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Magnetic Lineaments and their Relationships with Geological Structures in the Tanganyika Graben

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Abstract: This study investigates the distribution of magnetic lineaments in the Congolese sector of the Tanganyika Graben and their relationships with geological structures and rift architecture. Magnetic maps were generated and processed using digitized data from the aeromagnetic survey conducted by Kenting Surveys Ltd. (1983). The resulting maps were interpreted to delineate lineaments and assess their geometry, orientation, and spatial distribution. These results were then compared with the geological framework and existing 2D seismic interpretations. The mapped network comprises 30 lineaments with a combined length of 2,288.7 km. E–W and NW–SE trends account for 38.9% and 34.4% of the total length, respectively. Their distribution varies along the study area: NW–SE lineaments are more numerous in the north, whereas E–W lineaments predominate by number in the central and southern sectors. Geological comparisons distinguish segments that locally follow unit boundaries from transverse traces that cross several units. Seismic interpretations provide complementary evidence of normal faults, tilted blocks, and syntectonic sedimentary geometries. The study establishes a mapped and quantitative framework for examining the relationship between basement inheritance and extensional basin development, while assessing the sensitivity of some directional patterns to banding in the magnetic maps.

Keywords: *Tanganyika; Magnetic Lineaments; Structural Geology; Precambrian Basement; Rifting; Structural Inheritance; Artefacts.*

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I. INTRODUCTION

Rift basin architecture reflects the interaction between pre-existing basement structures, extensional faults, and sedimentary infill. The segmentation and asymmetry of the Tanganyika sub-basins make this interaction a central geological question. Integrating potential-field and seismic data offers a means of investigating buried structures and relating subsurface physical-property contrasts to basin geometry (Shaban et al., 2023).

Along the Congolese margin, magnetic data acquired in the 1980s provide a basis for regional structural mapping. Reinterpreting these records requires distinguishing geological features from patterns introduced by digitization, interpolation, or filtering. A magnetic lineament may mark a lithological boundary, a basement discontinuity, or a fault; its map expression alone does not uniquely identify its origin.

The aim of this study is to characterize lineament orientations, geometry, and spatial variability, and to examine their relationships with mapped geological units and the seismic architecture of the graben. Three questions guide the analysis: which directional sets define the mapped network, how do their relative contributions vary between sectors, and what evidence helps distinguish lithological contacts, inherited structures, and rift-related faults? The interpretation also considers the effects of mapping artefacts and data resolution.

II. MATERIALS AND METHODS

- *Materials*

The primary input consists of digitized magnetic data from the aeromagnetic survey conducted by Kenting Surveys Ltd. (1983). The dataset contains 4,716 points, each with longitude, latitude, and magnetic values. Processing and map production were carried out in Geosoft Oasis montaj 8.4 and Surfer 21. ArcGIS 10.8 and RockWorks 17 were used to analyse the geometry and orientations of the lineaments derived from map interpretation.

- *Methodological Approach*

The workflow comprised statistical quality control of the digitized data, magnetic map production, and filtering to enhance discontinuities. Lineaments were interpreted from these maps, digitized, and exported as shapefiles for length and orientation measurements and rose-diagram construction. Their spatial distribution was then examined against the geological framework and seismic interpretations to assess their structural significance.

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A. Study Area

➢ *Location*

The study area extends approximately from 4.0° to 8.2° S and from 27.75° to 30.70° E. It includes part of Lake Tanganyika and its margins, with particular emphasis on the Congolese sectors around Fizi, Kalemie, and Moba. The basin lies within the western branch of the East African Rift and comprises half-grabens, internal blocks, and relay zones linking adjacent segments. Figure 1 shows the regional setting of the lake and its margins.

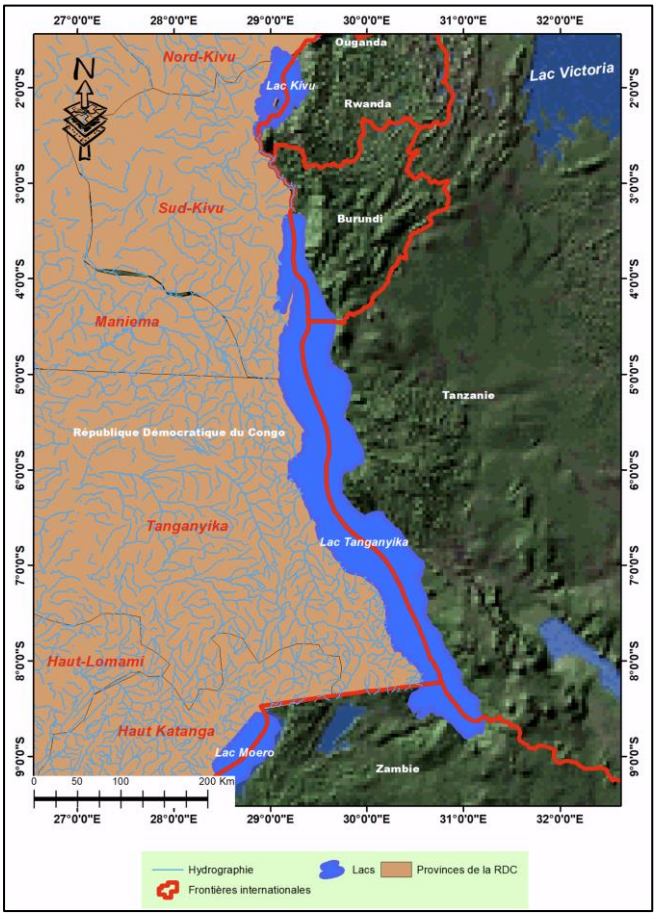


Fig 1 Location of the Study Area in the Lake Tanganyika Region.

➢ *Geographical Setting*

The lake and its margins offer contrasting windows into the geology: geological mapping mainly constrains exposed terrain, whereas seismic data image structures beneath the lake. Fizi, Kalemie, and Moba provide regional reference points. Neither the magnetic data footprint nor the distribution of interpreted traces provides uniform coverage. Differences in lineament counts between sectors therefore cannot be read directly as differences in actual fracture density.

