The West African Craton, Archean and Paleoproterozoic tectonic evolution, derived from in-situ zircon data

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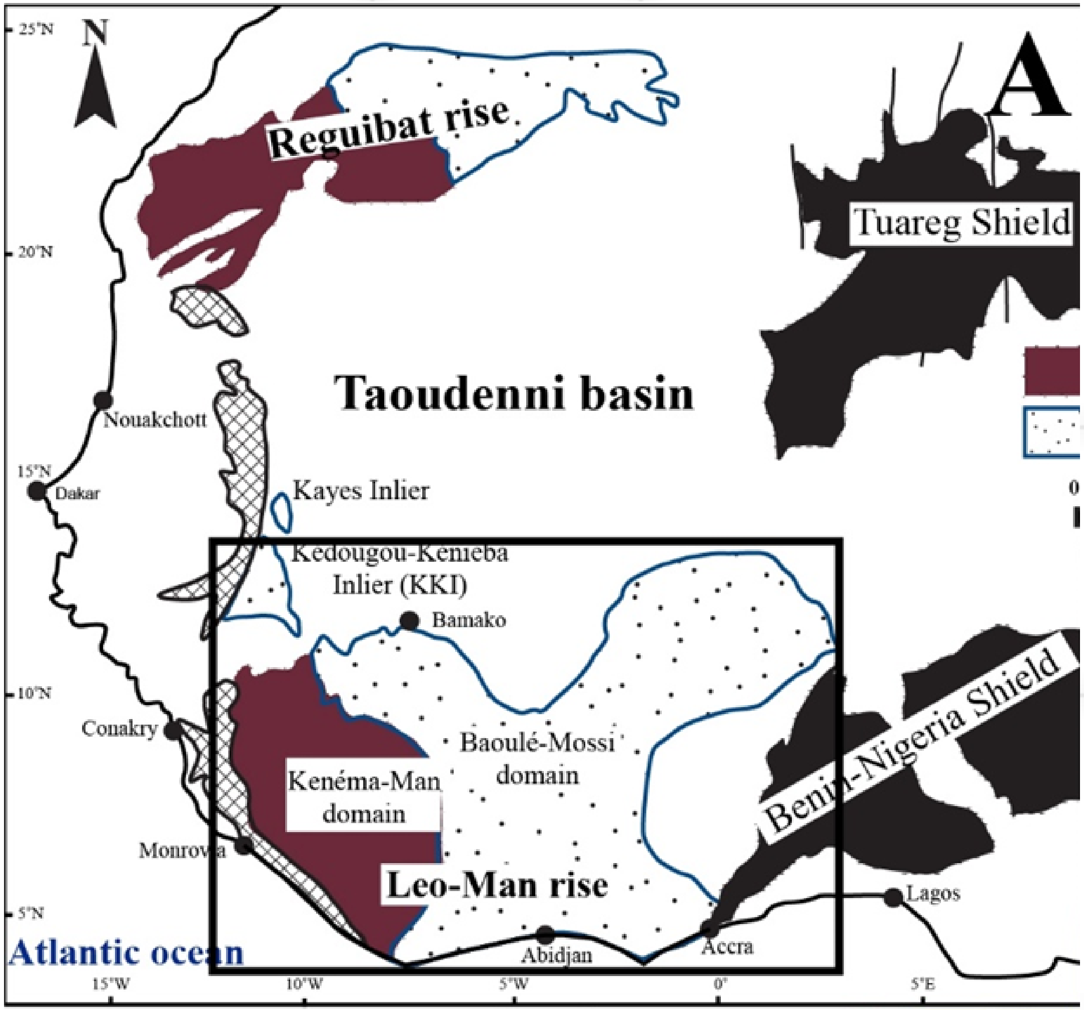
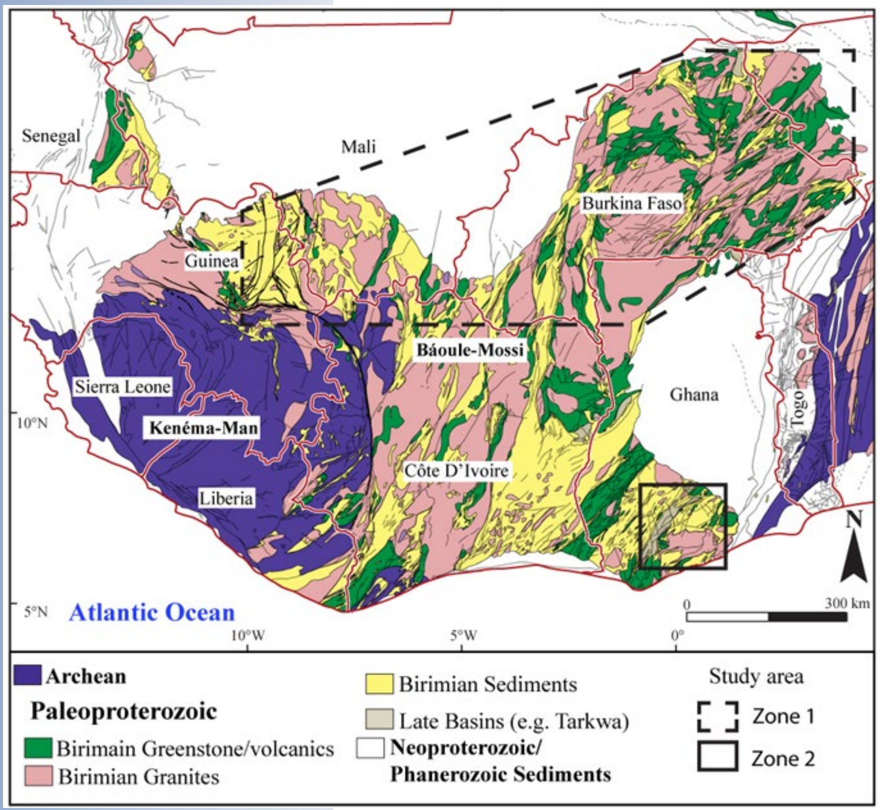
The West African Craton



Simplified map of the West Africa Craton, Boher et al. (1992). Note the Paleoproterozoic domains in the eastern portions, while the western regions are dominated by Archean nuclei.

