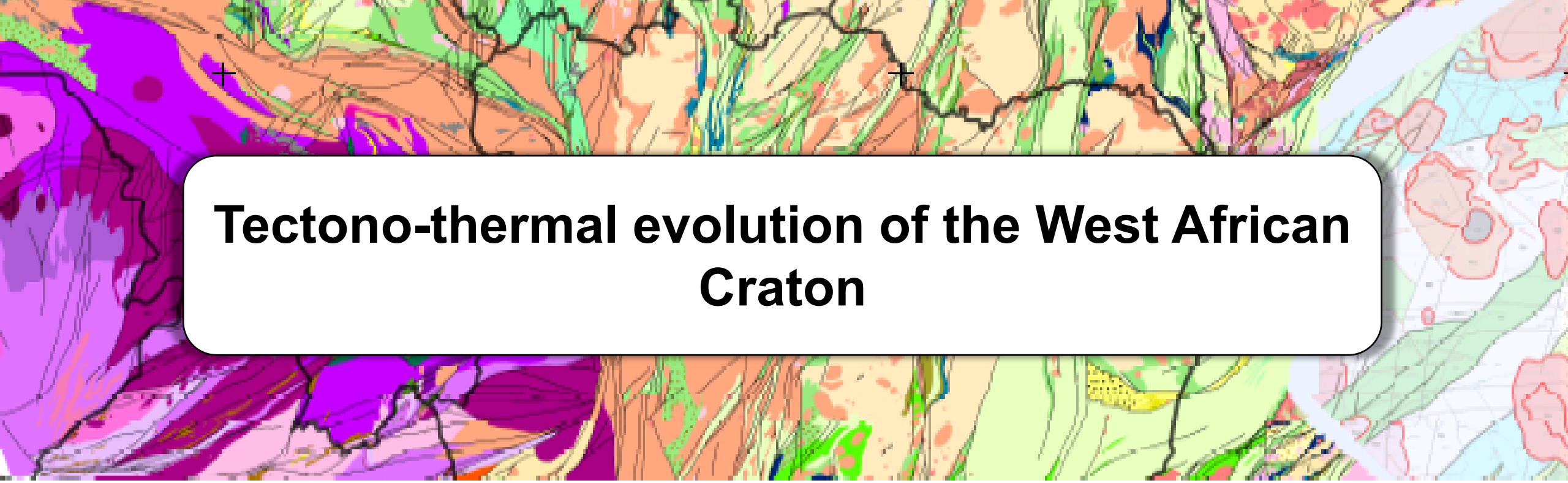


Tectono-thermal evolution of the West African Craton

Lenka Baratoux,
M.W. Jessell, S. Naba, Y.A. Koffi, A.N. Kouamelan, V. Metelka, P. Pitra, O. Vanderhaeghe, J. Miller, Q. Masurel, S. Perrouty, J. Kone, M. Diallo, H. McFarlane, S. Block and WAXI team

Université de Toulouse

WAXI West African Exploration Initiative

Institut de Recherche pour le Développement FRANCE

GET

UFR STRM

Université Félix Houphouët-Boigny

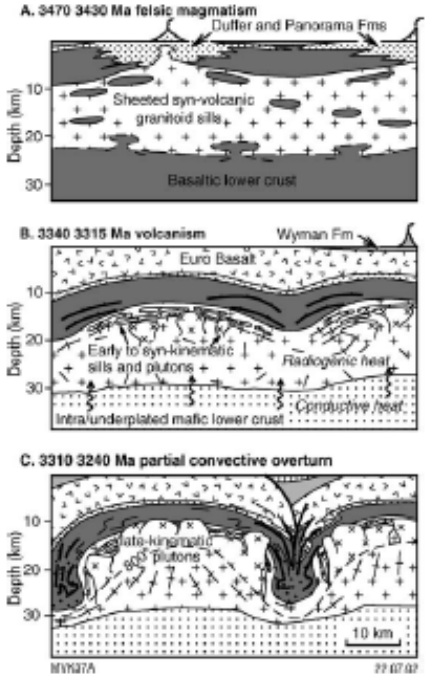
Sigillum Universitatis Dakarensis

The University of Western Australia

Centre for EXPLORATION TARGETING

Laurentian University / Université Laurentienne

Introduction – Precambrian geodynamics



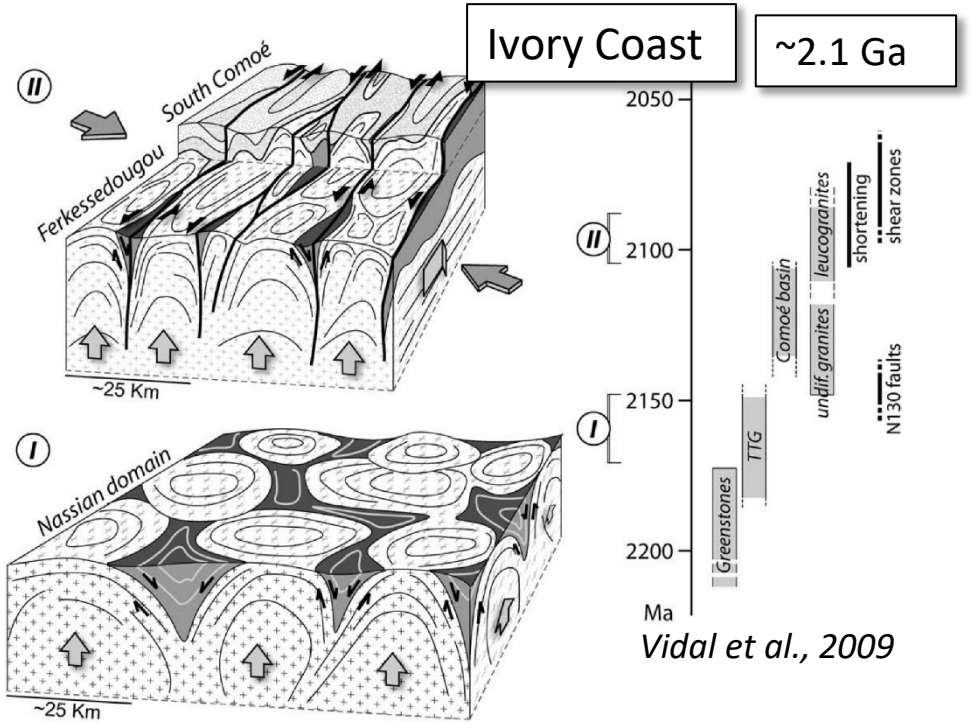
Pilbara, Australia

~3.4 Ga

Onset of the "modern" plate tectonics?

How was the tectonic style before it became "modern"?

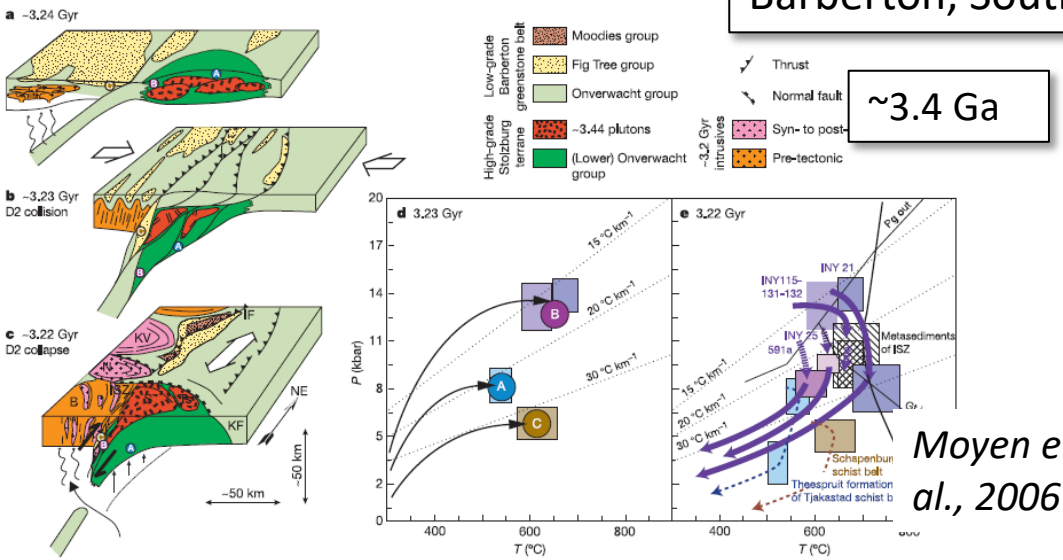
Van Kranendonk et al., 2004



Vidal et al., 2009

Barberton, South Africa

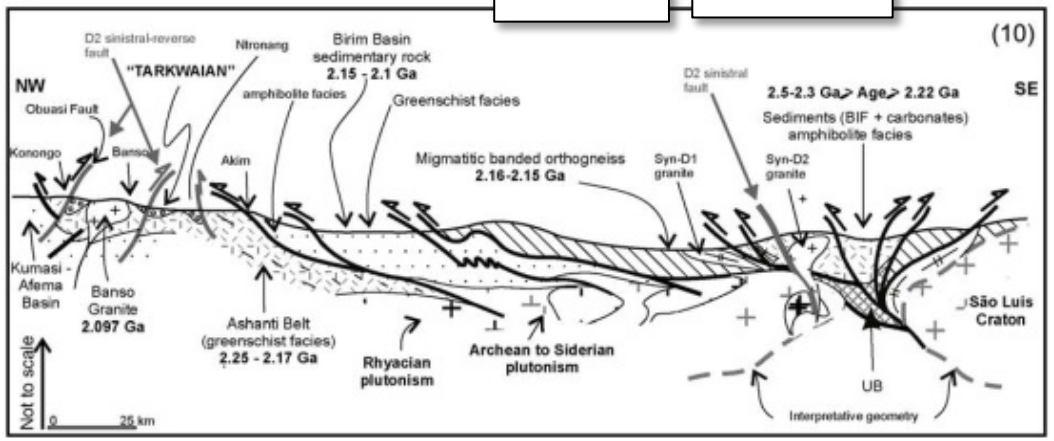
~3.4 Ga



Moyen et al., 2006

Ghana

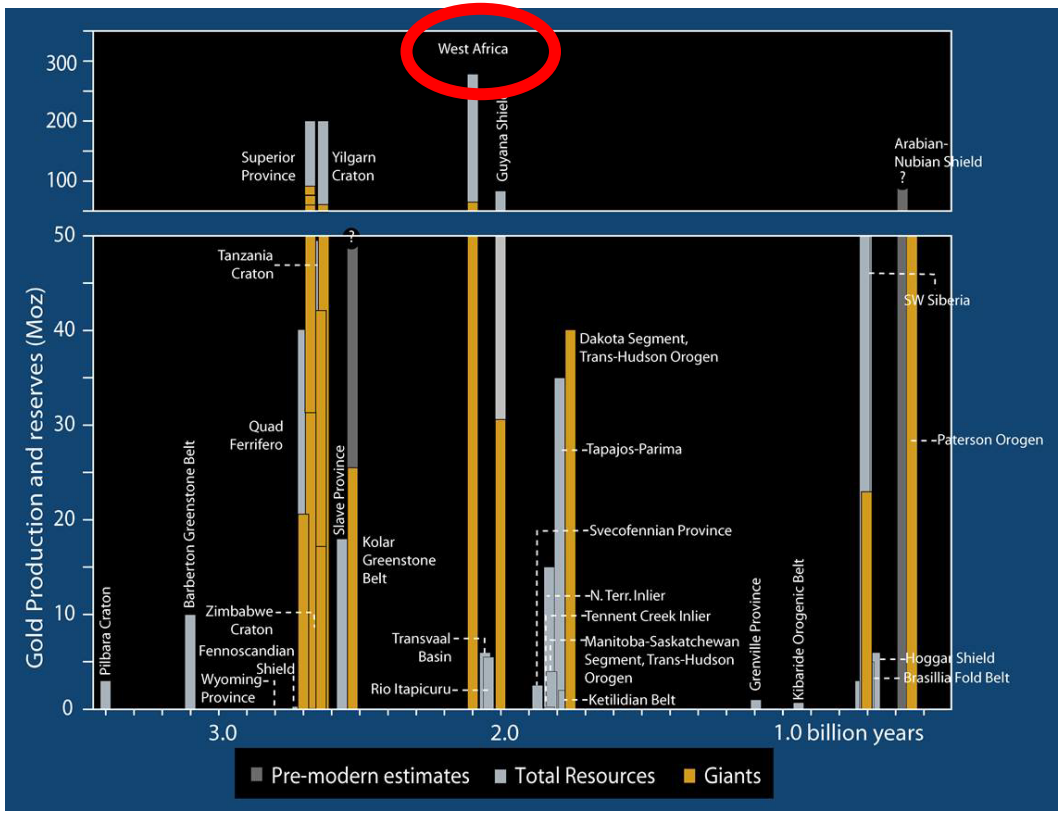
~2.1 Ga



Feybesse et al., 2006

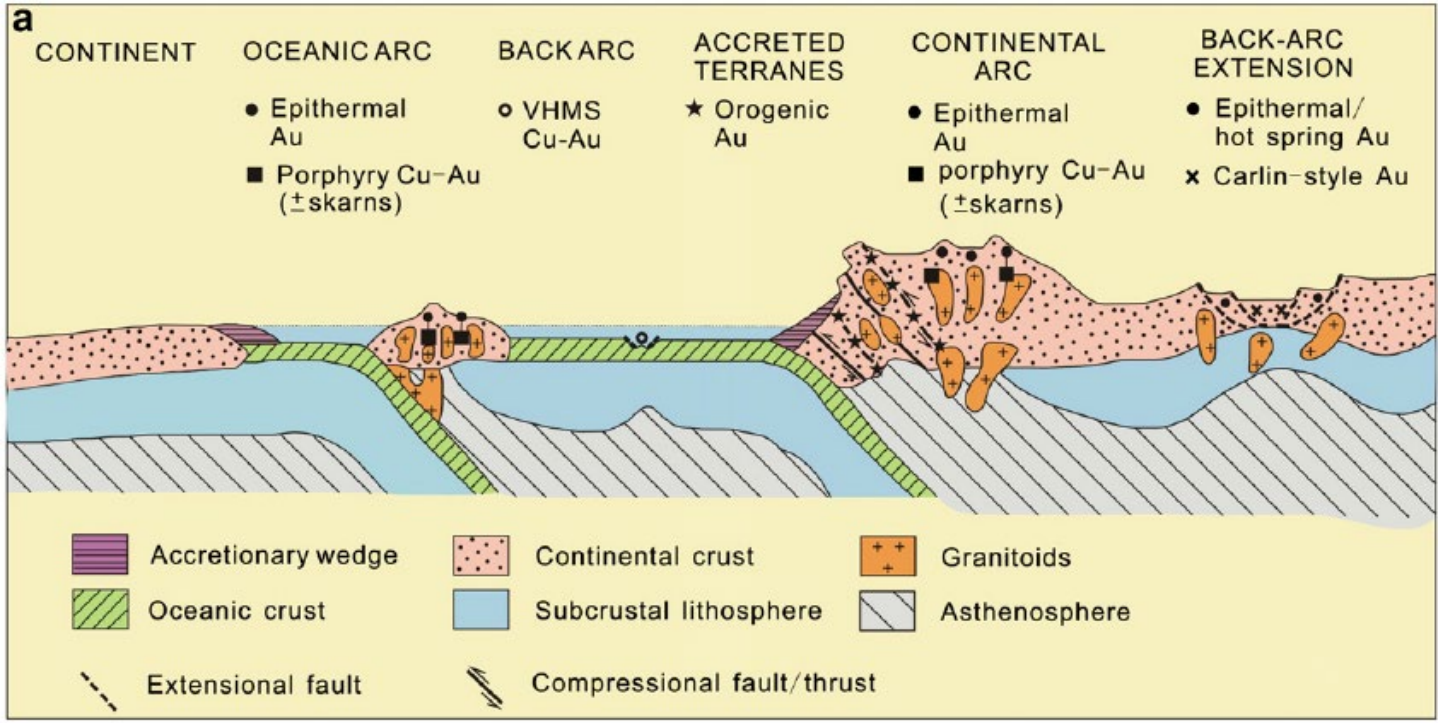
Introduction – Geodynamic setting and mineral deposits

Orogenic gold provinces through time



Goldfarb (2005)