➢ *Geological and Tectonic Setting*

The Tanganyika Graben forms part of the western branch of the East African Rift. It consists of a succession of half-grabens bounded by major faults and linked by accommodation zones. This segmentation governs the arrangement of tilted blocks, structural highs, and depocentres (Sander & Rosendahl, 1989). Extension is partitioned differently across the basement domains traversed by the rift, highlighting the influence of crustal inheritance on basin architecture (Wright et al., 2020).

In central Tanganyika, integrated magnetic, gravity, and seismic analyses have identified predominantly NW-trending deep structures and inherited shear zones (Shaban et al., 2023). The lineament analysis presented here examines their possible expression in the Congolese sector, characterizes the main directional sets, and assesses their relationships with geological contacts and basin segmentation.

B. Data Description

The study uses digitized data from the aeromagnetic survey conducted by Kenting Surveys Ltd. (1983). The survey comprised 17,354 line-km flown at an azimuth of 55°, with a nominal line spacing of 5 km and an acquisition altitude of 1,676 m above sea level.

The working dataset contains 4,716 points digitized from magnetic contours. Each record includes longitude, latitude, and a magnetic value in nanoteslas. These points provided the basis for map production and lineament interpretation.

The distribution of the digitized points shows the data footprint and spatial arrangement before gridding (Figure 2).

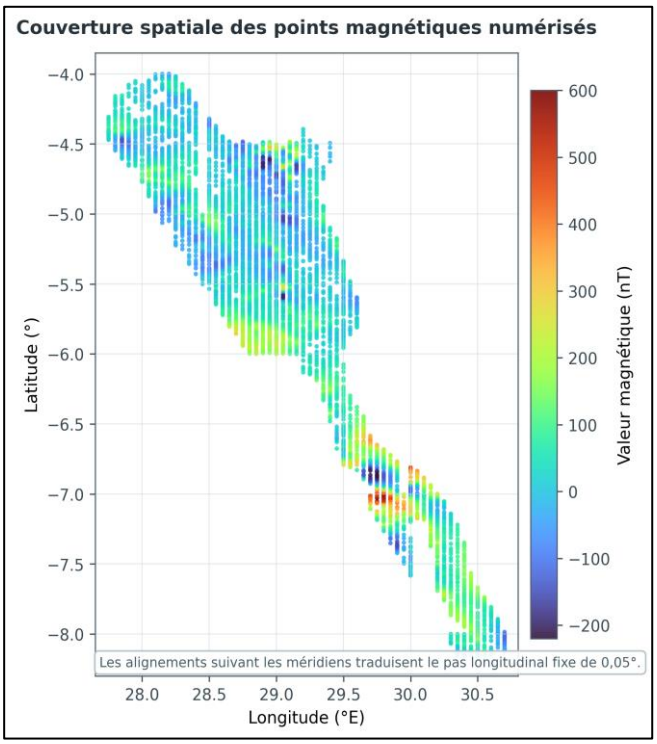


Fig 2 Spatial Distribution of the 4,716 Digitized Magnetic Points.

An initial statistical assessment checked record completeness, searched for duplicates, and characterized the spatial distribution and magnetic amplitudes. No missing values or exact duplicate records were found in the retained

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worksheet. The dataset contains 60 distinct longitudes and 163 magnetic levels; 98.39% of values are multiples of 5 nT, consistent with their derivation from digitized contours.

Point counts by longitude and the ranking of magnetic values complement this assessment by describing spatial sampling and the amplitude levels represented before interpolation and map processing (Figure 3).

Figure 3 shows the number of points at each longitude and the descending sequence of magnetic levels.

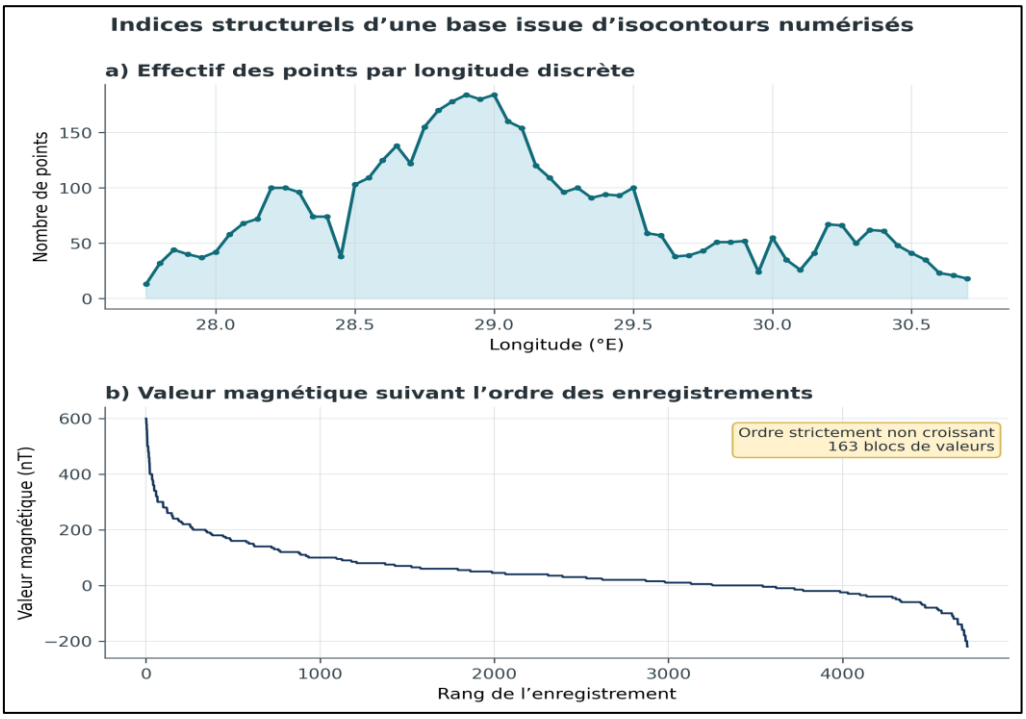
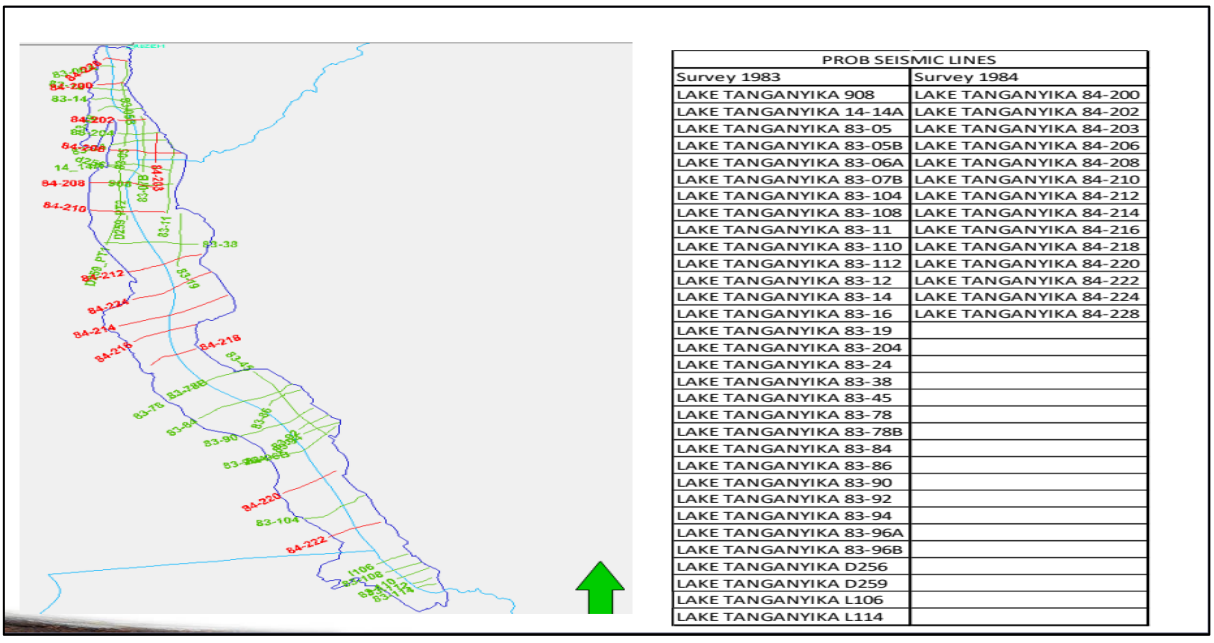


