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ARTICLE

Evidence of young, proximal and primary (YPP) diamond source occurring in alluviums in the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers in Coromandel region, Minas Gerais

Evidências de fonte jovem, próxima e primária (YPP) do diamante que ocorre nos aluviões dos rios Santo Antônio do Bonito, Santo Inácio e Douradinho na região de Coromandel, Minas Gerais

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ABSTRACT: Magmatism associated with the Alto Paranaíba structural high comprises kimberlites, kamafugites, and alkaline complexes, forming an approximately 400 x 150 km NW-SE belt in the southern São Francisco Craton. Dating of some intrusions reveals ages between 120 and 75 Ma. Chemical analyses of garnet recovered in alluvium from traditional diamond digging areas indicate peridotitic garnet windows in Três Ranchos and Coromandel. Six hundred and eighty (680) diamonds acquired or recovered during mineral exploration in the digging areas of Romaria, Estrela do Sul, Três Ranchos and Coromandel show unique characteristics, certain populations indicating young, proximal and primary sources (YPP). Analyses of 201 stones from Santo Antônio do Bonito, Santo Inácio and Douradinho rivers alluvium, Coromandel, present no evidence of transport, characterizing a proximal source. Within these river basins, exposures of the Late Cretaceous Capacete Formation basal conglomerate contain mainly small rounded and/or angular quartzite pebbles and of basic and ultrabasic rocks, as well as kimberlite minerals (garnet, ilmenite, spinel, sometimes diamond). A magnetotelluric profile between the Paraná and Sanfranciscana basins shows that the thick underlying lithosphere in the Coromandel region coincides with the peridotitic garnet window and with a diamond population displaying proximal source characteristics. Diamond-bearing kimberlite intrusions occur in different areas of Alto Paranaíba.

KEYWORDS: kimberlite, diamond, conglomerate, mineral chemistry, mineral exploration.

RESUMO: *O extenso magmatismo associado ao alto estrutural Alto Paranaíba, responsável pela intrusão de kimberlitos, kamafugitos e complexos alcalinos, forma faixa de aproximadamente 400 x 150 km e orientação noroeste-sudeste na porção sul do Cráton do São Francisco. Datações realizadas em algumas intrusões ao longo da faixa mostram idades entre 120 e 75 Ma. Análises químicas de granada recuperada em amostragem aluvionar na região de Coromandel e adjacências, tradicionalmente produtoras de diamante, mostram evidências de janelas distintas de granada peridotítica de alto interesse em Três Ranchos e Coromandel. Estudos de 680 diamantes adquiridos ou recuperados durante programas de prospecção nas principais áreas de garimpo em Romaria, Estrela do Sul, Três Ranchos e Coromandel apresentam características únicas, distintas entre si, em que determinadas populações indicam procedência de fontes jovens, próximas e primárias (YPP). Especificamente em Coromandel, análises de 201 pedras provenientes de aluviões dos rios Santo Antônio do Bonito, Santo Inácio e Douradinho não mostram evidências de transporte, caracterizando fonte proximal. Em diferentes pontos das bacias dos rios mencionados, ocorre o conglomerado basal da Formação Capacete, Grupo Mata da Corda, do Cretáceo Superior, contendo principalmente seixos pouco arredondados e/ou angulosos de quartzito e de diferentes tipos de rochas básicas e ultrabásicas. Granada, ilmenita, espinélio e, em casos restritos, diamante são recuperados no conglomerado. Perfil magnetotelúrico realizado entre as bacias do Paraná e Sanfranciscana mostra litosfera subjacente espessa na região de Coromandel, capaz de preservar diamante, coincidente com a janela de granada peridotítica de alto interesse e com a população de diamante com característica de fonte proximal identificadas na área. Intrusões de kimberlito diamantífero ocorrem em diferentes pontos do Alto Paranaíba.*

PALAVRAS-CHAVE: *kimberlito, diamante, conglomerado, química mineral, exploração mineral.*

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INTRODUCTION

According to Barbosa (1991), Francisco Machado da Silva found the first diamond in Brazil in 1714. The stone was recovered in the São Pedro gold mining, in Machado or Pinheiro stream, near the current town of Diamantina. The chronology of the discoveries in other regions of Minas Gerais or the colony is not clear. In many cases, diamonds appeared on the same occasion in different places of Minas Gerais or even in other areas of the country. Between 1764 and 1781, diamonds were recovered in the regions of Abaeté and Itacambiruçu Valley, in Grão Mongol. In the nineteenth century, especially between 1830 and 1840, diamond deposits were explored in Chapada Diamantina, Bahia. The region became famous for the production of carbonados, which are porous aggregates of gray or black micro diamonds. The carbonado Sérgio, weighing 3,167 carats, was found in Lençóis in 1895 (Franco 1981; Barbosa 1991). Still in the nineteenth century, deposits were discovered in the Bagagem River, west of Coromandel. It was in the alluvial deposits of this river that the 261.88-carat South Star diamond was found in 1853, and the 119.5-carat Dresden diamond was found four years later (Franco 1981; Machado & Figuerôa 1999). Between 1937 and 1943, diamonds over 200 carats were recovered to the east and southeast of Coromandel, more precisely in the alluvial deposits of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers, including the 726-carat Presidente Vargas, considered the largest one discovered in Brazil (Fig. 1) (Franco 1981; Barbosa 1991; Machado & Figuerôa 1999).

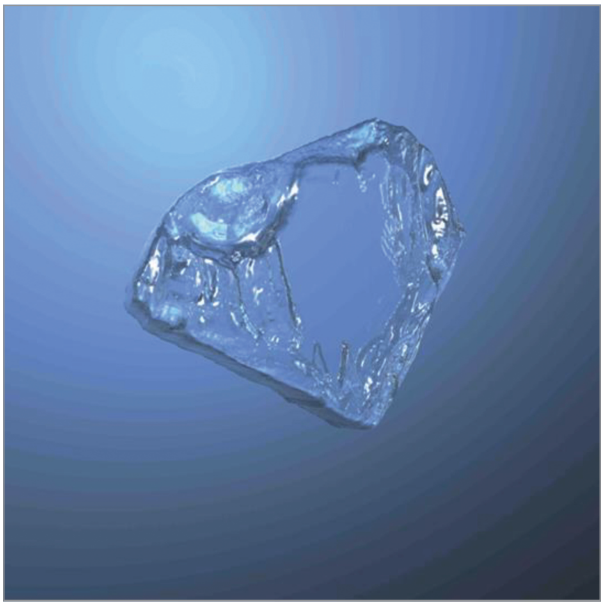

Figure 1. Graphic reproduction of the Presidente Vargas Diamond. Original dimensions 56.2x50x24.4 mm (Machado & Figuerôa 1999).

Most of the diamonds produced in the San Francisco Craton are probably from valley alluvium and terraces associated with the current drainage. Small productions were or are coming from the Mesoproterozoic conglomerates of the Sopa-Brumadinho Formation, in the Diamantina region, and from the Cretaceous conglomerates in Romaria. In the latter, the contribution of kimberlitic material such as rock fragments, minerals, and diamond is such that the diamond recovery is considered to be characteristic of kimberlite. In the Chapada Diamantina region, the diamonds recovered in the alluviums are directly associated with the erosion of the diamond-bearing conglomerates of the Tombador and Morro do Chapéu Formations, similarly to that of the Salobro Formation of the Rio Pardo Group, located about 50 km west of Canavieiras, South Bahia (Pereira 2007).

Although without economic potential, other diamond-bearing units in the São Francisco Craton are the Carboniferous Santa Fé Formation (Campos 1992), the Neoproterozoic Jequitaí and Samburá Formations and parts of the Neoproterozoic Ibiá (Gonzaga *et al.* 1994) and Macaúbas (Karfunkel *et al.* 2001) groups.

Kimberlite occurs in the northern and southern portions of the São Francisco Craton (Fig. 2) (Pereira 2007). In the northern portion, the intrusions are located in the Serrinha and Gavião blocks. The Braúna 03 kimberlite, classified as diopside-phlogopite kimberlite and located in the Braúna province, in the central Serrinha block, has been dated at 682 ± 20 Ma (Rb-Sr on phlogopite). In the Gavião block, the kimberlites are located near Barra do Mendes, close to the area of influence of the extensive Barra do Mendes-João Correa lineament that divides the Chapada Diamantina into east and west structural domains. The Rb-Sr dating on phlogopite of the Salvador 01 kimberlite provided an age of 1,152 Ma (Williamson & Pereira 1991; Pereira & Fuck 2005). Although sub-economic, the Salvador 01 kimberlite contains diamond. Recent evaluations of the Braúna 03 kimberlite indicate mine opening in this body (Donatti Filho *et al.* 2013a, b).

Unlike the Proterozoic kimberlites from the northern portion of the craton with predominant kimberlites over related rocks, the intrusions of the southern portion show Early and Late Cretaceous ages with widely predominant kamafugites over kimberlites.

Chemical analyses of kimberlite minerals recovered from alluvial sampling in the areas affected by Cretaceous magmatism in the southwestern portion of the São Francisco Craton, covering parts of Minas Gerais, São Paulo, and Goiás, allow delimiting peridotitic garnet windows, mainly of G9 lherzolitic-type, the pressure values of which, at the time of crystallization, are compatible with those of the diamond formation stability field, recorded in thick lithosphere. Geochemical data of minerals from the several kimberlite clusters found in the garnet window outlined in the Coromandel region evidence that the mantle at the time of intrusion presented temperatures between 960 and 1,200ºC and minimum garnet pressure values between 41 and 50 kbar. Comparison of garnet pressure values with data of clinopyroxene recovered from the kimberlite clusters indicate geothermal gradients of approximately 37–43 mW/m² for SCL6 and DDO4 kimberlites (Pereira 2007). The high temperatures recorded in clinopyroxene reflect probably local little depleted lherzolitic mantle, suggesting that, aside of Mesozoic mantle fertilization, the possibility of little depleted mantle should also be considered in the region. According to Gurney (1984), just 15% of peridotitic garnet inclusions in diamond correlate with lherzolitic garnet (or G9), whereas in global scale 85% of peridotitic garnet inclusions are of Ca-poor, Cr-rich harzburgitic (G10) type. Also, studies on the origin of diamonds recovered in mineral exploration campaigns or acquired in the different diggings show different characteristics. Some populations indicate YPP sources (Robinson 1991; Robinson *et al.* 1995; Pereira 2007). In the specific case of the alluvial diamond batch recovered in the Santo Antônio do Bonito, Santo Inácio, and Douradinho rivers, about 90% of the stones display no signs of transport, which together with the 12 diamonds presenting fragile or twinned forms suggest local primary sources.

