Supplementary Material

Deep Structure of the Benue Trough and Implications for Northern Cameroon Tectonics from 3D Gravity Inversion (XGM2016)

E.S. Chepgwa Tchouando et al.

1. Integrated Workflow

The workflow integrates qualitative and quantitative gravity analysis to constrain crustal and lithospheric structures.

Processing sequence:

XGM2016 → Filtering → Upward Continuation → Lineament Extraction → Euler Deconvolution → 3D Inversion → Geological Interpretation

2. Advanced Methodological Framework

This study combines multi-scale gravity analysis with 3D inversion to investigate the deep structure of the Benue Trough.

2.1 Multi-depth Gravity Analysis

Upward continuation (5–100 km) was used to isolate sources at different depths.

This approach highlights the transition from shallow crustal anomalies to deep lithospheric signals.

Key strength: allows direct discrimination between crustal and mantle contributions.

2.2 Structural Detection and Tectonic Fabric

The composite gradient maxima method reveals 171 gravity-derived lineaments, with a dominant NE–SW orientation.

This structural fabric:

- Matches Pan-African tectonic trends
- Extends continuously from Nigeria to northern Cameroon
- Indicates strong tectonic inheritance

Interpretation boost : Not just mapping - tectonic memory of the lithosphere

2.3 Depth Constraints (Euler Deconvolution)

Euler solutions (SI = 0) constrain fault-related structures down to ~24 km, suggesting:

- Major crustal discontinuities
- Deep-rooted fault systems
- Possible Moho-related transitions

This supports a structurally controlled rifting model.

2.4 High-Resolution 3D Inversion

The GRABLOX inversion (SVD + Tikhonov regularization) provides a stable density model:

- RMS misfit: 0.013 (excellent fit)
- Density contrast: 1.9–3.0 g/cm³
- 4,256 cells

Key strength: transforms qualitative anomalies into quantitative geological structures

3. Key Scientific Breakthrough

Evidence for a Dual Lithospheric Regime

This study provides the first gravity-based evidence of a sharp lithospheric transition

Region	**Interpretation**
Northern Cameroon	Intracrustal regime (≤ 25 km)
Nigeria	Lithospheric/mantle-involved regime (≥ 100 km)

Major implication: The Benue Trough is not a uniform rift system, but a segmented lithospheric structure.

4. Magmatic Plumbing System

The 3D density model reveals a structured magmatic system:

- High-density bodies (>2.6 g/cm³)
- Alignment along NE–SW fault corridors
- Vertical and lateral connectivity

Interpretation:

These bodies represent a fault-controlled magmatic plumbing system, linking deep sources to upper crustal structures.

5. Conceptual Geodynamic Model

The results support a polyphase tectonic evolution:

1. Pan-African structural inheritance (~600 Ma)
2. Cretaceous rifting (~120 Ma)
3. Reactivation and magmatic intrusion

This leads to a segmented lithosphere, with:

- Crustal thinning in Cameroon
- Lithospheric involvement in Nigeria

6. Scientific Impact and Applications

This study demonstrates that high-resolution global gravity models (XGM2016) can:

- Resolve deep crustal architecture in data-poor regions
- Constrain tectonic inheritance and reactivation
- Identify magmatic systems and structural traps

Applications :

- Seismic hazard assessment
- Hydrocarbon exploration
- Mineral prospectivity

7. Limitations

- Non-uniqueness of gravity inversion
- Decreasing resolution with depth
- Dependence on model parameterization

Despite these limitations, the consistency between independent methods (upward continuation, Euler, inversion) strengthens the robustness of the interpretations.

