WAXI- West African Exploration Initiative

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Lower crustal exhumation under transtension during the Palaeoproterozoic Eburnean Orogeny in Sefwi belt, SW Ghana

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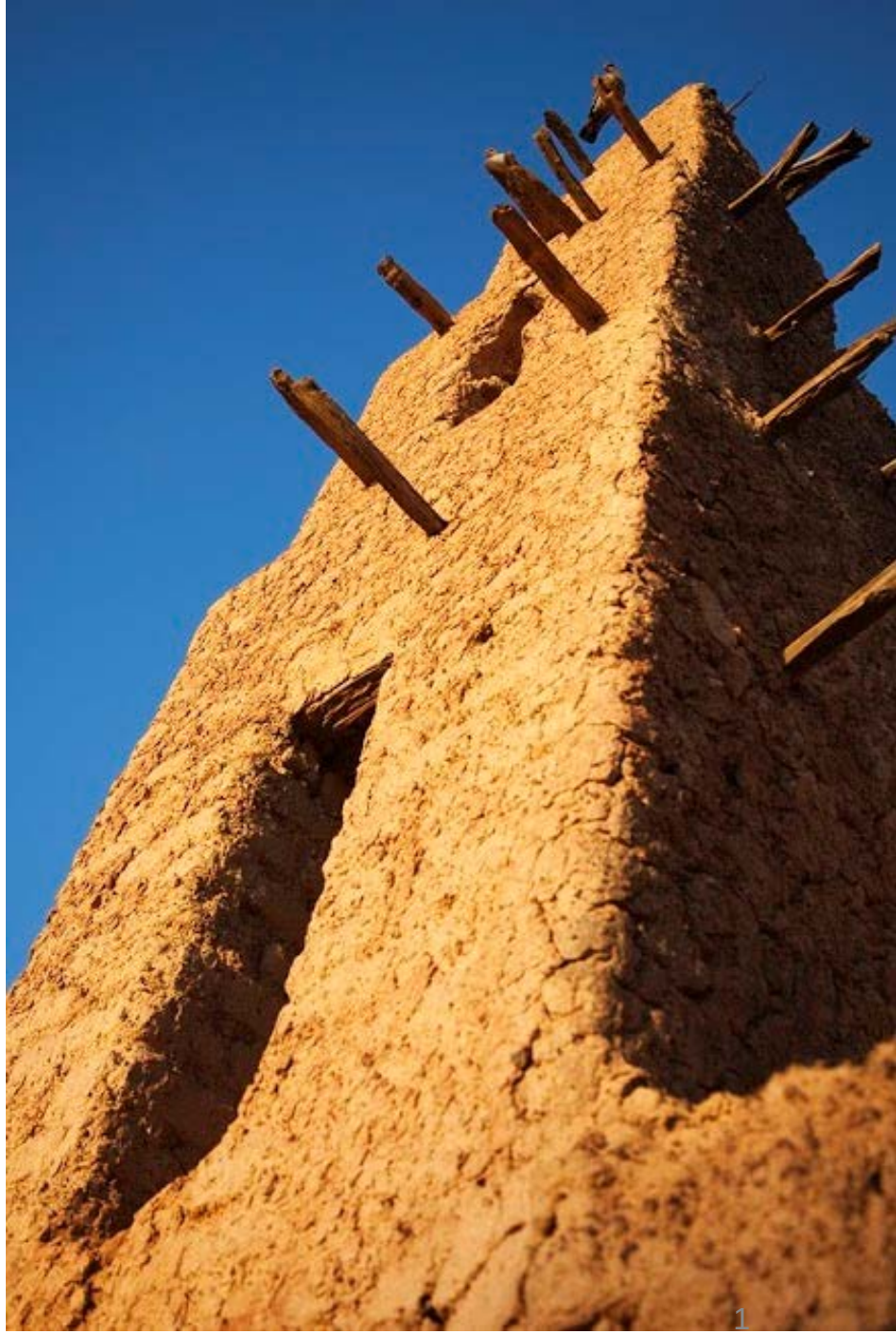
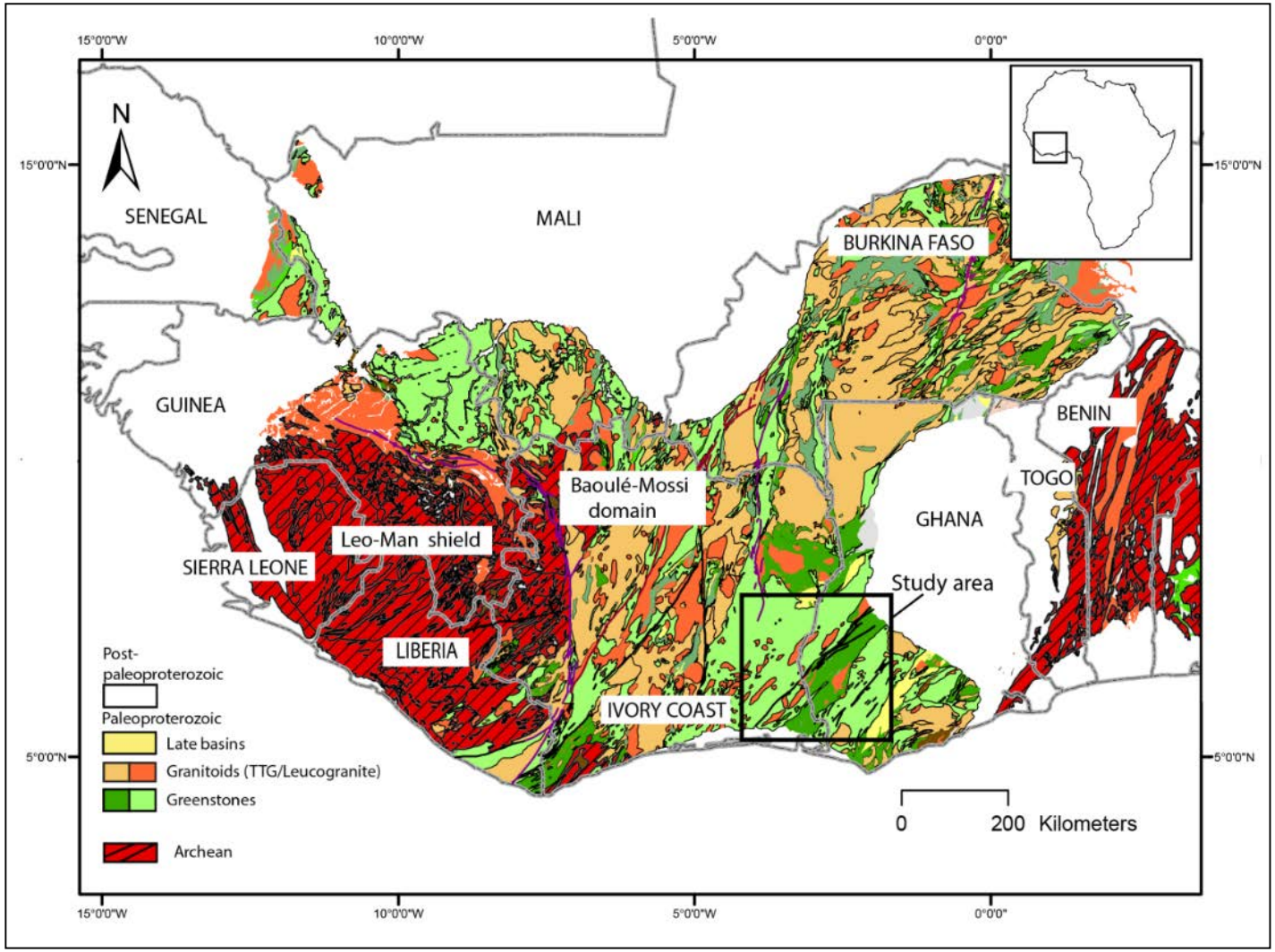


Geological context



Paleoproterozoic Baoulé-Mossin domain in the southern portion of the West African Craton (modified after Milési et al. 2004, BRGM SIGAfrique).

Eburnean Orogeny ~2.20-1.98 Ga

Magmatic accretion of the juvenile crust of the WAC (~2.20 – 2.15Ga)

Varied models for the Eburnean Orogeny across the WAC

Monocyclic Eburnean Orogenic event

High grade rocks juxtaposed against low grade supracrustal equivalents by differential exhumation

(eg Bessoles 1977; Leube et al. 1990; Eisenlohr and Hirdes 1992; Hirdes et al. 1996; Hirdes et al. 2007; Block et al. 2015)

Multiple, discreet tectono-thermal events.