Fig 3 Point Counts by Longitude and Ranked Magnetic Values.

To place the interpreted lineaments within the basin architecture, the magnetic results were compared with the seismic interpretations reported by FracGeo (2019). That report inventories 46 2D seismic profiles acquired in 1983 and 1984, with a combined length of approximately 1,400 km. Their distribution defines the spatial coverage available for comparing magnetic trends, faults, and sedimentary geometries (Figure 4).

Figure 4 shows the distribution of the seismic profiles used for comparison.



PROB SEISMIC LINES	
Survey 1983	Survey 1984
LAKE TANGANYIKA 908	LAKE TANGANYIKA 84-200
LAKE TANGANYIKA 14-14A	LAKE TANGANYIKA 84-202
LAKE TANGANYIKA 83-05	LAKE TANGANYIKA 84-203
LAKE TANGANYIKA 83-05B	LAKE TANGANYIKA 84-206
LAKE TANGANYIKA 83-06A	LAKE TANGANYIKA 84-208
LAKE TANGANYIKA 83-07B	LAKE TANGANYIKA 84-210
LAKE TANGANYIKA 83-104	LAKE TANGANYIKA 84-212
LAKE TANGANYIKA 83-108	LAKE TANGANYIKA 84-214
LAKE TANGANYIKA 83-11	LAKE TANGANYIKA 84-216
LAKE TANGANYIKA 83-110	LAKE TANGANYIKA 84-218
LAKE TANGANYIKA 83-112	LAKE TANGANYIKA 84-220
LAKE TANGANYIKA 83-12	LAKE TANGANYIKA 84-222
LAKE TANGANYIKA 83-14	LAKE TANGANYIKA 84-224
LAKE TANGANYIKA 83-16	LAKE TANGANYIKA 84-228
LAKE TANGANYIKA 83-19	
LAKE TANGANYIKA 83-204	
LAKE TANGANYIKA 83-24	
LAKE TANGANYIKA 83-38	
LAKE TANGANYIKA 83-45	
LAKE TANGANYIKA 83-78	
LAKE TANGANYIKA 83-78B	
LAKE TANGANYIKA 83-84	
LAKE TANGANYIKA 83-86	
LAKE TANGANYIKA 83-90	
LAKE TANGANYIKA 83-92	
LAKE TANGANYIKA 83-94	
LAKE TANGANYIKA 83-96A	
LAKE TANGANYIKA 83-96B	
LAKE TANGANYIKA D256	
LAKE TANGANYIKA D259	
LAKE TANGANYIKA L106	
LAKE TANGANYIKA L114	

Fig 4 Inventory and Distribution of the 1983 and 1984 2D Seismic Profiles (FracGeo, 2019).

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C. Data Processing

➢ *Magnetic Map Production and Processing*

The digitized data from Kenting Surveys Ltd. (1983) were checked and interpolated to produce contour, colour-shaded anomaly, and shaded-relief maps. A rectangular moving-average filter with a 5 × 5-cell window was applied twice in Surfer 21 to reduce local irregularities and clarify regional trends.

Processing in Geosoft Oasis montaj 8.4 included reduction to the pole, horizontal derivatives in the X and Y directions ($\partial T/\partial x$ and $\partial T/\partial y$), and the first vertical derivative ($\partial T/\partial z$). Reduction to the pole helps examine the relationship between anomalies and their sources under the assumed magnetization conditions. Horizontal derivatives enhance lateral field variations, while the vertical derivative emphasizes shorter-wavelength components. Together, these products support the recognition of magnetic discontinuities and their structural interpretation (Blakely, 1995).

➢ *Lineament Mapping and Directional Analysis*

The derivative grids described above were imported into Surfer 21 for interpretation and manual lineament tracing. Selection was guided by gradient breaks, aligned maxima and minima, and anomaly continuity across the processed maps. The retained traces were digitized as polylines and exported in shapefile format. The vector network was therefore an output of magnetic map interpretation rather than an independent input dataset.

