

IASGT 2026 · KEYNOTE ADDRESS

Structures of the Volta Basin

From Top to Bottom — or is it the other way round?

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*ex solo ad solem, वसुधैव कुटुम्बकम्
ex solo ad solem, Vasudhaiva Kutumbakam
from the earth to the sun, the world is one family*

The title says, “top to bottom.”

It's a lie of convenience.

The Volta Basin's sediments are the part everyone can see, sample, and drill — so every talk starts there. But the basement rocks beneath them are roughly **2,000 million years older**, and they never actually gave up control. The central finding of this talk is blunt about it: **basin architecture, fault distribution, and even present-day drainage are all fundamentally governed by inherited basement structure.**

So today, we tell the story the way the rocks built it: bottom to top.



we start here

OVERVIEW

HOW A TALK USUALLY GOES

- 1 Surface & drainage
- 2 Sedimentary cover
- 3 Faulting
- 4 Basement



HOW THE ROCKS WERE ACTUALLY BUILT

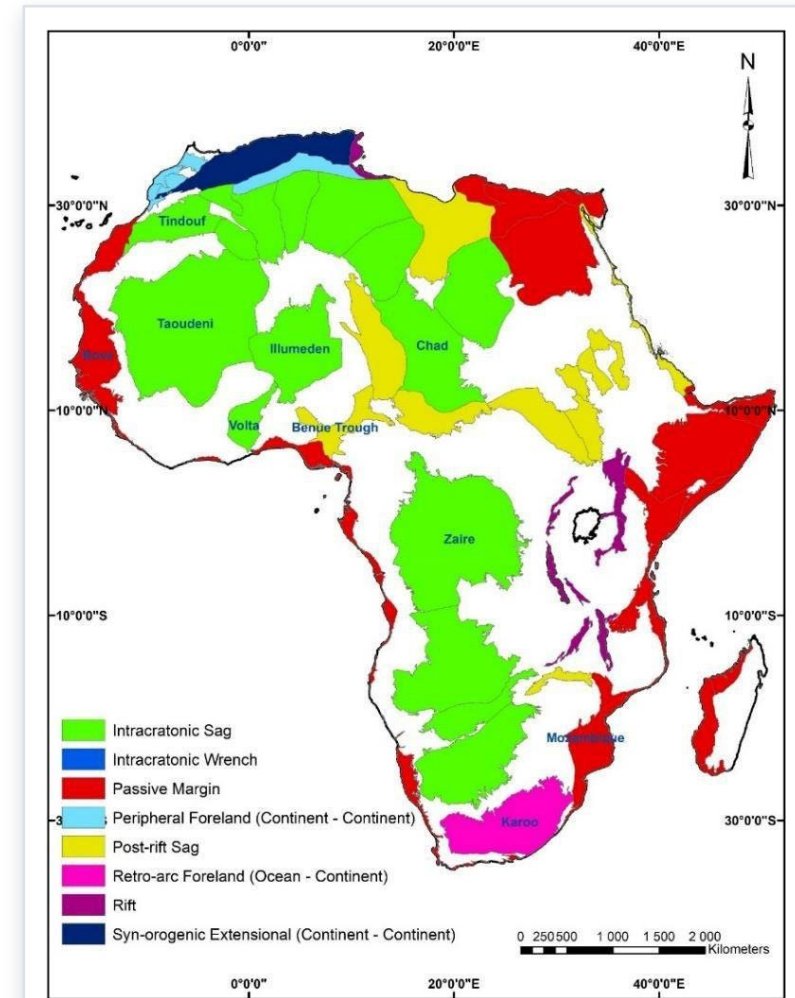
- 1 Basement architecture
- 2 Faulting & reactivation
- 3 Sedimentary cover
- 4 Surface & drainage
- 5 Synthesis & resources

One basin among Africa's intracratonic sags

The Volta Basin covers roughly **112,000 km²** of central Ghana, extending into Togo, Benin, Burkina Faso, and Niger.

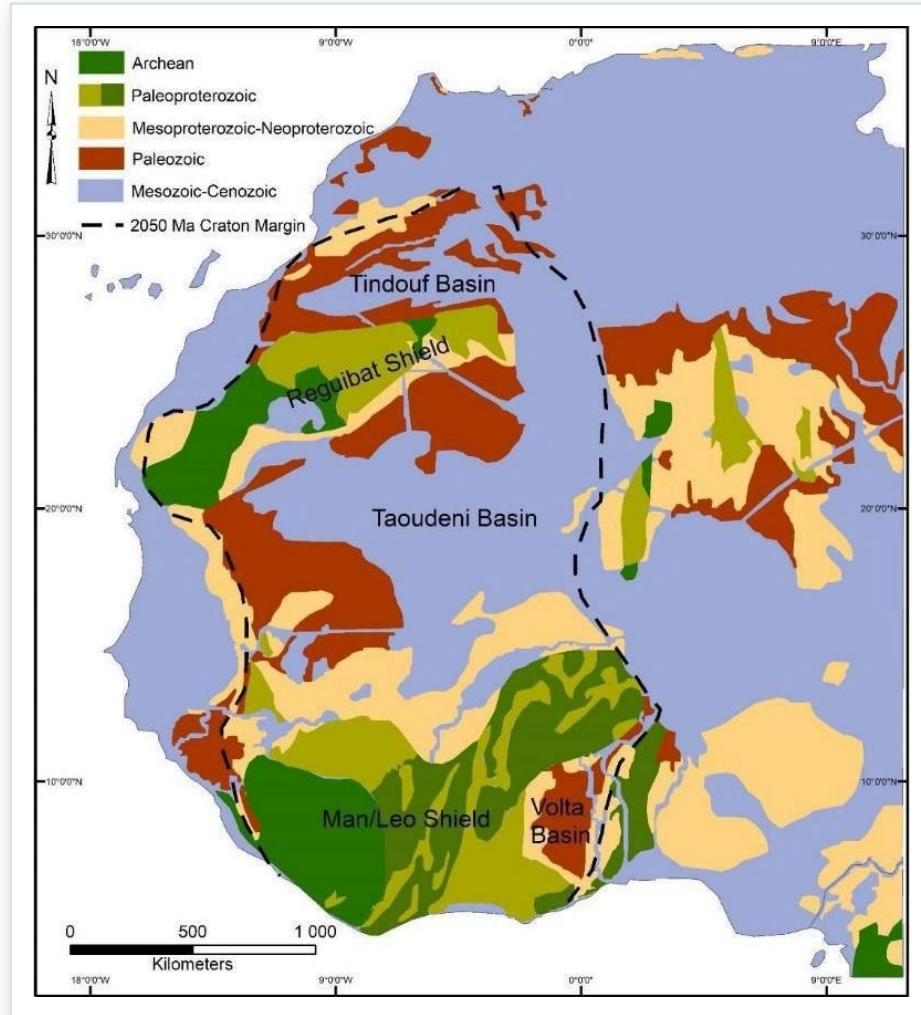
Classified alongside Taoudeni, Bové, and Chad as an **intracratonic sag** — basins that form over old, stable continental crust rather than at plate margins.

That crust is the whole point of today's talk.



Africa's sedimentary basins classified by tectonic style. Volta sits among the continent's intracratonic sags — broad, gently subsided basins floored by ancient continental crust.

Sitting on the West African Craton



The craton has two basement provinces:

- **Archaean nucleus** (Man–Leo / Kénéma–Man) — over 2,500 Ma
- **Birimian domain** (Baoulé–Mossi) — Palaeoproterozoic, ~2,200–2,000 Ma, built from greenstone belts and granitoid intrusions

The Volta Basin sits directly on the **Birimian** — basement that was already structurally complex more than a billion years before the first Volta Basin sediment was deposited.

Geology of the West African Craton. Volta Basin sits at the eastern edge of the Baoulé–Mossi (Birimian) domain, bordering the Man–Leo Archaean shield to the southwest.

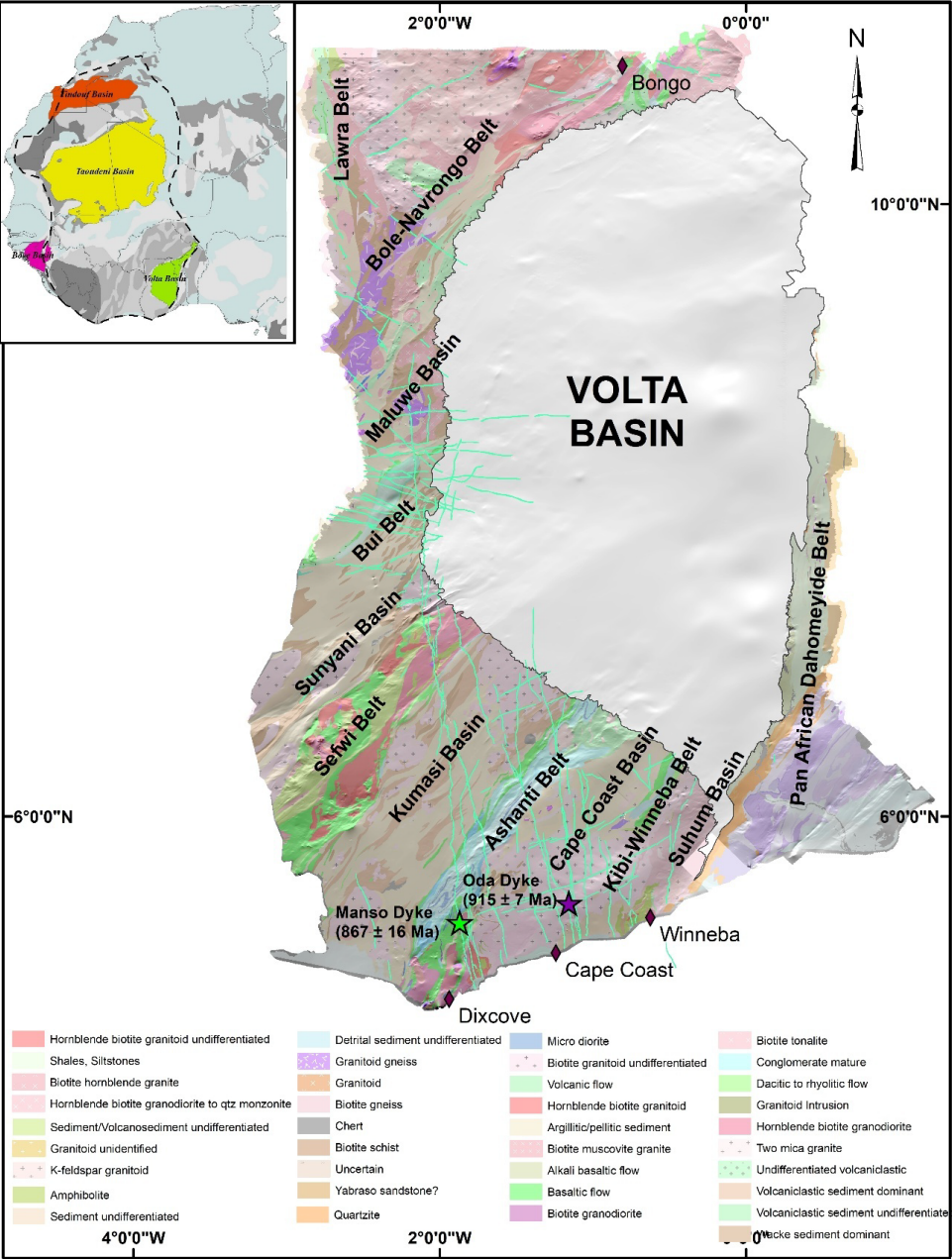
Ghana's greenstone belts frame an “empty” middle

On a standard geological map, the Volta Basin is a blank space — it simply hides everything beneath it.

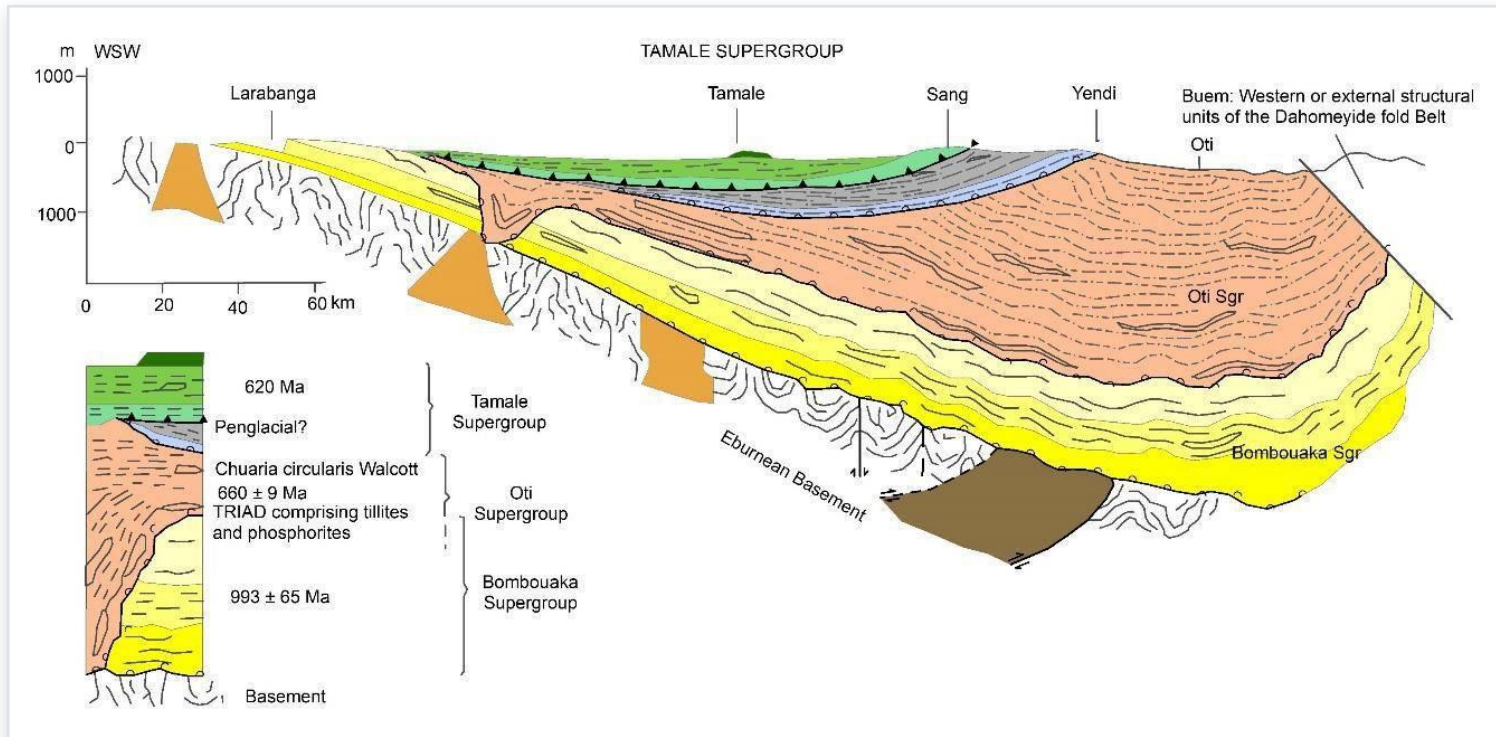
But the greenstone belts that surround it (Ashanti, Sefwi, Bui, Sunyani–Comoé, Bole–Navrongo, Lawra, Kibi–Winneba) don't stop at the basin's edge.

Do they continue underneath? — and if so, did they shape what sits on top of them?

Geological map of Ghana (after Agyei Duodo et al., 2009).



The part everyone already knows



Bombouaka Group

~993 Ma

Oti–Pendjari Group

~660 Ma

Obosum Group

~620 Ma

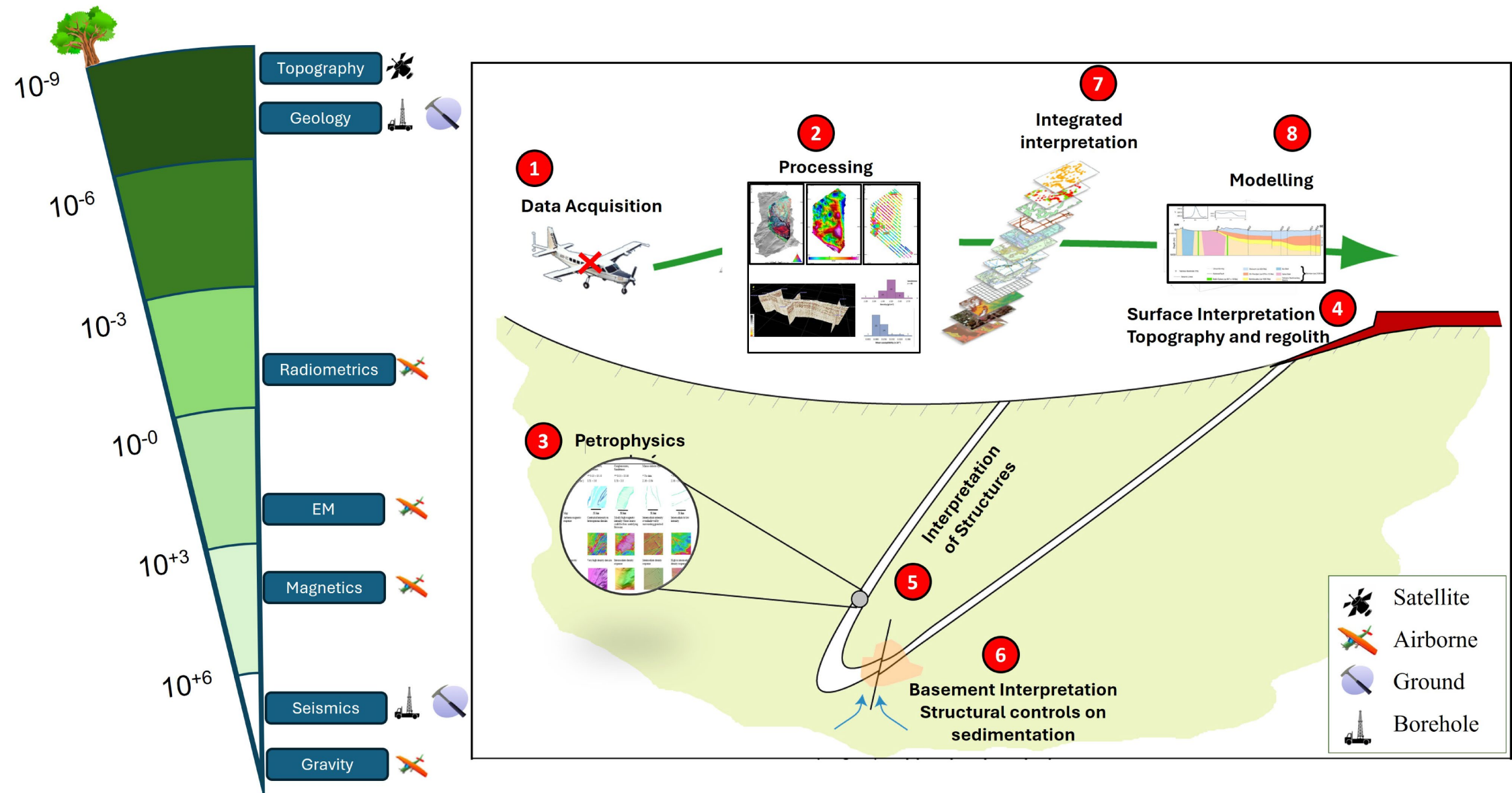
Asymmetric cross-section of the Volta Basin, after Affaton (1990), showing the three megasequences thickening toward the basin's depocentre.