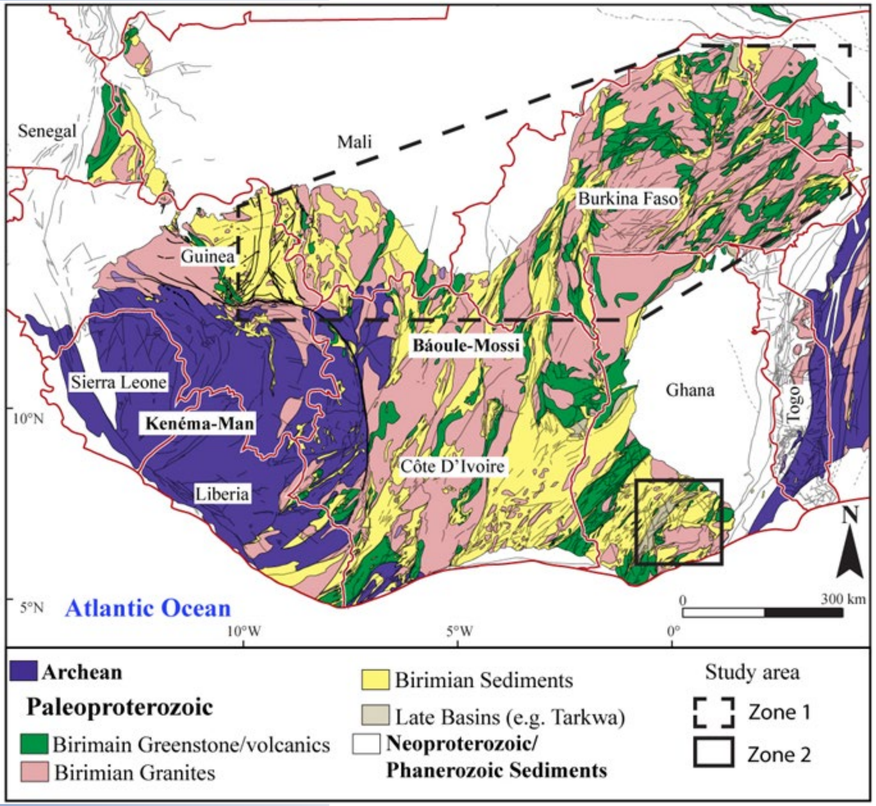
SWAC Regional Geology



Simplified geological map of the southern Leo-Man Rise of the West African Craton, after Lebrun et al., 2016; BRGM SIGAfrique map of Milési et al. (2004).

- Kénéma-Man domain
  - Evidence of pre-Leonian
  - Leonian (ca. 3050–2950 Ma) and Liberian (ca. 2850–2700 Ma)
    - orthogneiss
    - granitoids
    - metavolcanics/ metasediments

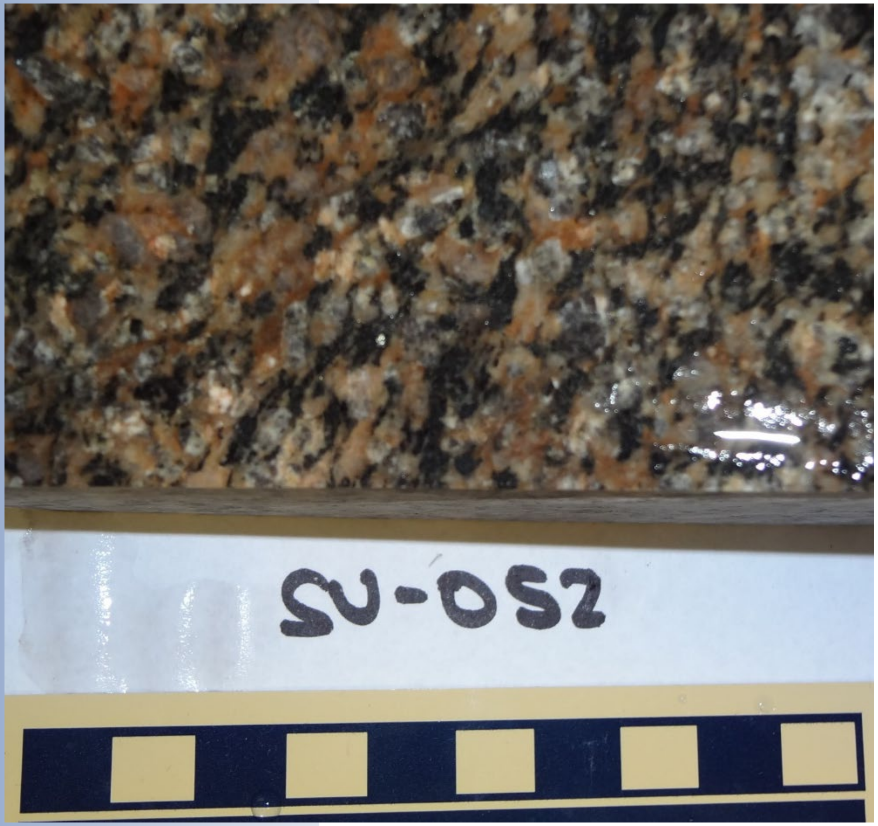
SWAC Regional Geology



Simplified geological map of the southern Leo-Man Rise of the West African Craton, after Lebrun et al., 2016; BRGM SIGAfrique map of Milési et al. (2004).

- Baoulé-Mossi domain
  - Eoeburnean (ca. 2266-2150 Ma) and Eburnean periods (ca. 2130-1980 Ma)
    - linear/arcuate volcanic belts and associated sedimentary basins
    - **Felsic intrusions**

SWAC Regional Geology



- Baoulé-Mossi domain
  - Felsic intrusions
    - commonly refer to as TTG
    - Foliated amphibole bearing rocks that are in some cases biotite rich, containing alkali feldspar, plagioclase, titanite, apatite and zircon
    - Potassic-alkaline intrusions (locally porphyritic)
    - Biotite rich rocks that lack amphibole, dominated by plagioclase, alkali feldspar quartz and in some cases muscovite

Why the Southern West African Craton-SWAC

- Multiple-conflicting nomenclature
- **Diversity of tectonic models**
- Outdated data
- Relatively underexplore regions/scarcity of outcrops/access

Diversity of tectonic models

- plume related-oceanic plateau, Abouchami et al., 1990
- subduction-related arcs then transcurrent shortening, Salah et al., 1996
- diapirs then transcurrent shortening, Vidal et al., 2009

Diversity of tectonic models

- collision zone between an Archean continental block (Sáo Luis Craton) and segments of newly formed paleoproterozoic crust, Feybesse et al., 2006
- arc-backarc basins complex in a Palaeoproterozoic intraoceanic environment, De Kock et al., 2012

The aims…

- Evaluate the evolution of the Paleoproterozoic Baoulé-Mossi domain
  - Study dispersal patters from eroded units
  - Evaluate spatial and temporal changes of felsic intrusions
  - Juvenile vs. Ancient

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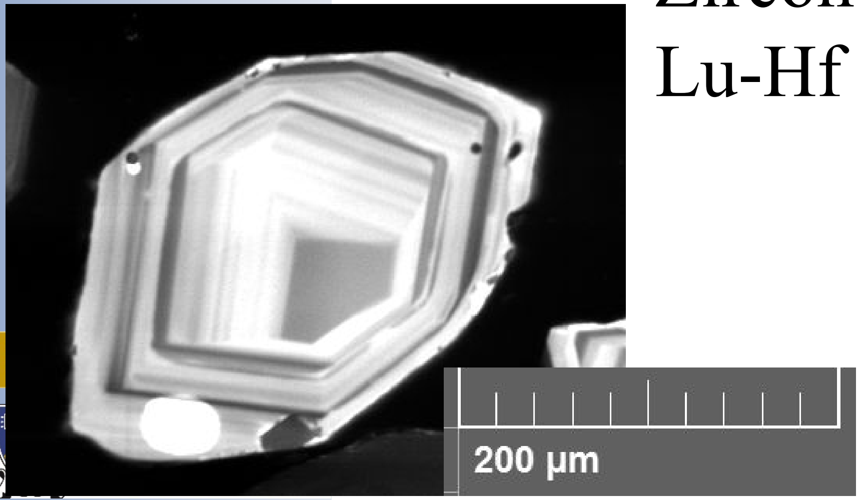
Methods