The polylines were imported into ArcGIS 10.8 to extract the coordinates of their endpoints: X_1 and Y_1 for the start point, and X_2 and Y_2 for the end point. These endpoints were used to determine each lineament's overall orientation. Lengths were calculated by summing geodesic distances between successive vertices on the WGS 84 ellipsoid.

Rose diagrams were constructed in RockWorks 17 using the endpoint coordinates. Orientations were expressed between 0° and 180° using an axial convention, in which opposite directions represent the same structural axis (Mardia & Jupp, 1999). Four 45° orientation classes were defined, centred on N–S, NE–SW, E–W, and NW–SE. Counts and cumulative lengths were compared to assess the contribution of each set to the network.

Spatial variability was examined in three sectors defined by the mean latitude of each lineament's endpoints: north, north of 5.5° S; central, between 5.5° and 6.8° S; and south, south of 6.8° S. Each trace was assigned to one sector. A sensitivity analysis compared the full network with a scenario excluding seven traces associated with regular map banding to assess the stability of the dominant trends. These analyses provided the basis for comparison with geological contacts and seismically interpreted structures.

III. RESULTS

➢ *Magnetic Value Distribution*

Magnetic values range from −220 to 600 nT, with a mean of 49.29 nT, a median of 35 nT, and a standard deviation of 92.09 nT. The mean exceeds the median, consistent with a distribution skewed towards higher positive amplitudes (Figure 5). These statistics describe the digitized points and complement the assessment of regional magnetic variability.

The histogram represents the distribution of sampled values rather than an area-weighted distribution of the magnetic field (Figure 5).

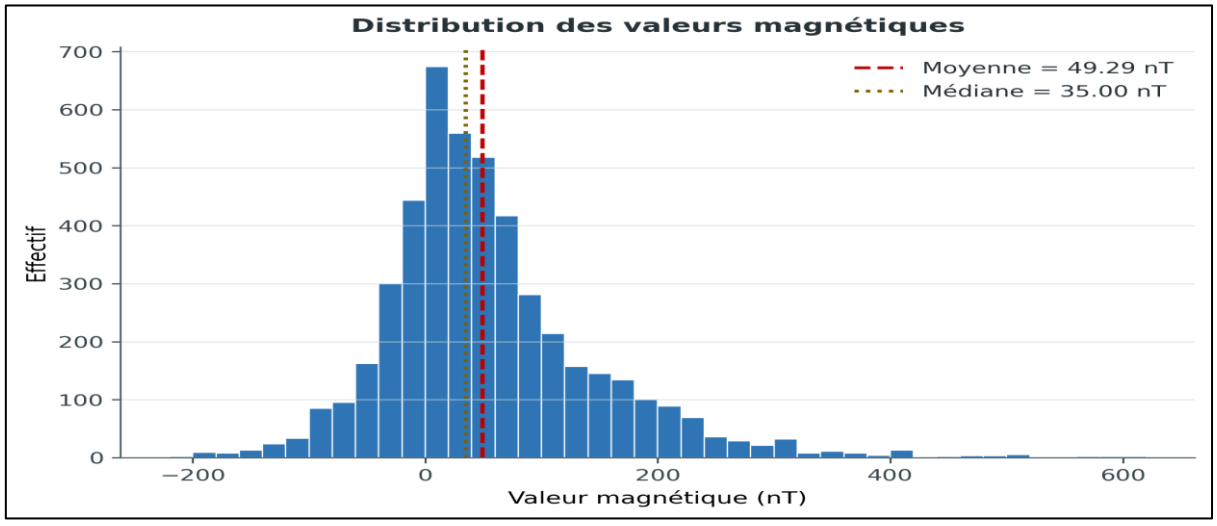


Fig 5 Histogram of Magnetic Values Showing the Mean and Median.

The magnetic map distinguishes three domains: a northern sector with generally low or negative values, a central domain characterized by positive anomalies around Kalemie, and a southern sector with a more pronounced alternation of anomalies (Figure 6). Gradient breaks between these domains guided the recognition of discontinuities and lineament tracing.

Figure 6 shows the amplitude domains and the gradients between them.

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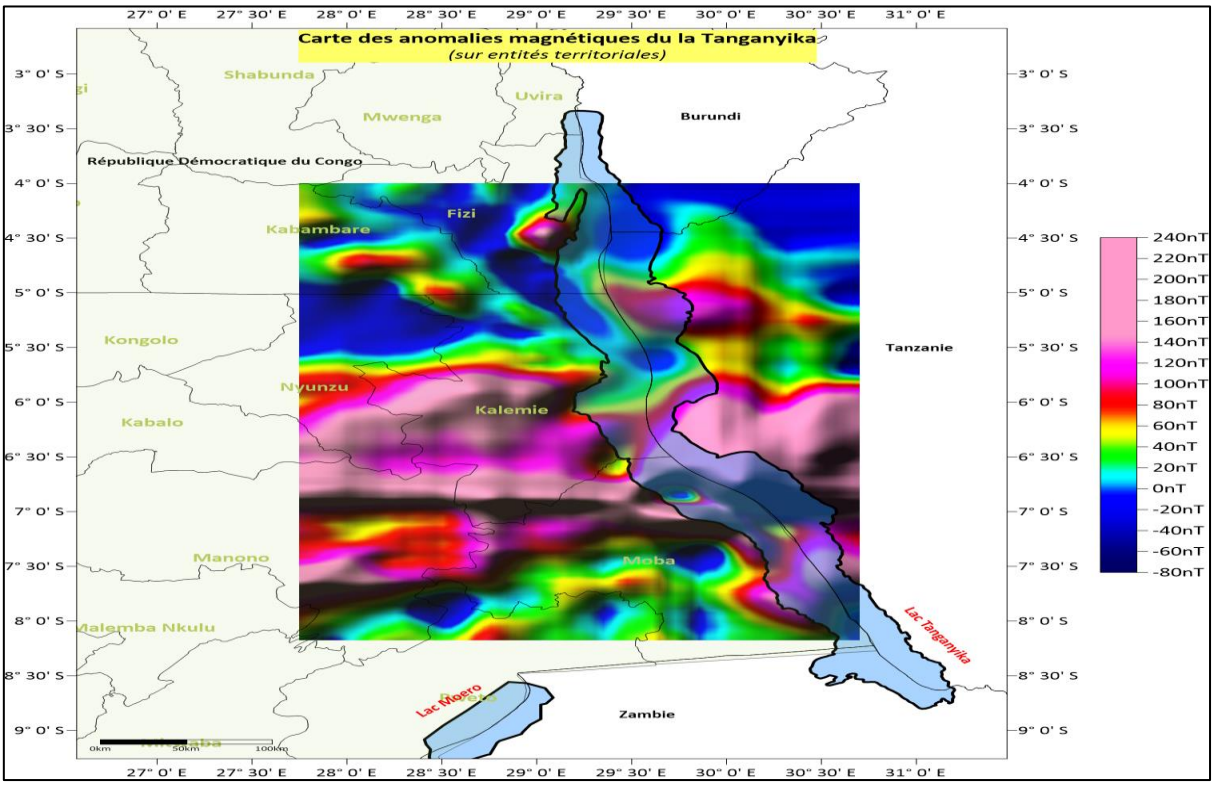


