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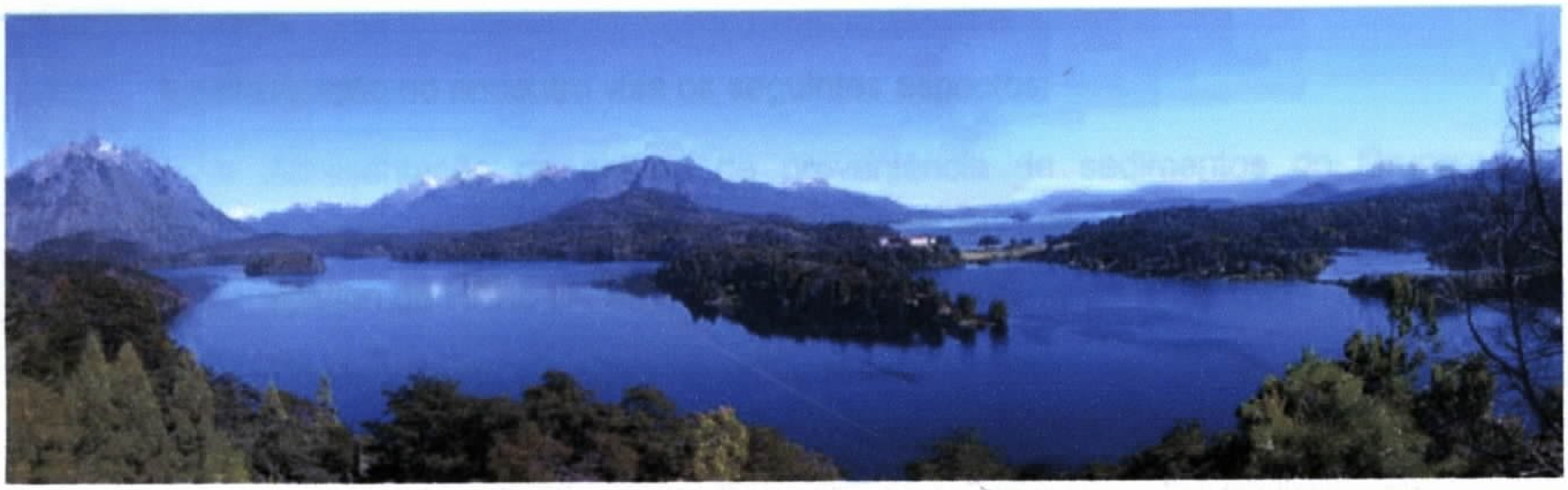
SECRETARIA DE GEOLOGIA, MINERAÇÃO E TRANSFORMAÇÃO MINERAL
CPRM – SERVIÇO GEOLÓGICO DO BRASIL

RELATÓRIO DE VIAGEM À ARGENTINA

VI Simpósio Sul-americano de Geologia Isotópica

VI South American Symposium on Isotope Geology *S.C de Bariloche, Argentina*



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Geóloga - SERAFI-Brasília

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CPRM Serviço Geológico do Brasil
Secretaria de Mineração, Geologia e Transformação Mineral
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BRASIL UM PAÍS DE TODOS

RELATÓRIO DE VIAGEM À ARGENTINA – Joseneusa Brilhante Rodrigues

1 - INTRODUÇÃO

Desde 1997 vem sendo realizado o Simpósio Sulamericano de Geologia Isotópica - SSAGI, visando a discussão e divulgação de métodos e aplicações deste ramo tão especializado da geologia. Já há alguns anos os geólogos da CPRM têm comparecido, apresentado trabalhos e firmado seu papel de geocientistas. Nesta sexta versão de encontro, mais uma vez temos muito a mostrar. Novos dados produzidos com novas tecnologias e com importantes implicações geotectônicas que têm no SSAGI um excelente fórum de debates e difusão.

2 - OBJETIVOS

A participação no encontro visa os seguintes aspectos:

- Apresentação do estudo de proveniência de sedimentos do Grupo Vazante, através da determinação da idade U-Pb de zircões detríticos e épsilon de Hf via LA-MC-ICP-MS;
- Conhecimento de técnicas inovadoras nos diferentes temas abordados no simpósio: - Geocronologia, Petrologia ígnea e metamórfica, Evolução crustal da América do Sul, Quimioestratigrafia, Paleoclimatologia, Hidrologia Isotópica, Exploração mineral, Exploração de óleo, Geologia Ambiental, geoarqueologia...
- Divulgação das atividades exercidas pela CPRM.

3 – ATIVIDADES

O simpósio foi realizado no período de 13 à 17 de abril de 2008, no Hotel Amancay, cerca de 25 Km da cidade de San Carlos de Bariloche. O dia 13 foi destinado à homologação de inscrição e cerimônia de abertura. Os dias 14 à 16 foram dedicados às apresentações de trabalhos e no dia 17 foi realizada uma saída de campo.

Os trabalhos nos quais tenho participação (anexo 1) foram expostos nos dias 14 e 16. No dia 14 na forma de poster (foto 1) e no dia 16 na forma oral (foto 2).