Three decades of stratigraphic and sedimentological work (Affaton 1990; Carney et al. 2010) have mapped this sequence in detail. What they couldn't see: what's holding it up.

Schools of thought...

Model	Gravity	Magnetics	Seismic	Geology
Foreland basin (Black, 1967)	Large isostatic gravity anomaly	Elevated magnetic basement in imbricated folded nappes Deeply depressed magnetic basement in fold basin Moderately deep magnetic basement in hinge zone Shallow magnetic basement in foreland platform	Arcuate or piecewise arcuate reflecting the geometry of subduction Fault	Deep water marine through shallow water to continental sediments
Passive Margin (Affaton, 1990; Villeneuve and Cornée, 1994)	Highest gravity seaward of continent-ocean transition Positive gravity anomaly because low flexural strength	High amplitude magnetic anomalies associated with high susceptibility Defined boundary between transitional crust and oceanic crust	Faulting Crustal thinning High gradient lower crust overlain by a thin velocity layer	Dykes Igneous intrusions Fluvial deposits Lacustrine deposits Syn rift fluvial-lacustrine deposits overlain by post-rift marine shelf and slope sediments
Composite basin (Caby, 1983) *polyphase basin overprinted by multiple tectonic regimes	Prominent elongate gravity anomaly Intra-basement high density bodies	High susceptibility volcano-sedimentary sequence and mafic intrusions Linear magnetic anomalies reflecting superposed structural fabrics	High velocity rocks at depth	Mafic and ultramafic intrusions Volcano-sedimentary sequence

Choice of resolution



Well-mapped cover, unknown foundation

1

Decades of surface work

Stratigraphy, sedimentology, and depositional history are richly documented across the basin.

2

A basement black box

Basement structural control on the basin had barely been resolved — buried under thick, low-relief sedimentary cover.

3

A live hypothesis

Regional studies elsewhere hinted that inherited crustal fabric quietly steers basin evolution. Does it here too?

The research question: does the Birimian basement fundamentally control Volta Basin architecture — and can geophysics prove it beneath 7+ km of cover?

SO LET'S FLIP THE SCRIPT

Bottom to Top

If the basement calls the shots, that's where we go first.



Threefold objectives



1. Delineate

Spatial extent and structural configuration of basement using aeromagnetic and gravity data



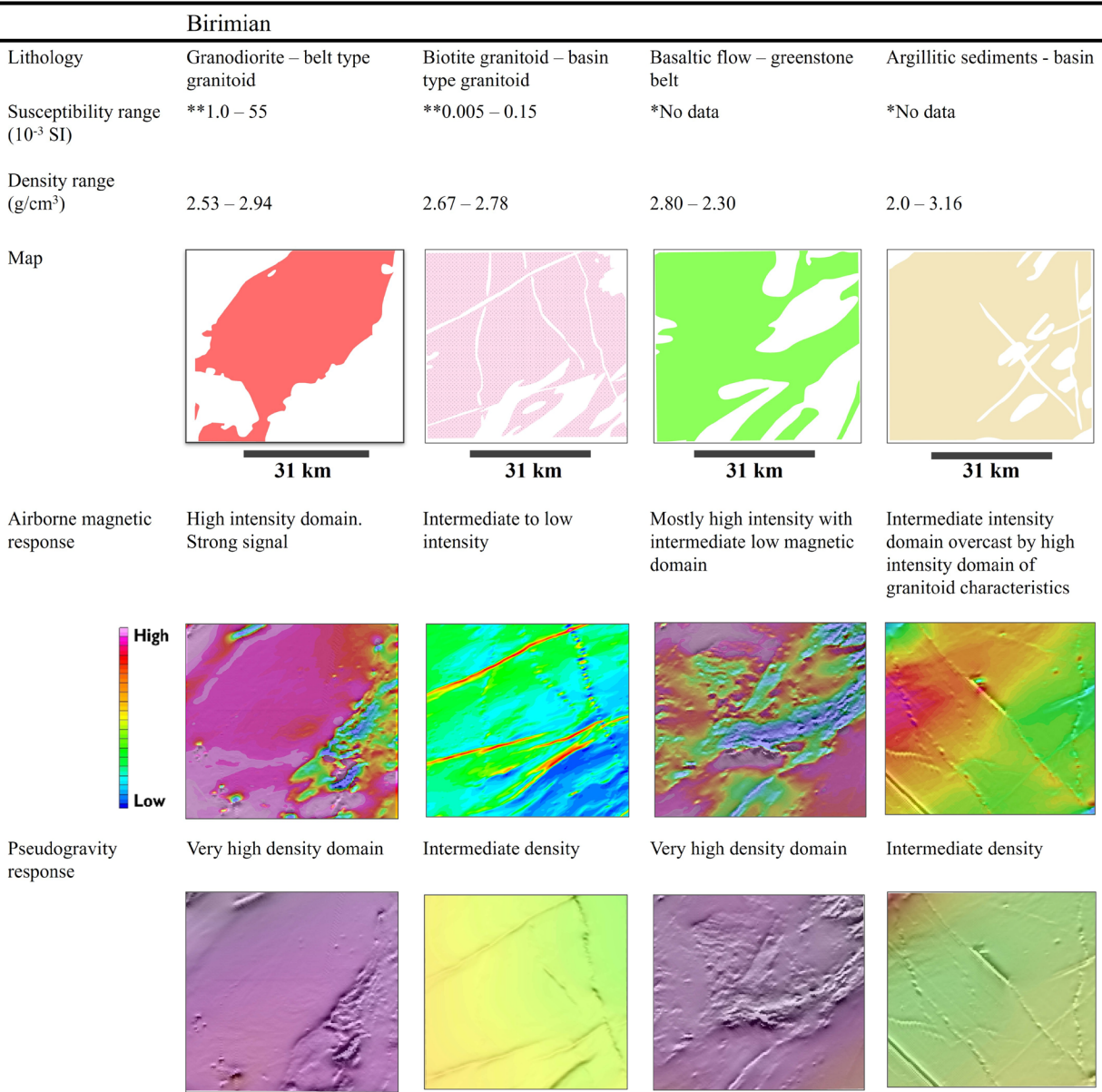
2. Identify

Fault systems and basement-sediment contact within the basin using seismic and radiometric signatures.

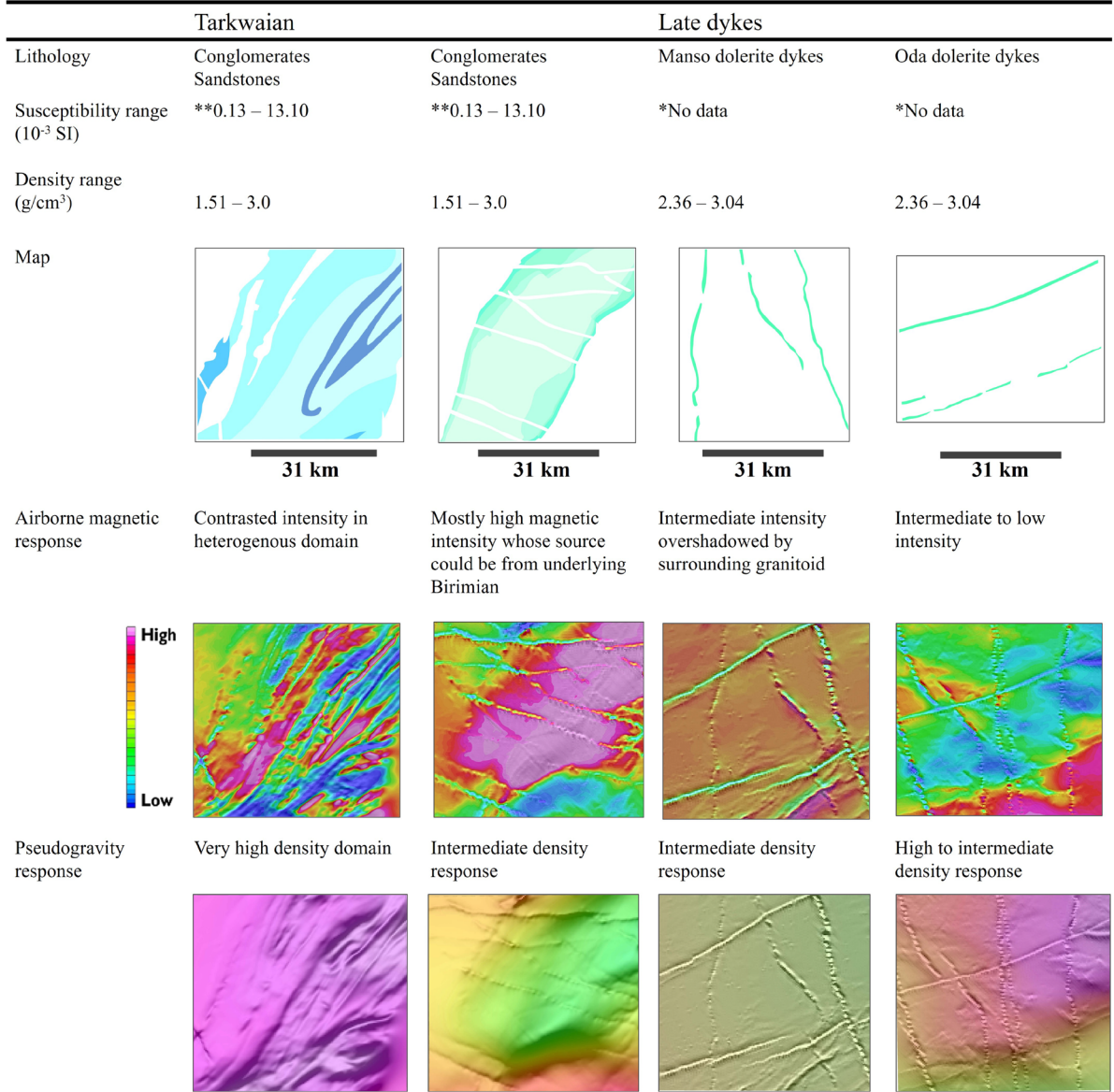


3. Constrain

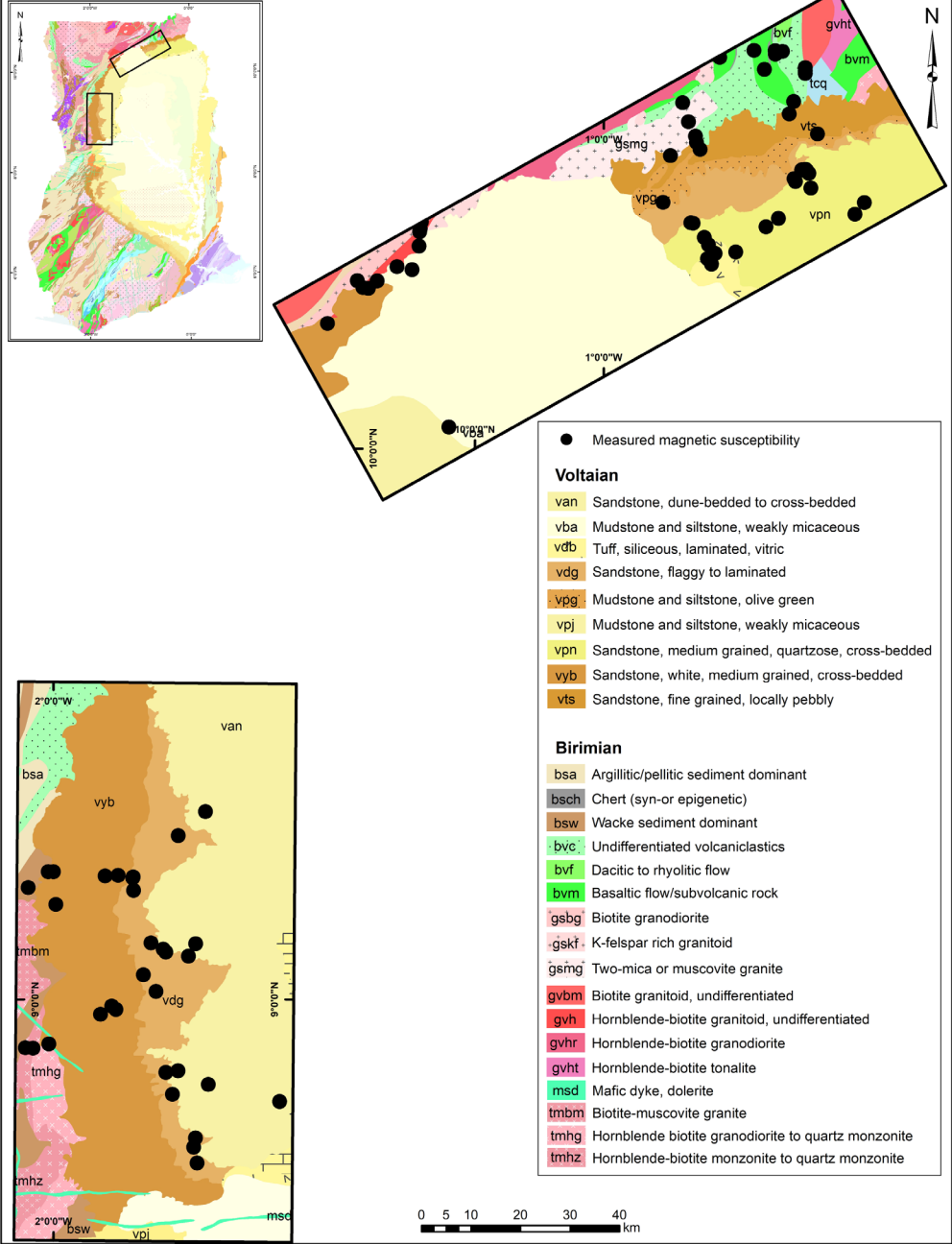
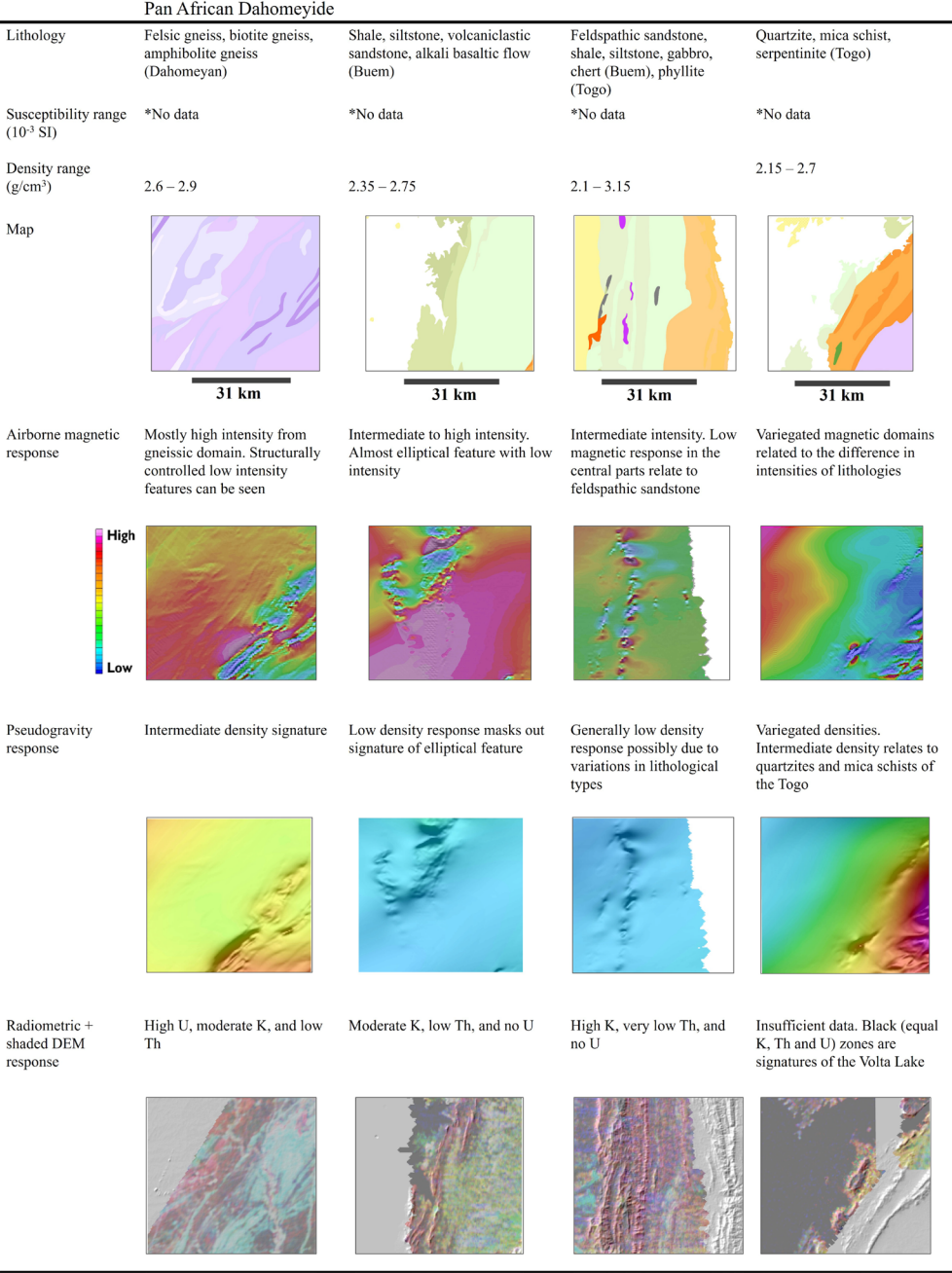
Lithological variations using petrophysical measurements



*No measured data available. Physical property values obtained from geophysical data
 **Petrophysical data obtained from [Perrouy et al \(2012\)](#) and [Block et al. \(2015\)](#)