Fig 6 Colour-Shaded Magnetic Anomaly Map.

➢ *Lineament Geometry and Orientations*

Interpretation of the magnetic maps identified 30 lineaments with a combined length of 2,288.7 km (Figure 7). Individual lengths range from 29.4 to 132.8 km, with a median of 74.2 km. Mean sinuosity is 1.019, indicating broadly straight traces at the mapping scale.

E–W and NW–SE lineaments dominate the network, together accounting for 73.3% of the total length. NE–SW trends make an intermediate contribution, whereas N–S traces are less common (Table 1).

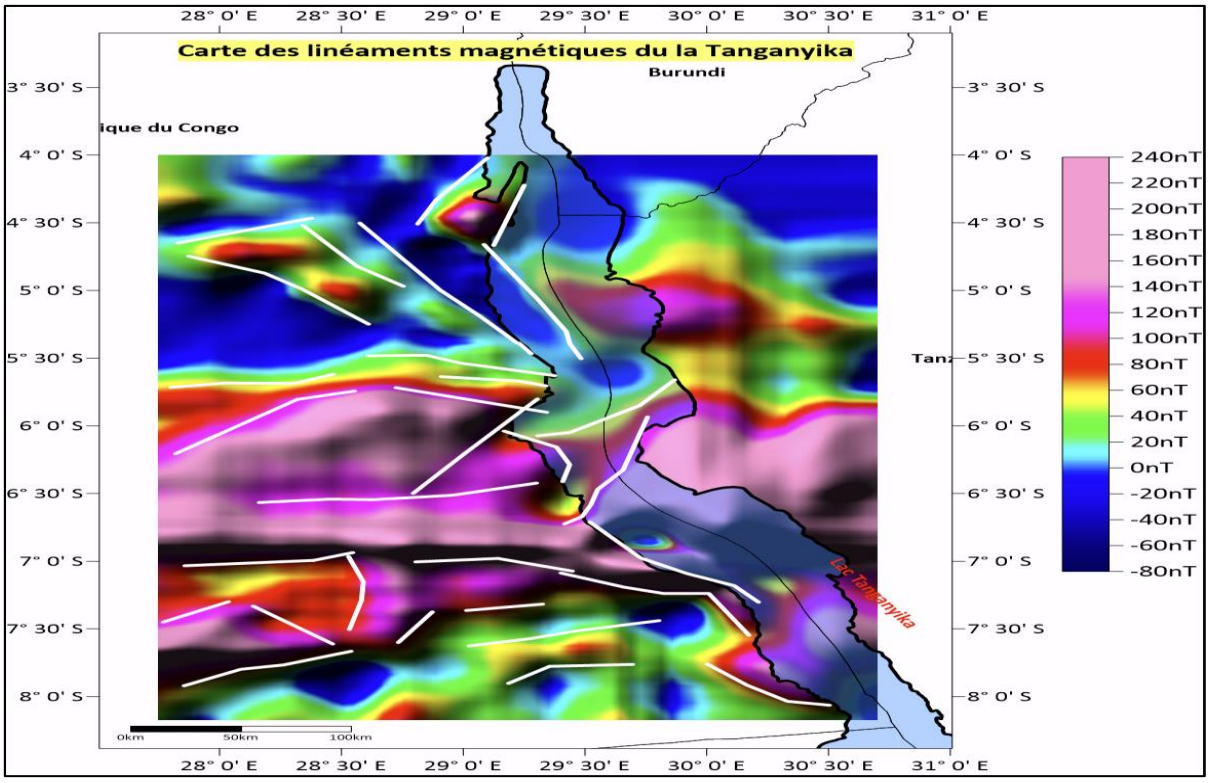


Fig 7 Interpreted Lineaments Superimposed on the Magnetic Anomaly Map.

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Table 1 Directional Distribution of the Interpreted Lineaments.

Set	Count	Length (km)	Share of total length
N–S	2	112.5	4.9 %
NE–SW	7	497.2	21.7 %
E–W	12	890.7	38.9 %
NW–SE	9	788.3	34.4 %
Total	30	2,288.7	100 %

- Note. Percentages are rounded. The sets describe the orientations of the mapped lineaments.

The length-weighted axial mean direction is approximately 95°, with a normalized resultant length of 0.29. This low concentration supports examining the individual directional sets rather than describing the network by a single mean axis (Figure 8).

Figure 8 compares the orientations, lengths, and spatial distribution of the full network.

