Precambrian Research 249 (2014) 273–287

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Geophysical characterization of the Azimuth 125° lineament with aeromagnetic data: Contributions to the geology of central Brazil

Loiane Gomes de Moraes Rocha*, Augusto César Bittencourt Pires, Adriana Chatack Carmelo, José Oswaldo de Araújo Filho

Universidade de Brasília, Instituto de Geociências, Campus Darcy Ribeiro, CEP: 70.910-900 Brasília, Distrito Federal, Brazil

ARTICLE INFO

Article history:
Received 12 December 2013
Received in revised form 28 April 2014
Accepted 13 May 2014
Available online 24 May 2014

Keywords:
Azimuth 125° lineament
Magnetometry
Alto Paranaíba Alkaline Province
Goiás Alkaline Province
Basic dikes

ABSTRACT

This study analyzes a portion of the Azimuth 125° lineament (Az 125°), located in the Brazilian states of Goiás and Minas Gerais, based on its magnetic signature and previous studies. In particular, the determination of a chronology of events that shaped the Az 125° lineament is the focus of this contribution. Geological provinces with highly economically valuable mineralizations occur along Az 125, including the most important carbonatite and kimberlite complexes in Brazil. Az 125° is the main structural feature associated with these complexes, consisting of an extensive set of NW-SE oriented faults (approximately 850 km long and 70 km wide), however it is not mapped on geological maps at a regional scale as a continuous structural feature, because it is not consistently visible on the surface or in satellite images. Magnetic signature characterizes the lineament as a set of linear features with regional continuity in the subsurface. It is characterized by a higher magnetic susceptibility response that contrasts with the response exhibited by surrounding host rocks. Field data support geophysical data: occasional outcrops resulting from active erosion reveal dikes formed by gabbroic rocks and diabase and define the Az 125° lineament as a set of dikes of different ages. Other magnetic anomalies that occur along Az 125° are associated with intrusive rocks from the Goiás and Alto Paranaíba alkaline provinces. Based on magnetic signatures and mapped igneous rocks chronology, the Az 125° is partitioned, within the study area, into three main systems (called L1, L2, and L3). This subdivision, in conjunction with the dates assigned to various basic dikes within the azimuth, reveals that the evolution of the azimuth can be associated with three events. The first event occurred during the Brasiliano (950–520 Ma). The second event occurred during the Gondwana fragmentation (starting circa 180 Ma). The third event is related to the tectono-magmatic activity of The Trindade plume (90–80 Ma). We posit that the L1 system includes the older dikes, and the L3 system includes the youngest dikes; the L2 system which is intersected by L3, is therefore, of intermediate age. The determination of a chronology of events that characterizes the segmented structure of the Az 125° lineament, here defined as L-systems (L1, L2, and L3), based on both geological and geophysical data, and not yet reported in earlier scientific articles, is the main contribution of this study.

1. Introduction

Bardet (1977) first described the Azimuth 125° (Az 125°) lineament as a succession of diamond deposits that were aligned from Abaeté (state of Minas Gerais) to Rio Machado (state of Rondônia) on a belt with an NW-SE orientation. This belt is 1800 km long and approximately 200–300 km wide. Az 125° lineament is known as the Pará de Minas Dike Swarm (Chaves and Neves, 2005) and as Alto Paranaíba lineament in the Triângulo Mineiro region (Schobbenhaus et al., 1975). According to Gonzaga and Tompkins (1991), Az 125° occurs from the state of Rondônia to the state of Rio de Janeiro (Fig. 1). Pereira et al. (2008) indicated that this azimuth is one of the most significant metallotects for kimberlite diatreme intrusions in Brazil and is a set of faults that operated as a conduit for kimberlite magma.

In Brazil, alkaline–carbonatite complexes and kimberlite provinces are located in fault zones and arched areas on the edges of the Paraná, Paranaíba (Almeida, 1986), and Amazonas basins (Biondi, 2003; Fig. 1) along the three main structural lineaments,

* Corresponding author at: SQSW 303 Bloco G Apartamento 201, Setor Sudoeste, CEP: 70.673-307 Brasília, Distrito Federal, Brazil. Tel.: +55 61 8216 8711/3344 4469.
E-mail addresses: loianemoraes@hotmail.com (L.G.d. Moraes Rocha), acbpires@unb.br (A.C.B. Pires), chatack@unb.br (A.C. Carmelo), oswaldo@unb.br (J.O.d. Araújo Filho).

http://dx.doi.org/10.1016/j.precamres.2014.05.005
0301-9268/

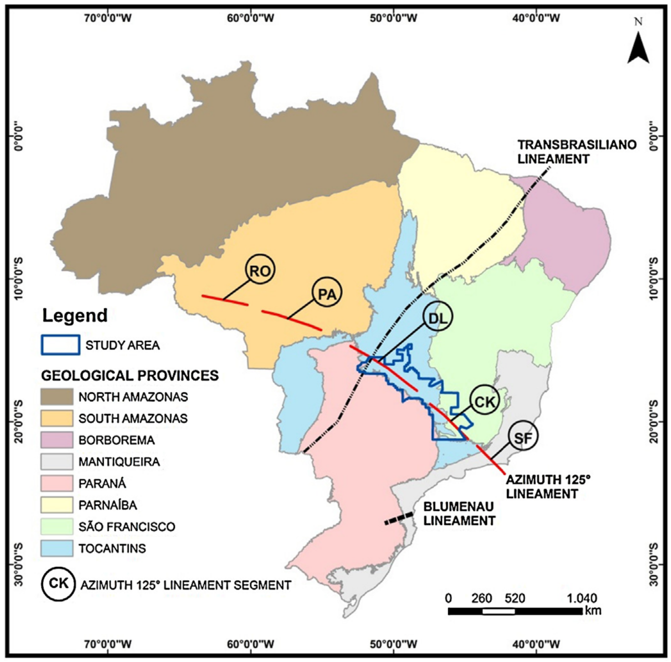

Fig. 1. Map of the geological provinces and major structural lineaments of Brazil, the location of study area, and the Az 125° lineament segments – RO: Rondoniense; PA: Parguazense; DL: Brasiliano (Dunites and Lamprophyres); CK Brasiliano (Carbonatites and Kimberlites); SF: Brasiliano (Syenites and Phonolites).

Modified from Gonzaga and Tompkins (1991), Delgado et al. (2003), Schobbenhaus and Brito Neves (2003), and Curto et al. (2013).

including the Transbrasiliano, Blumenau, and Az 125° lineaments. Az 125° is the most important lineament regarding carbonatite and kimberlite distributions in Brazil (Gonzaga and Tompkins, 1991). Carbonatite complexes typically occur in orthoplatforms and appear as dikes, stocks, and plugs that are associated with alkaline rocks (Lapin et al., 1999).

The Goiás Alkaline Province (GAP) and Alto Paranaíba Alkaline Province (APAP) are associated with the Az 125° lineament. Both of these provinces resulted from intense mafic-alkaline magmatic activity that occurred in the Upper Cretaceous (Dutra et al., 2012). The formation of these provinces has been attributed to thermal or chemical influences from mantle plumes that impacted the base of the continental lithosphere (Gibson et al., 1995, 1997; Thompson et al., 1998). Thus, the Upper Cretaceous magmatism of the GAP and APAP are considered to result from the Trindade plume (Crough et al., 1980; Gibson et al., 1995, 1997; Thompson et al., 1998).

Regional structures, such as faults, basic rock dikes and geological contacts, can often be identified based on their magnetic signatures. Kimberlites and other ultramafic rocks, which are often associated with these features, can be recognized in the same manner because they have high magnetic susceptibility (Power et al., 2004).

Geophysical methods are important tools for acquiring information and understanding geology. These methods provide a three-dimensional view of the study area (Moraes, 2007) and have been used to understand the geological setting. In recent decades, the magnetometric method has excelled in regional geology studies in Precambrian areas. The different magnetic susceptibilities between certain rocks and their host rocks may enable the identification of kimberlite bodies, regional faults, and basic dikes (Smith and Fountain, 1999). This identification is based on the structural and lithological characterization of the lateral differences in the crust's physical properties (Airo, 1999). Geophysical methods, such as magnetometry and gravimetry, have been applied at different scales to identify and describe environments that were formed by tectonomagmatic processes (including alkaline intrusions in different provinces) (Marangoni and Mantovani, 2013).

The relationships between the intersections of magnetic signatures with outcrops of known ages were used to determine the ages of Az 125° dikes in areas where this information was not available.

The geotectonic relationships that were involved in evaluating the Az 125° lineament indicated the presence of economically important mineralizations along the lineament (Moraes Rocha et al., 2011). These mineralizations included phosphate, niobium, barium, titanium, and rare earth elements (REE) (Brod et al., 2004).

2. Geological context

The study area is located in the central portion of the Az 125° lineament and covers the states of Goiás and Minas Gerais, in central Brazil. Three structural provinces with different stratigraphic, tectonic, magmatic, and metamorphic characteristics make up the area, namely, Tocantins, São Francisco, and Paraná (Almeida et al., 1977, 1981; Fig. 2).

The central Tocantins Province consists of a system of orogens (Fig. 3). These orogens are characterized by the mobile belts of Brasília, Paraguai, and Araguaia. These belts resulted from the convergence and collision of three blocks: the Amazonian Craton (west), the São Francisco Craton (east), and the Paranapanema Craton (southwest). Fuck et al. (1993) and Fuck (1994) partitioned the Tocantins province into the following tectonic units: (i) Cratonic Zone, (ii) Brasília Belt, (iii) Goiás Massif, (iv) Goiás Magmatic Arc (west), and (v) Paraguai-Araguaia Belt. Delgado et al. (2003) proposed a more detailed subdivision of the Tocantins Province that included the following tectonic domains: (i) Archean Granite-Greenstone Terrains and tonalite-trondhjemite-granodiorite (TTG) Domes, (ii) Porto Nacional-Nova Crixás Domain, (iii) Dianópolis-Silvânia Paleoproterozoic Mobile Belt, (iv) Goiás Mafic-Ultramafic Layered Complexes, (v) Paleoproterozoic Rift Basin, (vi) Remnants of Oceanic Crust, (vii) Brasiliano Orogens, and (viii) Terrain of Unknown Tectonic Significance (Fig. 3).

Intrusive complexes with known ages of the intrusion are significant for geological and geophysical characterization occur along the Az 125° lineament (Fig. 4). These complexes include the Americano do Brasil Mafic-Ultramafic, Santa Bárbara Gabbro-Diorite, and Rio Piracanjuba suites and the GAP and APAP alkaline provinces. These complexes and provinces are included in the Brasiliano Orogens tectonic domain of the Tocantins Province (Delgado et al., 2003). This set of orogens developed from a Pan-African/Brasiliano orogeny and is composed of the Paraguai, Araguaia and Brasília belts and the Goiás Magmatic Arc (Fuck, 1994; Trompette, 1994). The Americano do Brasil Mafic-Ultramafic Suite is part of the Goiás Magmatic Arc and is located in the state of Goiás (in the north portion of the study area, marked by bright green color in Fig. 3). This suite is represented by gabbros, gabbronorites, amphibolites, pyroxenites and dunites (Araújo and Moreton, 2008) dated at 626 ± 8 Ma (Laux et al., 2004). In addition, the Santa Bárbara Gabbro-Diorite Suite is also part of the Goiás Magmatic Arc in the northern portion of this area (Fig. 3, yellow color). Araújo (1997) subdivides it into a gabbroic zone, which is composed of metagabbros and meta-anorthosites, and a metadioritic zone, which is composed of metadiorites and amphibolites (622 ± 6 Ma) (Laux et al., 2004). The Rio Piracanjuba Suite and the Goiás and Alto Paranaíba alkaline provinces are included in the Brasília Belt. The Rio Piracanjuba Suite is located in the central portion of the area in the state of Goiás. This suite includes bodies that are composed of metagranite, metagranodiorite, and metatonalite. In addition, this suite is controlled by a ductile shear zone that gives the suite a gneissic feature with an age of approximately 1300 Ma (Tassinari, 1988). The Goiás Alkaline Province (GAP) is located in the northwest portion of this area and is represented by Upper Cretaceous