Eoeburnean (Eburnean I, Tangaean) deformation (~2.20– 2.15 Ga) evident in high grade rocks followed by the Eburnean, separated by extension (~2.13 – 1.98 Ga)

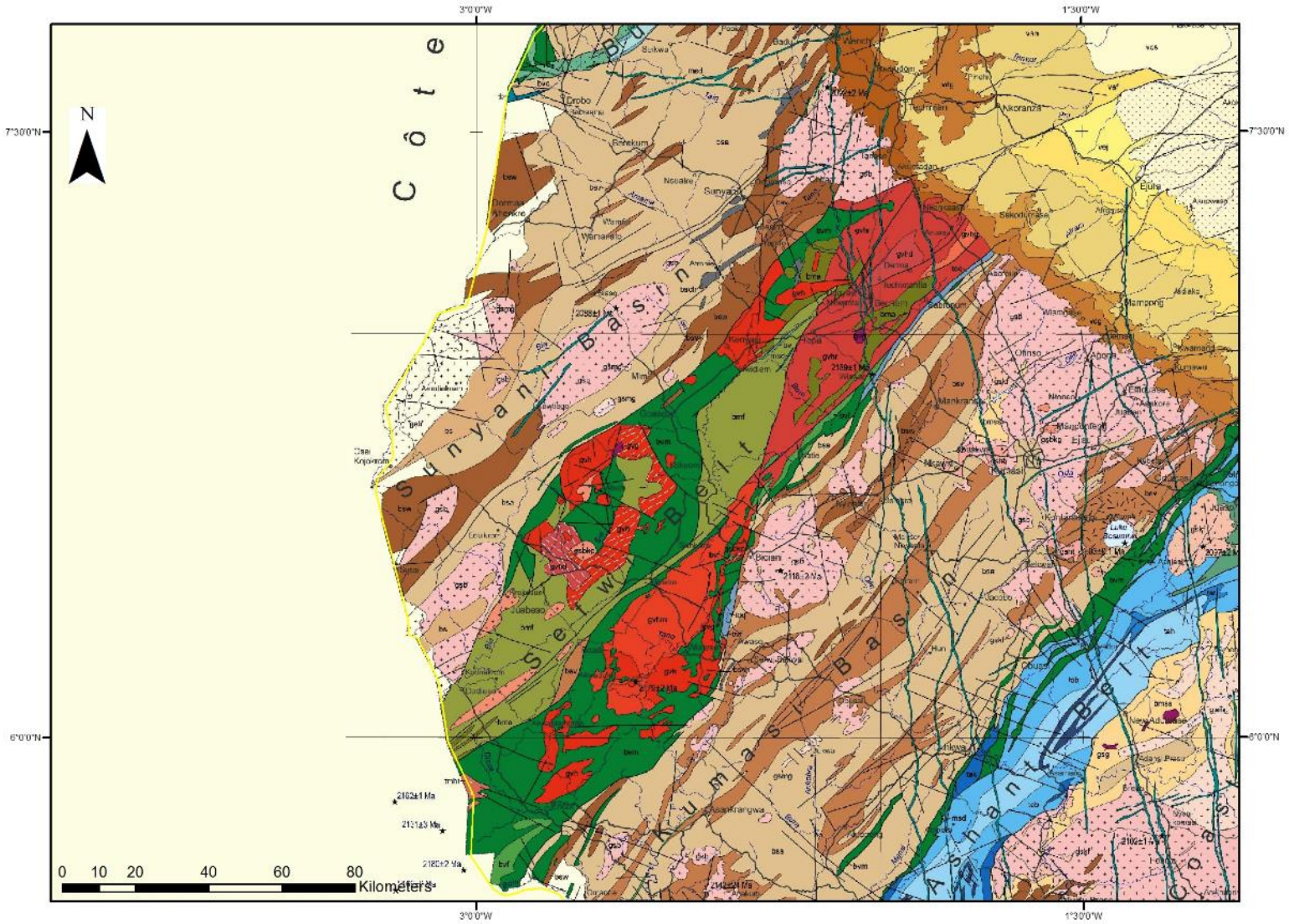
(eg Lemoine et al., 1990; De Kock et al. 2011; 2012; Hein, 2010; Feybesse et al., 2006; Perrouty et al. 2012)

Subsequent transcurrent tectonism

Early N-S sinistral shear zones in C.I., Senegal and western B.F. overprinted by NE-SW dextral shear zones in western Ghana and eastern B.F.

(Ledru et al. 1991; Feybesse et al. 2006; Pouclet et al. 2006; Perrouty et al. 2012; Jessell et al. 2012)

Existing map

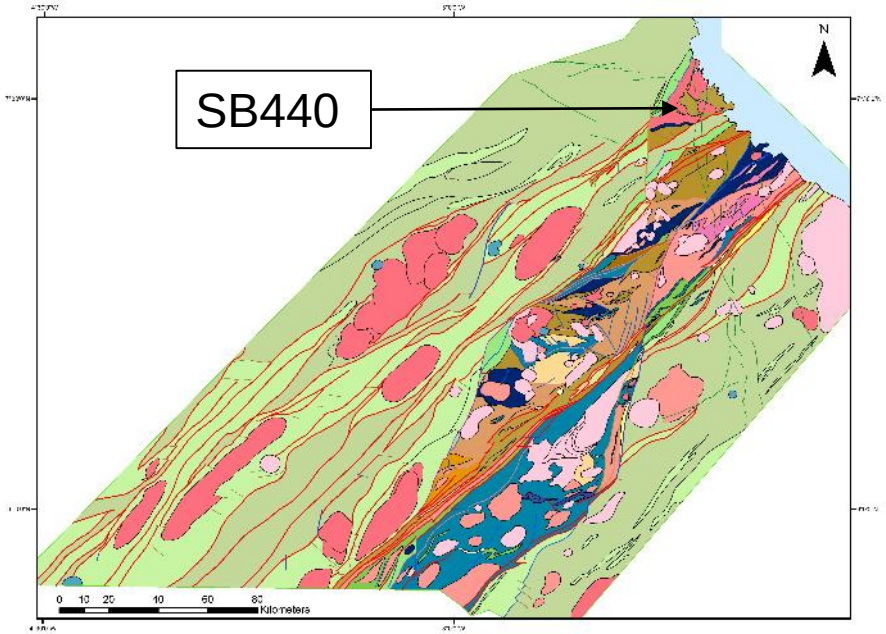


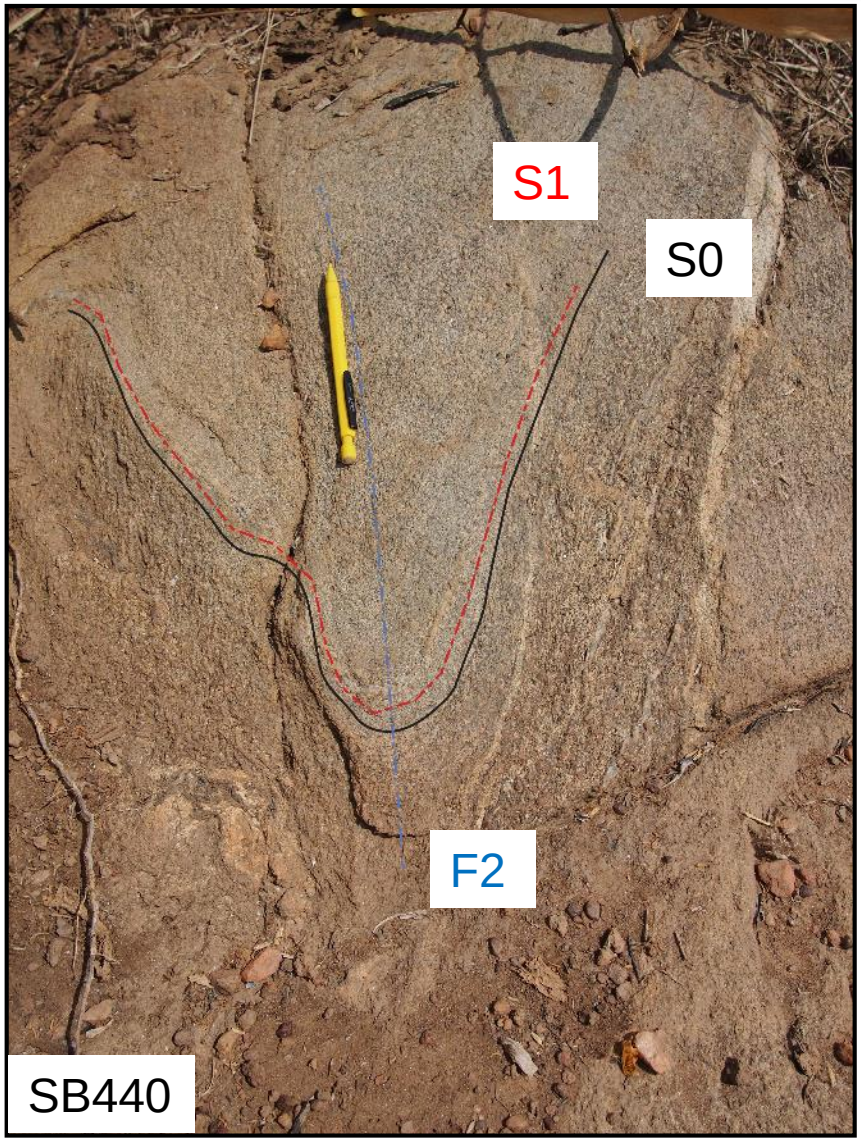
(Agyei Duodo et al. 2009)