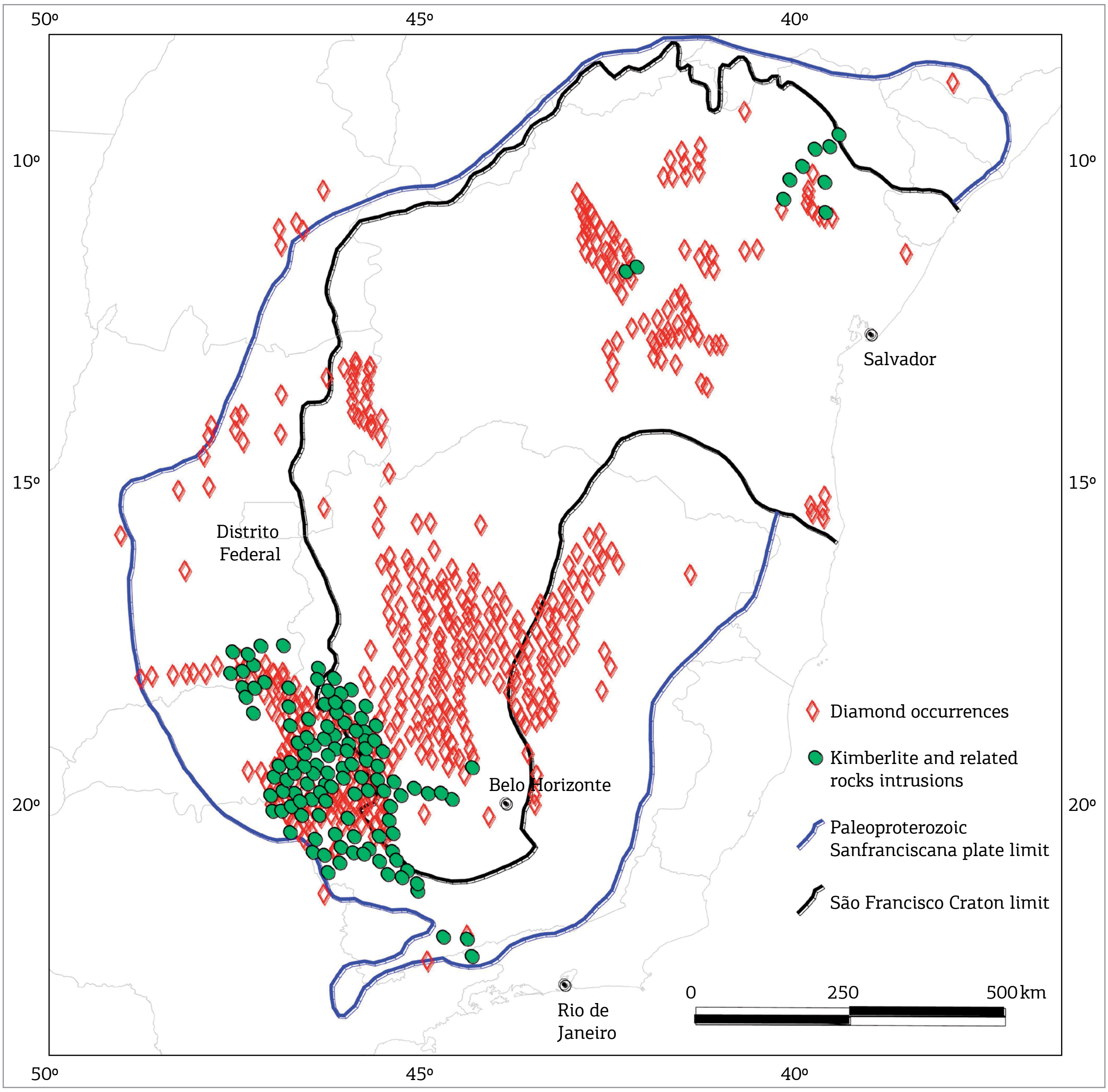

Figure 2. Diamond, kimberlite and related rocks distribution within the Sanfranciscana plate and São Francisco Craton (Pereira 2007).

The objective of this work was to point out and address details observed in the studied region in Minas Gerais, to suggest local/proximal sources for the unique diamond population found in the alluvial deposits of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers.

GEOLOGICAL AND STRUCTURAL SETTING

The evolution of the São Francisco Craton is marked by Paleoproterozoic orogeny, responsible for the amalgam and deformation of different Archaean blocks (Barbosa & Sabaté 2002, 2004; Alkmim & Teixeira 2017; Teixeira *et al.* 2017). The relatively stable geotectonic unit, comprising Paleoproterozoic and Archaean terrains, was partially reworked during the Brasiliano Orogeny in the Neoproterozoic. Polyphasic histories of the terrains are common in the northern and southern portions of the craton (Pereira 2007).

The crystallization and preservation of diamonds until their capture by kimberlite and/or lamproite require the presence of a thick, relatively cold, refractory, low-density peridotitic root isolated from heating and tectonic reworking (Haggerty 1986). These requirements are found in most Archaean terrains little affected by processes such as plumes, volcanism recurrence in extensional regimes, and collisions that destroy the favorable mantle regions under the Archaean-Paleoproterozoic cratons. The identification of such terrains is important in the exploration of diamond-bearing kimberlite.

Although it is not possible to establish a precise and continuous boundary between the reworked and preserved Archaean terrains in the southern portion of the São Francisco Craton, certain evidence allows to point out the least affected core during the Neoproterozoic Orogeny. This portion of the craton is characterized by the presence of Archaean terrains consisting of partially migmatized orthogneiss and sequences of volcano-sedimentary rocks developed between 3,200 and 2,700 Ma. Apparently, between 2,160 and 2,000 Ma, the edges of this set of rocks were partially reworked and incorporated in the Mineiro Belt, developed into an arch-shaped belt around the Archaean core (Alkmim & Marshak 1998) (Fig. 3). Numerous intrusions related to the evolution of the Mineiro Belt aged between 2,200 and 2,000 Ma and occur along the belt. It appears that the reworking inflects northward, under the Bambuí Basin to the Januária region, where the gneiss outcrop is aged 2,710 ± 7 Ma, and non-deformed granite dated at 2,163 ± 13 Ma (Pereira 2007) is exposed. Paleoproterozoic ages are also recorded further north, in Correntina and São Domingos (Rendon & Kuyunjian 2005). Therefore, the data suggest a basement composed of Paleoproterozoic-Archean terrains in the western portion of the São Francisco Craton, under the rocks of the Bambuí Basin. The craton boundary to the west corresponds to extensive thrust faults marking the transition between the fold- and thrust belt involving basement and the sub-horizontal covers inside the craton during the Brasiliano Orogeny in the Neoproterozoic, when the closure of the basins generated the marginal Brasília Belt (Dardenne 2000; Fuck *et al.* 2017). Seer *et al.* (2001, 2005) stated that the Araxá, Ibiá and Canastra groups, belonging to the southern sector of the Brasília Belt (Fuck 1994; Fuck *et al.* 2017) represent distinct tectonostratigraphic terrains, with no apparent genetic link, originated by tectonic transport of different geographic regions. The same authors classified these groups as tectonic slices formed of three types of terrain:

1. Canastra terrain - fragments of passive continental margin;
2. Ibiá terrain - fragments of a sedimentary portion of the volcanic arc;
3. Araxá terrain - fragments of oceanic crust intruded by collisional granites (Fig. 3).

Apparently, the tectonic sheets formed of these terrains and thrown from west to east against the edge of the craton during the Brasiliano compression did not affect the Paleoproterozoic-Archean basement of the São Francisco Craton, except, perhaps, in the Araxá terrain, where crustal melting took place. This inference is supported by the occurrence of diamond-bearing intrusions in the region.

The extensive magmatism associated with the development of the Alto Paranaíba structural high occurs along the Brasília Belt, from the Catalão region to the Passos Nappe or the southern end of the Bambuí Basin (Fig. 3) (Pereira 2007).

OBSERVATIONS ON THE ALTO PARANAÍBA, ASSOCIATED MAGMATISM, AND DIAMONDS

The Alto Paranaíba structural high, developed during the Mesozoic, divides the Paraná basin to the west and Sanfranciscana basin to the east. The main divide extends along the Brasília Belt; the northwest end borders Catalão while the southeast portion borders the vicinity of the Serra Negra intrusion. The extension caused by the arching probably moved the Brasiliano thrust/reverse faults along their planes, creating zones of magmatic permeability. Kimberlite and lamproite are usually located in such areas, characterized by successive intrusions of igneous rocks (Kaminsky *et al.* 1995). In certain cases, high permeability zones of the crust correspond to elongated areas, where horst- and graben-type structures show evidence of the extensional regime.

The magmatism responsible for the occurrences of kimberlites, kamafugites and alkaline complexes, known as the Alto Paranaíba Igneous Province (Gibson *et al.* 1995), covers an approximate 400 x 150 km northwest-southeast oriented band, in the southwest portion of the São Francisco Craton, where kamafugites largely predominate over kimberlites and alkaline complexes.

The quality of the lithospheric mantle in a given region can be monitored by analyzing the recovered minerals in the different volcanic pulses associated with the development of the system (O'Reilly & Griffin 1996). In the Alto Paranaíba region, the contrasting quality of the mantle sampled by kimberlite, aged between 120 and 90 Ma, compared to the Late Cretaceous kamafugites, aged between 85 and 75 Ma, indicates heating and thinning of the lithosphere in the area affected by the structural high. Pressure-temperature (P-T) results obtained on kimberlite-extracted clinopyroxene recovered at the headwaters of the Abaeté, São Bento, and Indaiá rivers, near Carmo do Paranaíba and Lagoa Formosa, and in the Coromandel region, indicate sampling in mantle regions between 700 and 950°C, while kamafugite-source clinopyroxene shows temperatures of 800 and 1,200°C, substantially warmer than that recorded by recovered kimberlite-clinopyroxene. Therefore, in the approximate 5 Ma range, between 90 and 85 Ma, about 250°C heating is observed in these regions (Read *et al.* 2003) (Figs. 4 and 5). Thus, comparisons of the mantle conditions obtained in successive kimberlite generations allow monitoring the evolution of the lithosphere and the diamond potential of a certain region (O'Reilly & Griffin 1996). According to Helmstaedt and Gurney (1994), information on lithospheric mantle conditions is also obtained by diamond abundance, garnet with high Cr_2O_3 and low CaO, and high Cr spinel (Cr> 60% wt%) recovered in the intrusions. As mentioned before, local little depleted lherzolitic mantle in the region should not be discarded. The presence of such a mantle would explain the abundant dissemination of lherzolitic garnet in the Coromandel area.

The thinning of the lithosphere and consequent alteration of the diamond stability field due to temperature increase between the Early and Late Cretaceous in Alto Paranaíba is evident when the analysis results of minerals from kimberlites are also compared to the Late Cretaceous rocks intruded into stable Archaean terrains, where the underlying lithosphere is preserved. This is observed, for example, in the same southern portion of the São Francisco Craton, where the garnet formation pressure increases as the kimberlite intrusions move from reworked terrain to a preserved Archaean area, as shown by the red arrow in Figure 3. Even inside the Archean terrain,

