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THE BRAZILIAN KIMBERLITE-KAMAFUGITE ASSOCIATION: A NEW AND IMPROVED GEOCHRONOLOGICAL AND GEOCHEMICAL INVESTIGATION

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INTRODUCTION

The Brazilian Potassic Province provides a unique opportunity to further our understanding of kimberlite magmatism, and the Earth's deep mantle as it plays host to a number of rare, mantle derived, potassic rocks, including "transitional" kimberlites. The province provides an interesting prospect as it is the only known example of co-magmatic kimberlite and kamafugite emplacement. Currently, a limited number of studies have been undertaken on the province, with the paucity most likely attributed to the highly altered nature of surface exposures and deep weathering profiles. The existing studies have all noted the potassicmagmatism is focused along a mega-lineament trending at 125°spaning from Rondonia to Minas Gerais (see Fig 1). However, there is still some debate as to the emplacement mechanism of the rock types and their geochemical affinity. One theory, regarding the emplacement mechanism, proposed by a number of authors, is that continental extension related to the opening of the Atlantic caused adiabatic decompression of the lithospheric mantle, which led to partial melting and production of the variable potassic magmas along the pre-existing lineament (Bizzi et al., 1995b; Meyer et al., 1995). Alternatively, based on K-Arphlogopite dating, Gibson et al (1995) proposed the potassicmagmatism was caused by conductive or advective heating of the Trindade plume as it travelled under the South American continent, as age of emplacement was found to decrease from north west to south east, mirroring the movement of the Trindade plume under the South American continent ~85ma. Further support for this theory has been subsiquently offered by a study by Sgarbi et al., (2004) where U-Pb perovskite dating has shown an age progression between the kamafugites from the GAP to the APIP. A third theory has also been proposed by

Read et al (2004), using stratigraphical relationships between the kimberlites and the kamafugites of the Quirico basin, Minas Gerais, and proposes the kimberlites were emplaced prior to the kamafugites and emplacement of the two rock types were triggered by different events.

Previously studies have also focused on the geochemical relationship between the Brazilian kimberlites and kamafugites, with major attention placed on investigating their geochemical (mineral/whole rock), and isotopic relationships, (Araujo et al., 2001; Bizzi et al., 1995a; Bizzi et al., 1995b; Carlson et al., 2007; Carlson et al., 1996; Gibson et al., 1995), with a number of varying interpretations regarding their source region being suggested.

The number of varying theories regarding the emplacement mechanism and geochemical relationship between the Brazilian kimberlites and