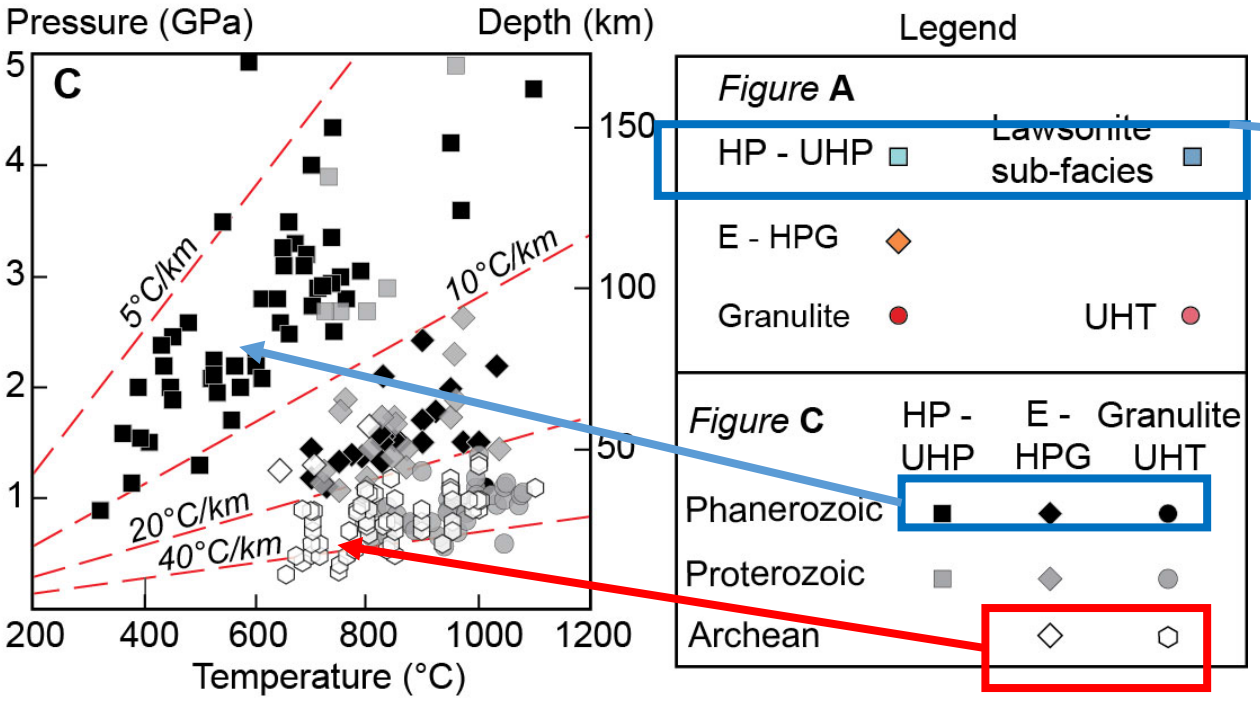
Geodynamic settings for various gold deposits



