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Occurrence of dravitic tourmaline in a diamond-bearing breccia: a possible lamproite deposit in the Alto Paranaíba Igneous Province

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Abstract

The mineral chemistry of diamond indicator minerals is used to trace mineralizations in primary rocks such as lamproites/kimberlites and in secondary deposits. Subcalcic garnets and magnesian ilmenites are both minerals associated with the diamond potential described in many deposits in the Alto Paranaíba Igneous Province where several kimberlitic pipes and alluvial deposits occur. Our study was conducted on the Romaria diamond deposit of (Brazil), where garnet, ilmenite and tourmaline grains were recovered from a diamon-bearing breccia were analyzed under electron microprobe. The garnet composition is compatible with G10, G9 and G5 types. Ilmenite grains are Mg- to Mn-rich. Nearly 80% of the tourmaline grains are dravite-type. This association of dravite tourmaline with diamond in rocks of lamproitic affinity may be common, as evidenced in the Argyle, Ellendale, Prairie Creek, Sask, Presidente Olegário and Ymi-1 pipes. We therefore suggest a possible lamproite origin for the studied diamond deposit.

KEYWORDS: mineral chemistry; lamproite; kimberlite; tourmaline; Alto Paranaíba;

INTRODUCTION

The search for the primary sources of diamonds has been a constant challenge for researchers and mining companies since the discovery of the kimberlites around Kimberley (South Africa) in 1872 (Mitchell 1986). In addition to aerogeophysical methods such as magnetometry, geochemical prospecting campaigns are one of the most important tools used to find these sources, mainly through the analysis of satellite minerals (Neto *et al*. 2017). The determination of its composition by means of electron microprobe analyzes is one of the most relevant steps to evaluate the diamond potential of a certain location. Minerals such as garnet, chromite, ilmenite, diopside, olivine and phlogopite, when found in the context of diamond mineralizations, can provide information about mantle provenance, since they occur in conditions similar to those of diamond formation and, when analyzed together, can differentiate kimberlites from lamproites (Mitchell 1986, 1995, Mitchell and Bergman 1991, Grutter *et al*. 2004, Wyatt *et al*. 2004, Scott-Smith *et al*. 2018).

In Brazil, diamonds have been mined in the Alto Paranaíba Igneous Province since 1880 in alluvial and colluvial deposits. The search for kimberlitic pipes and associated rocks in the province took place around 1960, with the discovery of the first Brazilian kimberlitic pipe, the Vargem 1 Kimberlite in Coromandel (Neto *et al*. 2017) in 1969, boosting the demand for economically viable primary sources in Brazil based on aeromagnetic surveys carried out through an agreement between Brazil and Germany in later years. Hundreds of anomalies were detected and attributed to kimberlitic and lamproitic bodies, and later projects were dedicated to detailing geophysical surveys and satellite mineral prospecting campaigns, mainly in the regions over the Brasília Fold Belt and on the south-west edge of the São Francisco Craton (Neto *et al*. 2017).

The mineral chemistry of indicator minerals was first described in the Romaria mine, one of the oldest in the Alto Paranaíba Igneous Province (APIP), by Svisero and Meyer (1981), Svisero (1995) and Coelho (2010), who mention the diamond potential of the deposit due to the presence of subcalcitic Cr-rich garnets and magnesian ilmenites, attributing a kimberlitic origin to it. This work contributes to the knowledge regarding the diamond occurrences in the APIP, presenting new mineral chemistry data collected in the Romaria mine

Supplementary data

Supplementary data associated with this article can be found in the online version: Suplementary Table A, Supplementary Table B, Supplementary Table C and Supplementary Table D.

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and proposing a possible alternative model for the source rock of the local diamonds.

Geological setting

The study area is located in the Alto Paranaíba region, which includes five geotectonic domains: the São Francisco Craton, the Brasilia orogenic belt, the Paraná Basin, the Sanfranciscan Basin and the Alto Paranaíba Igneous Province (APIP) (Fig. 1).

In this region, the São Francisco craton is covered by the neoproterozoic Bambuí group, which is represented by intercalations of siliciclastic and chemical lithofacies deposited in an extensive epicontinental sea in the context of a foreland basin related to the Brasilian orogeny of the Brasília belt (Canastra, Ibiá and Araxá Groups) (Alkmim and Martins-Neto 2001, Iglesias and Uhlein 2009).

In this region, two units of the Paraná basin gather volcano-sedimentary deposits of Cretaceous age, related to the break-up of the Godwana continent during the opening of the South Atlantic Ocean. The São Bento Group is characterized by eolian deposits of desert environment (Botucatu Formation) and by a thick, effusive volcanic sequence composed of continental basalt from the Serra Geral Formation (Paraná — Entedeka LIP). The Bauru Group includes eolian and fluvial deposits (Uberaba Formation) and fluvial and alluvial successions of the Marília Formation (Coelho 2010, Almeida *et al.* 2012, Neto *et al.* 2017).