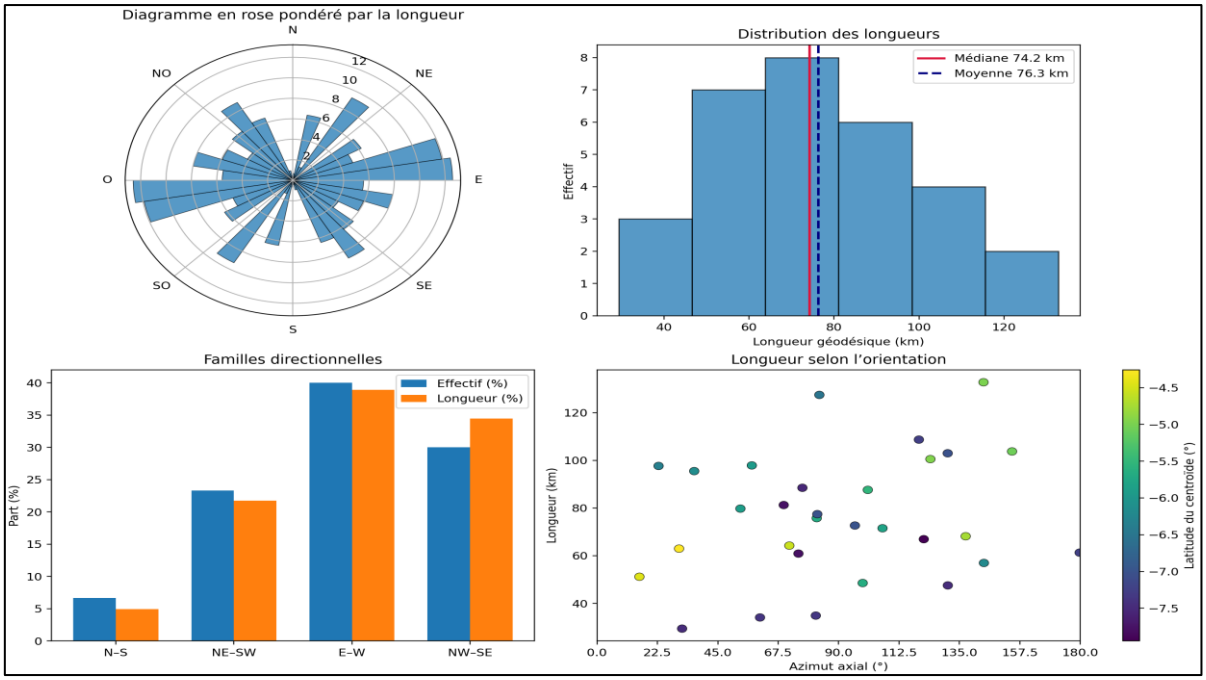


Fig 8 Orientations, Lengths, and Directional Sets of the 30 Interpreted Lineaments.

The network varies between sectors. The northern sector contains seven lineaments totalling 583.6 km, including four NW–SE traces. The central sector comprises ten lineaments totalling 838.6 km, mainly with E–W and NE–SW orientations. The southern sector contains 13 lineaments totalling 866.5 km; E–W traces are the most numerous, followed by NW–SE traces. These differences reveal spatial variation in the directional composition of the mapped network.

The sensitivity analysis further resolves this pattern. Excluding seven traces associated with regular map banding reduces the E–W share from 38.9% to approximately 19.9%, while the NW–SE share rises to approximately 45.2%. The NW–SE set thus remains prominent, whereas the relative contribution of E–W traces is sensitive to trace selection.

➢ *Relationships with Geology and Seismic Geometries*

Overlaying the lineaments on the geological map reveals two main configurations: segments locally subparallel to mapped boundaries and transverse traces crossing several units (Figure 9). In the north, several NW–SE lineaments cross units mapped as Mesozoic and Paleoproterozoic, whereas some segments near the western lake margin approximately follow geological boundaries.

In the central sector, E–W and NE–SW traces cross a mosaic of units. Farther south, several E–W traces extend across Mesoproterozoic and Neoproterozoic units. These relationships provide a basis for distinguishing lineaments associated with lithological contrasts from those that may represent transverse structural discontinuities. The unlabelled green category in the legend was not assigned to a geological unit.

Figure 9 presents the spatial comparison between the lineaments and mapped units.

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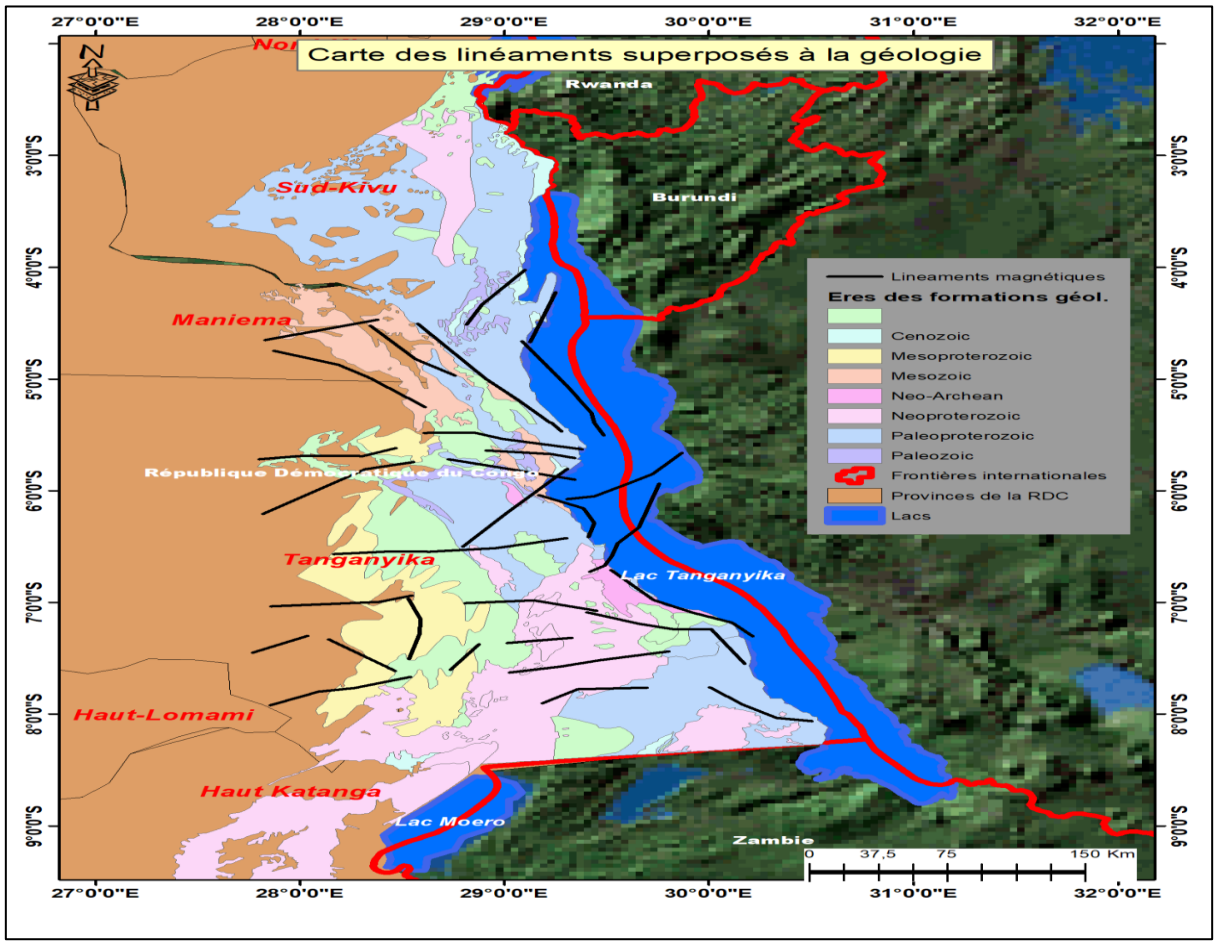


