Journal of South American Earth Sciences 28 (2009) 288–303

Contents lists available at ScienceDirect

Journal of South American Earth Sciences

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

The Fazenda Largo off-craton kimberlites of Piauí State, Brazil

Felix V. Kaminsky *, Sergei M. Sablukov, Ludmila I. Sablukova, Olga D. Zakharchenko

KM Diamond Exploration Ltd., 2446 Shadbolt Lane, West Vancouver, BC, Canada V7S 3J1

ARTICLE INFO

Article history:
Received 26 November 2008
Accepted 2 June 2009

Keywords:
Kimberlite
Off-craton
Pyrope
Diamond
Piauí
Brazil

ABSTRACT

In the late 1990s, the Fazenda Largo kimberlite cluster was discovered in the Piauí State of Brazil. As with earlier known kimberlites in this area – Redondão, Santa Filomena-Bom Jesus (Gilbues) and Picos – this cluster is located within the Palaeozoic Parnaiba Sedimentary Basin that separates the São Francisco and the Amazonian Precambrian cratons. Locations of kimberlites are controlled by the 'Transbrasiliano Lineament'. The Fazenda Largo kimberlites are intensely weathered, almost completely altered rocks with a fine-grained clastic structure, and contain variable amounts of terrigene admixture (quartz sand). These rocks represent near-surface volcano-sedimentary deposits of the crater parts of kimberlite pipes. By petrographic, mineralogical and chemical features, the Fazenda Largo kimberlites are similar to average kimberlite. The composition of the deep-seated material in the Fazenda Largo kimberlites is quite diverse: among mantle microxenoliths are amphibolitised pyrope peridotites, garnetised spinel peridotites, ilmenite peridotites, chromian spinel + chromian diopside + pyrope intergrowths, and large xenoliths of pyrope dunite. High-pressure minerals are predominantly of the ultramafic suite, Cr-association minerals (purplish-red and violet pyrope, chromian spinel, chromian diopside, Cr-pargasite and orthopyroxene). The Ti-association minerals of the ultramafic suite (picroilmenite and orange pyrope), as well as rare grains of orange pyrope-almandine of the eclogite association, are subordinate. Kimberlites from all four pipes contain rare grains of G10 pyrope of the diamond association, but chromian spinel of the diamond association was not encountered. By their tectonic position, by geochemical characteristics, and by the composition of kimberlite indicator minerals, the Fazenda Largo kimberlites, like the others of such type, are unlikely to be economic.

1. Introduction

In the late 1990s, the new cluster of kimberlites, termed the 'Fazenda Largo kimberlites' were discovered in Piauí State, Brazil. As with earlier known kimberlites, in this area: e.g., Redondão, Santa Filomena-Bom Jesus (Gilbues) and Picos, this cluster is located within the 'Transbrasiliano Lineament' (Fig. 1).

The Redondão kimberlite pipe (centered at 439270E and 8977210 N) was the first to be discovered, not only in Piauí State but also in all of Brazil. This kimberlite was recognised in the 1960s during the course of 1:1,000,000 scale geological mapping, in the upper course of the Ribeirão do Mateiro, the right tributary of the Rio Parnaiba (Melo and Porto, 1965; Ellert, 1971). Being very large (approximately 1 km in diameter), the Redondão pipe is discernible both on airborne photo images and on satellite Landsat imagery (Almeida and Castelo-Branco, 1992). This pipe has been the focus of numerous descriptive accounts in the literature (e.g., Svisero et al., 1977, 1984; Svisero and Meyer, 1986; Castelo Branco, 1986; Castelo Branco and Lasnier, 1991). The other kimberlite localities, Santa Filomena-Bom Jesus (Gilbues) and Picos are described by Tompkins (1994) and Svisero (1995).

Diamonds have been reported in alluvial deposits of Ribeirão do Mateiro, which washes out the Redondão pipe (Mapa geológico, 1995). However, only limited prospecting works were carried out there. Two of the diamonds that were recently reported upon from the Fazenda Largo kimberlites in this region, have been supplied to us for study.