8. High-Impact Figures

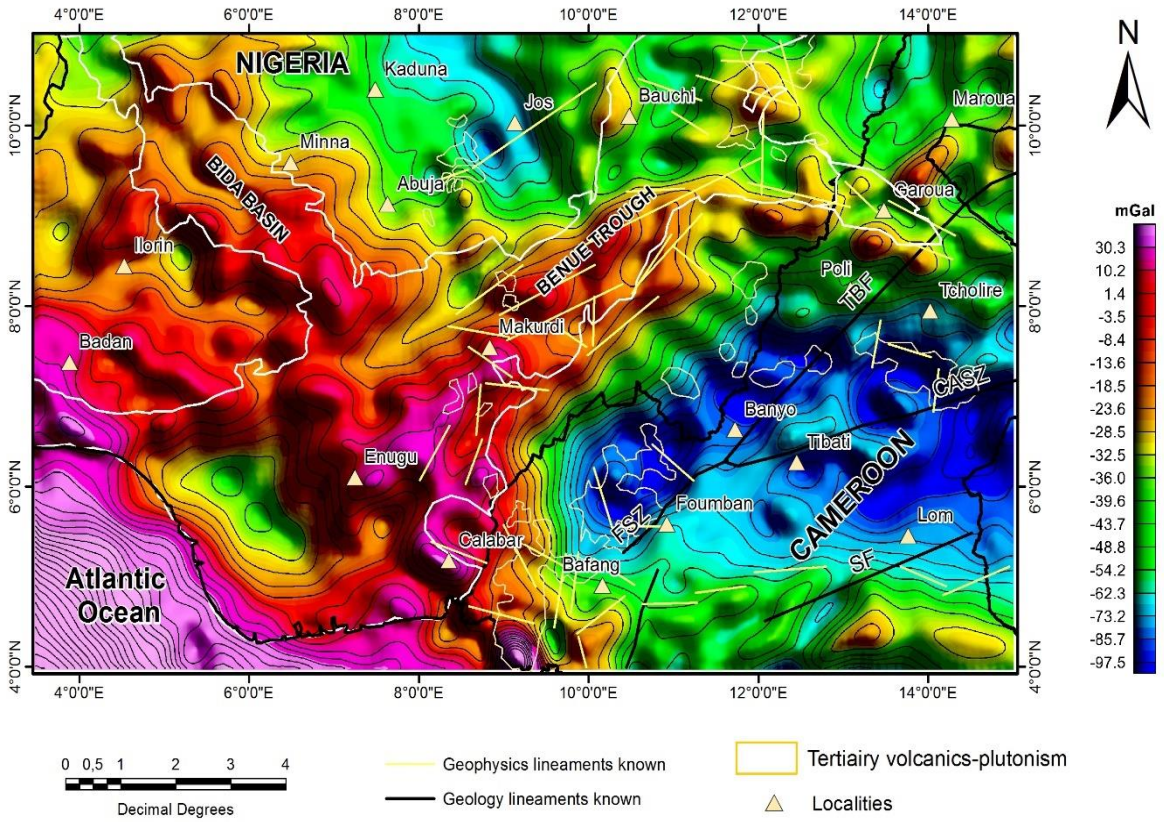

Figure 1: Bouguer anomaly map highlighting major positive and negative domains associated with deep crustal structures