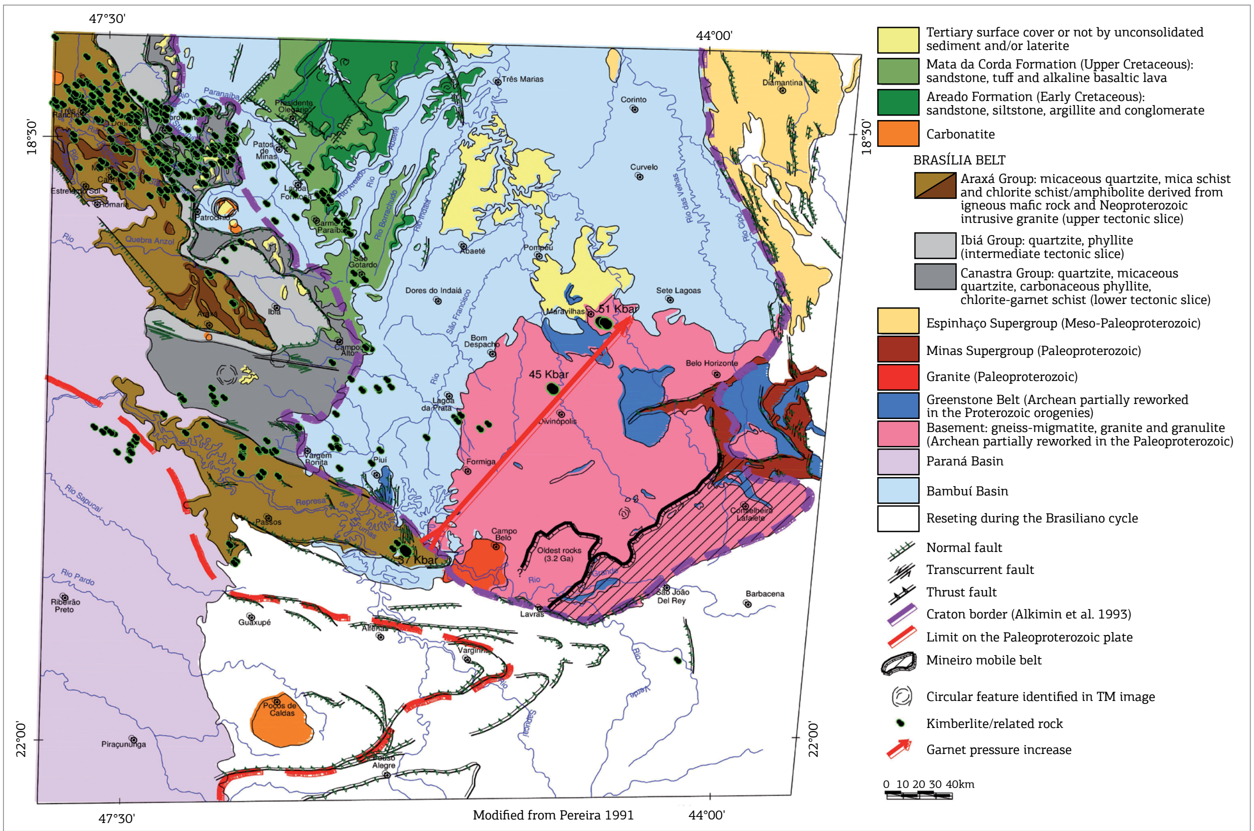

Figure 3. Distribution of kimberlite-related rock in the southern portion of the São Francisco Craton and Paleoproterozoic Mineiro Mobile Belt (modified from Pereira 2007).

mantle quality varies visibly as intrusions are placed more and more in the center of the preserved core. For example, analyses of Junco 01 kimberlite from Junco Province, aged 82 ± 5 Ma (U-Pb in zircon), show 5% spinel of high interest, 0.5% of subcalcic garnet and is negative for diamond, while the Maravilhas 03 kimberlite from the Maravilhas Province, aged 81 ± 2 Ma (Ar-Ar in garnet), indicates 30% spinel with high chromium, 6.3% of subcalcic garnet and a diamond content of 13.48 ct/100 t (Pereira 2007).

Mineral exploration programs in the Alto Paranaíba region identified primary sources of diamond-bearing alluvium, explored for years as digging areas. This fact is verified, for example, in the Vargem Bonita diggings in the high course of the São Francisco River, where alluvial sampling in the riverbed and different terraces along the diggings provided kimberlite minerals showing practically no signs of transport, and diamond with proximal source characteristics. Batches of diamonds recovered from alluvium and terraces along the diggings in material that originated from the Canastra 01 kimberlite, located near the upstream Cachoeirinha stream tributary, show octahedron and dodecahedron-shaped crystallization and stone corrosion characteristics common to the two environments (Pereira 2007). The digging areas of Vargem Bonita stretch for about 35 km along the São Francisco River, starting from the Casca D'Antas waterfall. It is estimated that 500,000 carats were produced between the 1930s and ~2000. Preliminary data indicate an intrusion area of 1.9 hectares, while significant grades are restricted to 0.9 hectare. Evaluations indicated about 40 cts/100 t valued at US$ 150/ct. Systematic alluvial sampling performed in every kilometer of the valley and in the tributaries of both banks of the São Francisco River shows no new

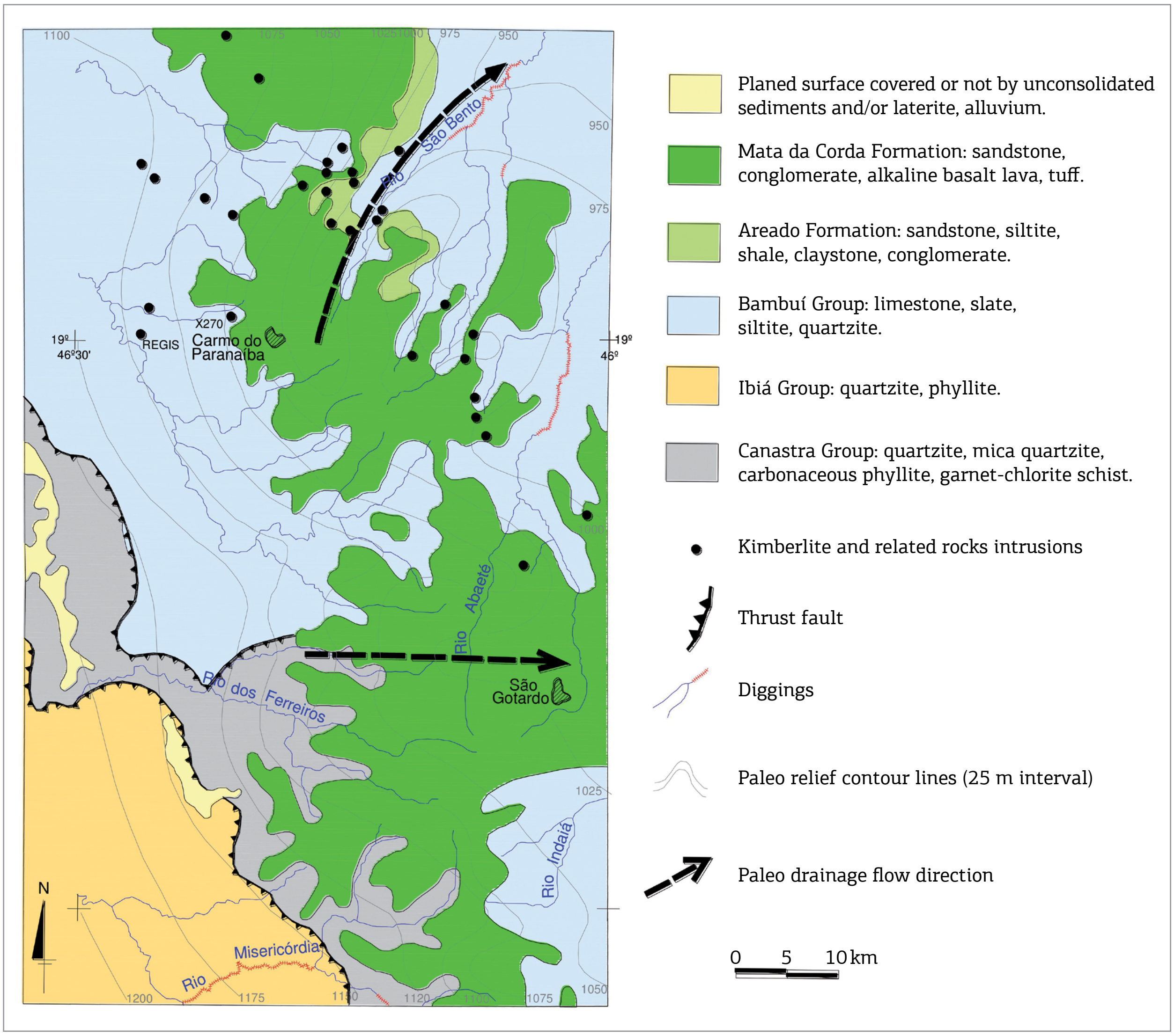

Figure 4. Kimberlites in the headwaters of the São Bento, Abaeté and Indaiá rivers. Contour lines represent post-Gondwana or before Mata da Corda Formation deposition paleo relief (Pereira 2007).

populations of kimberlite minerals or diamond, indicating that the Canastra 01 kimberlite constitutes the primary and only source of the diamond in the Vargem Bonita digging (Figs. 6 and 7) (Pereira & Neves 1996; Pereira 2007).

As in the case of Vargem Bonita, diamond batches recovered from the São Miguel River show that colored octahedral and dodecahedral-shaped diamonds, without transport signs, are dominant. A terrestrial magnetometry survey with a 25 x 10 m grid detected the Três Ranchos kimberlites (TRS) 101, 102, 104 near the diggings and about 20 km northeast of the Três Ranchos 04 kimberlite (Fig. 8). A 14 m^3 sample from the TRS 101 intrusion yielded 31 diamonds with 0.031-carat average weight, while a 9 m^3 sample from the TRS 102 intrusion

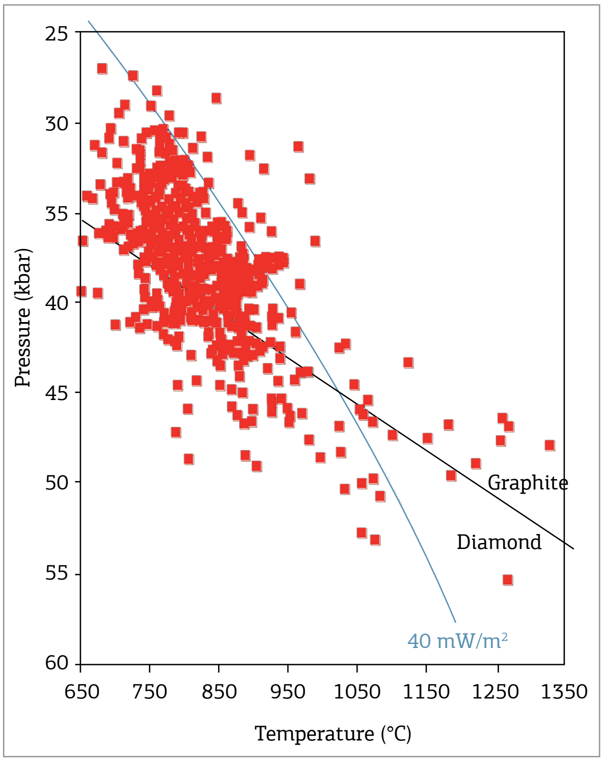

Figure 5. Pressure and temperature calculation of 517 garnet grains from the X-270, Regis, Vargem and Santa Rosa 04 kimberlites (modified after Read *et al.* 2003). Graphite and diamond fields are shown.

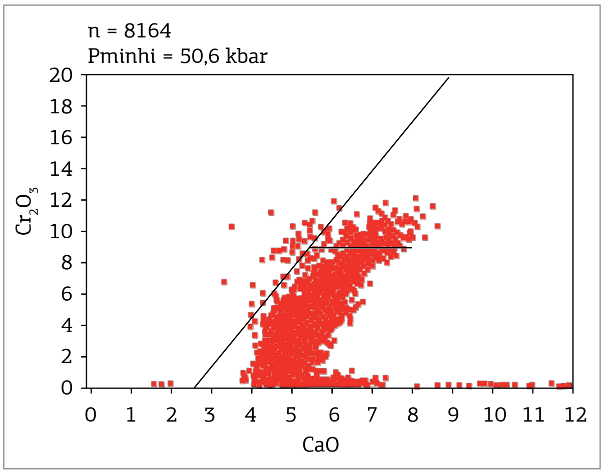

Figure 7. Cr2O3 x CaO diagram of garnet recovered from the Canastra 01 kimberlite (Pereira 2007).