The Sanfranciscana Basin is also correlated with the Gondwana break-up consisting of paleozoic/mesozoic sedimentary and volcanic rocks associated with alkaline magmatism belonging to the Alto Paranaiba Igneous Province. The Mata da Corda Group is part of this province and is composed of kamafugitic floods and pyroclastics rocks associated with epiclastic sedimentary deposits from alluvial and fluvial systems (Sgarbi 2000, Sgarbi *et al.* 2001). The origin behind the kamafugitic magmatism is likely related to the formation of the Alto Paranaíba Arch during the rise of the Trindade and Tristão da Cunha Plumes (Gibson *et al.* 1995, Thompson *et al.* 1998). This event was also responsible for the alkaline magmatism of the northeastern edge of the Paraná Basin after the reactivation of two major structural

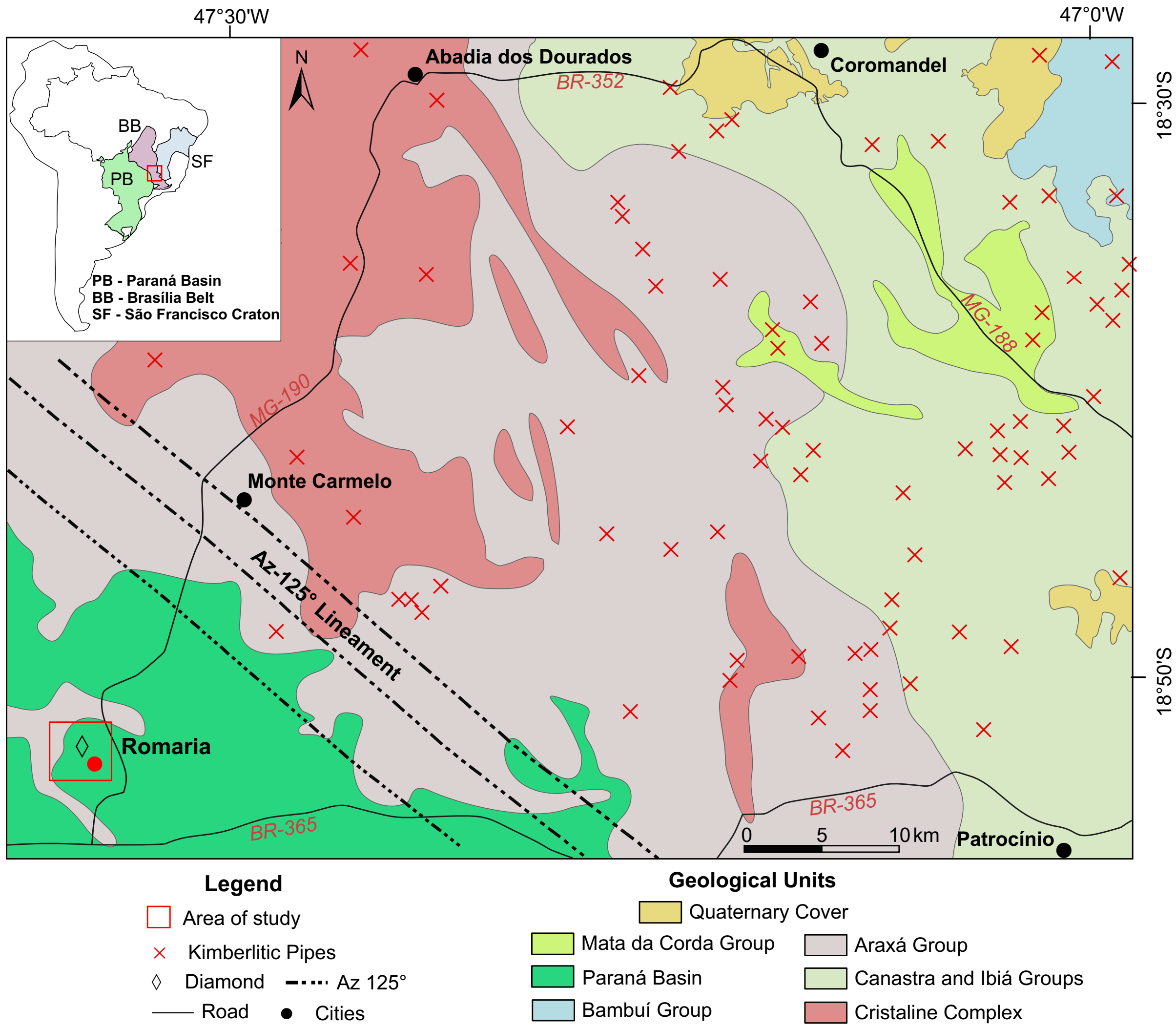

Figure 1. Geological context of the Romaria region, emphasizing the interface between the São Francisco (SF) Craton, the Brasília Belt (BB) and the Paraná Basin (PB) (Almeida *et al.* 2012), as well the location of the kimberlitic pipes of the Alto Paranaíba Arch, represented by the Az-125° lineament (Neto *et al.* 2017).

lineaments: the "Azimuth 125" (NW-SE direction), and the "Transbrasiliano" (NE-SW direction) lineaments (Pereira 2007, Silva 2015, Neto *et al.* 2017). Both lineaments acted as structural controls on the emplacement of carbonatitic, lamproitic and kimberlitic pipes observed on the Romaria region and other ocurrences along southeastern to northern Brazil (Toyoda *et al.* 1994, Thompson *et al.* 1998, Bizzi and Vidotti 2003, Pereira and Fuck 2005).

MATERIALS AND METHODS

For the separation of the heavy minerals, approximately 150 liters of rock were collected from the diamond-bearing breccia (Tauá Breccia). Sampling was carried out in the current mining front of GAR Mineração. The selected sample was properly disaggregated and washed under running water to remove the clay fraction, followed by sieving (16#, 6# and 4# sieves). The satellite minerals of diamonds such as garnet, ilmenite and tourmaline were obtained in granulometry through the 16# sieve. The selected material was dried in an oven at 60°C for 2 hours, then the magnetite grains were removed with the aid of a manual magnet. The residual concentrate was processed in a Frantz Isodynamic Separator, meeting the following configurations:

- 0.3A current for the separation of ilmenites;
- 0.4A current for the separation of minerals such as garnet and chromite;
- 0.5A current for diopside separation.