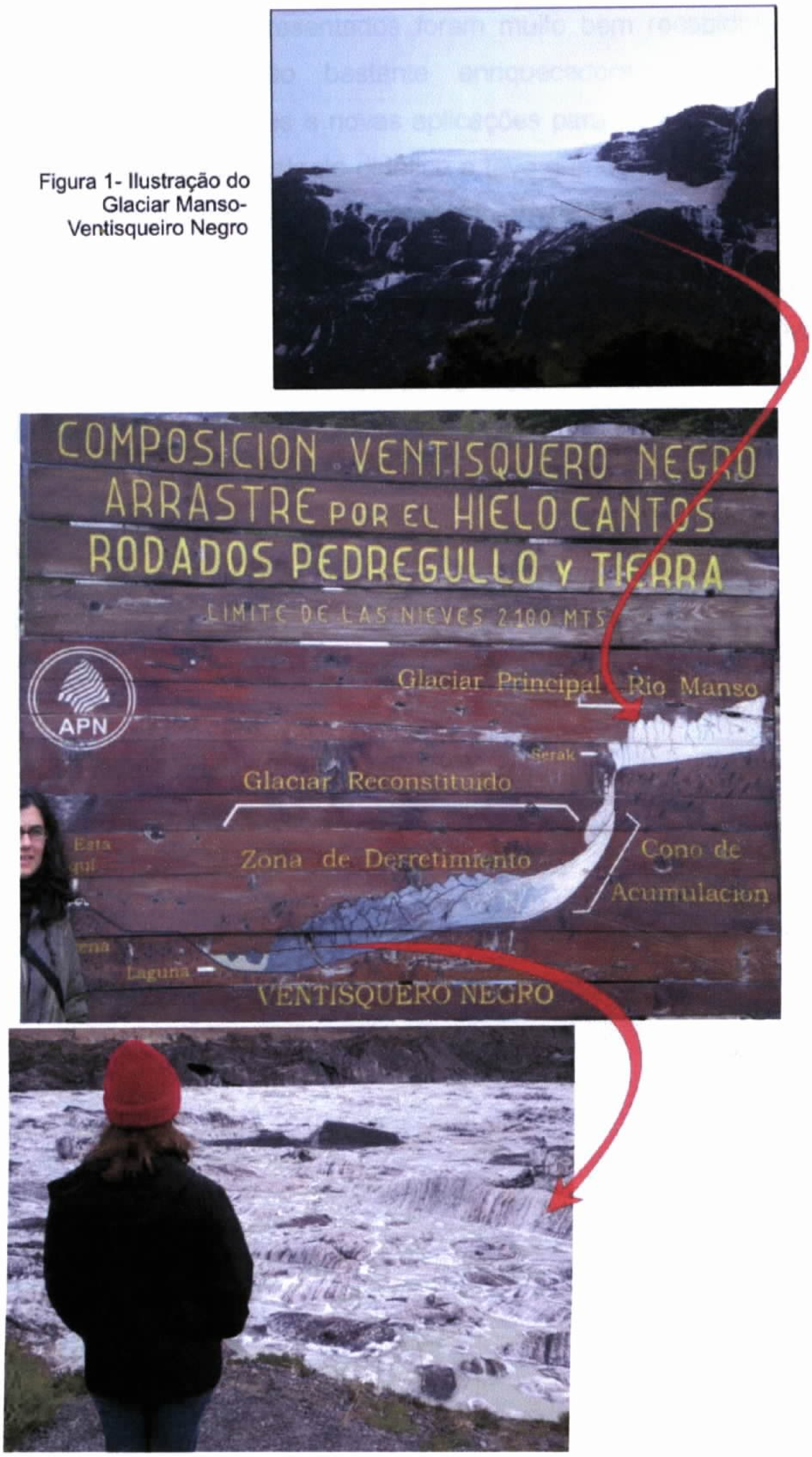
Foto 1

Foto 2

A saída de campo foi realizada nas imediaçoes dos lagos Gutiérrez e Mascardi, onde foram exibidos depósitos glacias, afloramentos clássicos de arco de ilha continental e um *glaciar* moderno. O *Glaciar del Manso* está localizado o *Cerro*

Tronado, do qual se descola e precipta na encosta da montanha, gerando o glaciar reconstituído, denominado *Ventisqueiro Negro* (Figura 1).

Figura 1- Ilustração do Glaciar Manso-Ventisqueiro Negro



4 - CONCLUSÕES

A viagem foi bastante proveitosa, uma vez que os objetivos foram alcançados com sucesso. Os trabalhos apresentados foram muito bem recebidos pelo público, proporcionando uma discussão bastante enriquecedora. No simpósio foram apresentadas técnicas inovadoras e novas aplicações para sistemas isotópicos pouco usuais. A saída de campo foi bastante didática e teve grande relevância, uma vez que o ambiente glacial recente não pode ser observado em território brasileiro.

5 – AGRADECIMENTOS

Gostaria de agradecer às duas instituições que tornaram possível minha participação neste congresso: - Universidade de Brasília e Companhia de Pesquisa de Recursos Minerais.

6 – ANEXOS

Seguem em anexo cópias dos artigos (3) que participo e foram apresentados no simpósio.

PROVENANCE OF VAZANTE GROUP – PRELIMINARY DATA

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Keywords: Vazante Group, Brasília Belt, provenance, U-Pb, LA-ICPMS

ABSTRACT

LA-ICPMS U-Pb ages of detrital zircon grains from sediments of the Vazante Group, Brasília Belt, central Brazil, are presented and their tectonic significance are discussed. The Vazante Group is a thick sedimentary unit of the Neoproterozoic Brasília Belt, which extends along the western border of the São Francisco-Congo Craton. Due to the important ore Pb, Zn and P deposits hosted mainly by dolomites of the Vazante Group, it has been investigated in many studies, but its age remains unknown. Six representative samples from Vazante Group have their provenance studied by LA-ICPMS dating of detrital zircons. The Santo Antônio do Bonito Formation sample contains few zircon grains and only nine of them produced concordant analysis, with ages varying from 995 to 1.850 Ma. The Rocinha Formation sample shows a broader age distribution, with major peaks at 0,94 and 2,2 Ga, and minor peaks at 1,2, 1,6 and 1,8 Ga. Samples of the Morro do Calcário and Lapa formations show similar provenance patterns, displaying important contribution from Mesoproterozoic (*ca.* 1,2 Ga) sources. Both samples from Serra do Garrote Fm(?) present a very simple provenance pattern with a single peak at 2,2 Ga. The results suggest that the São Francisco Craton represents the main source of the Vazante Group sediments. The new data presented here, combined with those previously published, suggest that the deposition of the Vazante Group took place in the time interval between *ca.* 0,94 and 0,78 Ga.

INTRODUCTION

The Vazante Group is one of the main lithostratigraphic units of the Neoproterozoic Brasilia Belt, an important orogenic belt developed along the western margin of the São Francisco Craton. The belt is the result of ocean basin closure during the Brasiliano Orogeny and displays tectonic and metamorphic vergence towards the Craton. Deformation and metamorphism increase towards the west. Because of its geological location and mineral resources, it has been the object of many studies. The absence of volcanic rocks, the tectonics boundaries with adjacent stratigraphic units, and the poor fossil record have contributed to the controversy concerning its age and tectonic significance. The main objectives of this study are: (i) to investigate the provenance pattern of the original sediments using LA-ICPMS U-Pb ages of detrital zircons, (ii) to constrain the depositional age of the Vazante Group, and (iii) contribute to the better understanding of the geological evolution of the Brasília Belt.

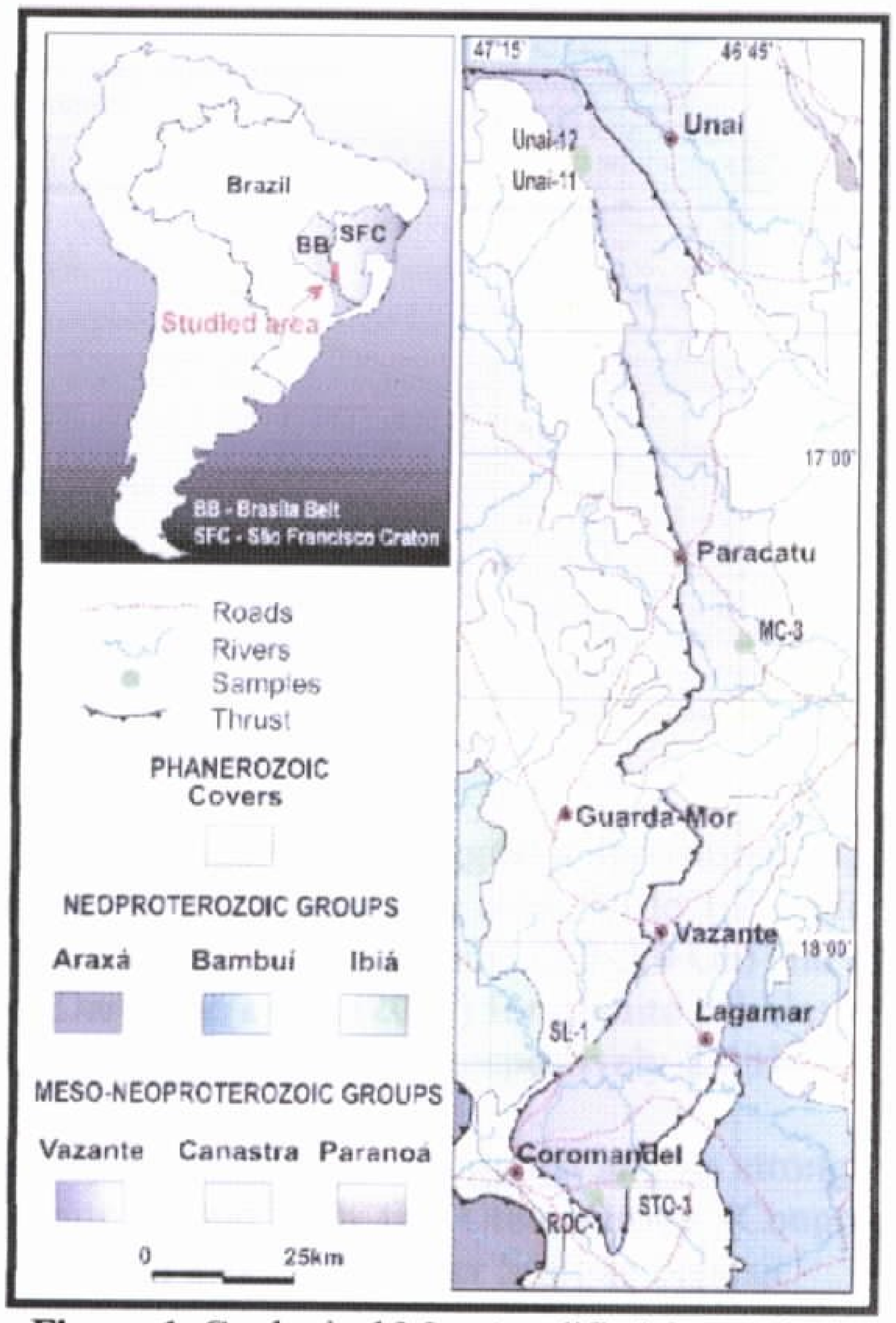

Figure 1. Geological Map (modified from Bizzi et al, 2001) of studied area with sample location.