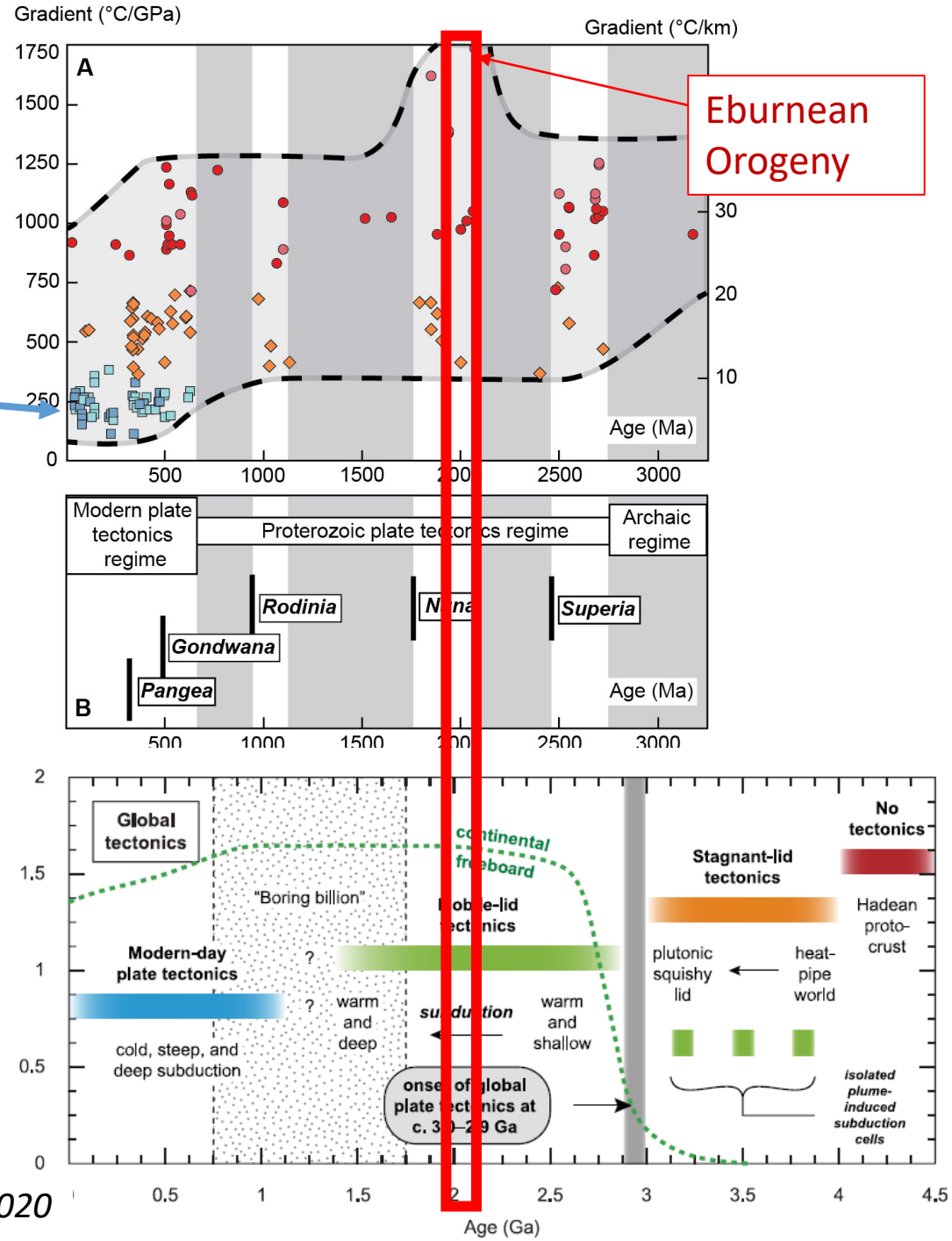
Groves et al., 2003

Introduction – Secular evolution of the Earth

Metamorphic grade

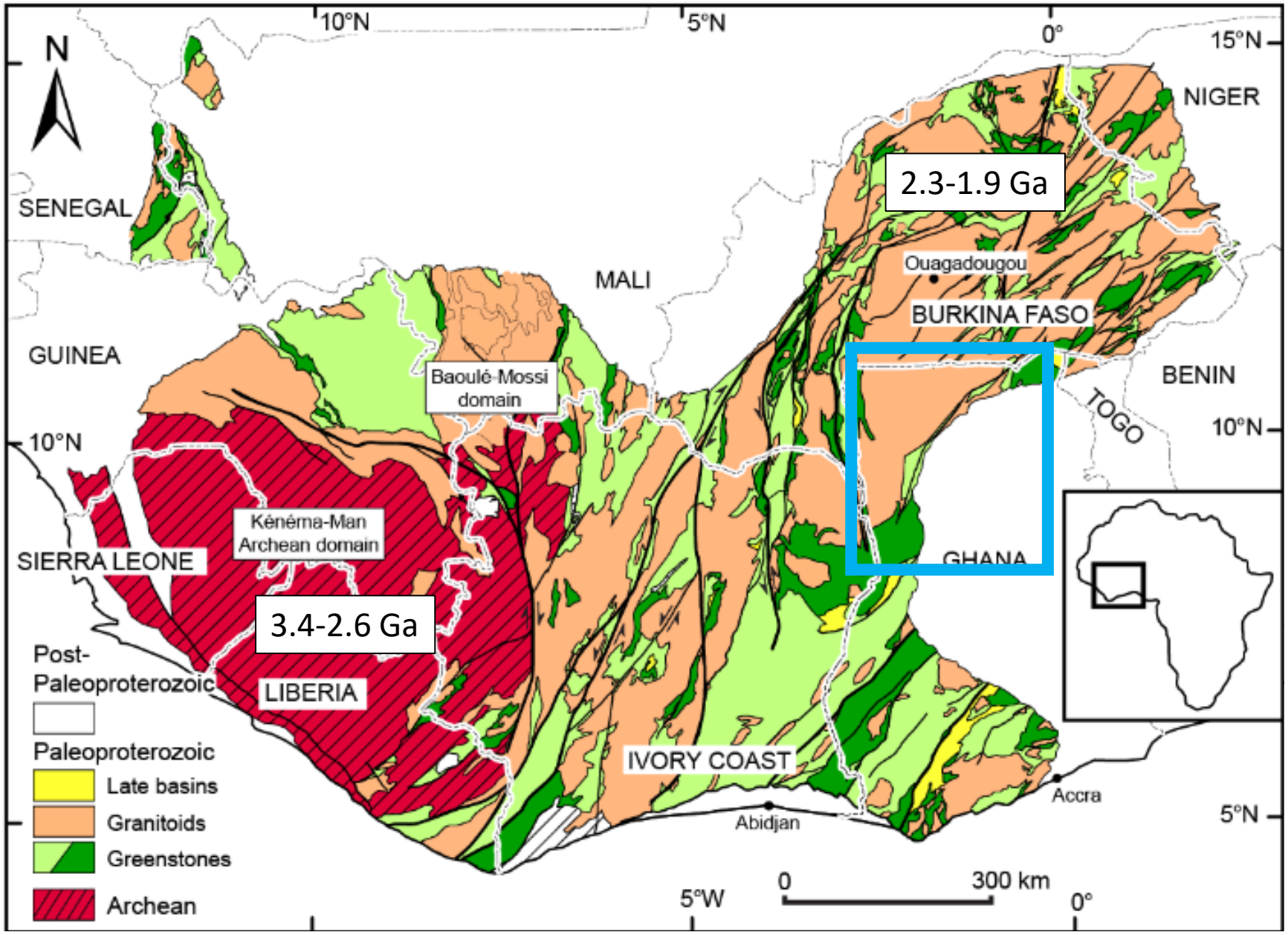


Brown, 2007



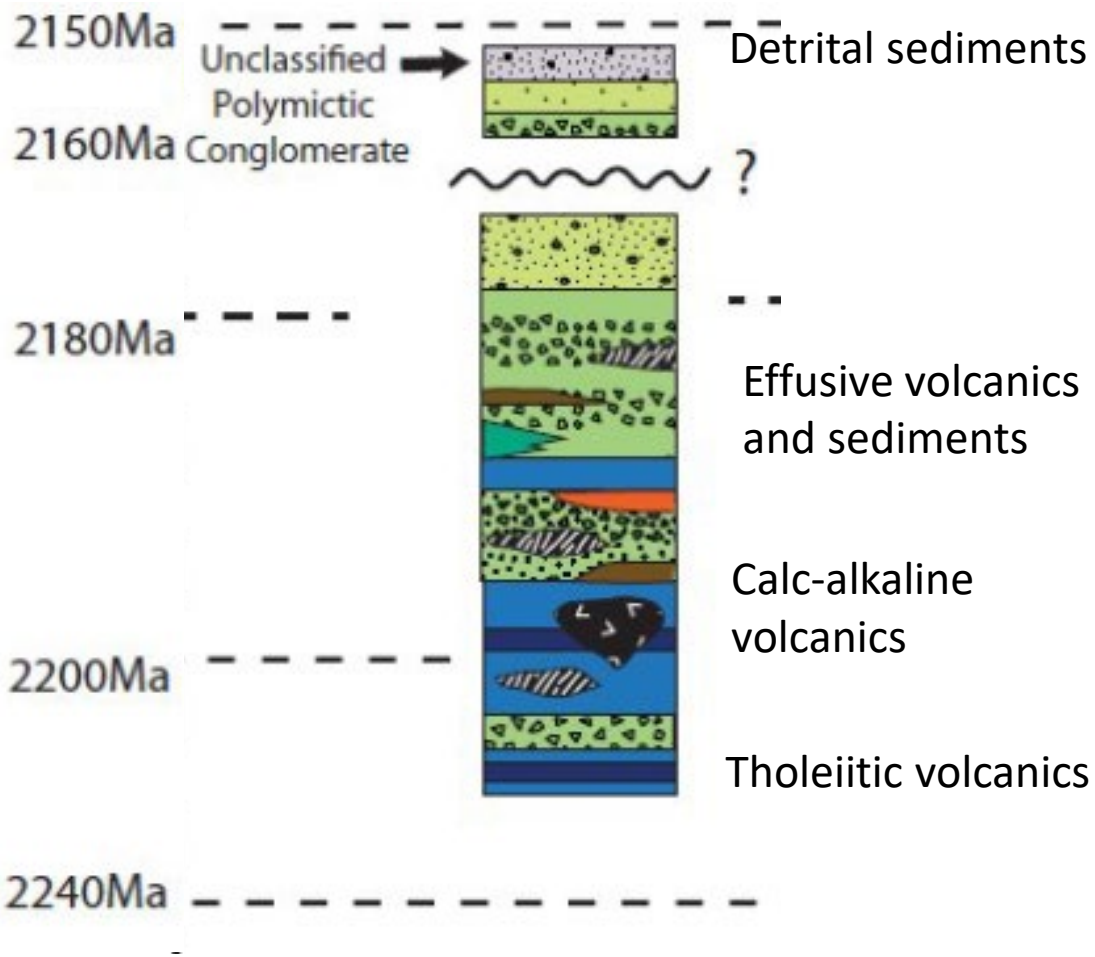
Palin et al., 2020

Paleoproterozoic terrains – example of NW Ghana

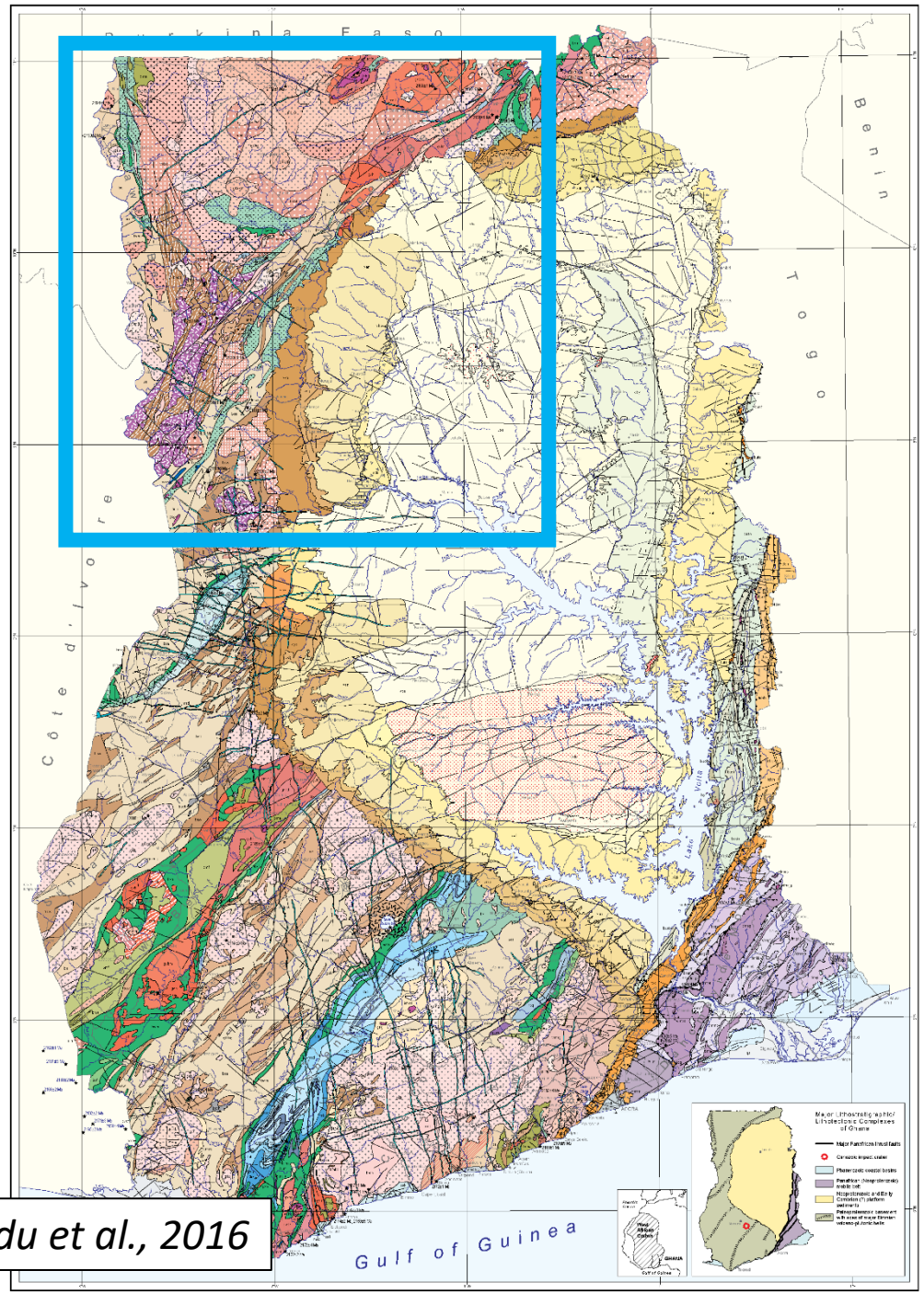


NW Ghana

Greenstone belts



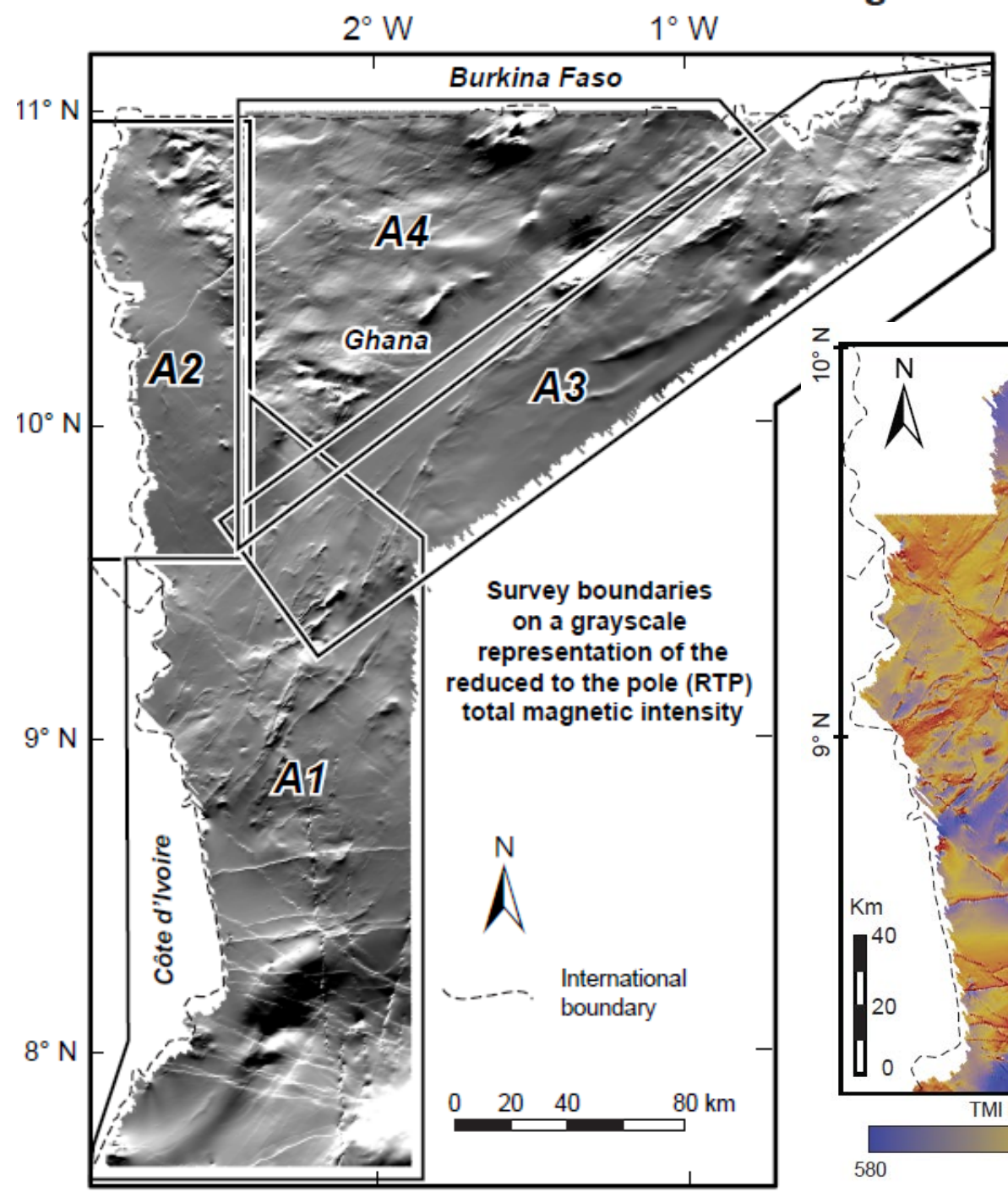
Block et al., 2016

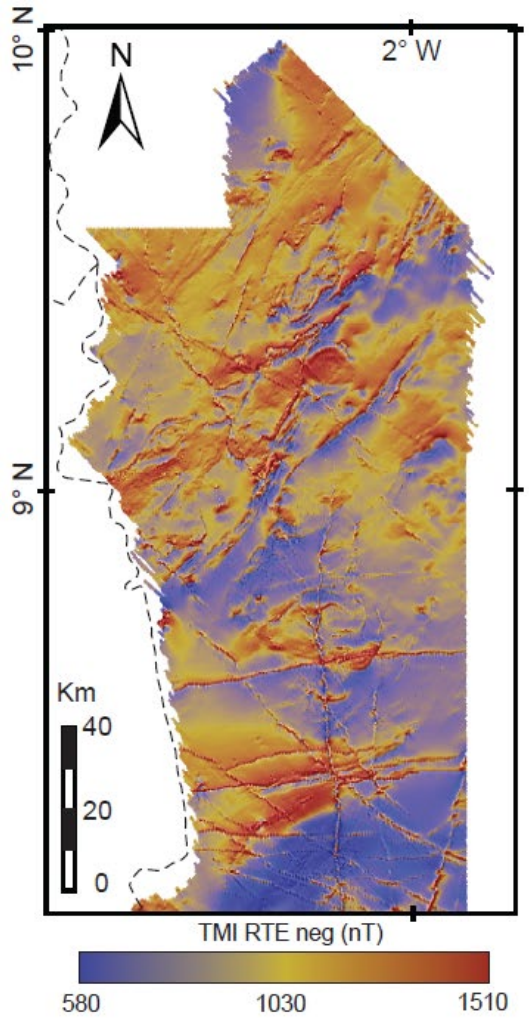


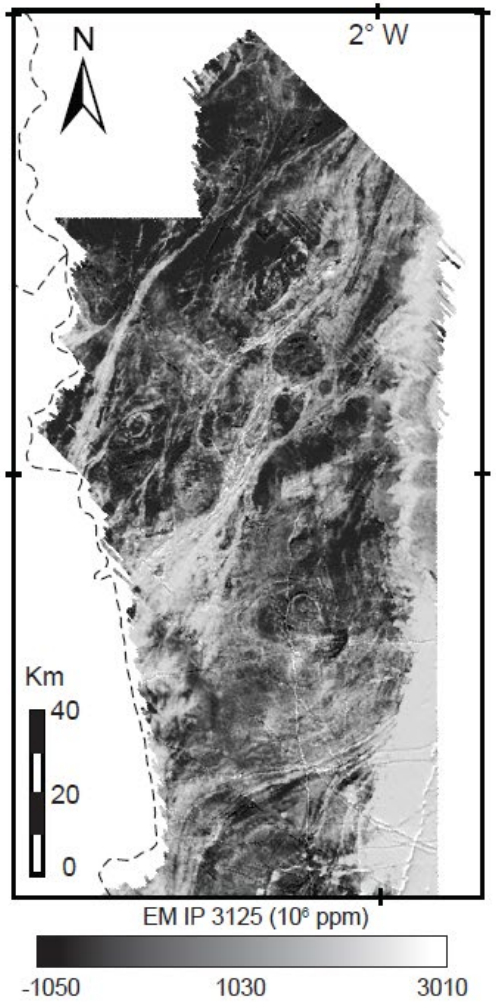
Agyei Duodu et al., 2016

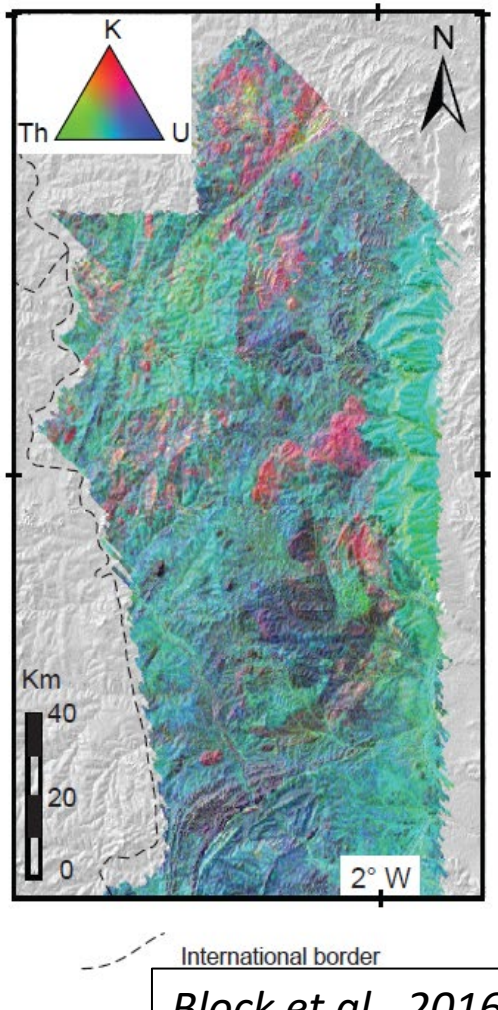
High resolution geophysical data – NW Ghana