- Streams/creeks:
  - Zircon U-Pb and Lu-Hf (LA-ICP-MS)
- Well constrain and chemically characterised felsic Intrusions:
  - Whole rock geochemistry
  - Zircon U-Pb (SHRIMP), O (SIMS), and Lu-Hf (LA-ICP-MS) isotopes



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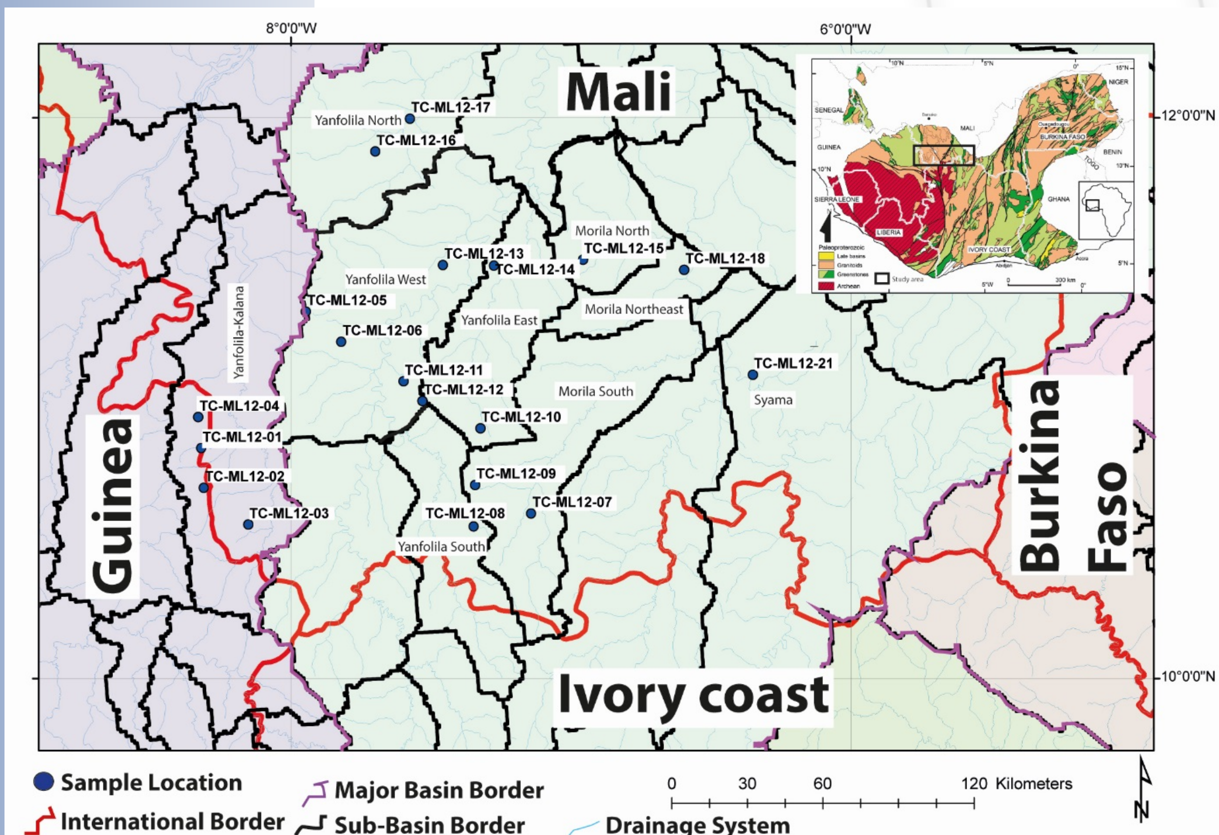
Detrital zircons: Streams/creeks



- Two drainage systems 22 samples:
  - Bani River (light green)
  - Niger River (purple)

After Parra-Avila et al. (2016), Basins and sub-basins defined after USGS drainage system map, Lehner, 2006)

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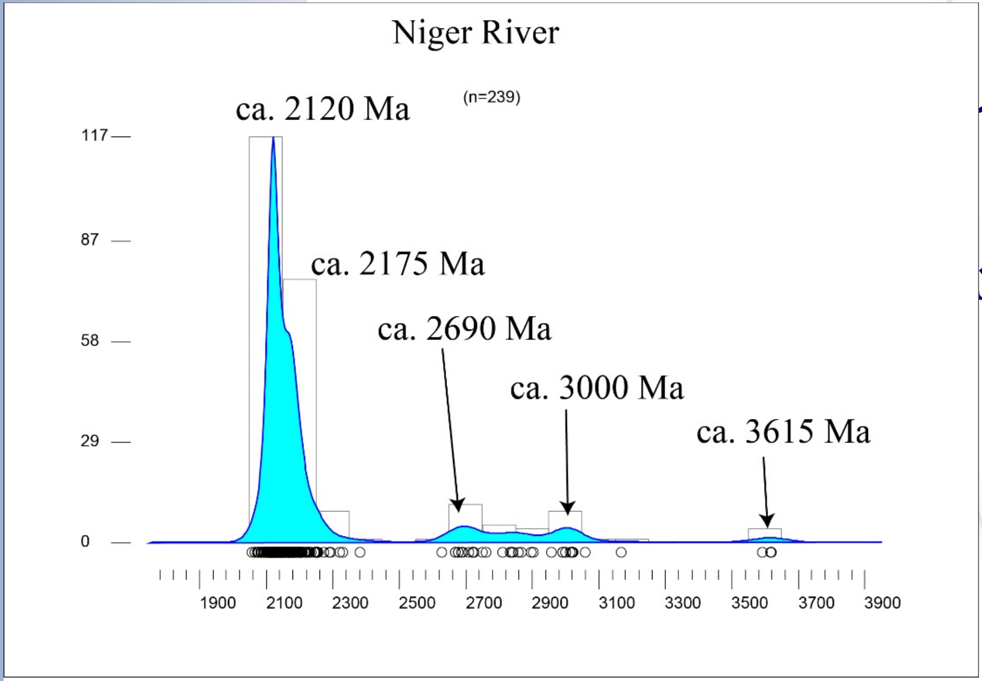