GEOLOGICAL SETTING

The Vazante Group is a thick sedimentary unit, exposed as a narrow and continuous (about 40x250Km) belt comprising a pelite-carbonate sequence, presenting fault contacts with the Canastra Group to the west and the Bambui Group to the east (Fig. 1). It is made of phyllite, slate, quartzite, metasiltstone, algal dolomite and minor limestone. It was deposited on a shallow marine platform during a regressive cycle (Dardenne, 1981 and 2000). The field studies carried out by several authors in the southern part of the group (Madalosso, 1980 Campos Neto, 1984 Rigobello *et al.*, 1988, Madalosso and Valle, 1978; Pinho, 1990; Nogueira, 1993; Dardenne *et al*, 1997, 1998, Souza, 1997) resulted in the stratigraphic column summarized by Dardenne (2000) (Fig. 2). Its sedimentation age, however, remains unknown.

Group	Formation	Description
VAZANTE GROUP	Lapa	Carbonaceous phyllite, metasiltstone, carbonatic metasiltstone, dolomitic lenses and quartzites beds. In Unai region: - Lithic sandstone and conglomerate intercalated with dark slate
	Morro do Calcário	Dolomite: biostromes and bioherms with convex lamination, breccia, dolorudite, oolitic dolarenite and oncolits
	Serra do Poço Verde	Pink limestone with stromatolitic mats, barite nodule and mud crack Greenish-grey slate with intercalations of pink dolomite Dark grey dolomite with stromatolitic mats and bird's eyes Grey to pink dolomite with layers of breccias and doloarenite
	Serra do Garrote	Dark grey-greenish slate, sometimes rhythmic, carbonaceous and/or pyrite-bearing with rare fine quartzite intercalations
	Lagamar	Stromatolitic bioherma laterally and vertically interdigitated with carbonate-bearing metasiltstone and slate. Dolomitic intrafomational breccia, passing to dark grey, well-stratified limestone layers with intercalations of lamellar breccia Conglomerate, quartzite, metasiltstone and slate
	Rocinha	Phophoarenite rich in Intraclasts and pellet Dark grey slate, with pyrite and phosphorite Rhythmic psamo-pelitic sequence, recovered by a thick and also rhythmic package of slate and metasiltstone
	Santo Antônio do Bonito/ Retiro	White quartzite, locally conglomeratic, intercalated with slate. Diamictitic beds with pebbles of quartzites, limestones, dolomites, metasiltstones and granitic rocks supported by pelitic-carbonatic-phosphatic matrix

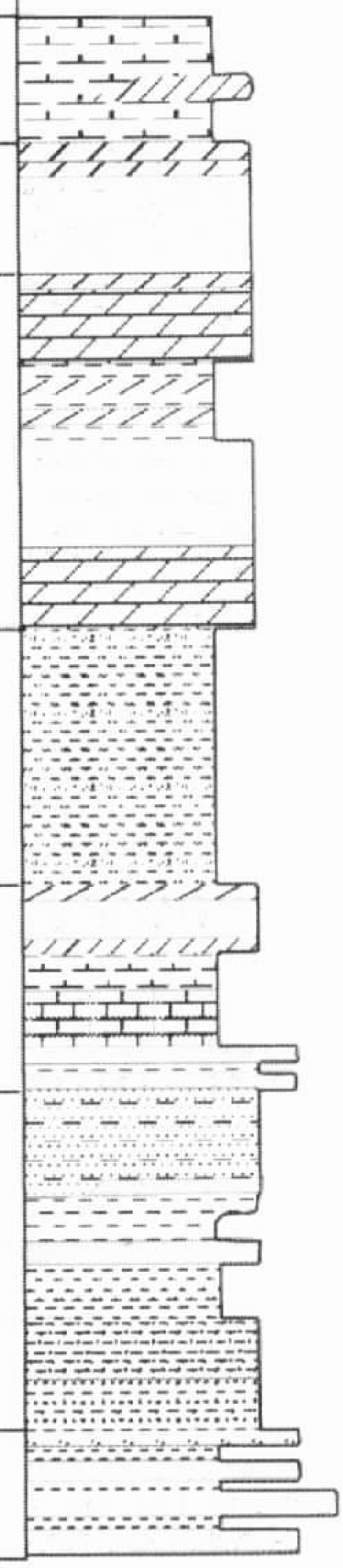

Figure 2. The Vazante Group stratigraphic column according to Dardenne (2000).

The presence of *Conophyton* stromatolites led Cloud and Dardenne (1973) to suggest a depositional age between 1,35 and 0,9 Ga. Pimentel *et al.* (2001) presented Sm-Nd model ages ranging from 2,1 to 1,7 Ga for pelitic rocks of the Vazante Group, which are intermediate between those of the Paranoá (2,3-2,0 Ga) and of the Bambuí groups(1,9-1,3 Ga). U-Pb zircon ages obtained by Dardenne *et al.* (2003) for granite pebbles of the Santo Antônio do Bonito Formation and for the Arrependido conglomerate are, respectively 2.081 ± 35 Ma and 2,18-1,85 Ga.

Azmy *et al* (2006), based on the newly interpreted glacial layer of the Lapa Formation and its strongly negative $\delta^{13}C$ anomaly, suggested a comparison of the Vazante Group with the Otavi Group (Congo), indicating that the Santo Antônio do Bonito diamictite might represent a discrete earlier Sturtian deposit.

SAMPLES ANALYSED AND LA-ICPMS AGES

Six samples from the Vazante Group were selected to be analysed by U-Pb LA-ICPMS at the Laboratório de Geocronologia, UnB. Samples were collected from different formations and geographic locations (Fig. 1). Only analyses with less than 10 % discordance (433 analyses) were used in the frequency diagrams (Fig. 3).