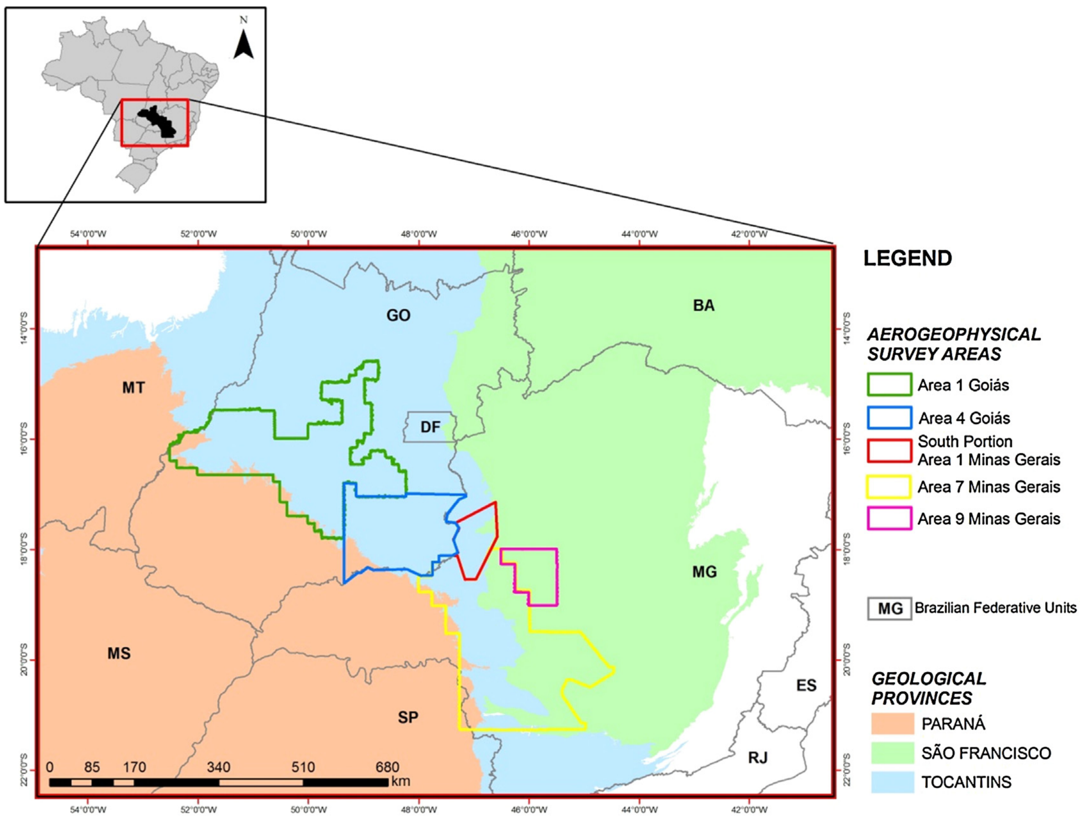

Fig. 2. Aerogeophysical survey areas and geological provinces.
Modified from Delgado et al. (2003), Schobbenhaus and Brito Neves (2003).

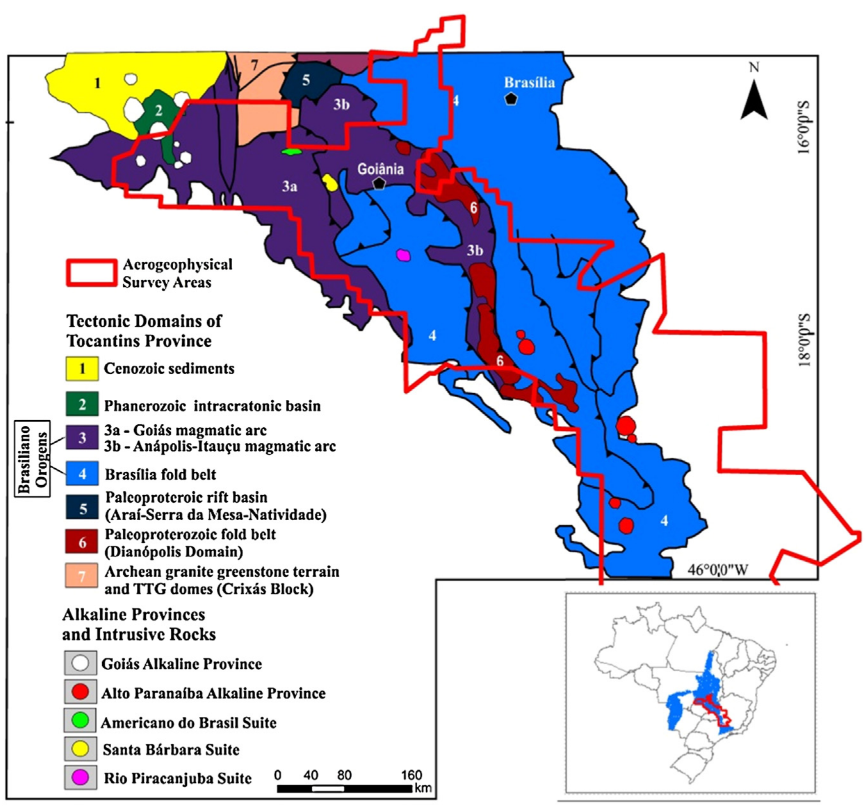

Fig. 3. The tectonic domains of the Tocantins Province, the intrusive rocks, and the associated alkaline provinces. (For interpretation of the references to color in text, the reader is referred to the web version of the article.)
Modified from Delgado et al. (2003), Schobbenhaus and Brito Neves (2003), Brod et al. (2004), Junqueira-Brod et al. (2005).

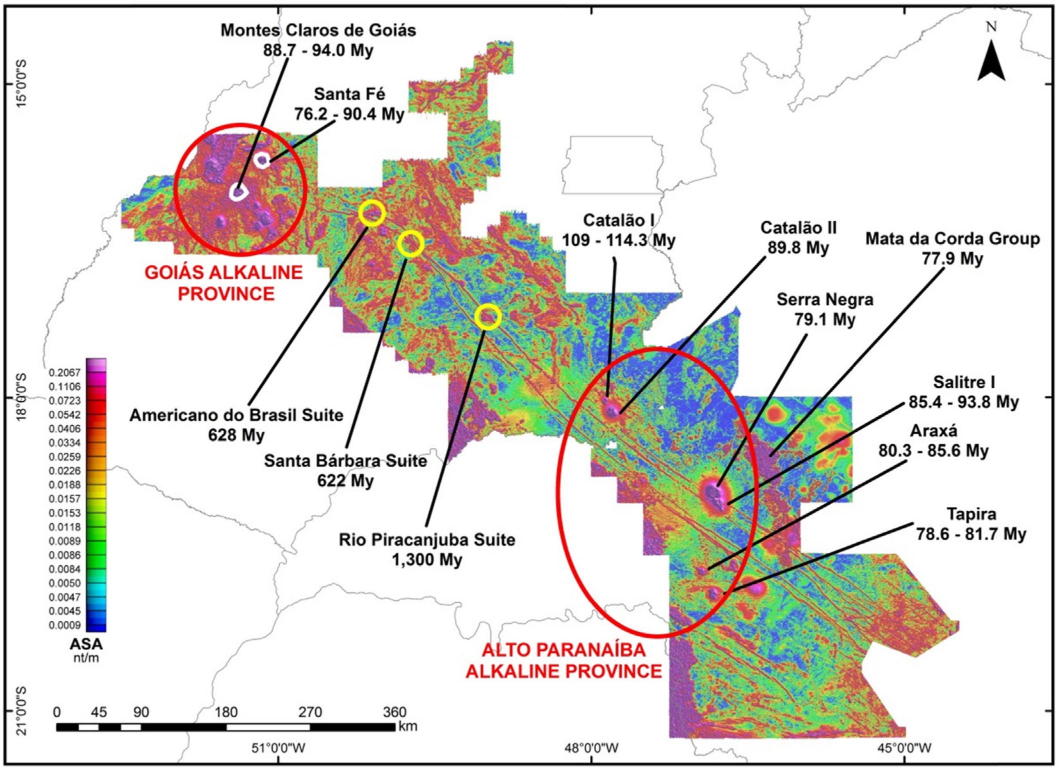

Fig. 4. Location of the alkaline provinces and the ages of some of the associated intrusive bodies in the Analytical Signal Amplitude geophysical image. Modified from Sonoki and Garda (1988), Eby and Mariano (1992), Brod et al. (2004), Junqueira-Brod et al. (2005).

kamafugitic rocks (Junqueira-Brod et al., 2005). Intrusive bodies are present in the central and southeastern portions of Goiás and Minas Gerais. These intrusive bodies form complexes that are composed of ultramafic alkaline rocks, carbonatites, and phoscorites (some of which form the APAP) (Brod et al., 2004). For example, the following complexes occur (Fig. 4): Catalão I (85 ± 6.9 Ma; Sonoki and Garda, 1988), Catalão II (87.1 ± 10.1 Ma; Eby and Mariano, 1992), Araxá (84.4 ± 1.9 Ma; Eby and Mariano, 1992), and Tapira (81.7 ± 7.9 Ma; Eby and Mariano, 1992).

The Maratá metavolcano sedimentary sequence is significant for the geological and geophysical characterization of the Az 125°. This sequence is part of the Dianópolis-Silvânia Paleoproterozoic Mobile Belt. It is composed of schists, metariolites, and milonites, with an age of approximately 790 Ma (Pimentel et al., 1991; Rodrigues, 1996; Bizzi et al., 2003).

Serra Negra (79.1 ± 8.7 Ma; Eby and Mariano, 1992), Salitre I (89.8 ± 6.9 Ma; Eby and Mariano, 1992) and Salitre II (82.6 ± 3.7 Ma; Eby and Mariano, 1992) carbonatite complexes, members of the APAP (Fig. 4), and the Mata da Corda Group (Hasui and Cordani, 1968; Fig. 4) are geotectonically important in this area and are included in the São Francisco Province. This province includes the oldest rocks in Brazil, which form small cores of TTG orthogneisses and are surrounded by younger rocks. These cores indicate that successive accretion events occurred during the construction of the older crustal segments (Delgado et al., 2003). The Mata da Corda Group, which is represented by intracontinental alkaline volcanism and is distributed over an area of approximately 2200 km^2, is composed of volcanic rocks dated at 77.9 ± 3.9 Ma (Hasui and Cordani, 1968).

The Paraná Province (Fig. 2) makes up three independent sedimentation areas, including the (i) Paraná Basin, (ii) Serra Geral Basin (consisting of aeolian sandstones of the Botucatu Formation and basaltic flows of the Serra Geral Formation), and (iii) Bauru Basin (an intracratonic basin) (Milani, 1997; Delgado et al., 2003). The substrate of Paraná Province includes cratonic blocks and massifs that are elongated in the NE-SW direction and are separated by the Brasiliano mobile belts (Milani and Ramos, 1998).

The Az 125° lineament was divided five segments by Gonzaga and Tompkins (1991) (Fig. 1): the Brasiliano segments (SF, CK, and DL); the Parguazense segment (PA); and the Rondoniense segment (RO). The study area is included in the Brasiliano segments DL and CK. The CK segment is considered the most important segment among a number of bodies that are associated with carbonatites and kimberlites. However, the primary mineralization of diamonds was not observed in the kimberlites, although some of the largest diamonds in Brazil were found in the area (Gonzaga and Tompkins, 1991). Thus, these diamonds were most likely associated with secondary sources.

Basic rock dikes are present in the study area along the Az 125° lineament. Some of these dikes are mentioned in technical reports, geological maps, and scientific articles (Silva et al., 1995; Baêta Junior, 2001; Raposo et al., 2004; Riccomini et al., 2005; Chaves and Neves, 2005; Kuchenbecker, 2011; Seer and Moraes, 2011). However, the descriptions of these dikes are not very detailed, and their georeferenced locations are not accurate. Silva et al. (1995) dated mafic dikes (oriented NW-SE) at approximately 906 Ma (U/Pb) and associated them with the early stages of the Pan-African/Brasiliano Event. A diabase dike outcrop in the state of Goiás (no coordinates found) was dated with the K/Ar method at 178 ± 5 Ma (Baêta Junior, 2001). Diabase dikes that are oriented NW-SE in the southeast portion of Minas Gerais were dated at 120 Ma (K/Ar) and are likely related to the Gondwana fragmentation (Silva et al., 1995). A metadiabase dike near the city of Brejão in Minas Gerais was dated at approximately 450 Ma (Hasui et al., 1975).

3. Materials and methods

Five aerogeophysical surveys were conducted between 2000 and 2007 in the study area, covering a total of 198,000 km^2. These

Table 1
Main characteristics of the aerogeophysical surveys in the study area.