Azumah Resources
flight height of 40 m and line spacing of 100 m



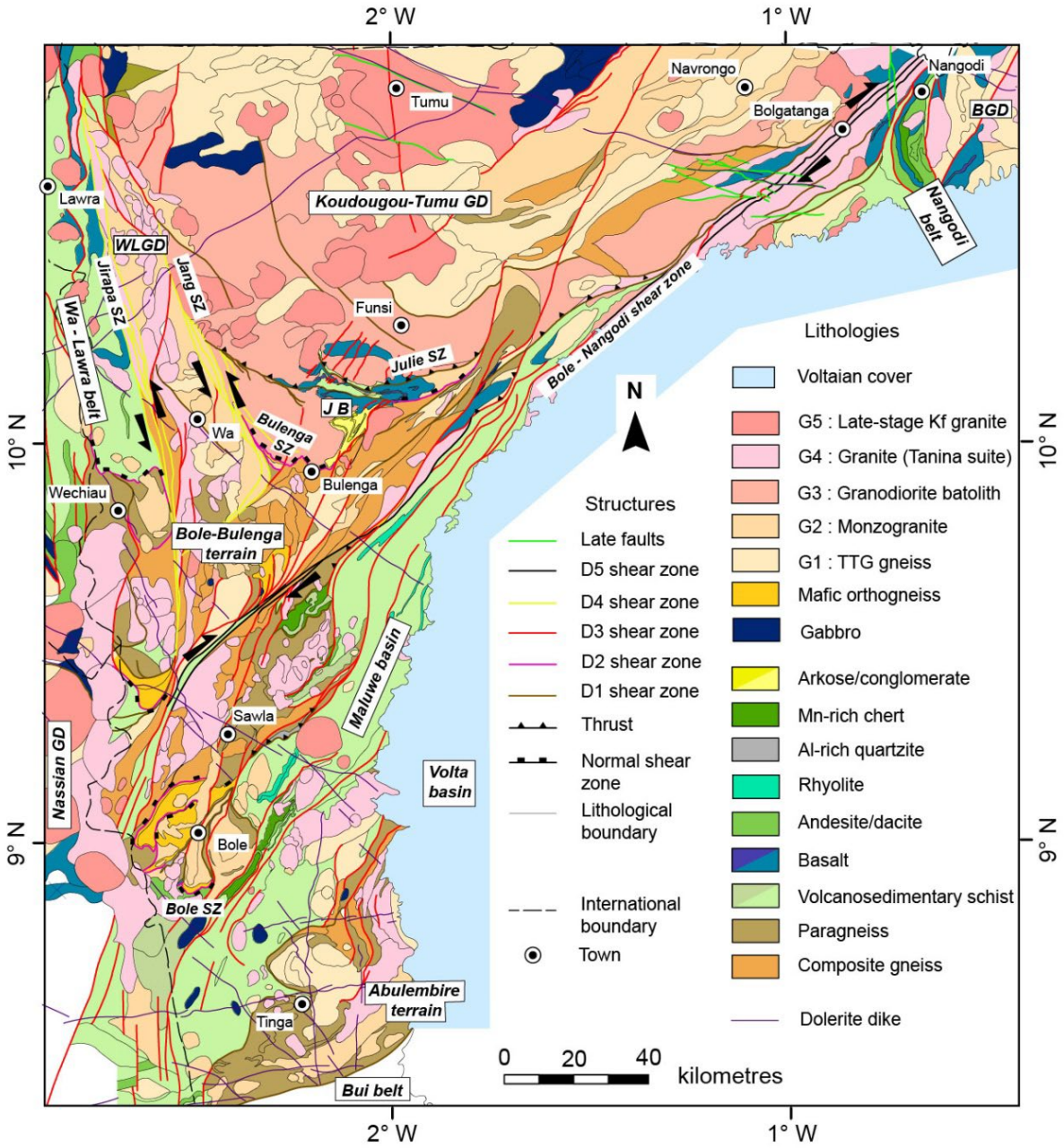






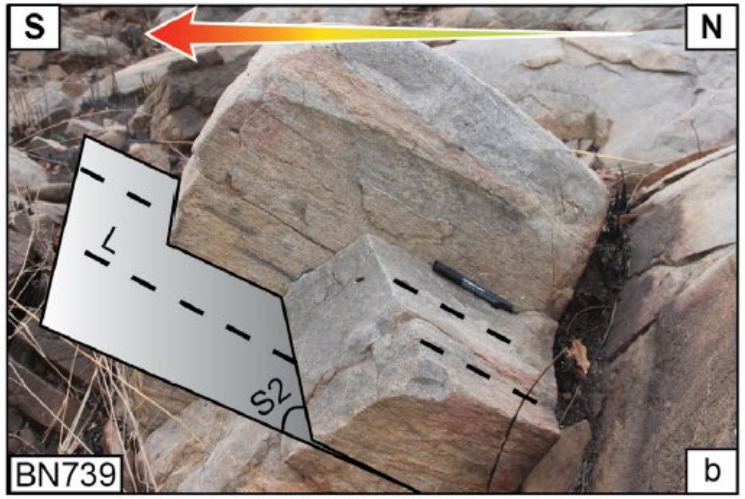
Block et al., 2016

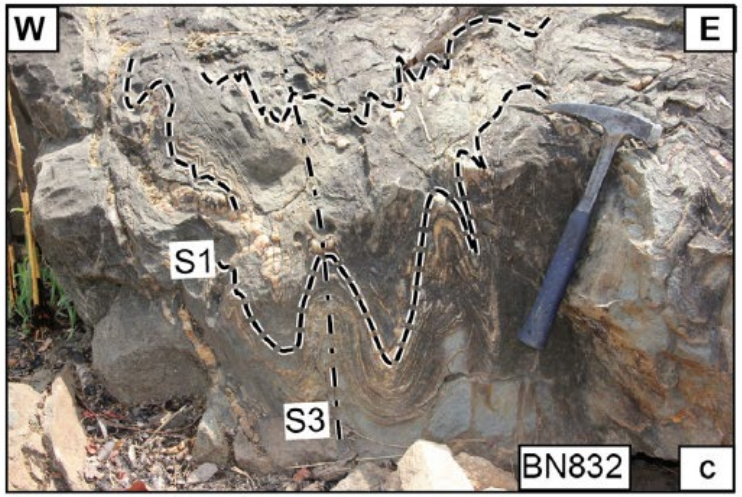
NW Ghana

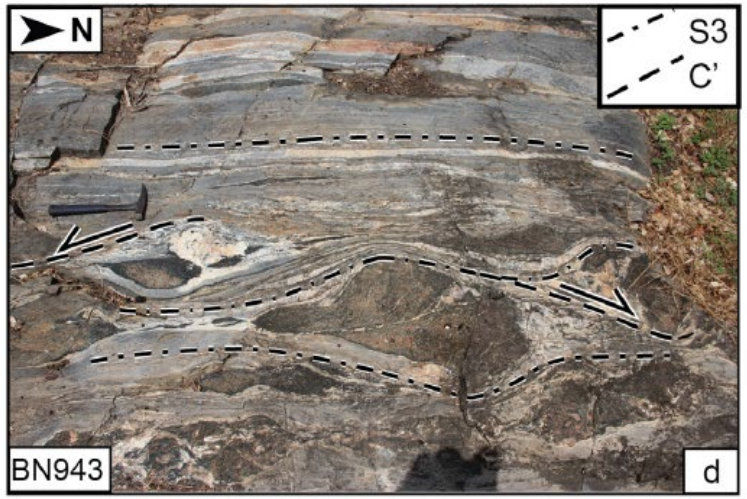


Block et al., 2016

Field structural data

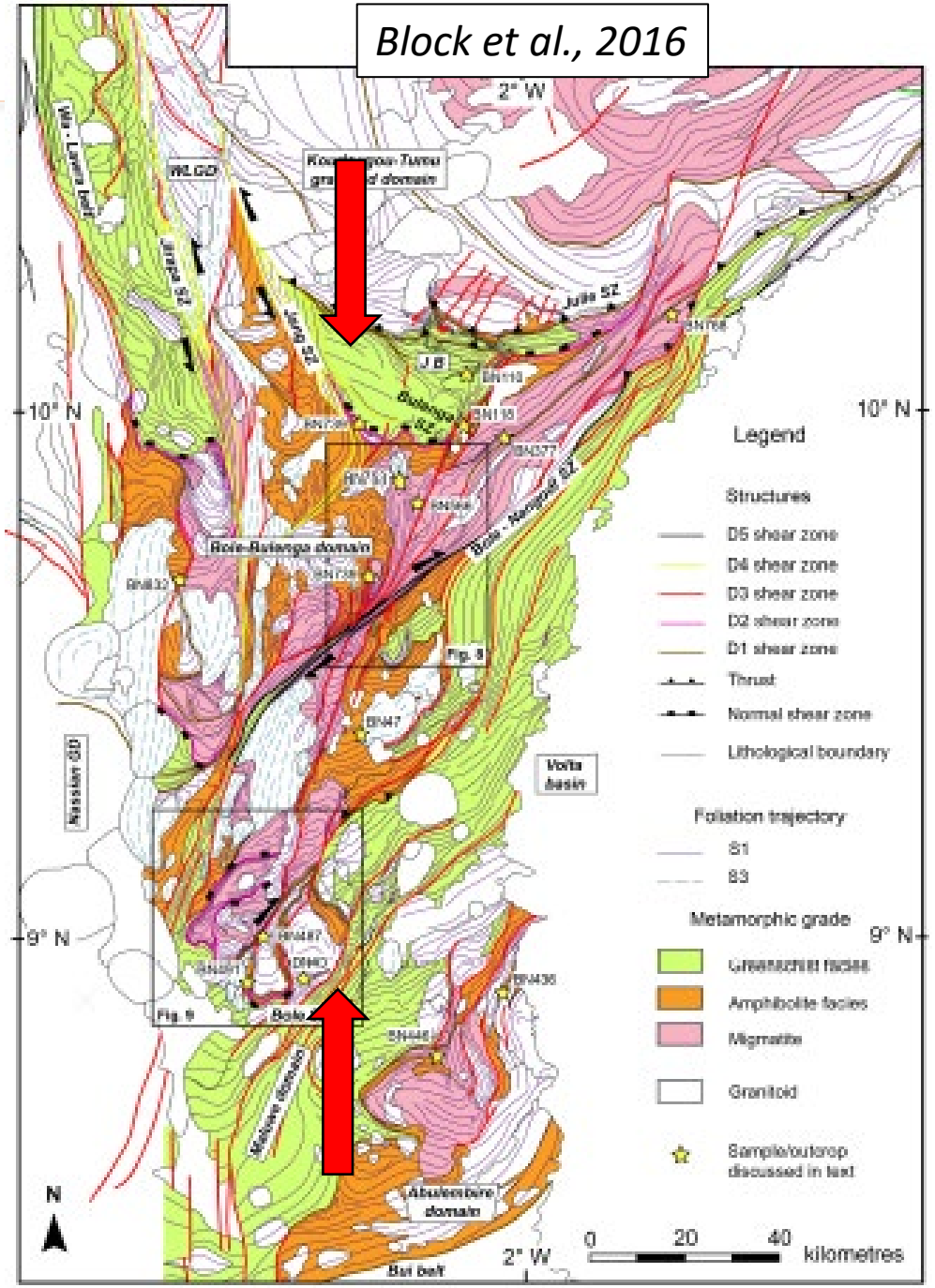




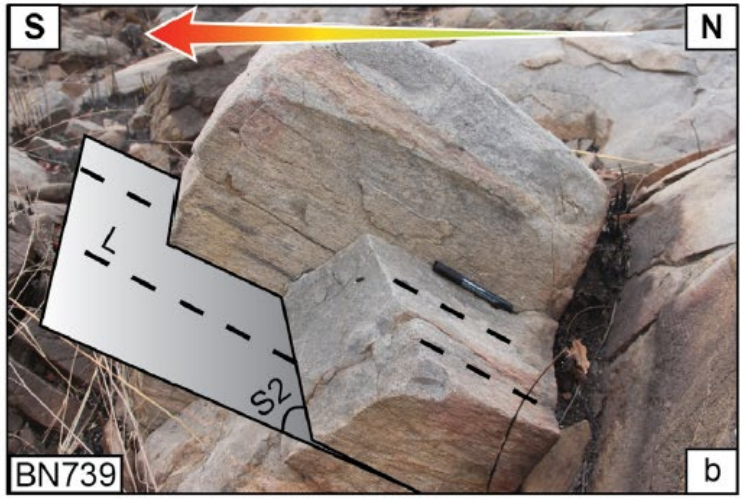