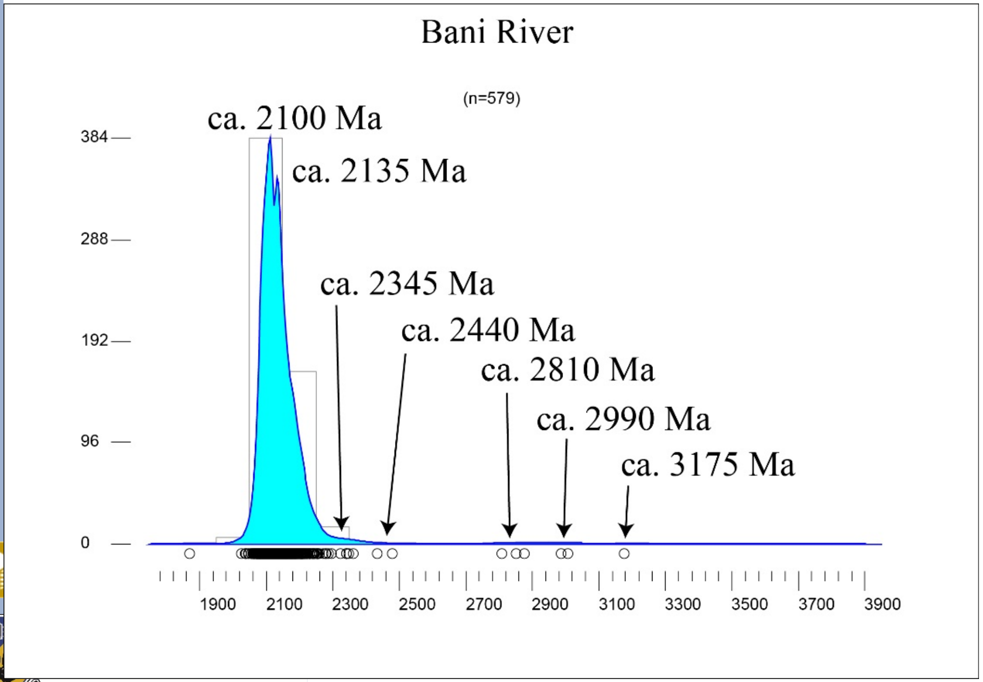

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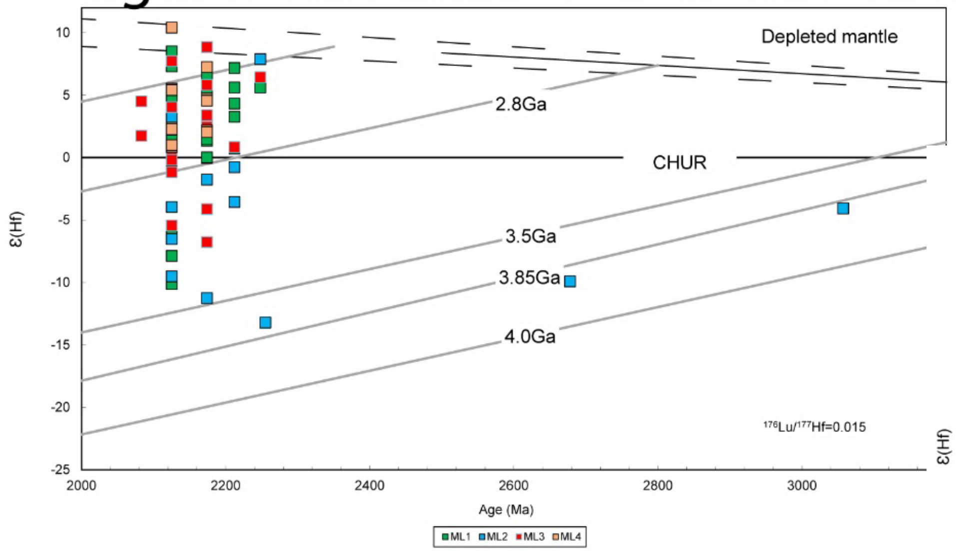
- Highlights:
- Common evolution history for the period ca. 2200-2100 Ma
- Main peak of activity ca. 2130-2090 Ma
- Niger river basin:
  - Older grains between ca. 3600 and 2600 Ma
- Bani river basin:
  - Older grains between ca. 3175 and 2350 Ma
- So what…
  - Source of Archean grains?
    - Transported from the Kénéma-Man domain
    - A different source?

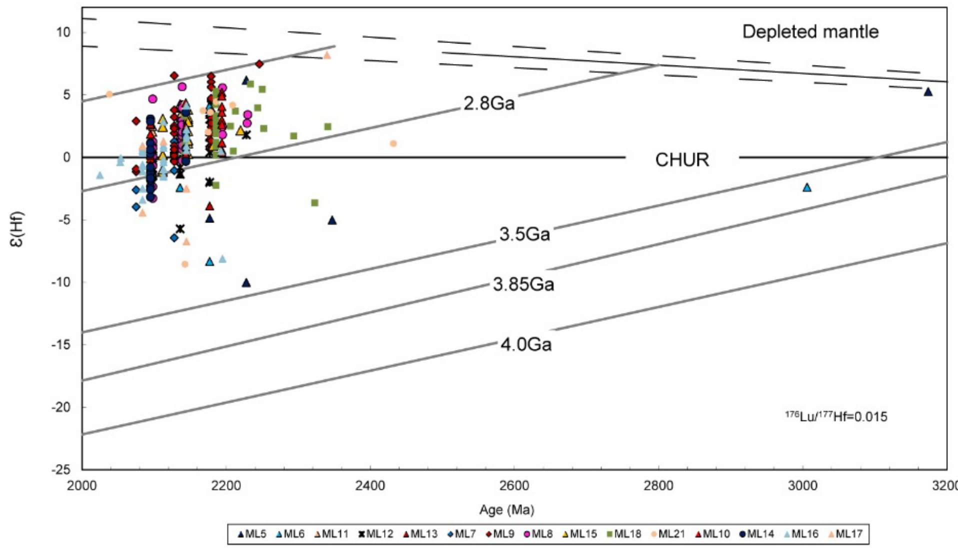
Niger River Basin: Kalana-Yanfolila



After Parra-Avila et al. (2016)

...l zircons:

Bani River Basin: All



Lu-Hf highlights:

- 80% of samples display εHf > 0 and 20%, εHf < 0
- Mixing array that points to greater crustal re-working

Detrital zircons: Streams/creeks

Detrital zircons

- Bulk of zircons yield Paleoproterozoic ages ca. 2400 - 2050 Ma
- A small group of zircons, yield U-Pb ages ca. 3600 – 2100 Ma
- Overall Hf-isotope signature yield model ages ranging between 3600 - 2800 Ma

Felsic intrusions characterisation

Generally grouped as:

- amphibole bearing granitic rocks, with or without biotite, usually foliated
- biotite bearing granitic rocks without amphibole
- potassic alkaline plutons.