Field Observations – D1

D1 Crustal thickening event

S_1 Bedding-parallel metamorphic foliation in schists, paragneisses





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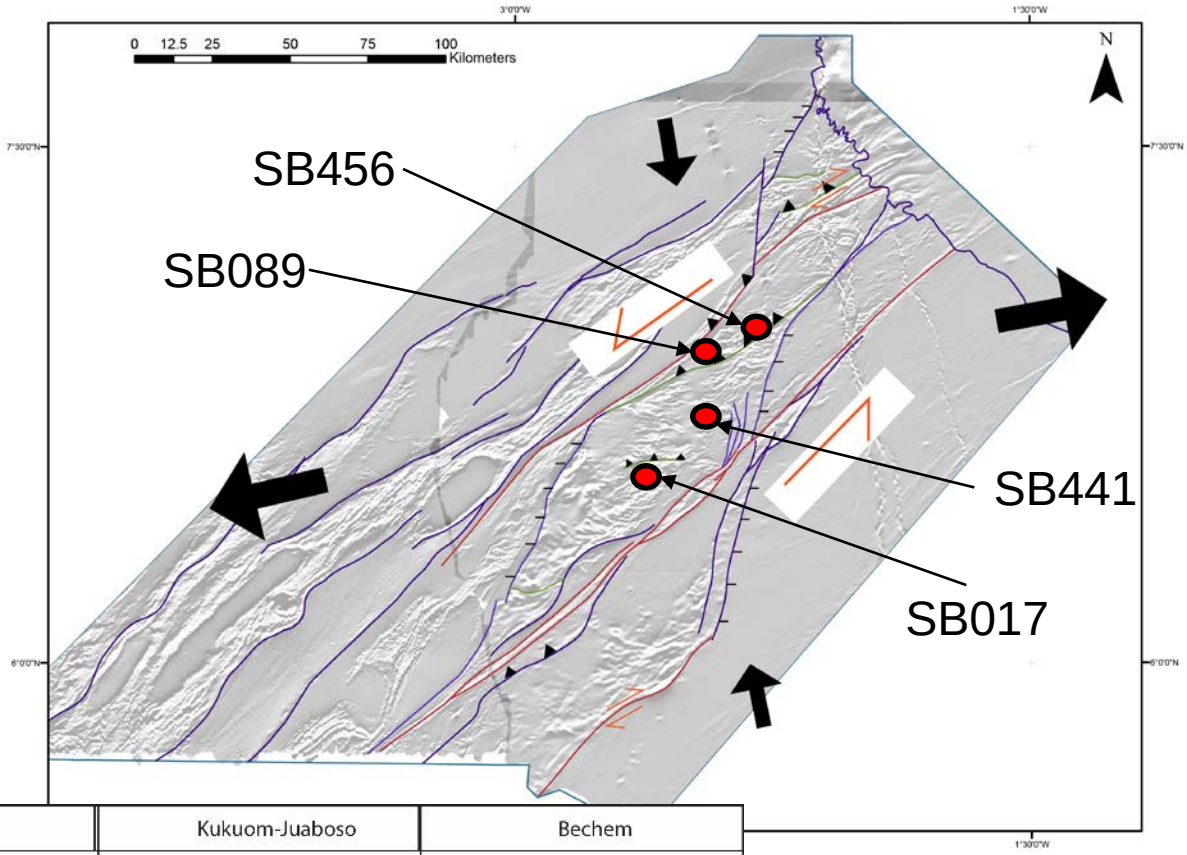
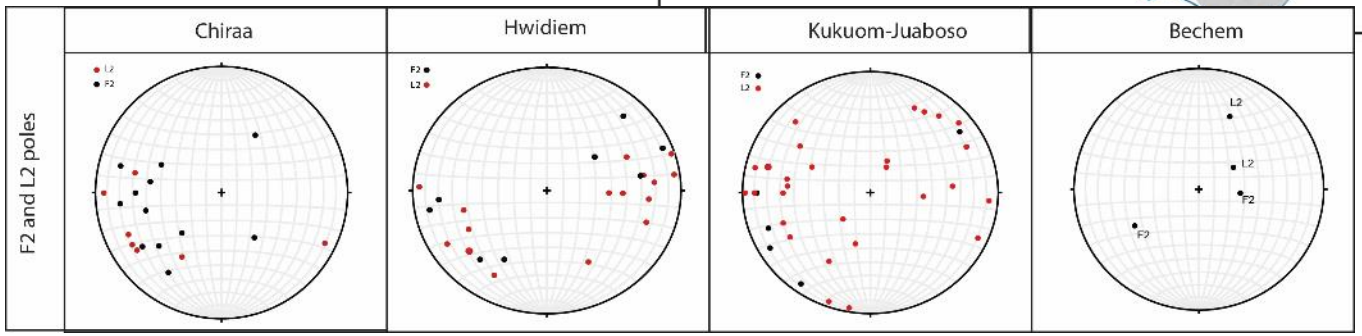
D2 transtension

Structural domains of the belt show close relationship between L2 and F2





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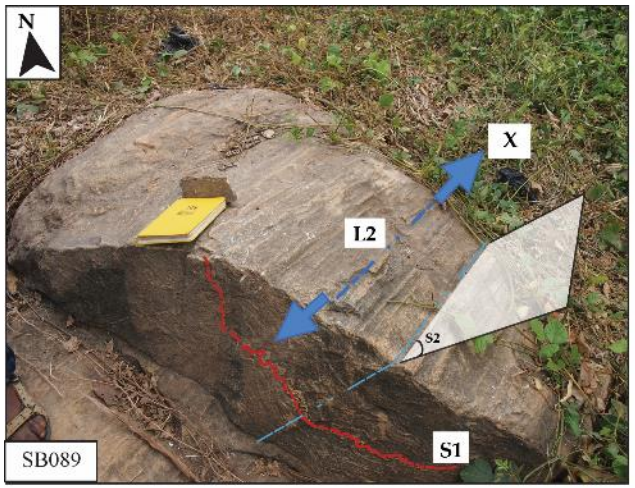
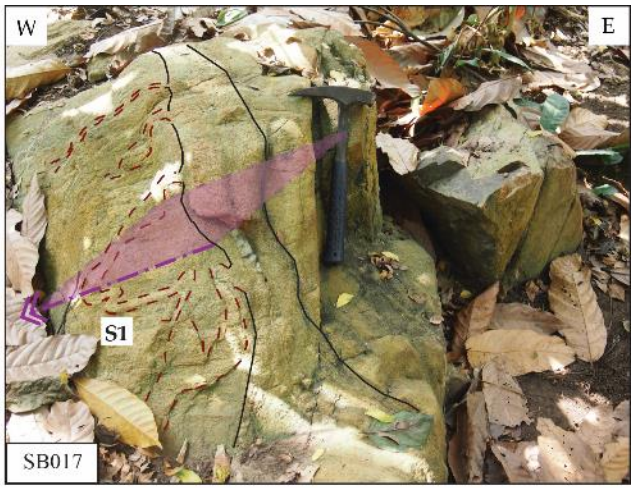
Field observations - D2

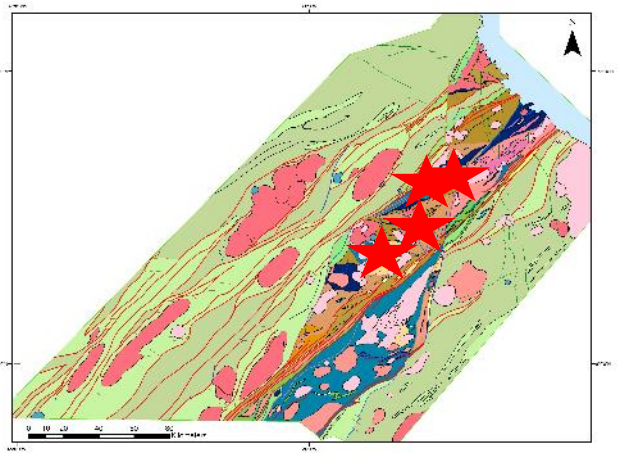
D2 ENE-WSW sinistral transtensional event