Project name	Direction and spacing between flight lines (m)	Direction and spacing between control lines (m)
Goiás – Arenópolis Magmatic Arc – Juscelândia Sequence (Area 1 of Goiás)[1]	N-S 500	E-W 5000
Southern Brasília Belt (Area 4 of Goiás)[1]	N-S 500	E-W 5000
Unaí – Paracatu – Vazante – Coromandel (Area 1 of Minas Gerais)[2]	N30W 250	N60E 2500
Patos de Minas – Araxá – Divinópolis (Area 7 of Minas Gerais)[2]	N-S 400	E-W 8000
João Pinheiro – Presidente Olegário – Tiros (Area 9 of Minas Gerais)[3]	N-S 400	E-W 8000

Notes: Responsible agencies: [1]**SGMTM** (Secretariat of Geology, Mining and Mineral Transformation)/**MME** (Ministry of Mines and Energy)/**SIC** (Secretariat of Industry and Commerce)/**SGM** (Superintendence of Geology and Mining)/**FUNMINERAL** (Mining Development Fund).
[2]**SEME** (State Secretariat of Mines and Energy).
[3]**SEDE** (Secretariat of Economic Development)/**CODEMIG** (Economic Development Company of Minas Gerais)/**MME** (Ministry of Mines and Energy)/**CPRM** (Research Company of Mineral Resources).

surveys were conducted at an average flying height of 100 m (Table 1 and Fig. 2).

The data were processed with the Oasis Montaj^{TM} software, version 7.1 (Geosoft, 2009). The magnetic data are presented in nanoteslas (nT). Data were checked for consistency and the spatial distribution analysis of the flight lines was conducted to eliminate positioning errors and data noise. MAGIGRF was used as the reference data channel, which was defined as the difference between the total and local magnetic fields. The bidirectional interpolation method was used to generate a grid in the Oasis Montaj^{TM} software by using the Bi-grid function (Geosoft, 2009). The generated new regular grid was used to establish the Anomalous Magnetic Field (AMF, Fig. 5), which was the basis for other magnetic products (Fig. 6).

Therefore, a Fourier transform was conducted based on the AMF grid. This Fourier transform generated the following products: Upward Continuations at 500, 1000 and 2000 m (UPCON; Kellogg, 1953), Directional Derivatives (Dx, Dy and Dz; Nabighian, 1984; Blakely, 1996), Analytical Signal Amplitudes (ASA; Nabighian, 1972; Fig. 4), Total Horizontal Gradient Amplitudes (THGA; Cordell and Grauch, 1985), the Reduction to the Pole (REDP, Baranov and Naudy, 1964), and the Tilt Angle Filter (TILT; Miller and Singh, 1994; Fig. 7). In addition, the Euler Deconvolution algorithm was used (EULER; Thompson, 1982) to estimate the depths of the magnetic sources in the area.

Field data were used to validate geophysical data. The field campaigns aimed to identify the surface features. In addition, samples were collected from rock outcrops to determine if they were part of the Az 125° lineament feature, which was characterized by a strong magnetic pattern in the region.

Visualization and interpretation of the data were performed using the Geographic Information System (GIS) in ArcGis 9.3 (ESRI, 2008).

4. Results

The AMF image (Fig. 5) shows irregular magnetic relief with bipolar anomalies. Most of these anomalies show a positive lobe to the north and a negative lobe to the south, which is typical in regions at low latitudes. However, some signatures have a reversed polarity pattern with the positive lobe to the south and the negative to the north. The most distinct anomalies correlate with the known outcropping alkaline intrusive bodies, however, many other anomalies may occur in intrusions that do not outcrop.

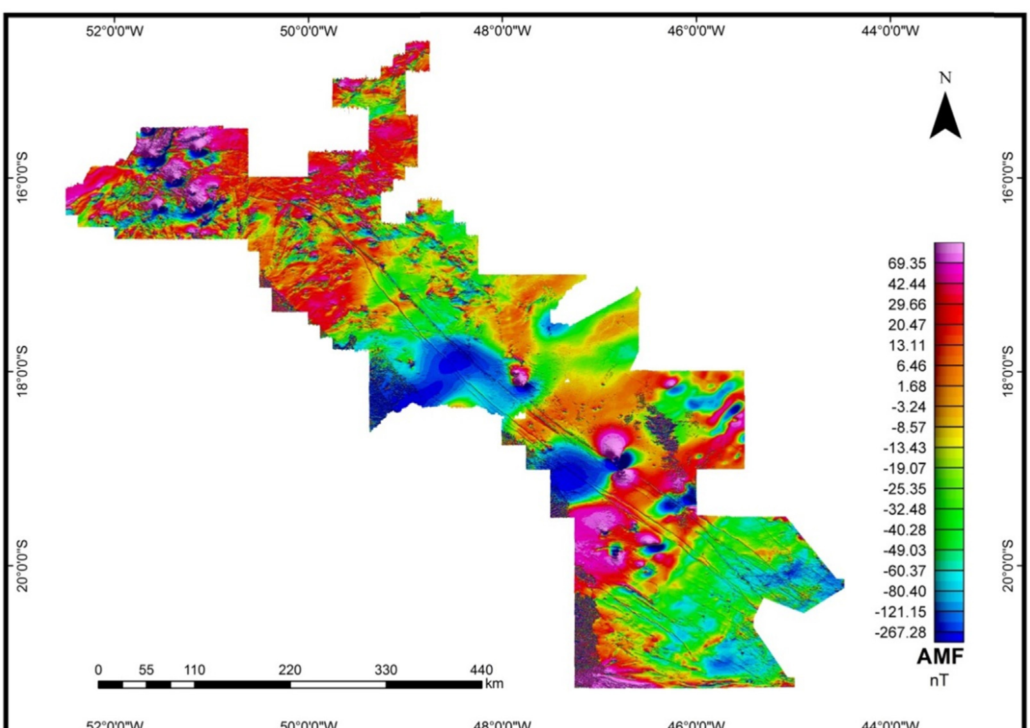

Fig. 5. Anomalous Magnetic Field (AMF) image.

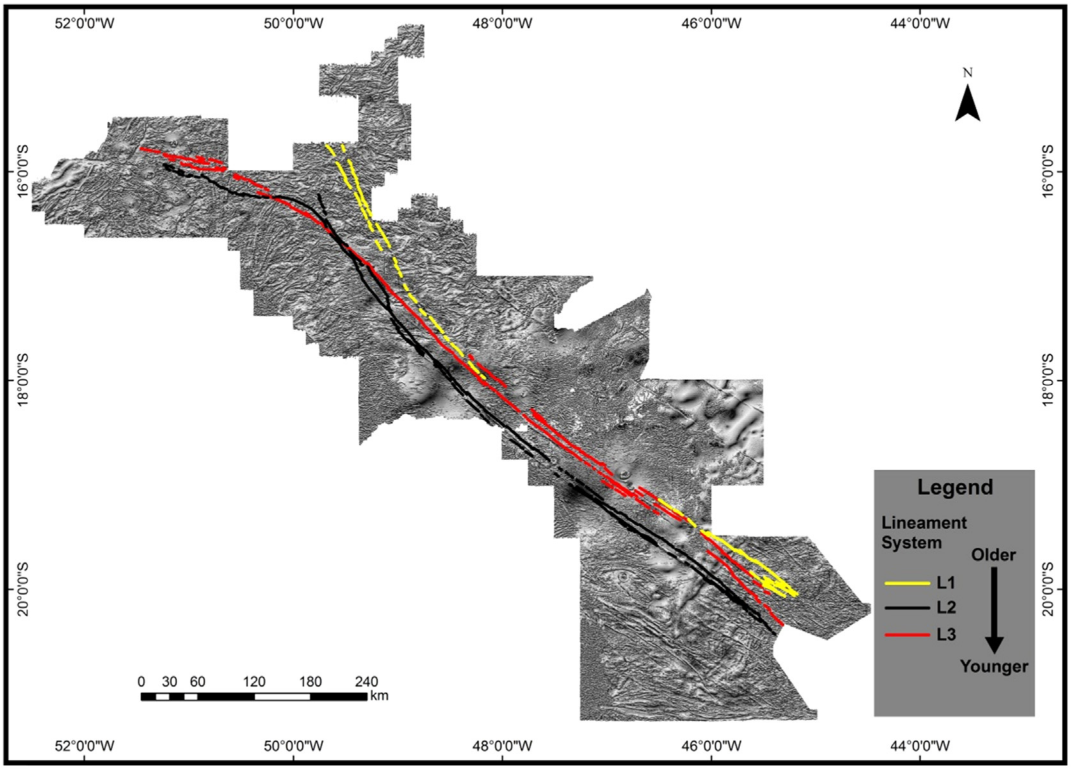

Fig. 6. Geophysical interpretation of the lineament systems for Az 125° in the TILT image: L3 in red; L2 in black; and L1 in yellow. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Based on the magnetic images and, especially, that from the Tilt Angle Filter (TILT), the lateral extensions of the magnetic sources were identified, and three main linear features (L1, L2, and L3, Fig. 6) corresponding to the Az 125° lineament were delineated.

All lineaments have NE-SE orientation. The L1 system is represented by smaller curved segmented magnetic lineaments with lengths of 3–30 km. This system occurs in both the southeast and northwest regions. L1 system is approximately 180 km long (in the southeast region), and 200 km long (in the northwest region), and 20 km wide. The L2 and L3 systems extend over entire study area. The L2 system displays magnetic lineaments with 2–60 km long segments. These segments are arranged on a belt that is up to 15 km wide and approximately 800 km long. The L3 system is composed of segmented magnetic lineaments with lengths of 2–50 km. These segments cover a total length of 850 km with maximum width of 15 km. Overall, the set of lineaments that forms Az 125° is approximately 850 km long (in the NW-SE direction) and 70 km wide. The magnetic signatures of the three systems are important because the L1 and L2 systems exhibit normal polarity, while the L3 system exhibits reversed polarity (Fig. 7). Generally, when the REDP transformation is applied, the bipolar anomalies become monopolar and are centered above the magnetic bodies or sources. However, anomalies of bodies with remanent magnetization (Shurbet et al., 1976; Schnetzler and Taylor, 1984; Roest and Pilkington, 1993) may not be transformed properly if the remanence direction is different from the current magnetic field direction. This situation occurs with the anomalies that are related to the L3 system and to the Tapira and Salitre II complexes (Fig. 7).

Based on the geological map of the Campos Altos Sheet, Seer and Moraes (2011) associated the subvertical sinistral shear zones to the Az 125° lineament. This connection strengthens the hypothesis that sinistral tectonics occur along the azimuth. The geophysical images in the northern portion of the L3 system and the central portion of the L2 and L3 systems (Fig. 8) clearly demonstrate the sinistral tectonics.

In the northern portion of the area, the L3 system intersects the L2 system twice (Fig. 9). These intersections are highlighted in the ASA image, which emphasizes that the L3 system crosses the L2 system. In addition, the ASA image shows that the L3 and L2 systems cross the magnetic anomaly related to the Santa Bárbara Intrusive Suite, the L2 system intersects the magnetic signature of the Americano do Brasil Complex, and the L3 system crosses the magnetic anomaly related to the Rio Piracanjuba Suite (Fig. 9). L1 system is intersected by L3 system in the central portion of the study area, and forms a slightly curved system that resembles a sinistral kinematic fault splay (Fig. 10). In addition, L2 and L3 systems intersect the Maratá metavolcanosedimentary Sequence while L1 system is intersected by it (Fig. 10).

