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Geochronology and Geochemistry of the Meta-Volcanic Rocks from Riacho do Tigre Complex, Borborema Province - Northeastern Brazil

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INTRODUCTION

The Riacho do Tigre Complex (RTC) is situated in the States of Pernambuco and Paraíba, in northeastern Brazil, and crops out in the neighborhood of São João do Tigre City close to the Tiger stream. It is a supracrustal unit constituted by a meta-volcano-sedimentary sequence, which has been found associated with peraluminous metagranitoid sheets. We analyzed whole-rock major and trace element compositions determined by ICP-ES in the ACME Labs-Analytical Laboratories Ltd, Sm-Nd isotopic compositions of meta-basic rocks obtained at the CPGEO-USP Laboratory, and U-Pb ages of zircon fractions separated from an acid meta-volcanic rock at the Geochronological Studies Laboratory-UnB. We discuss the geochemical signature, the crystallization ages and Nd isotopic compositions of the meta-volcanic rocks. The results were compared with some other examples of modern volcanic described in literature.

GEOLOGICAL SETTING OF THE RIACHO DO TIGRE COMPLEX

The RTC is situated in the Borborema Province, north of the Pernambuco Shear Zone, and it forms part of the Rio Capibaribe Terrain (Santos *et al.,* 2000). The Congo-Cruzeiro do Nordeste Shear Zone is the northwestern tectonic limit of this Complex (Figure 1), and also marks the strike-slip boundary between the Rio Capibaribe and Alto Moxotó Terrains.

The Pão de Açucar Complex has been considered an orthogneiss migmatitic basement of rhyacian age, and is tectonically imbricated with the RTC. Peraluminous meta-granitic rocks, which have been designated as Cariris Velhos Granite Unit, occasionally containing magnetite phenocrystals, are intrusive into both complexes as a consequence of tangential tectonics. In addition, neoproterozoic (Brazilian/Pan-African age) granitic rocks, sin- to post-tectonic in relation to the transcurrent deformation which occurred along the Pernambuco shear zone, are intrusive into the RTC. The rocks of the Itaporanga Intrusive Suite are calc-alkaline, while the Vila Moderna Intrusive Suite is alkaline to peralkaline. The RTC was deformed and recrystallized by at least two tectono-metamorphic events, which at first produced a penetrative sub-horizontal foliation that was partially overprinted by a sub-horizontal to sub-vertical foliation that corresponds to the steeply-dipping foliation in rocks found near the Congo-Cruzeiro do Nordeste Shear Zone.

PETROGRAPHIC ASPECTS OF RIACHO DO TIGRE COMPLEX

The RTC is represented by a sequence of meta-sediments (Fig. 2A) interbedded with meta-volcanic and meta-volcanoclastic rocks (Fig. 2B) and amphibolized mafic rocks. The meta-

sedimentary rocks are constituted by biotite-schist, tourmaline-bearing biotite-garnet schist, amphibole-biotite gneisses, and garnet-biotite gneisses. Part of the gneisses in the proximity of shear zones has garnet crystals involved by a mylonitic foliation.

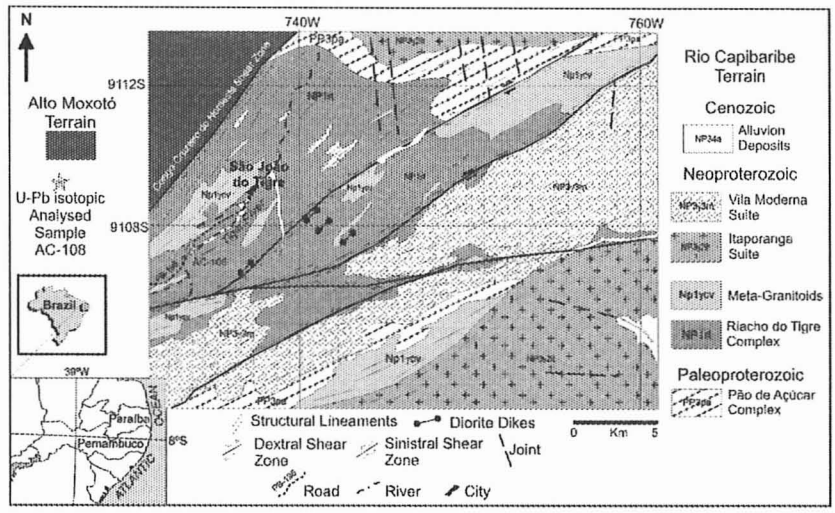


Figure 1 - Schematic Geological Map of part of the Riacho do Tigre Complex showing the location of the acid meta-volcanic sample analyzed by the U-Pb method.