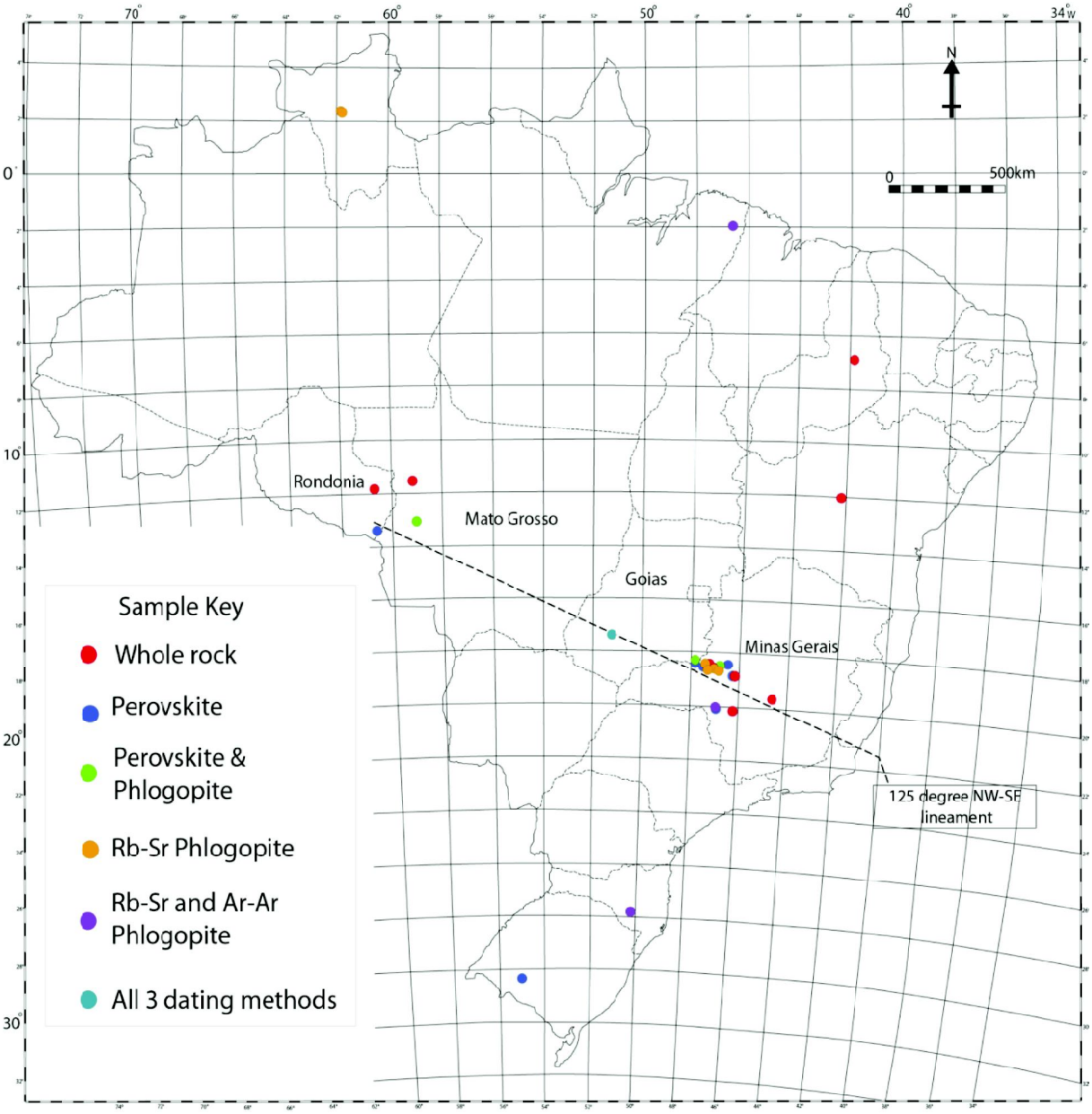

Fig 1: Locality map showing the locations of the samples for this study.

kamafugites highlight the need for further investigation. It must also be noted that the two major papers on this study area (Bizzi et al., 1995b, Gibson et al 1995) have used erroneous data and redundant dating techniques (K-Ar), respectively. Therefore this new study has been undertaken to provide a more accurate and representative dataset, enabling some of the outstanding theories to be tested and questions answered.

SAMPLE SUITE

The study consists of 52 drill core samples from 42 separate intrusions, the majority of which are located within the states of Rondonia (2 samples), MatoGrosso (2 samples), Gioas (3 Samples), and Minas Gerais (35 samples), along the 125° lineament. These samples include both kimberlite and kamafugite, which have been distinguished from one another by the application of petrology and whole rock major and trace element analysis.

METHODS

The hybrid nature of kimberlite and kamafugite coupled with their often highly altered state, present major challenges when trying to evaluate bulk rock isotopic data, (Heaman, 1989; Mitchell, 1986, 1995). An alternative to whole rock isotope analysis is to analyse an early crystallising primary phase, thought to have crystallised directly from the magma. It is believed this technique has the capacity to provide a more reliable estimate of the original isotopic signature of the parental magma, (Heaman, 1989). Perovskite, (CaTiO3), is a common accessory phase found in Brazilian kimberlites and kamafugites. It is believed to form during the early stages of magmatic crystallisation and record the least contaminated or contamination-free magma, (Wu et al., 2010). Perovskite is also extremely resistant to alteration and contains high amounts of Sr (>1000ppm), coupled with very low Rb (<2ppm), High Nd (>1000ppm), and relatively high Hf (~60ppm). This provides the perfect opportunity for Sr-Nd-Hf isotope studies, (Heaman, 1989; Wu et al., 2010). The high levels of Uranium in the Perovskite also make it suitable for U-Pb dating. So the analysis of Brazilian kimberlitic perovskite should help to provide isotopic data more representative of its kimberlitic magma and its source region compared to whole rock analyses previously obtained, whilst also providing the opportunity to determine the timing of kimberlitic intrusion.

GEOCHRONOLOGY

An in depth geochronological investigation has been carried out using 3 separate techniques firstly U-Pb analysis of perovskite grains (both solution and in situ) were employed. The in situ perovskite analysis follows the procedure reported in Wu et a,l (2010), with a spot size ranging from 26-54µm. However, as the Brazilian kimberlites and kamafugites have a substantial amount of "common" Pb the technique has been developed to include a second primary phase thought to have formed at the same time as the perovskite, with much lower uranium content. This phase acts as a natural anchor point on the $^{207}Pb/^{206}Pb$ axis of the Terra Wasserburg diagram where it acts to extend the spread of data and provide more accurate data.

The Perovskite data is also coupled with Rb-Sr and Ar-Arphlogopite techniques to provide a wider spread of age data as not all samples contain Perovskite. See fig 1 for information on the techniques used for each sample.

ISOTOPE GEOCHEMISTRY

This study has utilised both in-situ and isotope dilution perovskite techniques when investigating the Sr-Nd systems whilst also employing the isotope dilution technique to investigate Hf isotopic system. The isotope dilution analysis has also been used to cross reference the results obtained via laser ablation to further validate the in-situ technique. The in situ Rb procedure is the same as reported by Paton et al (2007b) with a spot size varying between 26-54µm, depending on grain size. Whereas the Nd procedure is that reported by Yang et al., (2009), again utilising a spot size ranging between 26-54µm.

RESULTS

Isotopic

Preliminary perovskite Rb-Nd isotope analysis have places both kimberlite and kamafugite in the transitional field, with kimberlitesSr (i) ~0.705 and kamafugiteSr (i) ~0.706, although there is a slight overlap between the two rock types.

Geochronological

Preliminary data shows a small age progression from NW-SE in the Rb-Srphlogopite and U-Pb perovskite ages along the lineament between Goias and Minas Gerais. In the samples which contain both phlogopite and perovskite, both ages correspond within error. One sample in the Rondoniastate produced a U-Pbage of 267±3Ma which corresponds well with the findings of Masun and Smith(2008), who report a kimberlite from the same state with an age of 230ma.

OVERVIEW

The implementation of all these techniques to the new sample suite have provided the opportunity to gain a greater understanding of the relationship between these two rock types whilst also allowing improvement of the perovskite U-Pb geochronological technique.

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