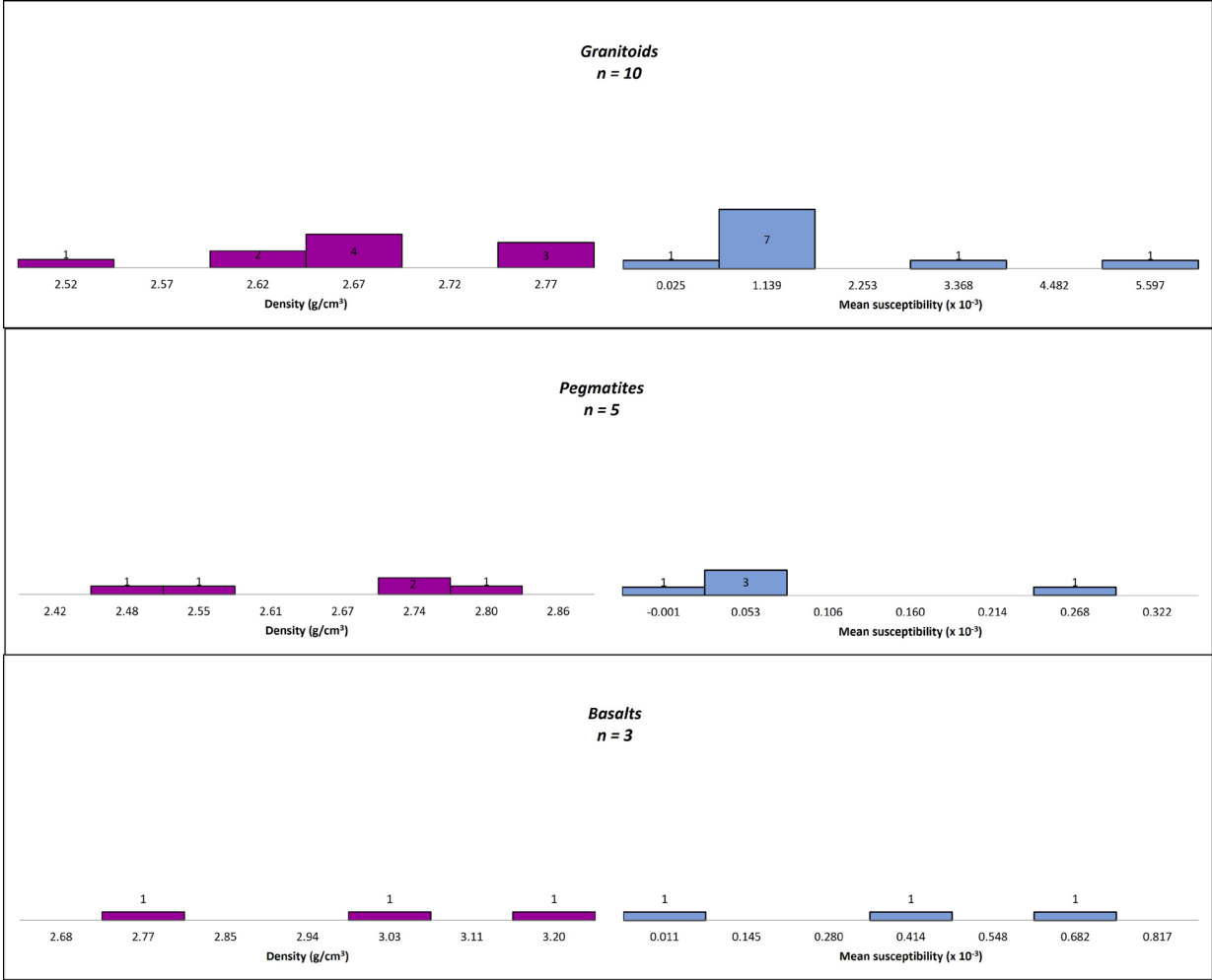
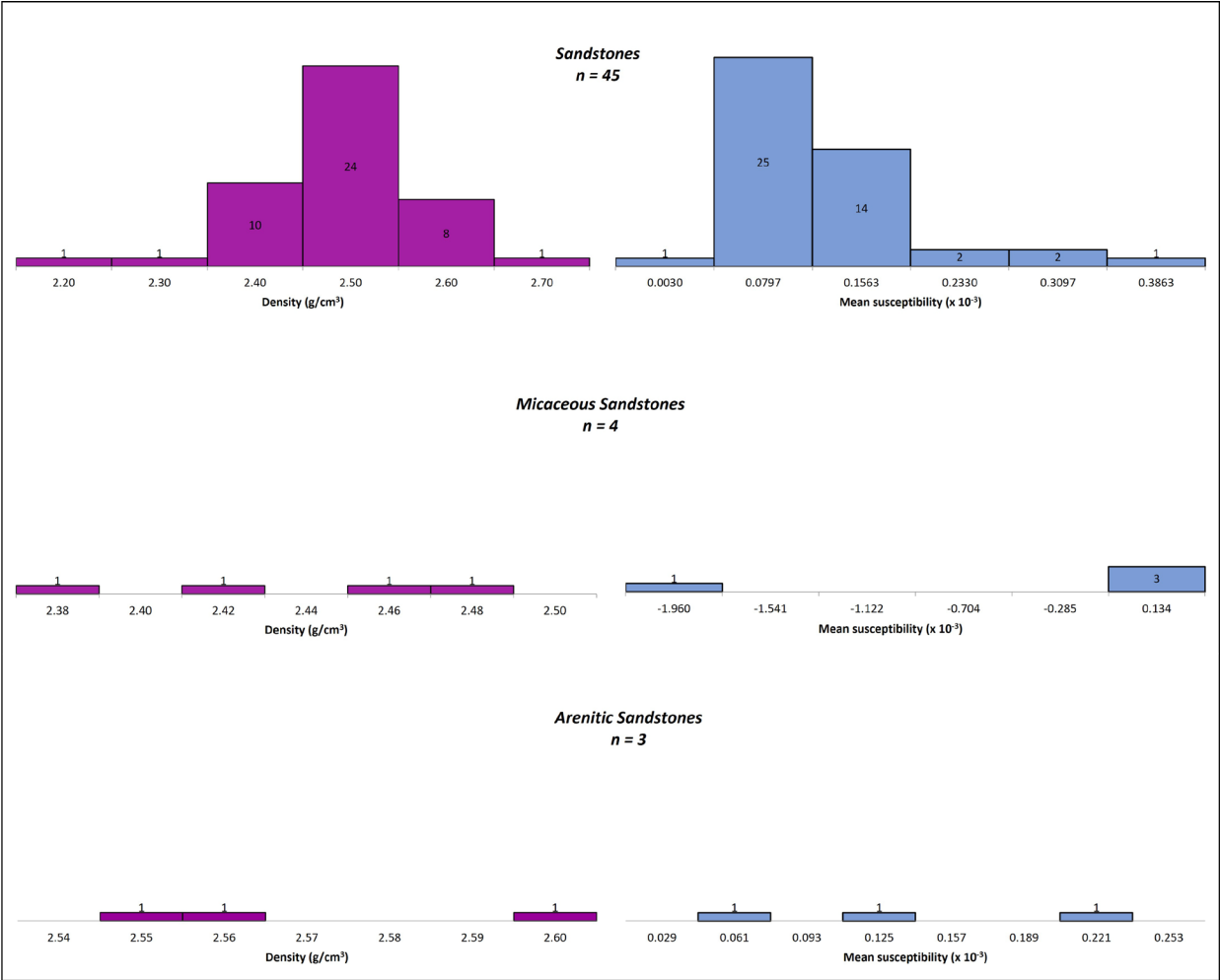


**Petrophysical data obtained from [Perrouy et al \(2012\)](#) and [Block et al. \(2015\)](#)



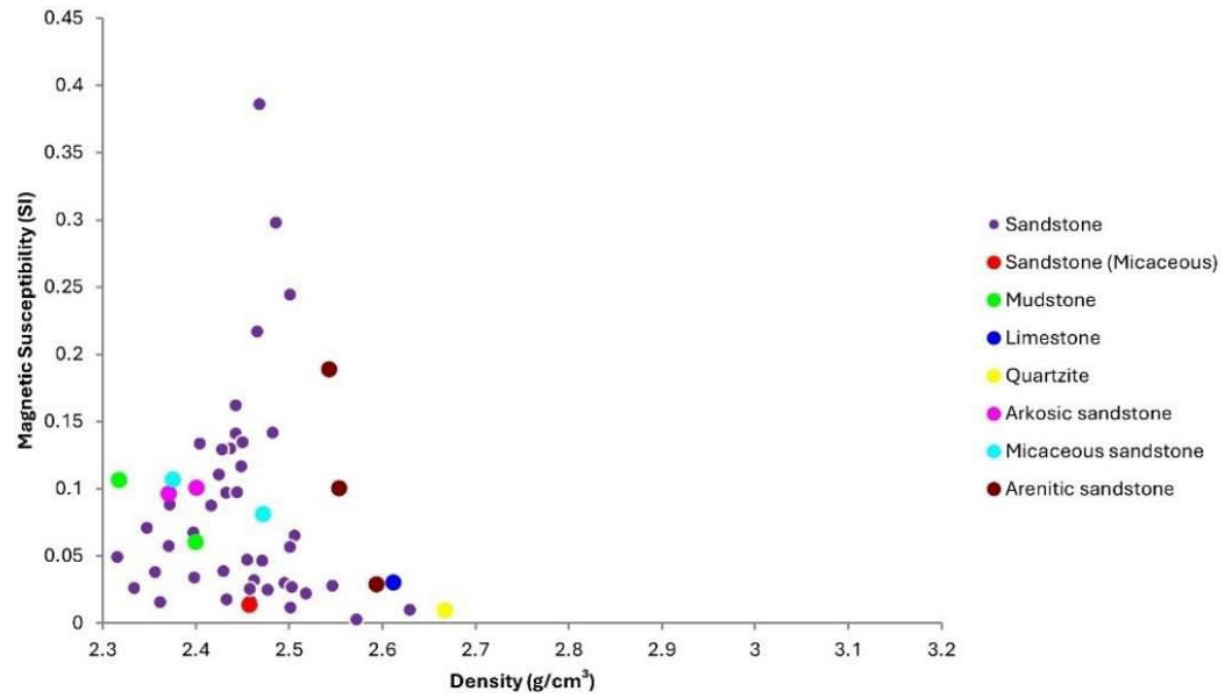
Petrophysics

DATA

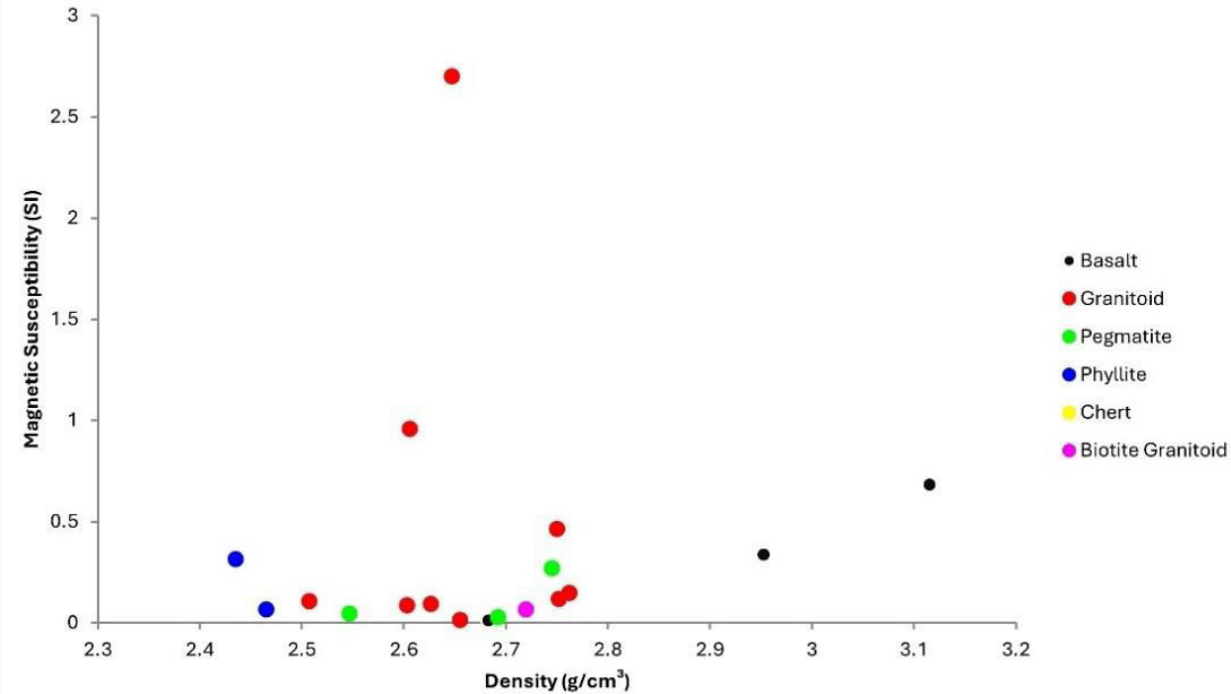


Petrophysics

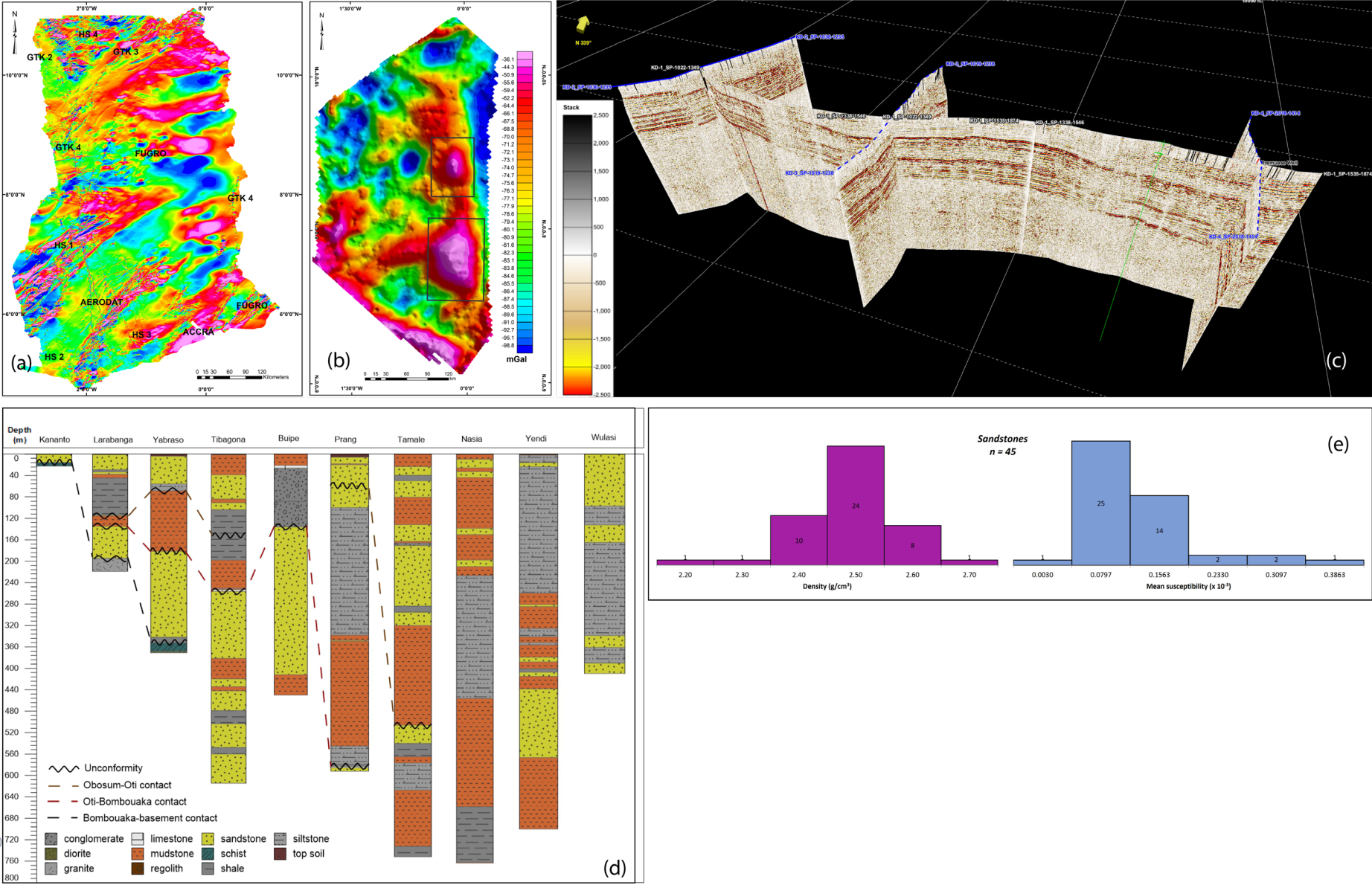
Magnetic susceptibility vs Density by Lithology - Voltaian Sediments



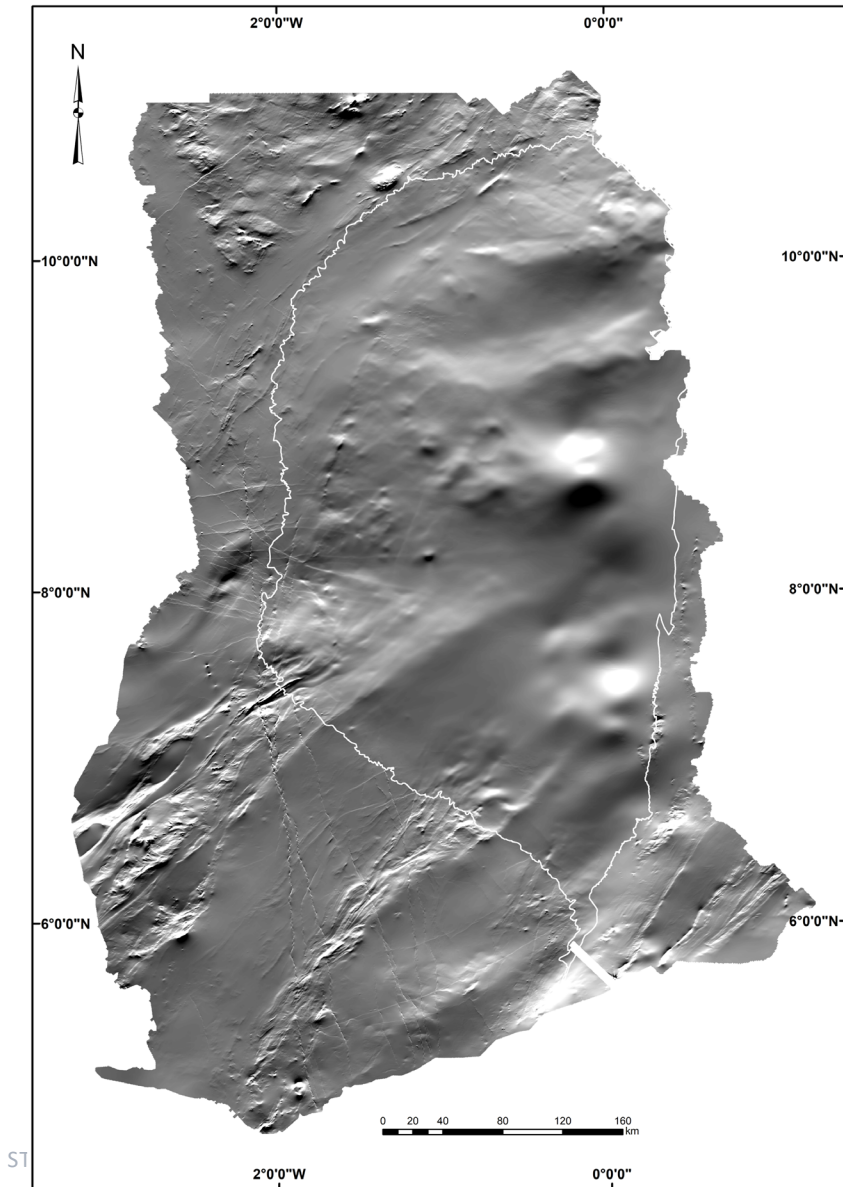
Magnetic Susceptibility vs Density by Lithology - Birimian Rocks



