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THE RIO ALEGRE VOLCANOSEDIMENTARY SEQUENCE (SW AMAZONIAN CRATON, BRAZIL): CHEMICAL AND ISOTOPE (U/Pb and Sm/Nd) CONSTRAINTS AND TECTONIC IMPLICATIONS

João Batista de Matos (Universidade federal do Mato Grosso) jmatos@cgi.ufmt.br
Johann Hans Daniel Schorscher (Universidade de São Paulo) hascho@usp.br
Mauro Cesar Geraldes (Universidade de São Paulo) mcgeral@usp.br
Maria Zélia Aguiar de Souza (DRM/UFMT) jgoulart@terra.com.br

Introduction

The Rio Alegre Volcanosedimentar sequence comprise felsic to mafic-ultramafic plutonic and volcanic rocks associated with banded-iron formations and cherts, which occur in the Rio Alegre valley in Mato Grosso State. Regional studies reported by Figueiredo et al. (1974); Barros et al. (1982), Neder et al. (1984), Matos and Ruiz, (1990), and Saes, (1999). Moraes and Makhoul (1986) correlated these rocks to the Rincon del Tigre complex described by Litherland et al. (1986) in Bolivia. Menezes et. al. (1993) included these rock-associations in the Pontes e Lacerda Volcanosedimentar Sequence and Matos (1994) reported a detailed geologic map for this unit and renamed it as the Rio Alegre Volcanosedimentar Sequence (RAVS). Pinho (1992) correlated the mafic metavolcanic rocks of the Rio Alegre valley with the Alto Jauru greenstone belt.

The RAVS occurs in a large area (50 x 200 km) bordered eastward by the Santa Helena batolith and the Alto Jauru Greenstone Belt. This boundary is also characterized by the presence of milonitic rocks of the Aguapei Group. The boundary to the south is covered by sedimentary rocks of Pantanal Formation (Quaternary), to the west it is overlain by flat sediments of the Aguapei Group; and limit to the north it is unknown.

Litological Description

The magmatic and volcanic metamorphosed lithologies observed in the Rio Alegre valley may be subdivided (Matos, 1994) as following: (1) Minouro Formation comprised of metabasites, fine-grained and equigranular with local porphyritic (hornblende) textures associated to fine-grained banded iron formations (with magnetite-bearing layers), chemical sedimentary rocks and cherts. Mafic dikes cut the volcanosedimentary rocks, presenting subvolcanic textures and equivalent composition. (2) Santa Isabel Formation, which comprises metabasalts, metapiroclastics and metariodacites actually presenting high oxidation and lateritization The greenish to gray volcanic rocks are isotropic or presenting slight foliation. Pyroclastic rocks present lapili texture within a fine-grained groundmass, the last partially replaced by carbonates.

Amphibolite and metaultrabasic rocks, with nematoblastic texture, are subordinated units interlayered in mica-schists. Differentiated complexes with gabbros and serpentinites with cumulate textures metamorphosed at greenschist facies compose the intrusive rocks.

(3) São Fabiano Formation, which includes clastic and chemical metasediments (phyllites, quartzites and carbonaceous layers), cherts, and metavolcanoclastic rocks, including

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garnet-kyanite bearing muscovite-biotite schists.

Muscovite biotite-schists with variable quartz amounts are observed with local occurrence of garnet and kyanite. Schists are coarse-grained with biotite or muscovite. Amphibolite and metaultrabasic rocks are subordinated units intercalated in mica-schists. They present nematoblastic texture where amphibole predominates on plagioclase, with quartz; titanite, biotite and epidote are accessory minerals.

Phylitic composition rocks are sericite, quartz-sericite and eventually biotite (Menezes et al., 1993). They may show centimetric crystals of pyrite or magnetite and rarely garnets. Carbonaceous layers are common but rarely search 10cm wide. Some volcanic-derived rocks show aspects very similar to these phylitic rocks, and they may be indistinguible from phylitic rocks due later deformation and metamorphism. Quartzite beds may occur as wide as 10 meters, usually with fine-grained and small layers of phylite. There are quartz aggregated suggesting the presence of microconglomerated levels.

Acid plutons in the Rio Alegre domain range from tonalite to granodiorite (Geraldes et al., 2001). Contact relationships are rarely exposed, but the relationship of plutonic rocks to the supracrustal sequence suggests that the plutonic rocks are intrusive bodies rather than underlying basement.

Lithogeochemistry

Matos (1994) and Matos and Schorscher (1997a, b) based on geochemical studies on metavolcanic and metaintrusives rocks from Rio Alegre Terrane, suggest a subalkaline signature for these rocks and a back-arc ocean-floor environment. Mineralogical alterations in these rocks are typical of ocean floor metassomatic process such as epidotization, carbonatization and sericitization. The geochemical data to intrusive rocks allowed to the authors to conclude that they are a result of an evolution and differentiation of tholeiitic magmas.

Menezes et al., (1993) present REE results for metabasalts from the Santa Isabel Formation showing MORB or immature island arc patterns. The authors suggest a magmatic origin from enriched-mantle source or from collision process in continental margin. The existence of ocean-floor related rocks, metamorphosed at greenschist facies, cut by pyroxenites and amphibolites may be interpreted as a collisional suture. In this way, future detailed research on this unit might take into account the possibility of the Rio Alegre terrane rock association might be an ophyolitic complex.