Geochronology basics…

Burkina Faso

- Goren Belt/Po-Tenkodogo-Yamba regions, ca. 2270 - 2120 Ma.
- Belahouro ca. 2180 - 2120 Ma
- Boromo-Hounde ca. 2180 - 2110 Ma
- Banfora ca. 2150 - 2110 Ma

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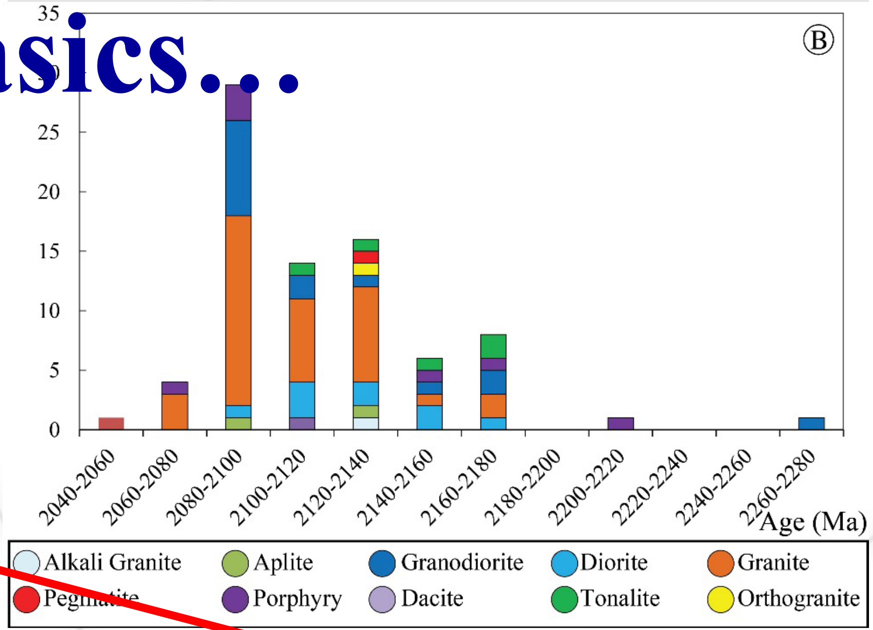
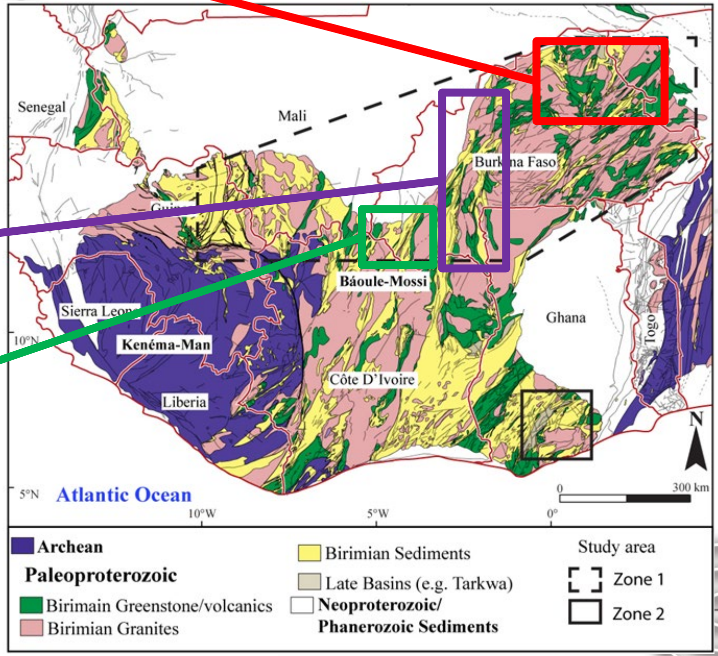
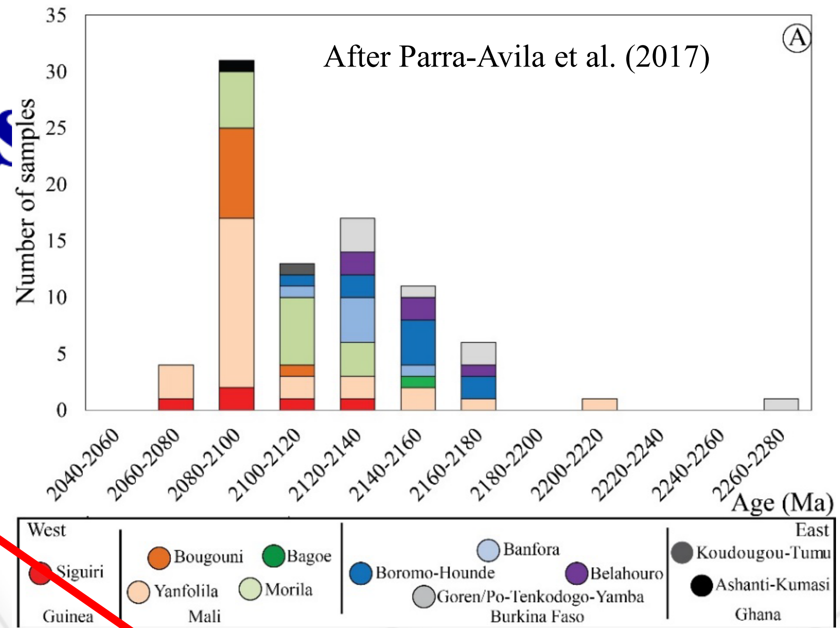