The residual material was subjected to a 0.6A current for the separation of the pyrope garnet. While using a current of 0.3A, the inclination of the Frantz Isodynamic Separator was set for a 10º frontal and 15º lateral, while in other current values a lateral inclination of 20º was used. The minerals ranges were identified with the aid of a binocular loupe. In the matrix of the diamond volcanogenic conglomerate garnet grains occur in a fraction of 1mm, while ilmenite and tourmaline grains occur < 1 mm.

The concentrated minerals were subjected to electron microprobe analysis (EMPA — model Cameca SXFive) with the electron beam set at 15 kV, 15 μA, 5μm spot size at the Laboratório de Microssonda Eletrônica from the Petrology and Geochemistry Study Center (Universidade Federal do Rio Grande do Sul, Porto Alegre/RS). The counting times on the peaks/background were 20s for all elements (Si, Al, Ti, Fe, Mn, Mg, Ca, Na, K and Cr), except for Ni, Zn and V (30s). Analytical standards are presented in Supplementary Table A. Analytical errors range between 0.20 and 0.86%. The core and rim of mineral grains were analyzed in a total of 555 spots on the following minerals: garnet (Grt), ilmenite (Ilm) and tourmaline (Tur). The structural formula of garnet, ilmenite and tourmaline were recalculated by equilibrium and stoichiometry equations following the work of Perkins (2007) for garnet; Droop (1987) for ilmenite; Selway (1999) for tourmalines with stoichiometric calculation for B_2O_3, H_2O and Li_2O, B = 3 apuf, OH+F = 4 apuf and structural formula with 15 cation normalization (Y+Z+T) for the structural sites. Compositional plots of mineral compositions were plotted in ternary diagrams using the TriQuick software (Dolivo-Dobrovolsky 2012).

RESULTS

Field description

The sampled material (Fig. 2) for analysis of mineral chemistry was taken from a diamond volcanoclastic facies of Romaria, called the "Tauá Breccia" by Drapper (1911) and local miners. These "breccias" are deposits from reworking of proximal volcanogenic rocks, which overlap erosively both the eolian sandstones of the Botucatu Formation and the mica-schist from the Araxá Group. This rock is weathered, massive and very poorly sorted, composed of millimeter to centimeter clasts (up to 30 centimeters) of sandstone, schist, basic rocks and massive kaolin (i.e., without zoning or differentiation compositional). These clasts are sub-rounded to angular, with a predominantly clay-rich reddish matrix. This entire sequence occupies irregular decametric depressions and is superimposed by an intercalation of siltstones and impure sandy levels. Between the volcanogenic conglomerate and the epiclastic rocks, a thin layer of opal may appear.

Mineral chemistry

Tourmaline

Tourmaline grains occur in the granulometric fraction < 1 mm and are rounded to prismatic, from dark brown to greenish colors when viewed in the stereo microscope. From the recalculation of the structural formula, a ternary diagram proposed by Henry *et al.* (2011) was used, with the tourmalines from the end members belonging to the alkaline group (dravite-schorl-elbaite), made from the proportions Mg^{2+}, Fe^{2+} and Li that appear in the structural site Y. Following the recalculation proposed by Selway (1999), out of the 145 tourmalines, 119 are dravites, 23 schorl and 3 uvites. Based on the diagram of Henry *et al.* (2011), 80 are dravites (55%) and 65 schorl (45%) (Fig. 3A). This difference is due to the

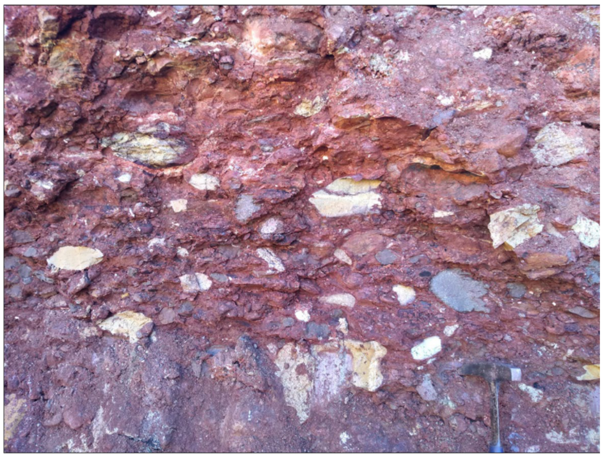

Figure 2. Tauá vulcanoclastic breccia, diamond level in the Romaria mine.

structural formula, considering the cationic proportions in the structural sites (Al and Fe^{3+} in Z; Al, Fe^{3+}, Mg, Fe^{2+} and Li in Y; Ca and Na in X) to name the minerals, while the triplot presents the cations on site Y. This way, all discussions are structured according to the formula, in view of the most complete proportion already mentioned, where the triplot is only illustrative (Fig. 3A).