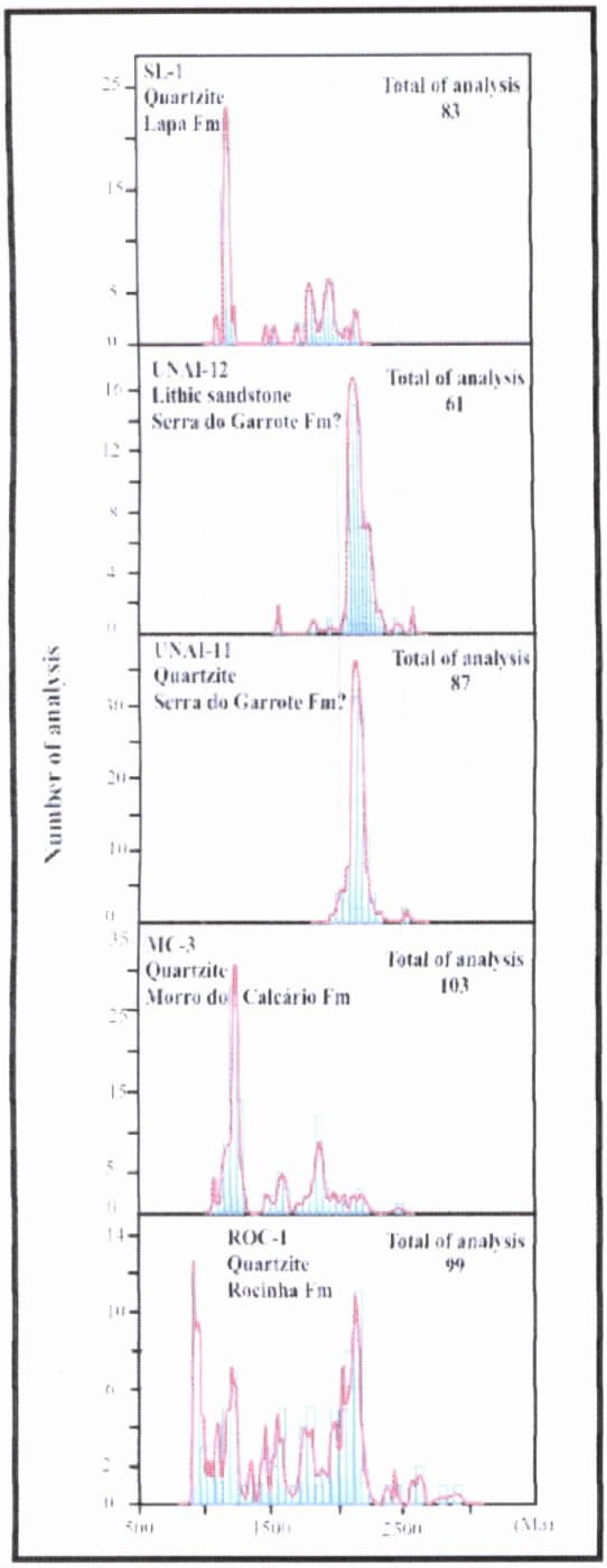

Figure 3. Frequency diagrams of samples from the Vazante Group. Ages are $^{206}Pb/^{238}U$ ages.

One diamictite sample from the basal Santo Antônio do Retiro Formation (STO-3) produced only a few zircons grains (18). Fifteen zircons were analysed, but only 9 yielded concordant results indicating ages between 995 and 1.850 Ma. The provenance pattern for the Rocinha Formation (sample ROC-1) show main peaks at 0,94 and 2,2 Ga, and minor populations at 1,2, 1,6 and 1,8 Ga. On the other hand, samples of the Morro do Calcário (MC-3) and Lapa (SL-1) formations show similar patterns indicating significant contribution from 1,2 Ga old sources. Samples collected in the northern part of the area (Unaí region – Fig. 1) display very different characteristics: - UNAI-11 is a coarse quartzite, with large rounded zircon grains and UNAI-12 is a lithic sandstone with small prismatic zircons. Despite the differences in shape and size of the zircon grains, both samples present a simple provenance pattern with a single peak at 2,2 Ga. In the samples form the southern part of the area, this Paleoproterozoic peak is observed only in the Rocinha Fm pattern.

CONCLUSIONS

The results discussed here show that the São Francisco Craton represents the major sediment source for the Vazante Group with distinct populations at 1,2 and 2,2 Ga. It is also evident that rocks from Vazante and Unaí regions have distinct provenance patterns. Data from the Unaí area suggest that the paleogeographic setting have limited the sediment input to a single Paleoproterozoic source.

It is noteworthy that the youngest zircon grains (*ca.* 0,94 Ga) only occur at the base of the sedimentary sequence, suggesting that this Neoproterozoic source was somehow isolated from the basin later on the stratigraphic section.

The data presented in this study, combined with those of Babinski *et al* (2005) suggest that the deposition of the original sediments of the Vazante Group took place between *ca.* 0,.94 and 0,.78 Ga. This is compatible with a Sturtian age for the diamictites at the base of the group, as already suggested by Asmy *et al* (2006).

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IN SITU LAM-ICPMS U-Pb AND Lu-Hf ANALYSES AT THE GEOCHRONOLOGY LABORATORY OF THE UNIVERSIDADE DE BRASÍLIA: EXAMPLES FROM HIGH-GRADE ROCKS OF THE BARRO ALTO MAFIC-ULTRAMAFIC COMPLEX

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Keywords: LAM-ICPMS, U-Pb, Lu-Hf, Barro Alto complex, Neoproterozoic

INTRODUCTION

A multi-collector LAM-ICPMS coupled to a Nd:YAG 213nm laser microprobe was recently installed at the Geochronology Laboratory of the Universidade de Brasília and has been in use for U-Pb and Lu-Hf in situ analyses of zircon, monazite, titanite and perovskite. In this paper we present a summary of the methodology and settings used, as well as some additional U-Pb and new Lu-Hf data on the age and nature of the high-grade rocks of the large Barro Alto mafic-ultramafic complex in the Brasília Belt, central Brazil.

New ID-TIMS and ICPMS data for selected rock units of the large mafic-ultramafic Barro Alto Complex are presented and confirms the Neoproterozoic age (780-800 Ma) for the Lower Series of the complex and the Mesoproterozoic age (*ca.* 1,25 Ga) for the Upper Series and associated Juscelândia volcano-sedimentary sequence. These are comparable to U-Pb data for corresponding series of the Niquelândia and Canabrava complexes, further to the northeast. Lu-Hf and Sm-Nd data indicates that the original magmas of the Lower Series have been strongly contaminated with older continental crust, whereas rocks of the Upper Series have been derived from a depleted mantle source, with limited crustal contamination.

LAM-ICPMS ANALYSES

Zircon separation was carried out at the Geochronology Laboratory of the Universidade de Brasilia. Heavy mineral concentrates were obtained using conventional gravimetric and magnetic techniques (panning, Densitest^R separator and Franz isodynamic separator). Final purification was achieved by hand picking using a binocular microscope and selected zircons grains were mounted on an epoxi mount. Two parts of Resin (Struer, Epo Fix Resin) and one part of Hardener (Struer, Epo Fix Hardener) were poured into the cast containing the zircon grains and the cast was let to rest for twelve hours. The mount was polished to obtain an even surface exposing the interior of zircons grains. Prior to LA-ICPMS analysis, the mounts were cleaned by carefully rising with dilute (2 %) HNO_3. Once fully dry, the samples were mounted in a specially adapted laser cell for thick sections, and loaded into an UP 213 Nd:YAG laser (□= 213 mm), linked to a multi-collector, high-resolution Neptune ICPMS. Helium was used as the carrier gas and mixed with Argon before entering the ICPMS. Each analysis was studied and only coherent intervals, with no signals of mixed age data or intercepted of secondary face fracture, were chosen for age calculation. All analyses were conducted in static mode with a laser beam diameter of 30 µm, operated with an output energy of 34 % and a pulse of rate of 10 Hz. Internal standard used was GJ-1 zircon (608,5 ± 1,5 Ma; Jackson *et al.*, 2004) and age calculation were performed using an in-house developed Excel ® worksheet, based on ISOPLOT V3 formulas (Ludwig 2003). Correction for common Pb were carried out in samples with $^{206}Pb/^{204}Pb$ lower the 1000, using Stacey and Kramers model (1975) for the age of crystallization. U-Pb data were plotted using ISOPLOT V3 (Ludwig, 2003). Errors for isotopic ratios are presented at the 2σ level.