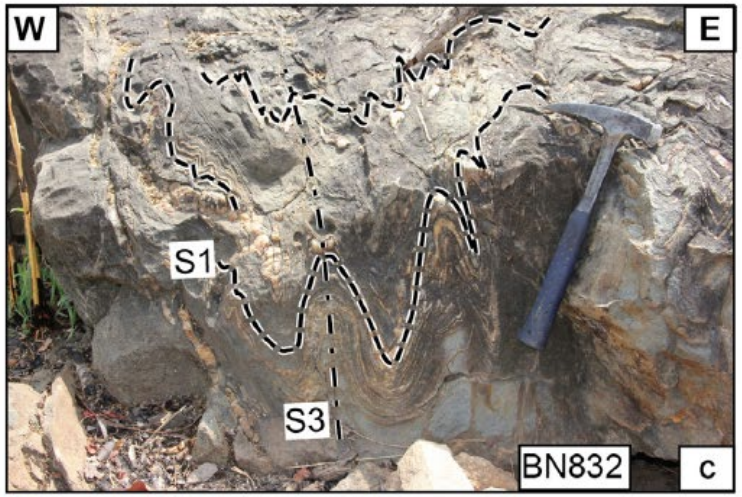
D1 – N-S shortening

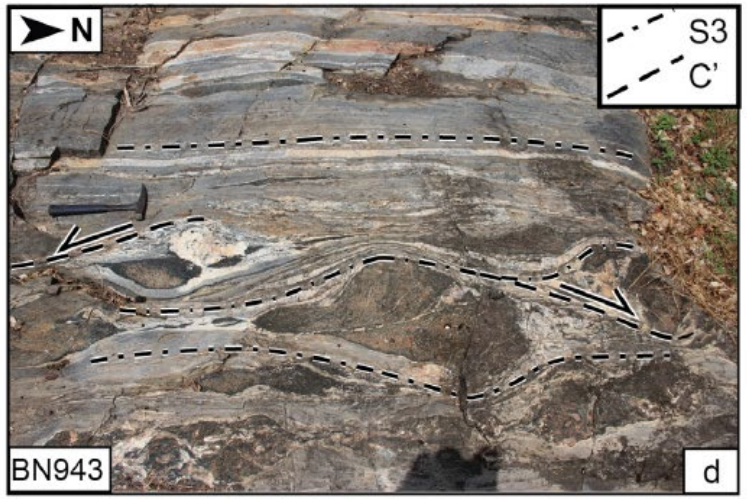
Block et al., 2016



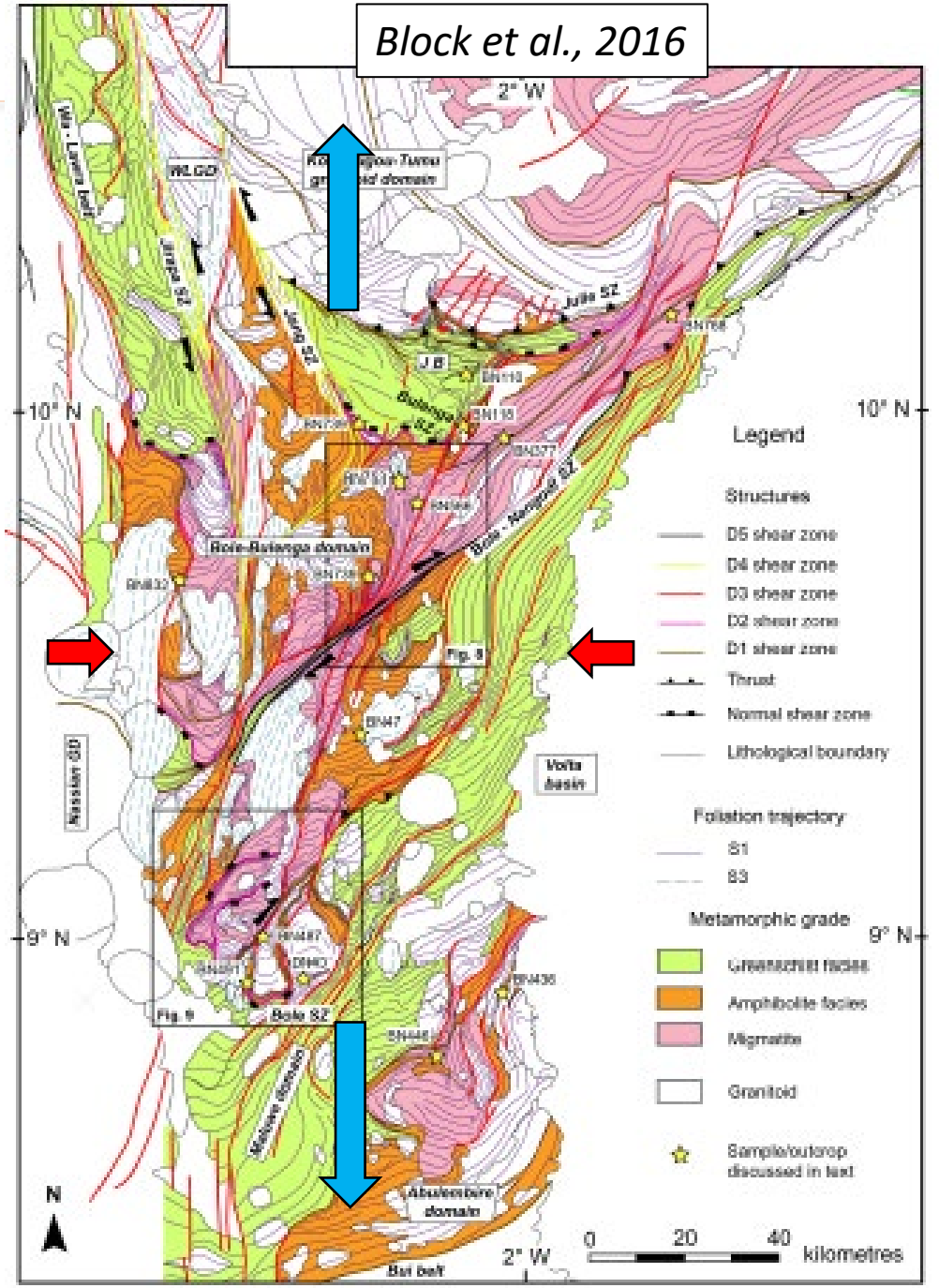
Field structural data



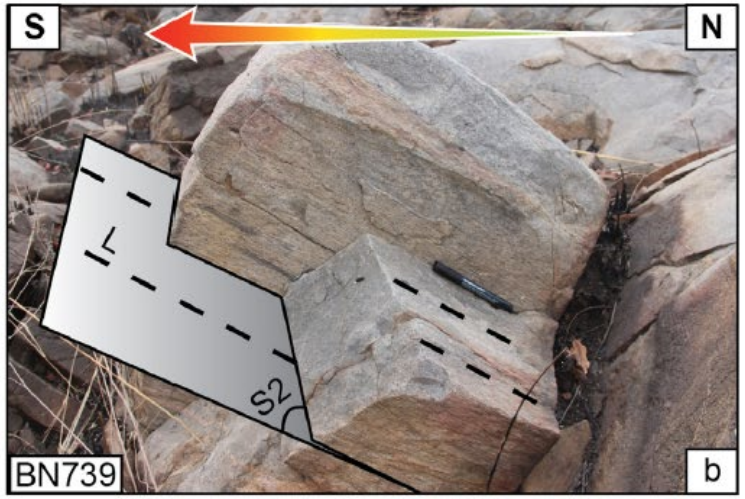


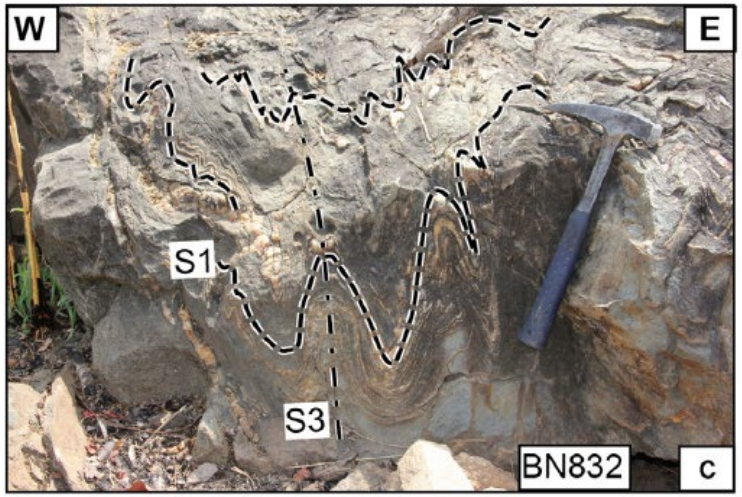


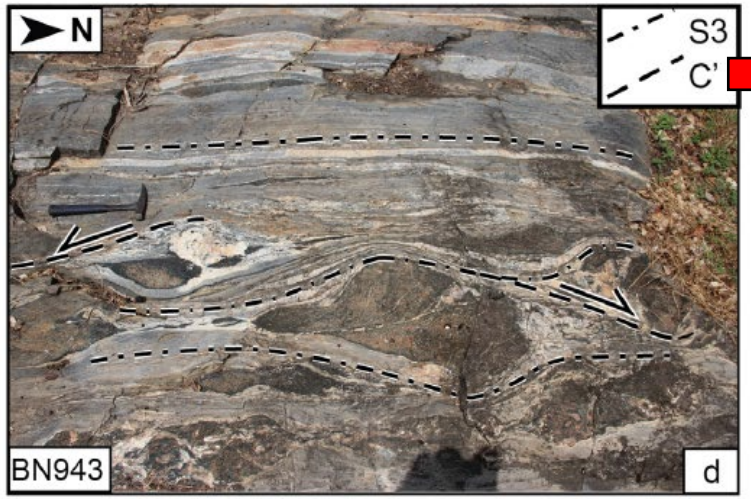
D2 – N-S extension



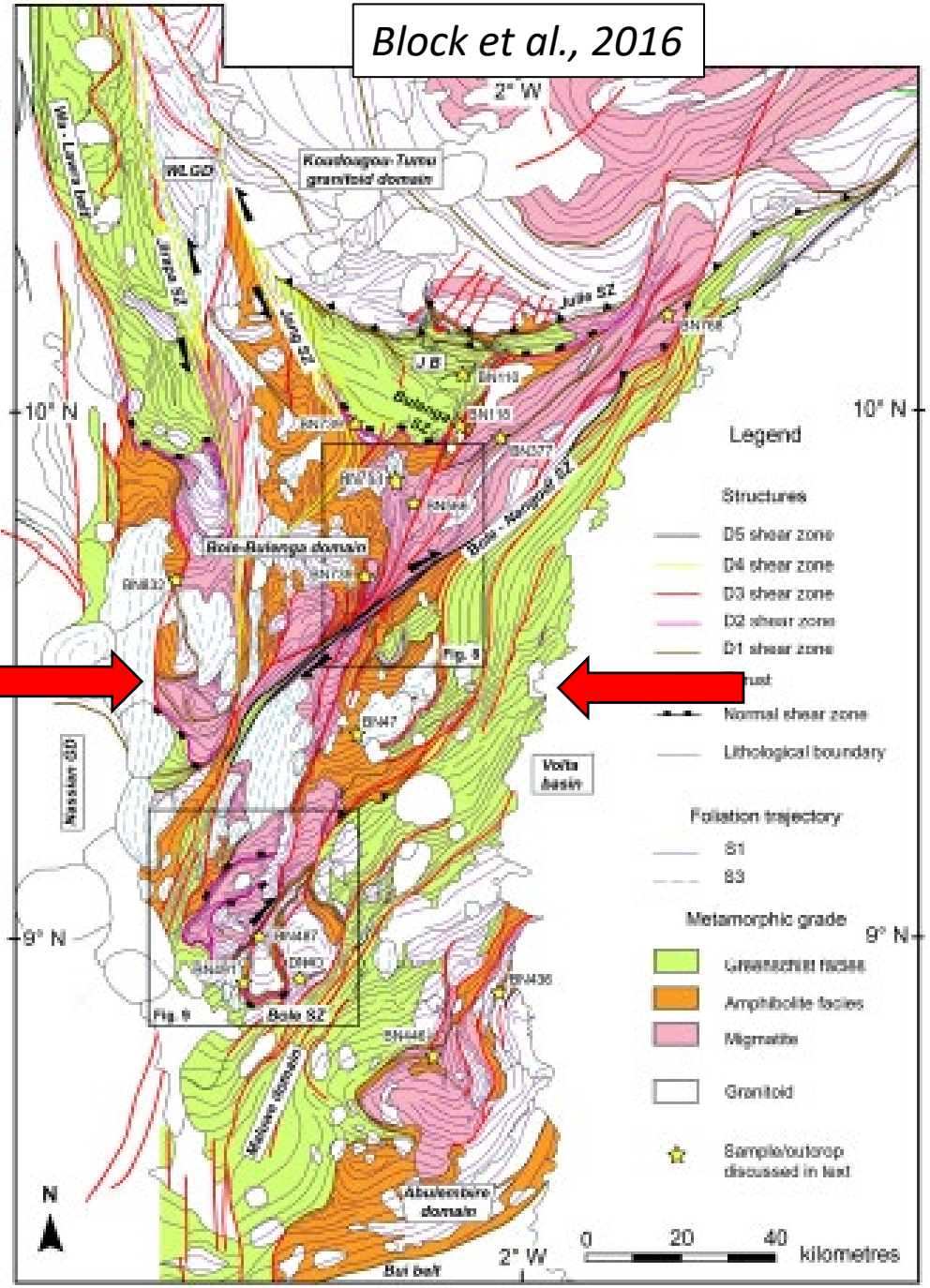
Field structural data