Based on the crosscutting relationships and known ages of the mafic-ultramafic suites and the carbonatite complexes and other rocks that occur in the area, we interpreted that: (i) the L3 system probably has ages between 118 Ma and 622 Ma. The lower limit of this range was defined because L3 intersects the Santa Bárbara Intrusive Suite (Fig. 9). In addition, the upper limit was based on the reversed polarity of the L3 system. Because it is intersected by Salitre I Complex (89.8 ± 6.9 Ma; Eby and Mariano, 1992; Fig. 13), L3 was likely formed during a reversed polarity period before 89 Ma. Based on the studies of Kent and Gradstein (1985), the magnetic reversal period before 89 Ma occurred at 118 Ma (Fig. 13); (ii) the L2 system is older than the L3 system, because L3 system intersects the L2 system (Fig. 9). However, it was not possible to determine the upper age limits of the rocks that were associated with the L2 system. The lower age limit of these rocks was estimated to be approximately 622 Ma, because L2 system also intersects the Santa Bárbara Intrusive Suite (Fig. 9); and (iii) the L1 is the oldest system of the Az 125° lineament. We determined the upper limit of the L1

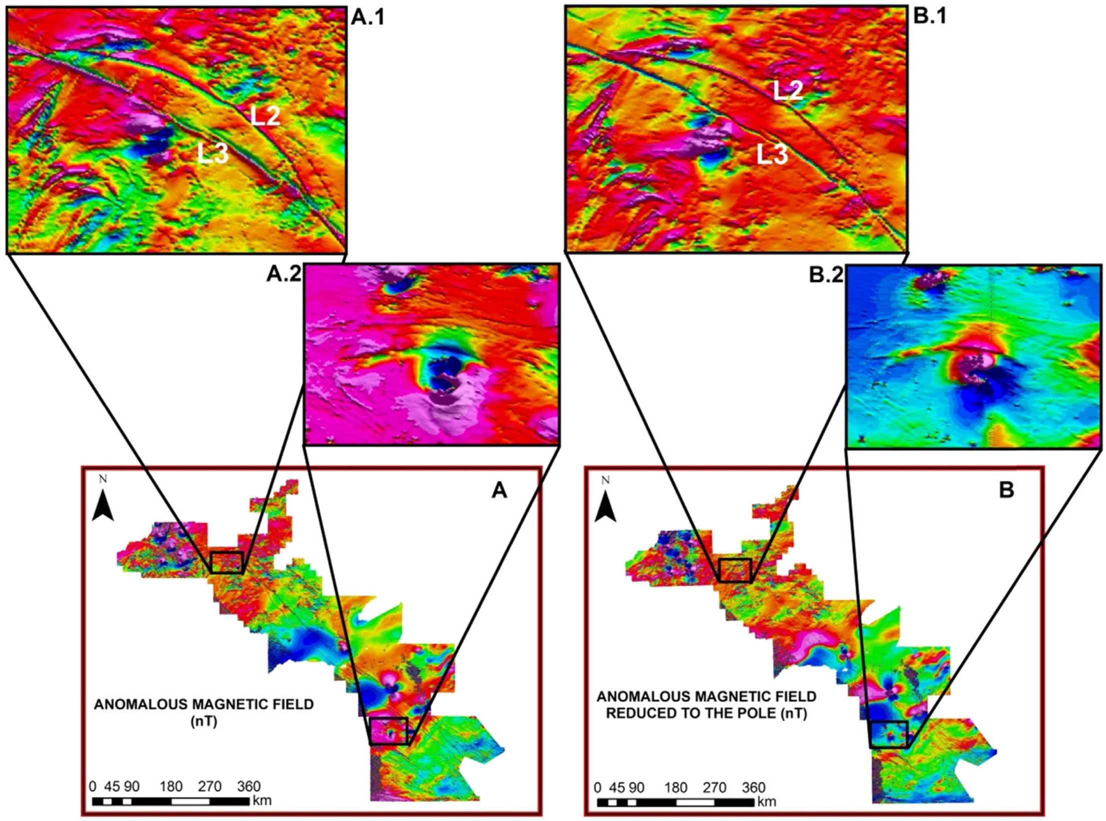

Fig. 7. (A) Anomalous Magnetic Field (AMF), and (B) AMF reduced-to-the-pole. Details of images A and B include the following: (A.1) signatures of L3 and L2 systems in the AMF image; (A.2) signature of the Tapira complex in the AMF image; (B.1) signatures of the L3 and L2 systems in the AMF reduced-to-the-pole image; and (B.2) signature of the Tapira Complex in the AMF reduced-to-the-pole image.

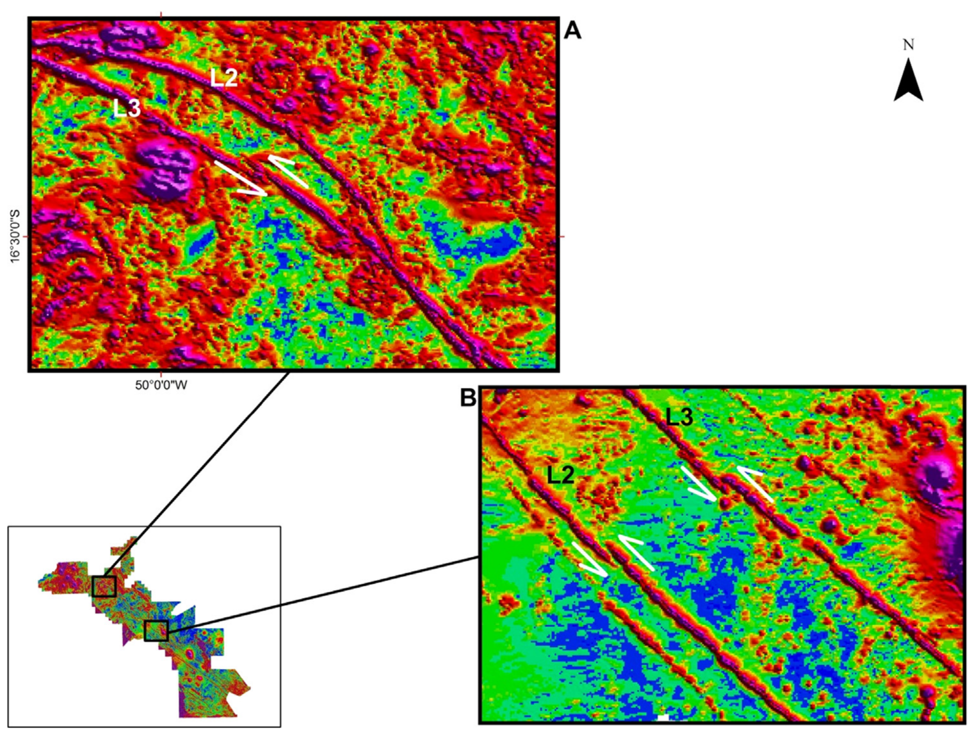

Fig. 8. Sinistral tectonics along the Az 125° lineament in the ASA image: (A) northern portion in the L3 system and (B) central portion in the L2 and L3 systems.

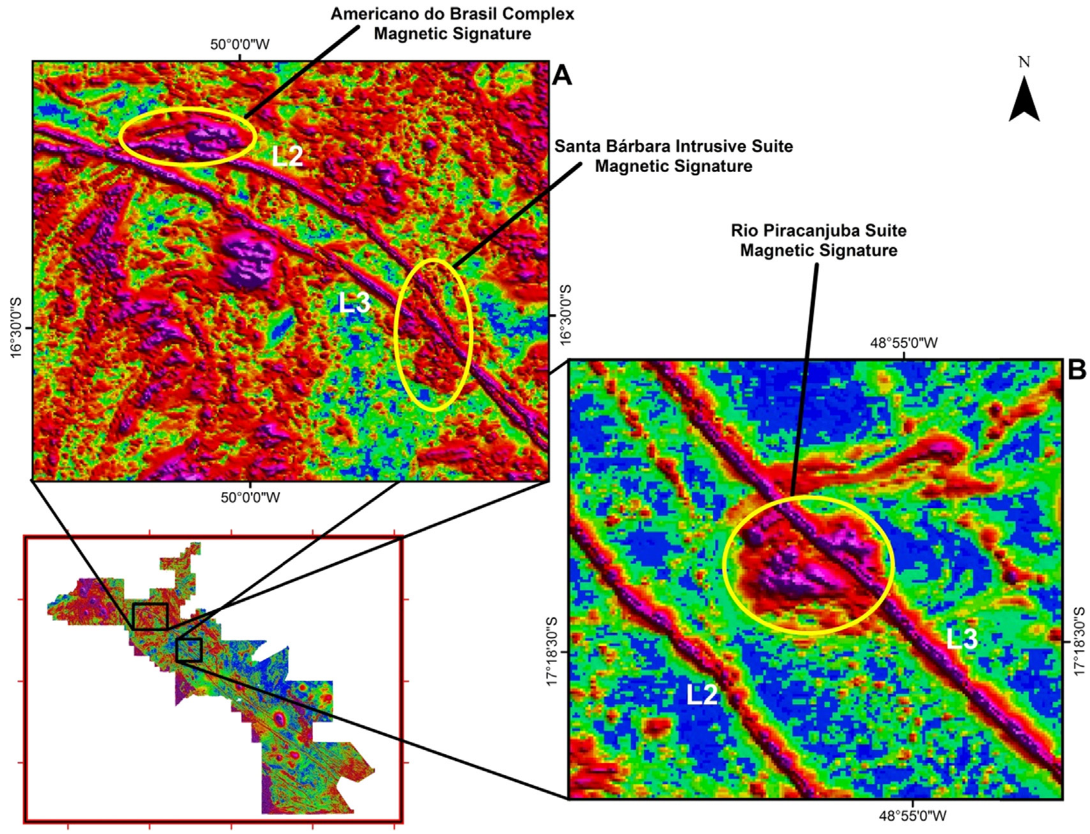

Fig. 9. The northern portion of the area in the ASA image: (A) the L2 system intersects the anomaly of the Americano do Brasil Complex, the L2 and L3 system cross the anomaly of the Santa Bárbara Intrusive Suite, and L2 is intersected by L3; and (B) the L3 system intersects the anomaly of the Rio Piracanjuba Suite.

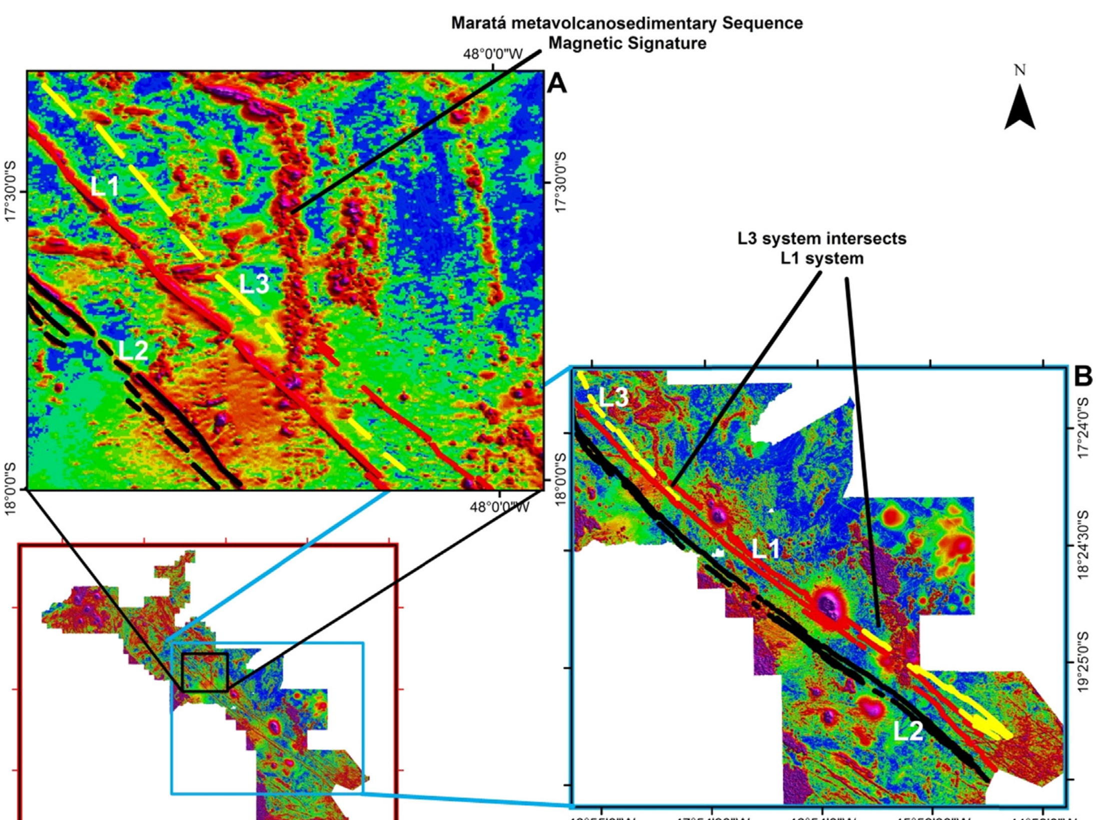

Fig. 10. The crosscutting relationships in the ASA image: (A) the L2 and L3 systems intersect the anomaly of the Maratá metavolcanosedimentary sequence, while L1 is intersected by it: (B) the L3 system intersects the L1 system.