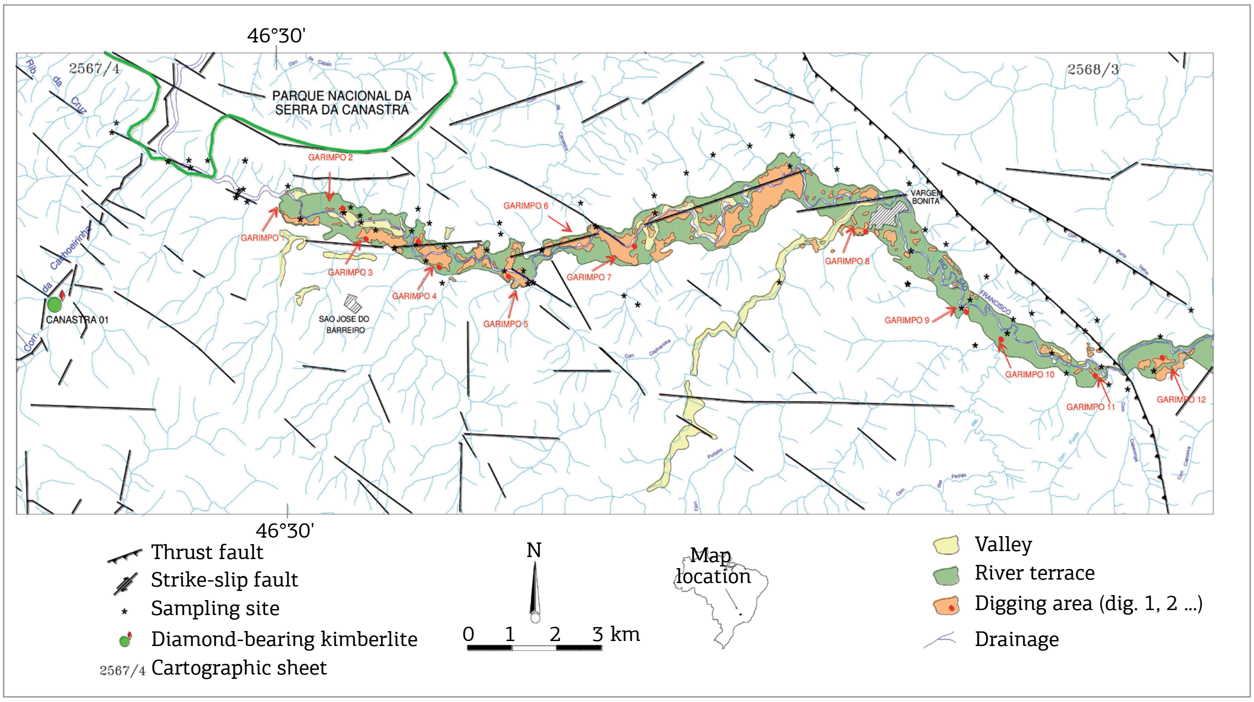

Figure 6. Alluvium sampling in digging areas and along São Francisco River tributaries and from the Canastra 01 (CAN 01) kimberlite, primary and single diamond source (modified from Pereira 2007).

provided 49 stones with 0.037-carat average weight. The diamonds recovered from kimberlite are dominantly dodecahedral and octahedral colored stones, very similar to those recovered in the digging. Cubic diamonds represent 10% of the population recovered in TRS 101, and 4% in TRS 102 intrusions. These kimberlites are considered the primary sources of the diamond diggings in the São Miguel River (Skinner 1996) and are, currently, being economically evaluated.

The diamond-bearing Três Ranchos 04 kimberlite (Fig. 8), aged 95 Ma, consists of a small intrusion, considered as one of the oldest discoveries in the region. Processing of 296 m^3 of rock material provided 371 diamonds. About 50% of the stones are described as gray and black in color and 30% as lighter-colored cubes, typical samples of mantle regions at the limit of the diamond stability field, around 44 kb pressure and about 1,000°C temperature. Analyses of recovered garnets indicate pressure values of at least 51 kbar (Pereira 2007).

In 1868, a diamond discovery on the banks of a small affluent stream of the Bagagem River gave origin to the mine and the village known as Água Suja, currently, the town of Romaria. The discovery site and the small stream are presently within the Romaria urban site (Fig. 3).

Svisero *et al.* (1981) and Fleischer (1998) described the geological features in the area around the mine. The authors refer that diamonds occur in a polymictic conglomerate containing blocks up to 80 cm in diameter and little rounded pebbles of micaschist, phyllite, quartzite, metabasite, Botucatu sandstone and basalt. Locally, the Tauá conglomerate is deposited on the aeolian Botucatu sandstone, which, in turn, covers discordantly the underlying Araxá Group micaschists and intrusive granites that serve as basement in the area (Fig. 9). The Tauá conglomerate is covered by another polymictic conglomerate called Secondina, which contains less diamond, smaller pebbles and has maximum thickness of 3 m, and which is probably the result of erosion of the Tauá conglomerate and subsequent deposition. The conglomerates are covered with a homogeneous succession composed of fine- and coarse-grained greenish sandstones, associated in this region of Minas Gerais with Late Cretaceous volcanic activity. Finally, the entire area is

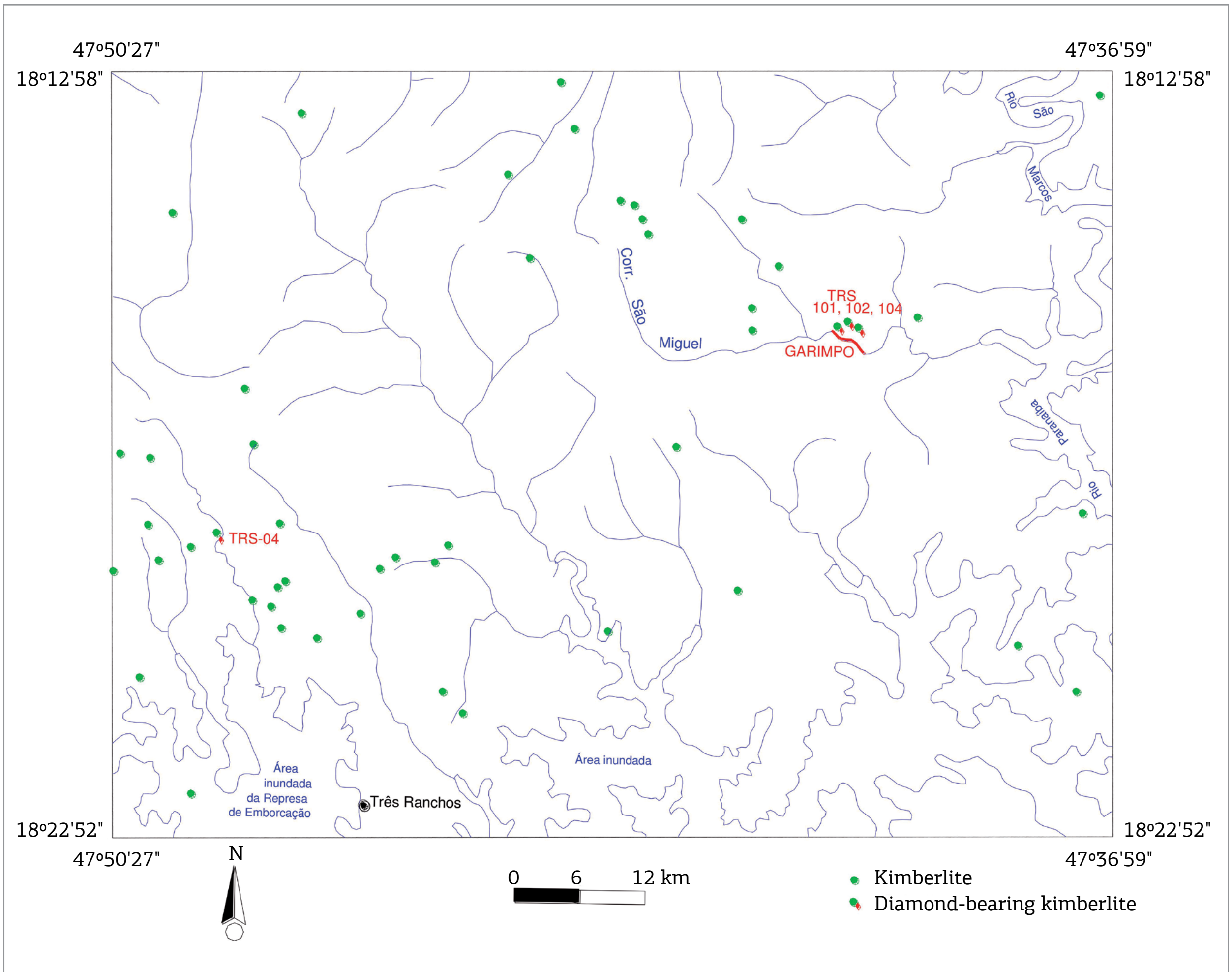

Figure 8. TRS-04, TRS-101, 102, 104 diamond-bearing kimberlites and the São Miguel River digging (Pereira 2007).

covered with unconsolidated Tertiary material formed of laterite, sandstone pebbles, laterized conglomerate blocks and clays (Pereira 2007).

Exposure of the working front of the Água Suja mine allowed Draper (1911), who already knew kimberlites in South Africa, to describe the geological units in detail. The good local exposure shows that the basal portion is composed of micaschist containing staurolite, garnet, rutile, tourmaline, cut in all directions by pegmatite veins and intrusions of mafic rock metamorphosed to amphibolite. According to Draper (1911), the conglomerate or breccia, with a maximum thickness of 13 m, rests discordantly on the basement and local intrusions, as well as on the sandstone. The unit is formed of angular or little-rounded fragments of basic igneous rock, granite, quartz, shale, and sandstone, cemented by red clay. Layers and masses of opal are observed in the conglomerate. Diamond, pyrope, perovskite, magnetite, ilmenite, and olivine occur in the clayey material that cement the fragments. According to the author, the conglomerate layer or breccia, as well as the minerals present, is of local origin.

Currently, the GAR Mineração company investigates the area of the former Água Suja mine. With the geologist and company director, Juliano Magalhães Macedo, we examined drill core samples and visited work fronts, where material is extracted for processing and diamond recovery. The high contribution of kimberlite fragments is noted in the material and, according to Juliano Macedo, thin layers, which are characteristic structures of epiclastic kimberlite, are observed in certain work fronts. The drill core samples represent a typical breccia in which kimberlite fragments examined under magnifying glass show abundant ilmenite and/or spinel (Fig. 10).

Based on the treatment plant recovery, Svisero and Meyer (1989) reported that the diamond content in the conglomerate ranged between 0.04 and 0.12 ct/m^3. A studied batch of 5,317 stones weighed 450 carats, corresponding to 0.084-carat average weight. The dominant shape is rhombododecahedron, followed by cube, octahedron and octahedron-rhombododecahedron combination. In Romaria, De Beers purchased a batch of 39 diamonds that weighed 3,508 carats, a 0.09-carat average weight. The diamonds were dominantly rounded dodecahedron and octahedron, while cube-shaped stones were between 10 and 15% (Robinson 1991; Robinson *et al.* 1995). According to the authors, the batch can be described as a mixture composed of cubic and dodecahedral stones of gray color, similar to the population from Três Ranchos 04 kimberlite and a distinct population, comprising mainly rounded dodecahedra. Abrasion is not evident, which could suggest either distal sources of diamonds transported under low energy systems (Robinson 1991) or, as indicated by other evidence, a YPP source of diamonds. Systematic sampling and concentrates analyzed in Romaria digging areas indicated garnet with pressure values of about 48 kbar and spinel grains typical of inclusions in diamonds (Fig. 11) (Pereira 2007).