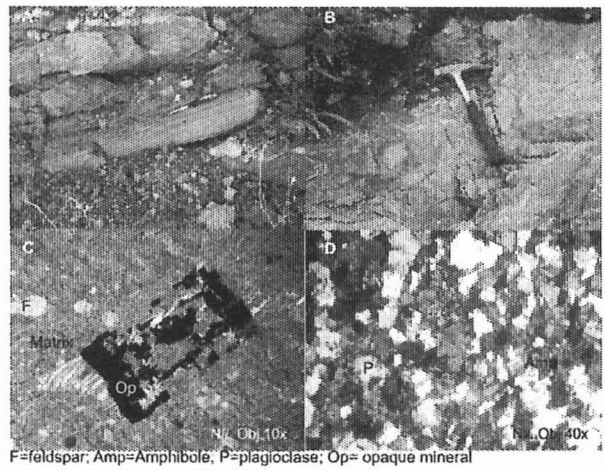
The meta-volcanic and meta-volcanoclastic rocks are mafic and intermediate to felsic, and are very fine-grained. The compositions of intermediate to felsic meta-volcanoclastic and meta-volcanic rocks are dominated by quartz and feldspar. Feldspar and opaque mineral crystals have deformation fringes (Fig. 2C) surrounded by a very fine-grained matrix which contains rare biotite, titanite and zircon. The meta-mafics are mainly amphibolites (Fig. 2D), constituted by amphibole + plagioclase + clinopyroxene + biotite/phlogopite + epidote + quartz + apatite. The main metamorphic event occurred under P/T conditions of the amphibolite facies.

GEOCHEMISTRY

The meta-volcanic rocks of the RTC were derived from sub-alkaline basalt, andesite, rhyodacite to rhyolite. The meta-basalts are both tholeiitic and calc-alkaline following the classification of Irvine & Baragar (1971). The calc-alkaline meta-basalts may be separated into high TiO_2 (>1.5 wt %) and low TiO_2 (<1.5 wt %) varieties, which were used to try to define the tectonic environment of deposition of the rocks. Patterns revealed in multi-element diagrams (REE patterns and spidergrams) using trace elements are rather irregular, especially the LILE in the spidergrams, which may reflect the effects of post-magmatic processes. The patterns defined by usually immobile elements (REE, HFSE) are influenced by processes such as fractional crystallization, in this case quite obvious for the negative anomalies show by Ti. In general, however, the spidergrams for the meta-basalts have the LILE patterns often attributed to the subduction zone contribution. The meta-basalts include, therefore, both calc-alkaline and island arc tholeiite rocks.

The meta-basic rocks are geochemically characterized by low REE contents (<100ppm) and relatively flat chondrite-normalized REE distribution patterns (La/Yb)CN ~2 (Fig. 3A). The patterns of the meta-intermediary/meta-acid volcanic types are considerably more fractionated than those of the meta-basic rocks, with (La/Yb)CN ~10-20. Negative Eu-

anomalies have been observed in most of the rocks although those of the meta-basics are smaller than those of the intermediary to acid meta-volcanic rocks. All of them show a similar spidergram signature. The spidergrams MORB-normalized (Fig. 3B) show values considerably higher of Rb, Ba and Th, with strong negative peaks of Nb, Ti and low values of HFSE (Zr, Hf and Y). These specters of the basic and acid rocks are typical of rocks produced from metassomatized mantle attributed to subductions zones (Wilson, 1989). Despite of combined trace element indicates that the factors which controlled the generation and evolution of magmas were complex, the preliminary results suggest that studied rocks are very similar with many moderns volcanic arcs rocks described in literature (Wilson, 1989; Castillo et al., 2007).



F=feldspar; Amp=Amphibole; P=plagioclase; Op= opaque mineral

Figure 2 - (A) Gneisses interbedded with meta-volcanics; (B) Outcrop of meta-volcanics rocks (C) Photomicrography of thin section showing opaque minerals with deformation fringes enclosed by quartz-feldspar matrix; (D) Photomicrography of thin section presenting amphiboles and plagioclases in amphibolitized mafic rock.