Geochronological and Isotopes Constraints

Magmatic activity of the Rio Alegre Terrane occurred during two time-periods (Geraldes, 2000): basic to intermediate rocks from 1509 Ma to 1494 Ma and acid rocks from 1480 Ma to 1460 Ma (Table 1). Outcrops of intermediate to felsic volcanic rocks are rare, and only two U/Pb ages are reported. The dacitic pyroclastic rocks (97-122 and 97-124) yielded zircons, which give ages of 1517 ± 27 and 1513 ± 9 Ma, respectively, with a composite regression age of 1512 ± 9 Ma. Sm/Nd analyses yield $\varepsilon_{Nd(t)}$= +4.3 and T_{DM} =1.54 Ga for 97-122 and $\varepsilon_{Nd(t)}$= +4.7 and T_{DM} =1.48 Ga for 97-124. The Sm/Nd data clearly indicate that the volcanic rocks are juvenile. Intrusive basic rocks, represented by the amphibolite gneiss yielded U/Pb age of 1494 ± 10 and $\varepsilon_{Nd(t)}$=2.5 and T_{DM} =1.68.

Two tonalites (97-113 and 97-140) yield U/Pb ages of 1465 ± 4 Ma and 1481 ± 7 Ma, respectively, with $\varepsilon_{Nd(t)}$= +3.8 and T_{DM} =1.53 Ga for 97-113 and $\varepsilon_{Nd(t)}$= +4.1 and T_{DM} =1.50 Ga for 97-140. The Sm/Nd data suggest that these plutonic rocks may be part of a juvenile terrane represented by the volcanic rocks (97-122 and 97-124).

Table 1. Summary of U/Pb and Sm/Nd data for rocks of the RAVS (Geraldes, 2000).

Field Number	Description	U/Pb Age (Ma)	εNd(0)	$\varepsilon_{Nd(t)}$	TDM (Ga)
Basic to intermediate rocks					
97-122	Metadacite	1517 ± 27	-2.8	4.3	1.54
97-124	Metadacite	1513 ± 09	-2.5	4.7	1.48
97-137	Amphibolitic gneiss	1494 ± 10	-11.3	2.5	1.68
Acid rocks					
97-140	Pau-a-Pique tonalite	1481 ± 07	-4.9	4.1	1.50
97-113	Lavrinha tonalite	1465 ± 04	-13.1	3.8	1.53

Discussion

The RAVS and associated plutonic rocks occur in the SW Amazonian Craton comprised of mafic and ultramafic volcanic rocks, chemical sedimentary rocks and mafic to felsic intrusive rocks metamorphosed at greenschist facies. Felsic rocks occur cutting mafic and ultramafic rocks as well sedimentary rocks. Petrographic, chemistry and isotopic studies allowed subdividing the complex into three subunits: Minouro Formation (base); Santa Isabel Formation (intermediary), and São Fabiano Formation (upper).

U/Pb zircon analysis on basic rock (metadiorite) yielded an age of 1.50 Ga and on intermediate volcanic rocks (metadacite) yielded ages from 1.51-1.50 Ga. T_{DM} of volcanic and mafic intrusive rocks vary from 1. 67 to 1.48 Ga and $\varepsilon_{Nd(t)}$ values from +4.7 to +2.8 suggesting a mantle-derived magma. U/Pb zircon analysis carried out in intrusive felsic rocks (tonalites) yielded ages of 1.48-1.46 Ga and T_{DM} of vary from 1. 53 Ga to 1.50 Ga and $\varepsilon_{Nd(t)}$ values from +3.7 to +4.1 suggesting a mantle-derived magma

The Rio Alegre association rocks were undergone on a metamorphic process that searched green-schists to lower amphibolite facies. Matos and Schorscher (1997a) reported mineral assembly correlated to cloritization and epidotization process, characterized by the authors as resulted of ocean-floor metassomatism. Menezes et al., (1993), reported metamorphised at amphibolite facies, characterized by chlorite-garnet-kyanite mineral association.

Deformation in Rio Alegre Terrane is characterized by a strong transposition of metasedimentary and metavolcanic rocks. Menezes et al., (1993) described this process as result of an intense milonitization developed crosscutting the original rock bedding. The main foliation direction is 30-50^{o} NW, 20-70^{o} SW dipping, indicating strain parallel to the border of

Amazonian Craton. The lineation variation (NW and SE) may represent resulted of a progressive deformational event, where initial sub-horizontal foliation (thrusting) chanced to a strike-slip movement under ductile conditions.

The Rio Alegre volcanosedimetar sequence was formerly correlated to the Alto Jauru greenstone belt (according to Menezes et al., 1993 and Pinho 1992) due the similarity of both rock associations and the lack of age constraints at that time. The new isotope and geochronological data don't allow to do this correlation, once the first is 1.50 Ga old and the second is 1.79-1.75 Ga old.

Rio Alegre Terrane may be interpreted as originated in an meso-ocean ridge (basaltic to acids volcanic and tuffs, BIF's and cherts) at ~1.50 Ga (U/Pb in zircon ages), metassomatized under sea water (cloritization and epidotization), and metamorphized under green schists to amphibolitic facies (biotite zone to garnet-kyanite zone), transposed until milonitization (NW foliation) during accrecionary process to the proto-Amazonian Craton during Mesoproterozoic times.

The actual data basin also allow to suggest that tectonic-metamorphic evolution of Rio Alegre Terrane might represent the suture zone recording the end of the ocean plate subducting process which was responsible for the Santa Helena batolith formation. According to this hypothesis the Santa Helena suite (U/Pb ages of 1.47-1.42 Ga and T_{DM} between 1.7 and 1.5 Ga) would be formed as result during the ocean plate represented patially by Rio Alegre terrane.

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