The operating data are listed in Table 1. During analytical session GJ-1 standard zircon was utilized for calibrating isotopic ratios using the standard-sample-standard "bracketing" method.

Lu-Hf isotopes were analysed on 14 zircon grains from four different samples, previously analyzed with U-Pb systematics. To remove isobaric interference of ^{176}Yb on ^{176}Lu, interference-free isotopes ^{171}Yb, ^{173}Yb and ^{175}Lu have been monitored during the analyses and the appropriate correction was carried out.

Instrument	MC-ICPMS Neptune
Mode of analysis	Static
Measured masses	238, 208, 207, 206, 204, 202
Laser	UP213 New Wave, 213 nm, Nd:YAG
Integration time	1 secs
Ablation time	40 secs
Spot size	30 □m
Laser settings	10 Hz, ~2J/cm^2
Auxiliary gas (He)	0,38-0,41 l/min
Sample gas (Ar)	0,903-0,995 l/min

Table 1. Instrument set up for in situ zircon analyses.

Hf isotope ratios were normalized to $^{171}Yb/^{173}Yb$ of and to $^{179}Hf/^{177}Hf$ of 0,7359 (Chu *et al.*, 2002) to correct mass-bias fractionation. Before Hf isotopes measurements on zircons, replicate analyses of a 200 ppb Hf JMC 475 standard solution doped with Yb (Yb/Hf = 0,02) were carried out ($^{176}Hf/^{177}Hf$ = 0,282015 ± 16 2σ, n = 6). During the analytical session 15 analyses of GJ-1 standard zircon were executed giving a $^{176}Hf/^{177}Hf$ ratio of 0,282015 ±16 2σ, n=15**).** ε_{Hf} values were calculated at the U-Pb age measured for every grain.

THE BARRO ALTO COMPLEX

One of the most important features of the Neoproterozoic geology of central Brazil is the presence of three large layered mafic-ultramafic complexes forming a ca. 300 km-long NNE discontinuous belt along the central part of the Brasília Belt. From south to north these are: the Barro Alto, Niquelândia and Canabrava complexes (Fig. 1). The Barro Alto Complex is the largest of the three mafic-ultramafic layered complexes and is formed by two different magmatic series (Fuck *et al.* 1981, Ferreira Filho 1998): the Serra de Santa Bárbara Sequence or lower series (LS) is made of a thick mafic unit made dominantly of gabbronorites and a less important ultramafic unit made of pyroxenite and peridotite; diorites are also present in the upper section of this series; (ii) the Serra da Malacacheta Sequence or Upper Series comprises mainly metagabbro (the Cafelândia Amphibolite), troctolite and anorthosite. Rocks of the LS display metamorphic assemblages indicating granulite facies metamorphism with local paragenesis of UHT metamorphism (Ferreira Filho *et al.* 1998, Moraes andck 2000). The LS is intruded by a number of granite intrusions also showing granulite facies mineral paragenesis. Rocks of the US were metamorphosed under P and T conditions of the amphibolites facies and have been also intruded by small tonalitic to granitic plutons.

The Barro Alto Complex is bordered to the north and to the west by the Mesoproterozoic Juscelândia volcano-sedimentary sequence, a bimodal sequence made of metabasalts and metarhyolites, representing a rift association (Moraes *et al.* 2006).

NEW ID-TIMS AND LAM-ICPMS DATA

This study was focused mainly on rocks of the Lower Series, however geochronological information on the age and nature of the Upper Series can also be inferred mainly from the study of inherited zircon grains in the LS intrusions. ID-TIMS and LAM-ICPMS U-Pb ages of gabbronorite samples of the Lower Series are between ca. 780-800 Ma. Igneous zircon grains from intrusive granites in the same series yield ages within the same range (see Figure 2 for some examples). Sample GBA-17 is a granulite-facies gabbronorite which represents the mafic unit of the Lower Series. Igneous zircon grains analysed by ID-TIMS yielded the age of 776 ± 2 Ma. Samples GBA-16A and GBA-09 are opx-bearing granitoid intrusions into the mafic rocks of the lower series and indicate LAM-ICPMS and ID-TIMS U-Pb ages between *ca.* 790 and 800 Ma. One quartz diorite sample (GBA-12) of the LS have been also analysed and yielded the LAM-ICPMS age of 800 ± 5 Ma. Most of the samples investigated display an inherited zircon population with U-Pb ages between *ca.* 1,22 and 1, Ga, which is here interpreted as the age of the Upper Series country-rocks. One sample of the US (GBA-08) also indicate the age of *ca.* 1,25 Ga. Conspicuous Mesoproterozoic (*ca.* 1,2-1,3 Ga) inheritance is also observed in two small *ca.* 0,77 Ga old granitic and tonalitic intrusions in the Cafelândia Amphibolite suggesting inheritance from the US rocks.

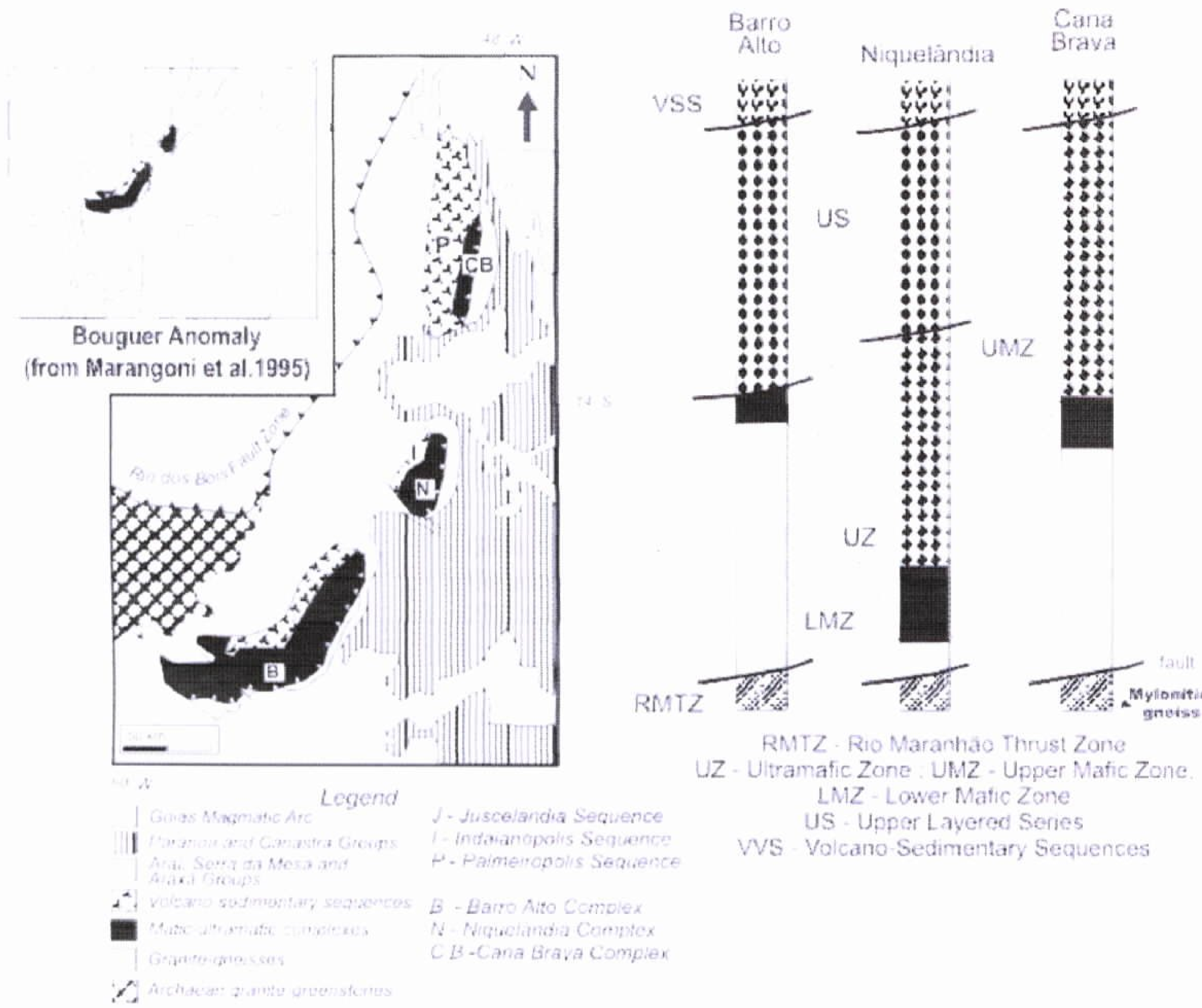

Figure 1. The three large layered mafic-ultramafic complexes in central Brazil (from Pimentel *et al.* 2006)

