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

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Paleoproterozoic Baoulé-Mossin domain in the southern portion of the West African Craton (modified after Milési et al. 2004, BRGM SIGAfrique).
Magmatic accretion of the juvenile crust of the WAC (~2.20 – 2.15 Ga)

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)
Field Observations – D1

D1 Crustal thickening event

$S_1$ Bedding-parallel metamorphic foliation in schists, paragneisses
D2 transtension

Structural domains of the belt show close relationship between L2 and F2
Field observations - D2

D2 ENE-WSW sinistral transtensional event

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

\[ \text{F2 approx.} = \text{L2 mineral stretching lineation} \]
Further evidence of transtension

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

F2 10 → 230

From Fossen et al 2013
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
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-C₃ fabrics
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
Litho-structural map
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
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

Gt porphyroblast

Cpx

Hbl rim

Cpx

Gt
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 PI and in contact with Cpx porphyroblast in leucosome (peak assemblage)
Preliminary pseudosections

a) Prograde path

b) Peak P-T after grt core fractionation

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

(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
  
  • Significant 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.
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References


BLOCK S., et al. 2015 Petrological and geochronological constraints on lower crust exhumation during Paleoproterozoic (Birimian) orogeny, NW Ghana, West African craton.


