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Data article

Magnetic and gamma-ray spectrometric airborne geophysical data for investigating potential mineral resources and generating geoscientific knowledge in Colombia

Datos geofísicos aerotransportados de magnetometría y gama espectrometría para investigación del potencial de recursos minerales y generación de conocimiento geocientífico en Colombia

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Abstract

The Servicio Geológico Colombiano has made available several airborne magnetometry and gamma-ray spectrometry datasets. The information was acquired in 15 blocks that cover approximately 520,000 square kilometers of Colombian territory, representing more than 850,000 linear kilometers of information. The data were collected along flight lines separated by 500 meters or 1000 meters, depending on the area, with sampling rates of 10 Hz (8 meters) and 1 Hz (80 meters) for the magnetometry and gamma-ray spectrometry data, respectively. The information is stored in 30 databases separated for each block and for each of the geophysical methods used. The Servicio Geológico Colombiano has provided a web portal that provides detailed specifications for each database and allows interested parties to see the terms and conditions to access the datasets and to check possible restrictions on access to information. To date, there is no geophysical database in Colombia with the coverage and resolution of these data sets, which will be very useful for geological research and research on potential mineral resources and to support geohazard monitoring, land-use planning and providing a baseline dataset for environmental monitoring.

Keywords: Airborne geophysical data, magnetometry, gamma-ray spectrometry, geological and mineral resource research.

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Resumen

El Servicio Geológico Colombiano presenta la información geofísica de magnetometría y gamma espectrometría adquirida mediante plataforma aerotransportada. La información fue adquirida en 15 bloques que cubren alrededor de 520 000 kilómetros cuadrados del territorio colombiano, representando más de 850 000 kilómetros lineales de información. Los datos fueron levantados en líneas de vuelo separadas cada 500 metros o 1000 metros, según el área, con una tasa de muestreo de 10 Hz (8 metros) y 1 Hz (80 metros) para magnetometría y gamma espectrometría, respectivamente. La información se encuentra almacenada en 30 bases de datos por cada bloque y por cada uno de los métodos geofísicos utilizados. El Servicio Geológico Colombiano ha dispuesto un portal web que muestra las especificaciones detalladas para cada base de datos y permite a terceros ver los términos y condiciones para acceder a la base de datos y consultar las condiciones y posibles restricciones de acceso a la información. Hasta la fecha no existía en Colombia una base de datos geofísicos con la cobertura y resolución de los presentes datos, que serán de gran utilidad para la investigación geológica, y sobre el potencial de recursos minerales, así como sobre el apoyo en el monitoreo de amenazas de origen geológico y la toma de decisiones sobre planificación y el uso del territorio.

Palabras clave: Datos geofísicos aerotransportados, magnetometría, gamma-ray espectrometría, investigación geológica y en recursos minerales.

1. Description of the data

The data correspond to approximately 850,000 linear kilometers of geophysical information obtained by magnetometry and gamma-ray spectrometry instruments on an airborne platform. The information was acquired by the Servicio Geológico Colombiano (SGC) through several projects executed between 2013 and 2018 that cover an approximate area of 520,000 square kilometers of Colombian territory, distributed in 15 blocks (Figure 1). The data are stored in 30 databases (GDB-Oasis montaj, Seequent), one for each surveyed block and one for each geophysical method used, and the databases contain information pertaining to the flight lines (date of acquisition, coordinates and flight height) and the processed and levelled data corresponding to total-field magnetic anomalies (TFMA), total gamma-ray count and relative concentration of equivalent uranium (eU, measured in ppm), equivalent thorium (eTh, measured in ppm) and potassium (K, measured in %). Information about queries for coverage and instructions for requesting access to the data for a specific area are detailed below.

2. Importance of the data

- The airborne geophysical information related to the Colombian territory has a resolution and regional coverage greater than previously available.
- The availability of digital data allows any researcher with an interest in geophysics to apply their own processing, modeling and interpretation methods.
- The geophysical data will be useful for the regional exploration of potential mineral resources, tectonic studies, regional geological mapping of difficult-to-access areas, land-use planning and management, geohazard research and provide a baseline dataset for environmental monitoring.

3. Access to data

For access to the airborne geophysical data, a link has been provided in the SGC portal (Table 1) which details the requirements, terms and conditions and potential restrictions for access to the data. The SGC will include new databases as new blocks become available.