GEOCHRONOLOGY AND Sm-Nd ISOTOPIC CONTENTS

U–Pb zircon geochronology had been obtained by LA-ICPMS (Thermo-Finnigan Neptune with laser ablation system) and Sm-Nd isotopic compositions were used to assess the crystallization age of the meta-volcanic from RTC, and to provide a base form discussion of the petrogenesis. U-Pb dating was undertaken on multicrystal zircon fractions separated from an acidic meta-volcanic rock, whose cathode-luminescence emissions were examined using a Luminoscope attachment to a conventional optical microscope fitted with a medium resolution digital camera. The CL images show that most zircon grains exhibit concentric zoning with alternation of yellowish white and dark blue or black zones. The former may be due to the presence of heavy REE and perhaps U and Th while the latter could be due to radiation damage. The zoning is sometimes rudimentary with a few, not very luminescent zones, but is more usually well-defined and repeated. Some of the grains have a bright border. In many grains an irregular dark nucleus, whose shape is not repeated by the zoning in the rest of the grains, is present, and is probably inherited. Most fractions yielded nearly-concordant isotopic ratios which defining an age of 960 ± 11 Ma, which is interpreted as the crystallization age (Figure 3C), and corresponds to that of the Cariris Velhos event (Santos et al., 2010). The T_{DM} model ages (table 1) obtained for associated amphibolitized mafic rocks (meta-basalt and meta-andesite) range from1.3 to 1.4 Ga. Some zircon fractions have also

concordant ages between 1.8Ga and 2.0Ga, and these are considered inherited ages from unexposed rocks formed during the rhyacian event. The ε_{Nd}(960Ma) values in amphibolites vary from +1.9 to +0.9, while their ($^{143}Nd/^{144}Nd$)i ratios vary from 0,511229 to 0,511251. The T_{DM} age of the meta-acid rock is 2.2 Ga with ε_{Nd}(960Ma) =-12.08. This result indicates that magma genesis mainly involved mixture of crustal and mantle components.

Table 1 – U-Pb and Sm-Nd isotopic data for the Riacho do Tigre Complex.

Sample	*Litotype*	*Crystallization Age (Ga)*	*Sm^{147}/Nd^{144}*	*Nd^{143}/Nd^{144}*	*T_{DM}(Ga)*	*ε_{Nd}(0,96Ga)*
AC-108D	Meta-rhyodacite	0,96	0,0995	0,511408	2,2	-12,08
AC-53B	Meta-basalt	-	0,1257	0,511229	1,3	+1,96
AC-637	Meta-Andesite	-	0,1277	0,512251	1,4	+0,93

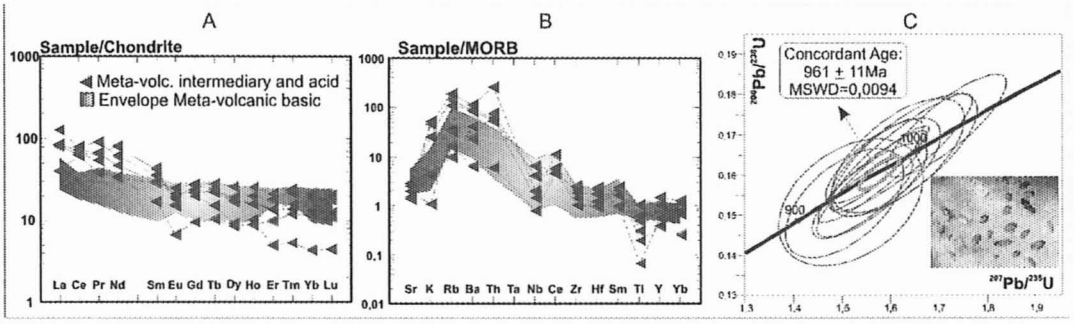


Figure 3 - Chondrite-normalized REE patterns (A) and spidergrams (B) for meta-volcanic (intermediary to acid) and meta-basics envelope. (C) Age of meta-volcanoclastic acid using U-Pb (LA-ICPMS) method in zircon.

CONCLUSIONS

The combined geochronological, geochemical, and Nd isotopic data suggest that the Riacho do Tigre Complex was formed during the Cariris Velhos event, and has many of the geochemical features associated with modern arc rocks. Crustal and mantle sources were probably involved, and the thermal effects of the intrusion of Brasiliano-Pan-African age granites may have affected the complex.

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