Fig 9 Lineaments Superimposed on the Major Geological Units Along the Congolese Margin.

Seismic interpretations provide complementary constraints on basin architecture. Profile 84-214 shows synthetic and antithetic normal faults and a depocentre located approximately between traces 600 and 1,000 on the Congolese side. Reflector divergence and thickening towards some faults indicate a relationship between deformation and sediment accumulation (FracGeo, 2019).

Figure 10 illustrates the seismic interpretation used to examine the faulted block and adjacent depocentre.

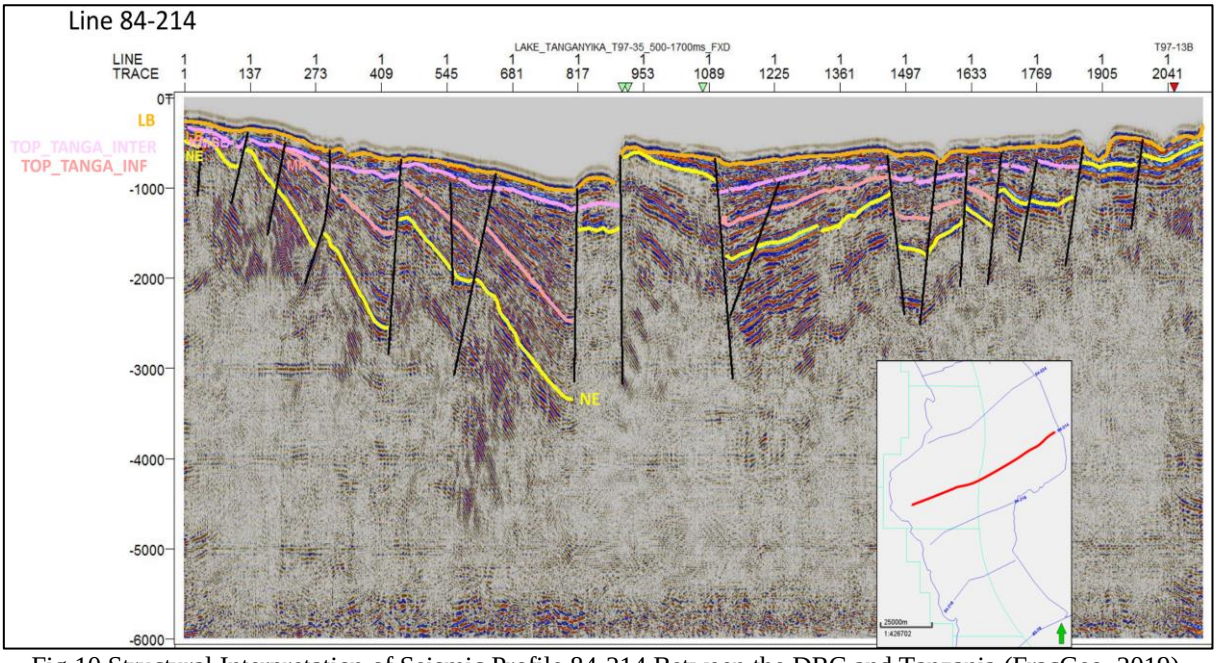


Fig 10 Structural Interpretation of Seismic Profile 84-214 Between the DRC and Tanzania (FracGeo, 2019).

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The interpretative model distinguishes three seismic units: TANGA_INF, TANGA_INTER, and TANGA_SUP. The lower two units show pronounced control by faults and subsiding areas, whereas the upper unit forms a more extensive drape. The regional model includes 59 interpreted faults and illustrates the compartmentalization of the basin fill. These units describe seismic geometries rather than dated lithostratigraphic formations.

Figure 11 summarizes the relationships between the seismic units and faults.