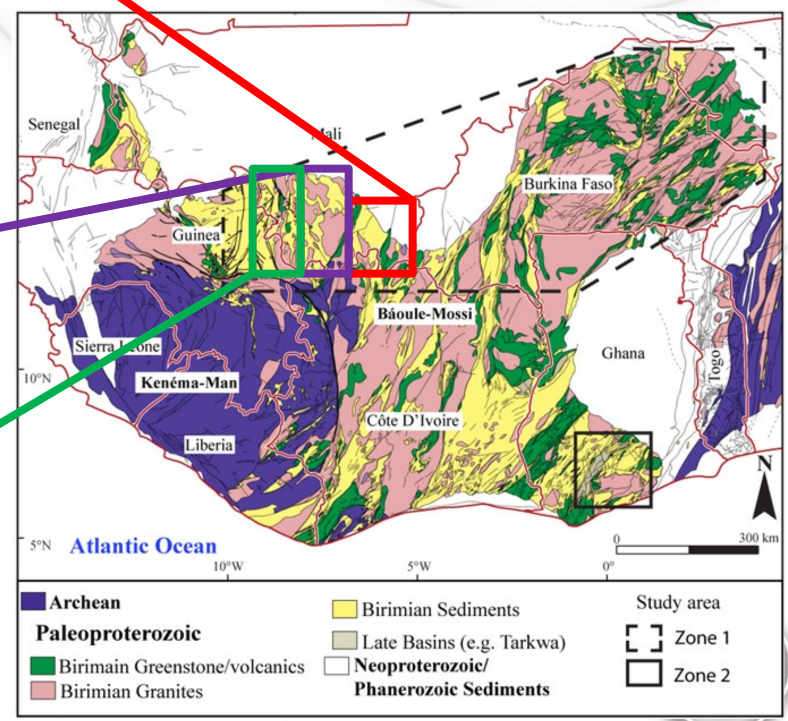


Geochronology bas

Southern Mali

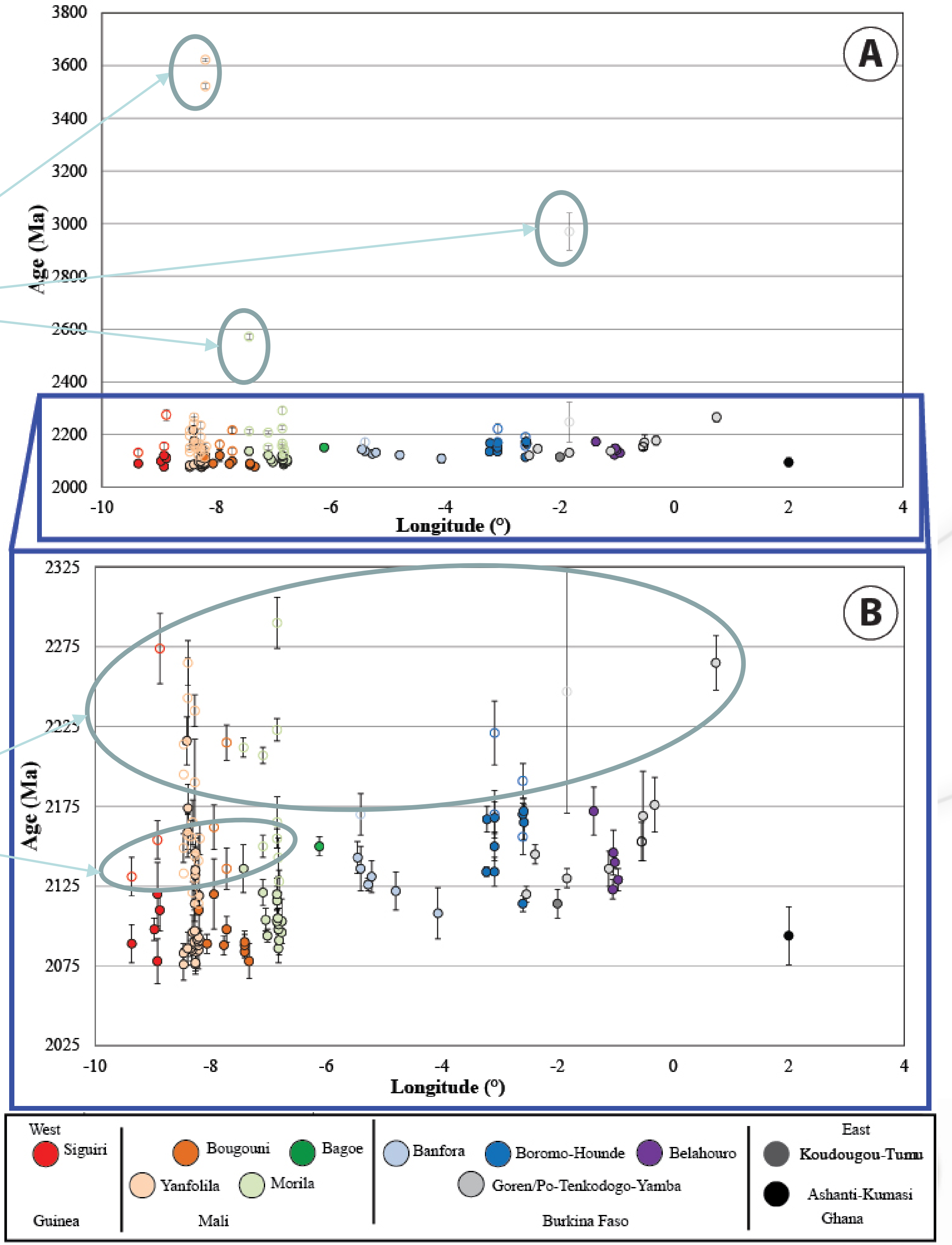
- Syama mine (Bagoe Belt) ages peak at ca. 2150 Ma
- Morila Belt inferred ages between ca. 2140 - 2080 Ma.
- Bougouni domain, ages between ca. 2100 - 2080 Ma.
- Yanfolila Belt, ca. 2220 - 2070 Ma.





Geochronology

- Presence of Inherited grains/core (4 total>2500 Ma)
- Inheritance increases in the western portion, predominately in samples younger than ca. 2125 Ma
- Inheritance mainly between ca. 2275 and 2130 Ma.



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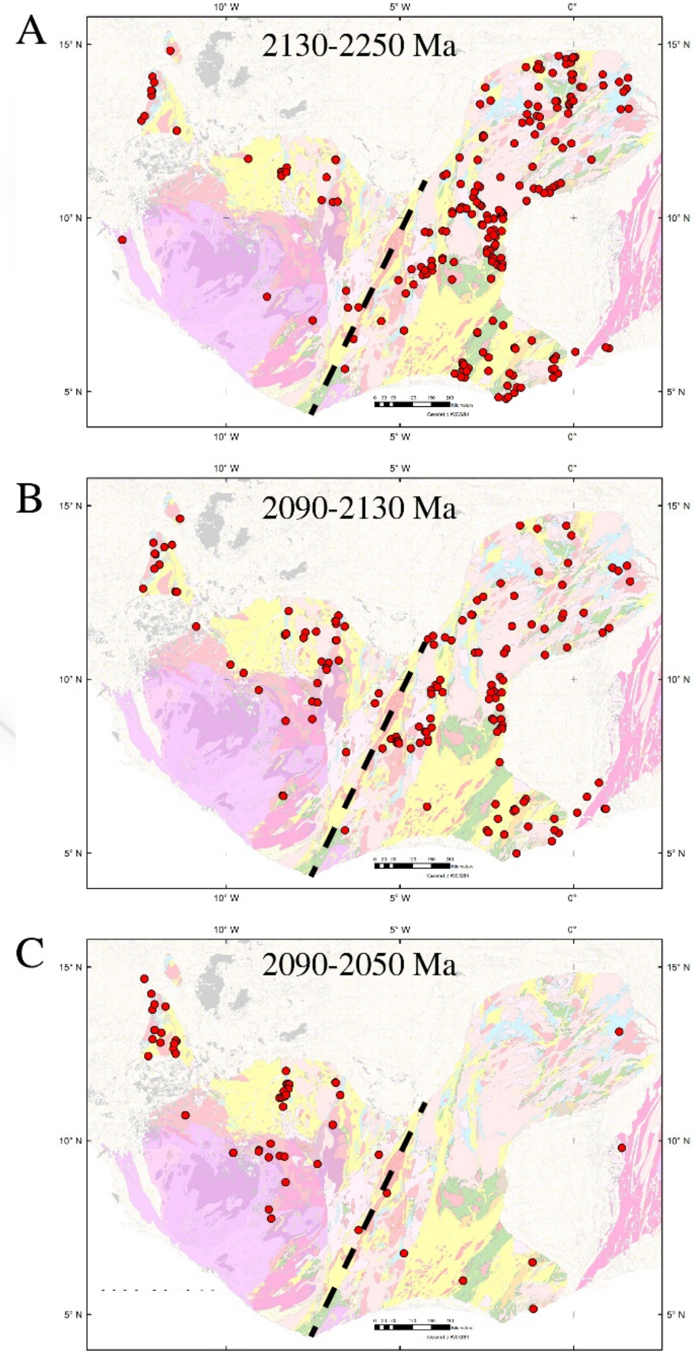
Geochronology basics.