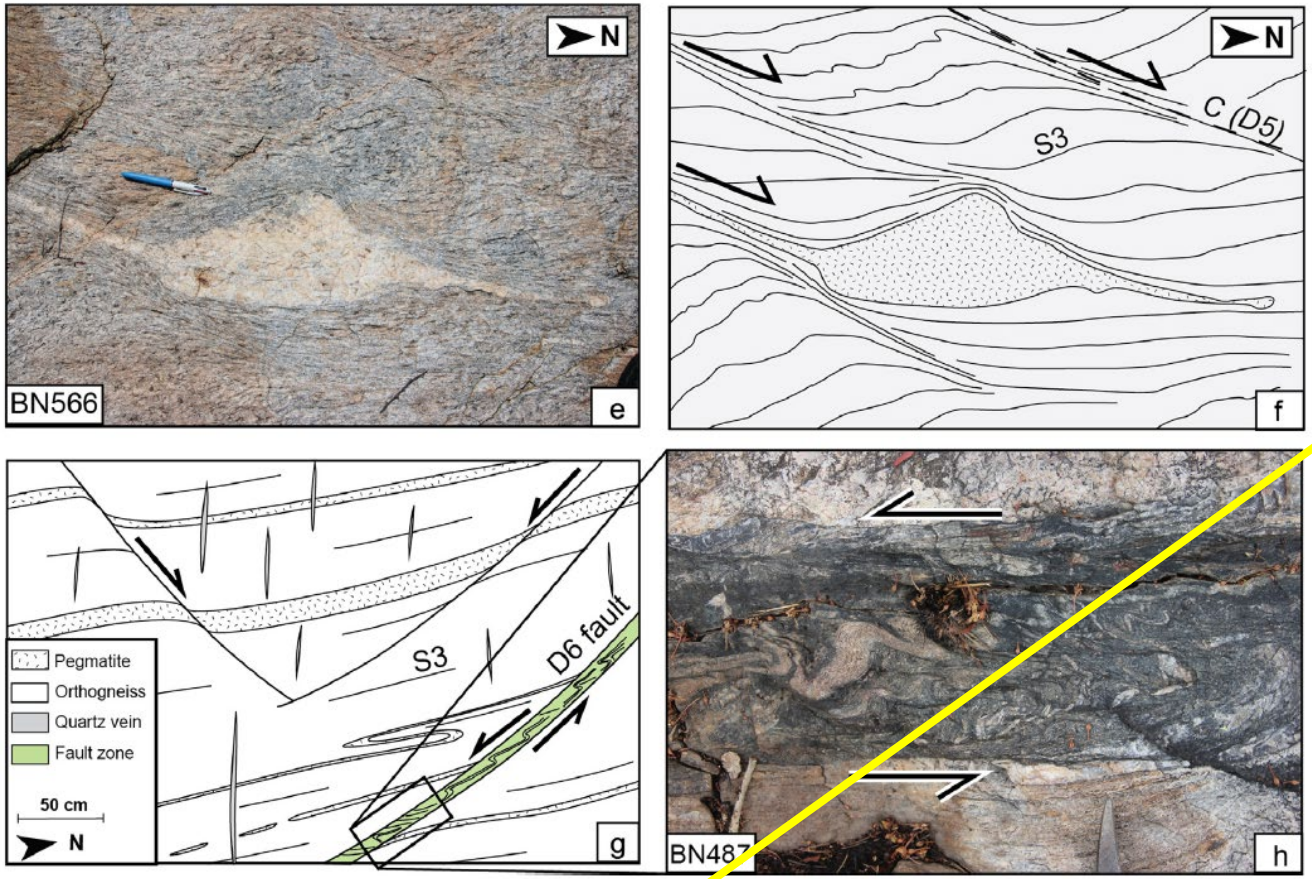


Block et al., 2016



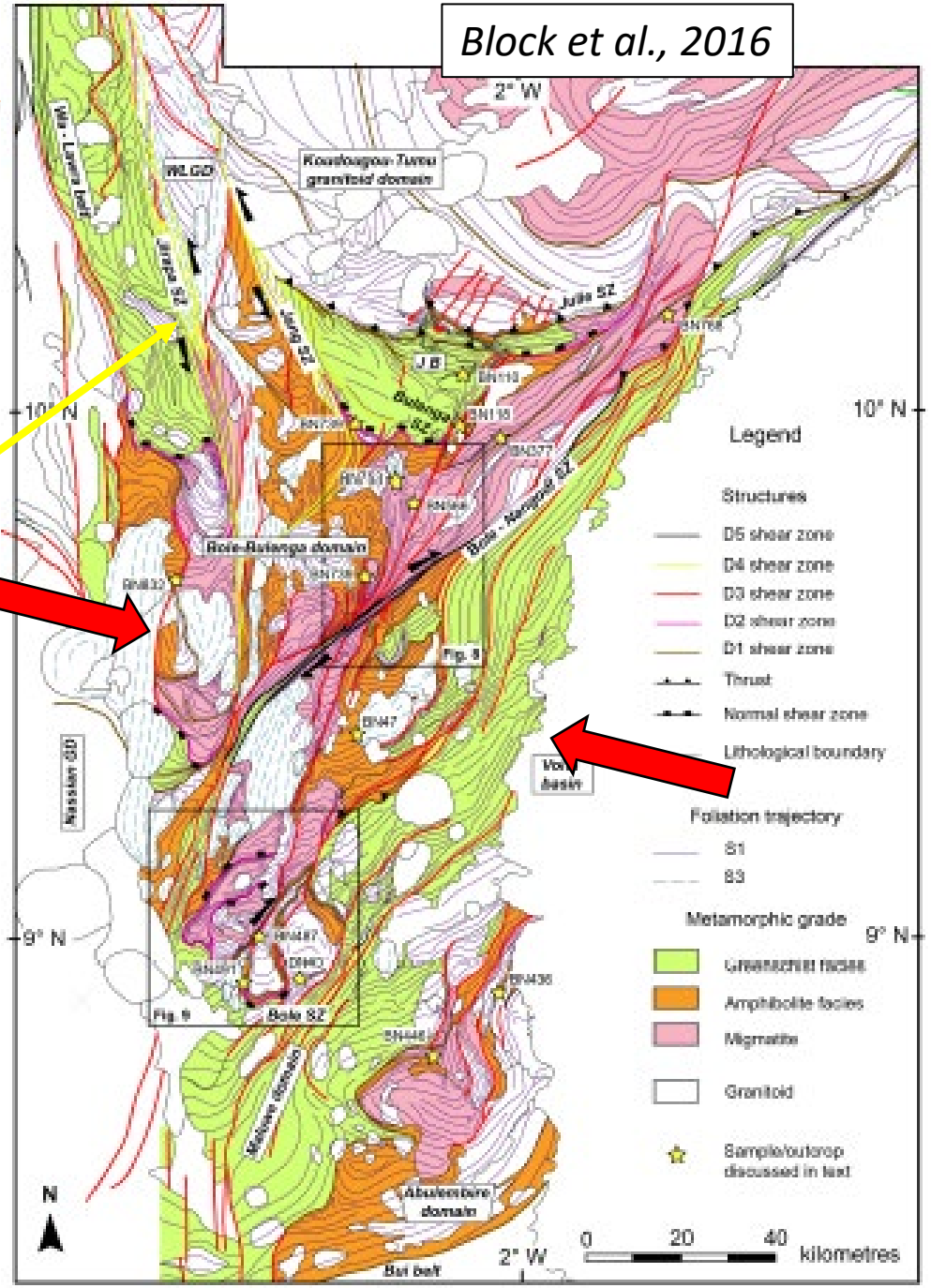
D3 – E-W to WNW-ESE shortening

Field structural data – NW Ghana

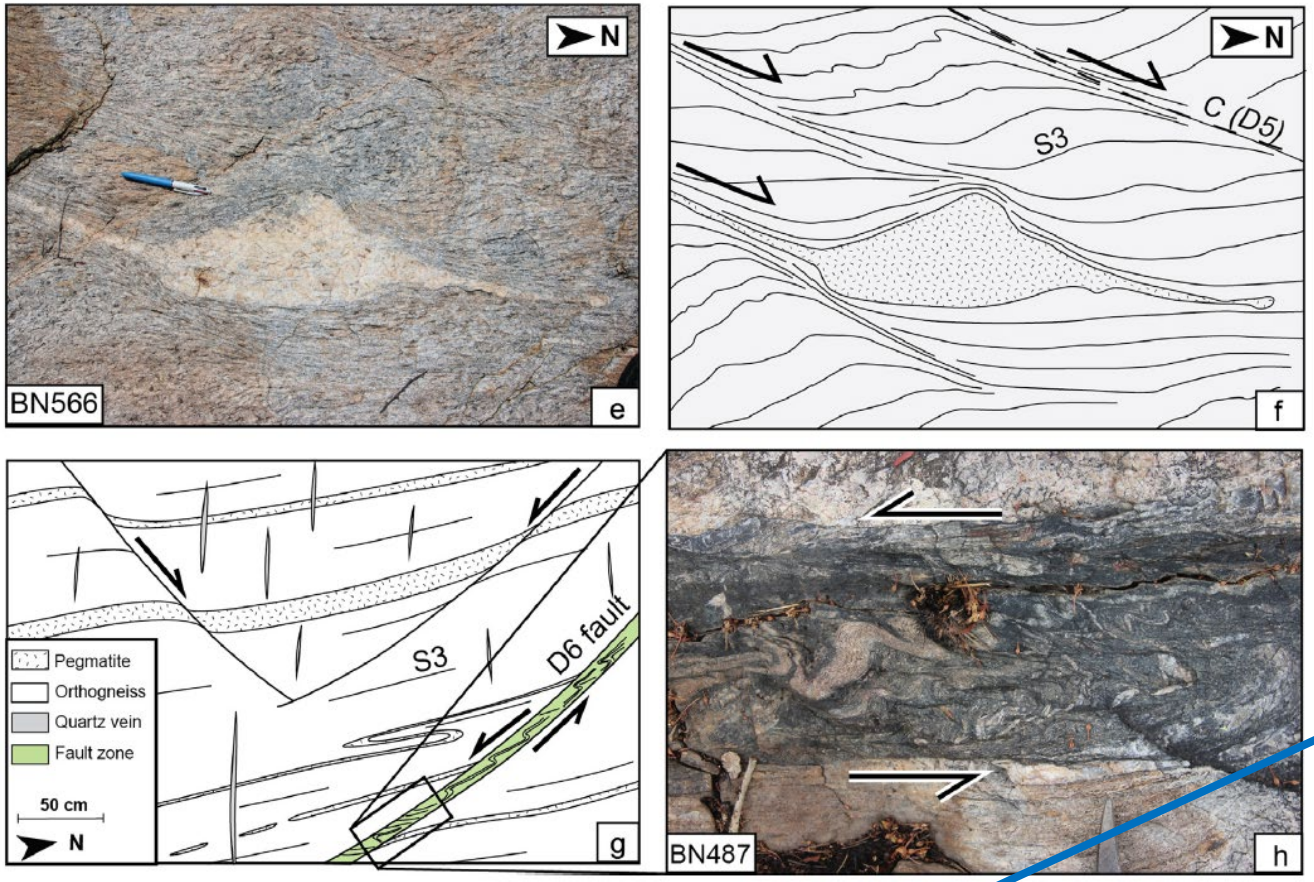


D4 – WNW-ESE shortening

Block et al., 2016

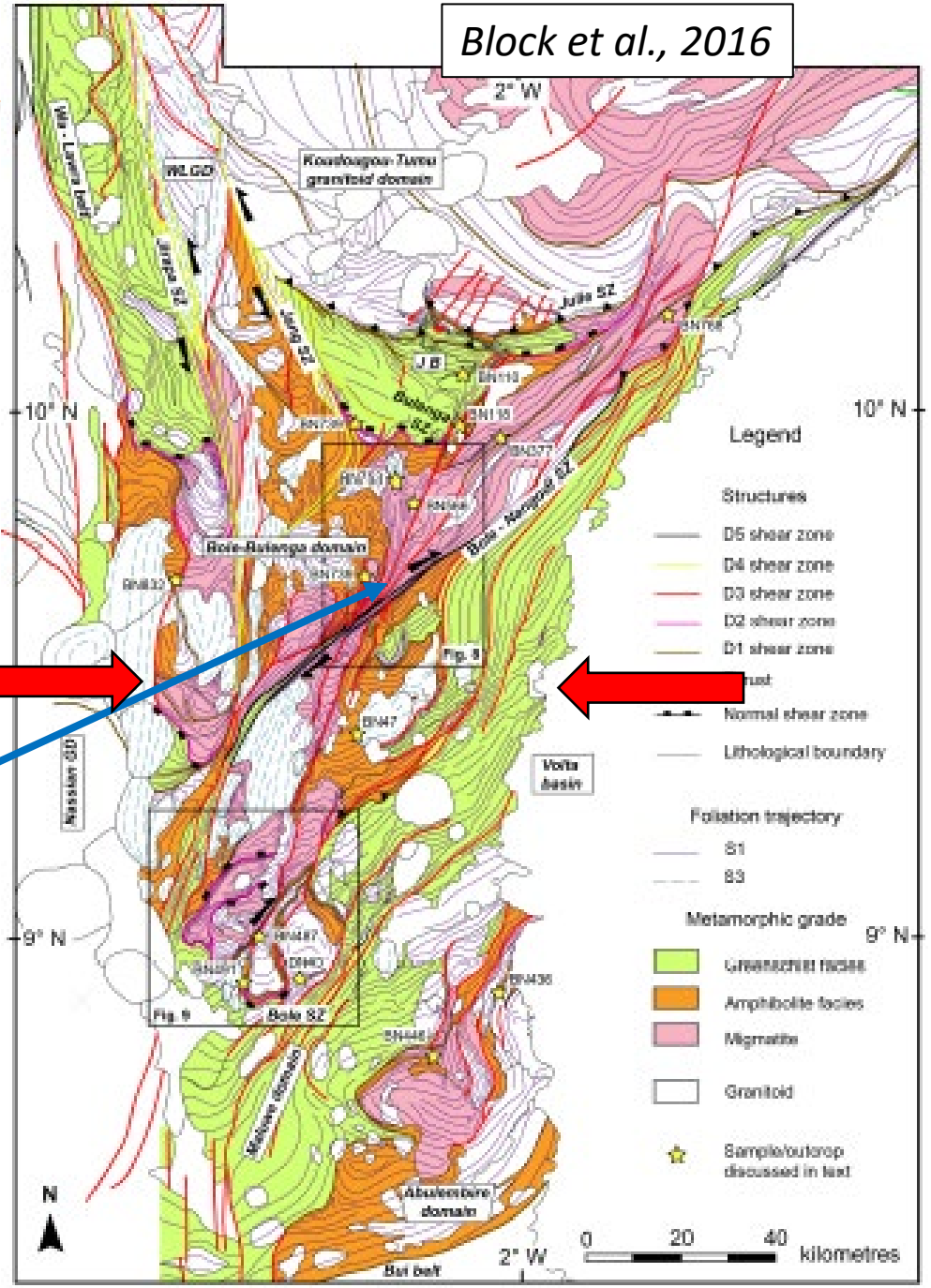


Field structural data – NW Ghana



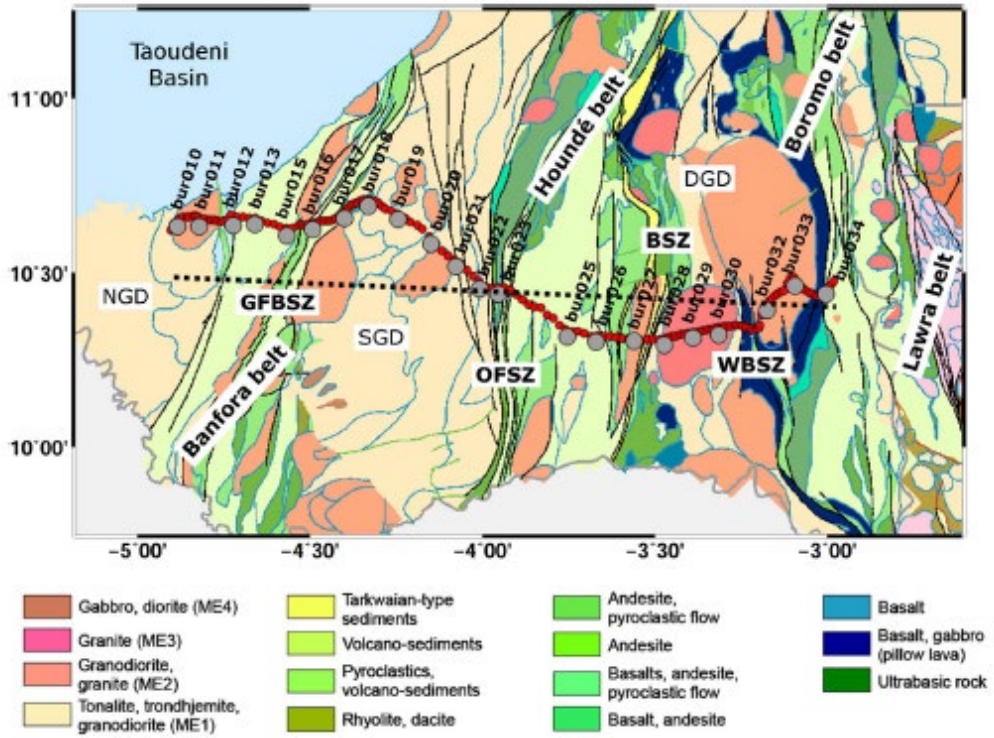
D5 – E-W shortening (ductile to brittle)