The average composition of the dravite grains is SiO_2 (34.19-37.26%) TiO_2 (0.15-1.29%), Al_2O_3 (28.63-34.33%), FeO (4.48-9.66%), MgO (4.86-8.69%), Na_2O (1.32-2.7%), MnO (0-0.12%), CaO (0.05-2.23%), K_2O (0-0.11%). The schorlite grains show a variation in SiO_2 (33.88-36.32%), TiO_2 (0.26-1.34%), Al_2O_3 (29.63-33.48%), FeO (8.49-13.04%), MgO (2.23-6.23%), Na_2O (1.28-2.54%), MnO (0-0.13%), CaO (0.08-2.07%), K_2O (0-0.07%) (Suppl. Tab. B).

Ilmenite

The ilmenite grains occur in the fraction < 1 mm, being rounded to sub-angular, with metallic luster and grayish color. After recalculation, the structural formula following Droop (1987), a ternary diagram proposed by Tompkins and Haggerty (1985) was used, with the ilmenite components: geikielite ($MgTiO_3$), ilmenite ($FeTiO_3$), hematite (Fe_2O_3) and pyrophanite ($MnTiO_3$) (Figs. 3B-3C). This was done to separate grains of ilmenite with more than 50% hematite as its main component, as grains with high oxidation are not representative for the study. The grains were then selected, presenting oxide closure above 96% after structural recalculation (Kostrovitsky *et al.* 2020).

The average composition of ilmenite grains presents the following range: SiO_2 (0.00-1.27%) TiO_2 (38.32-97.47%), Al_2O_3 (0.00-0.31%), Cr_2O_3 (0.00-3.35%), Fe_2O_3 (0.00-24.68% - recalculated) FeO (17.72-43.13%), MnO (0 , 02-18.49%), MgO (0.00-14.04%), CaO (0.00-0.04%), ZnO (0.00-0.73%). The grains with other compositions are appended in the Suppl. Tab. C.

Garnet

The garnet grains are found in the fraction > 1 mm, and are reddish to pink in color, being dodecahedral to rounded. Grains with total oxide weight percentage above 98% were considered for further analysis. From the core and edge analysis of the grains, compositional homogeneity was noted, which allowed compositions referring to the grain core, with the exception of 7 grains that, due to their microfractures, the chemical closure was below 98%. After recalculating the structural formula following Perkins (2007), the molar proportions between the garnet in the end members were obtained (Figs. 3D-3E). Supported by the triplot, there is a representative cluster of garnets with a higher proportion of pyrope, except for two grains that are close to the almandine-member garnet.

The average composition of the garnet grains is: SiO_2 (27.37-42.47%), TiO_2 (0.05-0.46%), Al_2O_3 (16.94-53.48%), Cr_2O_3 (0.02-8.41%), FeO (7.14-26.66%), MnO (0.03 -0.89%), MgO (1.71-21.69%), CaO (0.03-6.88%). The analyses of the grain edges are found in the Suppl. Tab. D.

DISCUSSION

Tourmaline

Considering that tourmaline, at first, is not a common mineral in diamond-bearing rocks, it required an investigation in the specialized literature regarding the occurrence of this mineral associated with diamond deposits.

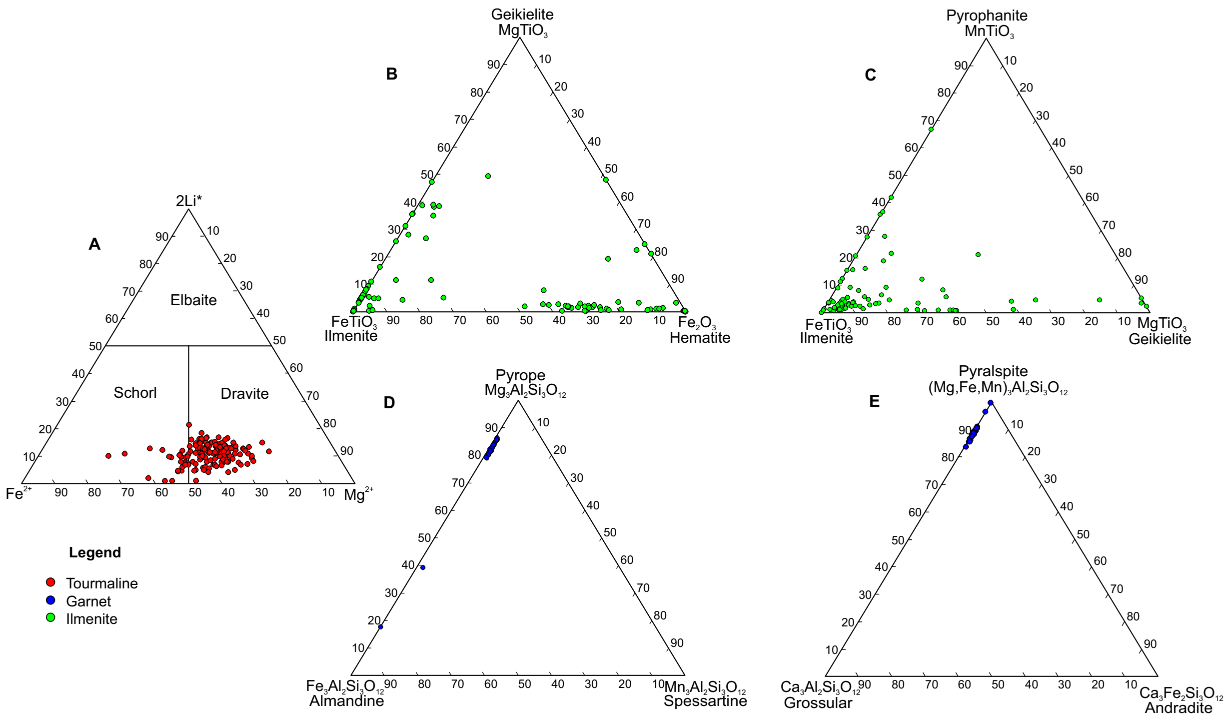

Figure 3. Ternary diagrams with (A) tourmaline ilmenite and (B and C) garnet (D and E) end-members.