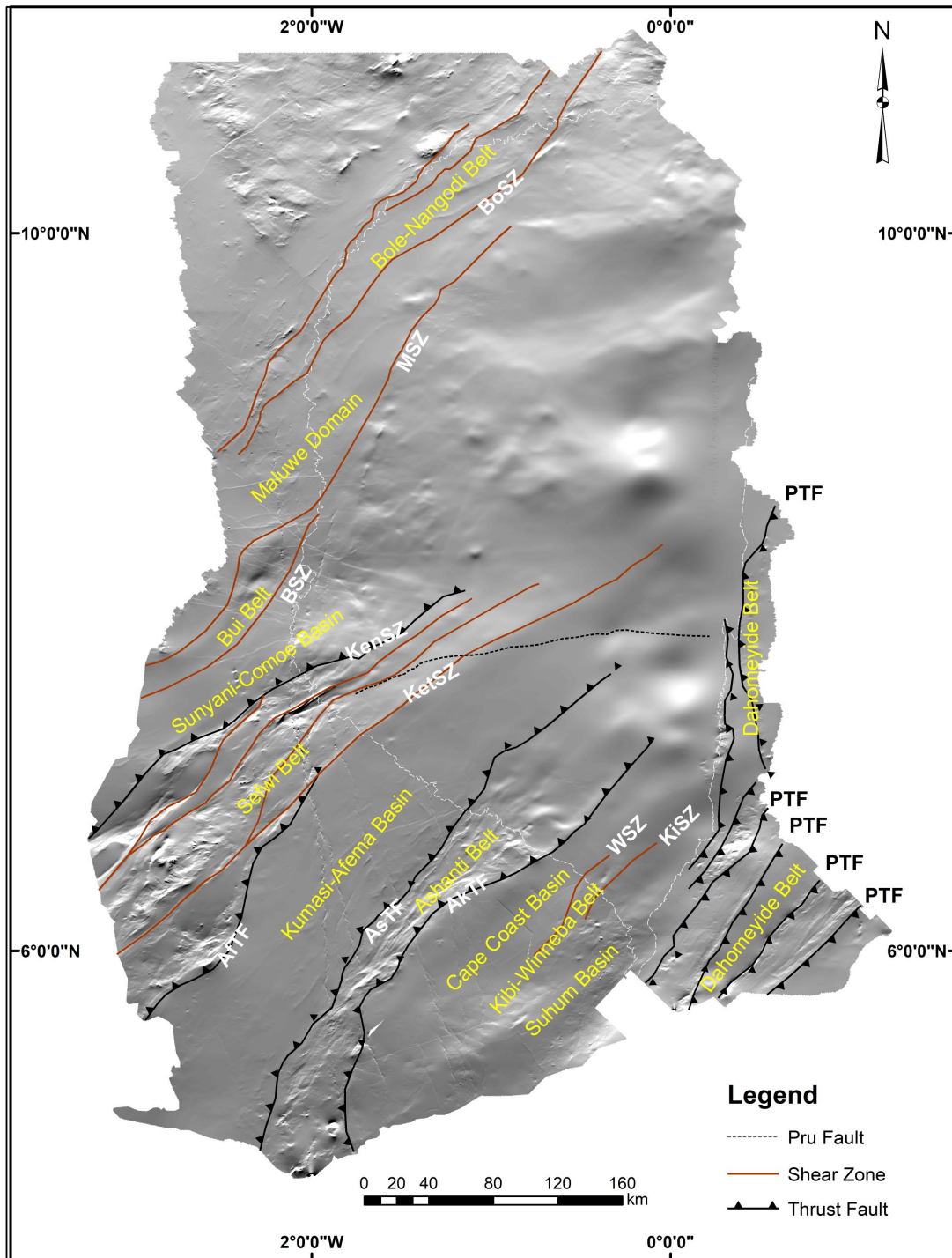
Five datasets, one integrated workflow



Greenstone belts don't stop at the basin edge



Reduced-to-equator TMI beneath the Volta Basin (outlined). Shear zones and greenstone belts trace continuously under the sedimentary cover.



p at the basin edge

BASEMENT

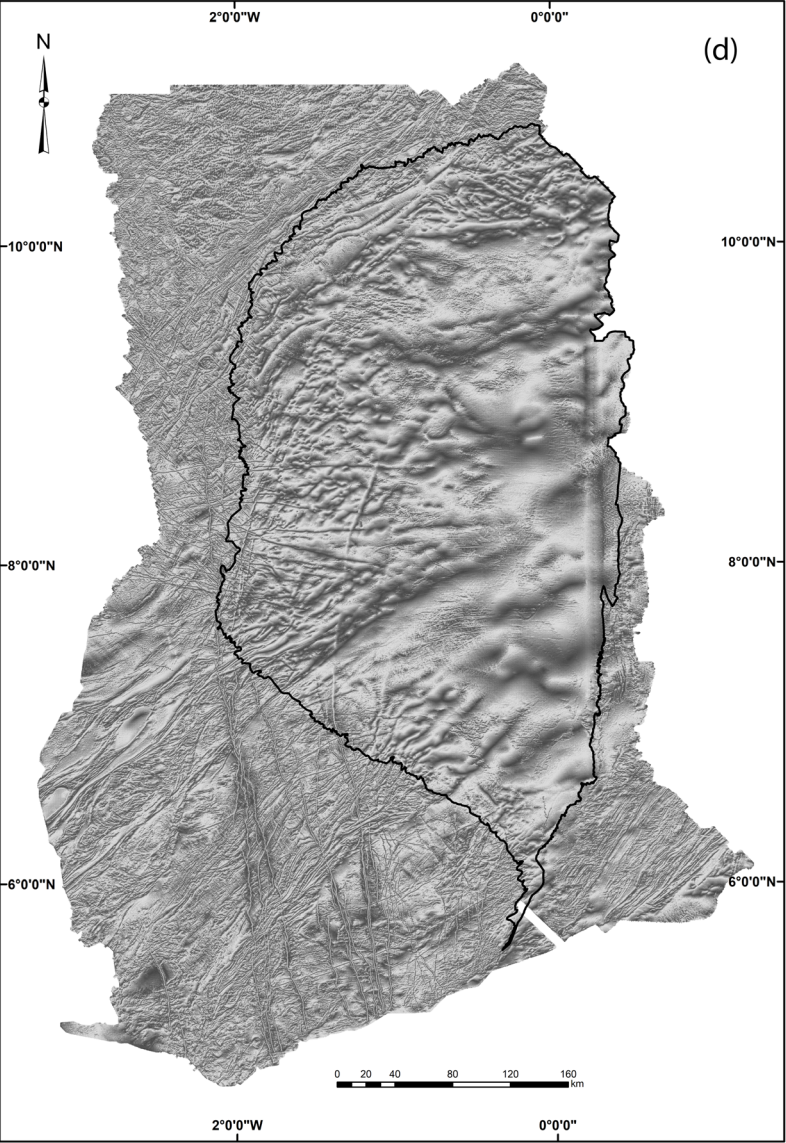
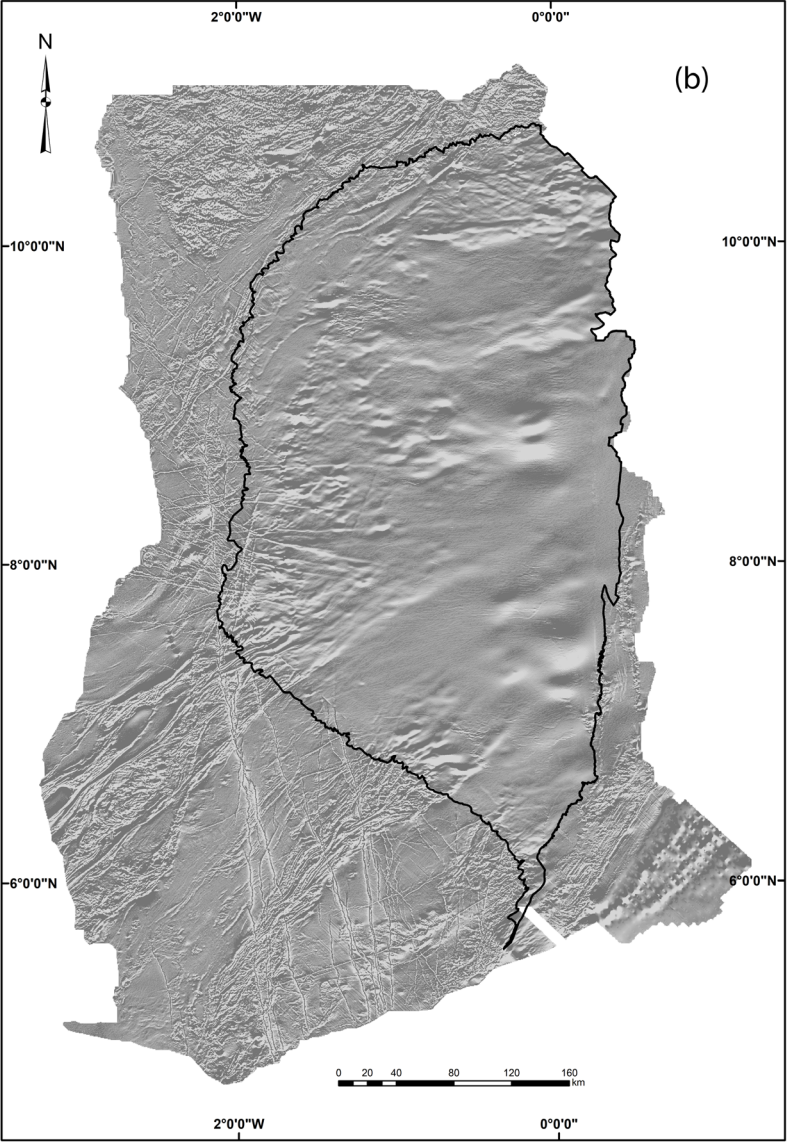
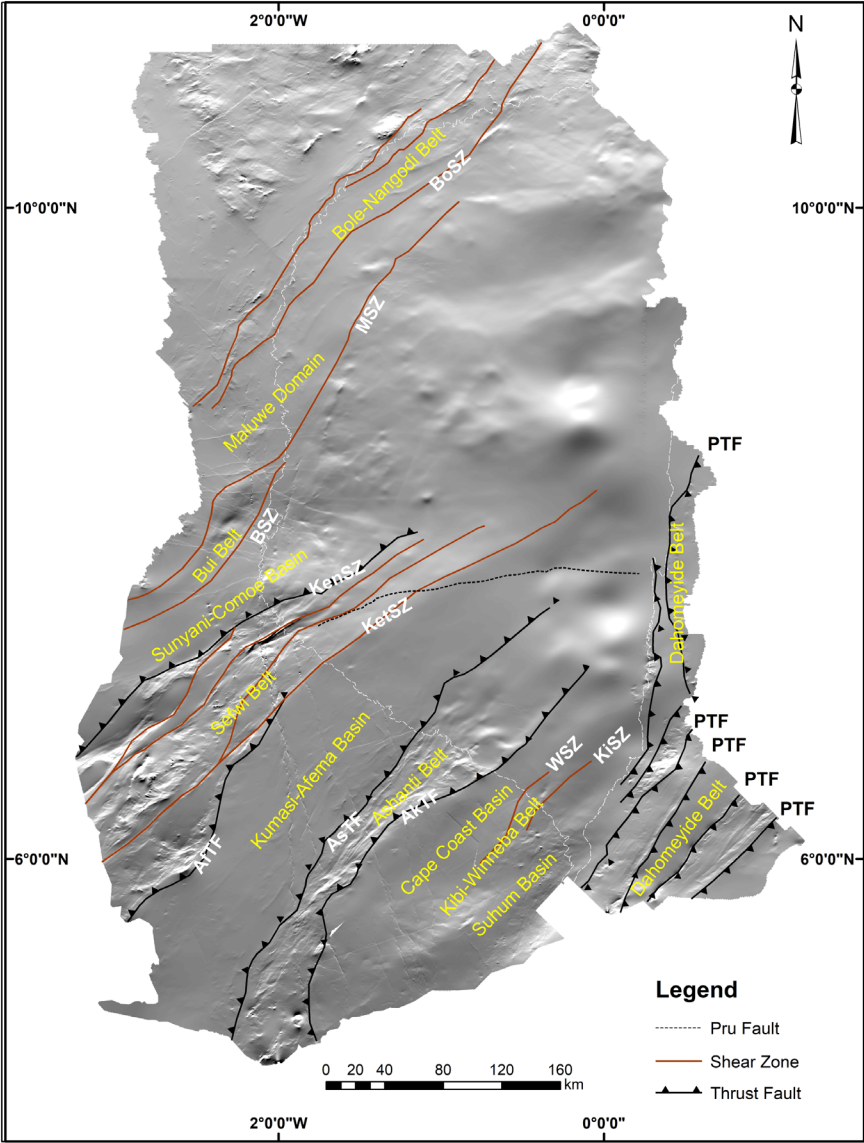
Tracing magnetic continuity beneath the cover, the Ashanti, Sefwi, Bole–Navrongo, and Bui greenstone belts extend laterally for approximately:

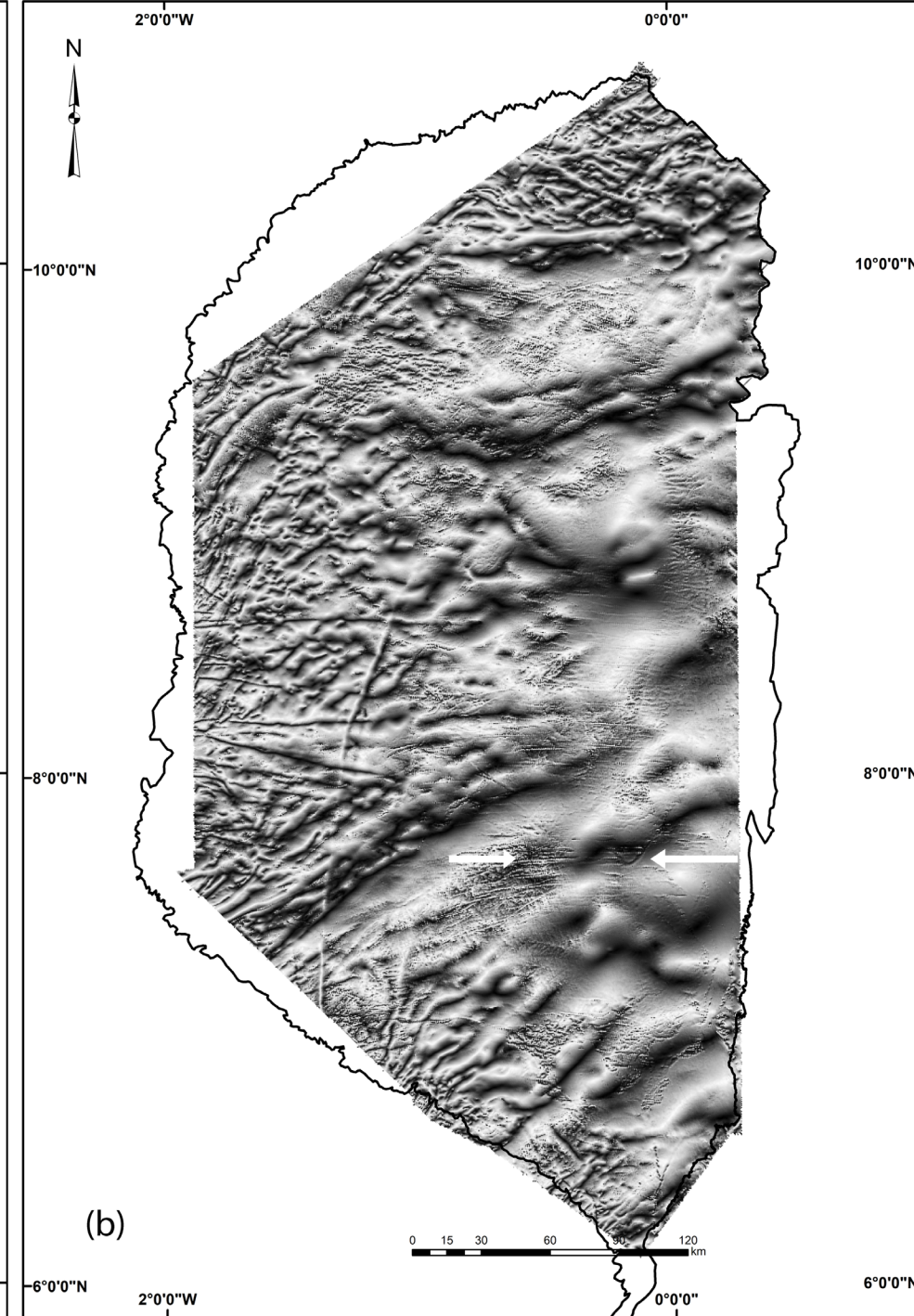
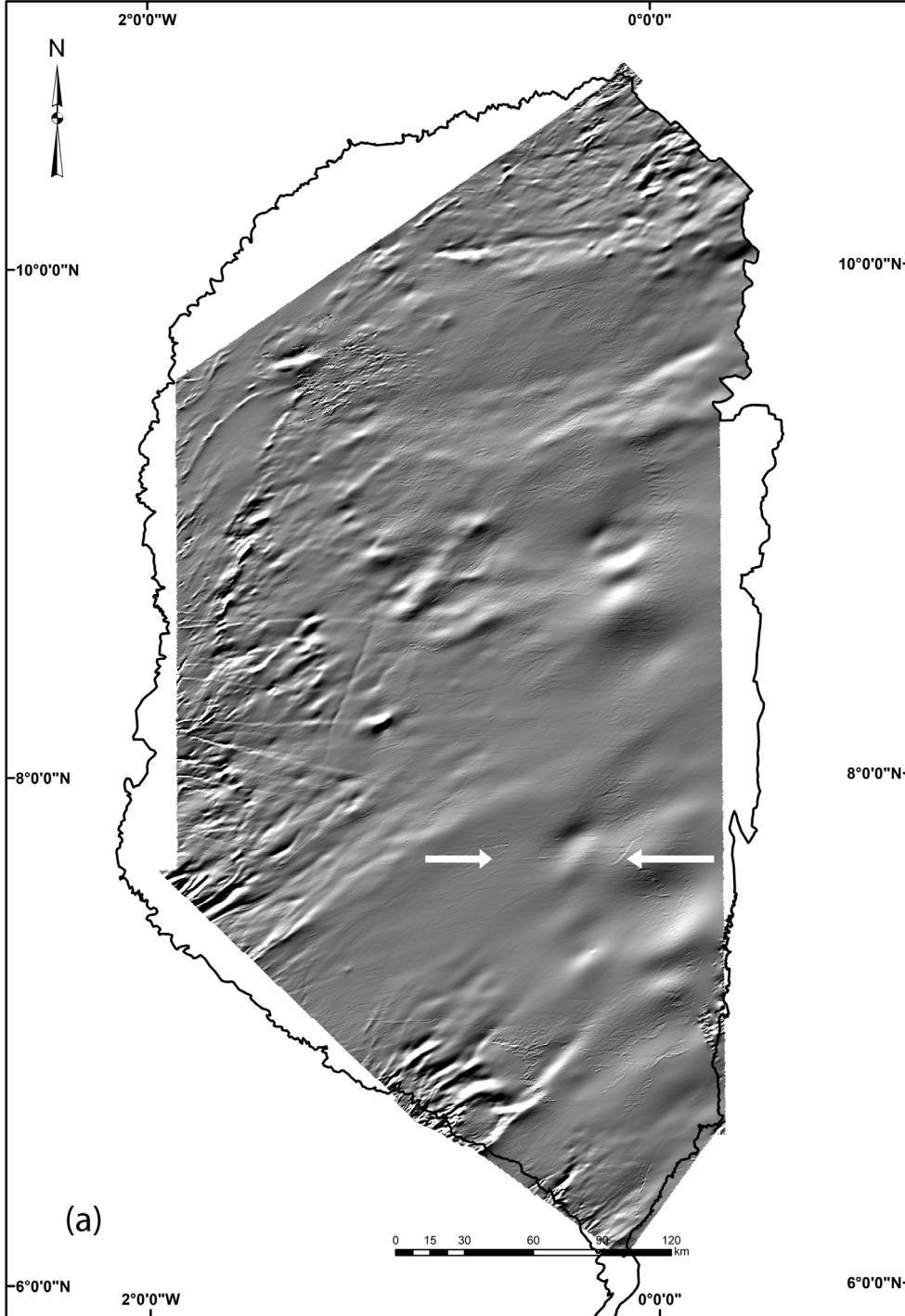
Ashanti Belt	113 km
Sefwi Belt	155 km
Bole–Navrongo Belt	195 km
Bui Belt	25 km