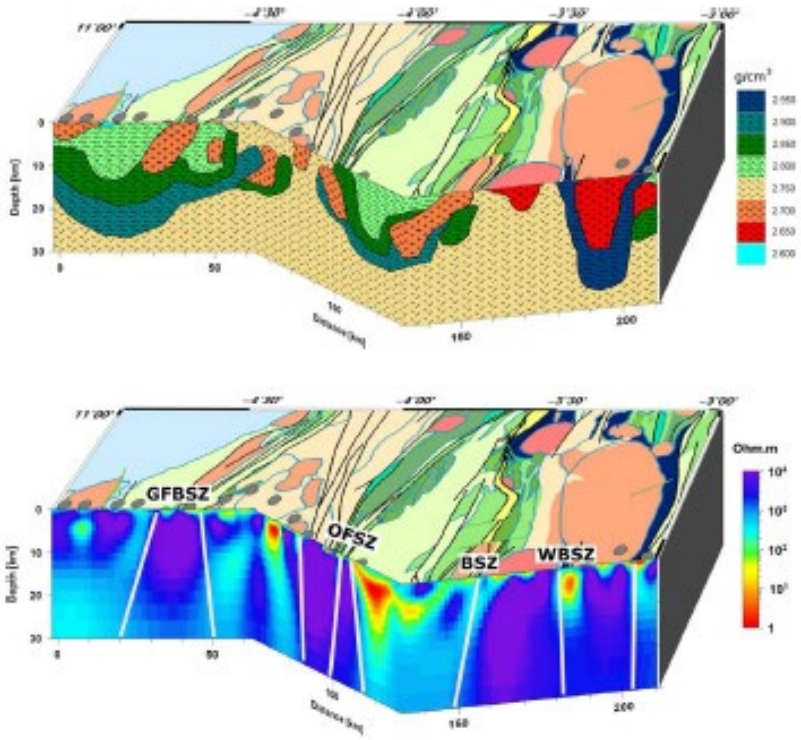
Block et al., 2016

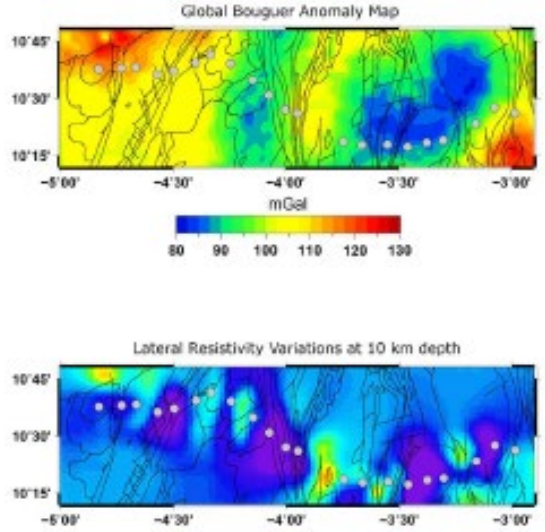


Magnetotelluric and gravimetric profiles – SW Burkina Faso

–> deep seated structures



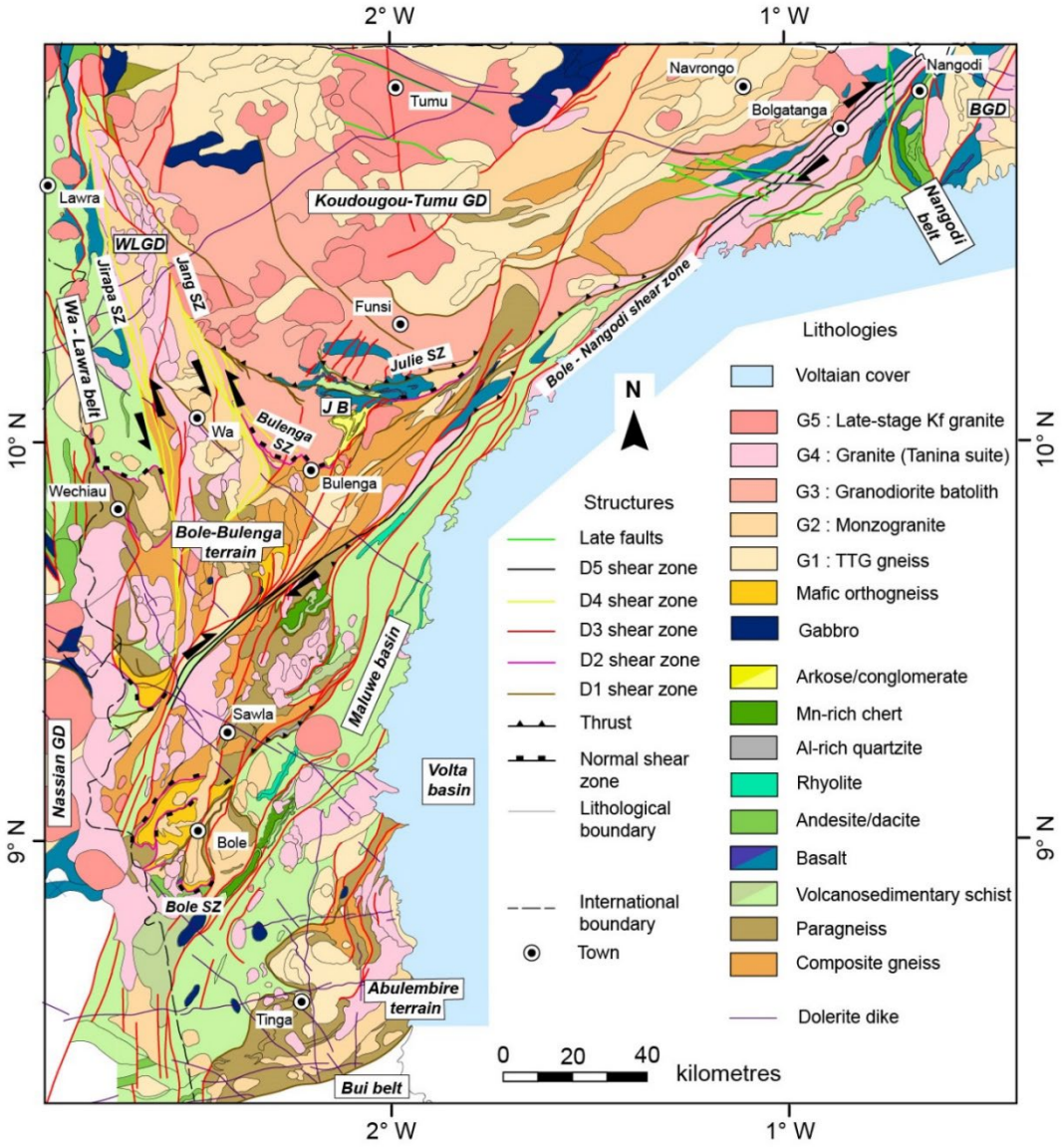




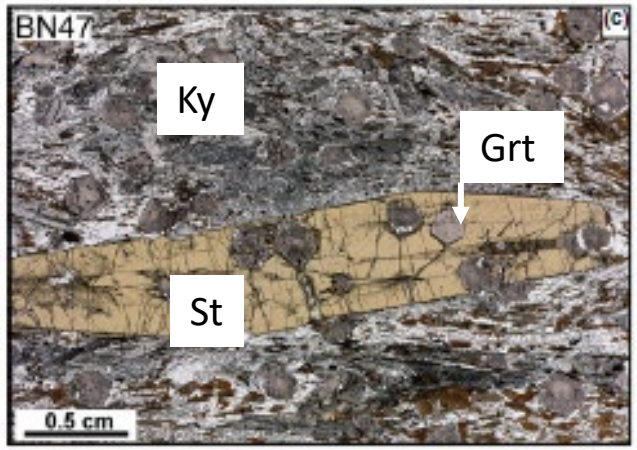
Geological map: Metelka et al., 2011

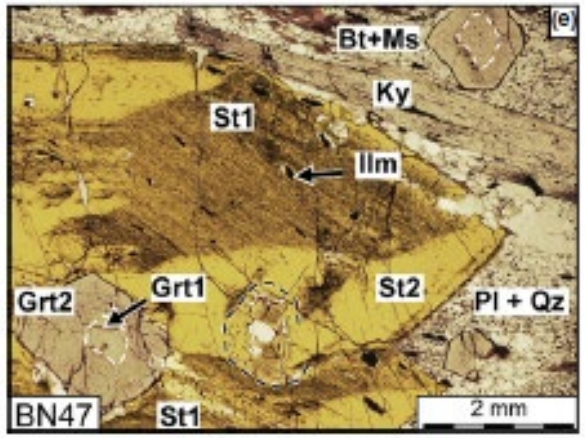
Le Pape et al., 2017

Metamorphic assemblages – NW Ghana

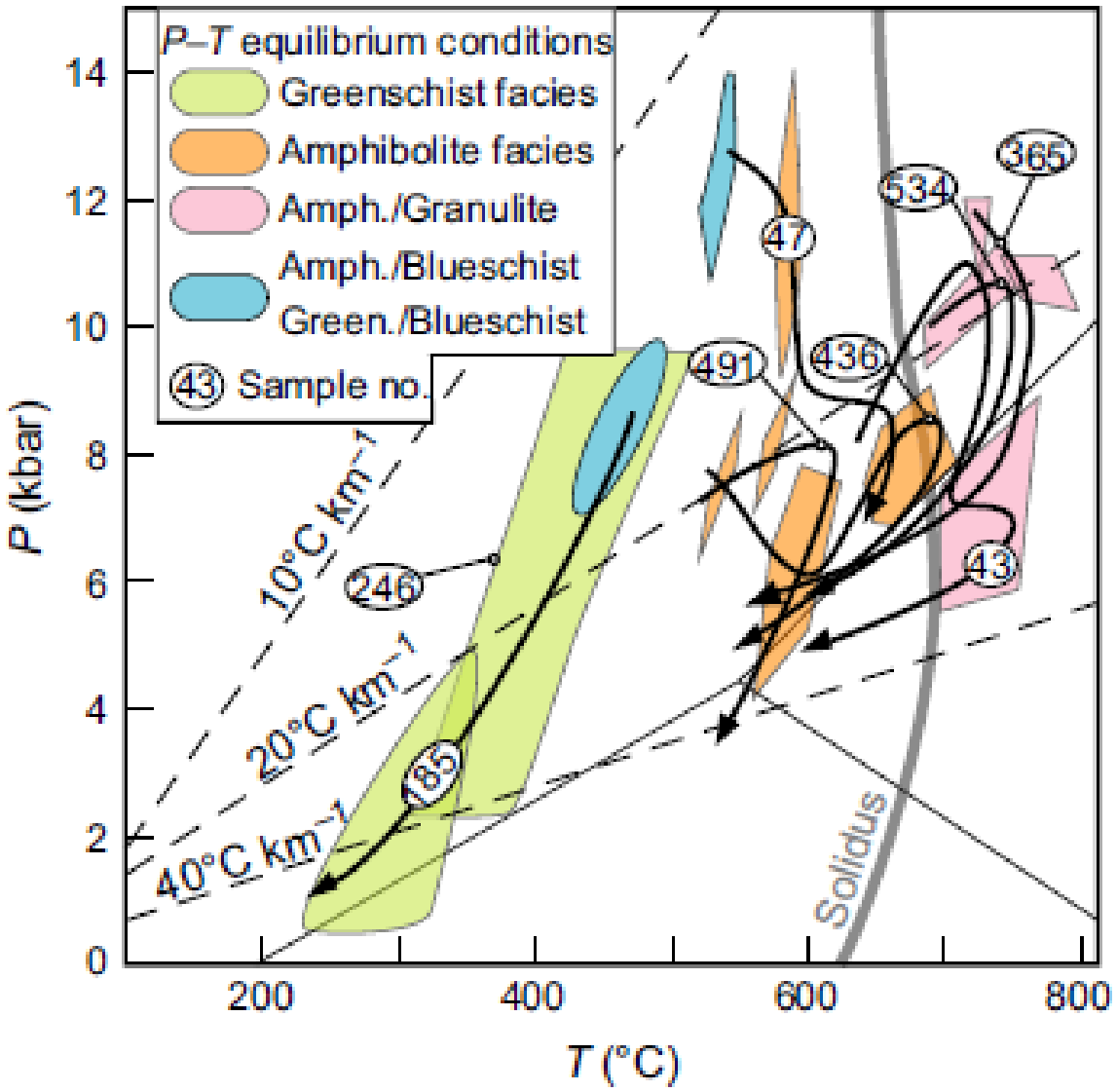


Block et al., 2015

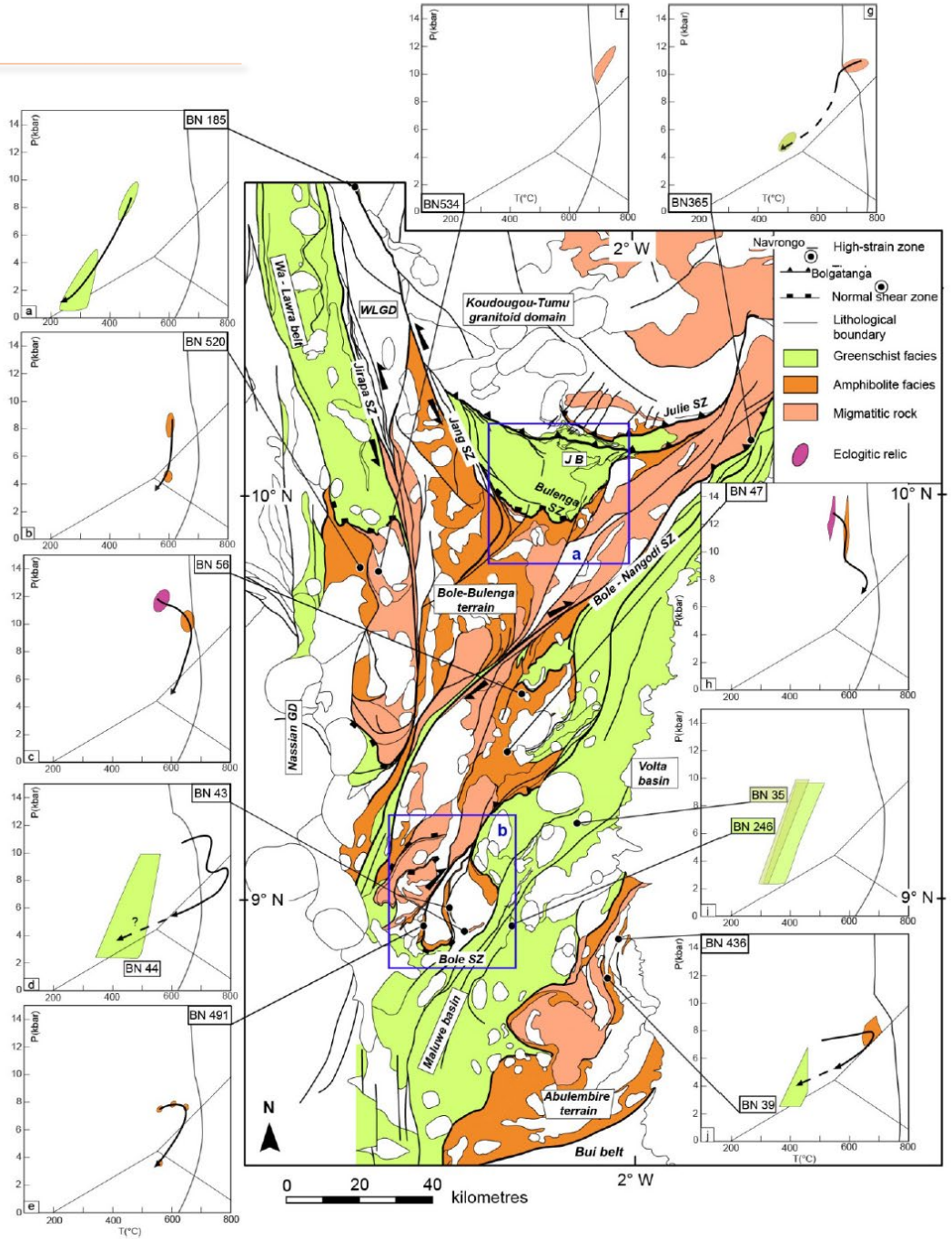




Metamorphic conditions – NW Ghana



Block et al., 2015



Timing of metamorphism and deformation

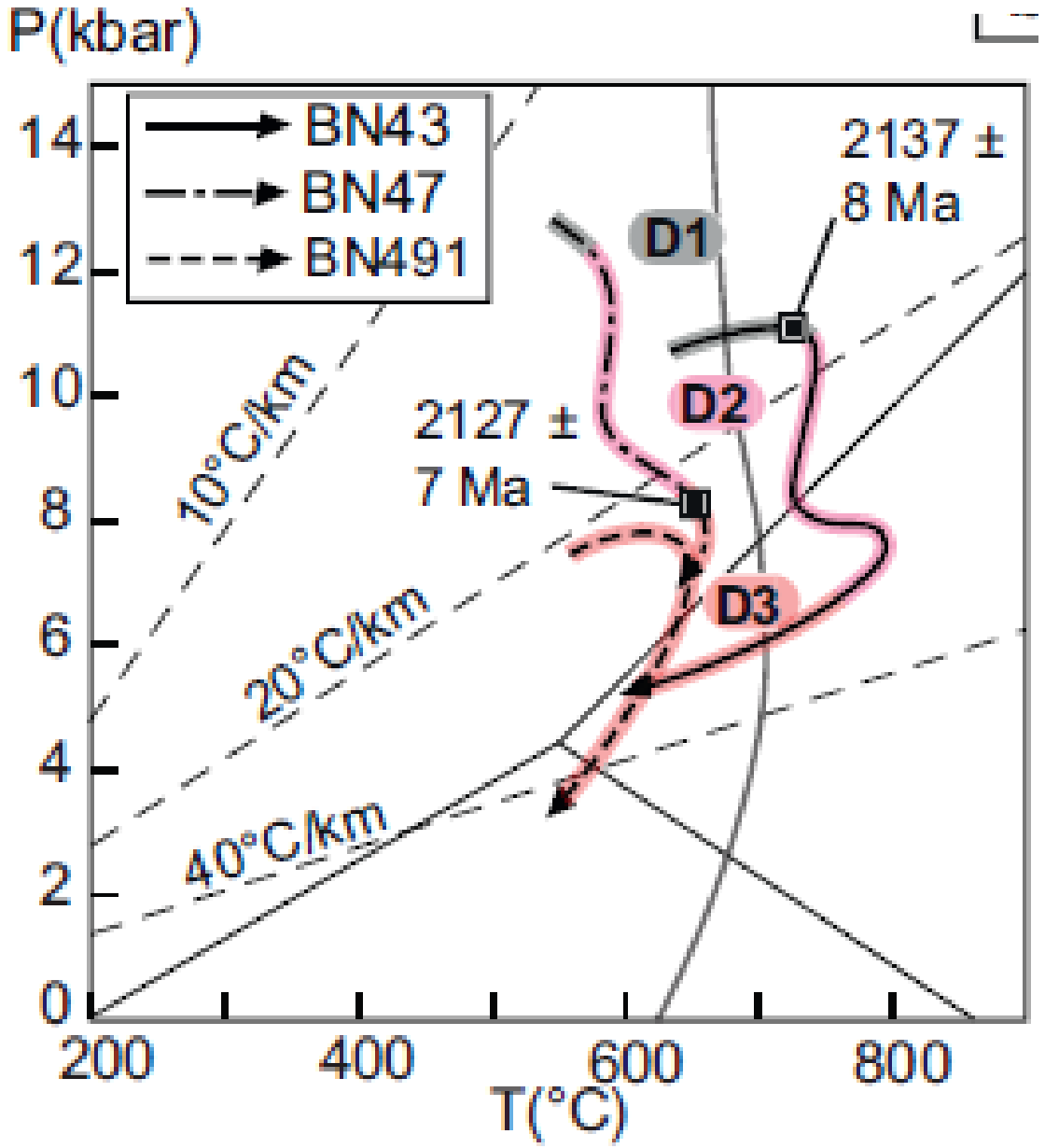
P-T-t-d paths
Polyphase metamorphism – deformation phases

U-Pb on monazite

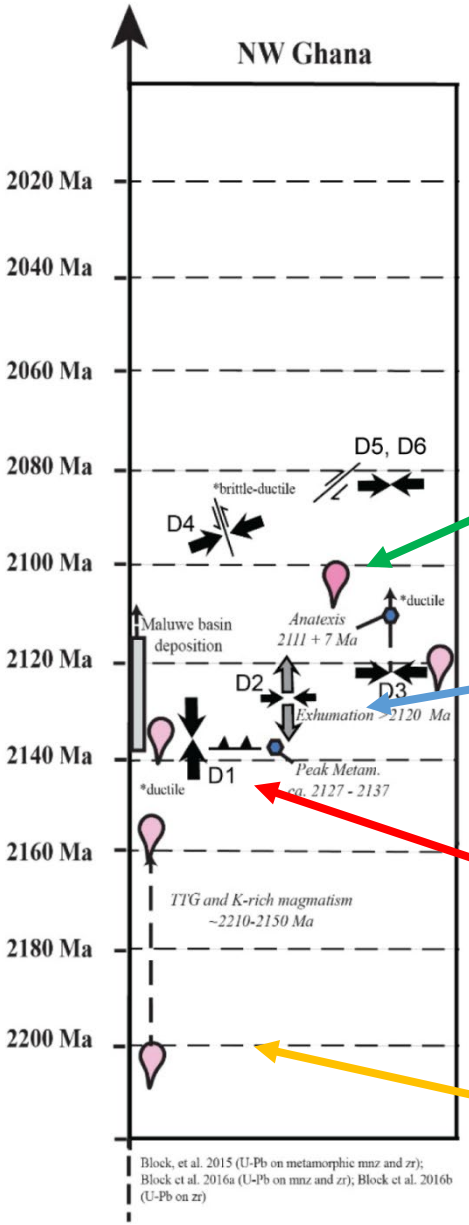
- BN43 – 2137 ± 8 Ma ; 2138 ± 7 Ma
- BN47 – 2127 ± 7 Ma ; 2130 ± 6 Ma
- BN436 – 2131 ± 6 Ma

-> age of HT metamorphic phase

Block et al., 2015, JMG
Block et al., 2015, PR



Geodynamic interpretations – NW Ghana



Important changes in the orientation of the shortening direction, which is hardly consistent with vertical tectonics

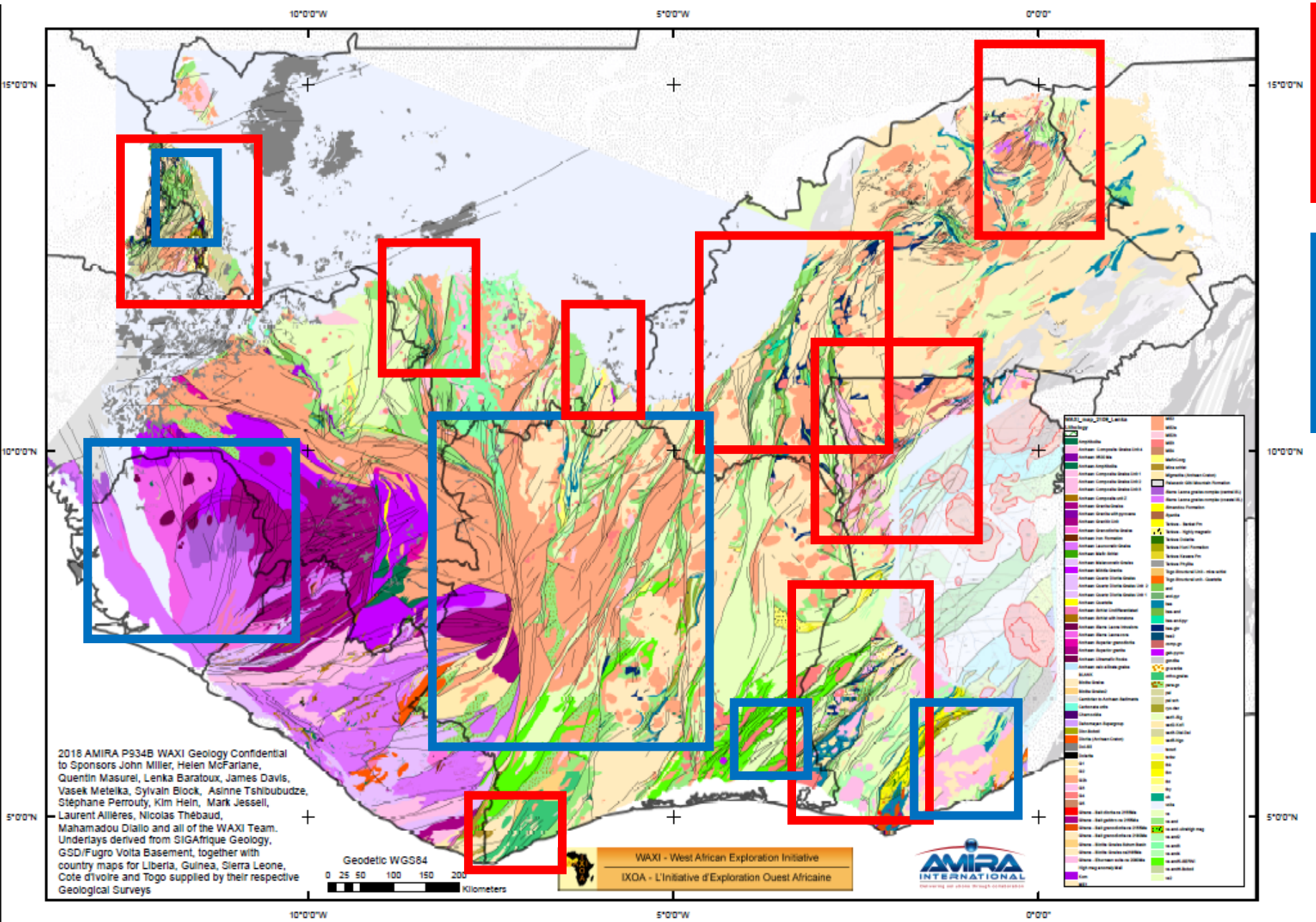
D3, D4, D5 – switch from predominant pure shear collisional regime to transcurrent regime, cooling and collapse of the orogen

D2 – extension or transtension and exhumation of the high grade rocks

D1 – major crustal shortening, rock burial and medium to high grade metamorphism

Oceanic plateaus and volcanic arcs, initial subduction zones

WAXI research in the sWAC



Past WAXI research (2006-2022)

Current WAXI 4 research (2022-2025)