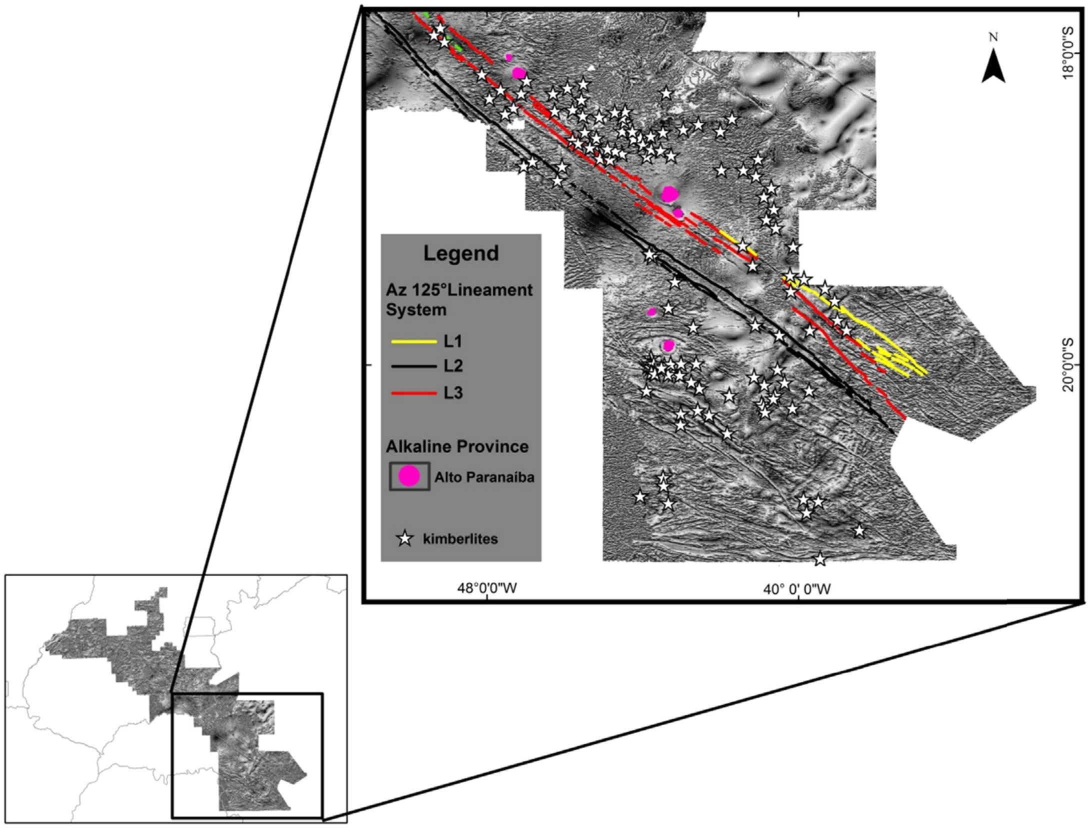

Fig. 11. Kimberlite bodies in the TILT image.
Modified from Gonzaga and Tompkins (1991) and Bizzi et al. (2003).

system as being circa 790 Ma, due to its crosscutting relationship with the Maratá metavolcanosedimentary sequence.

The generation of these three lineaments systems (L1, L2, and L3) ocurred at the same time, during the Brasiliano Event (started at *ca.* 950 Ma). It resulted in the formation of the Az 125° lineament, characterized by a large set of faults subsequently filled by magma. Basic dike swarms are generally associated with large shear zones under transcurrence (Wilson et al., 1985; Park and Tarney, 1987; Cadman et al., 1990). The sinistral movements that were observed along the Az 125° lineament indicate a likely association with a transcurrent shear zone. The intrusion of basic magma produced many dikes along the large faults that compose the Az 125° lineament, was facilitated by extension movements that were followed by regional sinistral kinematics (transtension). The injection of dike forming magma into the faults of the Az 125° lineament occurred during two or three different periods: (i) between 950 Ma and 520 Ma at two Brasiliano orogeny cycles, older (950–650 Ma), and younger (*ca.* 700–520 Ma) (Cordani et al., 2013), (ii) at approximately 180 Ma (during the fragmentation of Gondwana), and (iii) at circa 90 Ma (during the passage of the Trindade plume). The last period (90 Ma) maybe was a source of magma injection only in certain portions of the Az 125°. Worldwide, large igneous provinces have been associated with the passage of mantle plumes (White and McKenzie, 1989; Campbell et al., 1989; Ernst and Buchan, 1997).

Gonzaga and Tompkins (1991) suggest that significant diamond mineralizations occur worldwide in kimberlite and lamproite, where the last thermo-tectonic event occurred at more than 1500 Ma. The kimberlites in the studied region do not contain diamond mineralizations due to the passage of the Trindade plume between 79 and 89 Ma (Gonzaga and Tompkins, 1991; Gibson et al., 1995, 1997), which caused thermal and tectonic effects in the region and influenced the mineralization of diamonds. The spatial distribution of the kimberlites in the study area emphasizes that the Az 125° lineament facilitated the intrusion of these bodies (Fig. 11).

The seismic tomography low-velocity and high-seismicity anomalies indicated that stress focused on the upper crust; this stress resulted from lithospheric thinning and was most likely related to the Trindade plume (Rocha et al., 2011). Drift reconstructions of the tectonic plates were conducted by Morgan (1983); these reconstructions suggested that the central point of Trindade plume was located below the APAP at approximately 90 Ma. In addition, Gibson et al. (1995) suggested that the fusion that was responsible for the origin of the Province rocks was generated by conduction and advection in the potassium-rich sub-continental lithospheric mantle (Gibson et al., 1997) due to the high melting temperatures of the asthenosphere that resulted from the plume (Gibson et al., 1995).

Researchers have developed strategies for geophysical interpretation studies of the igneous bodies in the Goiás and Alto Paranaíba alkaline provinces (Marangoni, 1994; Dutra and Marangoni, 2009; Dutra, 2011; Oliveira and Mantovani, 2011; Requejo and Mantovani, 2011; Dutra et al., 2012; Marangoni and Mantovani, 2013; Jácomo, 2010; Feitoza et al., 2010). In the central portion of the study area (Fig. 12), the circular magnetic signatures that are associated with the Catalão I, Catalão II, Serra Negra, Salitre I and Salitre II carbonatite complexes follow a NW-SE trend along the magnetic anomaly that is related to the Az 125° lineament. In the southeast the Tapira Carbonatite Complex (n° 7) has reversed polarity (Fig. 7A2 and B2), which indicates that remanent magnetization occurred in the body. The same process may have occurred in the Salitre II Carbonatite Complex. Because this region shows four very intense anomalies (including Salitre II), the magnetic

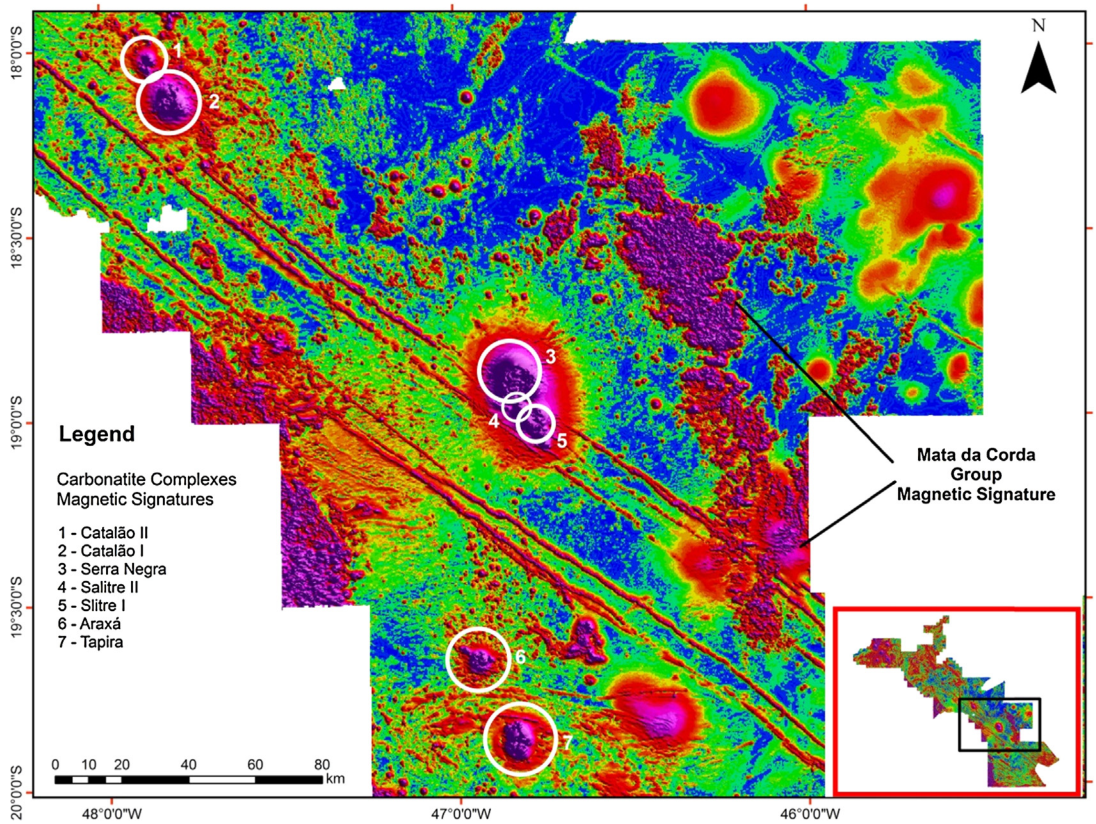

Fig. 12. Magnetic signatures of the carbonatite complexes and the Mata da Corda Group in the ASA image.

signatures of individual bodies are not well defined, which hinders our interpretation.

The geomagnetic polarity reversals provide information regarding the tectonic activity in the region. These reversals reveal magmatic events in the lineament belt that characterizes Az 125° or in its vicinity. The geomagnetic polarity time scale presented by Kent and Gradstein (1985) was correlated with the main bodies that compose the Alto Paranaíba Alkaline Province and with their respective ages as proposed by Eby and Mariano (1992) and Sonoki and Garda (1988; Fig. 13). These data indicate that the Tapira and Salitre II carbonatite complexes are in the same geomagnetic polarity reversal range, further supporting the timing of the Az 125° lineament and dikes formation.

The Euler deconvolutions were based on the AMF and were conducted for structural indices 1 (dikes and sills; Reid et al., 1990; Geosoft, 2009) and 2 (pipes; Geosoft, 2009). These deconvolutions were conducted to estimate the depths of the magnetic sources in the area. One advantage of the Euler deconvolution for interpreting magnetic data is that the direction of the magnetization source is not needed (Barbosa et al., 1999). After Euler deconvolution, the linear and circular features that are associated with the Az 125° lineament and the carbonatite complexes were highlighted. The areas near the carbonatite complexes had deeper magnetic sources than the areas near the Az 125° lineament sources. Near the lineament, the deepest sources for indices 1 and 2 were approximately 4 and 6 km, respectively. The radial power spectrum verified the Euler deconvolution results, in which three main groups of magnetic sources were located at depths of approximately 9, 4, and 1 km. The Upward Continuation Transformation (UPCON) was used to simulate a flying height that was greater than the height used in the aerial survey. A greater flying height enhances the magnetic signatures with greater wavelengths. This transformation indicated that the carbonatite complex areas had longer wavelengths than the Az 125° lineament areas (i.e., the magnetic sources associated with the carbonatite complexes were deeper than those associated with the Az 125° lineament).

Field study supported the findings of the geophysical interpretation. Five dikes were mapped (shown as white lines with labels in Figs. 14–16), three (A, B, and C) were located in the northern portion of the area (Fig. 15), and two (D and E) were located in the southeast portion of the area (Fig. 16). The overlapping between the mapped dikes and the geophysical images indicates that dikes are directly associated with the Az 125° magnetic lineament. Dikes A, B, C, and D occur in the L3 system and appear as centimeter- to meter-sized block outcrops. These dikes occur on a belt that is oriented NW-SE with lengths of 100–200 m and a width of 100 m (Fig. 15). Dikes A, B, and C intrude in schists of the Araxá Group (Baêta Junior, 2001). Dike D intrudes into the Bambuí Group. The blocks exhibit characteristics of hypabyssal intrusive rocks; they consist of dark gray olivine gabbro (characterized by a fine-grained texture) and olivine diabase with phaneritic texture. These rocks are mainly composed of plagioclase (46%), clinopyroxene (34%), magnetite (10%), iddingsite (6%), and others (4%). These rocks have magnetic susceptibility in the range of 35–40 $\times 10^{-3}$ SI, which agrees with the magnetic signatures of the sources shown on the ASA magnetic image (Fig. 14).