The newly discovered kimberlite group, known as the 'Fazenda Largo kimberlites', occurs approximately 95 km NE of the Redondão pipe, within the basin of Riacho do Loco, a right-side tributary of Rio Uruçui Preto belonging to the Rio Parnaiba system (Fig. 1). In the 'Mapa de Distribuição geoquimica' compiled by Projeto Platina Nacional, several localities of Jurassic-Cretaceous 'ultramafic rocks' were mapped in a number of local areas. During the 2001–2002 field works, igneous rock occurrences were found in three of these local areas, and all these rocks have subsequently been identified as epiclastic kimberlites of crater facies.

The main objective of this work, therefore, was to perform a comprehensive study of these new Brazilian off-craton kimberlites.

* Corresponding author. Tel.: +1 604 925 8755.
E-mail address: felixvkaminsky@cs.com (F.V. Kaminsky).

0895-9811/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jsames.2009.06.003

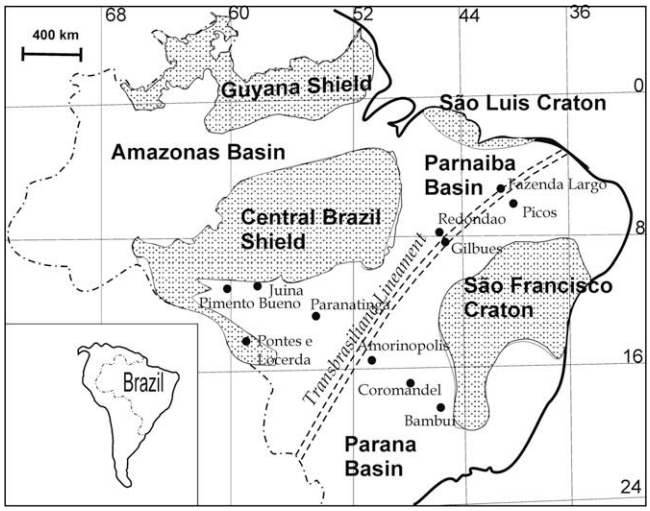

Fig. 1. Location and tectonic position of Fazenda Largo kimberlites (after Tompkins (1994), with corrections for kimberlite localities).

2. Area description

Tectonically, the main part of Piauí State, which includes the newly discovered kimberlites, is located within the Palaeozoic Parnaiba Sedimentary Basin, separating two cratons with Archaean nuclei: the São Francisco Craton with a cratonization age of 3.5–3.0 Ga, in the southeast, and the Amazonian Craton (Guaporé Shield) with a cratonization age of 3.0–2.5 Ga, to the west (Cordani and Teixeira, 2007) (Fig. 1). A regional Transbrasiliano Lineament Zone intersects the area from SW to NE (Tompkins, 1994); this was probably created during the Neoproterozoic Brazilian Orogeny, when the Amazonian and São Francisco cratons collided (Cordani and Teixeira, 2007). Besides the Redondão and Fazenda Largo kimberlite clusters, this Zone controls two others, namely Santa Filomena-Bom Jesus (Gilbues) and Picos (Tompkins, 1994). Extensional reactivation of the fault zone in Proterozoic times resulted in the formation of a graben structure which subsequently controlled the positioning of the Palaeozoic (Silurian to Cretaceous) sediments. Geophysical data suggest that, locally, a sedimentary sequence of Upper Proterozoic age lies beneath the Palaeozoic rocks, extending to a depth of 4500 ms. These are in-turn underlain by Precambrian crystalline basement.

The three Fazenda Largo kimberlites that form the basis of this study, along with several other inferred kimberlites (~10 in all) form a cluster with a locus at approximately 8°51′S and 44°51′W. The kimberlite bodies form a chain, approximately 14 km in length that extends in a NNW direction; it is perpendicular to the Transbrasiliano Lineament Zone. The kimberlites intrude the Carboniferous Piauí Formation.