Intervening Suhum, Cape Coast, Kumasi-Afema, and Maluwe basins account for most of the basement domain beneath the Voltaian cover.

Reduced-to-equator TMI beneath the Volta Basin (outlined). Shear zones and greenstone belts trace continuously under the sedimentary cover.

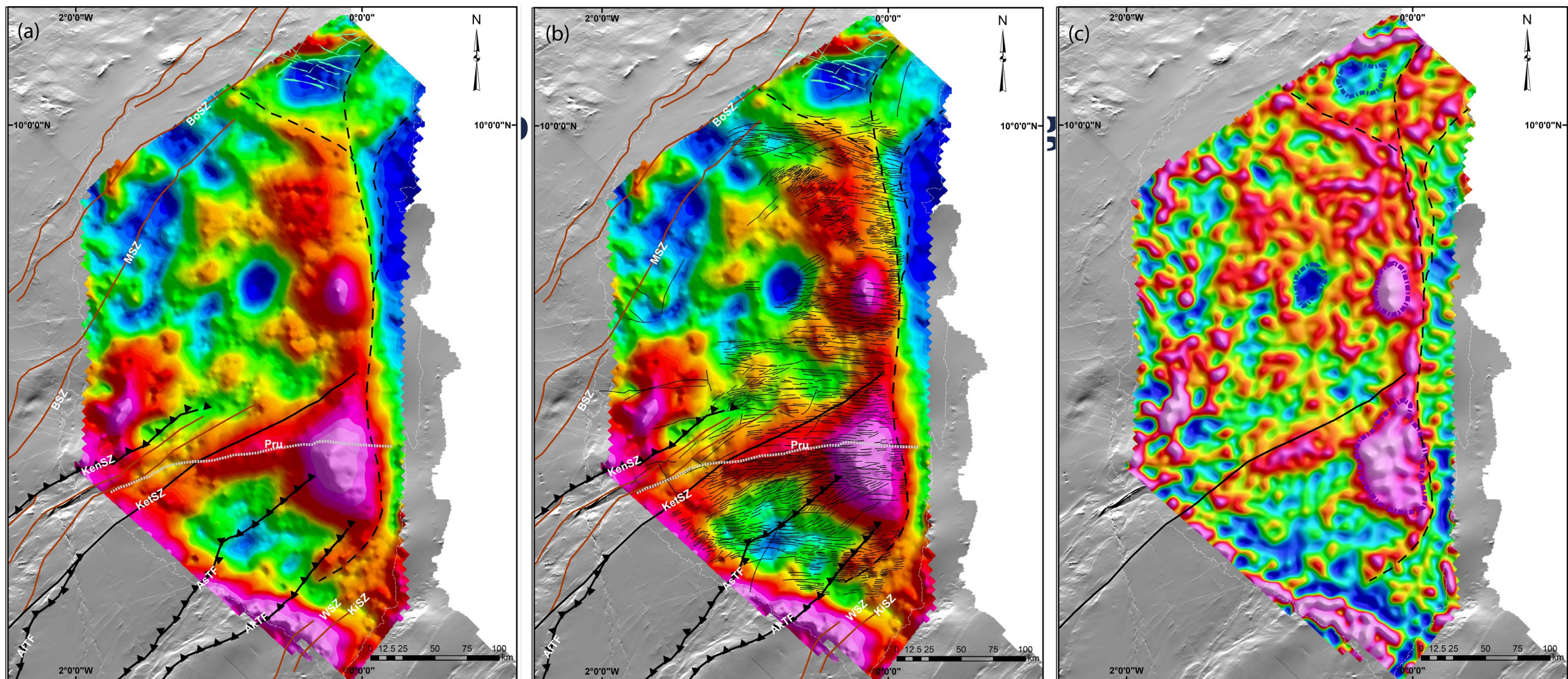
Greenstone belts don't stop at the basin edge





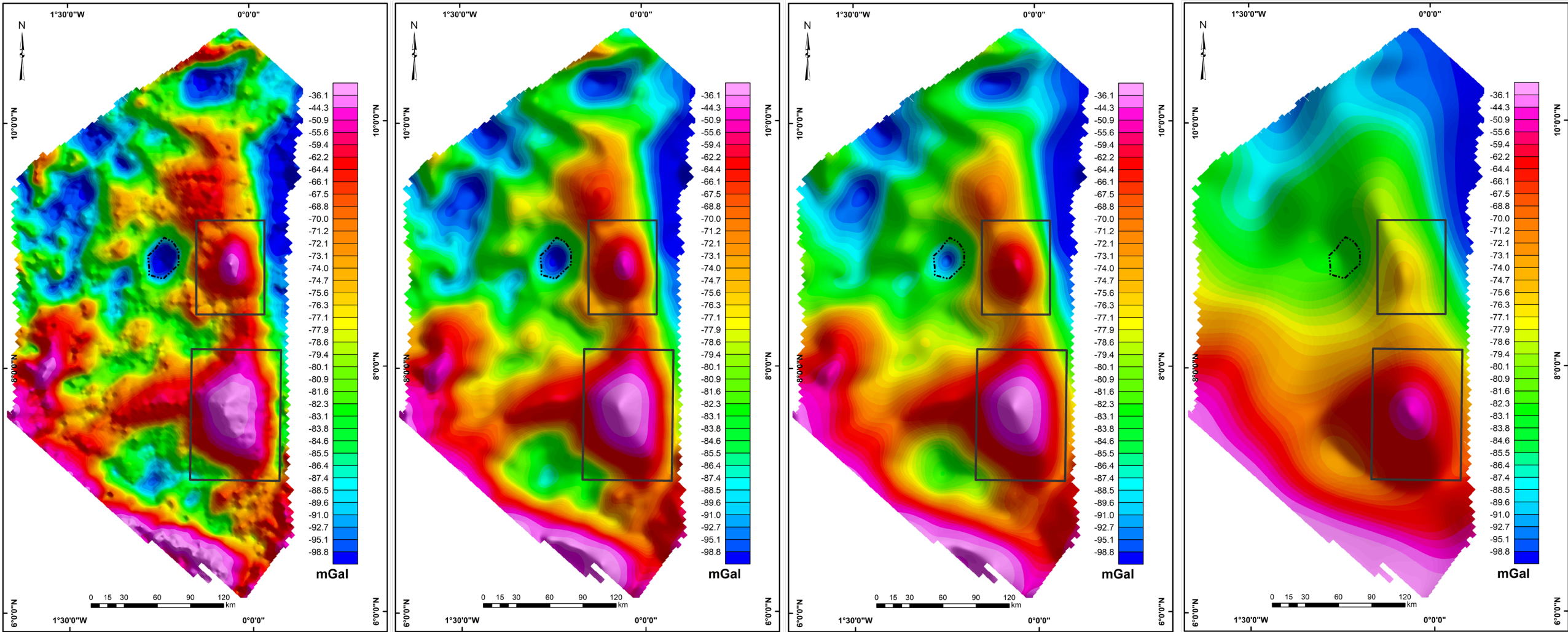
BASEMENT

Abrupt magnetic gradient transitions highlighted in: (a) First vertical derivative data and (b) Tilt derivative data of the Volta Basin delineating a network of intrabasin faults. White arrows show an example of such faults.



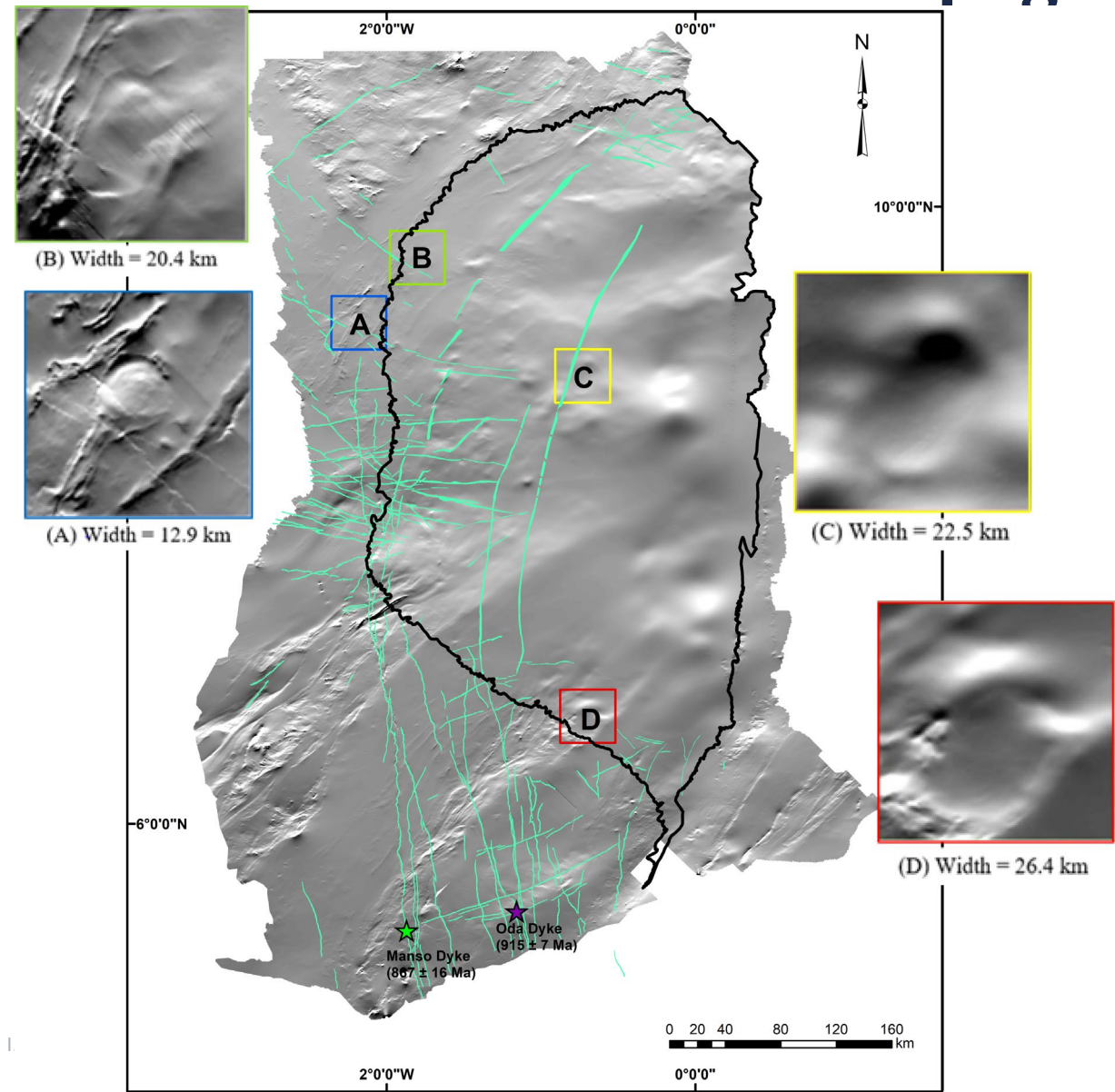
(a) Bouguer gravity map with superimposed faults and shear zones interpreted from the Reduced to Equator magnetic data extending from the outcropping Birimian basement, further underneath the basin. Dashed black line marks N-S horsetail feature. The NE–SW Ketesso shear zone (thick black dashed line) extends into the basement and is truncated ~12 km from the horsetail fault, while the Ashanti and Akyem thrust faults (AsTF and AkTF) appear to terminate at the southern gravity anomaly. (b) Bouguer gravity map with superimposed faults (dashed lines) interpreted from analytic signal and tilt derivatives of the Reduced to Equator magnetic data. The Pru and Ketesso (KetSZ) faults represent major loci of structural interference, indicative of polyphase deformation and basin compartmentalization. Dashed. North of the horsetail structure are splays of faults (green polygons) which coincide with magnetic lineaments interpreted as dykes. (c) First vertical derivative of low-pass filtered Bouguer gravity anomalies draped over a reduced-to-equator (RTE) magnetic map. Prominent N–S trending Bouguer highs (purple dashed lines) mark possible intrusive bodies, flanked by a 22 km-long N–S horsetail structure with multiple splays (light black dashes). Blue dashed lines highlight gravity lows interpreted as additional basement intrusions

Deep seated intrusion and basement topography

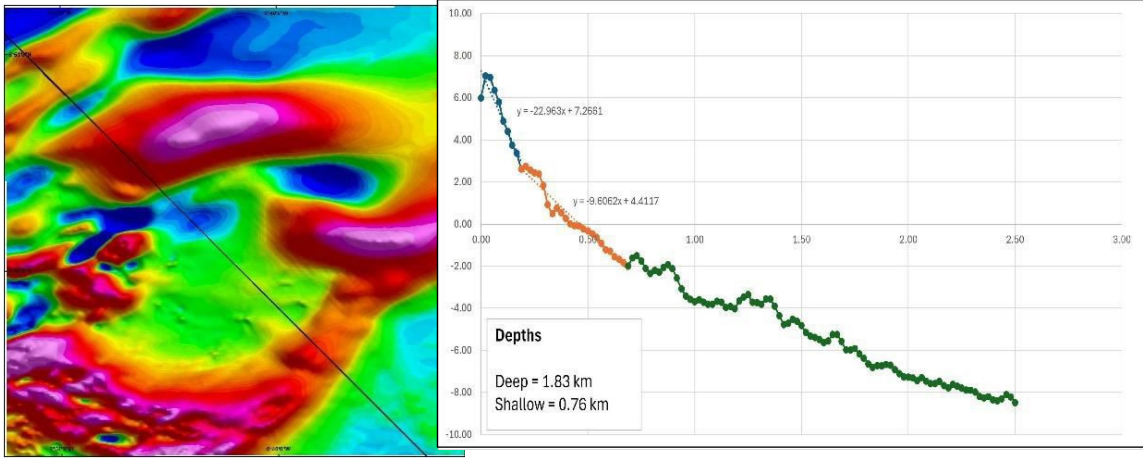
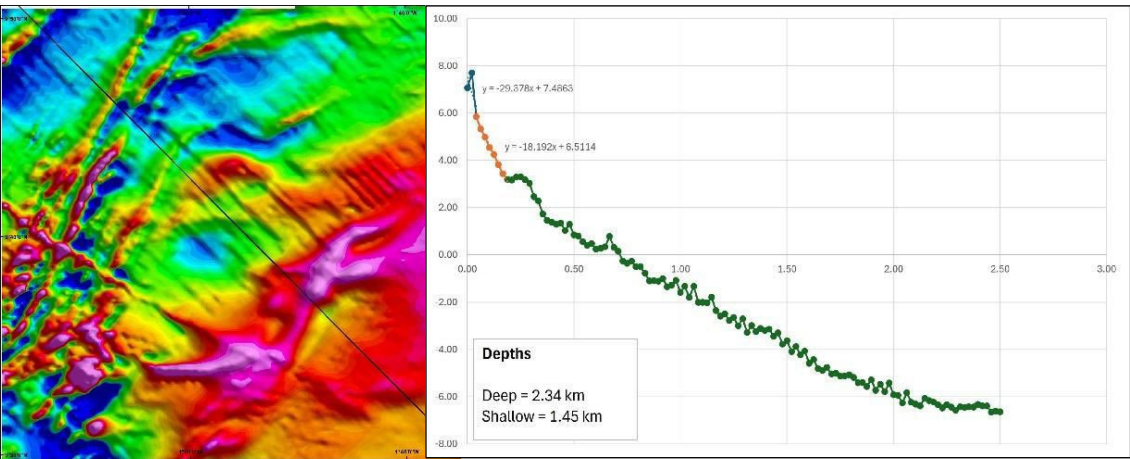
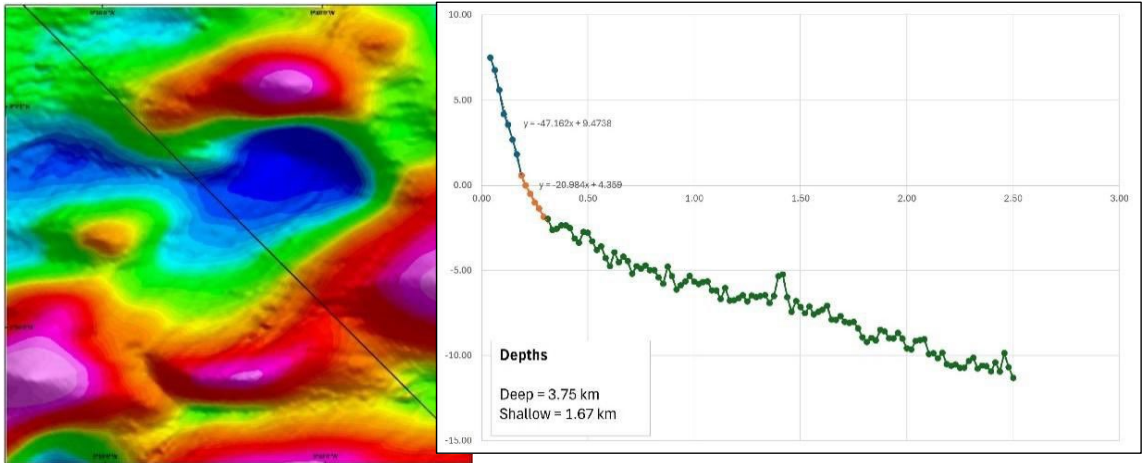
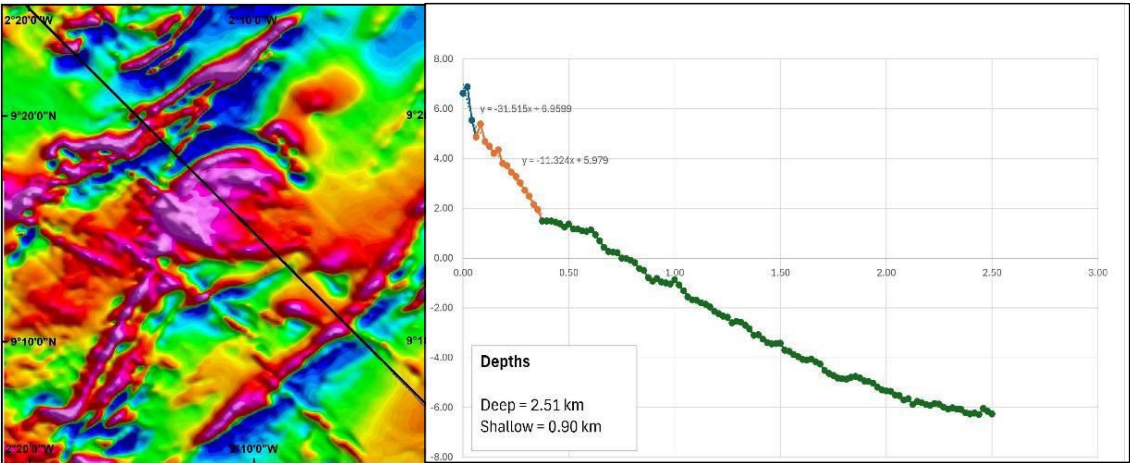