Dike E is related to the L1 system and outcrops as an elongated body that is oriented NW-SE. This dike is approximately 500 m long and 150 m wide and intrudes into the argillite of the Lower Serra da Saudade Formation (the Bambuí Group) (Kuchenbecker, 2011; Fig. 16). In addition, this dike is composed of grayish olivine gabbro with a fine-grained texture. Dike E is mainly composed of plagioclase (55%), clinopyroxene (30%), magnetite (7%), and iddingsite (8%) with magnetic susceptibility of approximately 30×10^{-3} SI.

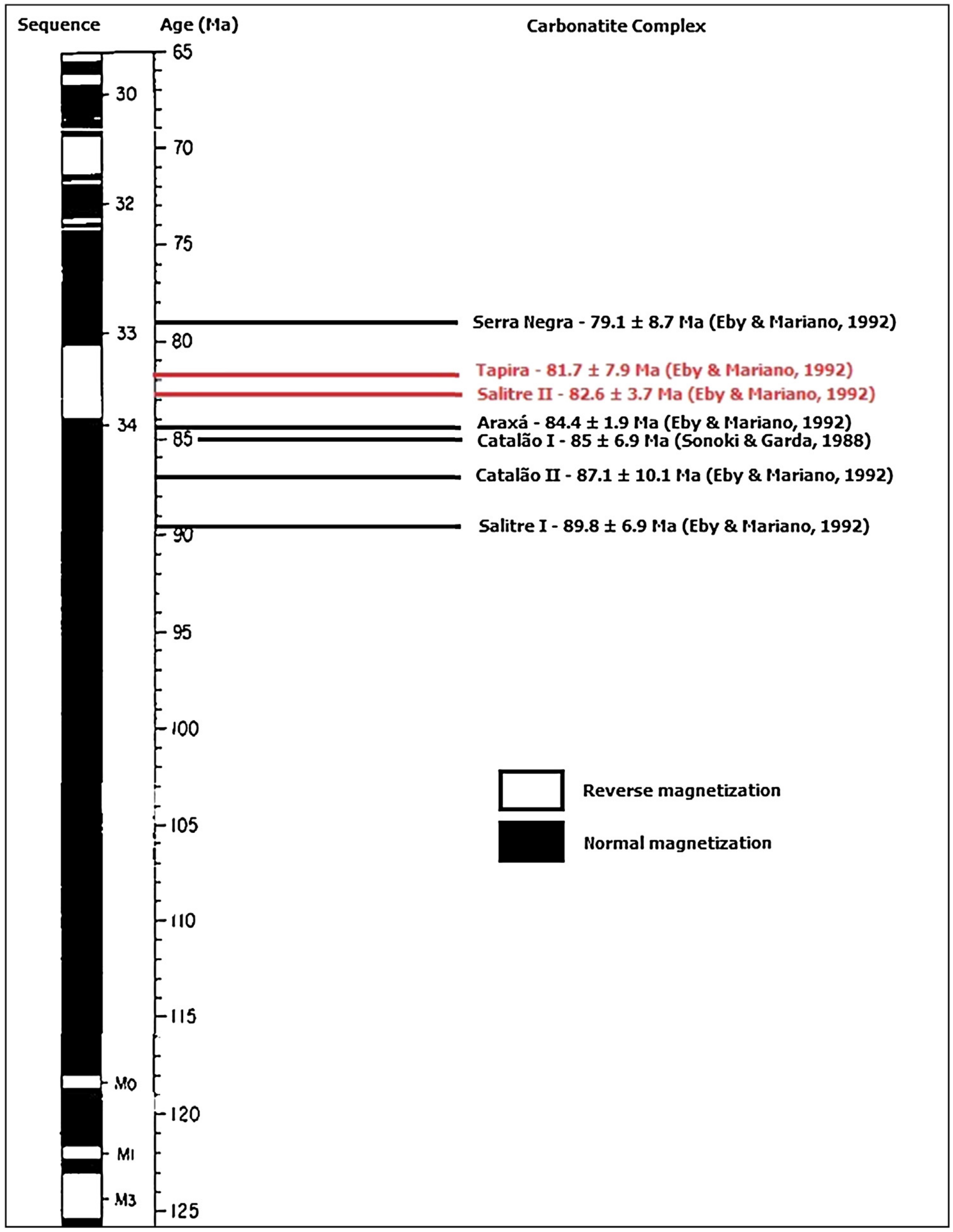

Fig. 13. Correlation between the ages (Eby and Mariano, 1992; Sonoki and Garda, 1988) of the APAP carbonatite complexes and the geomagnetic polarity scale (modified from Kent and Gradstein, 1985). Sequence filled in black = normal geomagnetic polarity (current); sequence filled in white = reversed geomagnetic polarity.

Microtectonic studies reveal shear deformation observed in field rock samples and in thin sections. These studies confirm the sinistral kinematic displayed in the geophysical data (Fig. 8).

The basic rock dikes that form the Az 125° lineament occasionally outcrop where weathering action and erosion processes have exposed them. This finding is explained by the hypabyssal formation environment of the intrusive igneous bodies, which occur deeper than the extrusive bodies.

A correlation of the main geophysical and geological characteristics of the Az 125° lineament systems are displayed in Table 2.

Table 2
Main characteristics of the L1, L2, and L3 systems of Az 125° lineament.

Lineament system	Estimative of age	Geophysical characteristics	Petrotectonic characteristics
L1	Upper limit at 790 Ma	Normal polarity	NW-SE direction; 200 km long (northwestern portion), 180 km long (southeastern portion), and 20 km wide; slightly curved with sinistral kinematic; olivine gabbro
L2	Lower limit at 622 Ma	Normal polarity	NW-SE direction; 800 km long and 15 km wide; sinistral kinematic; basic rocks.
L3	118–622 Ma	Reversed polarity	NW-SE direction; 850 km long and 15 km wide; sinistral kinematic; Olivine gabbro and olivine diabase

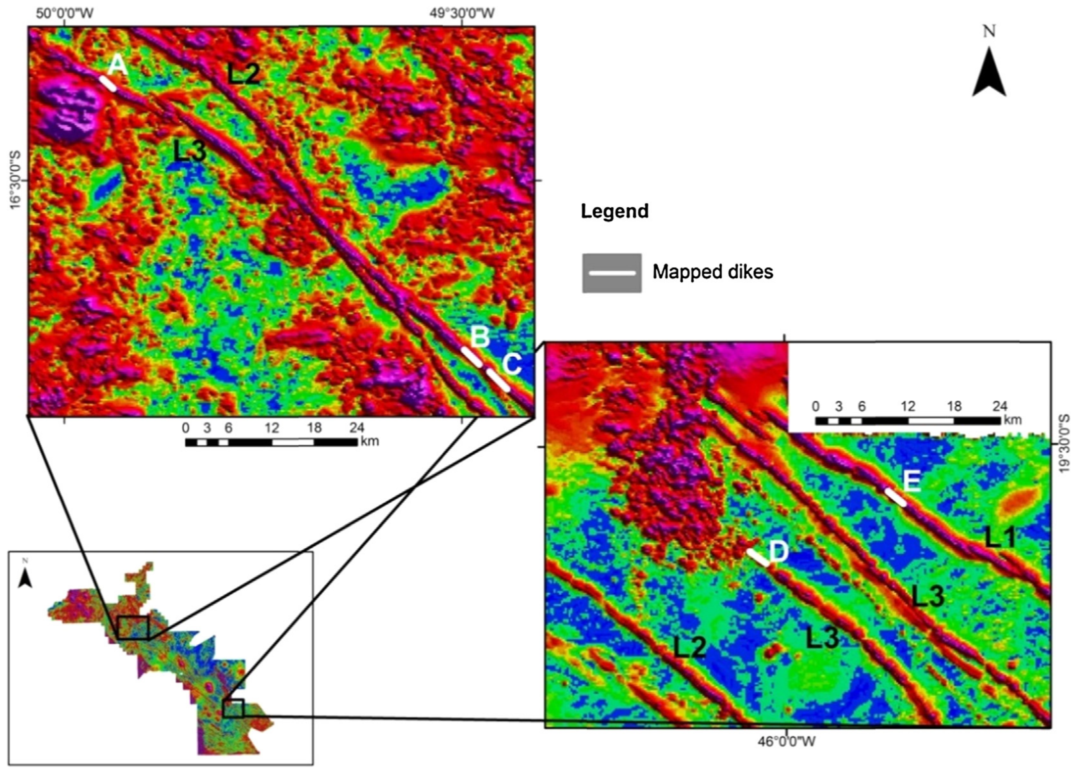

Fig. 14. Locations of the dikes that were mapped in the field in the ASA image: (i) dikes A, B, and C in the northern portion, and (ii) dikes D and E in the southern portion of the area.

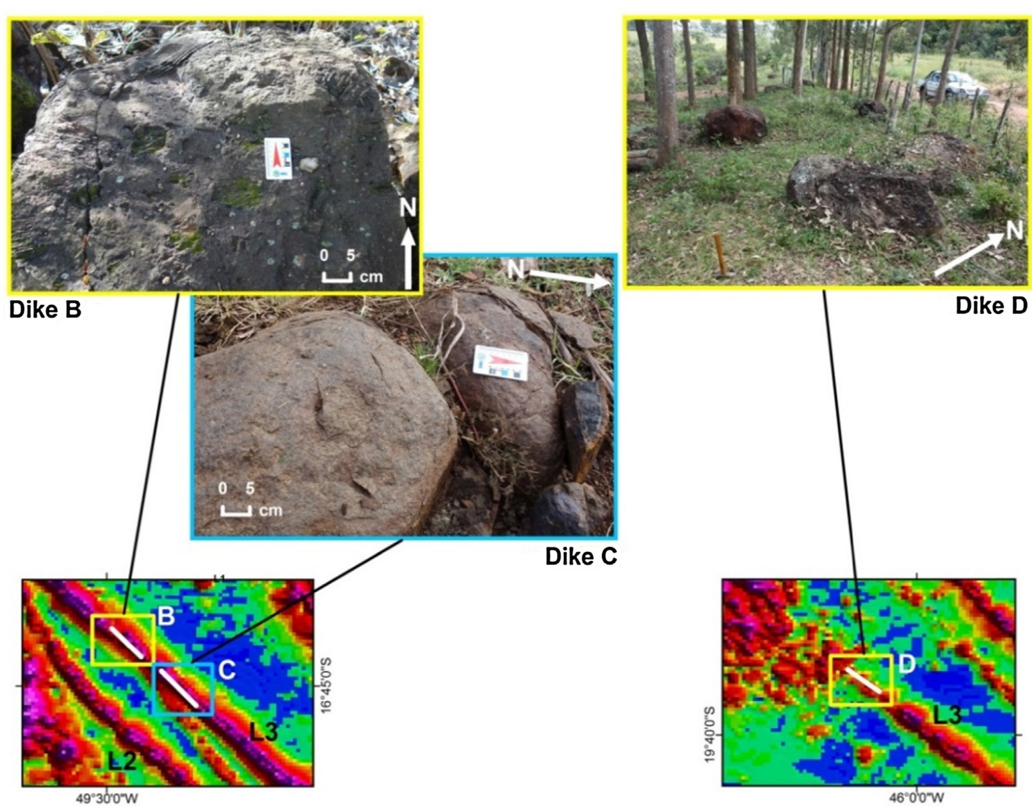

Fig. 15. Dikes B, C, and D (olivine gabbros and olivine diabases) associated with the L3 system of the Az 125° lineament over ASA image.

