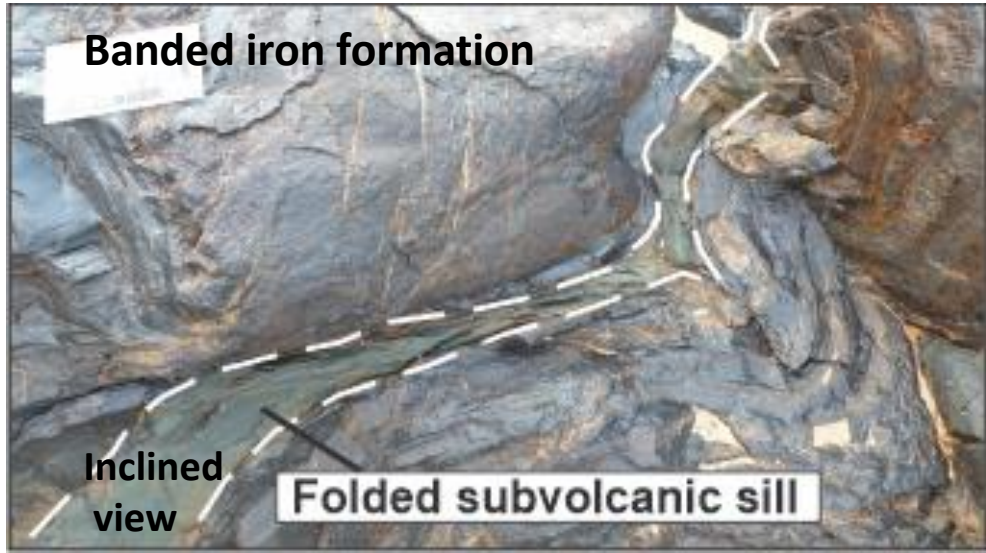
Banded iron formation

Phyllite



Pavement view





Lithostratigraphy - Middle greenstone Series

- Characterised by basaltic rocks, locally pillowed
- MGS and LGS pillow basalts are lithologically similar
- Minor textural differences