Lu-Hf isotopic compositions suggest that *ca.* 0,8 Ga zircon grains crystallized from mafic magmas which have been strongly contaminated with Paleoproterozoic continental crust, whereas those crystallized at *ca.* 1,25 Ga formed in juvenile magma derived from the depleted mantle with limited or no crustal contamination. This is compatible with whole-rock Sm-Nd isotopic data for rocks of the Upper and Lower Series.

CONCLUSIONS

LAM-ICPMS in situ U-Pb and Lu-Hf analyses, combined with new ID-TIMS U-Pb data constitute powerful tools to investigate the age and tectonic significance of layered mafic-ultramafic intrusions in central Brazil.

The new isotopic data indicate that the Barro Alto Complex is a composite intrusion made of a Neoproterozoic Lower Series which intruded into Mesoproterozoic rocks of the Upper Series and into Paleoproterozoic rocks of the sialic basement of the Brasília Belt. They show Sm-Nd and Lu-Hf isotopic compositions which indicate that the mafic magmas of the LS were strongly contaminated with Paleoproteorozoic continental crust, whereas the original magmas of the Upper Series was derived from melting of the depleted mantle with limited crustal contamination.

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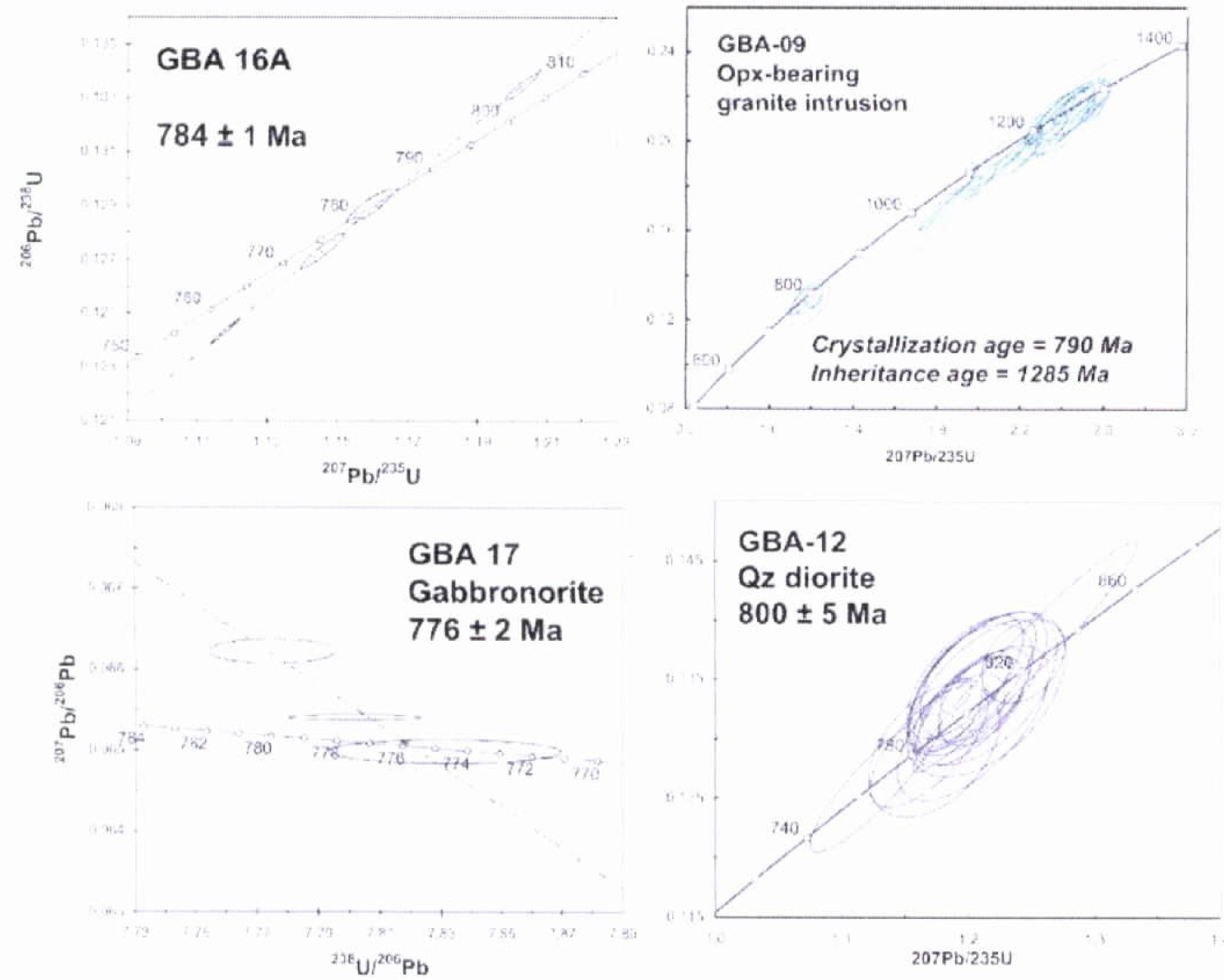

Figure 2. U-Pb Discordia diagrams for selected rock units from the Barro Alto mafic-ultramafic complex.

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COMBINED IN SITU U-Pb AND Lu-Hf LA-(MC)-ICPMS SYSTEMATICS APPLIED TO SEDIMENTS PROVENANCE STUDIES: THE NEOPROTEROZOIC VAZANTE GROUP AND THE CAMPINORTE SEQUENCE (BRASÍLIA BELT, CENTRAL BRAZIL).

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Keywords: Lu-Hf, LA-(MC) ICP-MS, Brasília Belt, sediment provenance, Proterozoic

INTRODUCTION

During the last decade the rapid progresses in Inductively Coupled Plasma mass spectrometry (ICP-MS) combined with the new techniques for in situ laser ablation microanalysis, made the Lutetium-Hafnium isotopic system, applied to zircon grain, one of the most innovative and powerful tools for geochronologic and isotopic studies (Vervoort and Blichert-Toft, 1999; Blichert-Toft and Albarede, 1997; Griffin *et al.*, 2000; Griffin *et al.*, 2002; Hawkesworth and Kemp, 2006). One of the most important applications of the Lu-Hf systematics is for sediment provenance studies using in situ microanalysis of detrital zircon grains. Zircon typically presents very low Lu/Hf ratio, and its $^{176}Hf/^{177}Hf$ ratio almost do not modify with time, so that its present-day ratio can be assumed as equal to the initial ratio. The calculation of ε (epsilon) notation permits, in analogy with the Sm-Nd systematic, to discriminate between crustal-derived ($\varepsilon<0$) and mantle-derived ($\varepsilon>0$) magmas. It has been demonstrated that the closure temperature for Hf in zircon is approximately 200^{0}C higher than that for Pb (Cherniak *et al.*, 1997a,b; Cherniak and Watson, 2000), implying that the Hf isotopic system remains closed during thermal events which take place after primary crystallization. In provenance studies the Lu-Hf system provides complementary information with respect to the other traditional methods (U-Pb and Sm-Nd). The Hf isotopic composition in zircon gives information on the nature of the protolith and on the crustal residence time of host sediment. It also permits to investigate the crustal evolution of a region and eventually to better correlate different sedimentary sequences. In this contribution we present two examples of a combined Lu-Hf and U-Pb provenance study of sediments from two stratigraphic units of the Brasilia Belt in Central Brazil: 1) the Neoproterozoic Vazante Group and 2) the Paleoproterozoic Campinorte sequence.