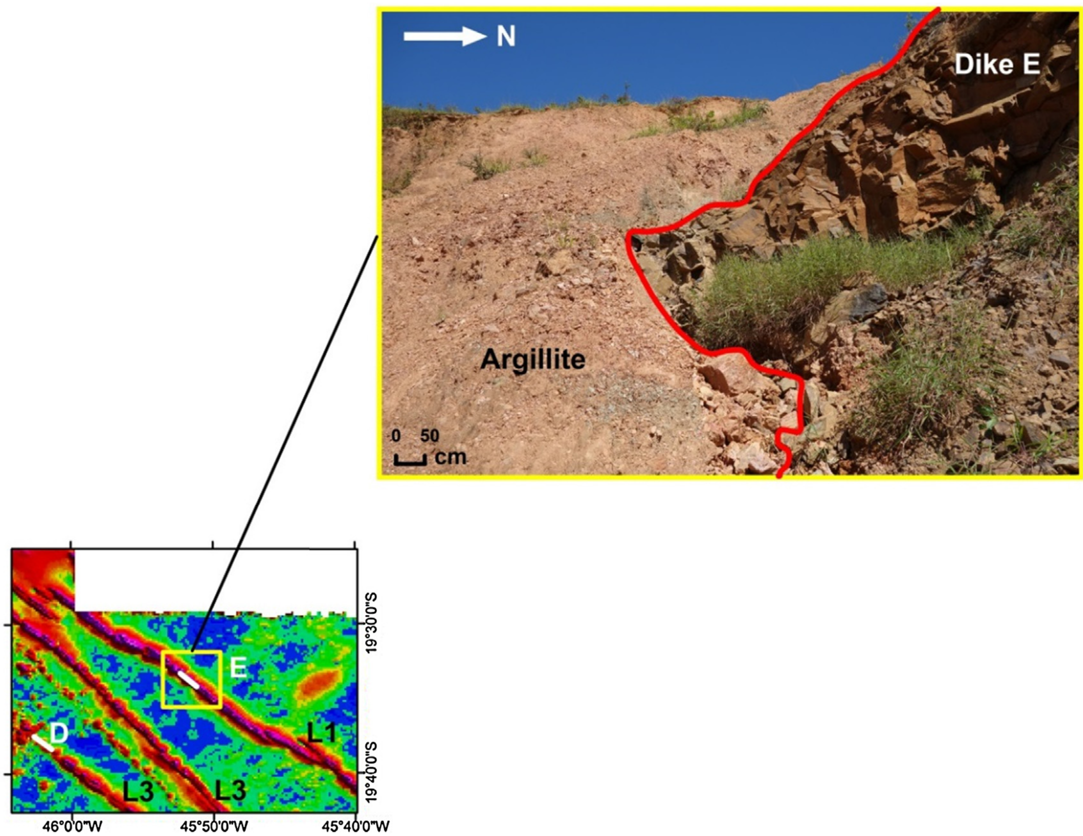

Fig. 16. Dike E (olivine gabbro) intruding in argillite of the Lower Serra da Saudade Formation, Bambuí Group – L1 system of the Az 125° lineament.

5. Conclusions

The Az 125° lineament, that covers an area of approximately 850 km in length and 70 km in width in Central and Southeastern Brazil, and is NW-SE orientated, was characterized magnetically by processing aeromagnetic data. In addition, the field data confirmed the magnetic behavior of the rocks that form the Az 125° lineament and its main host rocks.

The Az 125° shows magnetic signatures from high-intensity sources (as shown in the ASA image, between 0.05 and 0.20 nT/m), in contrast to signatures of the host rock source (between 0.045 and 0.015 nT/m). The estimated depth of the top of the lineament magnetic sources was 4–6 km. This depth was shallower than the depth of the main intrusive bodies that form the alkaline provinces they are related to. Rare outcrops of basic rock, gabbro and diabase dikes are found in the field and form the Az 125° lineament. These dikes have high magnetic susceptibility (between 35 and 40×10^{-3} SI).

Based on petrographic and magnetic evidence, the Az 125° lineament was divided into three magnetic lineament systems (L1, L2, and L3). These lineament systems exhibit different magnetization characteristics (normal and reversed polarity). In addition, the crosscutting relationships between the lineament systems indicated that different tectonomagmatic processes occurred in the study area. The L3 system exhibits reversed polarization, which indicates remanent magnetization in part of Az 125°. All of the systems are formed by segmented linear features with extensions of 2–60 km; these systems are associated with the subvertical shear zones that promoted a sinistral kinematic along Az 125°.

These informations allow us to interpret that the formation of the three lineaments systems occurred at the same time, during the Brasiliano Event (started at *ca.* 950 Ma). This process generated a large set of faults. The filling of these faults by basic magma was facilitated by transtensional movements during at two or three different time periods, including (i) between 950 Ma and 520 Ma (during the Brasiliano orogenic Event) (Cordani et al., 2013), (ii) at approximately 180 Ma (during the fragmentation of Gondwana), and (iii) at circa 90 Ma (during the passage of the Trindade plume). The last one event (90 Ma) maybe was source of magma injection only in certain portions of the Az 125°. Because this area is a rather extensive weakness zone, the Az 125° lineament is involved in controlling the geometry and the regional NW-SE tectonic pattern (NW-SE). This pattern has resulted in the placement of several intrusive bodies, such as carbonatites and kimberlites, that are located in the central and southeast portions of the study area.

Acknowledgements

We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the PhD scholarship and the Fundação de Apoio à Pesquisa do Distrito Federal (FAP-DF) for the financial support to the development of this work. In addition, we thank the Companhia de Pesquisa de Recursos Minerais (CPRM) for providing the geophysical data and the universities of Brasília (UnB, Brazil) and Colorado School of Mines (CSM, USA) for providing structure and physical space. We also thank Dr. Misac Nabighian for his scientific contributions, and Dr. Catarina Toledo and Renato Bernardes (UnB) for all the geological discussions and descriptions of the thin sections.

References

Airo, M.L., 1999. Aeromagnetic and petrophysical investigations applied to tectonic analysis in the northern Fennoscandian shield. Geol. Surv. Finl., Rep. Invest. 145, 51 pp.

Almeida, F.F.M., 1986. Distribuição regional e relações tectônicas do magmatismo pós-paleozoico no Brasil. Rev. Brasil. Geocienc. 16 (4), 325–349.

Almeida, F.F.M., Hasui, Y., Brito Neves, B.B., Fuck, R.A., 1977. Províncias estruturais brasileiras. Simpósio de Geologia do Nordeste, vol. 8. SBG, Campina Grande, pp. 363–391.

Almeida, F.F.M., Hasui, Y., Brito Neves, B.B., Fuck, R.A., 1981. Brazilian structural provinces: an introduction. Earth Sci. Rev. 17 (1/2), 1–29.

Araújo, V.A., 1997. Programa Levantamentos Geológicos Básicos do Brasil – PLGB. Folha SE.22-X-A-III. CPRM, Itaberaí, Brasília, 83 pp.

Araújo, V.A., Moreton, L.C., 2008. Unidades Litoestratigráficas. In: Moreira, M.L.O., Moreton, L.C., Araújo, V.A., Lacerda Filho, J.V., Costa, H.F. (Eds.), Geologia do Estado de Goiás e Distrito Federal. Escala 1:500.000. CPRM/SIC – FUNMINERAL, Goiânia.

Baêta Junior, J.D.A., 2001. Programa Levantamentos Geológicos Básicos do Brasil. Goiânia – Folha SE.22-X-B – Escala 1:250.000. CPRM – Serviço Geológico do Brasil, 72 pp.

Baranov, V., Naudy, H., 1964. Numerical calculation of the formula of reduction to the magnetic pole. Geophysics 29, 67–79.

Barbosa, V.C.F., Silva, J.B.C., Medeiros, W.E., 1999. Stability and improvement of structural index estimation in Euler deconvolution. Geophysics 64 (1), 48–60.

Bardet, M.G., 1977. Géologie du diamante. Troisième partie: Gisementes de diamants d'Asie, d'Amérique, d'Europeet d'Australasie. Mémoires du Bur. Res. Geol. Min. 83, 169 pp.

Biondi, J.C., 2003. Processos Metalogenéticos e Depósitos Minerais Brasileiros. Oficina de Textos, 528 pp.

Bizzi, L.A., Schobbenhaus, C., Vidotti, R.M., Gonçalves, J.H. (Eds.), 2003. Geologia, tectônica e recursos minerais do Brasil: Texto, Mapas e SIG. CPRM, Brasília.

Blakely, R.J., 1996. Potential Theory in Gravity and Magnetic Applications. Cambridge University Press, 464 pp.

Brod, J.A., Ribeiro, C.C., Gaspar, J.C., Junqueira-Brod, T.C., Barbosa, E.S.R., Riffel, B.F., Silva, J.F., Chaban, N., Ferrari, A.J.D., 2004. *Excursion guide*: Geologia e Mineralizações dos Complexos Alcalinos-Carbonatíticos da Província Ígnea do Alto Paranaíba. Sociedade Brasileira de Geologia.

Cadman, A., Tarney, J., Park, R.G., 1990. Intrusion and crystallization features in proterozoic dyke swarms. In: Parker, A.J., Rickwood, P.C., Tucker, D.H. (Eds.), Mafic Dykes and Emplacement Mechanisms: Proceedings of the Second International Dyke Conference. A. A. Balkema, Adelaide, South Australia, pp. 13–24.

Campbell, I.H., Griffiths, R.W., Hill, R.I., 1989. Melting in an Archean mantel plume: heads it's basalts, tails it's komatiites. Nature 339, 697–699.

Chaves, A.O., Neves, J.M.C., 2005. Radiometric ages, aeromagnetic expression, and general geology of mafic dykes from southeastern Brazil and implications for African-South American correlations. J. South Am. Earth Sci. 19, 387–397.

Cordani, U.G., Pimentel, M.M., Araújo, C.E.G., Fuck, R.A., 2013. The significance of the Transbrasiliano-Kandi tectonic corridor for the amalgamation of West Gondwana. Braz. J. Geol. 43 (3), 583–597.

Cordell, L., Grauch, V.J.S., 1985. Mapping basement magnetization zones from aeromagnetic data in the San Juan Basin, New Mexico. In: Hinze, W.J. (Ed.), The Utility of Regional Gravity and Magnetic Anomaly Maps. , pp. 181–197 (Chapter 16).

Crough, S.T., Morgan, W.G., Hargraves, R.B., 1980. Kimberlites and their relation to mantle hotspots. Earth Planet. Sci. Lett. 50, 260–274.

Curto, J.B., Vidotti, R.M., Fuck, R.A., Blakely, R.J., Alvarenga, C.J.S., Dantas, E.L., 2013. Unveiling the Transbrasiliano fault system in northern Paraná Basin using airborne magnetic data. In: International Congress of the Brazilian Geophysical Society, SBGf, 13, Rio de Janeiro.

Delgado, J.D.S., Silva, L.C., Silveira Filho, N.C., Santos, R.A., Pedreira, A.J., Guimarães, J.T., Angelim, L.A.A., Vasconcelos, A.M., Gomes, I.P., Lacerda Filho, J.V., Valente, C.R., Perrotta, M.M., Heineck, C.A., 2003. Geotectônica do Escudo Atlântico. In: Bizzi, L.A., Schobbenhaus, C., Vidotti, R.M., Gonçalves, J.H. (Eds.), Geologia, tectônica e recursos minerais do Brasil: Texto, Mapas e SIG. CPRM, Brasília, pp. 227–234 (Chapter 5).

Dutra, A.C., 2011. Investigação tri-dimensional de dados gravimétricos e magnéticos da Província Alcalina de Goiás: Investigando o controle tectônico. Tese de Doutorado, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, 151 pp.

Dutra, A.C., Marangoni, Y.R., 2009. Gravity and magnetic 3-D inversion of Morro do Engenho complex, central Brazil. J. South Am. Earth Sci. 28, 193–203.

Dutra, A.C., Marangoni, Y.R., Junqueira-Brod, T.C., 2012. Investigation of the Goiás Alkaline Province, Central Brazil: application of gravity and magnetic methods. J. South Am. Earth Sci. 33, 43–55.

Eby, G.N., Mariano, A.N., 1992. Geology and geochronology of carbonatites and associated alkaline rocks peripheral to the Paraná Basin, Brazil-Paraguay. J. South Am. Earth Sci. 6 (3), 207–216.

Ernst, R.E., Buchan, K.L., 1997. Giant radiating dyke swarms: their use in identifying pre-Mesozoic large igneous provinces and mantle plumes. In: Mahoney, J.J., Coffin, M.F. (Eds.), Large Igneous Provinces: Continental, Oceanic, and Planetary Flood Volcanism. American Geophysical Union, Geophysical Monograph 100, pp. 297–333.

