

Analysis and Interpretation of Geomagnetic Anomalies in the Kinshasa Region (DRC) Using Satellite Data (Swarm Mission)

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Abstract: This study analyzes geomagnetic anomalies in the Kinshasa region using satellite data from the Swarm mission. The objective is to identify spatial variations in the Earth magnetic field and interpret the anomalies associated with regional geological structures. Geomagnetic data were extracted for a geographic window covering the Kinshasa region and processed to calculate magnetic anomalies. The results highlight variations in the magnetic field that may be linked to lithological contrasts and deep structures in the Congo Basin. This study demonstrates the value of satellite data in regional geophysical investigations in Central Africa.

Keywords: Geomagnetism, Magnetic Anomalies, Swarm, Geophysics, Congo Basin.

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I. INTRODUCTION

The magnetic field is very important for studying the Earth's internal structure and analyzing geological formation. [Spdf.gsfc.Nasa.gov] Magnetic anomalies detected at the Earth's surface are primarily linked to variations in the magnetic properties of rocks of the Earth's crust [Handbook of Geomathematic 2015]. Geomagnetic methods are widely used in applied geophysical studies, particularly in geological mapping, mineral exploration, and the identification of tectonic structures [Blakely RJ, 1996; John M. Reynolds, 2011].

Modern satellite missions now allow us to make highly precise observations of the magnetic field [essd.copernicus.org]. The Swarm mission, developed by the European Space Agency, is among the sources used in geomagnetics in current scientific studies. [Christopher C. Finaly et al, 2015; Nils Olsen, 2016].

The Central African region is characterized by significant variations in magnetic fields linked to its proximity

to the geomagnetic equator and to equatorial ionospheric currents [Zana et al., 2022]

Kinshasa region is located in the Congo Basin, one of the largest sedimentary basins in the world. This basin is characterized by a succession of sedimentary formations resting on an ancient crystalline basement [David Gubbins & Emilio Herrero-Bervera, 2007].

The objective of this study is to analyze and interpret geomagnetic anomalies in the Kinshasa region from Swarm satellite data in order to better understand the regional geological structure.

II. THE AREA TO BE STUDIED

➤ Geographical Study

Our study focuses on the city of Kinshasa, province of the DRC, in Central Africa. [24] the approximate coordinates of the middle of our study area:

- Latitude: 4°19' South
- Longitude: 15°19' East

- Latitude: -6° to -3°
- Longitude: 14° to 17°

In order to cover Kinshasa and its surroundings, the area analyzed in this study is defined by the following geographical window:

This area encompasses not only the city of Kinshasa but also the surrounding geological formations which can influence the spatial distribution of geomagnetic anomalies. Our study area is shown in Figure 1.



Fig 1 Location of the Study Area.

➤ *Geological Context*

The Kinshasa region belongs to the vast Congo Basin, one of the largest sedimentary basins in the world. This basin was formed during the geological evolution of the African craton and is characterized by a succession of sedimentary formations deposited from the Upper Precambrian to the Quaternary.

- *The Geological Formations of the Region are Dominated by:*
 - ✓ sands and Sandstone
 - ✓ Clays
 - ✓ Recent Alluvial Deposits

These formations rest on an older crystalline basement belonging to the African craton. Lithological variations between these different units can lead to disparities in the magnetic characterization of the rocks, resulting in the presence of geomagnetic anomalies detectable by satellite.

➤ *Tectonic Context*

From a tectonic perspective, the region is influenced by several structures inherited from the geodynamic evolution of Central Africa. Although the Congo Basin is considered relatively tectonically stable, certain deep structures and crustal discontinuities can influence the distribution of magnetic anomalies.

- *The Study of Geomagnetic Anomalies in this Region can therefore Provide Important Information on:*

- ✓ The structure of the base
- ✓ The distribution of lithological formations
- ✓ Deep tectonic discontinuities.

III. DATA AND METHODOLOGY

A. Geomagnetic Data

We used satellite data from the Swarm mission, a space mission designed to study magnetic fields. This mission, developed by the European Space Agency, includes three satellites in low Earth orbit equipped with high-precision magnetometers.

Swarm satellites allow for very precise measurement of the different components of magnetic fields and help to distinguish the contributions of: [essd.copernicus.org]

- Of the earth Core;
- Of the earth crust;
- Of the ionosphere and magnetosphere[23]

The data used in this study correspond to measurements of the total magnetic field as well as the vector components of

the magnetic field recorded by the Swarm satellites. [Géorge. V, Khazanov “space weather fundamentals”crcpress,2016]

B. Geomagnetic Parameters Analyzed

The geomagnetic parameters considered in this study include:

- F: Total Intensity of magnetic field
- Bx: component of the magnetic field along north axis
- By: component along the east axis
- Bz: vertical component.