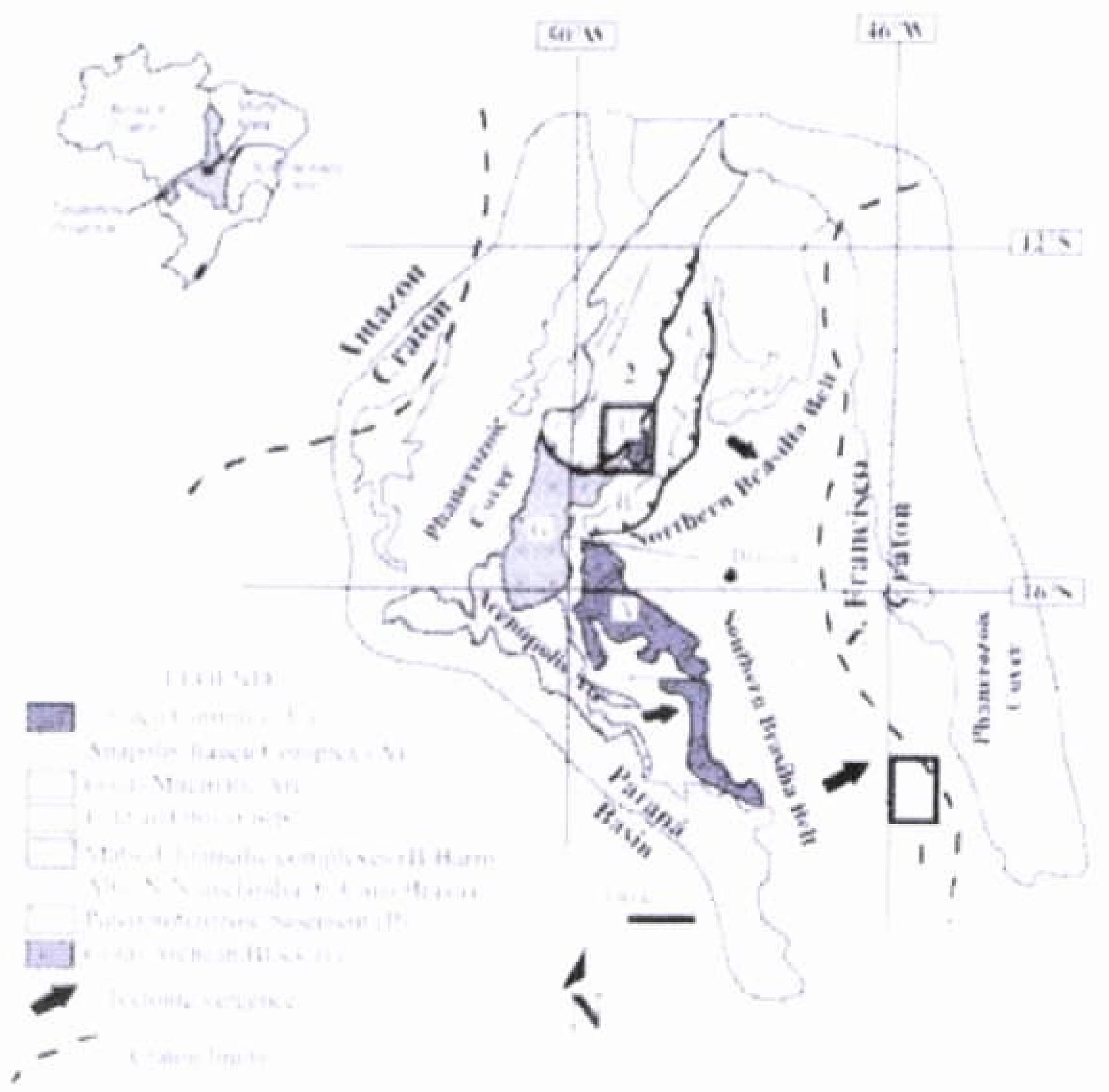

Figure 1. Geological sketch map of the Goiás Magmatic Arc. Study areas are shown: 1) Vazante Group; 2) Campinorte sequence.

GEOLOGICAL SETTING

The Brasília Belt is an important fold and thrust belt developed on the western margin of the São Francisco craton and represents the central-eastern sector of the larger Neoproterozoic orogenic zone known as the Tocantins Province. The Brasília Belt is constituted by different tectonic units of different ages: 1) the Goiás Magmatic Arc (Pimentel and Fuck, 1992; Pimentel *et al.*, 1997). 2) the Archean-Proterozoic Goiás Massif (Fuck *et al.*, 1993, 1994 Pimentel *et al.*, 2000a,b), 3) a Meso-Neoproteroic metasedimentary sequence (Pimentel *et al.*, 2000a; Dardenne, 2000).

The Vazante Group is one of the main lithostratigraphic units of the Neoproterozoic Brasilia Belt, exposed as a narrow and continuous (approximately 40x250 km) belt comprising a pelite-carbonate sequence. It is made of phyllite, slate, quartzite, metasiltstone, algal dolomite and minor limestone, deposited on a shallow marine platform during a regressive cycle (Dardenne, 2000).

The Paleoproterozoic Campinorte volcano-sedimentary sequence forms part of the Goiás Massif, surrounding an Archean TTG-greenstone core (Fuck *et al.*, 1993, 1994; Pimentel *et al.*, 2000a,b). It is dominantly made of detrital metasediments. Quartz micaschists, with variable amounts of carbonaceous material represent the main rock type and are associated to psammitic rocks including micaceous quartzites and orthoquartzites. Chemical deposits, such as gondites and metacherts, and felsic volcaniclastic rocks occur as small, elongate bodies interlayered within the metasedimentary sequence (Oliveira *et al.*, 2006)

ANALYTICAL METHODS

Lu-Hf isotopes were analyzed on 39 zircon grains from three different samples, previously analyzed with the U-Pb systematics. In the case of sample SL-1 from Vazante Group, we first calculate the statistical distribution of the $^{206}Pb/^{238}U$ ages of the 100 zircon grains previously analyzed with LA-MC-ICP-MS for U-Pb. For each significative U-Pb age group, representative zircon grains were selected for Lu-Hf analysis. In the case of samples PP4 and CAMP 16 we select representative zircon grains from the unique homogeneous populations. Lu-Hf isotopic data were collected during 40 sec of ablation time and using a spot size of 40 micron; other operational parameters are listed in Table 1. The measurements were made close to the previous laser ablation pit left by U-Pb analyses, aiming to sampling the same portion of the zircon grain. Isotope ratios measured were processed off-line in order to choose only the homogenous portions of an analyzed zircon grain. To remove isobaric interferences of ^{176}Yb and ^{176}Lu on mass ^{176}Hf, interference-free isotopes ^{171}Yb, ^{173}Yb and ^{175}Lu have been monitored during the analyses. To correct mass-bias fractionation the ^{176}Lu and ^{176}Yb were calculated using a $^{176}Yb/^{173}Yb$ normalization factor of 0,796218 (Chu *et al.*, 2002) whereas Hf isotope ratios were normalized to $^{179}Hf/^{177}Hf$ factor of 0,7359 (Chu *et al.*, 2002).