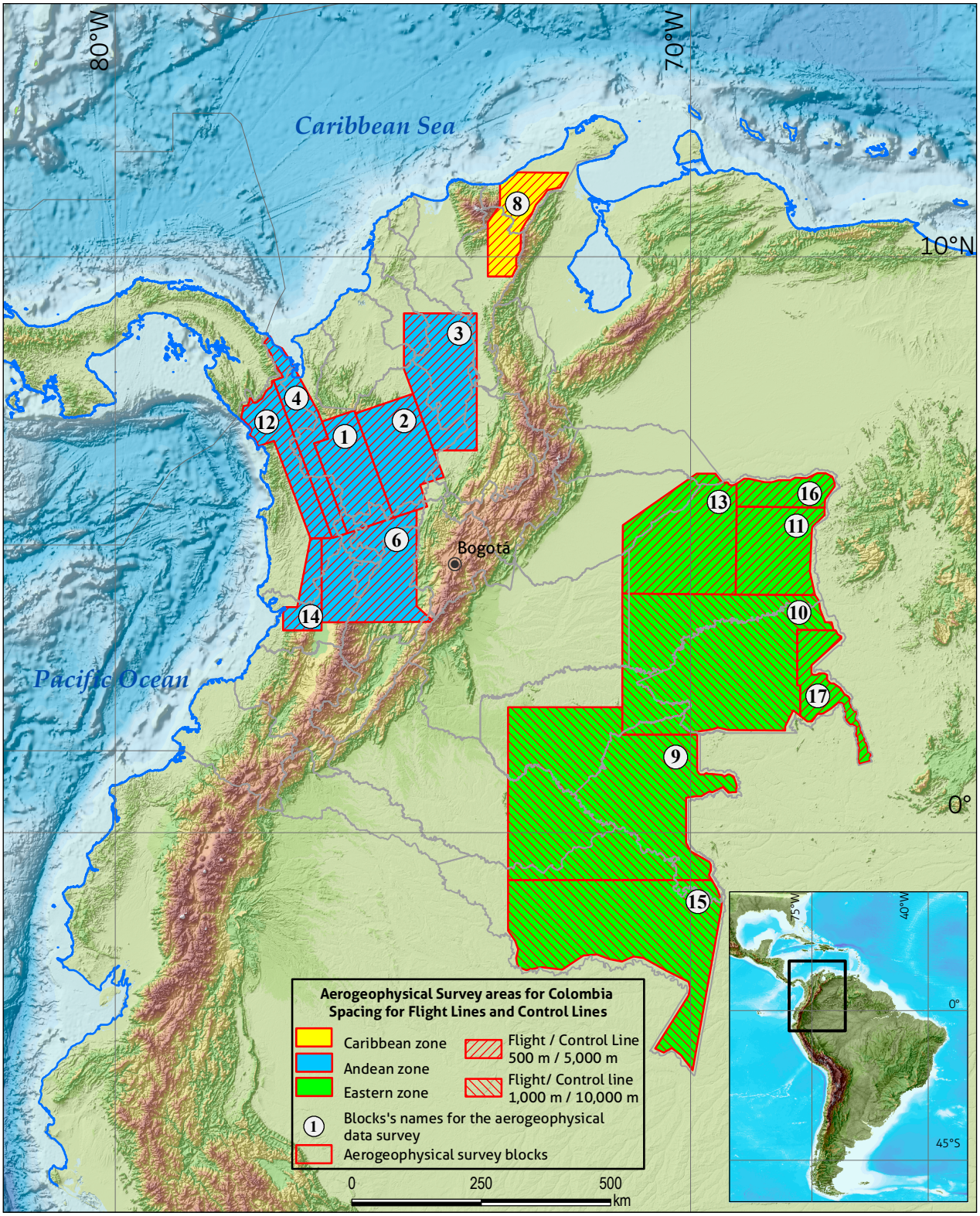

Figure 1. Location of the 15 blocks that contain airborne information
The color of each block corresponds to the geographical region (green: Amazonas-Orinoquía; blue: Andean; yellow: Caribbean), and the hatching details show the distance between the flight lines (NE-SW: 500 m, NW-SE: 1000 m). Block names: Antioquia W (1), Antioquia E (2), Bolívar (3), Urabá (4), Andes N (6), Amazonas N (9), Guainía (10), Vichada (11), Darién (12), Vichada W (13), Buenaventura (14), Amazonas S (15), Vichada N (16), Guainía E (17).