- all zircon ages (magmatic, metamorphic and detrital) supports diachronous evolution
- Cessation and retreat of magmatic activity
- Westward migration of the magmatic front of approximately 35 km/Myr.
- Offset of magmatism and distribution of inherited zircons points towards two crustal blocks
- An accretionary process might have started as early as ca. 2175 Ma. At this time a minor peak of magmatic activity is identified east of the Banfora Belt.
- Intrusions younger than ca. 2130 Ma generally contain inherited grains with ages up to 2250 Ma, mainly in the western portion of the Baoulé-Mossi domain.

Zircon Ages Distribution



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The O and Lu-Hf signatures

- Large $\delta^{18}O$ variability across Banfora Belt
- Increasing $\delta^{18}O$ from east to west
- Samples predominately show relatively high $\delta^{18}O$
- $\delta^{18}O$ values over 8 => Contamination with crustal material subject to near surface processes

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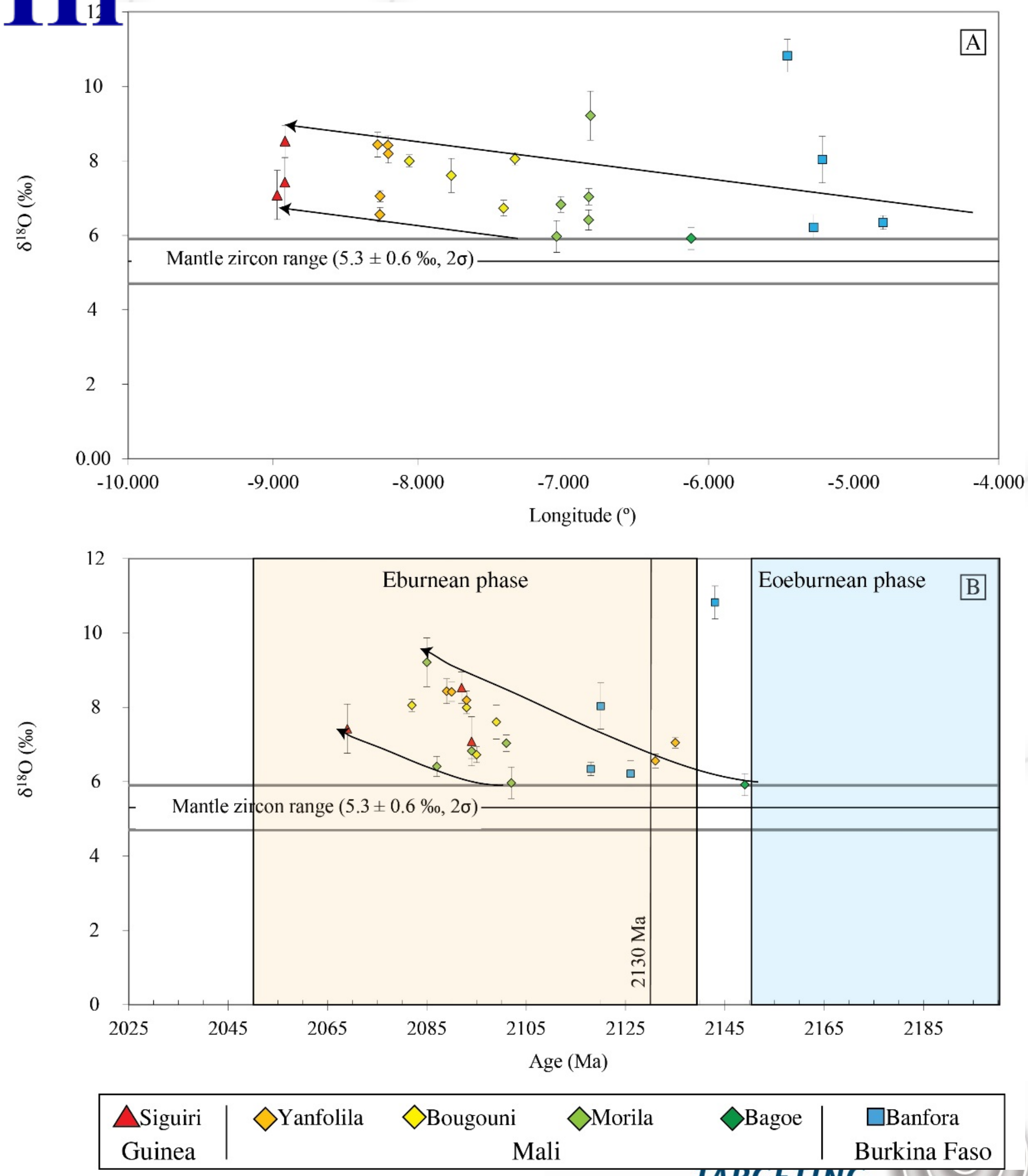

The O and Lu-Hf signatures

εHf from felsic intrusions mainly > 0

- Independent from belt sampling site
- Large variability among samples
- Predominately juvenile source
- Some mixing with a crustal component potentially as old as ca. 2700 Ma