Two of the studied kimberlites (that are named after the Fazenda owners) are of several hundreds of metres in diameter: the Domingo pipe (centred at 518410E and 9018415 N; all data falling within UTM Zone 23) and the José Milhudo pipe (centred at 519310E and 9015150 N). Each exhibits evidence of the previous prospecting. The third, the Young pipe (the northernmost of the three, located near Fazenda Largo, and centred on 516940E and 9024690 N), is newly discovered. This kimberlite is approximately 530 × 410 m in size, elongated NNW, in accordance with the general orientation of the kimberlite cluster. The localisation of this pipe was verified by the excavation of four trenches of up to 4–5 m in depth, and two shafts with a 2 × 2 m cross section. Shaft #1 was sunk to a depth of 41 m; at a depth of 26 m, it encountered ground water and at 36 m it entered fresh kimberlite. Shaft #2 was terminated at a depth of 12 m in weathered kimberlite.

3. Samples and methods of study

For this study, we collected kimberlite samples from all four above-mentioned pipes (labelled 'R' – for the Redondão pipe, 'JM' – for the José Milhudo pipe, 'D' – for the Domingo pipe, and 'Y' – for the Young pipe). The samples from the Young pipe shaft represent relatively fresh kimberlite, whereas samples from the remaining three pipes are very intensely weathered rocks. In addition to the kimberlite rock samples, two pyrope-peridotite xenoliths from the Young pipe were also sampled and studied. Panning samples of kimberlite eluvium, collected from each pipe and panned at the sample site, have also been subjected to mineralogical analysis. Furthermore, two diamonds, reportedly from the Young kimberlite, were recently supplied to us by BrazDiamond Mining Co., and form part of this study.

Our studies of the rocks were based on visual examination of the collected rock samples, microscopic examination of sixteen thin and polished sections, silicate whole-rock analysis, inductively coupled plasma-mass spectrometry (ICP-MS) analysis, phase analysis by X-ray diffractometry, mineralogical analysis, and determination of the chemical composition of rock-forming and kimberlite indicator minerals (KIMs), utilising electron probe microanalysis (EPMA).

Whole rock analysis for 16 components was performed on six samples using wet chemical methods in the Analytical Centre of the Russian Academy of Sciences. For the ICP-MS analysis, the samples were ground to powder and then dissolved in acids, in an autoclave. The analysis was performed using a PLASMA QD analyser in the laboratory of IMGRE. Nine samples, including five analyses of autoliths, were analysed for 41 elements.

X-ray diffractometric semi-quantitative phase analysis of representative samples was performed in the laboratory of VIMS, using an ADP-1 X-ray diffractometer (Cu Kα; U = 40 kV; I = 40 mA). Eight analyses were made, including three analyses of autoliths. The material subject to phase analysis was selected from a homogenised, weighted sample of the bulk rock. The procedure of phase analysis included the following operations: (1) In the first instance, the sample was examined so as to identify all mineral phases present within. In this analysis, we calculated the concentrations (in percent) of all identified minerals, with the exception of minerals from the layered clay fraction, which were taken as a residuum. (2) The clay-sized fraction (particles approximately 0.001 mm in size) was separated from the initial sample by gravitational methods, using the following procedure: a sample of up to 5 g was comminuted to 0.5–1 mm and then placed into a porcelain mortar with distilled water. The sample was then pounded, rubbed and stirred to form a stable suspension of clay particles, whereupon the suspension was poured into a test tube. While the suspension settled, we prepared the substrates for the analytical specimens (slides degreased with alcohol). Upon complete settling of the particles with densities of greater than 2.5 g/cm^3, which is necessary for the separation of the fine fraction for the analysis, the suspension was sampled using a pipette, placed onto the slides and allowed to dry for 12 h, to obtain oriented specimens. Once completely dried, the analytical specimens (slides with settled layers of oriented clay particles, four slides were prepared for each sample) were ready for further examination. (3) For precise identification of clay minerals we recorded diffractograms of oriented analytical specimens saturated with ethylene glycol; specimens were calcinated for one hour at 550 °C. The duration of saturation with ethylene glycol was one day. Identification of the clay minerals present in the samples was based on joint interpretation of the compositions