Occurrences of dravite-type tourmalines associated with diamondiferous rocks have been described in two main contexts:

- Related to microdiamonds found in supracrustal rocks of the ultra-high-pressure (UHP) metamorphic orogenic belt of Kokchetav (Kazakhstan), after the eclogitization of the oceanic lithosphere in a context of subduction of supracrustal rocks rich in B that, after dehydrated, generated a high flow of fluids that allowed the formation of tourmaline (Hwang *et al.* 2005, Ota *et al.* 2008, Shimizu and Ogasawara 2013, Berryman *et al.* 2015; and references therein);
- Associated with lamproitic affinity rocks, having as examples the tourmalines found in the lamproitic pipes of Prairie Creek (Arkansas, USA, Fipke 1991), Jack (Canada, Fipke 1991), Argyle and Ellendale (Australia, Fipke 1991), Ymi-1 (Paraguay, Presser 2019) and in the lamprophyre dykes from northern Canada (Scribner *et al.* 2018).

The occurrence of tourmaline-dravite in the region of Romaria, MG suggests a lamproitic affiliation in terms of Fipke (1991) and Presser (2019), since lamproites were recognized and described in the Alto Paranaíba Igneous Province (Neto *et al.* 2017).

The tourmaline described in lamproitic bodies by Fipke (1991), does not present compositional zoning and has an abrasive texture that causes roundness to the grains, this morphology is attributed by the author to magmatic reactions. Fipke (1991) adapted the diagram of Moore (1986) for the ratios of TiO_2 x K_2O (Fig. 4), indicating that the formation of dravites from magmatic reactions between olivine, clinopyroxene and kyanite during differentiation of eclogitic magmas with high K^+ and Ti^{4+} activities for lamproitic magmas (Fipke 1991).

Through plotting the data of the Romaria tourmaline dravites in the binary diagram $K_2O \times TiO_2$ (Fig. 4), it is possible to observe that 39 grains are part of the GI field (with TiO_2 variations of 0.27-1.12% and K_2O of 0.04-0.08%), *i.e.*, the representative field of tourmalines that occur associated with the diamond. Most grains are softly rounded, while some still exhibit sharp edges. The diagram in Fig. 4 released data from the Romaria dravites in conjunction with tourmalines associated with the diamonds studied by Fipke (1991) and Presser (2019).

On the other hand, the presence of boron in the crystal structure of diamonds from fluids enriched by the dissolution of serpentinites from the oceanic crust subducted to the lower mantle (Smith *et al.* 2018), instigates the assumption that the formation of tourmalines (dravites) in kimberlites occurred during the rise of the magma in the crustal environment.

Ilmenite

High magnesium ilmenite (picroilmenite) is a mineral widely used during the indication and prospecting of kimberlitic rocks due to its easy concentration and high resistance to chemical and physical weathering, and are rarely found as inclusions in diamonds (Tompkins and Haggerty 1985, Mitchell 1986). Ilmenite is an accessory mineral in several types of