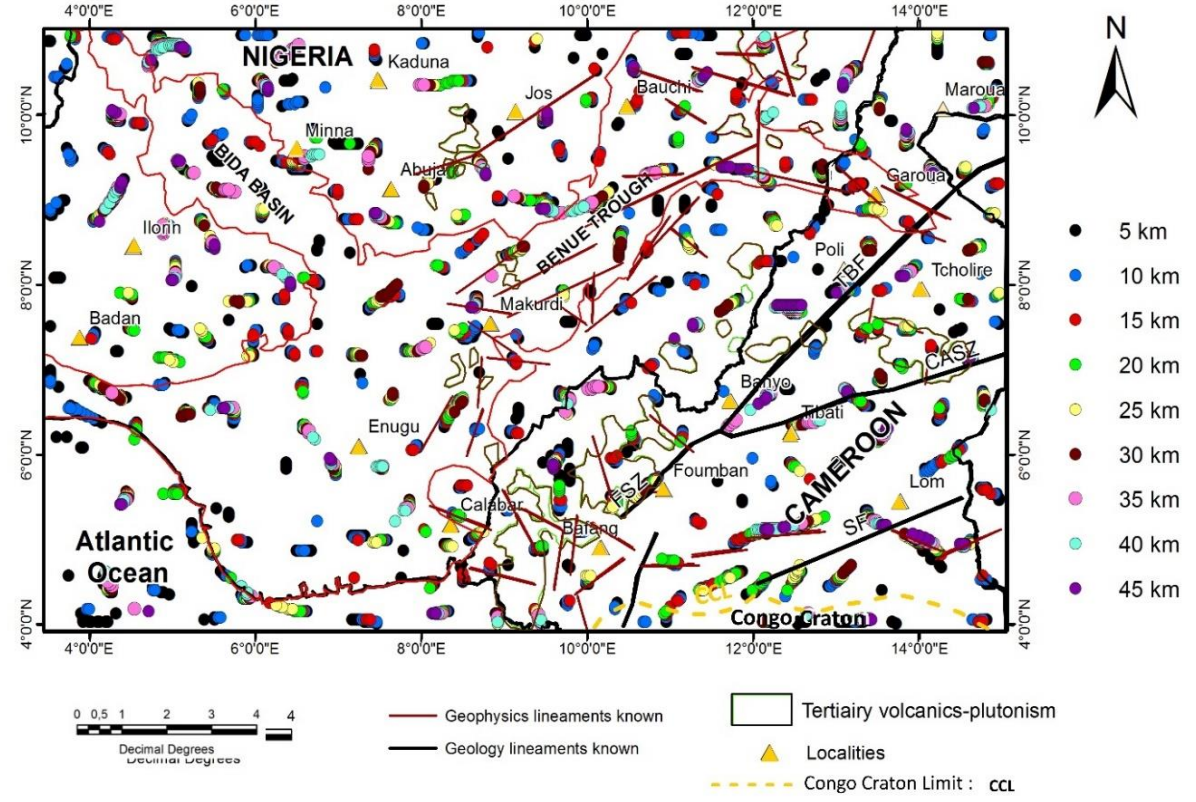

Figure 2: Gradient maxima map accurately delineating major structural axes and confirming the tectonic segmentation of the rift. The dominant orientations are NE–SW and NW–SE.

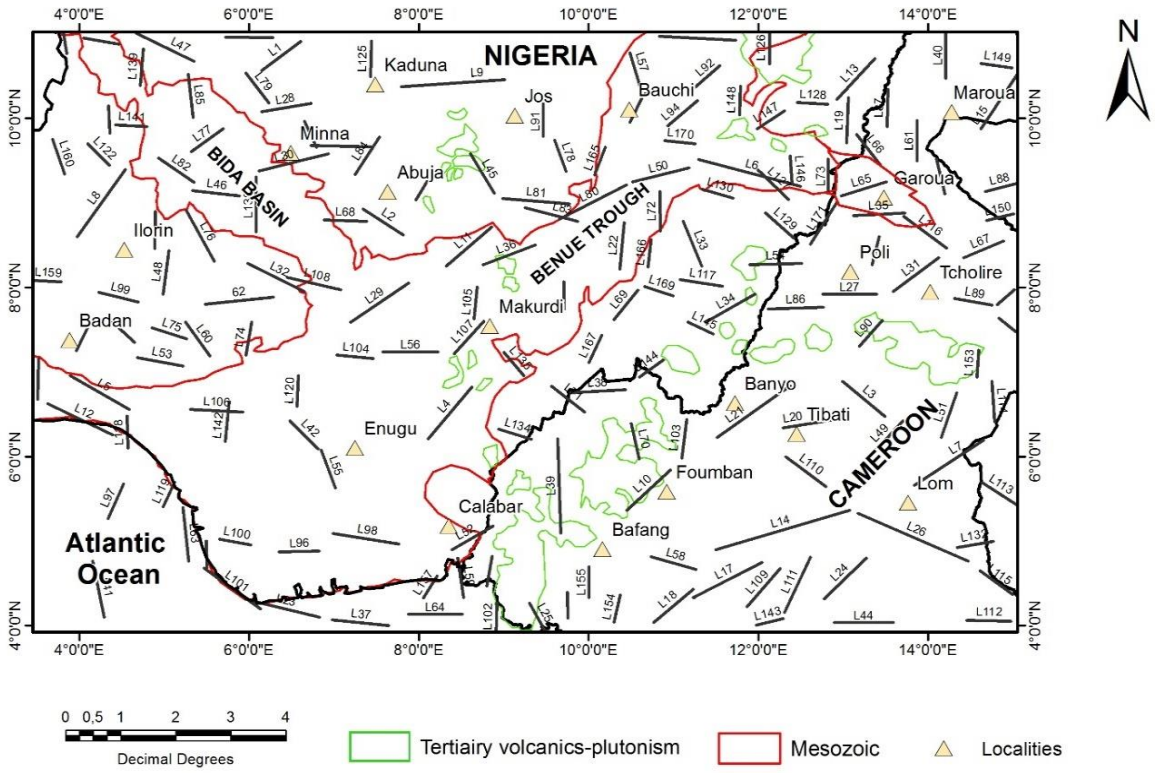

Figure 3: Simplified gravimetric lineament map accurately illustrating the organized network of major lithospheric discontinuities in the Benue Trough.