Open to tight E-W to NE-SW F2 folds

F2 approx. = L2 mineral stretching lineation







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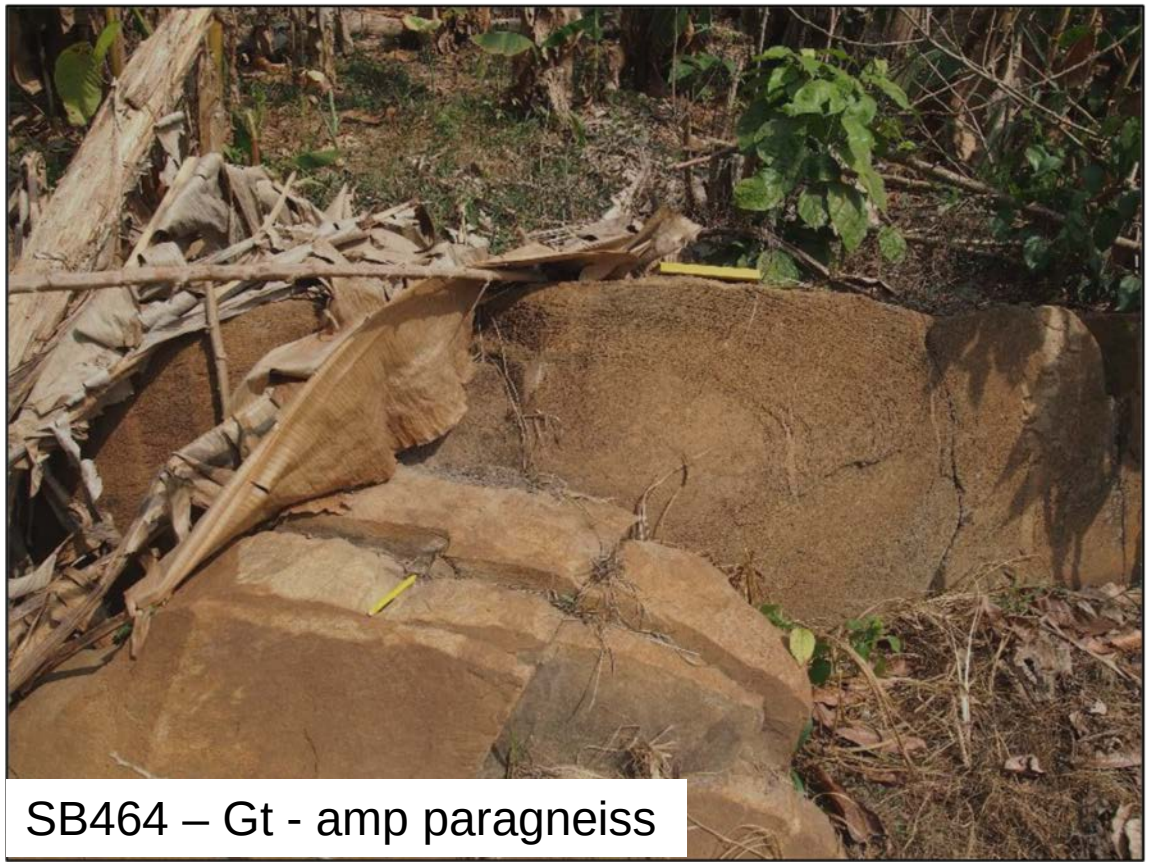
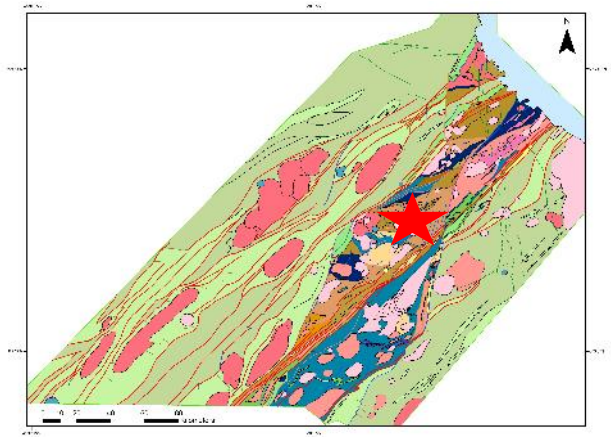
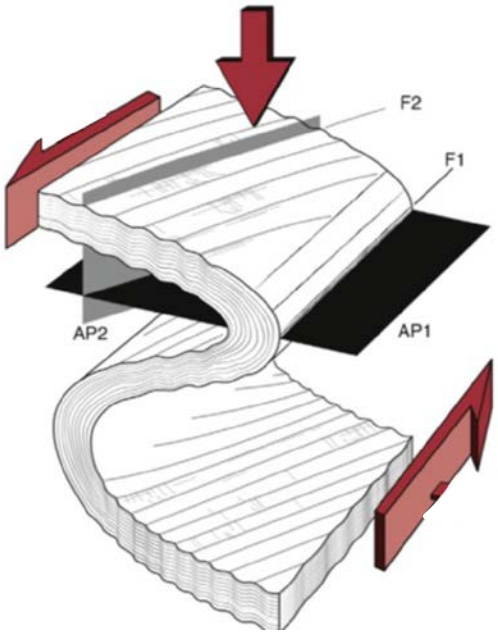
Further evidence of transtension



SB464 – Gt - amp paragneiss





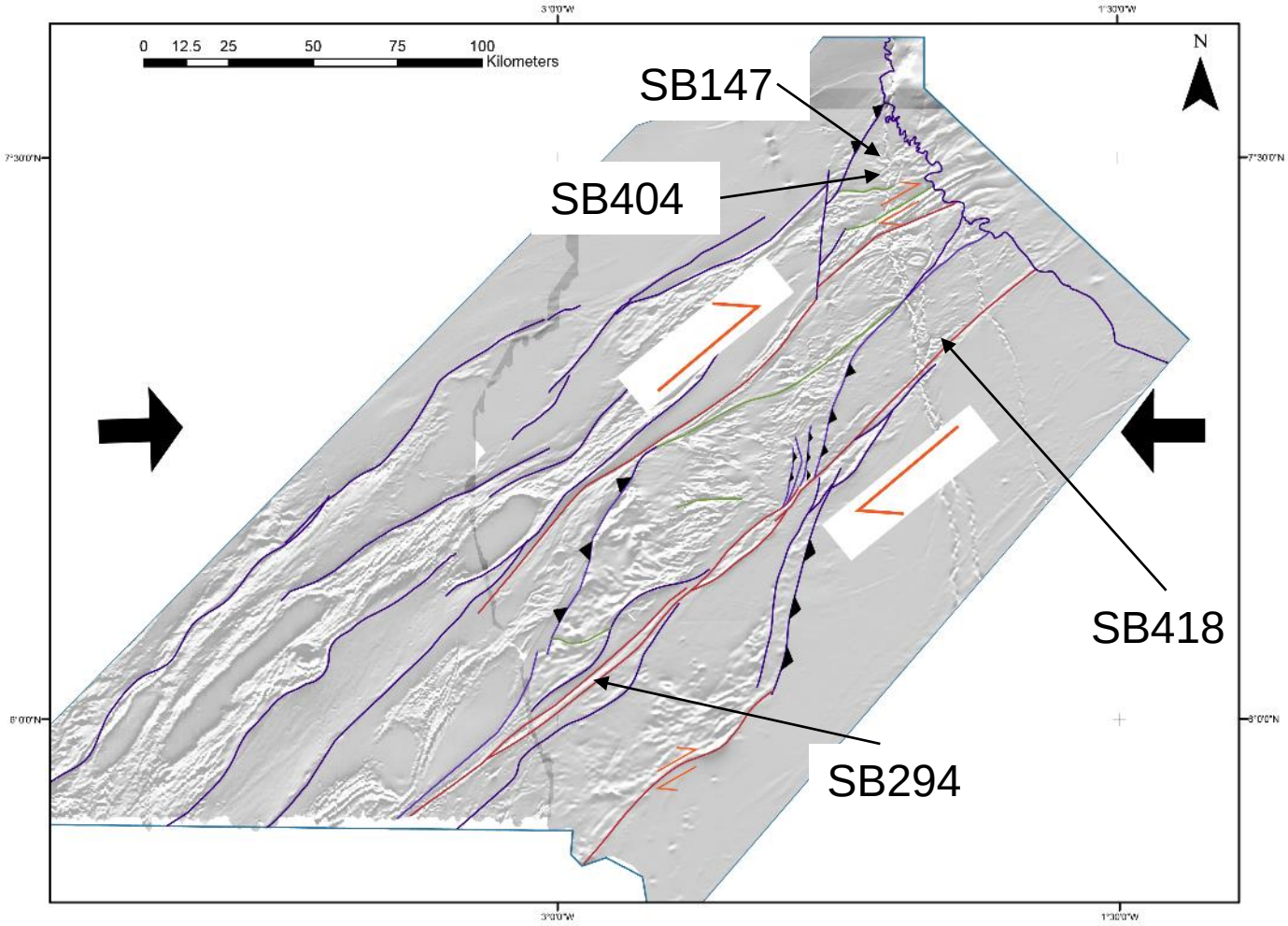
From Fossen et al 2013

Fold superposition during progressive transtension.
NB Pencil on subhorizontal L2 intersection lineation (10 → 250)