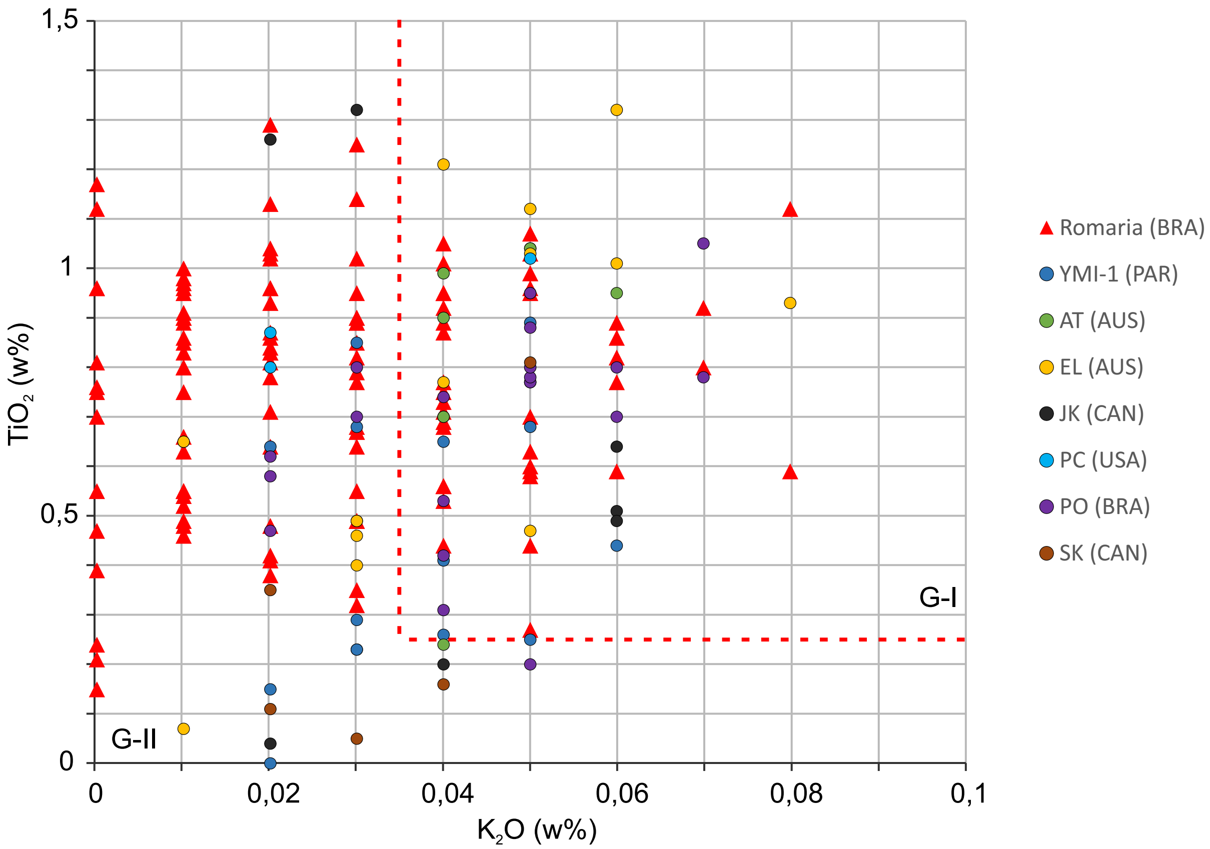

Figure 4. Binary diagram K_2OxTiO_2 proposed by Fipke (1991) to separate diamond tourmaline (G-I) from non- associated tourmaline (G-II). The grains represented in the diagram with the Romaria grains are: Ymi-1 (Presser 2019); AT: Argyle, EL: Ellendale, JK: Jack, PC: Prairie Creek, PO: President Olegario, SK: Sask (Fipke 1991).

rocks, requiring a distinction between kimberlite and non-kimberlite ilmenites, and even though kimberlite and lamproite ilmenites have a similar mantle derivation, they represent different exploration contexts (Wyatt *et al.* 2004). The determination of kimberlitic and non-kimberlitic ilmenites is obtained through a $TiO_2 \times MgO$ binary diagram, as well as $Cr_2O_3 \times MgO$ (Wyatt *et al.* 2004, following Haggerty 1975, 1991) (Fig. 5A). Manganese ilmenites as well as picroilmenites were recovered in exploration campaigns of the lamproite bodies (Argyle and Ellendale — Australia; Jack — Canada and Praire Creek — United States) by Fipke (1991) and in the Ypro-1 lamproitic pipe (Paraguay) by Presser (2019).

Inclusion of low-Mg manganese ilmenite was described by Meyer and Svisero (1975), Kaminsky *et al.* (2001) and Kaminsky and Belousova (2009) in diamonds from the Juína field (kimberlitic pipe Pandrea-7, Mato Grosso/Brazil). The MgO × MnO binary diagram (Fig. 5B) used by Kaminsky and Belousova (2009) to separate picroilmenite from the manganese ilmenite included in diamond revealed that the kimberlitic ilmenites in Figure 5C are the same evidenced by the upward trend in Figure 5B, while the non-kimberlitic ilmenites show MgO contents below 3.9% when plotted on the MgO × MnO diagram, concentrating closely to the MnO axis. On the other hand, Castillo-Oliver *et al.* (2017) points out that ilmenites rich in Mn, when plotted on the TiO_2 x MgO diagram proposed by Wyatt *et al.* (2004) fall into the field of non-kimberlitic ilmenites (Fig. 5C).

Garnet

Garnet crystals were separated between mantle-derived and crustal-derived from the variation of Ca/(Ca+Mg) × Mg/(Mg+Fe) (Fig. 6A) as proposed by Schulze (2003), with a