Before Hf isotopes measurements on zircons, replicate analysis of 200 ppb Hf JMC 475 standard solution doped with Yb (Yb/Hf=0.02) were carried out ($^{176}Hf/^{177}H$ f= 0,282160 ± 12, n=4) . During analytical session 12 analyses of GJ-1 standard zircon were carried out giving a $^{176}Hf/^{177}Hf$ ratio of 0,282031 ± 19).

Instrument	Neptune
Scan Mode	Static
Scanned masses	171, 173, 175, 176, 177, 178, 179, 180
Laser	UP213 New Wave, 213 nm, Nd:YAG
Integration time	1 sec
Ablation time	40 secs
Spot size	40 μm
Laser settings	7 Hz, ~2J/cm^2

Table 1. Operating conditions and instrument settings during analytical session.

DATA DISCUSSION AND CONCLUSIONS

One quartzite sample (SL-1) from the Lapa Formation corresponding to the upper part of the Neoproterozoic Vazante Group was investigated: In situ U-Pb zircon provenance study of this sample has been carried out by Rodrigues *et al.* (this Symposium, 2007). According to the frequency age distribution diagrams (Fig. 2) we selected to be analyzed a number of zircon grains proportional to the abundance of each age group. The $^{206}Pb/^{238}U$ age probability density plot for sample SL-1 shows a main peak at 1,1-1,3 Ga, a minor peak at ~1,5 Ga and an homogeneous distribution of ages between 1,7 and 2,2 Ga.

The εHf vs time diagram (Fig. 2) shows that the youngest group of zircon is characterized by variable εHf values ranging between approximately +6 and -7. Zircons with intermediate εHf, between ~+2 and -2, fall in the evolution field of paleoproterozoic crust (T_{DM}Hf of 2,1-2,4 Ga) indicating that old crustal material participated in the origin of the host magma.

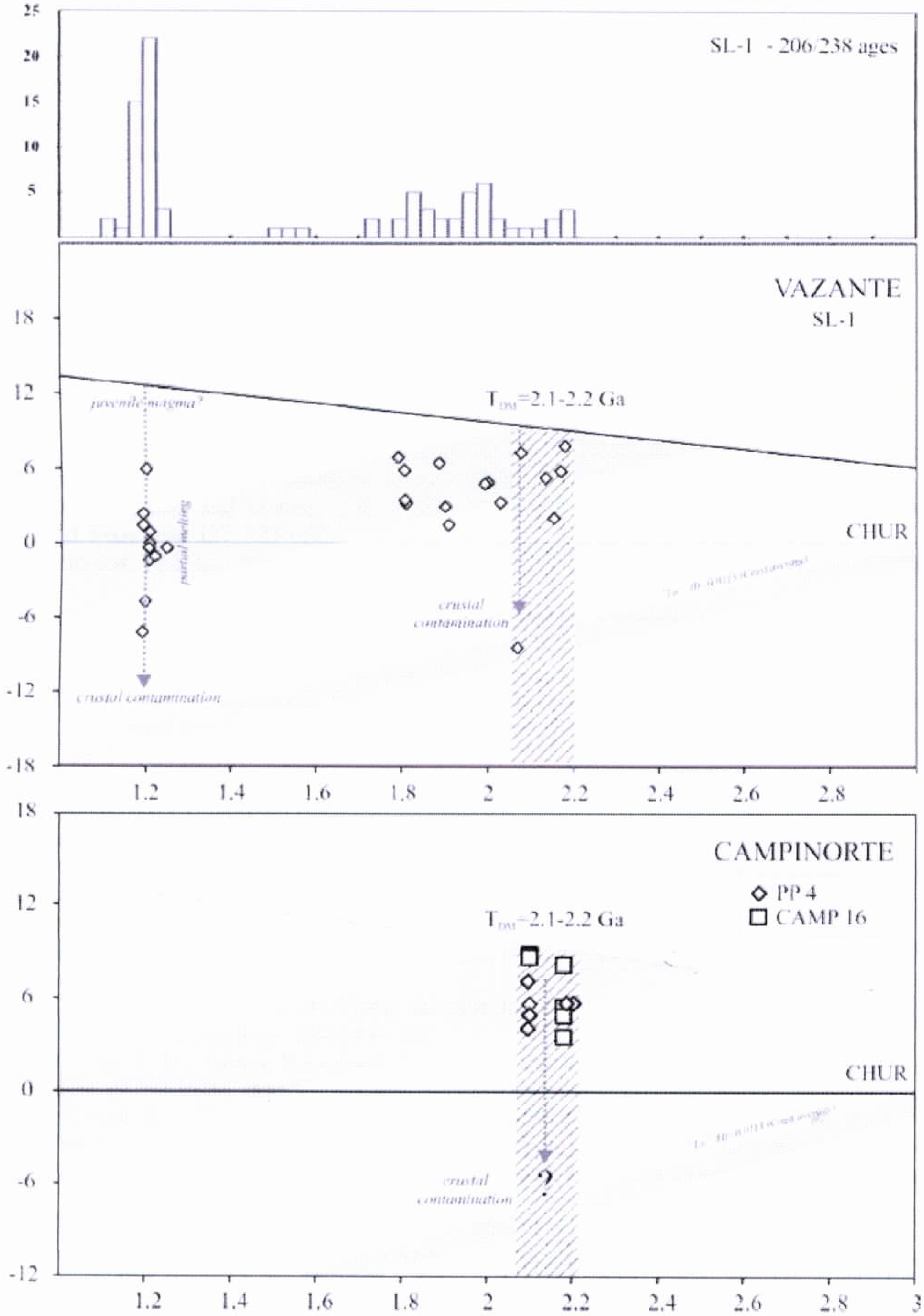

Figure 2. Comparative εHf evolution diagram showing the results of in situ zircon LA-ICP-MS analyses. The $^{206}Pb/^{238}U$ ages probability density plot for sample SL-1 from Vazante Group is shown.

Zircon with εHf of ~+6 indicates that a juvenile magmatic event occurred at 1,2 Ga at the source area of the sediments. The juvenile magmas subsequently underwent assimilation or mixing processes with crustal material of paleoproterozoic or older (Archean?) crust, represented by zircons with lower εHf (~ -7) and U–Pb age of ~1,2 Ga. The group of zircons with U-Pb ages between approximately 1,6 and 2,2 Ga, is characterized by high εHf suggesting the presence of first juvenile magmatic pulse at 2,1-2,2 Ga which was followed by other magmatic events that recycled the paleoproterozoic juvenile crust. The presence of a 2,1

Ga aged zircon grain with low εHf (~-8) points to the presence of an archean crust that variably contaminated the juvenile magma, producing the little scatter of εHf data.

Two samples from the Paleoproterozoic Campinorte metasedimentary sequence have been analysed: a metatonalite saprolith (sample PP4) and a micaceous quartzite (sample CAMP 16). The samples PP4 and Camp 16 are characterized by a very homogeneous zircon population defining U-Pb ages of 2.154 and 2.190 Ma respectively (Giustina, M.E.S.D. *et al.*; this Symposium, 2007). In the εHf vs time diagram of Fig. 2 the highest εHf data confirm the presence of the juvenile magmatism at 2,1-2,2 Ga. The small but significant scatter of εHf value between approximately +6 and +3,5, suggests that juvenile magma could have been contaminated by archean crust, in agreement with the interpretation of Hf isotope data from the Vazante Group.

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