The relationship below expresses the overall intensity of the magnetic field:

$$F = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

Or:

Bx, By and Bz represent the components of the magnetic field vector. [Géorge. V, Khazanov “space weather fundamentals”crcpress,2016]

Table 1 presents the main geomagnetic parameters.

Table 1 Geomagnetic Variables Employed in this Study

Setting	Symbol	Unit	Description
Total magnetic field strength	F	nT	1. Total intensity of the Earth's magnetic field measured by satellite[essd.copernicus.org]
Northern component	Bx	nT	2. the north-facing component of the field
Component is	By	nT	3. Horizontal component oriented towards the east
Vertical component	Bz	nT	4. Vertical component of the magnetic field
Magnetic anomaly	ΔF	nT	5. Difference between the Observed Field and the Reference Field[dokum.pub]
Reference magnetic field	IGRF	nT	6. Main magnetic field given by the international reference geomagnetic field model, le modèle de reference[Spdf.gsfc.Nasa.gov]

C. Data Extraction

Geomagnetic data was extracted for an area covering the Kinshasa region and its surroundings.

➤ *The Geographical Window Selected for the Analysis is Defined by:*

- Latitude: -6° to -3°
- Longitude: 14° to 17°

This area allows us to cover the entire region under study as well as the surrounding geological structures that may influence the distribution of the magnetic field.

Satellite data were selected for a specific observation period to ensure sufficient spatial coverage of the study area.

D. Data Processing

The processing of geomagnetic data consisted of several steps:

- Selection of satellite data corresponding to the study area.

- Data filtering to eliminate external disturbances related to ionospheric and magnetospheric effects.
- Calcul de l'intensité du Champ Magnétique total en se basant sur les composantes vectorielles.
- Mapping of the spatial distribution of the magnetic field in the studied area. [Spdf.gsfc.Nasa.gov]
- Identification of magnetic anomalies associated with geological structures.

The magnetic maps obtained allow us to analyze the spatial distribution of geomagnetic anomalies and to interpret their relationship with the regional geological structure.

E. Calculation of Magnetic Anomalies

The magnetic anomalies were established based on the difference between the magnetic field observed by the Swarm mission and the reference magnetic field provided by the International Geomagnetic Reference Field.magnetic field provided by the International Geomagnetic Reference Field. [Géorge. V, Khazanov “space weather fundamentals”crcpress,2016]

➤ *The Magnetic Anomaly is given by the Following Relationship:*

$$\Delta F = F_{\text{observed}} - F_{\text{IGRF}}$$

Or:

- ΔF represents the magnetic anomaly
- The observed F corresponds to the magnetic field measured by satellite.
- F_{IGRF} represents the principal magnetic field calculated by the IGRF model.

F. Advanced Magnetic Data Processing

To improve the interpretation of geomagnetic anomalies in the Kinshasa region, several magnetic data processing techniques have been applied. These methods allow for a better understanding of the geological structures responsible for the observed anomalies.

➤ *Magnetic Field Gradient*

The Magnetic Field gradient makes it possible to identify rapid spatial variations in the magnetic field and to locate geological structures more precisely. [Géorge. V, Khazanov “space weather fundamentals”crcpress,2016]

- *The Gradient can be Expressed as:*

$$G = \frac{\partial F}{\partial x}$$

Or:

- ✓ G represents the gradient of the Magnetic Field
- ✓ F the intensity of The Magnetic Field
- ✓ x corresponds to The horizontal direction.

- *This Method is Particularly Useful for Detecting:*

- ✓ Geological Faults
- ✓ Lithological Contacts
- ✓ Magmatic Intrusions.

➤ *Vertical Derivative*

The vertical derivative of the magnetic field helps to strengthen anomalies related to shallow sources and to attenuate the effects of deep sources.

- *It can be Expressed as:*

$$VD = \frac{\partial F}{\partial z}$$

Or:

- ✓ VD represents the vertical derivative
- ✓ F is the magnetic field

- ✓ z corresponds to the vertical direction.

This technique is often used to improve the resolution of magnetic anomalies associated with shallow geological structures.