Over 100 peer-reviewed papers

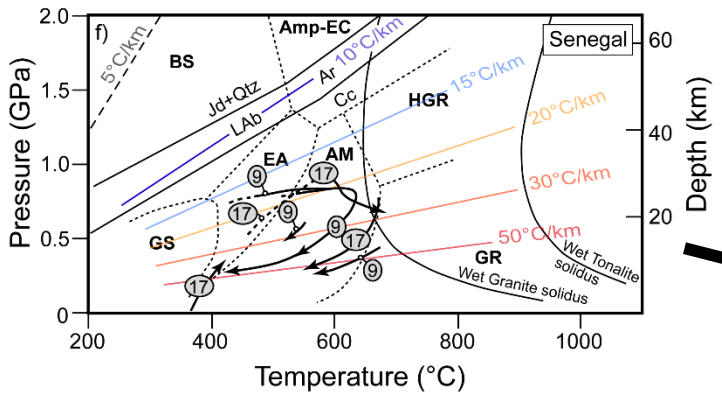
Over 100 Master, PhD students and post-docs

WAXI
West African Exploration Initiative

sWAC metamorphic conditions and timing

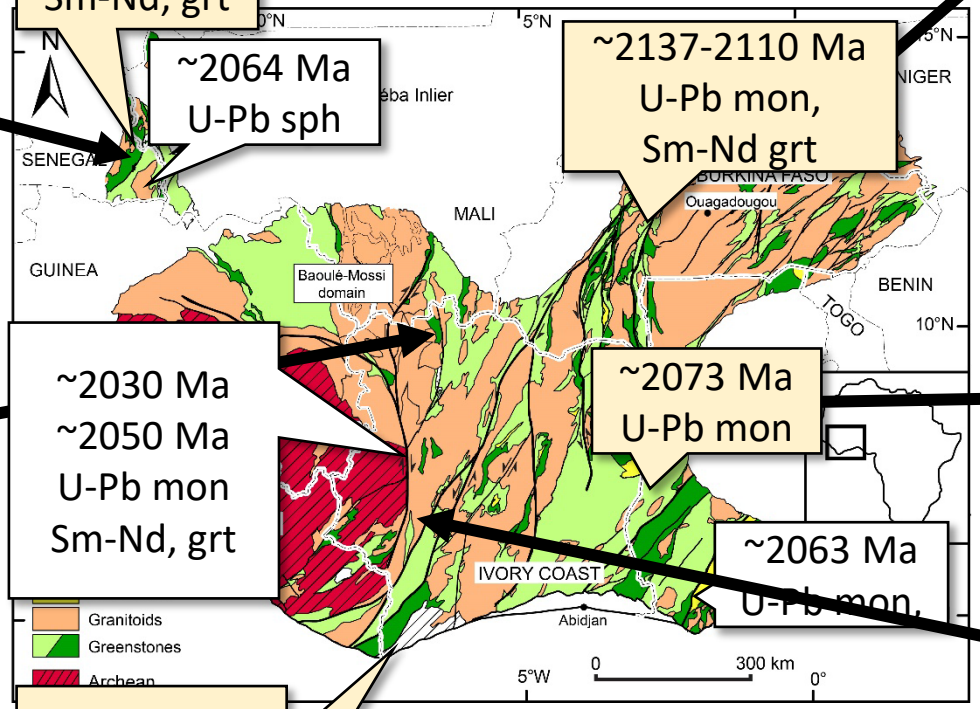
WAXI data

bibliography

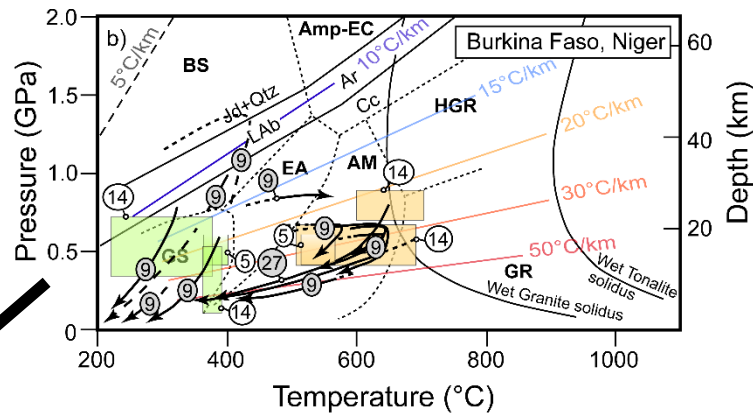


~2090 Ma
~2050 Ma
U-Pb mon
Sm-Nd, grt

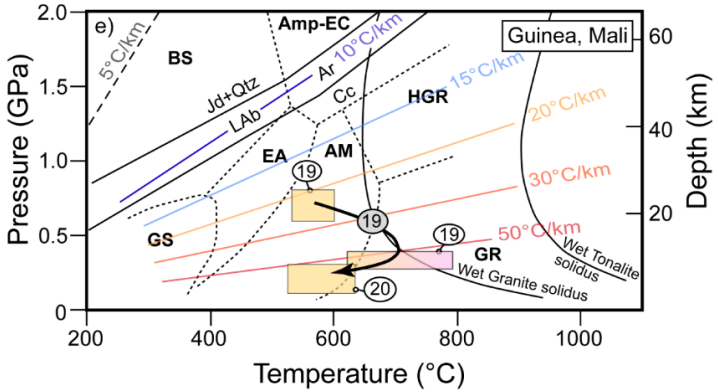
~2064 Ma
U-Pb sph



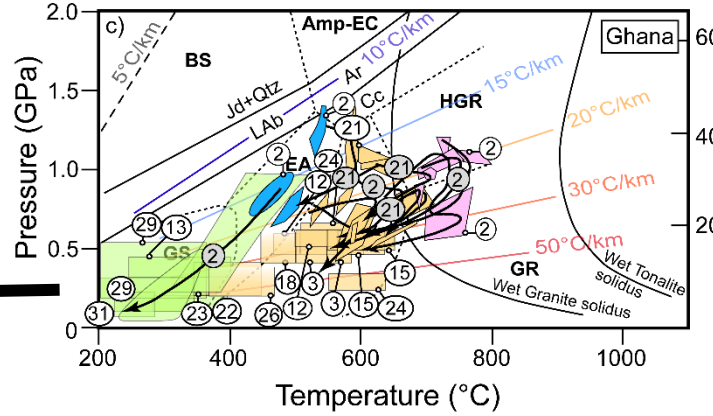
~2137-2110 Ma
U-Pb mon,
Sm-Nd grt



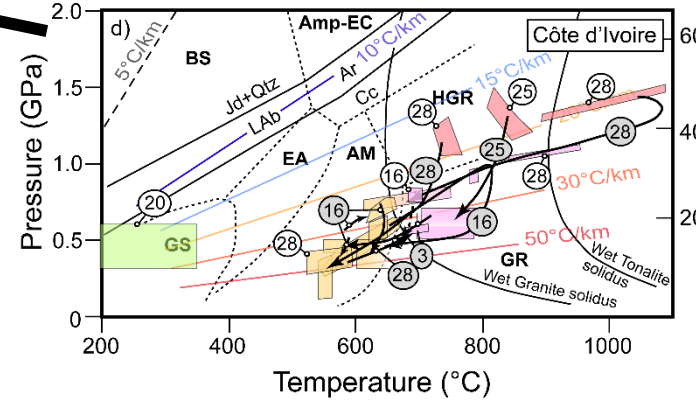
~2030 Ma
~2050 Ma
U-Pb mon
Sm-Nd, grt



~2073 Ma
U-Pb mon



~2063 Ma
U-Pb mon,



~2626 Ma
~2527 Ma
~2040 Ma
~2000 Ma
~1950 Ma
U-Pb mon

Baratoux et al., 2024

Geodynamic Atlas

Metamorphic Grade

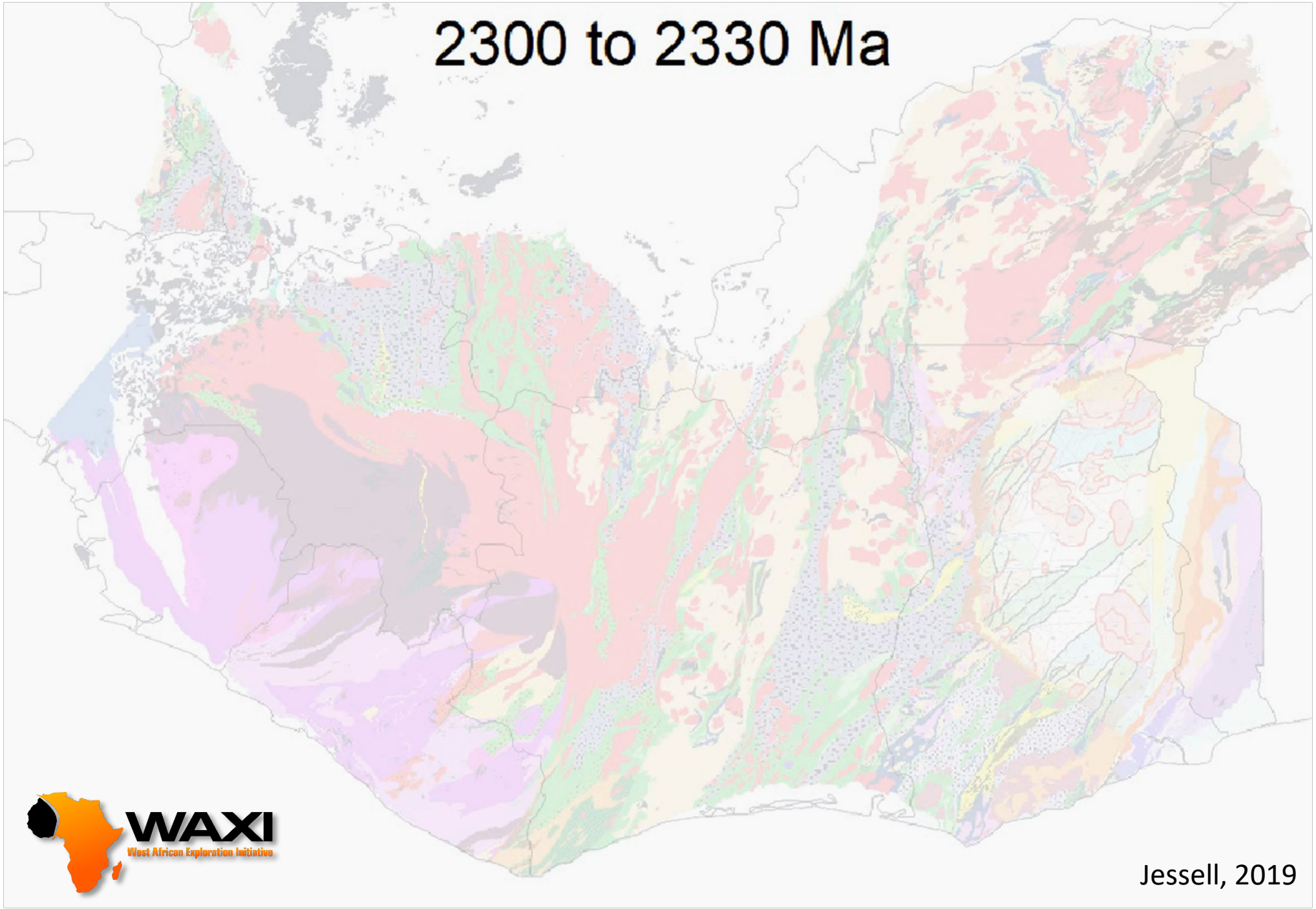
Mineral Deposits

Intrusions

Deformation

Sed/Volc

200 Ma of tectonic and metallogenic evolution



Key observations in Paleoproterozoic domains

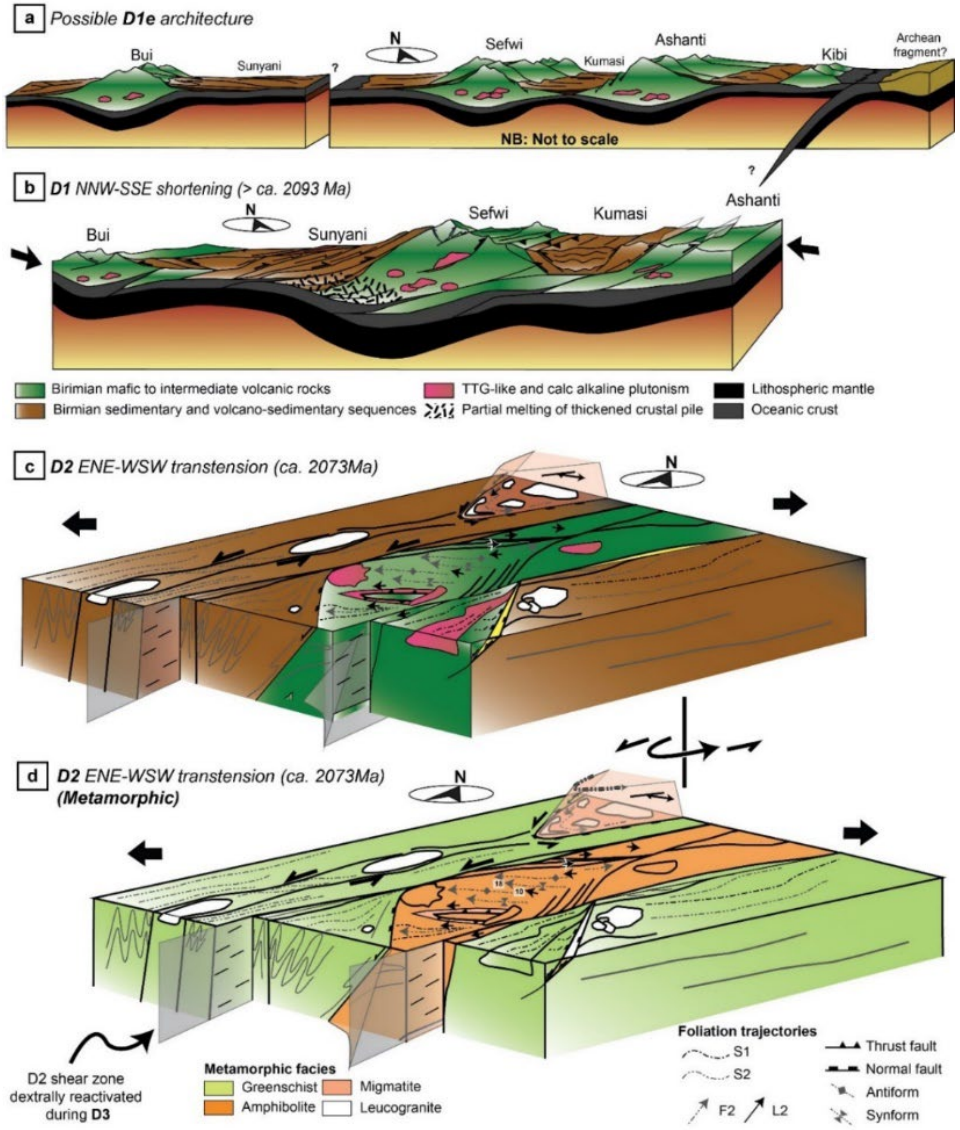
- Linear granitoid-greenstone belts
- Komatiites extremely rare (found only in Guinea), most of the mafic rocks are tholeiites, voluminous effusive calc-alkaline volcanism (volcanic arcs)
- Voluminous magmatism of sodic calc-alkaline character (TTG-like)
- Polyphase deformation; significant changes in stress field orientation during the Eburnean Orogeny
- Crustal-scale deep-seated shear zones, distributed across the craton
- Diachronous record of magmatism and metamorphism across the WAC (50 Ma difference between the E and W parts)
- Clockwise P-T paths, cold apparent geothermal gradients at early metamorphic stages (10-15°C/km); no ultra-high pressure metamorphism
- Tectonically driven burial and exhumation of supracrustal rocks

Conclusions

- The **geodynamic setting in Paleoproterozoic domains** is transitional between the **(hot) "archaic" style in** Archean domains of the WAC and **modern plate tectonics** style

- The data are consistent with an evolution from **primitive tholeiitic volcanism** (probably plume-triggered extension of the pre-existing Archean continents), formation of **volcanic arcs, accretion of these arcs** (subduction needed!), **collisional thickening** of the newly formed crust and **thermal relaxation, heating** and **collapse of the orogeny**

- **Same processes** but **diachroneous** across the West African Craton



McFarlane et al., 2019


WAXI
West African Exploration Initiative
https://waxi4.org/
Thank you for your attention!

Conclusions