Table 1. Data specifications

Subject	Geophysics
Specific subject area	Geology, mineral resources.
Type of data	Magnetometry and gamma-ray spectrometry data.
How the data were acquired	Survey using an airborne platform.
Data format	The levelled data provided in GDB/XYZ/GRD format (compatible with Seequent Oasis montaj)
Parameters for data collection	The data were acquired in 15 blocks with flight lines separated by 500 m or 1000 m, depending on the area covered. Data sensors were 100 m above the ground (where safety and topography allowed it), and sampled at a rate of 10 Hz for the magnetometry data and 1 Hz for the gamma-ray spectrometry data.
Description of the data collection	The data are stored in a magnetometry geodatabase and a gamma-ray spectrometry geodatabase for each of the 15 blocks surveyed.
Location of the data source	Server at the headquarters of the Servicio Geológico Colombiano, Bogotá, Colombia.
Data accessibility	https://www2.sgc.gov.co/ProgramasDeInvestigacion/DireccionTecnicaRecursosMinerales/Paginas/consulta-informacion-geofisica.aspx
Additional information related to the data sets.	Authors: Moyano, I., Lara, N., Ospina, D., Salamanca, A., Arias, H., Gómez E., Puentes, M., & Rojas, O. (2018). Title: *Mapa de anomalías geofísicas de Colombia para recursos minerales, versión 2018 (Geophysical anomalies map of Colombia for mineral resources, 2018 version).* Metadata link: http://adminmiig.sgc.gov.co/Lists/RecursosSGC/DispForm.aspx?ID=67421 Authors: Moyano Nieto, I. E., Cordani, R., Cárdenas Espinosa, L. P., Lara Martínez, N. M., Rojas Sarmiento, O. E., Puentes Torres, M. F., Ospina Montes, D. L., Salamanca Saavedra, A. F., & Prieto Rincón, G. (2020) Title: Interpretation of geophysical anomalies for mineral resource potential evaluation in Colombia: Examples from the northern Andes and Amazonian regions. Journal: *Boletín Geológico*, (46), 5-22. DOI: https://doi.org/10.32685/0120-1425/boletingeo.46.2020.514 Authors: Moyano Nieto, I. E., Cordani, R., Cárdenas Espinosa, L. P., Lara Martínez, N. M., Rojas Sarmiento, O. E., Puentes Torres, M. F., Ospina Montes, D. L., Salamanca Saavedra, A. F., & Prieto Rincón, G. (2020). Title: Contribution of new airborne geophysical information to the geological knowledge of eastern Colombia. Book: *The Geology of Colombia* DOI: https://doi.org/10.32685/pub.esp.35.2019.02

4. Materials and methods

Data collection in all blocks was carried out using airborne platforms (fixed-wing aircraft) at a nominal height of 100 meters above the ground, where topographic conditions (particularly in the Andean zone) and operational safety conditions allowed it. Each aircraft was equipped with a high-precision global navigation satellite systems (GNSS) sensor used to navigate and position the aircraft as well as magnetometers and gamma-ray spectrometers configured to record variations in the terrestrial magnetic field and count the radiogenic particles at rates of 10 Hz and 1 Hz, respectively. This configuration ensured a magnetic field sampling density of 8 meters and spectrometric gamma-ray counts every 80 meters along each flight line.

The distance between the flight lines in 12 of the 15 blocks was 500 meters (the blocks with NE-SW hatching on Figure 1). For the remaining three blocks in the Colombian Amazon, the distance between the flight lines was 1000 meters (blocks with NW-SE hatching). The direction of the traverse lines varied depending on the geologic strike, being N 20 W in the Darién, Urabá, Antioquia W and Antioquia E blocks (the blue blocks labelled 1, 2, 4 and 12 in the north-west part of Figure 1) and N-S in the other blocks. For levelling the magnetic data, control lines (tie-lines) perpendicular to the traverse lines were established, with distances of 5000 m (blocks with flight lines every 500 m) and 10,000 m (blocks with flight lines every 1000 m).

Quality control was performed daily during data acquisition to ensure that the data was within the survey specifications (Table 2). Similarly, quality control was performed after final levelling of the magnetic data and conversion of the gamma-ray spectrometry data to maps of the relative concentrations of eU, eTh, and K.

The data in the databases for each block are in the .GDB format of the Oasis montaj software (Seequent). The databases are accessed in montaj and contain the following non-geophysical data: the traverse line number, fiducial (seconds after UTC midnight), date, coordinates (latitude, longitude) and flight height. The geophysical data in the databases include raw (measured magnetic field & energy spectrum for gamma-ray), pre-processed (ex. mag compensated, diurnal, levelled) and final processed data for the magnetometry (TFMA) and for the spectrometry database the total count and relative concentrations of eU (ppm), eTh (ppm) and K (%), after noise reduction by noise–adjusted singular-value decomposition (NASVD).

5. Uses of the data

The magnetic and gamma-ray data can be used for a variety of purposes. The magnetic data, shown in Figure 2a, can be used to identify the strike of geological features, the dips, any brittle structures that might have displaced the geological features, igneous intrusions, and locations where metamorphism or hydrothermal alteration may have created or destroyed mag-