➤ *Reduction at the Pole (RTP)*

Pole reduction is a mathematical transformation used in geophysics to reposition magnetic anomalies directly above their sources.

This transformation is particularly important in regions close to the equator, such as the Kinshasa region, where magnetic anomalies may appear offset from their geological sources due to the tilt of the Earth's magnetic field.

- *The RTP Transformation therefore Allows:*

- ✓ To improve the localization of magnetic sources
- ✓ To facilitate the geological interpretation of anomalies.

IV. RESULTS AND INTERPRETATION

A. Total Magnetic Field Distribution

Analysis of data from the Swarm mission makes it possible to determine the spatial distribution of the Earth's magnetic field in the Kinshasa region and its surroundings. [essd.copernicus.org]

The results show that the total magnetic field strength exhibits significant spatial variations on a regional scale. In the area studied, the values of the total magnetic field generally vary between approximately 32,000 nT and 33,500 nT, which corresponds to the typical values observed in equatorial regions. Figure 2 shows the spatial distribution of field intensity in the region.

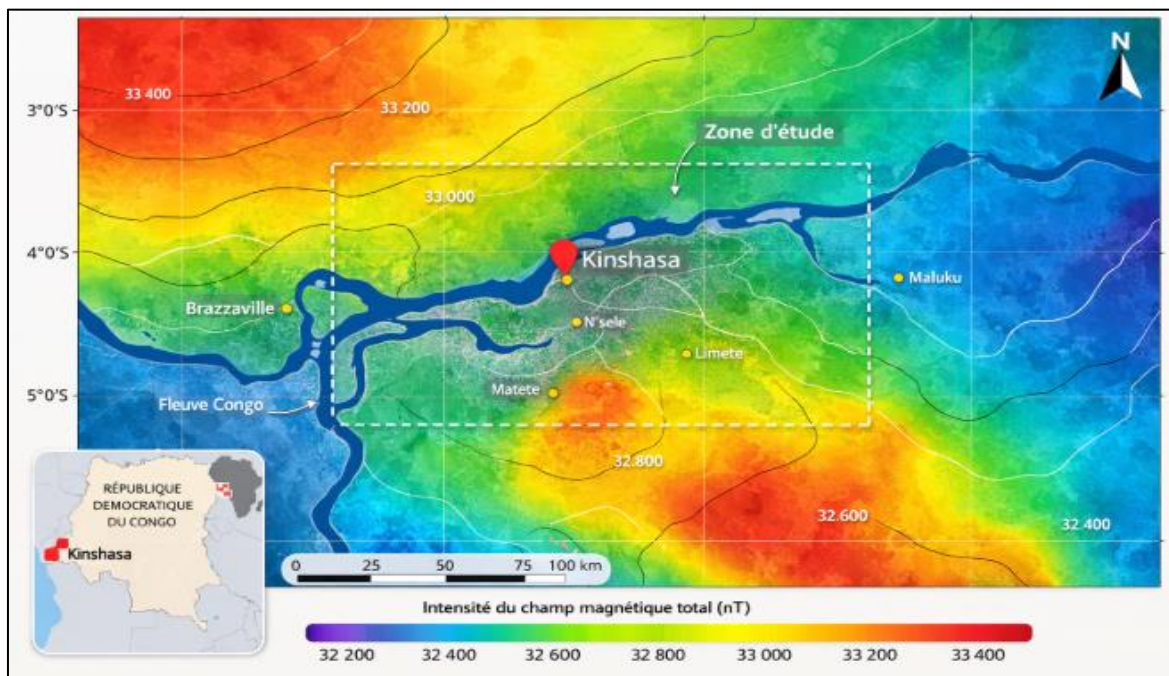


Fig 2 Representation of the Spatial Distribution of Global Intensity in the Kinshasa Region Obtained from Data from the Swarm Mission

The spatial distribution of these values highlights certain areas characterized by local variations in the magnetic field, which may reflect the presence of lithological contrasts in the subsoil. [R. B. Bank. "Geomagnetic variation and the Electrical Conductivity of the upper mantle"]

B. Identification of Geomagnetic Anomalies

Analysis of magnetic maps makes it possible to identify several local geomagnetic anomalies in the studied region.

The magnetic anomalies obtained after data processing highlight several areas characterized by positive and negative variations in the magnetic field in the Kinshasa region. Figure 3 shows the spatial distribution of these anomalies.