The identification of diamond-bearing kimberlite in different areas of Alto Paranaíba makes it clear that kimberlite intrusions, especially of the Early Cretaceous, sampled mantle regions favorable to the crystallization and preservation of diamond.

The Três Ranchos 04, Três Ranchos 101, 102, 104 kimberlites and the primary source of Água Suja diamond in Romaria, responsible for the cubic diamond populations in the region, intruded into the Araxá Group terrain, where Neoproterozoic intrusions of collisional granites indicate crustal melting. This fact may be an indication that the Paleoproterozoic-Archaean lithosphere has undergone some alteration at the western edge of the São Francisco Craton, favoring crystallization of cubic diamond (Pereira 2007).

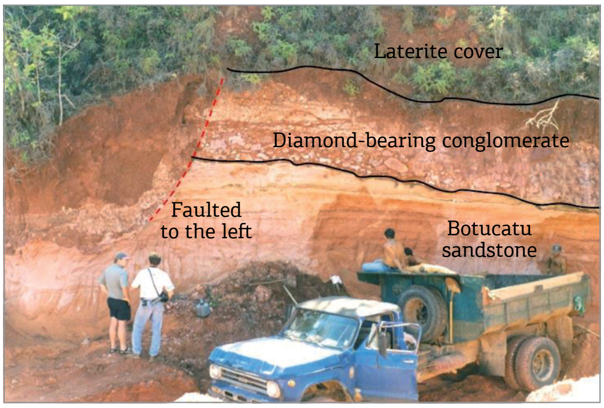

Figure 9. Diamond-bearing conglomerate overlying Botucatu sandstone in the old Água Suja digging, Romaria. Note down-thrown block to the left along a normal fault; such structures are commonly observed in the Alto Paranaíba high (Coelho *et al.* 2010).

Figure 10. Exploitation of diamond-bearing conglomerate near Romaria. Evaluation of conglomerate and epiclastic kimberlite by GAR Mineração.

BASAL CONGLOMERATE OF CAPACETE FORMATION, MATA DA CORDA GROUP

As mentioned above, the development of Alto Paranaíba structural high in the Mesozoic was responsible for magmatic events, comprising kimberlites, kamafugites, carbonatites and related rocks, which constitute hundreds of individual intrusions along an approximately 400-km-long northwest-southeast trending belt. The sedimentary-magmatic sequence occurring along the Brasília Belt and the edges of the Paraná and Sanfranciscana basins is, to some extent, limited by the development of the extensional regime, where horst and graben are characteristic structures in the evolution of linear structural highs.

The basal conglomerate of the Capacete Formation (Sgarbi *et al.* 2001), or Tauá as it is known in Romaria, is widespread in the Alto Paranaíba. The deposition occurred on a rugged relief, where paleo channels and lowered blocks along normal faults are recorded in the Araxá Group micaschist and/or in the Botucatu sandstone that discordantly covers the Proterozoic rocks of this group in Romaria (Fig. 9).

Exposures along the work fronts during diamond exploration in the old Água Suja mine allowed Draper (1911) and Svisero *et al.* (1981) to observe rocks and their contact relationships *in loco*. Thus, Draper (1911) concluded that the conglomerate or breccia layer, and the minerals present are of local origin. The author enumerates some facts for this assertion:

- The Tauá conglomerate, local name for the conglomerate, is composed of rocks found *in situ*, underlying portions of the conglomerate layer itself.
- Fragments of the rocks that make up the conglomerate are angular, indicating little transport.
- Occurrence of conglomerate blocks within the Botucatu sandstone, whose deposition extended from the Triassic-Jurassic to the beginning of the Cretaceous, showing the contemporaneity of the two units in the final deposition phase of the Botucatu sandstone.
- The deep weathering observed in every Tauá layer cannot be attributed to the infiltration of surface water. Besides the intense decomposition of the layer, the igneous rocks of the local basement are also totally altered.

The age of the intrusion could not be determined because the kimberlite conduit was not found; however, intrusions in the local stratigraphy indicate an Early Cretaceous age for the hidden body.

On eastern Alto Paranaíba, the western border of the Sanfranciscana Basin, the crater facies of the X-270 kimberlite, dated at 89.5 ± 3.4 Ma, shows sandstone clasts, and quartz and feldspar grains, confirming the presence of semi-consolidated sediments from the Early Cretaceous Areado Group (Fig. 4) (Read *et al.* 2003).

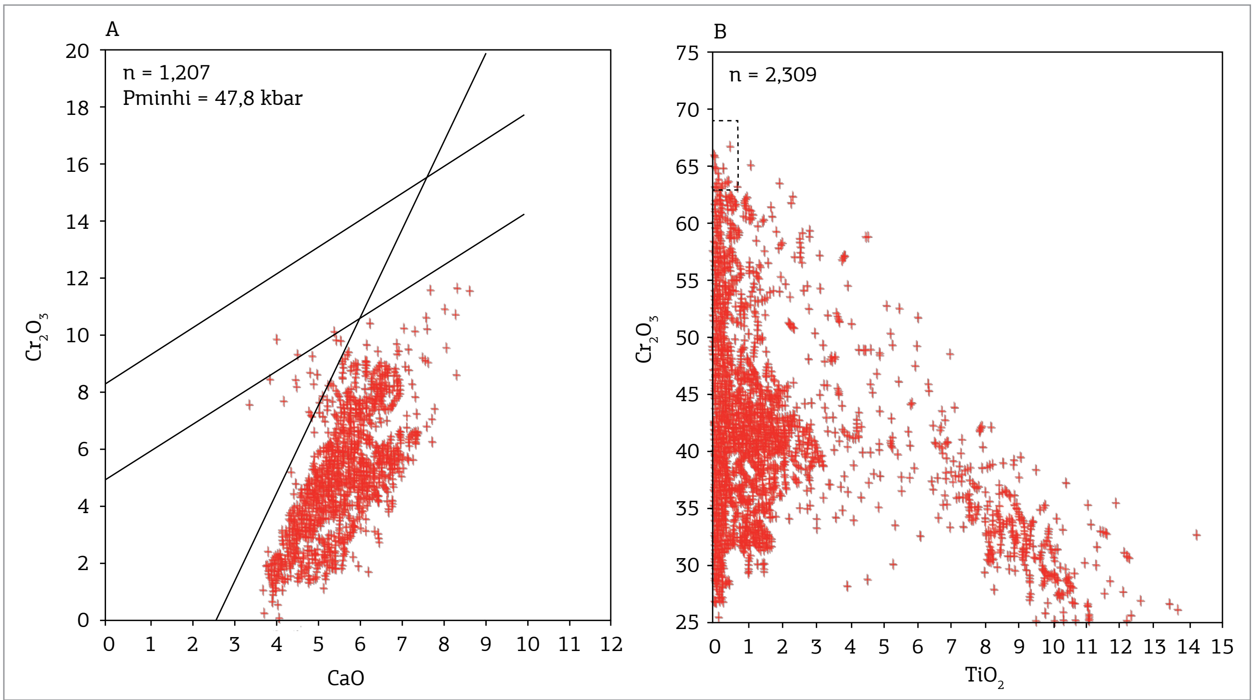

Figure 11. Analyses of heavy mineral concentrates recovered from conglomerates and digging areas in Romaria: (A) garnet, (B) spinel (Pereira 2007). Higher Cr2O3 concentrations in garnet correspond to equilibrium conditions in greater depths within the lithosphere mantle and consequently higher pressures.

The basal conglomerate of the Capacete Formation is exposed in several parts of the structural high, with thickness varying between 15 and 20 m (Fernandes *et al.* 2014). In Romaria, the maximum thickness is 13 m, consisting of boulders and angular pebbles of micaschist, phyllite, quartzite, metabasite, granite and Botucatu sandstone, cemented by clayey material containing diamond, garnet, perovskite, magnetite, ilmenite and olivine (Draper 1911; Svisero *et al.* 1981; Fleischer 1998). The larger or smaller presence of quartzite, sandstone and siltstone pebbles and other Proterozoic rocks vary according to the bedrock or rocks of the Araxá, Ibiá and Canastra groups underlying the conglomerate. Angular pebbles and/or fragments of volcanic rocks, as well as kimberlite minerals, bordered by alteration or with a keliphitic corona, characteristic of little transport, are frequently found in outcrops close to intrusions inferred beneath the conglomerate.

The old digging known as Canastrel, between the Santo Antônio do Bonito and Santo Inácio rivers, was developed directly on the conglomerate. The exposed outcrop shows at least a 3-m-thick alternation between tuff and conglomerate material. In some cases, the conglomerate grades to coarse-grained, commonly cross-laminated sandstone. Clasts of volcanic and Proterozoic rocks, about 20 cm in diameter, are present in the conglomerate layer. As in other outcrops, the top of the succession is covered by thick lateritic material. The brown matrix of the conglomerate bears altered feldspar and phlogopite (Karfunkel *et al.* 2014). Garnet and ilmenite mantled above 50% by alteration material are recovered in the soil along the outcrop, meaning practically no transport. The clasts observed in the conglomerate diggings and in other exposures in the region do not show any sorting as to pebble size increase from the top to the base next to the bedrock (Fig. 12). According to Karfunkel *et al.* (2014), the last owner recovered 3 stones in the digging, weighing about 2 carats. Analyses of two of the stones indicated white and yellow colored, gem-type diamonds weighing 0.750 and 0.497 carats, respectively, and possibly dodecahedral (Karfunkel *et al.* 2014). As for surface features associated with transport, the authors reported absence of percussion marks and severe breakage, reflecting completely different transport and deposition histories from what is observed, for example, in Diamantina diamonds (Karfunkel *et al.* 2014). Although analyses of only two stones do not represent statistical data, the results are very similar to those obtained by Robinson *et al.* (1995) on 201 diamonds from alluvium of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers. Also, kimberlite ilmenite and garnet with keliphitic coronae or with almost intact alteration mantles were recovered in the Canastrel digging, indicating absence of transport (Karfunkel *et al.* 2014).

Figure 12. Detail of basal conglomerate of the basal Capacete Formation in the Canastrel digging. Note the lack of pebble sorting from top to base.

DIAMOND-BEARING ALLUVIUM

Recovery of diamond with other kimberlite minerals in alluvium does not imply in common primary source. As a rather robust mineral, diamonds resist to transport over large distances, being incorporated into sediments carried along different drainages by capture processes and, therefore, in the majority of cases, without any genetic link with the other kimberlite minerals present in the deposit. However, the agreement between certain localities of diamond and kimberlite occurrences in the San Francisco Craton is not random (Fig. 13).

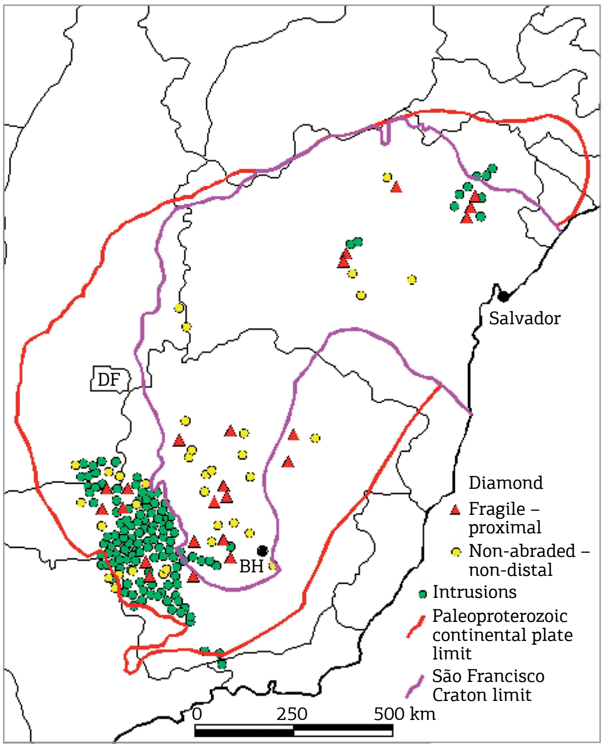

Figura 13. Diamond provenance study in occurrence areas in the São Francisco Craton (Pereira 2007).