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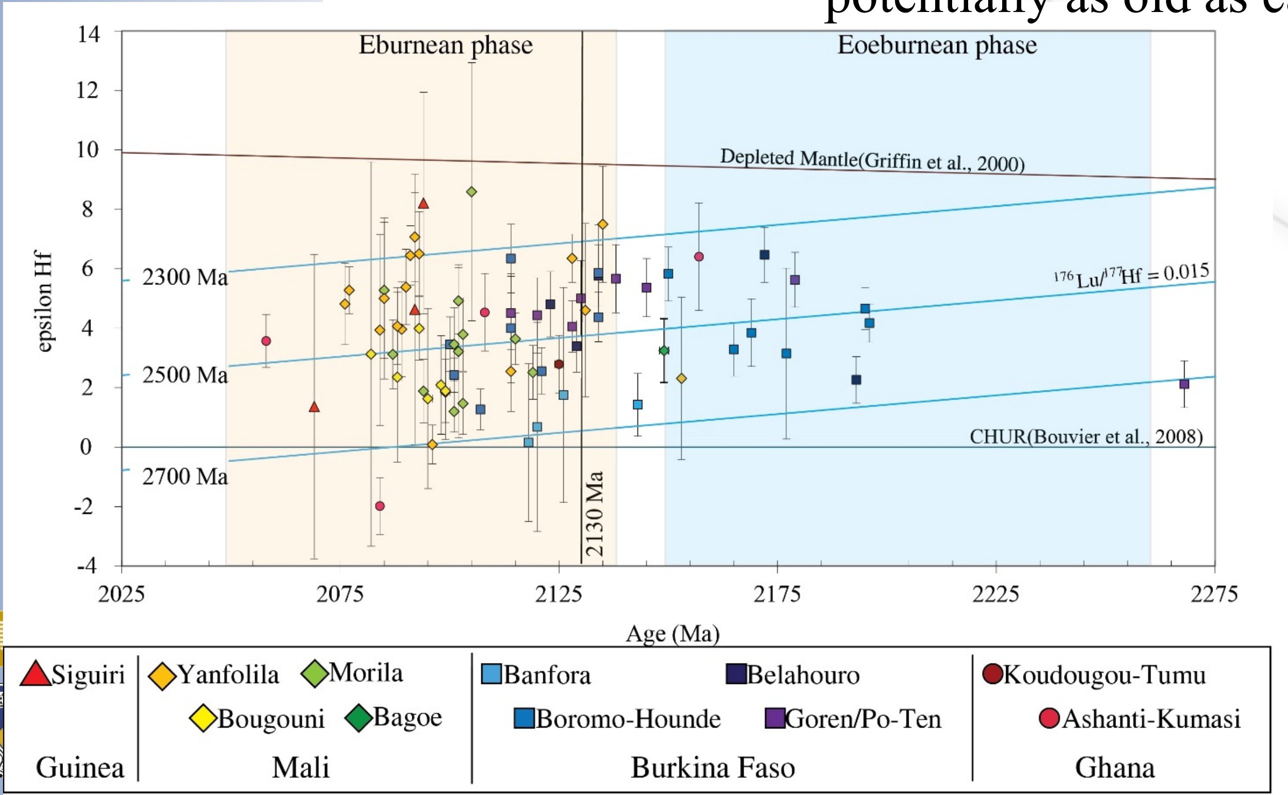

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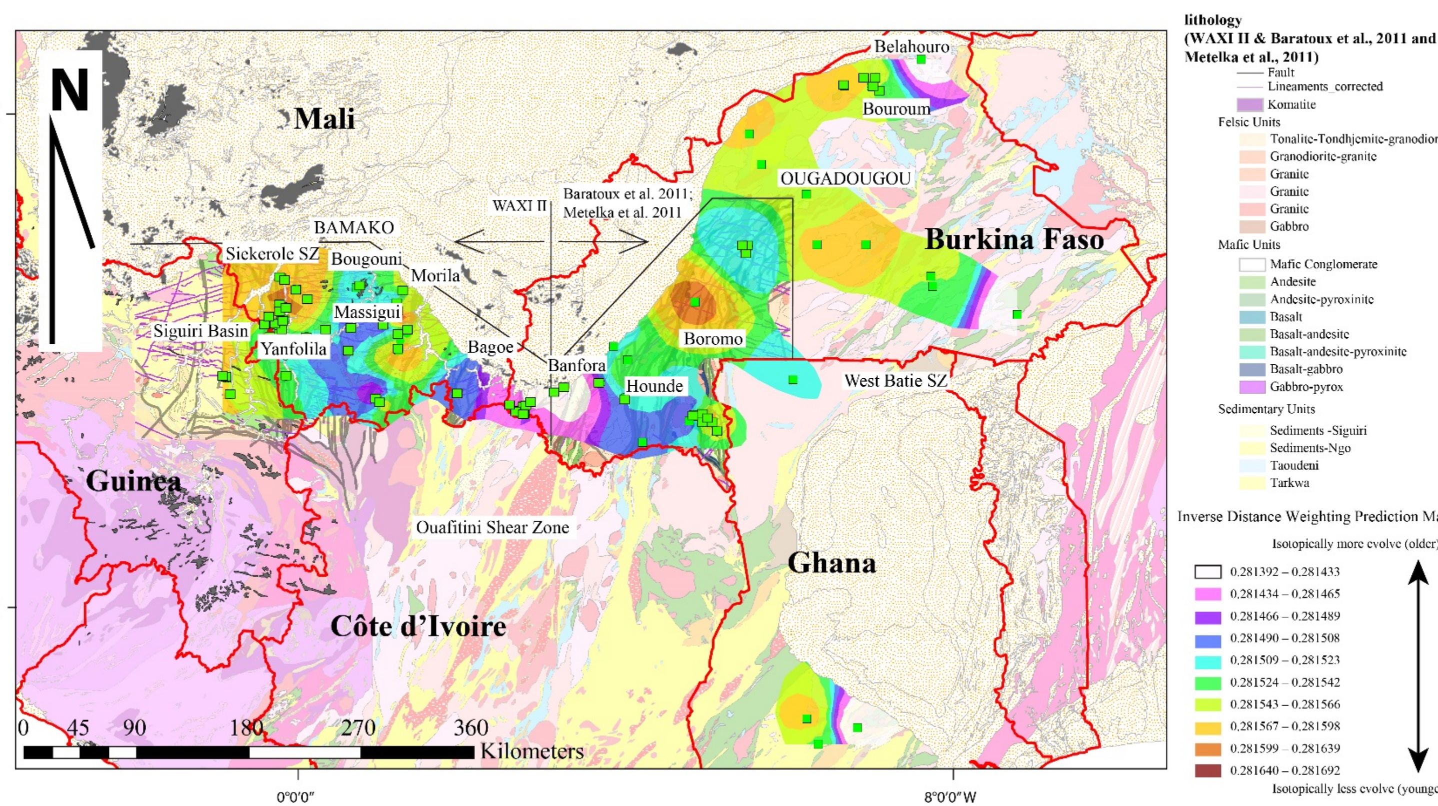
The O and Lu-Hf signatures

Potentially two crustal blocks

- Banfora – Bagoe belt a boundary?
    - Less radiogenic Hf signature
- South extension through the Greenville-Ferkessedougou-Bobo-Dioulasso fault



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The O and Lu-Hf signatures

Felsic Intrusions, O and Lu-Hf isotopes

- Two predominately juvenile regions
- One less radiogenic Hf signature between Banforal and Bagoe belts
- A crustal component potentially as old as ca. 2800 Ma
- Westernmost part has a higher proportion of older crustal material in the source when compared to the easternmost area
  - Greater interaction between Paleoproterozoic and Archean domains
- O-isotope data supports crustal contamination/interaction with supracrustal materials

SUMMARY

- Detrital zircons match mean peaks of magmatic activity identified from the igneous record.
- Diachronous evolution
  - East magmatic activity ca. 2.26 - 2.13 Ga, peak at ca. 2.15-214 Ga.
  - West magmatic activity between ca. 2.10 and 2.07 Ga, peak at ca. 2.09 Ga.
- Inherited ages between ca. 3.6 and 2.13 Ga.
- O (magmatic zircons) and Hf data (detrital/magmatic zircons) suggest mixing and recycling of a crustal source as old as 2.8 Ga.

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