THE PASSIRA ANORTHOSITIC COMPLEX AND ASSOCIATED GRANITES: AN EXAMPLE OF THE ANOROGENIC MAGMATISM (CALYMMIAN/STATHERIAN) EVENT IN THE EASTERN BORBOREMA PROVINCE, NE BRAZIL

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ABSTRACT
The Passira Anorthositic Complex (PAC) is situated in Pernambuco State, Northeastern Brazil, within the Rio Capibaribe Terrain of the Borborema Province. Host rocks are rhiacian migmatitic gneisses. The PAC is a massif-type complex of batholithic proportions composed mainly of metamorphosed anorthosite, gabbro, norite, diorite and ultramafic lenses mineralized in Fe-Ti oxide minerals. A dyke swarm formed by apatite-rich ferro-diorite enriched in Zr, Ba and LREE, occurs around the complex. A multicrystal U-Pb zircon age of 1.70±0.02 Ga was obtained for the anorthosite, which is interpreted as the age of crystallization. The associated granites (now orthogneisses) include metaluminous alkaline; sub-alkaline garnet-bearing and peraluminous types having anorogenic geochemical characteristics. They have U-Pb ages between 1.58±0.09 Ga and 1.68±0.09 Ga, obtained in zircon and monazite monocrystals by laser ablation mass spectrometry. The PAC and associated granites behaved as a tectonic unit during the Brasiliano-age deformations. The association was formed in Rio Capibaribe Terrain during an extensional event occurred at the Statherian-Callymian transition.
Keywords: Metanorthosites and associated granites, Massif-type Anorthosite, Anorogenic characteristic.

RESUMO
O Complexo Anortosítico de Passira (CAP) localiza-se no Estado de Pernambuco, Nordeste Brasileiro, e está geotectonicamente inserido no Terreno Rio Capibaribe (TRC) da Zona Transversal da Província Borborema. Gnaisses migmatíticos encaixam o CAP. O CAP é um Complexo anortosítico do tipo maciço com proporções batolíticas que é composto principalmente de metanortositos, metagabros, metanoritos, metadioritos e lentes ultramaficas portadoras de Fe e Ti. Uma série de diques compostos por apatita-dioritos, enriquecidos em Zr, Ba and LREE cortam o complexo. O metanortosito foi datado através do método convencional de U-Pb em zircão de 1.70±0.02 Ga. Os (meta) granitos associados aos corpos básicos possuem tendência geoquímica alcalina; metaluminosa subalcalina e peraluminosa, estas últimas apresentam granada modal. Todos os tipos possuem características geoquímicas anorogênicas. Os granitos apresentam idades U-Pb entre 1.58±0.09 Ga e 1.68±0.09 Ga, obtidas através de análises em zircões e monazitas por ICP-MS com *laser ablation*. O complexo foi formado no TRC durante um episódio extensional de transição Estateriana-Caliminiana.
Palavras-chave: magmatismo anorogênico, complexos anortosíticos, granitóides caliminianos.

1- INTRODUCTION

The Passira (meta)Anorthositic Complex (PAC: from now on, the "meta" prefix is dropped) is situated in the Rio Capibaribe Terrain of the Transverse Zone of the Borborema Province (Brito Neves et al., 2000). The ages of crystallization of the PAC and associated granites, and the identification of the tectonic setting of these rocks are thus critical points to understand the evolution of this part of the Borborema Province. Most of proterozoic massif-type anorthosites described in the literature have a spatially associated suite of K-rich

plutonic rocks which are considered by some authors (Ashwal, 1993; Emslie et al., 1994) to form part of a typical association.