Detailed studies on diamond origin, alluvial deposits and analyses of thousands of kimberlite minerals show that diamonds contained in Cenozoic deposits in certain areas of the southern portion of the craton originate directly from identified primary sources. The diamonds contained in the Cretaceous Tauá conglomerates in Romaria and in the basal conglomerate of the Capacete Formation, in other areas of the Santo Antônio do Bonito, Santo Inácio and Douradinho river basins, are considered as originating directly from local primary sources, which were not properly located up to now (Pereira 2007).

As emphasized above, diamond-bearing kimberlites, especially those aged between 120 and 90 Ma, occur in different points of Alto Paranaíba, some of them constituting the primary sources of diamonds recovered in alluvial deposits associated with the current drainage and exploited as digging areas.

The peridotitic garnet window of high interest inferred in exploration of diamond-bearing kimberlite corresponds to kimberlite clusters located in the Coromandel region, some of which hidden beneath the conglomerate (Pereira 2007).

The main sources of alluvial diamond deposits in the drainage to the south and southeast of Coromandel, especially in the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers, are the basal conglomerates of the Capacete Formation and rocks of the Araxá, Ibiá and Canastra groups, which serve as bedrock for the conglomerates (Fernandes *et al.* 2014; Karfunkel *et al.* 2014). Also, kimberlites of different ages, kamafugites and related rocks contributed to the formation of the alluvium associated to the current drainage. In certain diggings, it is possible to recognize fragments or pebbles of kimberlites with marked characteristics. For example, in the diggings of the Vendome Mines company, the small mounds of pebbles and fragments of extremely silicified kimberlite observed in the yard of the treatment plant, or "*osso de boi*" ("ox bone") as called by the diggers, come from the erosion of an extensive strip of silicified kimberlite, consisting of dikes and blows, that extends for more than 10 km along the roughly north-south right bank of the Santo Antônio do Bonito River (Figs. 14 and 15). Currently, digging activities in the region are restricted to the river terraces, as it is forbidden to throw tailings in the active bed of the drainage.

Among the rivers and tributary streams carrying the same diamond population in the region, the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers are the most important ones. The largest diamonds in the country were found in this area (Fig. 16). The average value of the stones from Coromandel ranges from US$ 200.00 to US$ 300.00/ct (Pereira 2007).

The batch of 201 diamonds studied shows a unique characteristic, totally different not only from the stones from the southern portion of the São Francisco Craton but also from other regions in Brazil. Typically, the stones are brown, occasionally yellow or gray, and usually distorted. The rounded dodecahedron shape is the most common one, with no remnants of octahedral and cubic faces. Finely spaced lamination lines and zig-zag patterns are quite common. About 90% of the diamonds do not show evidence of transport, a fact that, added to the 12 stones with fragile shapes or twinning, suggests proximal and primary source. The provenance study of this batch emphasizes that no peculiar differences were detected in any of the streams that indicated individual populations. In addition, inclusion of silicates or olivine and garnet are rare, while sulfide was found only in two stones (Robinson *et al.* 1995; Pereira 2007).

The peridotitic garnet window of high interest inferred in exploration of diamond-bearing kimberlite and alluvium is corroborated by the magnetotelluric profile surveyed between the Paraná and Sanfranciscana basins (Bologna *et al.* 2006).

Figure 14. Kimberlite outcrop at the beginning of the more than 10 km long, grossly north-south silicified belt along the Santo Antônio do Bonito River right bank.

Figure 15. Fragments and blocks of silicified kimberlite at Vendome Mines processing plant.

The profile extends for 180 km in the WSW-ESE direction, and crosses the igneous rocks associated with the Alto Paranaíba high close to Coromandel. In this region, the data show the underlying lithosphere with a thickness of about 150 km (Bologna *et al.* 2006), coinciding with the peridotitic garnet windows and with the unique diamond population bearing proximal and primary source characteristics (Fig. 17). As it is known, the diamond stability field in the

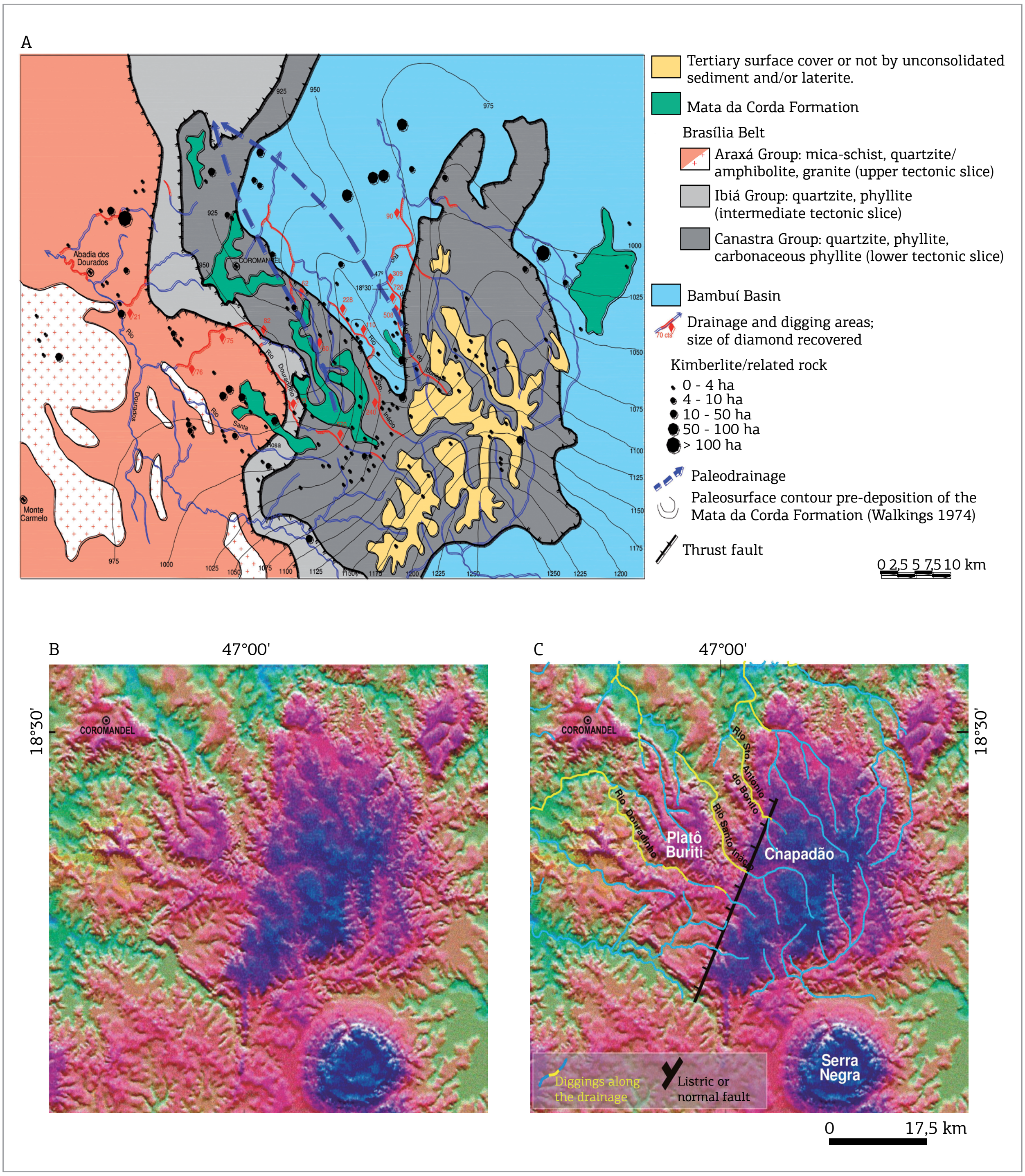

Figura 16. (A) Large dodecahedral diamonds recovered in the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers in the Coromandel area; (B) digital terrain model of the Chapadão area; (C) positioning of normal fault in relation to the start of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers diggings and localization of the Buriti plateau within the downthrown block to the west of the fault. Note absence of diggings on the east side of the Chapadão.

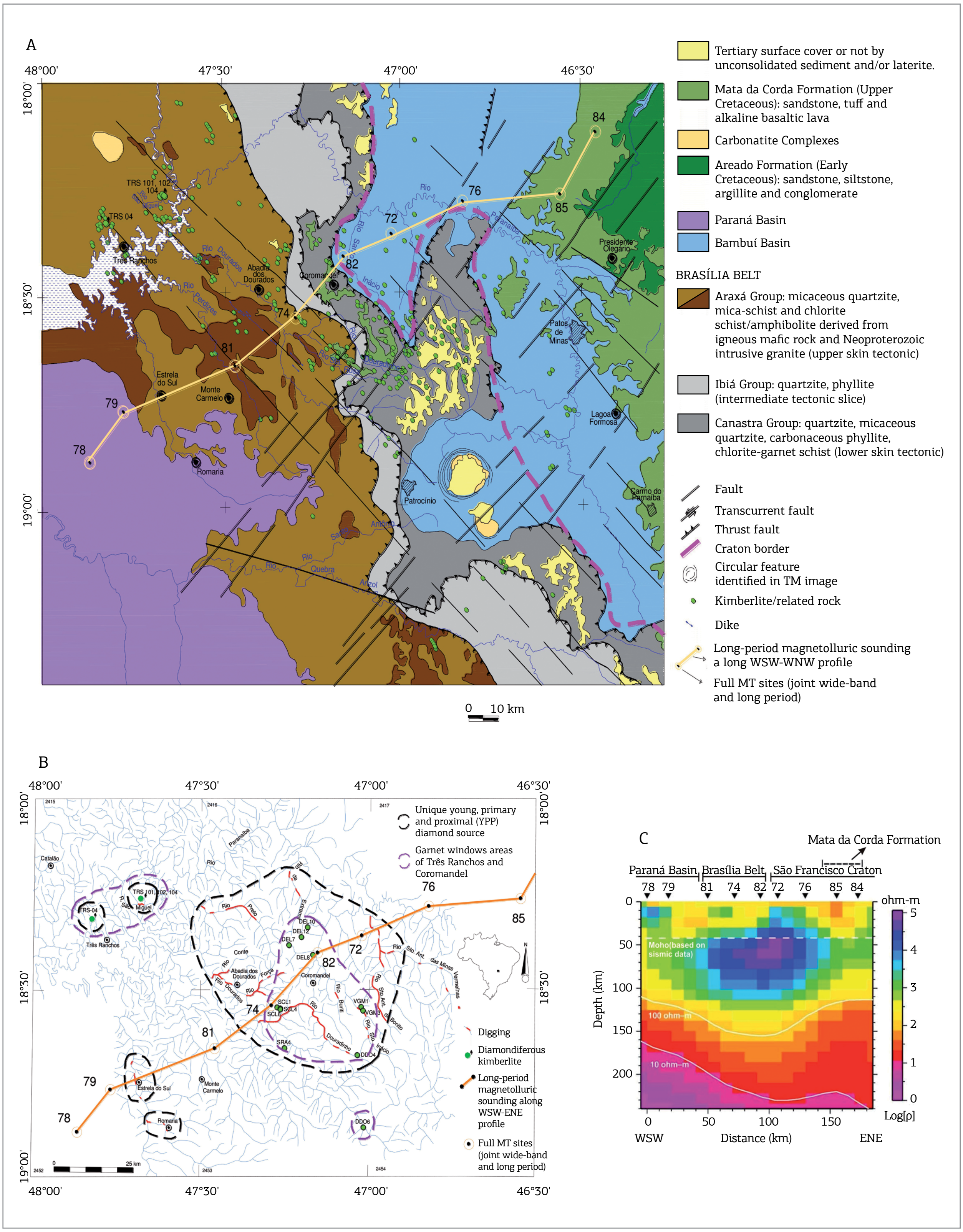

Figure 17. Long period magnetotelluric sounding available in a 180 km long WSW-ENE profile across the magmatism associated to the Alto Paranaíba structural high (Bologna *et al.* 2006); (A) geological map of the region and location of the profile; (B) Três Ranchos-Coromandel garnet windows and localities of distinct diamond population with characteristics of unique young, proximal and primary diamond source (Pereira 2007); (C) occurrence of thick lithosphere (depths larger than 150 km) bellow the garnet window of high interest and localities of unique young primary proximal diamond source in the terrain surface (modified from Bologna *et al.* 2006).