Bouguer anomaly maps of the Volta Basin showing basement related features (highlighted with black box) interpreted as pre-Eburnean intrusions. The maps show the use of the upward continuation technique to identify deep seated features. (a) No upward continuation. (b) Upward continuation at 5000 m. (c) Upward continuation at 10000 m. (d) Upward continuation at 30000 m. A third pre-Eburnean intrusion of contrasting density is highlighted in black dashed polygon. This circular granitoid corresponds with granitoid C in the magnetic dataset shown

Deep seated intrusion and basement topography



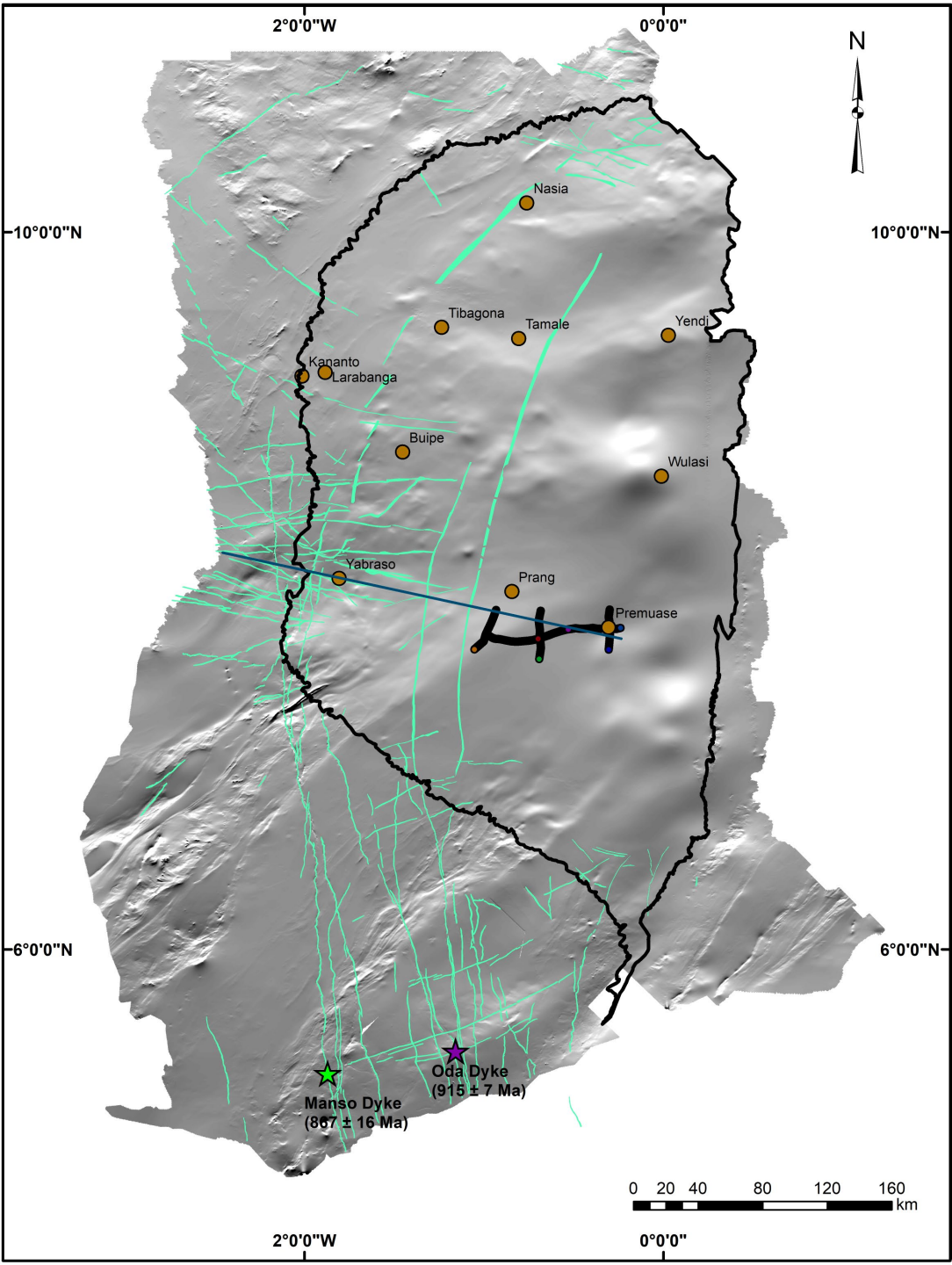
Deep seated intrusion and basement topography



ROCK BOTTOM, LITERALLY

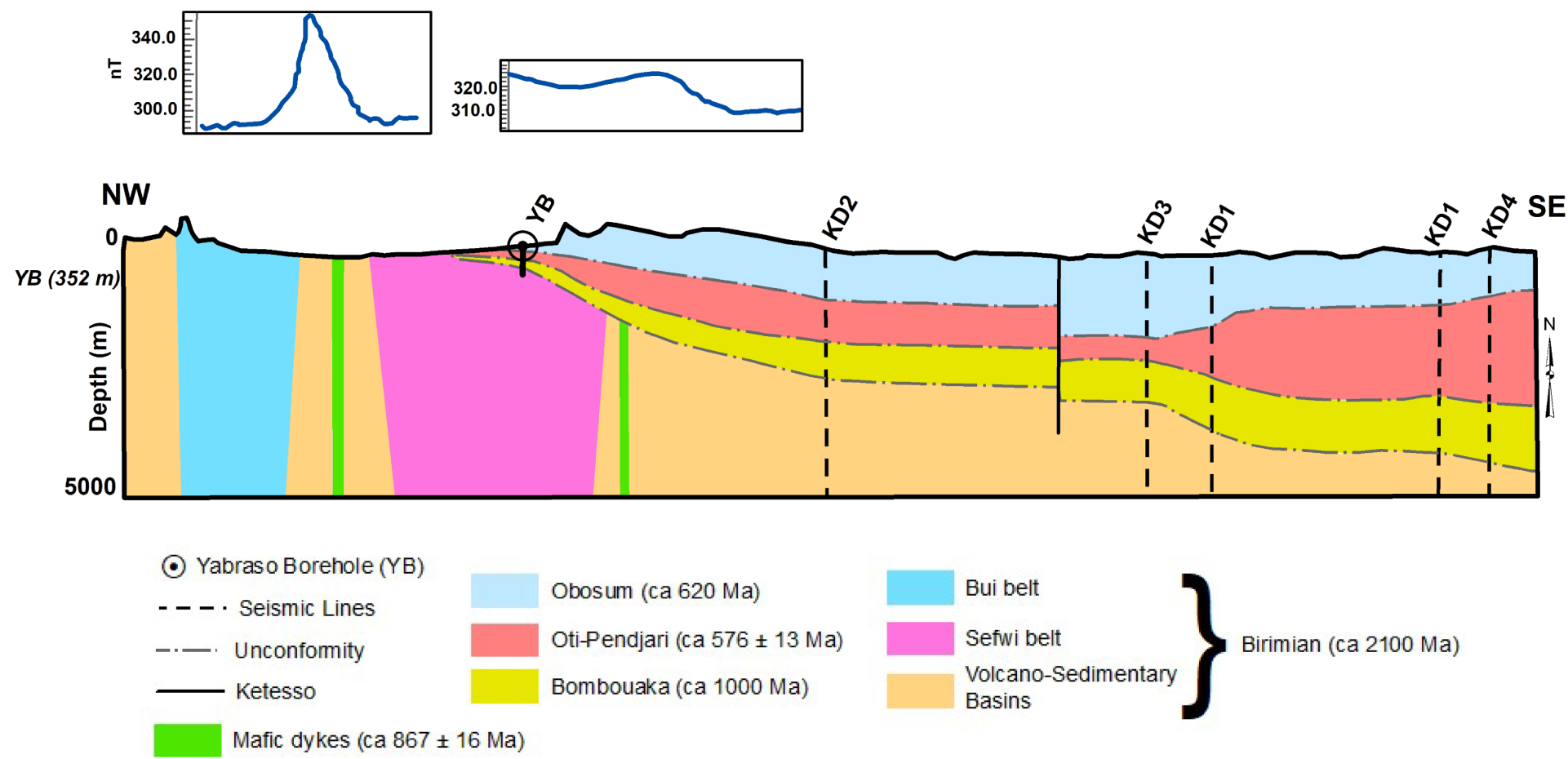
Mafic dykes

Negative RTE map showing outcropping mafic dyke swarms (green polygons) in the Birimian basement and their N-S, E-W, NW-SE extensions into the Volta Basin (outlined in black). Green and purple stars show where Oda and Manso dykes were sampled and dated respectively. Yellow dots are the positions of boreholes in the Volta basin.



BASEMENT

Geological modelling



3Interpreted 2D geological cross-section across the Volta Basin integrating seismic constraints, Yabrasso borehole data, and the subsurface projection of mapped and age-constrained Manso dykes (~887 Ma). Assuming a susceptibility of 1.2 SI units and a width of ~1.5 km where exposed for the dykes, the model suggests a minimum depth to the top of about 600 m for its subsurface expression. Magnetic profile comparisons between exposed and buried segments of the dykes reveal clear differences in wavelength and amplitude, validating this depth interpretation and its use as a reliable marker for constraining basin stratigraphy and structure. The profile is also constrained by the 325 m Yabrasso borehole which intersects the Birimian basement.

ROCK BOTTOM, LITERALLY

A geological map — of rock no one has ever seen

Granitoids.

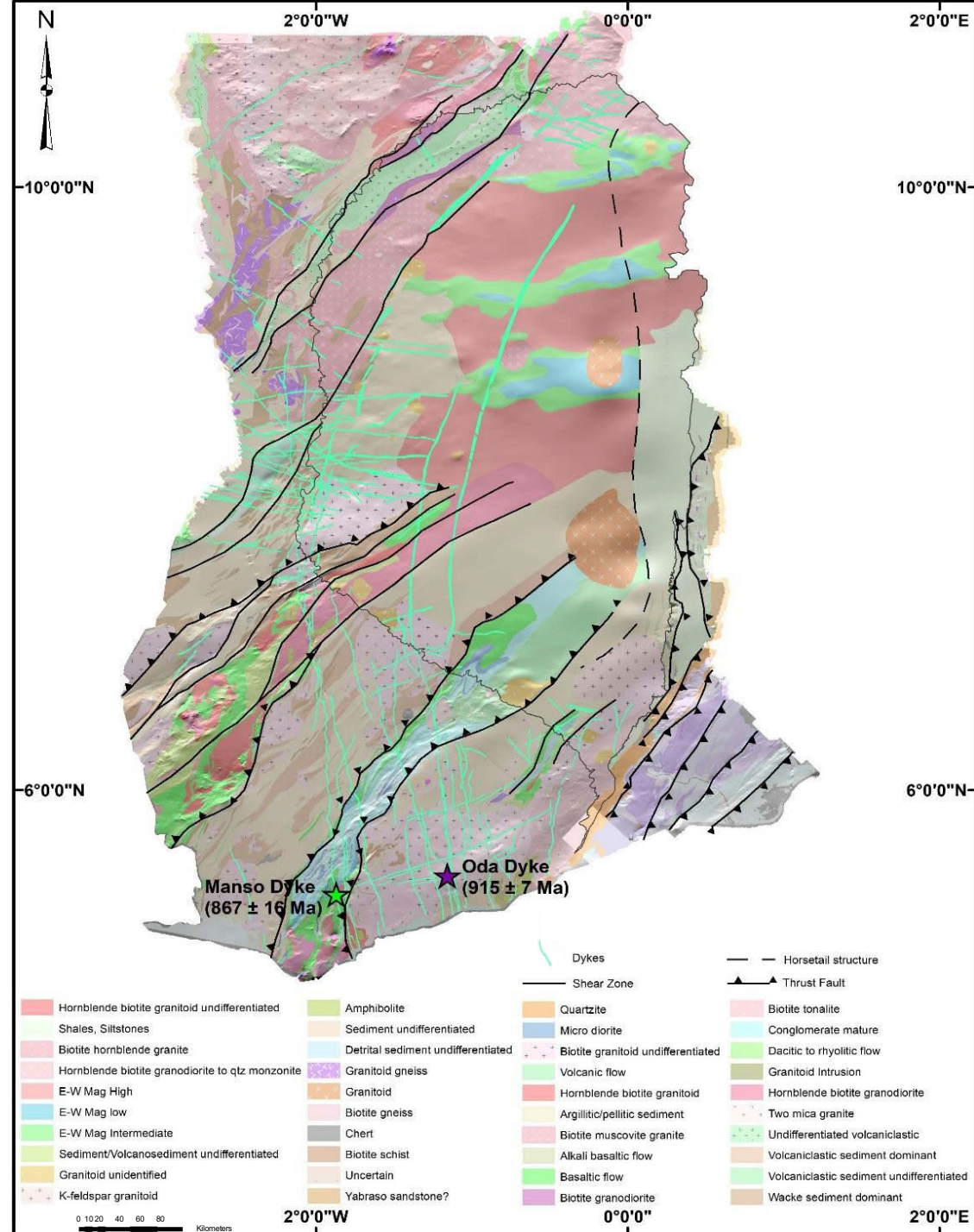
Dykes.

Shear zones.

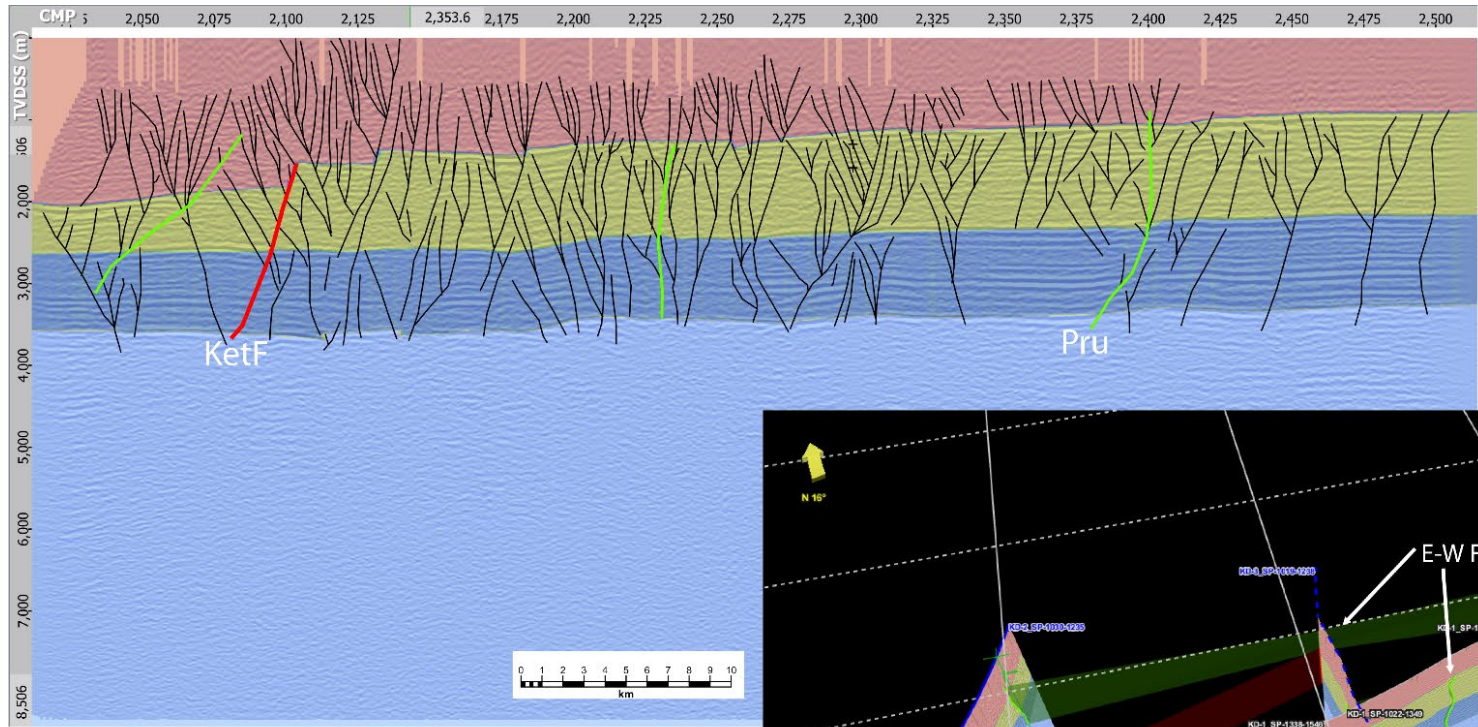
Compiled entirely from potential-field signatures — a full basement geological map, built without a single outcrop.