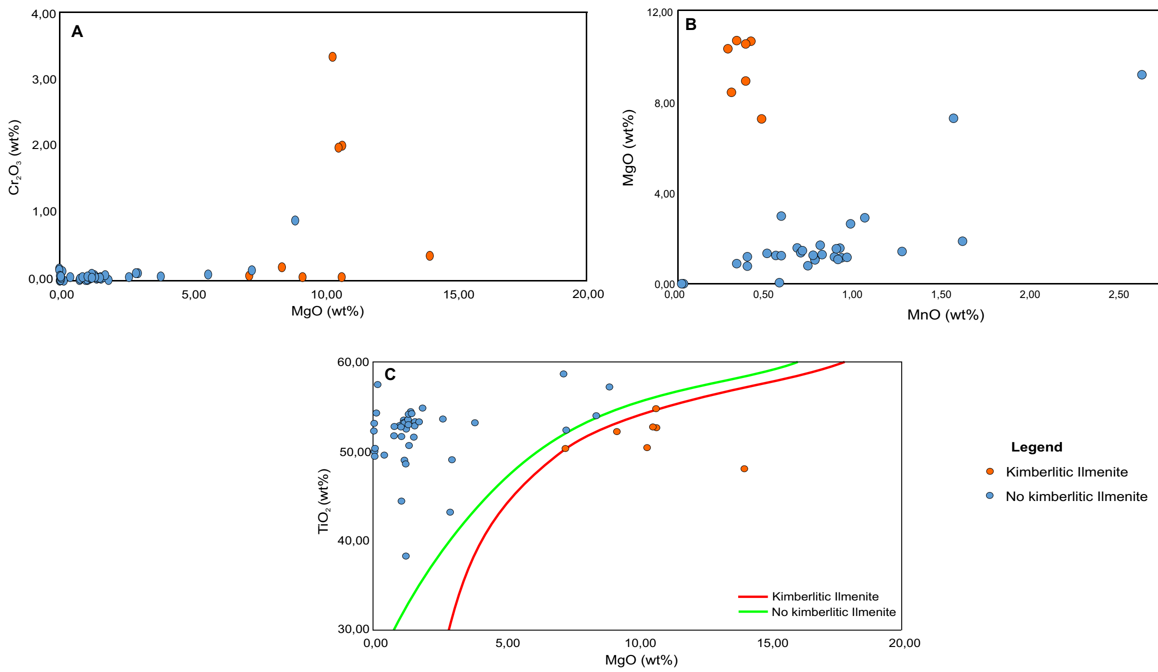

Figure 5. Binary diagrams for characterizing ilmenites. (A) Cr_2O_3 × MgO, as proposed by Wyatt *et al.* (2004); (B) MgOxMnO diagram proposed by Kaminsky and Belousova (2009) showing the percentage of Mn in diamond ilmenites; (C) MgO × TiO_2 diagram with a curve proposed by Wyatt *et al.* (2004) to separate kimberlitic and non-kimberlitic ilmenites.

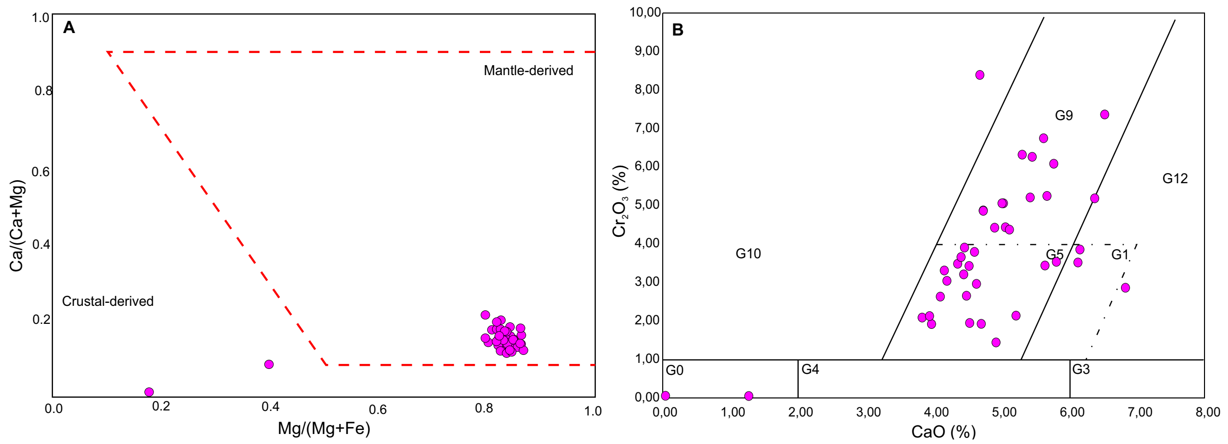

Figure 6. Binary diagrams for garnet characterization. (A) Relationship proposed by Schulze (2003) to separate mantle-derived from crustal garnets; (B) Fields proposed by Grutter *et al.* (2004) to garnet characterization according to the content of Cr_2O_3 and CaO.

predominance of mantle-derived garnets and only two crustal-derived grains. These garnets are classified according to their mantle nature when plotted on the binary $Cr_2O_3 \times CaO$ diagram proposed by Grutter *et al.* (2004), with predominance of grains in the G9 and G5 field, two grains in G12, G1 and G0, one grain in G10 (Fig. 6B).

G9 garnets are Cr-pyropes derived from lherzolites, widely recovered in the context of diamond exploration and abundant as xenocrystals in diamond kimberlites, rarely occurring as inclusions in diamonds. G5 are moderate to low-Cr garnets derived from pyroxenites, similar to G9 but richer in Fe, being a possible indicator of lithosphere destruction. The G12 are Wehrlitic type, rarely found included in diamond. G1 can occur in kimberlites but are also found in other types of rock, mainly in alkaline basalts. G0 do not have a relationship with any specific mantle rock. And lastly, G10 garnets are of harzburgitic affinity, widely found as inclusions in diamonds, thus presenting characteristics of T and P compatible with those of diamond formation, being used as a standard to determine diamond potential in exploration projects (Grutter *et al.* 2004).

The two grains found in the G0 field are both crustal-derived, likely from the Araxá micaschist, a region that presents garnets in its modal composition. The single garnet grain in the G10 field is compatible with the data mentioned by Svisero and Meyer (1981), Svisero (1995) and Coelho (2010), who only found two grains in the G10 field. Most grains belong to the G5 field, which, as stated above, are possible indicators of lithosphere destruction. G5 garnets were found as inclusions in diamonds recovered from lamproites and can be used to assist exploratory campaigns when related to other indicator minerals, such as ilmenite and chromite (Fipke 1991).

Comparative with other lamproitic rocks

Based on mineralogical associations that occur in some lamproites in Brazil, Paraguay, Australia, Canada and the United States, we present the comparative Table 1, which shows the similar occurrence of G5 and G9 garnet, Mn-rich ilmenite and tourmaline dravite, never described in Romaria/MG.

As seen in Table 1, the diamond deposit of Romaria, when compared to other Brazilian occurrences, presents G5 and G9 garnets and Mg-rich ilmenite in the pipe Abél Régis and

Table 1. Comparative between the diamond indicator minerals found in Romaria in relation to kimberlitic and lamproitic pipes from other locations.