Archaean lithosphere base shows temperature and pressure ranging approximately between 900 and 1,200°C and 45 to 65 kb, corresponding to depths between 150 and 300 km (Boyd *et al.* 1985; Haggerty 1986). Despite of the reduced area or extent of thick lithosphere, its presence is important because it indicates that the Archaean-Paleoproterozoic terrain of the western border of the São Francisco Craton was characterized by thick lithosphere, capable of crystallizing and preserving diamond.

DISCUSSION

Probably from the Pleistocene to the Holocene, the large flat plateau area observed in the southwestern portion of the São Francisco Craton that developed during Tertiary peneplanation in Brazil and South America started to undergo erosive processes. In this area, remains of the old surface showing the lateritic cover that characterizes the top of the erosion surface can be seen. In some cases, the incision of the current drainage reaches the rocks of the Araxá, Ibiá and Canastra groups. The basal conglomerate of Capacete Formation, in a frank erosion process, is the main source of the diamond-bearing alluvium of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers. However, rocks of different ages from the magmatism associated with Alto Paranaíba also contributed to the formation of alluvium. Observations of the diamond-bearing alluvium indicate only one high terrace level. Apparently, the region underwent little movement or block accommodation after the Tertiary, unlike, for example, the Serra da Canastra region, where the areas upstream of the Vargem Bonita digging, on the São Francisco River, show three distinct terrace levels. The pebble distribution in the alluvium is less chaotic, indicating currents with greater capacity to concentrate the dispersed diamond in the basal conglomerate of the Capacete Formation, considered as the secondary source of the diamond recovered to the south and southeast of Coromandel (Figs. 18 and 19). Despite all indications of source or local primary sources for the diamonds contained in the conglomerate and concentrated in alluviums, such sources have not yet been located.

Certain factors, or the conjunction of factors, may hinder the location of certain intrusions in the region, especially of the potentially diamond-bearing Early Cretaceous kimberlites. The aeromagnetic survey conducted in the Coromandel region was considered a great success in terms of responses associated with intrusions. Thousands of anomalies compatible with kimberlite intrusions were selected and hundreds were positive in field follow-up, especially of kamafugites and related rocks intruded in the Late Cretaceous. The Mata da Corda volcanism is extremely magnetic and capable of masking any underlying individual anomaly. For example, analysis of drill core samples from 56 selected anomalies, including the Omega 22 intrusion at the top of the Chapadão, the common source area of the Santo Antônio do Bonito, Santo

Figure 18. Diamond-bearing alluvial deposit within AMEEX Mineração area, belonging to Mr. Milton Soares França. Note pebble sorting from top to base next to the bedrock.

Figure 19. Erratic pebble distribution in the basal Capacete Formation conglomerate.

Inácio and Douradinho rivers, were classified as related to Late Cretaceous intrusions without potential for diamond. Another factor associated with the high magnetism of Mata da Corda volcanism that could also mask older intrusions would be the emplacement of intrusions in graben zones, where tens of meters of the conglomerate are covered by the volcanic rocks of the Late Cretaceous Mata da Corda Group, and in some cases by Tertiary deposits, resulting in a quite thick coverage over potentially diamond-bearing intrusions. Finally, a rarer, but not uncommon case, would be either little or non-magnetic kimberlite emplaced in the described situations (Fig. 20).

At the time of the systematic exploration conducted in the region, a gravimetric survey was considered, however the high cost of gravimetry associated with the size of the area made the project unfeasible.

Some studies should be carried out as an attempt to reduce the area for an eventual gravimetric survey in the southern and southeastern regions of Coromandel, as follows:

1. Surveying all occurrences or outcrops of the basal conglomerate of the Capacete Formation.
2. Analyzing the frequency of angular fragments or pebbles of volcanic rocks, especially kimberlites, and the nature of the more or less sandy or clayey matrix of the outcrops.
3. Collecting at least 500 L of the material, with special care to avoid contamination.
4. Recovering the heavy minerals up to the panning level.
5. Analyzing specially garnet and spinel, and, in the case of diamond recovery, performing provenance studies.

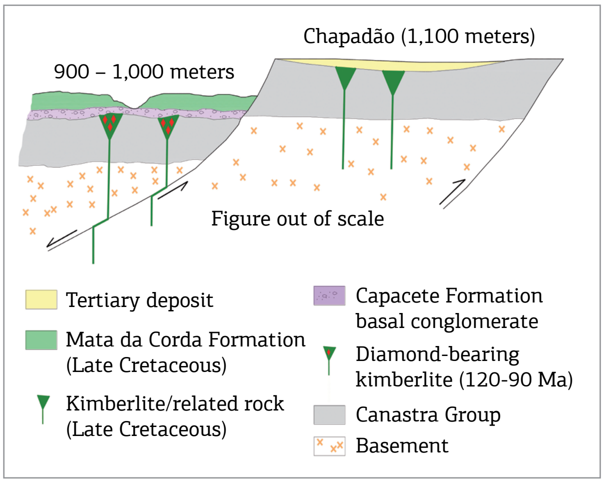

Figure 20. Hypothetical normal fault developed during the Alto Paranaíba structural high uplift. Probably developed along thrust fault planes related to the Brasiliano Orogeny, normal faults are possible secondary controls for intrusions emplacement, at the time when Cretaceous-Tertiary sediments were deposited over downthrown blocks (modified from Pereira 2007).

The set of results could indicate more accurately the proximity to possible primary diamond sources, helping to define the most appropriate area for the gravimetric survey, or even for drilling, following a convenient grid of borehole distribution if the reduced surveying area is compatible with the cost.

CONCLUSION

Geological knowledge is cumulative and continually updated through research and collection of information inserted in a given context of paradigms.

In 1968, SOPEMI – Pesquisa e Exploração de Minérios S.A,, a joint venture between France's BRGM (Bureau de Recherches Géologiques et Minières) and CAEMI (Antunes Group), discovered the first kimberlite in the Santo Inácio River, in the São Francisco Craton. In 1974, after the BRGM departure, the De Beers Group, which had joined SOPEMI, took control of the company. Since then, De Beers and other companies invested continuously for more than two decades in diamond prospecting in Brazil and other countries in South America, discovering hundreds of kimberlites and related rocks.

The main research focus was the São Francisco Craton, covering the digging areas in the regions of Lençóis, Andaraí, Mucugê in the Chapada Diamantina, in the northern portion of the craton, but intensive work was also conducted in the traditionally producing areas of southwest Minas Gerais, in the southern portion of the craton.

Among the most used techniques worldwide to explore kimberlite and lamproite are the sampling and recovery of heavy minerals such as garnet, spinel, diopside and ilmenite, followed by aerial or terrestrial geophysics and remote sensing. The combined data obtained using these techniques become important when searching for favorable targets of kimberlite intrusion. The data include petrology, mineralogy, geochemistry, geochronology, geophysics, remote sensing, and, if possible, additional field work, such as grain size and soil color variations, specific local anomalies of certain vegetation species and minerals identified in the waste of anthills or termite mounds.

In the region of Alto Paranaíba, an aeromagnetic survey was extremely effective, allowing the direct detection of hundreds of kimberlites and/or related rocks. The coverage of the Coromandel area, with 8,520 km^2, in three stages, allowed selecting 1,184 anomalies, which were classified as grade 1, 2 and 3. Among the 986 tested, 435 intrusions (44%) were proven, of which 120 (27.6%) correspond to already known kimberlites/related rocks (Skinner 1996; Pereira 2007). To reach these results, a lot of work had to be done to define the anomalies only in this area. Approximately 15,600 km/line, with 50 x 25 m intervals between the lines and stations and 100 x 50 m in the terrestrial magnetometry survey, covered the 986 anomalies, classifying them as good (485), medium (211) and poor (290). Approximately 33,594 samples were collected, including 22,161 soil, 7,750 alluvium, 3,080 drill cores, and 603 rock samples (Skinner 1996; Pereira 2007).

The São Francisco Craton exploration yielded two important results; it identified a thick lithosphere capable of crystallizing and preserving diamond in the northern portion, and located diamond-bearing kimberlites in the southern portion of the craton.

The kimberlites of the Braúna Province, in the north portion of the craton, located in the Archean core of the central portion of the Serrinha Block, are diamondiferous (Pereira & Fuck 2005; Pereira 2007; Donatti *et al.* 2013a, b). The Salvador 01 kimberlite was also identified in Chapada Diamantina, Gavião Block, whose outcrops show low-grade metamorphism, hypabissal facies and phlogopite Rb-Sr age of 1,152 Ma. The kimberlite was considered at the time as sin deposition of the diamond-bearing conglomerate of the Tombador Formation. Subsequently, aeromagnetic survey in the region indicated anomalies northwest of Salvador 01 (SVR 01). Drilling detected kimberlitic rocks at 246 and 159 m in two anomalies. Drill cores show crater facies rocks, metamorphosed and placed at the base of the Morro do Chapéu Formation quartzites, therefore intrusive in the rocks that constitute the underlying Tombador and Caboclo formations. The findings indicate a time of intrusions younger than the primary sources that provided diamonds to the known diamondiferous Tombador Formation conglomerates (Pereira 2007).

In the south portion of the craton, the De Beers mineral exploration indicated the location of diamond-bearing kimberlites, constituting, in some cases, the primary source of the diamonds extracted from the bed alluvium and terraces of certain streams. In addition to the identification of diamond-bearing kimberlites in Alto Paranaíba, exploration also identified the conglomerate containing angular pebbles of basic and ultrabasic rocks, quartzites, shales and amphibolites, underlying the Mata da Corda Group. The conglomerate outcrops show distribution of pebbles without any sorting and deposition in rugged relief, where normal faults are common. Sampling of the conglomerate indicates in some places presence of abundant garnet, spinel and ilmenite of high interest with kelifitic coronae or alteration mantles, comprising more than 50% of the mineral, implying in reduced transport or local origin.