Composite basement geology beneath the Volta Basin, compiled from magnetic and gravity data and dated mafic dykes (Oda ~915 Ma, Manso ~887 Ma).

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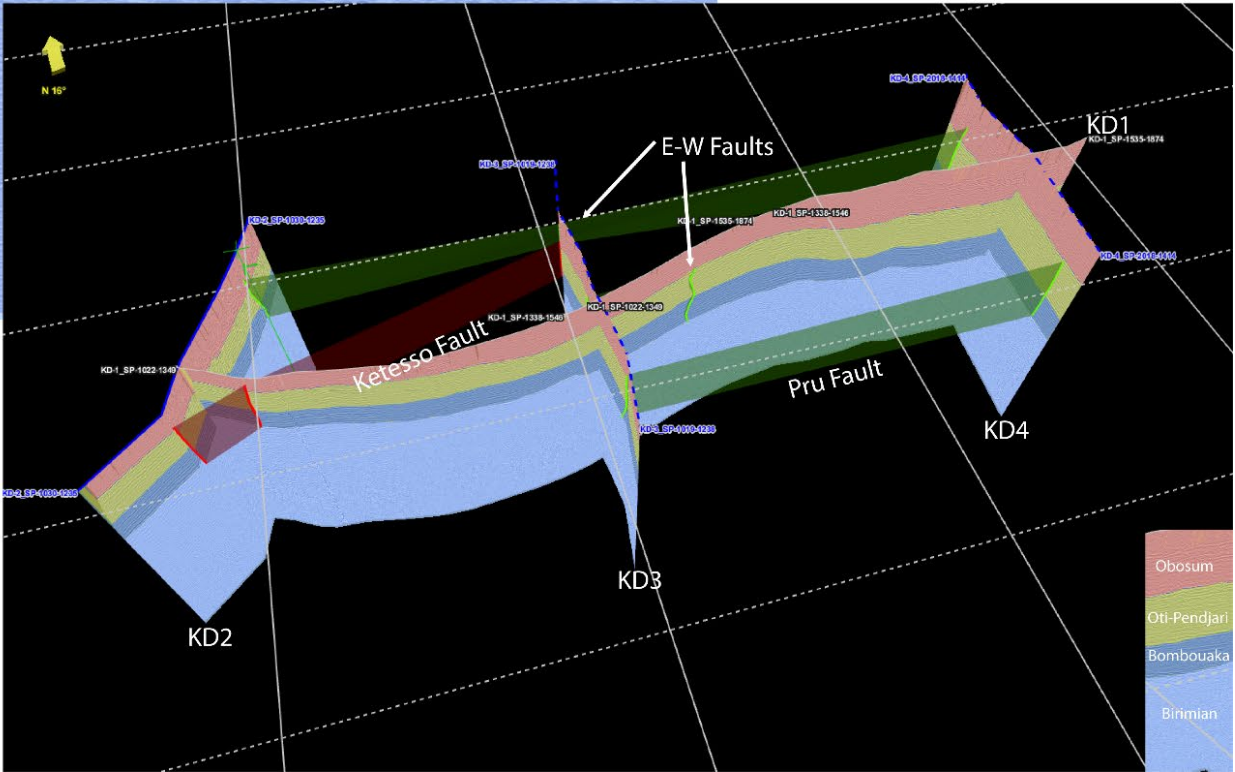


...and seismic??



b) Interpreted faults, including the Ketesso and Pru faults on time to depth converted line, KD3; Inset: 2D seismic lines in 3D view showing NE-SW Ketesso Fault in red and the reactivated E-W Pru fault in green.

(b)



Basement reactivation

The basement to the Volta Basin records a series of pre-basin events including:

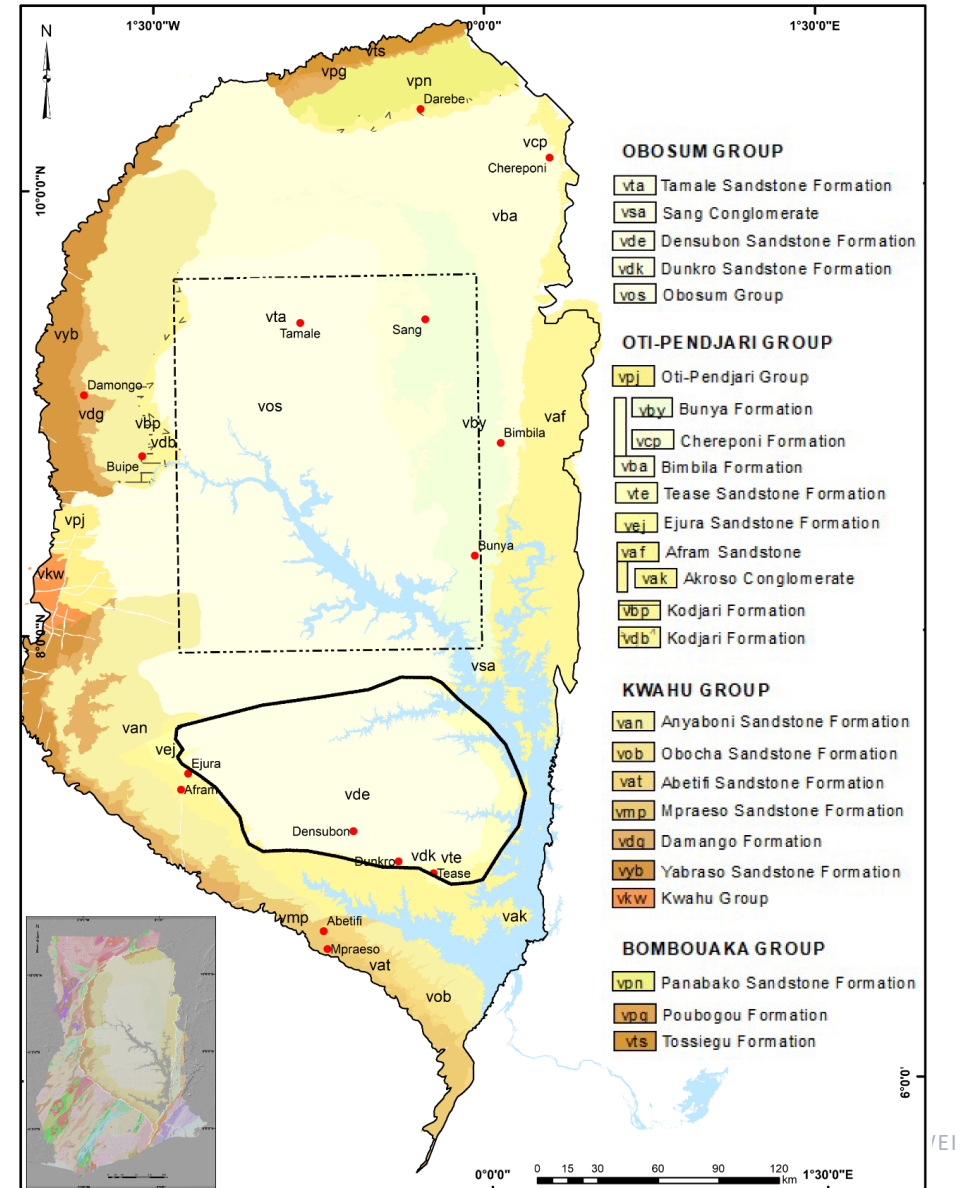
- Pre- to syn-Eburnean magmatism and crustal growth within the Birimian basement, establishing a heterogeneous structural template,
- Neoproterozoic intraplate extension and associated dyke emplacement affecting the inherited Birimian basement, perhaps even contributing to initial accommodation space and basin initiation in a cratonic setting,
- Reactivation of basement shear zones influencing sediment accommodation and basin segmentation during basin development.

Basement reactivation

The two most important observations are:

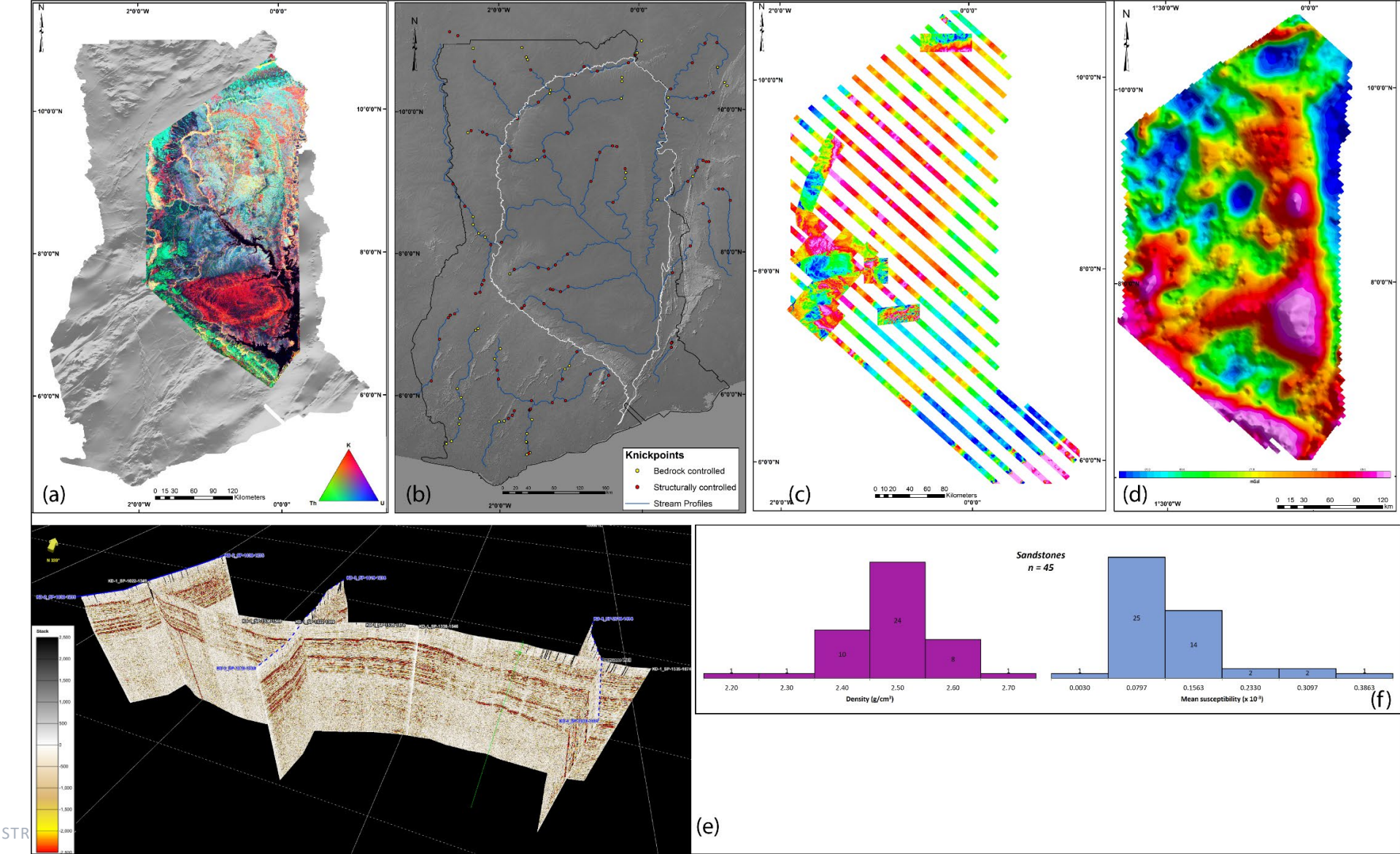
- offset sedimentary packages observed on 2D seismic data coinciding with the trace of Birimian structures mapped from magnetic data,
- Euler depth to source solutions suggesting compartmentalisation of the basin with trends following pre-basement structural orientations

Watching a basement fault climb into the cover



Geological map of the Volta Basin showing the distribution of the major stratigraphic groups. Both the Kwahu and Bombouaka groups are considered age equivalents, although they are geographically separated within the basin (Deynoux et al., 2006; Carney et al., 2010). The red dots mark the type localities where specific rock types were first sampled. The black polygon outlines the Obosum sub-basin, discussed in later sections, while the dashed black box indicates the location of the palaeochannels analysed subsequently. The inset shows the geological map of Ghana.

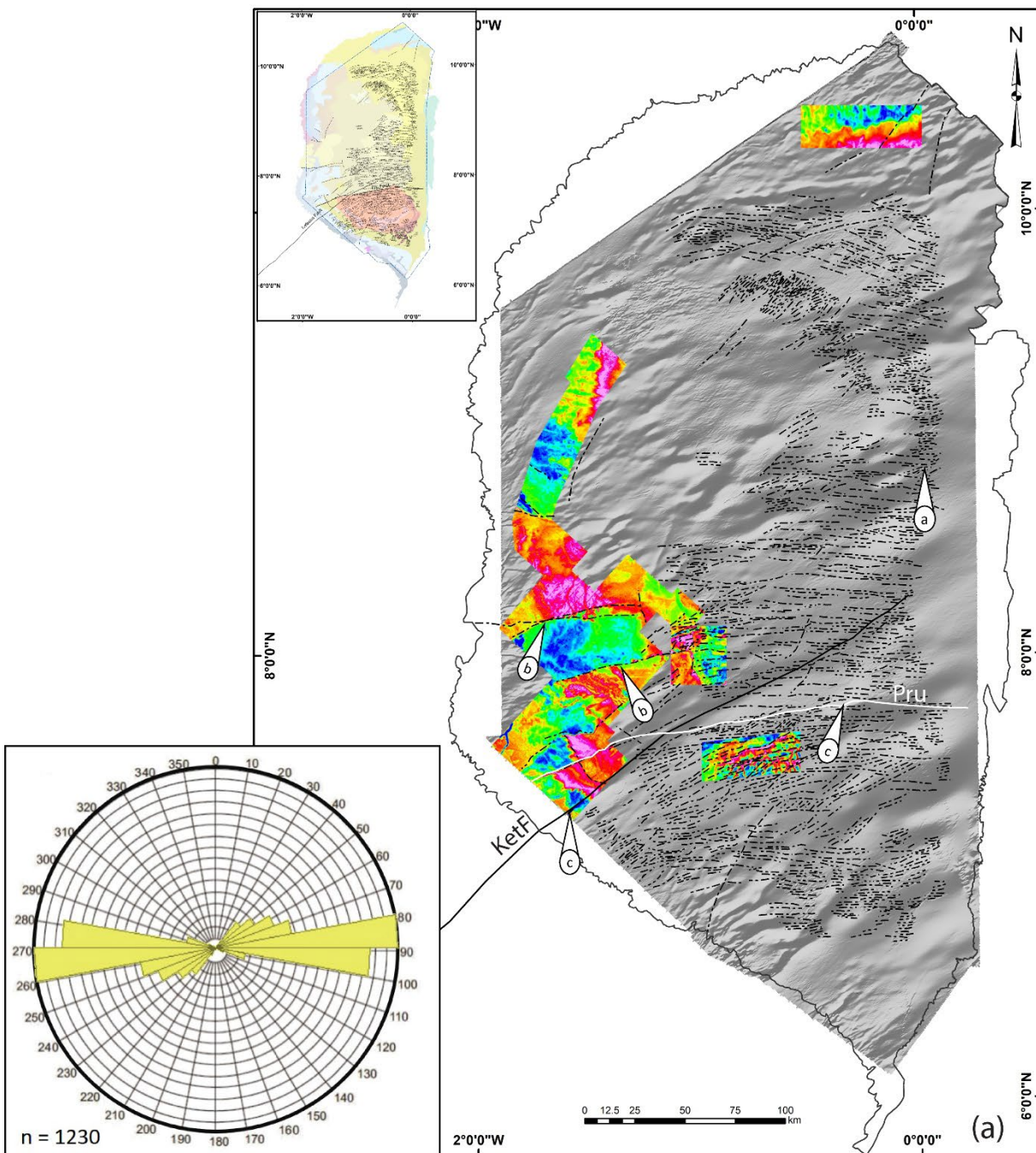
Watching a basement fault climb into the cover