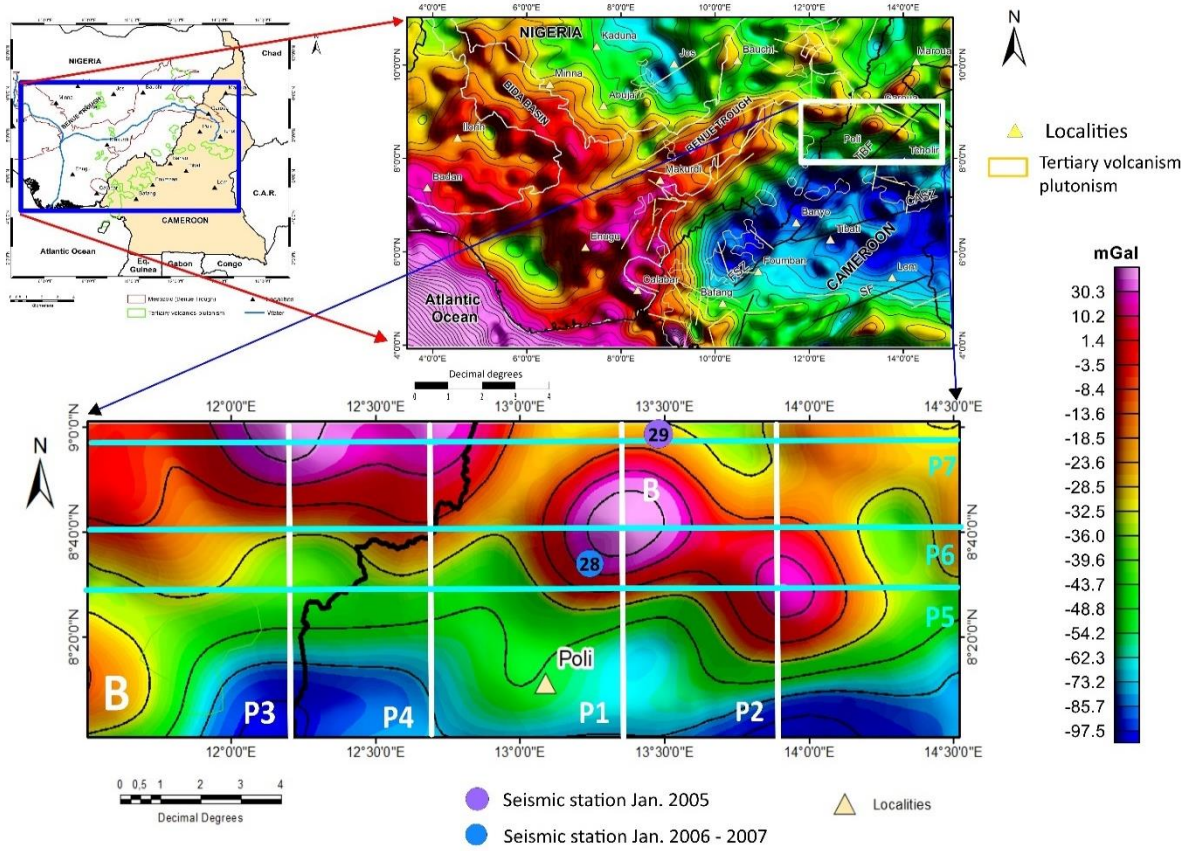

Figure 4 : Study area map accurately delineating the location of seismic stations CM28 and CM29, the configuration of profiles, and the area targeted for 3D inversion over the Garoua Rift. The profiles used for longitudinal and lateral segmentation analyses are indicated, illustrating the rift architecture down to 4-45 km depth