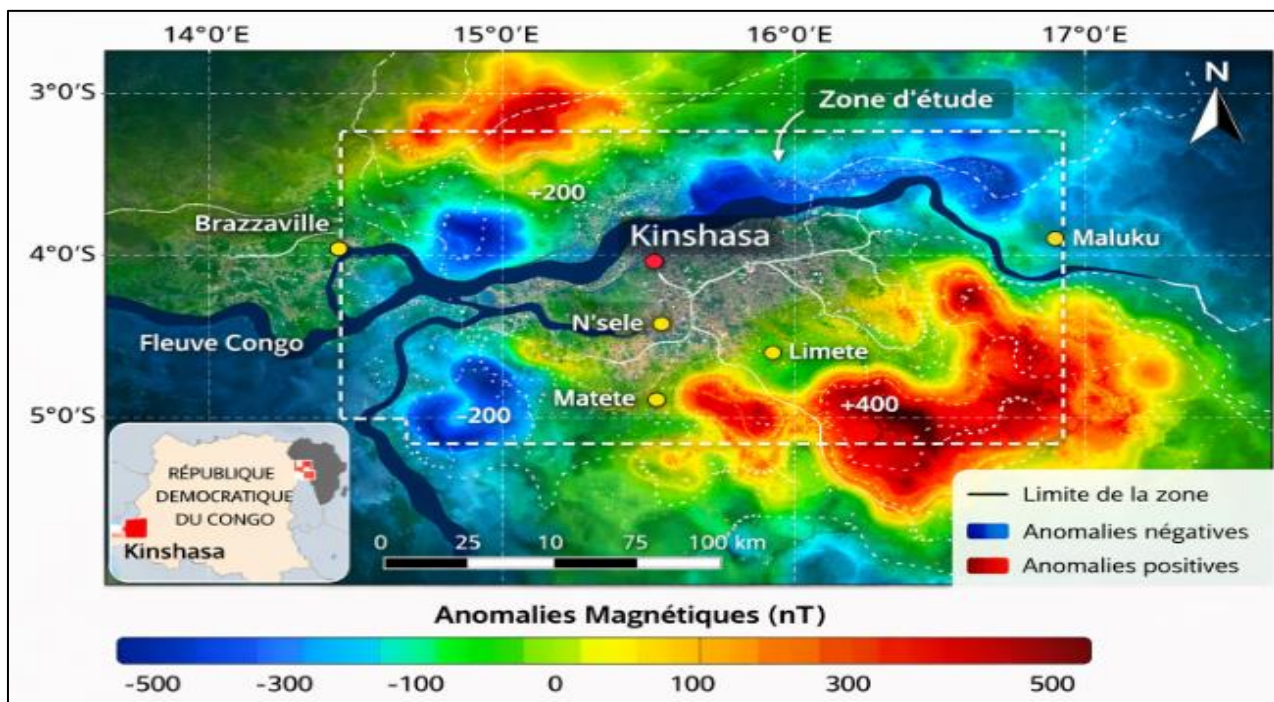


Fig 3 Magnetic Anomalies in the Kinshasa Region Obtained after Subtracting the Reference Magnetic Field, Highlighting the Positive and Negative Anomalies Associated with Local Geological Structures. Magnetic Anomalies can be Classified into Two Main Categories

➤ *Positive Anomalies*

Positive anomalies correspond to areas where the magnetic field strength is higher than the regional average. These anomalies may be associated with the presence of geological formations containing ferromagnetic minerals such as:

- Magnetite
- Ilmenite
- Certain Types of igneous rocks.

➤ *Negative Anomalies*

Negative anomalies correspond to areas characterized by lower magnetic intensity. These anomalies may be related to:

- Sedimentary formations poor in magnetic minerals
- Deep tectonic structures
- Variations in the thickness of geological formations.

C. *Geological Interpretation*

The magnetic anomalies observed in the Kinshasa region could be associated with lithological variations between the sedimentary formations of the Congo Basin and the underlying Precambrian crystalline basement. Positive anomalies may correspond to the presence of rocks rich in ferromagnetic minerals such as magnetite, while negative anomalies may reflect weakly magnetized sedimentary formations. [Repository.futminna.edu.ng]

These results also suggest the possible existence of deep structures or crustal discontinuities influencing the distribution of the magnetic field in the region. [Géorge. V, Khazanov “space weather fundamentals”crcpress,2016]

The observed magnetic contrasts can thus provide indications of the subsoil structure and contribute to a better understanding of the regional geological organization. [18]

V. DISCUSSION

The magnetic anomalies identified in this study may be associated with lithological contrasts present in the geological formations of the Congo Basin. Rocks containing ferromagnetic minerals such as magnetite can produce positive magnetic field anomalies (Ronald T. Merrill et al., 1996).