F2 10 → 230

D3/D4 E-W shortening

D3 – Refolding of F2s and reactivation of pre-existing D2 faults as thrusts



Late D3/4 continued strain localization along narrow high strain zones

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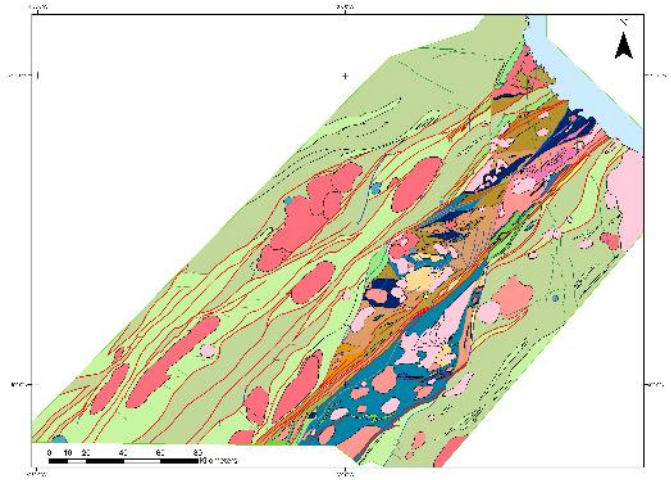
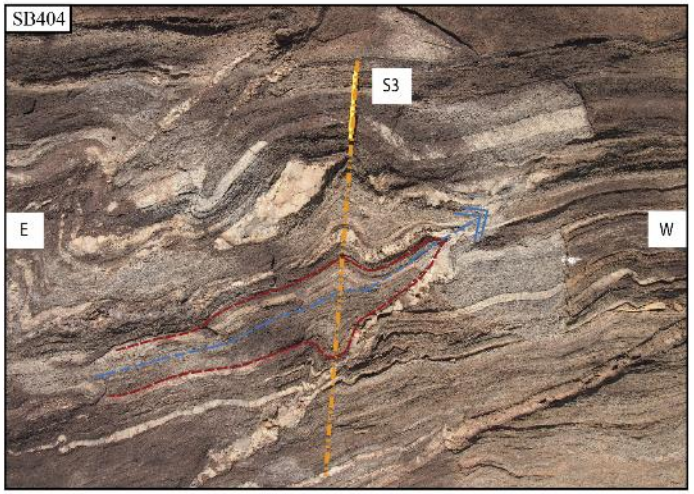
Structural observation: D3 /4

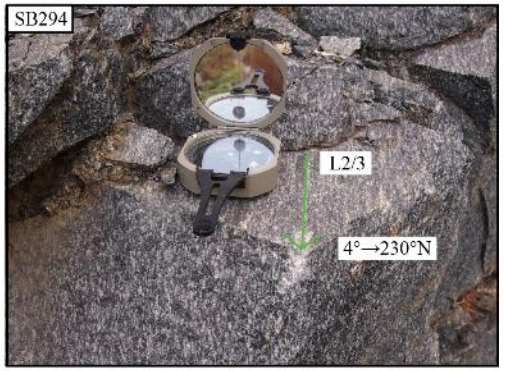
N-S upright F3 folds overprint E-W folds

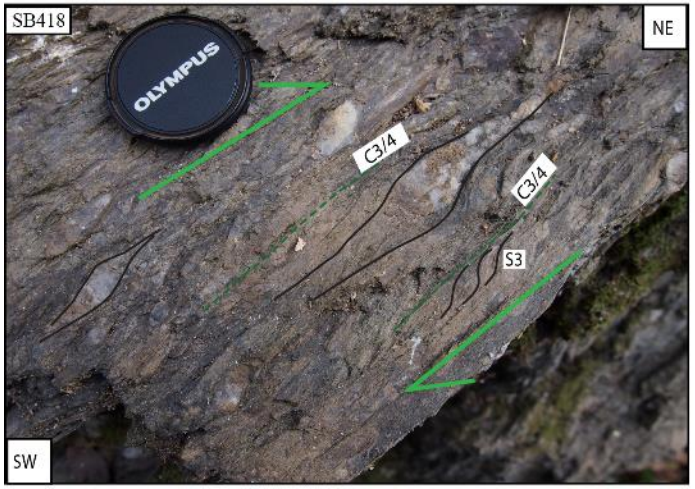
S3 defined by N-striking crenulation cleavage
and NE-SW striking S-C3/4 fabric in shear zones

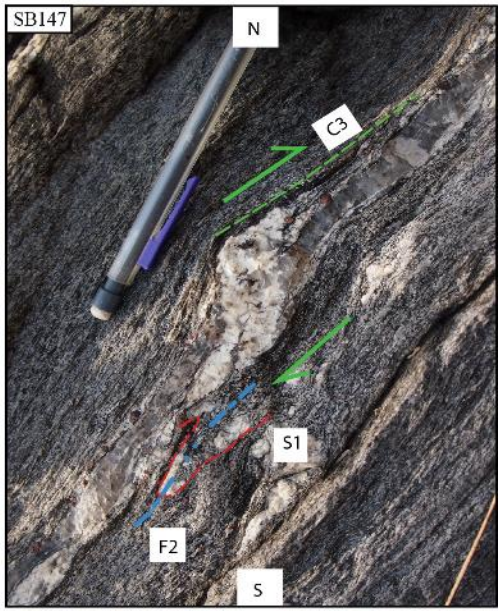
L-tectonites and S-C_3 fabrics











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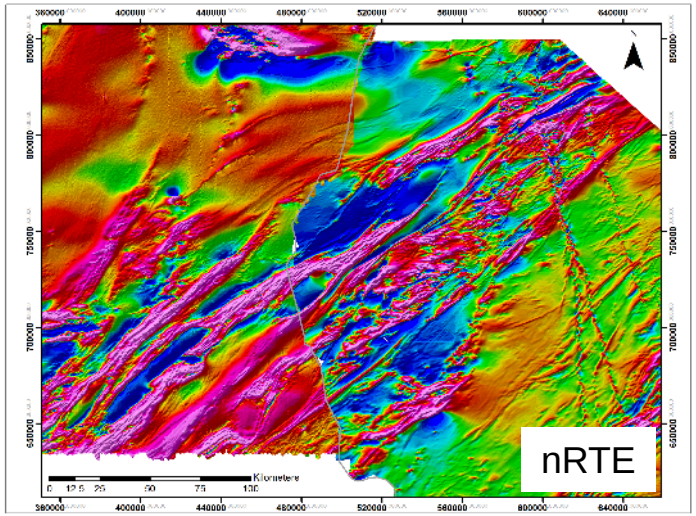
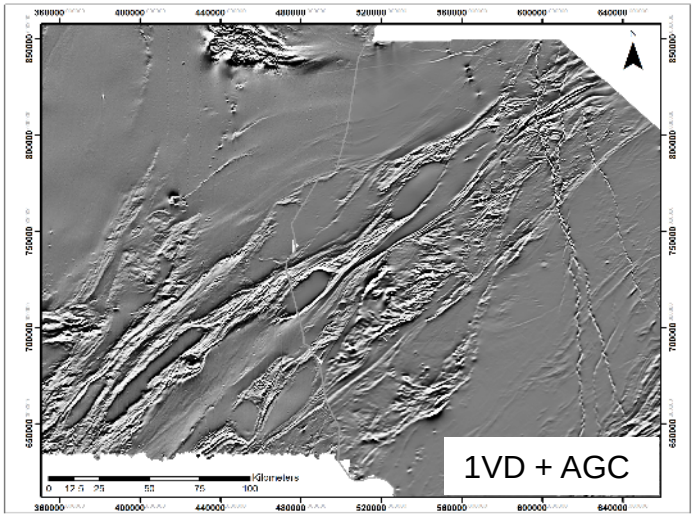
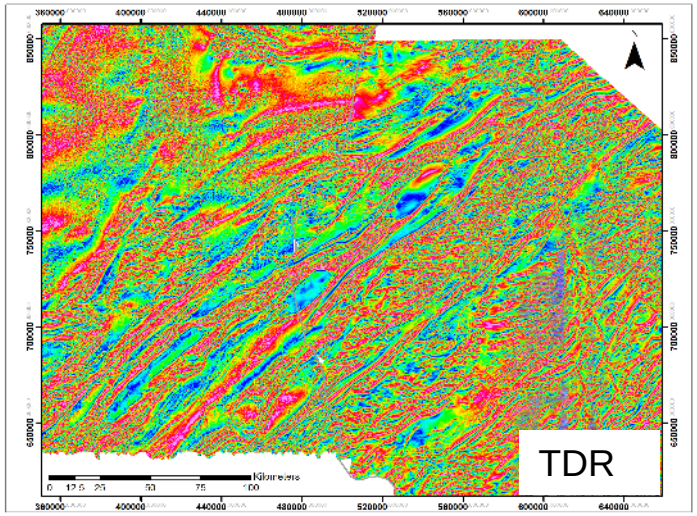
Regional data sets