Deposit	Locality	Diamong-bearing	Dia	G5 Grt	G9 Grt	G10 Grt	Mg-Ilm	Mn-Ilm	Drv	Phl	Ol	Cpx	Chr	Reference
Água Suja Mine	Romaria (Brazil)	Vulcanoclastic Breccia	x	x	x	x	x	x	x					This Paper
Pipe Abél Régis	Carmo do Paranaíba (Brazil)	Lamproite	x	x	x		x					x	x	Chaves *et al.* (2009)
Presidente Olegário	Brazil	Probable Lamproite	x				x		x			x	x	Fipke (1991)
Pipe Ymi-1	Valle de Acahay (Paraguay)	Lamproite	x				x		x	x	x	x	x	Presser (2019)
Argyle	Australia	Lamproite	x	x			x	x	x			x	x	Fipke (1991)
Ellandale 4	Australia	Lamproite	x	x	x	x	x	x	x			x	x	Fipke (1991)
Jack	Canada	Lamproite	x	x				x	x			x	x	Fipke (1991)
Prairie Creek	Arkansas (United States)	Lamproite	x	x	x		x		x			x	x	Fipke (1991)
Icó	Braúna Field (Brazil)	Lamproite						x			x		x	Santos (2019)
Areado_002	Mato Grosso (Brazil)	Kimberlite				x	x							Neto *et al.* (2017)
Batovi_006	Mato Grosso (Brazil)	Kimberlite				x	x			x			x	Neto *et al.* (2017)
Collier_004	Mato Grosso (Brazil)	Kimberlite	x			x	x							Neto *et al.* (2017)
Juina_005	Mato Grosso (Brazil)	Kimberlite	x			x	x					x		Neto *et al.* (2017)
Piranhas_001	Mato Grosso (Brazil)	Kimberlite				x	x			x			x	Neto *et al.* (2017)
Pandrea_3	Mato Grosso (Brazil)	Kimberlite	x			x		x						Kaminsky and Belousova (2009)

Dia: diamond; Grt: garnet; Ilm: ilmenite; Drv: dravitic tourmaline; Phl: phlogopite; Ol: olivine; Cpx: clinopyroxene; Chr: chromite (Whitney and Evans 2010).

Mg-rich ilmenite and dravite in the possible lamproite found in Presidente Olegário. While the presence of G10 garnet and Mn-ilmenite is similar the Pandrea_7 pipe in the Juína field (Mato Grosso).

When compared to deposits in Australia, it presents significant mineralogical similarities with the deposit of Ellendale (Australia) from the presence of diamonds, G5, G9 and G10 garnets, Mn-ilmenite and Mg-ilmenite and dravite; Mn-Ilmenite and dravite from Argyle. In comparison to the Jack and Prairie Creek deposits, there are G5 garnets, Mn-ilmenite and dravites, while in the Ymi-1 lamproitic pipe in Paraguay, it presents Mg-ilmenite and dravite.

General implications

The volcanoclastic sequence of the Água Suja Mine (GAR-Mineração and surroundings) has been correlated to the Marília (Chaves and Dias 2017, Seer and Moraes 2017) or the Uberaba Formation (Gravina *et al.* 2002, Gravina 2003).

Chaves *et al.* (2009) worked with the Abel Régis (Carmo do Paranaíba, Minas Gerais state, Brazil) lamproitic intrusion where there is a high concentration of garnets in the G5 and G9 fields of Grutter *et al.* (2004) and MgO-poor ilmenites. Kaminsky and Belousova (2009) identified manganese ilmenite in kimberlitic pipes from to the Juina kimberlitic field (Mato Grosso state, Brazil).G5 garnets are interpreted by Grutter *et al.* (2004) as indicative of a destroyed lithosphere and are also correlated to lamproitic rocks when associated with manganoan ilmenites and dravitic tourmalines (Fipke 1991, Presser 2019).

Considering that lamproites occur mainly associated with mobile belts (Mitchell and Bergaman 1991) and most of the diamond pipes in the the APIP region occur in the Brasília belt, Marini *et al.* (2002), Romeiro-Silva and Zalan (2005) and Zalan and Silva (2007) identified from geophysical methods that below this belt there is a crystalline basement that is undeformed (thin skinned tectonic contex).

The occurrence of G5 and G9 garnets and low-MgO ilmenite in the lamproitic pipe Abel Régis (Chaves *et al.* 2009), can be related to the mineral assembly found in the diamond deposit of Romaria, suggesting a lamproitic source, although primary rock was not found to characterize the representative faciologies of this type of diamond-bearing rock.

CONCLUSIONS

Dravitic tourmalines, G5 G9 and G10 garnets, Mg-rich and Mn-rich ilmenites when associated with the occurrence of diamond corroborate with a possible lamprotic affinity for the deposit, as seen in lamproites from Australia, Canada and Paraguay. The mineralogical assembly described in the diamond deposits of the Romaria and the chemical composition of the analysed minerals are compatible with the diamond stability field, especially the garnets and ilmenites. In addition, there are dravites belonging to the diamond association field (G-I), being described for the first time once G10 garnets and picroilmenites have already been found by Svisero and Meyer (1981), Svisero (1995) and Coelho (2010).

Although the association of the studied minerals with the diamond in the Tauá volcanoclastic breccia give the deposit a lamproitic affinity, the absence of fresh rocks associated to the high concentration of purely kimberlitic bodies in the Alto Paranaíba region and the lack of information on local lamproites makes exact determination difficult. This fact leads us to emphasize the need for further research in the area, seeking to find the possible lamproitic/kimberlitic pipe around Romaria.

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