Table 2. Technical specifications of the geophysical equipment used

Onboard magnetometer	
Sensitivity	0.01 nT
Absolute accuracy after compensation	± 10 nT
Dynamic range	20000-100000 nT
Heading effect	< 2.0 nT
Sampling interval	0.1 s (10 Hz)
Noise level (fourth difference)	<± 0.05 nT for more than 10% of readings in each interval of 120 s
Ground magnetometer	
Sensitivity	0.01 nT
Recording interval	< 3 s
Noise level	0.1 nT. The diurnal variation cannot exceed 5 nT in 5 minutes
Gamma-ray spectrometer	
Volume	Minimum of 32 liters (2048 in3) (downward detector)
Channels	256, 512 or 1024
Sampling interval	1 s (1 Hz)

netite (Dentith and Mudge, 2014). Gamma-ray spectrometry data (Figure 2b) can be used to map lithologies, drainage features and alteration, such as potassic alteration (Dentith and Mudge, 2014). The large-scale magnetic features can be used to better understand large-scale tectonic features and to infer the geological history of the area. The lithologies, structures and alteration in the area can be used to assist in looking for mineral deposits, such as the Titiribí, Quebradona, Marmato, Caramanta, La Cabaña-Río Dulce and Murindó porphyry-type deposits and Cerromatoso (Ultramafic lateritic Ni-Fe deposit) deposits (Sepúlveda et al., 2020). These deposits, among others, have clear magnetic expression that can be used as an example to identify new areas for detailed exploration (Moyano et al., 2018).

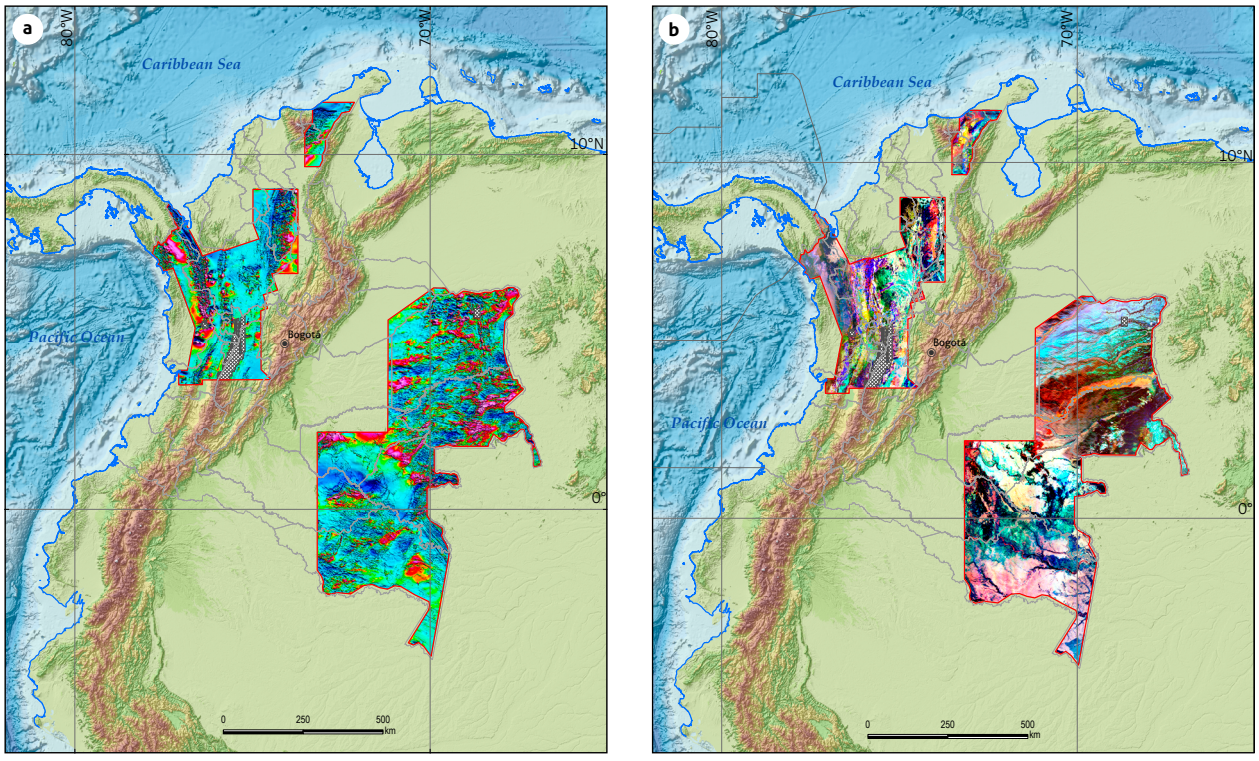

Figure 2. a) Image of TFMA. b) Ternary image distribution of the equivalent concentration of U, Th, and K. ▨: area not covered

The gamma-ray spectrometry data is useful for mapping near surface soils, so this can be used for land-use planning and for providing a baseline dataset to mapping changes to the environment that may result from future development. This type of geophysical data can also be used for mapping geohazards (Chen and Chan, 2002; Boonya and Bhongsuwan, 2013).

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Conflict of interest

The authors declare that they have no competing economic interests or personal relationships that could have influenced the work reported in this document.

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