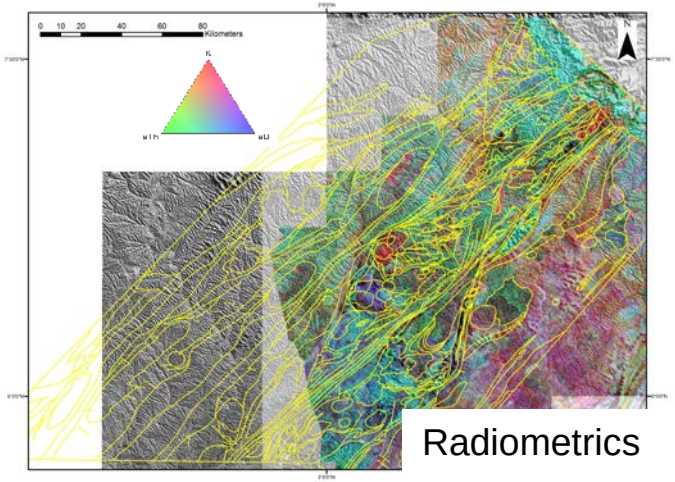
Regional geophysical datasets used to interpret the regional scale structures

- 484 outcrop localities
- Newmont and Kinross outcrop databases
- Measurements of the petrophysical properties of the major lithologies









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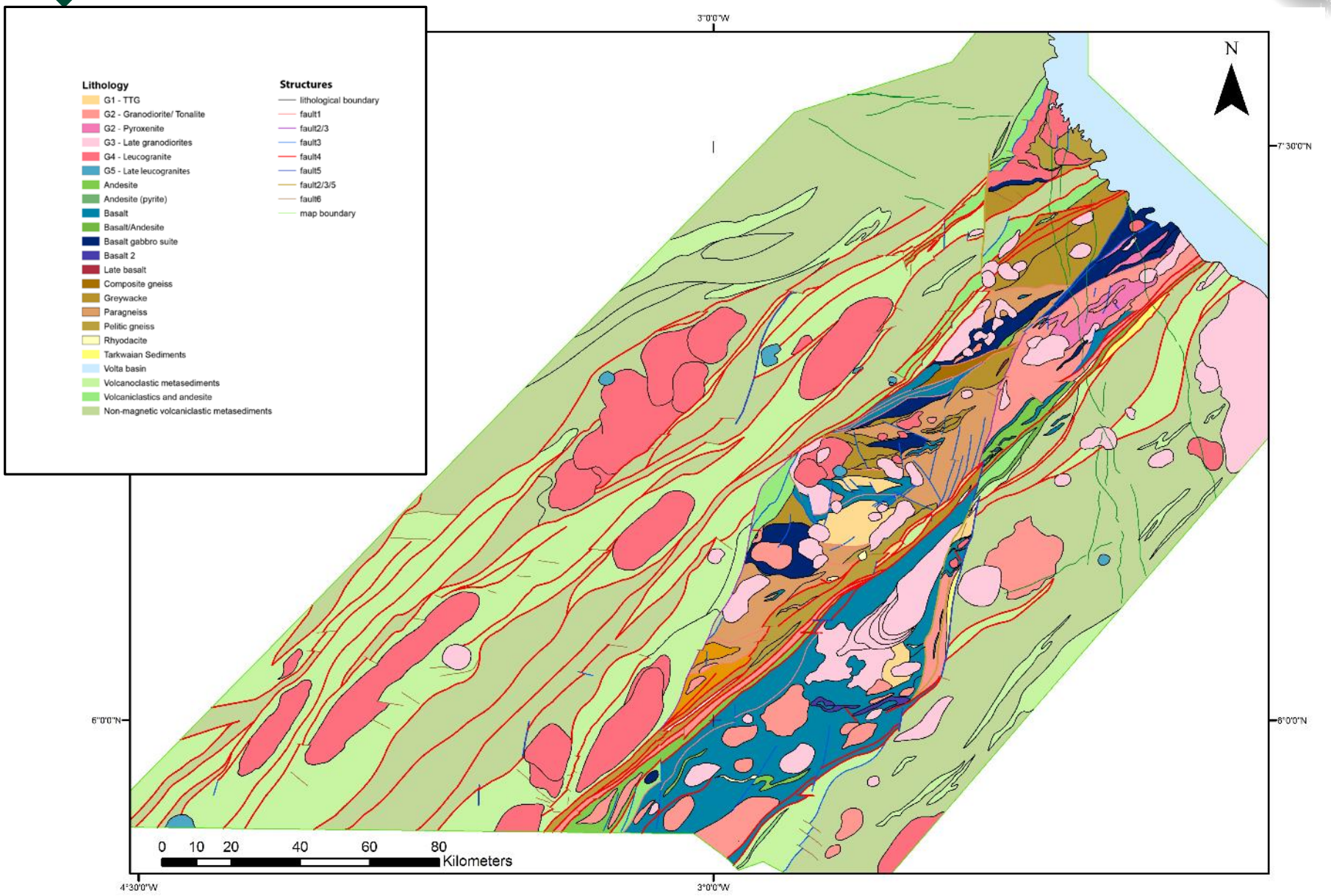
Litho-structural map



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Structural and metamorphic evolution

- D1 Early gneissic or layer parallel foliation
  - Burial of supracrustal rocks during crustal thickening

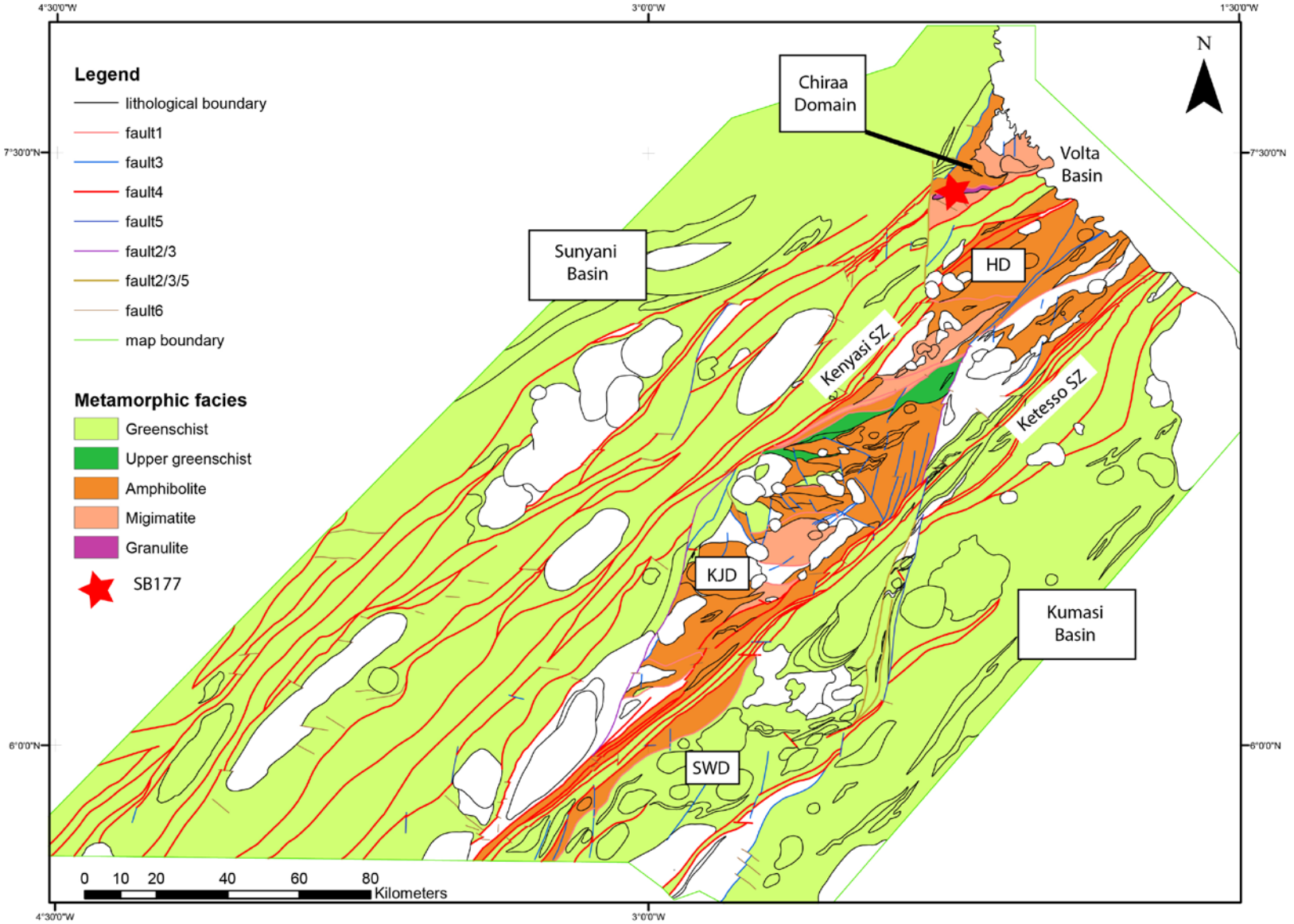
- Anatexis: Late D1 to syn-D2

- D2 ENE-WSW transtension (with NNW-SSE shortening event)
  - Tight, upright to inclined E-W to ENE-WSW F2 folds and oblique thrust faults
  - Prominent elongation along F2 fold axes (L2 subparallel with F2)
  - Oblique sinistral reverse movement on major shear zones
  - Amphibolite facies conditions