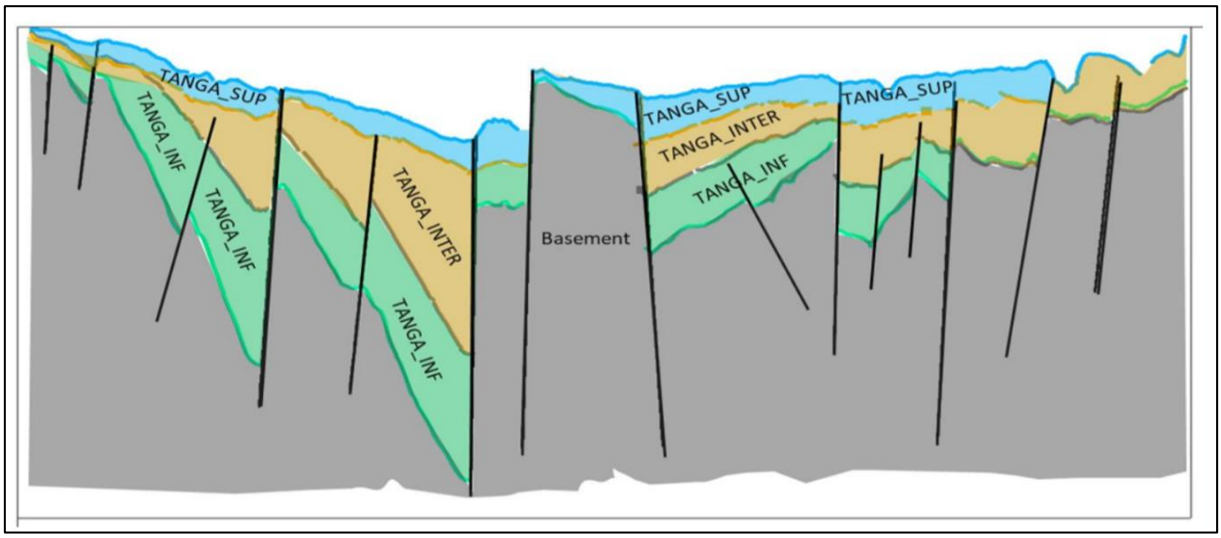


Fig 11 Conceptual Model of the TANGA_INF, TANGA_INTER, and TANGA_SUP Units and their Relationship to Faulting (FracGeo, 2019).

IV. DISCUSSIONS

➢ *Contribution of Magnetic Mapping to Structural Characterization*

Magnetic processing and map interpretation defined a regional network of discontinuities, its principal orientations, and its spatial variability. The approach is particularly useful for tracing magnetic contrasts beyond areas accessible to direct geological observation.

Amplitude differences and gradients may reflect lithological variation, changes in source depth, or structural discontinuities (Blakely, 1995). Comparing these patterns with geological units helps clarify lineament significance by distinguishing contact-parallel segments from transverse traces.

➢ *Basement Inheritance and Rift Architecture*

The substantial NW–SE component provides a basis for comparison with basement structures documented in Tanganyika. Shaban et al. (2023) identify a predominantly NW-trending deep fabric and show how inherited shear zones influenced parts of the basin structure. The results from the Congolese sector contribute to this question by identifying areas where the relationship between basement structure and extensional deformation can be investigated further.

The range of orientations suggests a network more complex than the simple reactivation of a single structural trend. The transverse E–W and NE–SW sets are relevant to examining boundaries between structural domains and possible relay zones. Their tectonic role needs to be assessed from their geometry and relationships with recognized faults.

The differences between sectors can be considered in relation to basement heterogeneity and the partitioning of extension described by Wright et al. (2020). Seismic interpretations complement this framework by documenting tilted blocks, normal faults, and syntectonic geometries within the basin fill (FracGeo, 2019).

➢ *Interpretation Robustness and Further Work*

The sensitivity analysis shows that the ranking of E–W and NW–SE sets depends partly on traces associated with regular banding. The full network and the trace-selection scenario should therefore be considered together. Geological correspondences are assessed at the regional scale of the available map and do not, on their own, establish the nature or kinematics of a discontinuity.

The interpretation can be strengthened through quantitative comparison with mapped contacts and faults, followed by targeted field observations and seismic correlations. These steps would help establish the nature of individual structures and assess possible reactivation.

V. CONCLUSION

Interpreting maps generated from the digitized aeromagnetic data of Kenting Surveys Ltd. (1983) yielded 30 lineaments with a total length of 2,288.7 km. E–W and NW–SE sets account for 38.9% and 34.4% of the cumulative length, respectively. Their distribution varies along the study area, with NW–SE traces more numerous in the north and E–W traces predominant by number in the central and southern sectors.

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Comparison with geological units identifies both segments locally aligned with contacts and transverse traces crossing several units. These configurations suggest that the magnetic expression of the network reflects a combination of lithological contrasts and structural discontinuities. Seismic interpretations complement this picture by documenting an extensional architecture of normal faults, tilted blocks, and depocentres, together with evidence linking deformation to sediment accumulation.

The substantial NW–SE component is relevant to assessing how inherited basement structures influenced graben development. Transverse sets also offer a basis for investigating relationships between structural domains and possible relay zones. The sensitivity analysis highlights the value of comparing mapped orientations across magnetic products and against geological observations.

This study provides a mapped and quantitative basis for characterizing the structural organization of the Congolese sector of Tanganyika. It identifies the main discontinuity sets and areas to prioritize for geological correlation, seismic comparison, and field verification, supporting a clearer understanding of the relationship between basement inheritance and rift segmentation.

REFERENCES

[1.] Blakely, R. J. (1995). *Potential theory in gravity and magnetic applications*. Cambridge University Press. https://doi.org/10.1017/CBO9780511549816

[2.] FracGeo. (2019). *Bassin rift Tanganyika : Étude d'exploration — Interprétation, analyses, modèles, pièges, prospects et volume d'hydrocarbures* [Tanganyika Rift Basin: Exploration study—Interpretation, analyses, models, traps, prospects, and hydrocarbon volume] [Final report prepared for SONAHYDROC SA].

[3.] Kenting Surveys Ltd. (1983). [Aeromagnetic survey data and metadata for the Tanganyika sector].

[4.] Mardia, K. V., & Jupp, P. E. (1999). *Directional statistics*. John Wiley & Sons. https://doi.org/10.1002/9780470316979

[5.] Sander, S., & Rosendahl, B. R. (1989). The geometry of rifting in Lake Tanganyika, East Africa. *Journal of African Earth Sciences (and the Middle East), 8*(2–4), 323–354. https://doi.org/10.1016/S0899-5362(89)80031-4

[6.] Shaban, S. N., Kolawole, F., & Scholz, C. A. (2023). The deep basin and underlying basement structure of the Tanganyika Rift. *Tectonics, 42*(7), e2022TC007726. https://doi.org/10.1029/2022TC007726

[7.] Wright, L. J. M., Muirhead, J. D., & Scholz, C. A. (2020). Spatiotemporal variations in upper crustal extension across the different basement terranes of the Lake Tanganyika Rift, East Africa. *Tectonics, 39*(3), e2019TC006019. https://doi.org/10.1029/2019TC006019.