Sedimentary formations, on the other hand, generally exhibit weaker magnetic properties and can be associated with negative anomalies. The variations observed in the studied region may therefore reflect contrasts between the sedimentary deposits and the underlying crystalline basement.

In regions near the equator, such as Kinshasa, interpreting anomalies can be more complex due to the shallow tilt of the Earth's magnetic field.

Therefore, in such cases, certain data processing techniques, such as pole reduction, are often used to improve the localization of magnetic sources. [“ use of ground magnetic

survey in exploration of geothermal springs in a ùeta morphic terrain”]

The results obtained show that satellite data is an effective tool for studying regional geological structures and can contribute to improving the understanding of the subsoil structure in the Kinshasa region.

VI. CONCLUSION

This study analyzed and interpreted geomagnetic anomalies in the Kinshasa region using satellite data from the Swarm mission.

The results obtained show that the Intensity of the Magnetic Field exhibits local anomalies that may be associated with lithological contrasts and subsurface geological structures. These magnetic variations may be linked to the presence of sedimentary formations, the structure of the underlying basement, and regional tectonic discontinuities in the Congo Basin.

The use of satellite data from the Swarm mission demonstrates the value of geomagnetic observations for studying regional geological structures. This data is an important tool for improving our understanding of the subsurface and can contribute to geophysical investigations, particularly in the fields of geological mapping and natural resource exploration.

The results of this study also open up perspectives for future research aimed at integrating other geophysical methods, such as gravimetric and geoelectric methods, in order to obtain a better characterization of the subsoil in the Kinshasa region. [hai-insu.archives-ouvertes.fr]

REFERENCES

- [1]. ZANA. N (2004) Geophysics Course, University of Kinshasa
- [2]. United States Geological Survey (2020)
- [3]. Handbook of Geomathematic 2015
- [4]. Spdf.gsfc.Nasa.gov
- [5]. Word magnetic model technical report
- [6]. International Association of Geomagnetism and Aeronomy (2015) International geomagnetic Field;
- [7]. Swarm Exploring the Earth Magnetic Field European Space Agency ;
- [8]. Blakely RJ (1996), Potential Theory in Gravity and Magnetic Application. Cambridge University Press;
- [9]. John M. Reynolds (2011) An Introduction to Applied and Environmental Geophysics Wiley Blackwell;
- [10]. William J. Hinze et al. (2013) Gravity and Magnetic Exploration, Principles, Practices, and Application. Cambridge University press;
- [11]. Nils Olsen, Christopher C. Finlay et al. (2016), The Swarm Satellite constellation application and research facilitu (SCARF) and Swarm Data Products;
- [12]. Christopher C. Finlay, et al. (2015) International Geomagnetic Reference Field: the twelfth generation;

- [13]. ZANA.N.(2004) Study of the Variation of the Horizontal H and Vertical Z components of the Earth's magnetic field at Binza from 1960 to 1970. Geophysical Research Center (CRG)
- [14]. [essd.copernicus.org](https://www.esdd.copernicus.org)
- [15]. Géorge. V, Khazanov “space weather fundamentals” CRCpress, 2016
- [16]. R. B. Bank. “Geomagnetic variation and the Electrical conductivity of the upper mantle
- [17]. [Repository.futminna.edu.ng](https://www.repository.futminna.edu.ng)
- [18]. www.researchgate.org, tendacnce récentes dans l'application de la tomographie. Falae Philips.
- [19]. M. P. Thilakarathna, A. M. Abeysinghe, N.D. Subasinghe, “use of ground magnetic survey in exploration of geothermal springs in a ùeta morphic terrain”.
- [20]. [Hai-insu.archives-ouvertes.fr](https://www.hai-insu.archives-ouvertes.fr)
- [21]. www.preprints.org
- [22]. [Geomag.bgs.ac.uk](https://www.geomag.bgs.ac.uk)
- [23]. Paola de Michelis, giuseppe et al”observation des fluctuation du champ géomagnétique”
- [24]. University of southampton student papers
- [25]. [D.nb.info](https://www.d.nb.info)
- [26]. David C. Tanner.Hermann Bunes. Jan Igel, Thomas Gunther et al.”Fault detection”
- [27]. [Journal.tubitak.gov.fr](https://www.journal.tubitak.gov.fr)