- D3/D4 E-W shortening event (D3)
  - Regional, narrow, NE-SW high strain dextral shear zones
  - Local NE-SW S4-C fabrics, including transposition early structures
  - GS facies metamorphic overprint
  - Reactivation of D2 faults as reverse faults

- D5 Late NNE-SSW strike slip faults with apparent sinistral displacement

Metamorphic map



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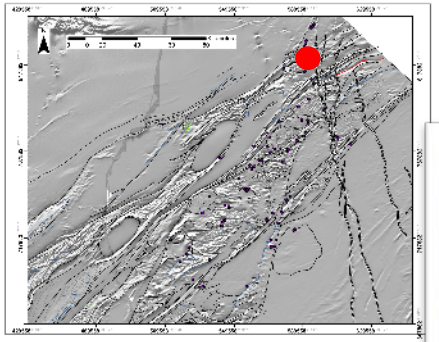
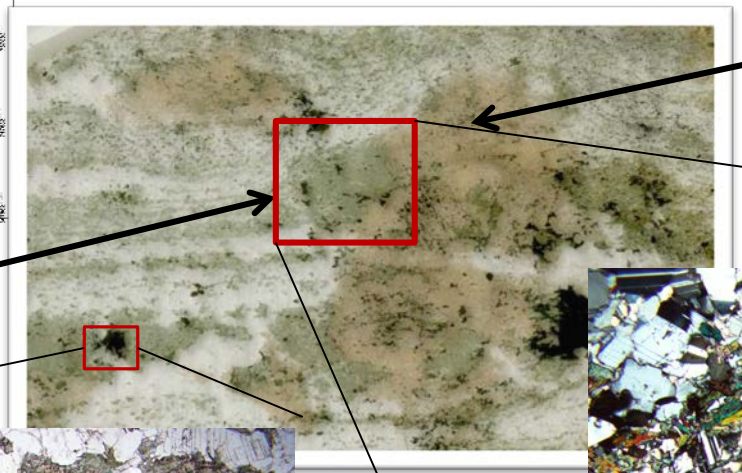
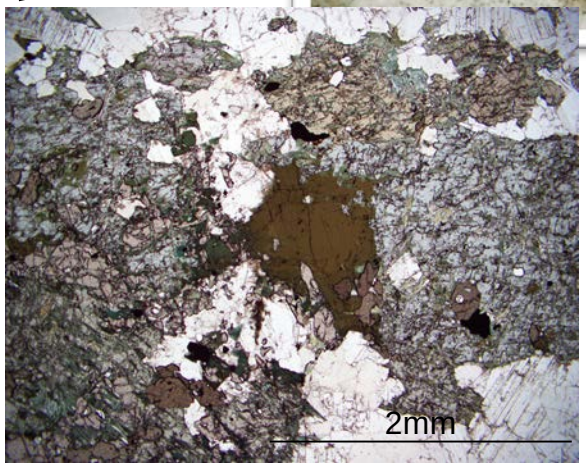
SB177: Mafic Granulite

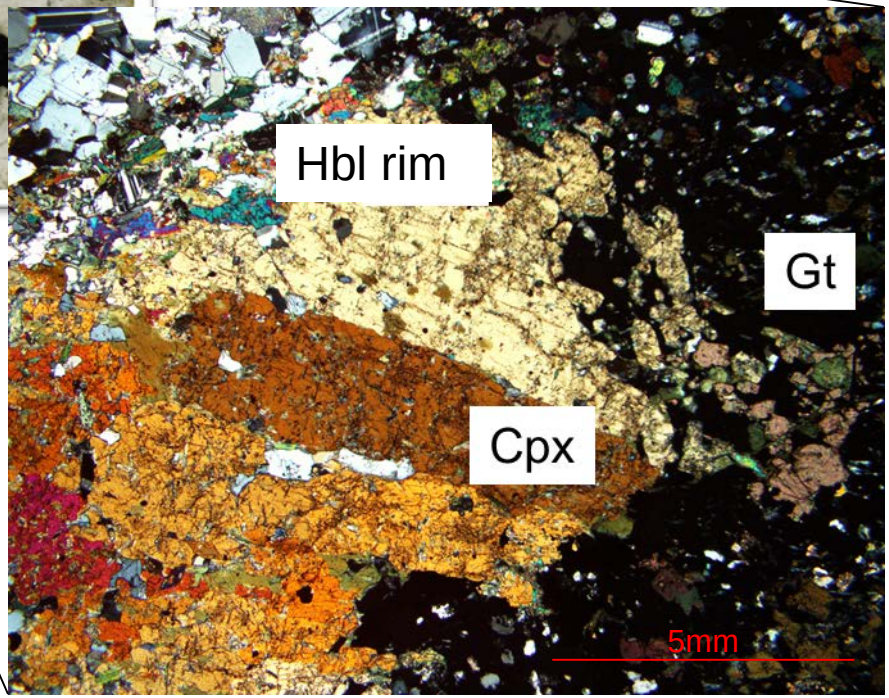


Peak assemblage: Cpx + Pl + Gt + Spn(Tnt) ± Qtz + melt





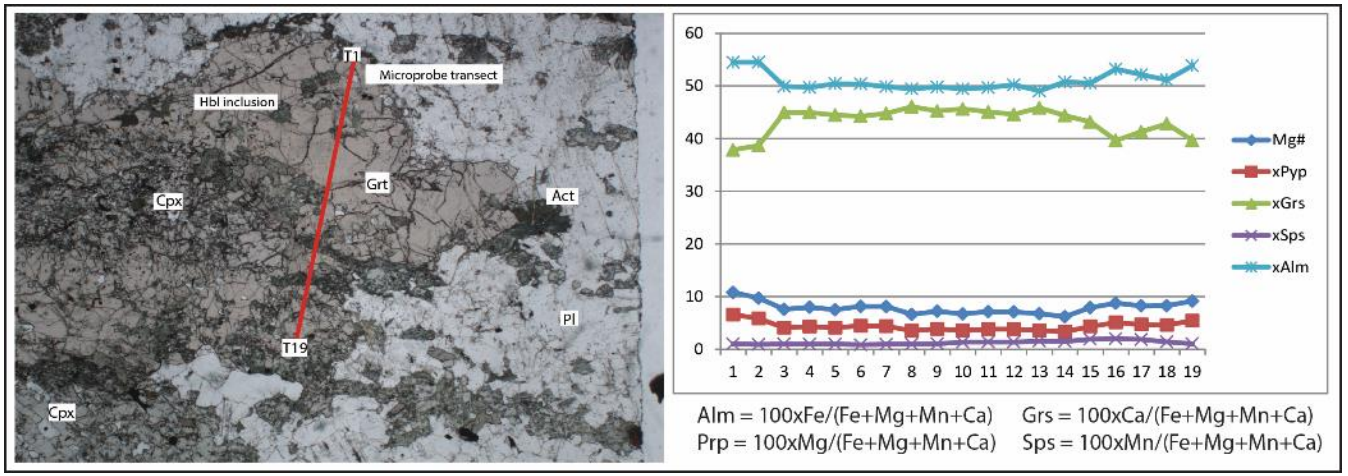
Hbl in boudin neck of Cpx
= Retrogression