ESRI, 2008. ArcGis version 9. 3. ESRI, Environmental Systems Research Institute, Inc., United States.

Feitoza, L.M., Carmelo, A.C., Pires, A.C.B., Araújo Filho, J.O., Vidotti, R.M., 2010. Magnetometric beahavior of alkaline rocks in Iporá region, Southwest of Goiás, central Brazil. In: Meeting of the Americas. AGU, Foz do Iguassu, Brazil.

Fuck, R.A., Jardim de Sá, E.F., Pimentel, M.M., Dardenne, M.A., Pedrosa-Soares, A.C., 1993. As faixas de dobramentos marginais do Cráton do São Francisco: Síntese dos conhecimentos. In: Domingues e, J.M.L., Misi, A. (Eds.), O Cráton do São Francisco. SBG/SGM/CNPq, pp. 161–185.

Fuck, R.A., 1994. A Faixa Brasília e a Compartimentação Tectônica na Província Tocantins. In: Simpósio de Geologia do Centro-Oeste, SBG, 4, Brasília, pp. 184–187.

Geosoft, 2009. Oasis Montaj™ 7.1.1. Geosoft Inc., Toronto, Canada.

Gibson, S.A., Thompson, R.N., Leonardos, O.H., Dickin, A.P., Mitchell, J.G., 1995. The Late Cretaceous impact of the Trindade mantle plume: evidence from large-volume, mafic, potassic magmatism in SE Brazil. J. Petrol. 36 (1), 189–229.

Gibson, S.A., Thompson, R.N., Eska, R.K., Dickin, A.P., 1997. Late Cretaceous rift-related upwelling and melting of the Trindade starting mantle plume head beneath western Brazil. Contrib. Mineral. Petrol. 126, 303–314.

Gonzaga, G.M., Tompkins, L.A., 1991. Geologia do diamante. In: Schobbenhaus, C., Queiroz, E.T., Coelho, C.E.S. (Eds.), Principais depósitos minerais do Brasil, Parte A, vol. IV, pp. 53–116.

Hasui, Y., Cordani, U.G., 1968. Idades Potássio Argônio de rochas eruptivas mesozóicas do oeste mineiro e sul de Goiás. In: Congresso Brasileiro de Geologia, SBG, 22, Belo Horizonte, 1, pp. 139–143.

Hasui, Y., Sadowski, G.R., Suguio, K., Fuck, G.F., 1975. The Phanerozoic tectonic evolution of the western MG state. An. Acad. Brasil. Cienc. 47 (3/4), 431–438.

Jácomo, M.H., (Dissertação de Mestrado) 2010. Associação de magnetometria, gamaespectrometria, geoquímica e petrografia para modelamento tridimensional da mineralização de nióbio do depósito Morro do Padre, Goiás, Brasil. Instituto de Geociências, Universidade de Brasília, 110 pp.

Junqueira-Brod, T.C., Gaspar, J.C., Brod, J.A., Jost, H., Barbosa, E.S.R., Kafino, C.V., 2005. Emplacement of kamafugite lavas from the Goiás alkaline province, Brazil: constraints from whole-rock simulations. J. South Am. Earth Sci. 18, 323–335.

Kellogg, O.D., 1953. Foundations of Potential Theory. Dover Publications.

Kent, D.V., Gradstein, F.M., 1985. A Cretaceous and Jurassic geochronology. Geol. Soc. Am. Bull. 96, 1419–1427.

Kuchenbecker, M.,2011. Projeto Alto Paranaíba – Folha Luz – SE.23-Y-D-V – Escala 1:100.000. In: Programa Mapeamento Geológico do Estado de Minas Gerais. CODEMIG – UFMG (Chapter VIII).

Lapin, A.V., Anuch, W., Ploshko, V.V., 1999. Carbonatitos lineares de cinturões móveis: uma síntese. Rev. Brasil. Geocienc. 29 (4), 483–490.

Laux, J.H., Pimentel, M.M., Dantas, E.L., Armstrong, R., Armele, A., Nilson, A.A., 2004. Mafic magmatism associated with the Goiás Magmatic Arc in Anicuns region, Goiás, central Brazil: Sm–Nd isotopes and new ID-TIMS and SHRIMP U–Pb data. J. South Am. Earth Sci. 16, 599–614.

Marangoni, Y.R., 1994. Modelo crustal para o norte de Goiás a partir de dados gravimétricos. Tese de Doutorado, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, 135 pp.

Marangoni, Y.R., Mantovani, M.S.M., 2013. Geophysical signatures of the alkaline intrusions bordering the Paraná Basin. J. South Am. Earth Sci. 41, 83–98.

Milani, E.J., 1997. Evolução tectono-estratigráfica da Bacia do Paraná e seu relacionamento com a geodinâmica fanerozóica do Gondwana sul-ocidental. Tese de doutorado, Universidade do Rio Grande do Sul, 225 pp.

Milani, E.J., Ramos, V.A., 1998. Orogenias paleozóicas no Domínio sul-ocidental do Gondwana e os ciclos de subsidência da Bacia do Paraná. Rev. Brasil. Geocienc. 28 (4), 473–484.

Miller, H.G., Singh, V., 1994. Potential field tilt – a new concept for location of potential field sources. J. Appl. Geophys. 32, 213–217.

Moraes, L.G. de, (Dissertação de Mestrado) 2007. Processamento, interpretação e integração dos dados aerogeofísicos do Projeto Rio do Sangue – MT, aplicados ao mapeamento geológico e à prospecção mineral. Instituto de Geociências, Universidade de Brasília, 158 pp.

Moraes Rocha, L.G., de, M., Pires, A.C.B., Carmelo, A.C., Araújo Filho, J.O., 2011. Processing and Integration of airborne magnetometry data for the assessment of geotectonic context of the central portion of Az 125° lineament. In: International Congress of the Brazilian Geophysical Society, 12, SBGf. Rio de Janeiro.

Morgan, W.J., 1983. Hot spot tracks and the early rifting of the Atlantic. Tectonophysics 94, 123–139.

Nabighian, M.N., 1972. The analytic signal of two-dimensional magnetic bodies with polygonal cross-section: its properties and use for automated anomaly interpretation. Geophysics 37 (3), 507–517.

Nabighian, M.N., 1984. Toward a three-dimensional automatic interpretation of potential field data via generalized Hilbert transforms – fundamental relations. Geophysics 49, 780–786.

Oliveira, D.S., Mantovani, M.S.M., 2011. Study of Pratinha II magnetic anomaly: acquisition, processing and interpretation of aeromagnetic and gravimetric data. In: International Congress of the Brazilian Geophysical Society, SBGf, 12, Rio de Janeiro.

Park, R.G., Tarney, J., 1987. Evolution of the Lewisian Complex and comparable Precambrian high grade terrains. Geological Society, London, 315 pp.

Pereira, R.M., Roza, T., Castro, C., Neumann, R., Brot, P., Karfunkel, J., Sgarbi, G.N., 2008. Dispersão da picroilmenita: estudo de caso aplicado ao kimberlito Cancã, Ilicínea, Minas Gerais. Geociências 27 (1), 79–86 (UNESP).

Pimentel, M.M., Heaman, L.L., Fuck, R.A., 1991. Idade do metarriolito da Sequência Maratá. Grupo Araxá, Goiás.

Power, M., Belcourt, G., Rockel, E., 2004. Geophysical methods for kimberlite exploration in northern Canada. The Leading Edge 23 (11), 1124–1129.

Raposo, M.I.B., Chaves, A.O., Lojkasek-Lima, P., D'Agrella-Filho, M.S., Teixeira, W., 2004. Magnetic fabrics and rock magnetism of Proterozoic dike swarm from the southern São Francisco Craton, Minas Gerais State, Brazil. Tectonophysics 378, 43–63.

Reid, A.B., Allsop, J.M., Granser, H., Millett, A.J., Somerton, I.W., 1990. Magnetic interpretation in three dimensions using Euler deconvolution. Geophysics 55 (1), 80–91.

Requejo, H., Mantovani, M.S.M., 2011. Catalão I Alkaline Complex: gravimetric and magnetic inversions. In: International Congress of the Brazilian Geophysical Society, SBGf, 12, Rio de Janeiro.
Riccomini, C., Velázquez, V.F., Gomes, C.B., 2005. Tectonic controls of the mesozoic and cenozoic alkaline magmatism in central-southeastern Brazilian platform. In: Comin-Chiaramonti, P., Gomes, C.B. (Eds.), Mesozoic to Cenozoic Alkaline Magmatism in Brazilian Platform. EDUSP – FAPESP, São Paulo, pp. 31–55 (Chapter II).
Rocha, M.P., Schimmel, M., Assumpção, M., 2011. Upper-mantle seismic structure beneath SE and central Brazil from P and S wave regional travel time tomography. Geophys. J. Int. 184, 268–286.
Rodrigues, J.B., (Dissertação de Mestrado) 1996. Geocronologia e geoquímica da sequência vulcano-sedimentar de Iporá e rochas graníticas associadas. Instituto de Geociências, Universidade de Brasília, 99 pp.
Roest, W.R., Pilkington, M., 1993. Identifying remanent magnetization effects in magnetic data. Geophysics 58, 653–659.
Schnetzler, C.C., Taylor, P.T., 1984. Evaluation of an observational method for estimation of remanent magnetization. Geophysics 49 (3), 282–290.
Schobbenhaus, C., Oguino, K., Ribeiro, C.L., Oliva, L.A., Takanohashi, J.T., 1975. Carta geológica do Brasil ao milionésimo. DNPM-DGM, Brasília, Folha SE-22, Goiânia.
Schobbenhaus, C., Brito Neves, B.B., 2003. A Geologia do Brasil no Contexto da Plataforma Sul-Americana. In: Bizzi, L.A., Schobbenhaus, C., Vidotti, R.M., Gonçalves, J.H. (Eds.), Geologia, tectônica e recursos minerais do Brasil: Texto, Mapas e SIG. CPRM, Brasília, pp. 5–54 (Chapter I).
Seer, H.J., Moraes, L.C.,2011. Projeto Alto Paranaíba – Folha Campos Altos – SE. 23-Y-D-IV – Escala 1:100.000. In: Programa Mapeamento Geológico do Estado de Minas Gerais. CODEMIG – UFMG (Chapter VI).
Shurbet, D.H., Keller, G.R., Friess, J.P., 1976. Remanent magnetization from comparison of gravity and magnetic anomalies. Geophysics 41 (1), 56–61.
Silva, A.M., Chemale Jr., F., Kuyumjian, R.M., Heaman, L., 1995. Mafic dikes swarms of Quadrilátero Ferrífero and southern Espinhaço, Minas Gerais, Brazil. Rev. Brasil. Geocienc. 25 (2), 124–137.
Smith, R.S., Fountain, D.K., 1999. Geophysics and diamond exploration – a review. Fugro airborne Presented at Irish Association of Economic Geology Week-end Course.
Sonoki, I.K., Garda, G.M., 1988. Idades K-Ar de rochas alcalinas do Brasil Meridional e Paraguai Oriental: compilação e adaptação às novas constantes de decaimento. Boletim IG, USP, Série Científica, 19., pp. 63–85.
Tassinari, C.C.G., 1988. Comentários sobre a geocronologia das folhas 1:100.000 do Programa Levantamentos Geológicos Básicos do Brasil, Projeto Sudeste de Goiás. Goiânia, CPRM/DNPM.
Thompson, D.T., 1982. EULDPH – a new technique for making computer-assisted depth estimates from magnetic data. Geophysics 47, 31–37.
Thompson, R.N., Gibson, S.A., Mitchell, J.G., Dickin, A.P., Leonardos, O.H., Brod, J.A., Greenwood, J.C., 1998. Migrating Cretaceous-Eocene magmatism in the Serra do Mar Alkaline Province, SE Brazil: melts from the deflected Trindade Mantle Plume? J. Petrol. 39, 1493–1526.
Trompette, R., 1994. Geology of Western Gondwana (2000–500 Ma). Pan-African-Brasiliano Aggregation of South America and Africa. A.A. Balkema, 350 pp.
White, R.S., McKenzie, D., 1989. Magmatism at rift zones: the generation of volcanic continental margins and flood basalt. J. Geophys. Res. 94, 7685–7729.
Wilson, B.C., Dixon, J.M., Helmstaedt, H., 1985. Dyke intrusion in shear fractures: stress orientation and depth of emplacement. In: International Conference on Mafic Dyke Swarms, 1, pp. 186–188 (Abstracts).