2- GEOLOGY AND GEOCHEMISTRY

The PAC is a body of batholithic dimensions (Figure 1) and its present outcrop pattern is sigmoid as a consequence of movements along two shear zones which form the limits of the area. Deformed anorthosite and gabbro together with other ultramafic and mafic rocks compose the complex. Pegmatitic, pyroxene-bearing and foliated anorthosites are the main facies, while leuconorites, garnet-bearing and foliated gabbros, lenses of pyroxenites with concentrations of Fe-Ti oxide and apatite-rich ferro-diorites complete the association. A multicrystal U-Pb zircon age of 1.70+0.02 Ga was obtained for the anorthosite (Accioly, 2000), which is interpreted as the age of crystallization. The associated granitic orthogneisses can be divided into two groups as below defined.

2.1 - Metaluminous alkalic (Sipuá Hill) granite type

This type occurs in the ENE-WSW-oriented Sipuá Hill, an important topographic feature in the northern part of the area. The rocks include syenite, quartz syenite and syeno-granite. The alkalinity is reflected by the presence of greenish blue aegirina-augita, which is the most important variety mineral, associated with apatite, alkali feldspar and/or amphibole. Biotite, titanite, zircon and magnetite are also present. Chondrite-normalized rare earth element (REE) patterns (Figure1B) show modest light REE enrichment (La_N/Yb_N~10) and strong negative Eu anomalies (Eu/Eu*=0.2). Compositions fall in the within-plate granite field of the Y x Nb and Y+Nb x Rb diagrams (Figure 1C).

2.2 - Garnet-bearing metaluminous subalkalic or peraluminous (Bengala, Passira, Candiais) granites types

These granites are mainly emplaced as sheets at the borders of, or around the complex. The first two clearly cut both anorthosite and gabbro at the north and northeastern extremities, respectively, of the complex. The Candiais sheet involves the western part of the complex. The main difference between the three bodies lies in the quantities of mafic minerals present. The compositions of rocks vary from porphyritic alkali-feldspar granite, syeno-granite, quartz monzonite to monzogranite with low to higher (~38%) colour index, in which biotite $\pm$ hedenbergite and hornblende to Fe-kaersutita are present, and the accessory minerals include garnet, allanite, apatite, titanite, magnetite and ilmenite. Most of these granites have Fe# $\geq$ 0.96, and K_20/Na_2O>1, as well as high concentrations of Ba, U, La, Ce and Zr and low concentrations of Sr and Nb, however the average Nb concentration is roughly equal to that of average A-type granite (Whalen et al., 1987).