More recent work has contributed significantly to the knowledge of the post-Gondwana stratigraphy in Alto Paranaíba (Sgarbi *et al.* 2001; Fernandes *et al.* 2014; Karfunkel *et al.* 2014). In addition to confirming the presence of diamond in the basal conglomerate of the Capacete Formation, the description of diamonds recovered in the Canastrel digging, extracted directly from the conglomerate (Karfunkel *et al.* 2014), sheds light on the fact that the components of this formation constitute the secondary source of diamonds extracted in the alluvium of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers.

The presence of diamond-bearing kimberlites at different locations in the region and the identification of thick lithosphere capable of crystallizing and preserving diamond, associated to the recovery of kimberlite minerals extracted directly from the conglomerate with characteristics of local origin, as well as diamonds with little transport, allow to strongly consider the presence of YPP sources, which eroded, fed the basal conglomerate of the Capacete Formation. These minerals, including diamond, were later reconcentrated in the alluvium of the Santo Antônio do Bonito, Santo Inácio and Douradinho rivers.

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REFERENCES

Alkmim F.F. & Marshak S. 1998. Transamazonian Orogeny in the southern São Francisco Craton region, Minas Gerais, Brasil: Evidence for Paleoproterozoic collision and collapse in the Quadrilátero Ferrífero. *Precambrian Research*, **90**:29-58.

Alkmim F.F. & Teixeira W. 2017. The Paleoproterozoic Mineiro Belt and the Quadrilátero Ferrífero. In: Heilbron, M., Cordani, U.G.C., Alkmim, F.F. (Org.). São Francisco Craton, Eastern Brazil. Zurich, Springer International, p.71-94.

Barbosa J.S.F. & Sabaté P. 2002. Geological features and the Paleoproterozoic collision of the four Archean crustal segments of the São Francisco Craton, Bahia, Brazil. A synthesis. *Anais da Academia Brasileira de Ciências*, **74**(2):343-359.

Barbosa J.S.F. & Sabaté P. 2004. Archean and Paleoproterozoic crust of the São Francisco Craton, Bahia, Brazil: Geodynamic Features. *Precambrian Research*, **133**:1-27.

Barbosa O. 1991. *Diamante no Brasil: histórico, ocorrência, prospecção e lavra*. CPRM, Brasília, 136p.

Bologna M.S., Padilha A. L., Vitorello I., Fontes S. L. 2006. Tectonic insight into a pericratonic subcrustal lithosphere affected by anorogenic Cretaceous magmatism in central Brazil inferred from long-period Magnetotelluric. *Earth and Planetary Science Letters,* **241**:603-616.

Boyd R.F., Gurney J.J., Richardson S.H. 1985. Evidence for a 150-200 km thick Achaean lithosphere from diamond inclusion thermobarometry. *Nature,* **325**:387-389.

Campos J.E.G. 1992. *A glaciação permo-carbonífera nas regiões de Canabrava e Santa Fé de Minas-MG*. Dissertação de Mestrado, Instituto de Geociências, Universidade de Brasília, Brasília.

Coelho F.M., Svisero D.P., Filho W.F. 2010. Geologia e Mineralogia da Mina de Diamante de Romaria, Minas Gerais. *5º Simpósio Brasileiro de Geologia do Diamante*. Tibagi, Paraná, Brasil, p.50.

Dardenne M.A. 2000. The Brasilia Fold Belt. In: Cordani U.G., Milani E.J., Thomaz Filho A., Campos D.A. (Org.) *Tectonic Evolution of South America*. Rio de Janeiro: 31st International Geological Congress, p.231-263.

Donatti Filho J.P., Oliveira E.P., McNaughton N.J. 2013a. Provenance of zircon xenocrysts in the Neoproterozoic Brauna Kimberlite field, São Francisco Craton, Brazil: Evidence for a thick Paleoproterozoic lithosphere beneath the Serrinha block. *Journal of South American Earth Sciences,* **45**:83-96.

Donatti Filho J.P., Tappe S., Oliveira E.P., Heaman L. 2013b. Age and origin of the Neoproterozoic Brauna kimberlites: Melt generation within the metasomatized base of the São Francisco craton. *Chemical Geology,* **353**:19-35.

Draper D. 1911. The diamond-bearing deposits of Bagagem and Agua Suja in the state of Minas Gerais, Brazil. *Transactions of the Geological Society of South Africa*, **XIV**, 8-23.

Fernandes A.F., Karfunkel J., Hoover D. B., Sgarbi P.B.A., Sgarbi G.N.C., Oliveira G.D., Gomes J.C.S.P., Kambrock K, 2014. The Basal Conglomeration of the Capacete Formation (Mata da Corda Group) and its Relation to Diamond Distributions in Coromandel, Minas Gerais State, Brazil. *Brazilian Journal of Geology*, **44**(1):91-103, March 2014.

Fleischer R. 1998. A rift model for the sedimentary diamond deposits of Brasil. *Mineralium Deposita,* **33**:238-254.

Franco R.R. 1981. *Diamante*. Apostila preparada com base nos livros e publicações: Recursos Minerais do Brasil de Sylvio Fróes Abreu, Editora Blucher Ltda. e Editora da Universidade de São Paulo, vol. I p.267-294. 1973; Van Nostrand´s Standard Catalogue of Gems de Sinkankas, Editora Van Nostrand Reinhold Company, New York. 1968. Boletim de Preços, Bens Minerais e Produtos Metalúrgicos MME, DNPM, Brasília, DF. 1980.

Fuck R.A. 1994. A Faixa Brasília e a compartimentação tectônica na Província Tocantins. SBG. Simpósio de Geologia do Centro-Oeste, 4. Brasília, *Anais*, p.184-187.

Fuck R.A., Pimentel M.M., Alvarenga C.J.S., Dantas E.L. 2017. The Northern Brasília Belt. In: Heilbron, M., Cordani, U.G., Alkmim, F.F. (Org.). São Francisco Craton, Eastern Brazil. Zurich: Springer, p.205-220.

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. *Journal of Petrology,* **36**:189-229.

Gonzaga G.M., Teixeira N.A., Gaspar J.C. 1994. The origin of diamonds in Western Minas Gerais, Brazil. *Mineralium Deposita,* **3**:414-421.

Gurney J.J. 1984. A correlation between garnets and diamonds in kimberlites. In: Glover J.E., Harris P.G. (eds.) *Kimberlite occurrence and origin:* A basis for conceptual models in exploration. Geology Department and University Extension, University of Western Australia. Publication **8**:143-166.

Haggerty S.E. 1986. Diamond genesis in a multiply constrained model. *Nature*, **320**:34-38.

Helmstaedt H.H. & Gurney, J.J. 1994. Geotectonic controls of primary diamond deposits: Implications of ore selections. In Diamond Exploration: Into the 21st century. Edited by W.L. Griffin. *Journal of Exploration Geochemistry*, **53**:125-144.

Kaminsky F.V., Feldman A.A., Varlamov V.A., Boyko A.N., Olofinsky L.N., Shofman I.L., Vaganov V.I. 1995. Prognostication of primary diamond deposit. *Journal of Geochemical Exploration,* **53**:167-182.

Karfunkel J., Hoover D., Fernandes A.F., Sgarbi G.N.C., Kambrock K., Oliveira G.D. 2014. Diamonds from the Coromandel Area, West Minas Gerais State, Brazil: A update and new data on surface sources and origin. *Brazilian Journal of Geology,* **44**(2):325-338.

Karfunkel J., Martins M.S., Scholz R., McCandless T. 2001. Diamonds from the Macaúbas River Basin (MG, Brazil): Characteristics and possible source. *Revista Brasileira de Geociências,* **31**(4):445-456.

Machado I.F. & Figuerôa S.F.M. 1999. 500 years of mining in Brazil: A brief review. *Ciência e Cultura, Journal of the Brazilian Association for Advancement of Science,* **51**(3/4):287-301.

O'Reilly S.Y. & Griffin W.L. 1996. 4-D Lithosphere mapping: Methodology and examples. *Tectonophysics,* **262**:3-18.

Pereira R.S. 2007. *Cráton do São Francisco Kimberlitos e Diamantes.* Tese de Doutorado, Universidade de Brasília, Brasília, Brasil, 200p.

Pereira R.S. & Fuck R.A. 2005. Achaean nucleii and the distribution of kimberlite and related rocks in the São Francisco Craton, Brazil. *Revista Brasileira de Geociências* **35**(3), 297-310.

Pereira R.S. & Neves R.R. 1996. *Fotointerpretação estrutural, anomalias e garimpos (delimitação do vale e terraços) no rio São Francisco. Mapa (esc. original 1:50.000).* Unidade de Sensoriamento Remoto, De Beers Brasil, Brasília.

Read G., Grutter H., Winter S., Luckman N., Gaunt F. 2003. Stratigraphic relations kimberlite emplacement and lithospheric thermal evolution, Quiricó Basin, Minas Gerais State, Brazil. *8th International Kimberlite Conference Extended Abstract*, Toronto, Canada.

Rendón C.A., Kuyumjian R.M. 2005. Mineralizações de ouro do tipo orogênico em arco magmático paleoproterozóico, borda oeste do Cráton do São Francisco, regiões de São Domingos (GO) e Correntina (BA). *Revista Brasileira de Geociências*, **35**(2):187-198.

Robinson D.N. 1991. The characteristics and significance of some Brazilian diamond samples examined mainly in the offices of Sopemi. *Internal Report*, De Beers Brasil, Brasília.

Robinson D.N., Phillips D., Anderson V.G. 1995. The characteristics and interpretation of Brazilian diamond samples examined in the Sopemi office. *Internal Report*, De Beers Brasil, Brasília.

Seer H.J., Brod J.A., Fuck R.A., Pimentel M.P., Boaventura G.R., Dardenne M.A. 2001. O Grupo Araxá em sua área tipo: Um fragmento de crosta oceânica neoproterozóica na faixa de dobramento Brasília. *Revista Brasileira de Geociências,* **31**:385-396.

Seer H.J., Brod J.A., Valeriano C.M., Fuck R.A. 2005. Leucogranitos intrusivos no Grupo Araxá: Registro de um evento magmático durante colisão neoproterozóica na porção meridional da Faixa Brasília. *Revista Brasileira de Geociências*, **35**:33-42.

Sgarbi G.N.C., Sgarbi P.D.A., Campos J.E.G., Dardenne M.A., Penha U.C. 2001. Bacia Sanfranciscana: O registro fanerozóico da Bacia do São Francisco. In: Pinto C. & Martins-Neto M.A. (eds *). Bacia do São Francisco, Geologia e Recursos Minerais*. Belo Horizonte, SBG/MG, p. 93-138.

Skinner C. 1996. Prospecting in western Minas Gerais, Brazil. *Internal Report*, De Beers Brasil, Brasília, 47p.

Svisero D.P., Felitti W., Almeida J.S. 1981. Geologia da mina de diamantes de Romaria, município de Romaria, M.G. *Mineração e Metalurgia* RJ, **44**(425):4:14.

Svisero D.P. & Meyer H.O.A. 1989. Diamonds from Romaria Mine, Minas Gerais, Brazil. Washington, *28th International Geological Congress*, p.113-114.

Teixeira W., Oliveira E.P., Marques L. 2017. Nature and evolution of the Archean crust of the São Francisco Craton. In: Heilbron M., Cordani U.G., Alkmim F.F. (Org.). *São Francisco Craton, Eastern Brazil.* Zurich, Springer International, p.29-56.

Williamson P.A. & Pereira R.S. 1991. The Salvador 01 Kimberlite, Bahia, Brazil: Its regional and local geological setting with comments on the sequence of prospecting activities leading to its discovery. Strategic Services Unit, *Internal Report*, De Beers Brasil, Brasilia, 27p.

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