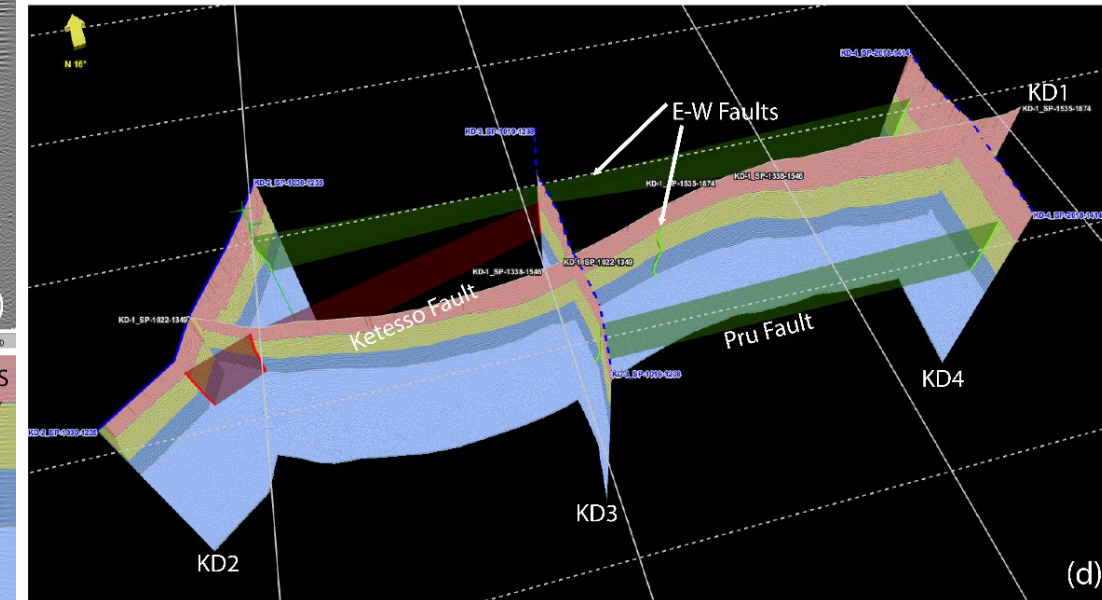
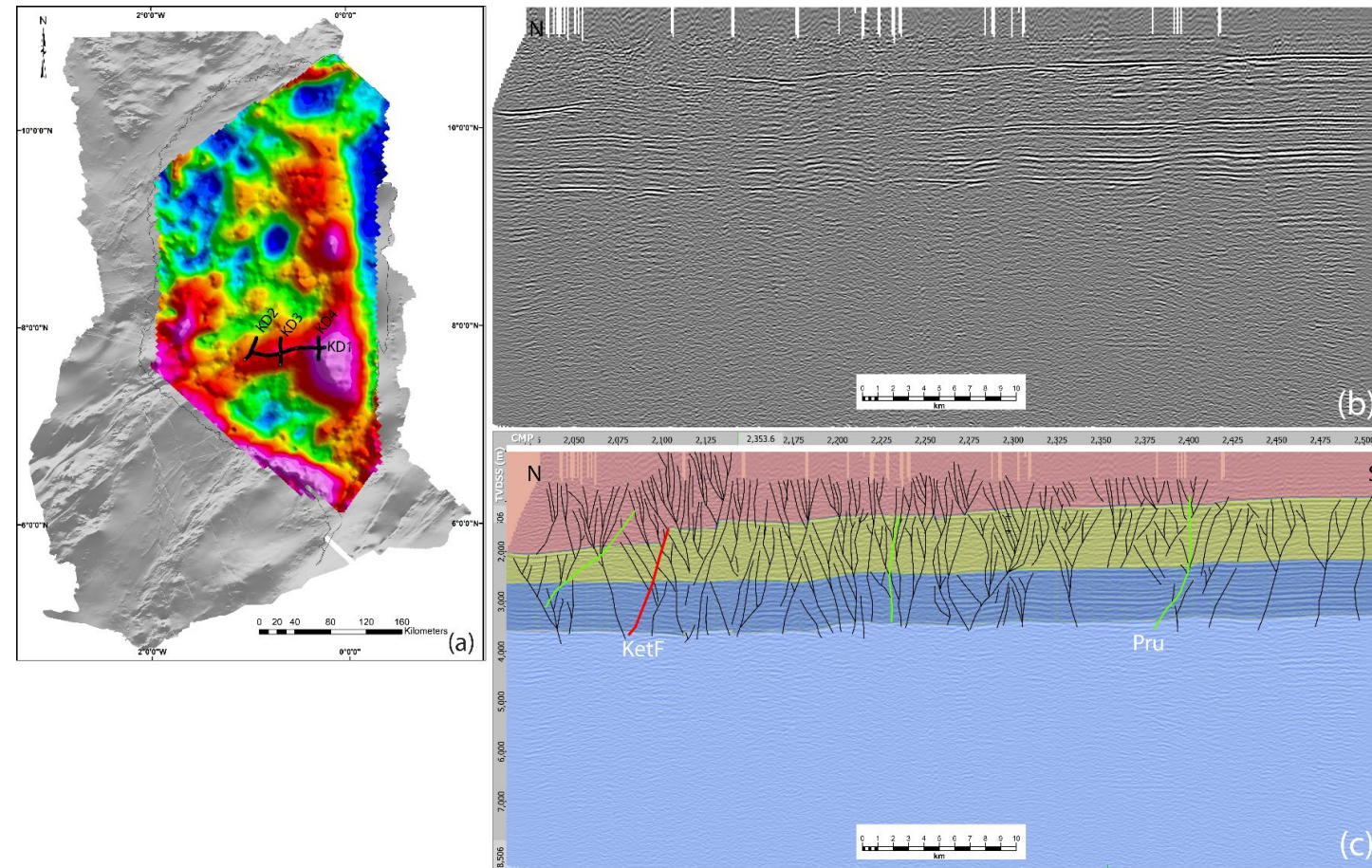
Geophysical datasets

FAULTING

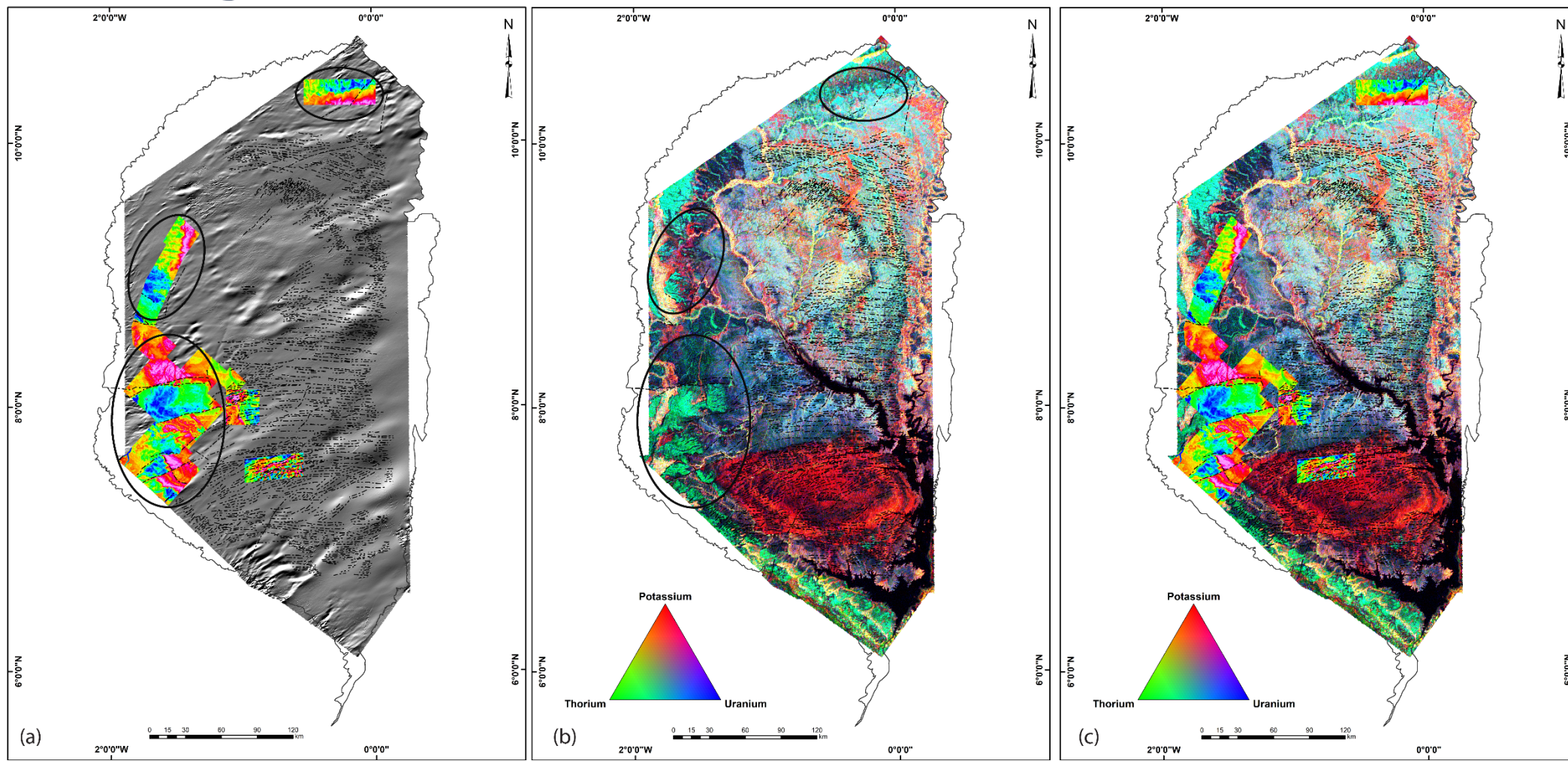
1VD/RTE magnetic and EM data reveal pervasive E–W intrabasin faults across the Volta Basin, expressed as short-wavelength magnetic anomalies and low-conductivity EM zones; these faults variably align with drainage systems, truncate lithological units, or link to NNE–SSW structures connecting to basement faults (Ketesso, Pru). Zoomed panels (b, c) show fault density and drainage alignment, with a rose diagram confirming a dominant E–W orientation and minor NE–SW/NNE–SSW trends.



Watching a basement fault climb into the cover

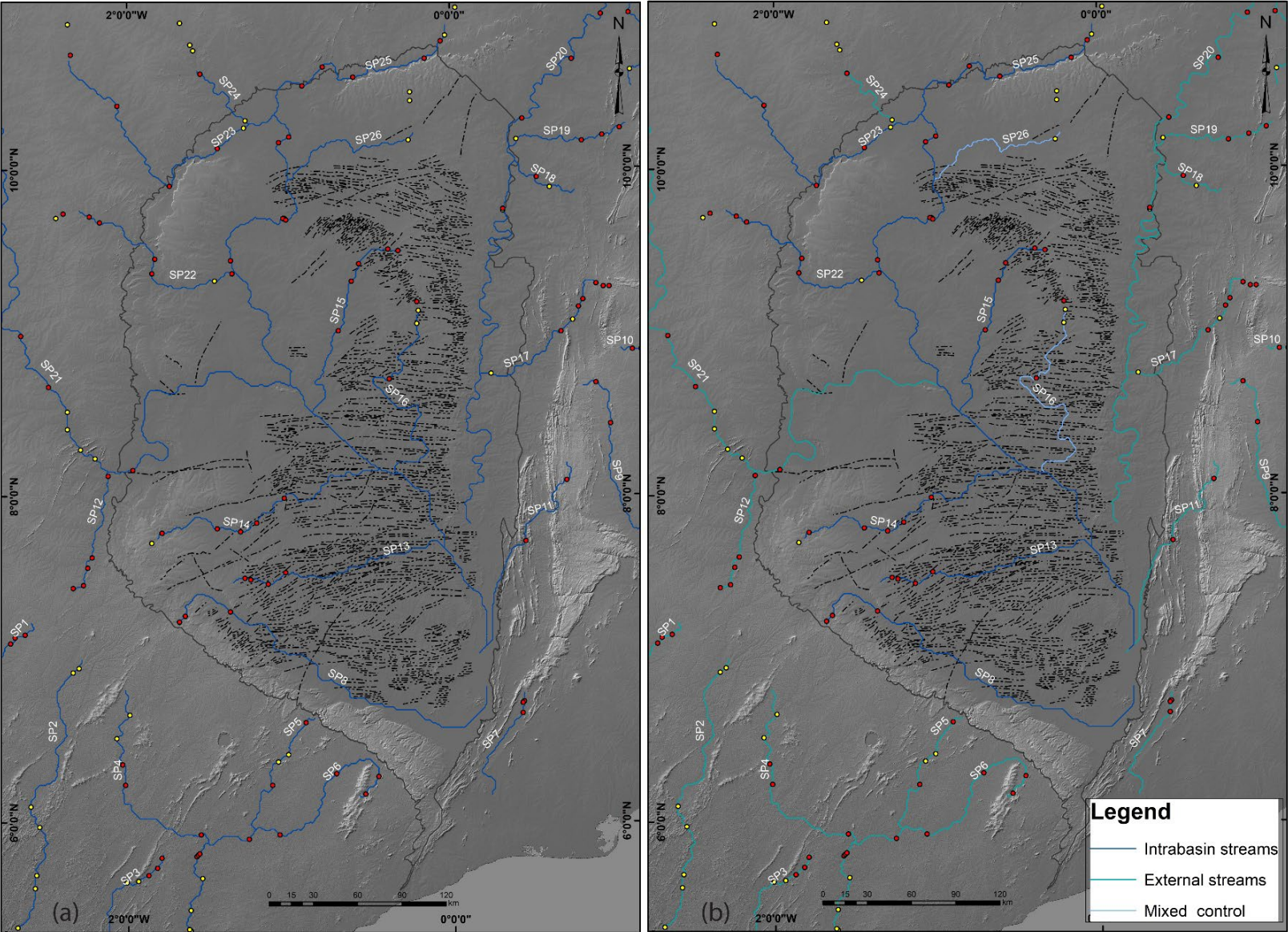


Watching a basement fault climb into the cover

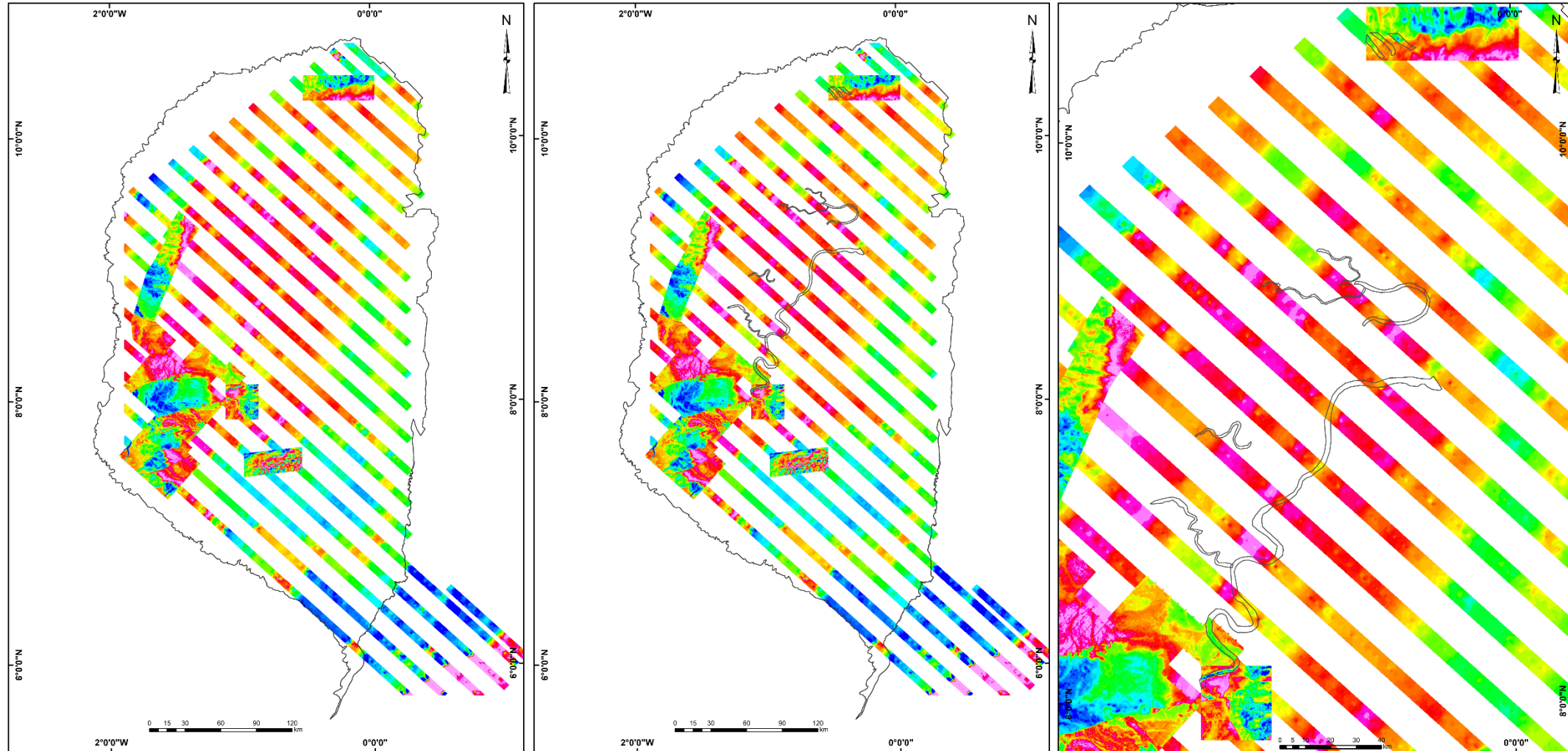


Multi-panel geophysical data of the Volta Basin, showing (a) conductivity-derived features [hot zones = high conductivity; cool zones = low conductivity], (b) RGB ternary radiometric data (K, eTh, eU), and (c) integrated structural mapping. Circled regions highlight spatial overlap between radiometric anomalies and conductivity-defined structures, revealing coherent east–west linear trends aligned with magnetic/EM faults. These discontinuities, particularly pronounced in the sparsely faulted western sector, indicate fault-controlled lithological offsets and alteration zones, underscoring the role of tectonic structures in shaping subsurface heterogeneity.

The faults keep going — right into the basin



Fault guided paleochannels and their geophysical expression



A familiar paradox in cratonic basins worldwide

The cratonic paradox

Longevity reflects lithospheric rigidity.

Internal complexity arises from recurrent reactivation of the very structures that rigidity preserved.

Stability and complexity, it turns out, come from the same source.

Good company

The Volta Basin joins a global pattern seen in the **Illinois Basin** and the **Parnaíba Basin** — long-lived intracratonic basins where basement control persists despite apparent tectonic quiescence.

Three ideas travel with this thesis anywhere in the world:

1. **Basement inheritance sets basin geometry**
2. **Polyphase reactivation, not steady subsidence**
3. **Multi-method geophysics resolves what outcrop can't**

Knowing the basement pays off

Gold

Shear-zone-hosted mineralisation follows the same reactivated Birimian structures now mapped beneath the cover — sharpening exploration targeting under thick regolith.

Groundwater

Fracture corridors linked to reactivated shear zones can guide borehole siting in a basin where success rates have historically been poor.

Future 3D models

Joint inversion and 3D crustal modelling are the natural next step — resolving granitoid geometry and quantifying basement control on sediment thickness.

Six takeaways

Basement architecture fundamentally governs Volta Basin geometry, fault distribution, and segmentation.

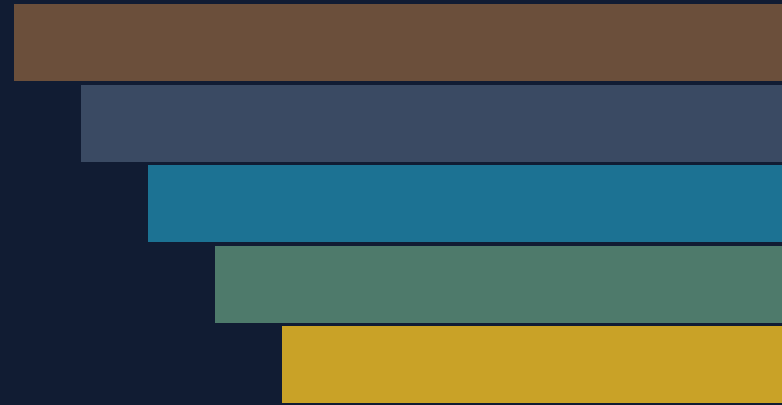
The basin defies simple classification as passive margin or foreland — it's a composite, polyphase system.

Integrated multi-method geophysics resolves subsurface structure that no single dataset could recover alone.

Birimian greenstone belts trace continuously beneath the basin for over 170 km before reaching the reworked craton edge.

Basement faults are demonstrably reactivated, propagating deformation up through the cover to the modern surface.

The approach is a transferable template for sediment-covered cratonic basins worldwide.



SO — TOP TO BOTTOM, OR BOTTOM TO TOP?

In the Volta Basin, the basement always has the final word.

Thank you

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With thanks to Prof. Susan Webb, Prof. Mark Jessell, and Dr. Stephanie Scheiber-Enslin

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