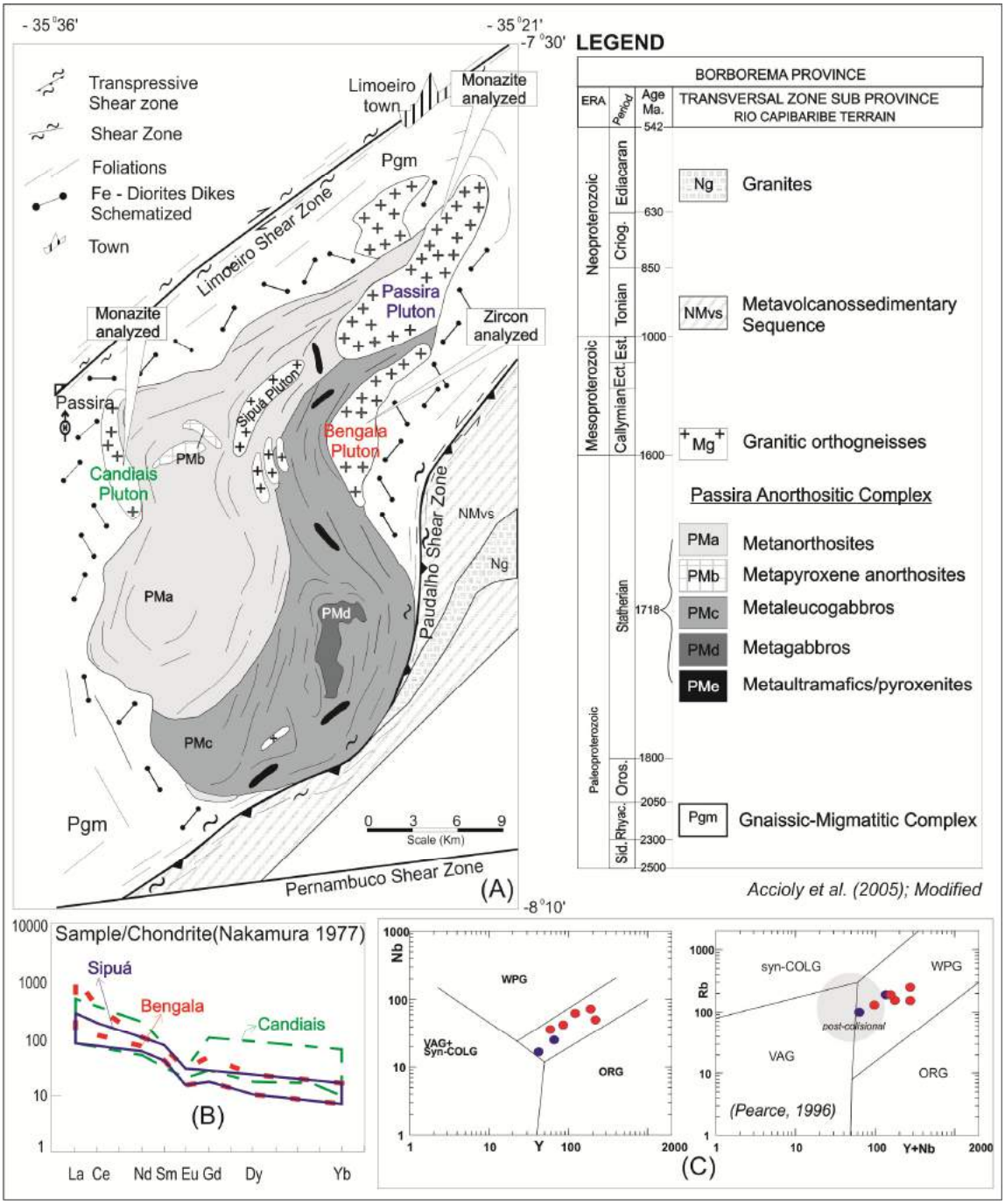

Figure 1 – (A) Schematic geological map of the Passira Complex and the main associated granites showing the location of the analyzed sample; (B) envelop of REE patterns for granites and (C) tectonic discriminants diagrams (after Pearce 1996) for Bengala and Sipuá granites type.

Chondrite-normalized REE patterns for garnet-bearing granites have stronger LREE enrichment as well as they are intraplate granites in tectonic discriminants diagrams. Some of these granites can be recognized as ferroan (Frost & Frost, 2011) granitic rocks differentiated from a tholeiitic gabbro parent composition.

3- MONAZITE AND ZIRCON AGES OF THE GARNET-BEARING GRANITES

Laser-ablation ICP-MS analyses of monazites and zircon from the Passira and Candiais and zircon from Bengala granitic intrusions yielded ages using the Montel et al. (1994) method which are slightly younger and less precise than those obtained using zircon from the anorthosite. The obtained ages are between 1.58±0.09 and 1.68±0.09 Ga interpreted as crystallization ages. Nd TDM ages of these granites are between 2.0 and 2.2 Ga with εNd(1.6Ga) values of -2 to –3.

4-DISCUSSION

The older Candiais and Passira granite magmas were probably approximately contemporaneous with the magmas responsible for the formation of the PAC, and thus the magmatism was bimodal, a feature rather typical of intraplate environments. The broad spectrum of granitoids can be referred as ferroan granitoids (Frost & Frost, 2011) reflecting distinct petrological processes in an anorogenic tectonic setting. The isotopic compositions of the PAC rocks and the associated granites show signs of crustal participation in magma Genesis.

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