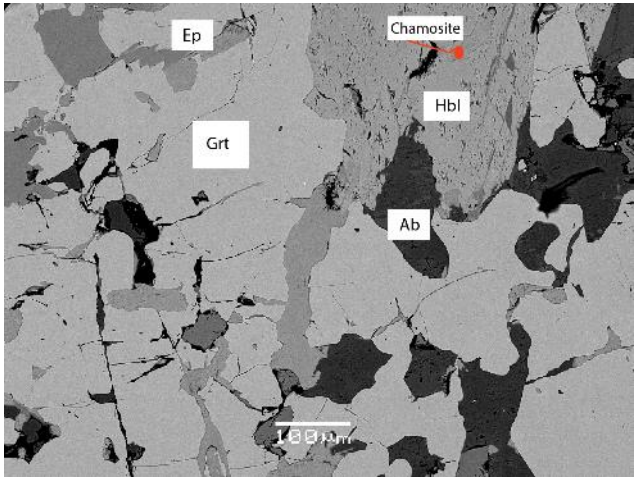


High T shearing: Cpx in strain shadow of garnet porphyroblast

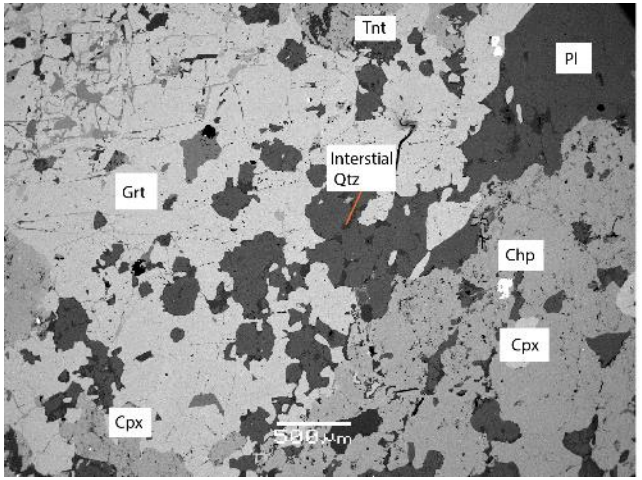
Pseudosection constraints

Radial transect of Grt porphyroblast showing chemical composition variation





a) BSE image showing M1e greenschist to amphibolite facies assemblage preserved in Grt core inclusions



b) BSE image of rim of Grt porphyroblast intergrown with Pl and in contact with Cpx porphyroblast in leucosome (peak assemblage)

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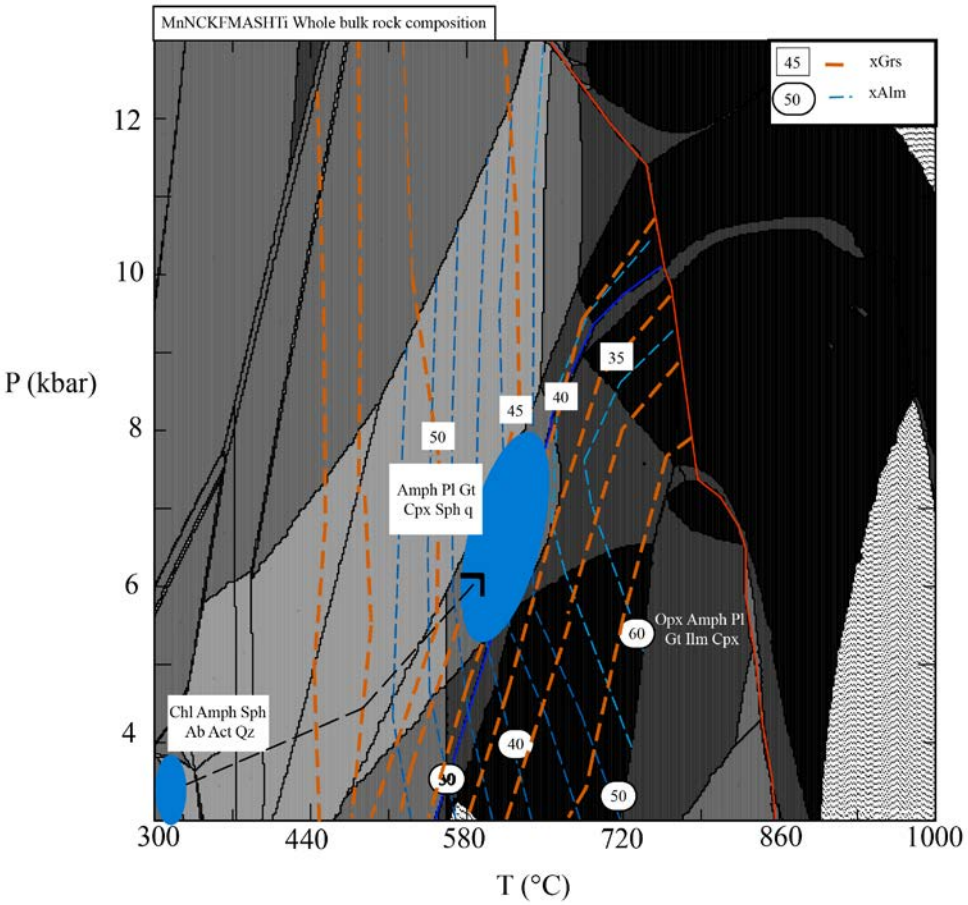
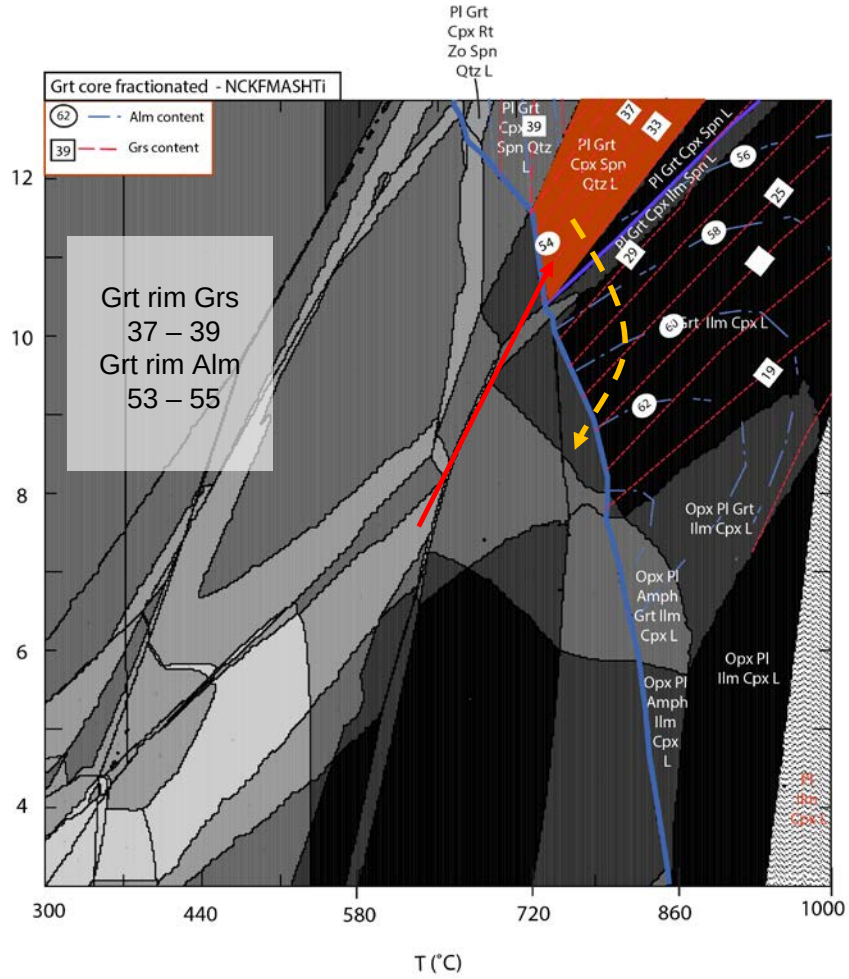
Preliminary pseudosections

a) Prograde path



b) Peak P-T after grt core fractionation



For mafic granulites at P >10kbar, reaction (R1) Hbl + Pl + Qtz = Grt +Cpx + L

(Pattison et al. 2003)

Key findings:

- Peak metamorphic conditions of buried supracrustal rocks in belt record anatexis at 10 – 12 kbar, 700 - 800°C → associated with major crustal thickening D1
- Exhumation of high grade rocks eg. mafic granulite during D2 transtension
- Three major, discreet tectonic events produced the regional architecture of the Sefwi belt.
  - D1 - crustal thickening driven by external tectonic forces
  - D2 - transtensional event
  - D3 - transpressional event
- Tectonic juxtaposition of high grade rocks and greenschist facies lithologies prior to regional shearing (D4)
- First evidence of exhumation by transtension proposed for WAC during the Palaeoproterozoic

Context within western Ghana

- Results show contrasting strain regimes, metamorphic histories and exhumation methods records in WAC greenstone belts

  - Signinficant D1 crustal thickening evident in both Sefwi (this study) and Wa-Bole regions (eg. Block et al., 2015)

  - D1/2 early fabric recognised in Sefwi Group in Ashanti belt (Allibone et al, 2002; Perrouty et al. 2012) and in this study

  - New exhumation mechanism proposed for high grade rocks in Sefwi belt – transtension (extension axis ~90° to that in NW Ghana)

  - Ashanti belt shows prominent NW-SE shortening in D3 and subsequent sinistral reactivation of the Ashanti fault (Perrouty et al. 2012), where D3 is represented by long lived E-W shortening, however timing unconstrained thus far.

Acknowledgements

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